FINAL

# Remedial Action Plan
# Former Community Linen Site
# 1800, 1824, and 1826 61st Street

Prepared for

Sacramento Municipal Utilities District

Sacramento, California

March 2, 2021

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# Former Community Linen Site
# 1800, 1824, and 1826 61st Street

Prepared for

Sacramento Municipal Utility District
6201 S Street
Sacramento, CA 95817

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| | |
|---|---|
| 3D | three dimensional |
| µg/L | micrograms per liter |
| µg/m³ | micrograms per cubic meter |
| AF | Attenuation Factor |
| amsl | above mean sea level |
| BC | Brown and Caldwell, Inc. |
| CalEPA | California Environmental Protection Agency |
| Cal/OSHA | California Division of Occupational Safety and Health |
| CFM | cubic feet per minute |
| cis-1,2-DCE | cis-1,2-dichloroethene |
| CPT | cone penetration test |
| CSIA | compound specific isotope analysis |
| CSM | Conceptual Site Model |
| CSR | Closure Strategy Report |
| CVOC | chlorinated volatile organic compound |
| CVRWQCB | California Regional Water Quality Control Board, Central Valley Region |
| DHC | Dehalococcoides sp. |
| DO | dissolved oxygen |
| DOT | Department of Transportation |
| DPT | Direct Push Technology |
| DTSC | California Department of Toxic Substances Control |
| DWR | Department of Water Resources |
| EC | electrical conductivity |
| EHC® | EHC® ISCR Amendment |
| EHC®-L | EHC® Liquid |
| EMD | Environmental Management Department |
| ESA | environmental site assessment |
| ESL | environmental screening level |
| FFS | Focused Feasibility Study |
| ft bgs | feet below ground surface |
| Ft/ft | feet per foot |
| GA | groundwater amendment |
| GAC | granular activated carbon |
| GA Work Plan | GA Pilot Test Report Work Plan |
| GA Pilot Test Work Plan | Addendum to the GA Pilot Test Report Work Plan |
| GF Soluble | GeoForm™ Soluble |
| gpm | gallons per minute |
| HERO | DTSC Human and Ecological Risk Office |
| in-WC | inches of water column |
| ISB | in situ bioremediation |
| ISCR | in situ chemical reduction |
| Kramer | Kramer Carton Company |
| LTMP | Long-term Monitoring Program |
| MCL | maximum concentration limits |
| mg/kg | milligram per kilogram |
| mg/L | milligrams per liter |
| Order No. R5-2015-0012-023 | Monitoring and Reporting Program for In Situ Groundwater Remediation and Discharge of Treated Groundwater to Land, Order No. R5-2015-0012-023 |
| NACSM | North American Commission on Stratigraphic Nomenclature |
| Offsite area | Area south of the Site between S Street and Fourth Avenue |
| O&M | Observation and Monitoring |
| ORP | oxidation-reduction potential |
| PCE | tetrachloroethylene |
| PEL | Permissible Exposure Level |
| PHG | Public Health Goal |
| Project Site | Collectively refers to the Site and Offsite Monitoring Area together |
| Plumestop® | Plumestop® Liquid Activated Carbon™ |
| PPBV | parts per billion by volume |
| PRZ | Permeable Reactive Zone |
| psi | pounds per square inch |
| PVC | polyvinyl chloride |
| RAO | Remedial Action Objectives |

| | |
|---|---|
| RAP | Remedial Action Plan |
| RDIP | Remedial Design and Implementation Plan |
| ROI | radius of influence |
| RSL | Regional Screening Levels |
| S-MicroZVI® | sulfidated micro zero-valent iron |
| SCR | Site Characterization Report |
| SG | Soil Gas |
| SI | Site Investigation |
| Sierra West | Sierra West Consultants |
| Site | 1800, 1824, and 1826 61st Street, Sacramento, California |
| SL | Screening level |
| SMAQMD | Sacramento Metropolitan Air Quality Management District |
| SMUD | Sacramento Municipal Utilities District |
| SRS | Sensitive Receptor Survey |
| SVE | Soil Vapor Extraction |
| SVI | Soil Vapor Intrusion |
| SWRCB | California State Water Resources Control Board |
| TCE | trichloroethylene |
| TDS | total dissolved solids |
| TM | Technical Memorandum |
| TOC | total organic carbon |
| trans-1,2-DCE | trans-1,2-dichloroethene |
| USEPA | United State Environmental Protection Agency |
| USGS | United States Geological Survey |
| UST | underground storage tank |
| VC | vinyl chloride |
| VOCs | Volatile Organic Compounds |
| VFA | volatile fatty acids |
| ZVI | zero-valent iron |

# Executive Summary

This Remedial Action Plan (RAP) has been prepared by Brown and Caldwell. (BC) for the Former Community Linen Site (the Site), located at 1800, 1824, and 1826 61st Street in Sacramento, California pursuant to recommendations presented in the Final In Situ Bench Scale Treatability Report dated March 18, 2020 and the Soil Vapor Extraction Pilot Test Report dated September 16, 2016. This RAP documents the selection of the preferred remedial approach for the site based on data from investigation and feasibility study activities conducted since 2009.

The Site, comprised of three properties (1800, 1824, and 1826 61st Street, Sacramento, California [Figure 1]), is upgradient (geographically north) of Highway 50. Between 1957 and 1981, Community Linen operated a steam laundry business at 1826 61st Street and later expanded to 1824. In 1981, Community Linen sold the properties to Sacramento Municipal Utilities District (SMUD) and the steam laundry business and associated equipment to Mission Laundry. SMUD subsequently leased the properties to Mission Laundry to operate the steam laundry business. In 1985, SMUD terminated the lease and converted the 1826 61st Street building into office space. Between 1985 and 2007, SMUD demolished the buildings at both properties and ultimately converted the property to an employee parking lot with a solar charging station that is used by employees at the neighboring SMUD headquarters building. The property at 1800 61st Street was formerly operated as Kramer Carton Company, who began operating a paper box manufacturing and printing facility from 1952 to 2009. This property was purchased by SMUD on May 4, 2016 and the building was demolished in 2019.

The Former Community Linen/Mission Laundry operations and, to a lesser extent, the Former Kramer Carton (Kramer) operations, are the source of historical releases of contaminants in the subsurface at some point during their operating histories. The suspected primary source of contaminants in the subsurface is a historic underground storage tank (UST) that was previously located at the Project Site property. While the exact use of the former UST is unknown, data collected to date suggest that tetrachloroethylene (PCE) was stored in this UST in some capacity and leaked from there into the subsurface. Minor additional sources of PCE have been observed at the Former Kramer Carton property.

SMUD has addressed the Site environmental impacts by conducting a number of source area and offsite investigations from 2009 to present. The Site and the Offsite areas are defined as the "Project Site" in this document and in Figure 2. Additionally, BC has prepared a three-dimensional (3D) model of the subsurface that was created using the historic Site data. The evaluation of the historical data and the 3D model have shown the following conditions:

- PCE and other related contaminants are present above acceptable levels in soil, groundwater, and soil vapor onsite in the subsurface
- PCE and other related contaminants in groundwater have migrated to the south offsite beneath Highway 50
- PCE is in groundwater in the area south of the Site between S Street and Fourth Avenue (Offsite area) and is the source of PCE concentrations in soil vapor in the Offsite area
- The extent of contaminants in shallow groundwater and Project Site soil vapor are defined and require remedial actions to address any potential current or future environmental or health risks associated with the PCE and other contaminants

Although SMUD was not operating the laundry or other previous Site facilities during the time of the contaminant release, investigation and cleanup actions have been completed by SMUD to protect their employees and the public, as well as maintain regulatory compliance for SMUD-owned properties. In order to address the subsurface contamination described, soil vapor and groundwater remedial activities were initiated in 2016 when BC performed a soil vapor extraction (SVE) pilot test. The results of this SVE test indicated that this technology would likely be effective for remediation of PCE and other contaminants in soil and soil vapor beneath the suspected source area. From 2017 through 2020, BC conducted several phases of groundwater amendment pilot testing and feasibility analysis. The results of these groundwater remedial alternatives analysis indicated that remediation of PCE and related contaminants could be effectively achieved through in situ amendment injections that would enhance biodegradation of the contaminants.

Elements of this RAP include SMUD and BCs proposed remedies to clean up the contaminated soil, soil vapor, and groundwater in the Site and Offsite areas. The recommendations described herein have been developed after evaluating Project Site data, utilizing the 3D model that depicts the data, and the results of the SVE and groundwater amendment pilot testing activities. The evaluations included potential remedial effectiveness, feasibility, restoration of the nearby community, and (to a lesser degree) costs. The evaluation resulted in the recommendations presented herein that the following remedial full-scale remedial design elements be completed:

- A full-scale SVE system that will address source area soil and soil vapor concerns at the Site (onsite area only) and in areas where elevated soil vapor concentrations have been historically observed
- A full-scale groundwater amendment injection remedy to address areas on the Site where elevated PCE concentrations have been observed
- A permeable treatment zone to remediate groundwater contamination and prevent impacts from migrating to the Offsite area south of Highway 50
- A groundwater monitoring plan intended to evaluate remedial progress and long-term contaminant degradation until contaminant trends in groundwater indicate a reasonable timeframe to applicable proposed screening levels

This RAP provides an overall strategy and approach for implementation of the elements described above. The proposed SVE system will include a total of seven SVE wells and four monitoring points to assess ongoing progress and to assess when remediation of the soil and soil vapor is complete. Proposed actions for system design, installation, and observation, maintenance and monitoring (OM&M) are also described herein. Upon approval of a RAP, SMUD and BC will prepare a Remedial Design and Implementation Plan (RDIP) that will include detailed design specifications and operations based on the criteria proposed herein.

This RAP also provides an overall strategy for groundwater amendment injection using EHC-L®. This reagent was selected after evaluating several different amendments in the pilot and feasibility testing process. The overall groundwater remedial strategy includes:

- Focused source area amendment (EHC-L®) injections to reduce the highest Site concentrations of PCE footprint and additional injections along the downgradient Site boundary to reduce PCE and related contaminant concentrations of groundwater flowing to the Offsite area. Multiple injections over time are expected until PCE groundwater concentrations decrease to a point where health risks and migration potential are significantly reduced.
- To reduce PCE and related contaminant impacts to the Offsite area and treat the influx of contaminated groundwater from under Highway 50, a permeable reactive zone (PRZ) consisting of 22 injection locations are proposed along T street. Due to the unknown contaminant mass in

groundwater under Highway 50 and the known longevity of the solution-based amendments, a second injection event may be needed in approximately three years after the initial Offsite area injections to maintain treatment of groundwater into the Offsite area.

Project Site investigations are not complete for the overall project. The vertical extent of PCE and related compounds in the Offsite area is not defined. Additionally, human health risk evaluation activities are being conducted for soil vapor migration in the Offsite area. The most recent data collected as documented in the *Additional Offsite Soil Gas Investigation Report* dated August 31, 2020, indicates that there are no risks to human health in the Offsite area, however additional investigation activities are planned to verify the absence of risks. If data from these activities indicate that remedial activities are necessary in Offsite area, an amendment to this RAP will be prepared and made available for public comment.

A draft RAP was made available for public comment on January 4, 2021 and this comment period extended to February 17, 2021. During that period, no public comments were received and this RAP has been finalized consistent with the draft RAP.

BC and SMUD will prepare the proposed RDIP after the RAP has been approved. We anticipate the initial full-scale SVE and groundwater remedy installation activities will be conducted in the next 12 to 24 months, as described in the schedule included herein.

## Section 1

# Introduction

On behalf of Sacramento Municipal Utilities District (SMUD), Brown and Caldwell (BC) has prepared this Remedial Action Plan (RAP) for the Former Community Linen Site (Project Site) in response to the Central Valley Regional Water Quality Control Board's (CVRWQCB) request included in their April 27, 2020 letter *Review of In Situ Treatment Bench-Scale Treatability Study Report, Former Community Linen Site, 1800, 1824, & 1826 61st Street,* Sacramento County. This RAP has been prepared in accordance with recommendations made by SMUD and CVRWQCB in the following documents, collectively referred to as the Feasibility Reports:

- Soil Vapor Extraction (SVE) Pilot Test Report (BC, 2016c)
- Groundwater Pilot Test (GA Pilot Test) 2017 Semi-Annual Report (BC, 2018a)
- Groundwater Remedial Implementation Focused Feasibility Study (BC, 2019d)
- In Situ Treatment and Bench Scale Treatability Test Report (BC, 2020a)
- Addendum to the Groundwater Remedial Implementation – Focused Feasibility Study (BC, 2020b)

These Feasibility Reports documented BC's evaluation for future actions to remediate impacts of chlorinated volatile organic compounds (CVOCs), most notably tetrachloroethylene (PCE) and its degradation product trichloroethylene (TCE) in the soil, soil vapor, and groundwater at the properties consisting of 1800, 1824 and 1826 61st Street, Sacramento, California (Figure 1). Impacts of CVOCs have also affected a residential neighborhood south of the properties listed above. The location of this area is depicted in Figure 2. (hereinafter referred to the Offsite area). The properties north of the Highway 50 are hereinafter referred to as the "Site". The Site and Offsite area are collectively referred to as the "Project Site" for this Report and are shown in Figure 2.

This RAP has been prepared to document selection of the preferred remedial approach for the Project Site based on data from the investigation and feasibility study activities.

## 1.1 Regulatory Framework

SMUD began work on the property at 1800 61st Street by performing a Phase 1 Environmental Site Assessment (ESA) in advance of purchasing the property (BC, 2008). This initial investigation led to a follow on Phase II evaluation, where subsurface contamination was identified beneath the three properties that are included in the Project Site. This contamination was reported to the CVRWQCB, who has served as the primary regulatory oversight since that time. Two cases are listed on the Geotracker database. The global ID for the 1800 $61^{st}$ Street property is listed as T10000006064 and for 1824/1826 Street, it is listed as T10000004660. After initial investigations were completed, SMUD concluded that the primary source of subsurface contamination beneath the Project Site originated from 1824/1826 Street (described in more detail in Section 2 below). As such, project documents and regulatory correspondence are primarily recorded on the under the Global ID for this property.

A draft RAP was made available for public comment on January 4, 2021 remained open for public comment until February 17, 2021. On January 27, 2021 SMUD, BC and the RWQCB participated in a meeting where key elements of this RAP were presented to members of the public. The invitation for the meeting was extended to property owners and occupants south of Highway 50 in areas that would potentially be affected by remedial activities or additional testing in the area. Project fact sheets were also sent out to property owners/residents in the Site vicinity. At the end of the draft RAP comment period on February 17, 2021, no comments from the public had been received. The draft RAP was then finalized consistent with the draft content.

## 1.2 Purpose and Objective

This RAP proposes full-scale remedies that address Site groundwater, soil, and soil vapor as well as Offsite shallow groundwater CVOC impacts. For the impacts at the shallow groundwater on the Site, in situ anaerobic biotreatment is proposed. The conceptual remedial injection design for full scale remediation focuses on the >500 micrograms per liter (µg/L) PCE plume footprint and an Offsite area injection plan to treat CVOC impacts flowing offsite south of Highway 50 (Figure 2).

SVE will be implemented to remediate soil and soil vapor impact in Site source areas. The SVE system will consist of a blower and granular activated carbon (GAC) to extract and treat vadose zone CVOC mass.

## 1.3 Evaluation of the Proposed Remedial Alternatives

Based on the results of the remedial investigations, groundwater and vadose zone soil are the impacted media at the Site. Groundwater has been identified as the impacted media at the Offsite location. Soil vapor has been impacted Offsite, but only as the result of groundwater impacts. Soil vapor impacts in the Offsite area are planned to be remediated by the removal of the groundwater source.

### 1.3.1 Onsite Soil and Soil Vapor

In July 2016, an SVE pilot test was performed at the Site to evaluate potential use of SVE to remediate source area PCE impact to the vadose zone. In September 2016, BC prepared and submitted Soil Vapor Extraction Pilot Test Report (SVE Report; BC, 2016c) to document the findings of the pilot test. The Report concluded that SVE was an effective technology for removing contaminant mass from high permeability soils within the shallow vadose zone (approximately 13 to 18 feet below ground surface [ft bgs]), while less effective though still useful in mitigating contaminants from within lower permeability soils in the deeper vadose zone (23 to 32 ft bgs). After reviewing the SVE Report, the CVRWQCB issued a letter, dated October 13, 2016 (CVRWQCB, 2016), concurring with the use of SVE.

### 1.3.2 Onsite and Offsite Shallow Groundwater

Enhanced anaerobic biodegradation through direct amendment injections, confirmed through 2017 pilot testing, is the selected remedy for shallow groundwater remediation at the Site. For the direct injections, a proof-of-concept Groundwater Amendment (GA) Pilot Test was performed in 2017 (BC, 2018c) as described in Section 4.4. Although the results using EHC® slurry-based amendment showed significant reductions in PCE and TCE concentrations in groundwater, challenges were encountered while injecting the EHC® slurry.

Following the GA Pilot Test completion in 2018, a Focused Feasibility Study (FFS) was performed and BC submitted a technical memorandum (TM) to the CVRWQCB in July 2019 (BC, 2019d) which described remedial alternatives for shallow groundwater. Because of the challenges encountered in injecting the slurry-based amendment during the GA Pilot Test, the FFS compared the performance and cost of the EHC® slurry-based amendment with other soluble reagent-type amendments to select the most cost-effective and performance-effective amendment for the full-scale remedy.

Additionally, the FFS revisited groundwater recirculation, a remedial option considered prior to the GA Pilot Test.

As part of the FFS, evaluation of alternative delivery mechanisms to inject slurry-based amendments was also conducted such as: 1) specialized high- pressure injections that involve inscribing a notch into the wall of the borehole to propagate the injection radius resulting in the slurry-based amendment being placed at a greater radius than with traditional injection tooling, and 2) Using proprietary injection pumps and equipment that can inject fluids at high pressures. The FFS described that these delivery mechanisms at relatively shallow intervals would likely result in the amendment daylighting or short-circuiting into a subsurface utility. Considering such risks and the significant additional cost, these alternative delivery methods were not considered as a feasible delivery options.

In addition to alternative delivery techniques, the FFS also evaluated nine in situ amendments (four slurry-based and five solution-based) to enhance reduction of CVOCs such that natural process following active remediation could be considered as a closure remedy. The FFS evaluated the short-term effectiveness defined as achieving reduced CVOC concentrations at the Site, and long-term effectiveness defined as the ability to remediate upgradient CVOC mass from the Highway 50 area prior to migrating into the Offsite area. Effectiveness also evaluated combinations of amendment and delivery mechanisms to determine which would result in optimal amendment distribution. The 'retained' amendments ranked based on delivery, cost and performance were EHC® Liquid, GeoForm™ Soluble, and PlumeStop® + sulfidated micro zerovalent iron (S-MicroZVI®). A description of each amendment is provided in the FFS. These solution-based amendments were tested at bench-scale as described in Section 4.1 to select the most appropriate one for the full-scale remedy implementation.

## 1.4 Organization of Remedial Action Plan

This RAP briefly summarizes Project Site conditions, findings of previous activities, and selection of a remedial approach. Additional technical details are described in the referenced documents. Following approval of the RAP, a more detailed description of the remedial activities will be presented in the Remedial Design and Implementation Plan (RDIP). This report consists of the following sections:

- **Section 1:** Provides the objective of this RAP, the regulatory framework, and the organization of this report.
- **Section 2:** Presents a description of the Project Site history, current land use, surface features, regional geology and hydrogeology, and area water use.
- **Section 3:** Presents an interpretation of hydrogeologic conditions and the distribution of CVOCs in the various hydrogeologic units beneath the Site (i.e., site conceptual model).
- **Section 4**: Provides a summary of the remedial alternative feasibility testing that has been performed.
- **Section 5:** Presents a summary of the Project Site-specific health risk assessment activities, presents updates to select exposure pathways, and describes the approach to the future risk assessment update.
- **Section 6**: Discusses the Site Remedial Action Objectives (RAOs) and proposed corrective measures.
- **Section 7:** Discusses the screening of general response actions, remedial technologies, process options, an evaluation of potentially applicable remedial alternatives, and selection of the preferred remedial approaches.

- **Section 8:** Presents the anticipated schedule for implementation of the RAP.

Section 2

# Site Background and Current Conditions

## 2.1 Project Site Background and History

The Site, comprised of three properties (1800, 1824, and 1826 61st Street, Sacramento, California [Figure 1]), is upgradient (geographically north) of Highway 50 and. The following provides background information including previous investigation activities.

The former Mission Laundry and Community Linen properties located at 1824 and 1826 61st Street cover an area of approximately 2 acres. In 1957, Community Linen began operating a steam laundry business at 1826 61st Street. In 1960, Community Linen expanded the business to a second facility at 1824 61st Street. In 1981, Community Linen sold the properties to SMUD and the steam laundry business and associated equipment to Mission Laundry (also known as Mission Linen Supply). SMUD subsequently leased the properties to Mission Laundry to operate the steam laundry business. In 1985, SMUD terminated the lease and converted the 1826 61st Street building into office space. In 1986, SMUD demolished the building at 1824 61st Street and constructed an employee parking lot which is still in use today. In 2007, SMUD demolished the building at 1826 61st Street and constructed a hydrogen vehicle fueling facility. SMUD subsequently converted the property into an electric vehicle charging facility, additional employee parking, and a solar panel array.

The property at 1800 61st Street covers an area of approximately 2.5 acres. In 1952, Kramer Carton Company (Kramer) began operating a paper box manufacturing and printing facility. Kramer operated until 2009 and used both petroleum hydrocarbons and CVOCs in the printmaking process. The building featured several large printing press areas, a production office, prepress area, compressor area, and a chemical storage/maintenance area, including a solvent parts wash tank and underground storage tanks (USTs). Willamette Capital Management, Ltd. sold this property to SMUD on May 4, 2016.

The former laundry facilities (1824 and 1826) were the focus of a removal action of four USTs, a Phase II site investigation (SI), a feasibility study and a 1985-1987 remedial action that resulted in the removal of petroleum impacts in soil. In 2006, SMUD discovered an unknown fifth UST under the 1826 61st Street building foundation and removed it later that year. After review of the results of the remedial actions, the Sacramento County Environmental Management Department (EMD) issued a letter providing a "no further action" status for USTs on the property. Since the contaminant of concern for the USTs were petroleum-related, samples collected for the assessment were only submitted for analysis of petroleum hydrocarbon constituents. However, analytical data from soil and soil vapor sampling collected since 2006 has indicated that this fifth UST was a likely source of CVOCs present in the subsurface.

Subsurface investigations to date have consisted of both Site and Offsite area efforts (Figure 2). Previous Project Site actions were targeted to delineate CVOC source contaminants (PCE and TCE), primarily in soil, soil vapor, and groundwater beneath the Project Site, and to help select pilot testing of potential remediation technologies. The following lists the prior Project Site investigations:

- 1824 and 1826 61st Street properties:
  - Underground Storage Tank Removal Action, and
  - 2012-2013 Soil Vapor and Groundwater Investigation.
- 1800 61st Street property:
  - 1998 Phase I Environmental Site Assessment (ESA) and Phase II ESA,
  - 2008 Phase I ESA and Soil Vapor and Groundwater Investigation,
  - 2009 Soil Vapor Investigation,
  - 2014 Soil and Groundwater Investigation, and
  - 2015 Soil, Soil Vapor, and Groundwater Investigation.
- Offsite Monitoring Area:
  - 2016 Offsite Soil Vapor and Groundwater Investigation,
  - 2019 Offsite PCE/TCE in Soil Vapor over Groundwater Plume Investigation, and
  - 2019/2020 Additional Offsite SG Investigation
- Site and Offsite Monitoring Area:
  - 2016 Groundwater Investigation and Aquifer Test, and
  - 2016/2017 Offsite Soil and Groundwater Investigation.
  - 2017/2018/2019/2020 Offsite Soil and Groundwater Investigation.

The following remedial activities have been performed at the Site:

- 2016 Soil Vapor Extraction (SVE) Pilot Test,
- 2017/2018 Groundwater Amendment Pilot Test, and
- 2019 Bench-scale Treatability Study.

## 2.2 Current Land Use

The Site is currently owned by SMUD and is being used for a solar parking charging station and parking lot. The former Kramer Carton building foundation remains present. The building was demolished in 2019. The parking areas are predominantly asphalt paved. The building foundation is elevated approximately three or four feet from the surrounding areas and has a concrete surface. There are no immediate plans to change the current use of the Site.

## 2.3 Topography, Surface Water, and Site Drainage

Topographic information based on the 1992 United States Geological Survey (USGS) 7.5-minute topographic map, Sacramento East, California Quadrangle. The elevation of the Site is approximately 33 feet above mean sea level (amsl). The Site area is flat with a slight slope downward to the west. The Southern Pacific Railroad borders the Site area to the north and paved roads surround the remainder of the Site. The American River is approximately 1-mile northeast of the Site area. No surface water bodies are located in the Site or Offsite areas.

Surface and storm water run-off flows into storm drains located along the Site parking area and along Offsite roads. Storm water is conveyed through drains located in the Site and Offsite areas and along the neighboring streets.

## 2.4 Regional Geologic Setting

The regional setting provides the geologic background that supports the Project Site-specific geologic conditions observed. The subsurface varies between the Site and Offsite areas as a result of their different depositional environments. As described in subsequent sections, the subsurface geologic conditions are the primary driver for contaminant transport.

The Project Site lies within the South American Subbasin portion of the Sacramento Valley Groundwater Basin (California Department of Water Resources ([DWR], 2003). The subbasin is bounded on the east by the Sierra Nevada mountain range, on the west by the Sacramento River, on the north by the American River, and on the south by the Cosumnes and Mokelumne rivers.

The South American subbasin aquifer system is comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include younger alluvium (consisting of flood basin deposits, dredge tailings and Holocene stream channel deposits), older alluvium, and Miocene/Pliocene volcanics. The cumulative thickness of these deposits increases from a few hundred feet near the Sierra Nevada foothills on the east to over 2,500 feet along the western margin of the subbasin. The maximum combined thickness of all the younger alluvial units is about 100 feet. The thickness of the older alluvium is about 100 to 650 feet.

For the Site and Offsite areas, the younger and older alluvial units are defined to include all post-Mehrten sediments (as described below) and are designated as the Laguna Formation. This broader definition is employed because the numerous Quaternary formations others have proposed are based on geomorphic or buried-soil information rather than on criteria by which formal formations are distinguished as specified in the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature [NACSM], 2005). More importantly, the criteria used by others cannot be easily distinguished in drill cuttings. In the Oroville area, Blair and others (1991) used this same broader definition and also designated the units above the Mehrten Formation as the Laguna Formation.

The Laguna Formation primarily consists of fluvial deposits, or deposits formed from the processes of rivers and streams. Characteristic of former river systems is the deposition of interbedded sands, gravels, silts and clays whereby the sand and gravel units represent material deposited within the high velocity flows of the main river channels and the silts and clays represent material deposited within areas of low velocity flows such as the floodplains. This variety of sediments are observed in the Site and Offsite areas as depicted in the 3D model. Such conditions commonly form preferential groundwater flow paths and soil vapor preferential pathways along the sands and gravels of the former river channels.

Underlying the Laguna Formation is the Mehrten Formation, which also consists of fluvial deposits but represents a period when the source rocks for the paleo-river systems were primarily volcanic material. Blair and others (1991) distinguished the Mehrten Formation from the overlying Laguna Formation by the presence of either greater than 50 percent pumiceous material or gravel clasts and/or sand grains consisting of a composition greater than 50 percent andesite, andesitic basalt, and/or dacite.

## 2.5 Site Stratigraphy

A detailed description of the Site subsurface stratigraphy is included in the Site Characterization Report (BC, 2015; SCR) from the geologic boring logs and cone penetration test (CPT) logs performed at the Site during the Site Characterization investigation and previous investigations. Subsequent borings from a Site soil vapor pilot test (BC, 2016c) and groundwater amendment pilot test (BC, 2018a) encountered similar stratigraphy and supported Site subsurface stratigraphy reported in the SCR.

The surface unit observed at soil boring locations is asphalt or concrete directly underlain by 1- to 5-feet of fill material. Underlying the fill material is the Laguna Formation consisting of interbedded sands, silts, gravels, and clays to the maximum depth of 84 ft bgs observed at MWD-4, MWD-5, and MWD-6. Hydrostratigraphic units presented on the cross-sections for the Laguna Formation are distinguished based on relative permeability's as follows:

- Low permeability silts and clays;
- Intermediate permeable silty sands; and
- Permeable sands and gravels

The subsurface below fill material is generally composed of low permeability silty clay to clayey silt to a depth of approximately 10 to 12 ft bgs, intermediate permeability sandy silts from approximately 12 to 15 ft bgs, relatively more permeable sands and gravels from approximately 15 to 19 ft bgs, relatively lower permeability silty clay from approximately 19 to 23 ft bgs, and interbedded intermediate permeable sandy silts and permeable sands from approximately 23 to 40 ft bgs. The continuity of permeable sands and gravels from approximately 15 to 26 ft bgs across the Site is supported by SCR soil boring data. The monitoring well boreholes completed to 84 ft bgs noted silty sands with interbedded silt and clay lens from approximately 40 ft bgs to total drilling depth. Continual recovery of soil cores beyond 26 ft bgs (approximately) was not achieved from the soil borings competed within the footprint of the former Kramer Carton building. As such, the continuity of lithologic units beyond this depth could not be confirmed.

## 2.6 Offsite Stratigraphy

Lithologic descriptions and CPT data from the Offsite area are from several borings installed as reported in the SCR, Addendum to Closure Strategy Report (BC, 2016d), Addendum to the Groundwater Amendment Pilot Test Report Work Plan (BC, 2016b), Offsite Investigation Report (BC, 2017a), Addendum to Closure Strategy Report [(CSR) BC, 2018b], and Additional Offsite Groundwater Assessment Report (BC, 2019b) provide the data interpreted for the understanding of the Offsite stratigraphy. A greater understanding of the shallow subsurface is available due to all but two borings being installed in the shallow subsurface (less than approximately 50 ft bgs).

In the Offsite area, the surface at soil boring locations is asphaltic concrete or concrete directly underlain by approximately 2 to 5 feet of fill material. Beneath the fill, the Laguna Formation is observed throughout the Offsite area and consists of interbedded intervals composed of low permeability silty clay to clayey silt, intermediate permeability sandy silts, and relatively higher permeability silty sands. At depths greater than 46 ft bgs, deep CPT borings have been installed (GGD-1 and GGD-2) and indicate mostly very dense and stiff soil conditions, with only minor interbedded sandy silt to silty sand layers encountered (less than 2 feet thick), to a maximum depth of 85 ft bgs. Unlike at the Site area, intervals of relatively higher permeability clean sands and gravels were not observed in the Offsite borings.

Section 3

# Conceptual Site Model

The SMUD Former Community Linen conceptual site model (CSM), developed primarily from historical and recently collected Project Site-specific data, describes the subsurface conditions and extents of CVOC contamination in groundwater and soil vapor at the Site and in the Offsite area. The objective of the CSM is to provide a current understanding of the migration of CVOC impacted groundwater from the Site to the Offsite area and the migration of CVOCs to soil vapor that is sourced primarily from groundwater residual CVOC impacts. The CSM focuses on PCE largely due to the higher PCE concentrations in groundwater and soil vapor relative to other CVOCs. In the Offsite area, TCE does exceed screening levels in soil vapor at a subset of locations, however PCE concentrations overall represent the majority of the concentrations above applicable screening levels. The overall footprint of the TCE groundwater plume is greater in length than for PCE, however these distal TCE concentrations in the Offsite area are lower than concentrations that correspond to the PCE footprint.

The primary data sets used to develop the CSM are: (1) regional geologic information and lithologic data from soil borings (see Sections 2.4 through 2.6 for further detail); (2) groundwater elevation and CVOC (PCE and TCE) concentration data; (3) Offsite soil vapor sample PCE concentrations; (4) Offsite area residential building types; and (5) Offsite subsurface utility information. Site geologic and groundwater concentration data is included in the CSM as the assumed source area is the Former Community Linen building. Visualization of the data is critical to communicate the CSM so a three-dimensional (3D) model was developed for this purpose. This section will describe the data used, how it was incorporated into the 3D model, and an interpretation of the 3D model.

## 3.1 Site Hydrogeology

The direction of groundwater flow across the Site is from north to south with a hydraulic gradient on the order of 0.001 feet/foot (Ft/ft) in shallow groundwater. The most recent calculated groundwater flow direction, based on shallow groundwater elevation data from the Site and Offsite areas as detailed in the Second Quarter 2020 Groundwater & Soil Gas Monitoring Report (BC, 2020c), ranged from 2.04 to 4.66 feet above mean sea level (amsl) (depth to groundwater from these wells ranged from approximately 27 to 32 ft bgs). The reported groundwater flow direction and calculated gradient of 0.001 Ft/ft has been consistent during past investigations and monitoring events. Seasonal groundwater table fluctuations have been observed along with increasing elevation trends.

As described in Section 2.4 of the Addendum to the GA Pilot Test Work Plan (BC, 2016b), a number of single well tests and one constant rate aquifer test were performed to quantify aquifer hydraulic properties, including transmissivity and hydraulic conductivity for the shallow portion of the groundwater aquifer. These data were used to select and support the design of the amendment delivery mechanism. Estimates of hydraulic conductivity and transmissivity were calculated primarily from the constant rate test, with estimates from the single well tests providing secondary data. The single well tests were performed at wells CWS-2, CWS-3, and GMW-1 and the constant rate aquifer test was performed on well GMW-1.

In general, the wells tested responded quickly to pumping stress and achieved relatively stable drawdowns at pumping rates four gallons per minute (gpm) or less. After pumping, wells recovered quickly to pre-test levels, on the order of seconds to one minute. Based on standard aquifer test curve-matching techniques (such as Theis, 1935 and Cooper-Jacob, 1946), the quick responses to pumping and recovery are indicative of relatively lower aquifer transmissivity, while the stable drawdowns achieved during pumping are indicative of relatively higher transmissivities. Review of the pumping and response data from the single well tests and the constant rate test show that overall transmissivity estimates vary by an order of magnitude, depending upon whether drawdown or recovery is the basis of the estimate. This variation is likely due to the short-term nature of the tests, which likely affect only a limited amount of aquifer material in the direct vicinity of the well. The test deemed most representative of aquifer characteristics on a larger scale is the constant rate test, which produced stable drawdown in well GMW-1 for 8 hours. As such, the transmissivity estimate from this test will be considered the most representative of Site aquifer characteristics, with analyses from the single well test providing secondary data. The aquifer tests are summarized in Table 3-3 of the Addendum to the GA Pilot Test Work Plan (BC, 2016b).

## 3.2 Source Evaluation

As described in Section 2 – Project Site Background and Current Conditions and in the SCR (BC, 2015), a fifth UST was discovered in 2006 under the Former Community Linen building foundation near the boiler room. This previously unknown UST is assumed to be the primary source of CVOC contamination at the Site (assumed to be PCE based on data later collected). Onsite data support that lesser sources of CVOCs are present and likely from the former Kramer Carton Company building. Documentation supporting these locations as known releases or CVOC use is not available. Because of this, there is uncertainty regarding the primary release locations and mechanisms of contamination entering the subsurface. Based on historical property use at both the Former Community Linen and Former Kramer Carton, CVOCs could have been released through surface leaks and spills, through leaking underground tanks, dumping of solvents directly to the ground surface, or discharges to sanitary and/or storm sewers.

## 3.3 Nature and Extent of CVOCs

The objective of the remedies included in this RAP is to address CVOC impacted media. This section describes the nature and extent of the CVOC impacts based on data from previous Site and Offsite investigations. The discussion in the following subsections has been separated by impacted media type. Soil, groundwater, and soil vapor are impacted with CVOCs at the Site, whereas soil and groundwater are impacted in the Offsite area. CVOCs are present in soil vapor in the Offsite area as a result of off gassing from impacted groundwater. For this reason, these soil vapor impacts are discussed herein in relation to the groundwater impacts. PCE is the primary compound present with TCE and other CVOCs detected at much lower concentrations.

### 3.3.1 Shallow Soil

CVOC soil data reported in the CSR for the Site area was comprised from grab samples near utilities, soil borings and samples collected during the installation of MW-1 through MW-4 (Brusca, 2014). A comparison of the soil sample data sets collected from within the Kramer Carton facility showed the highest PCE detections were from the unsaturated zone in MW-4 (at 15 ft bgs) at 0.33 milligrams per kilogram (mg/kg) and the utility excavation sample SE-2 AT 4' (at 4 ft bgs) at 0.14 mg/kg. Similarly, the highest TCE detections from the unsaturated zone as reported by the CSR were within the Kramer Carton facility from SB-9 (at 15 ft bgs) 0.012 mg/kg. Soil samples were collected and tested while constructing SVE wells for the pilot tests; the results are summarized in Table 4-1 of the SVE Pilot Test Report (Appendix A). PCE and TCE concentration in source area soils were significantly greater than the 0.0023 mg/kg and 0.0018 mg/kg (respectively) environmental screening levels (ESLs) to preserve groundwater quality ranging from 0.0072 to 0.41 mg/kg and 0.0013J (detected above laboratory detection limit but below the reporting limit) to 0.14 mg/kg (respectively) from soil samples collected while installing the SVE pilot test wells.

### 3.3.2 Shallow Groundwater

Grab groundwater samples were collected in the vicinity of the suspected source area in 2012 (as reported in the CSR). Of these samples, a grab sample from GG-6 had the highest PCE concentration (3,100 μg/L) detected on the Site and was located in close proximity to the suspected source UST described in Section 3.2.

Recent groundwater sampling performed in June 2020 (as reported in Second Quarter 2020 Groundwater & Soil Gas Monitoring Report; BC, 2020c) provides a current understanding of the extents of CVOC impacts in shallow groundwater. PCE was detected in the 18 monitoring wells, with concentrations ranging from 0.54 μg/L (MWS-14C) to 2,100 μg/L (MWS-6); TCE was detected in 16 of 18 monitoring wells, with concentrations ranging from 0.31 J μg/L (MWD-5) to 330 μg/L (MWS-6); cis-1,2-dichloroethylene (cis-1,2-DCE) was detected in 11 of 18 monitoring wells, with concentrations ranging from 0.30 μg/L (MWS-13) to 340 μg/L (CWS-1); trans-1,2-dichloroethylene (trans-1,2-DCE) was detected in 5 of 18 monitoring wells, with concentrations ranging from 0.17 J μg/L (MWS-7) to 5.0 J μg/L (CWS-1); and vinyl chloride (VC) was detected in 5 of 18 monitoring wells, with concentrations ranging from 0.26 J μg/L (MWS-7) to 65 μg/L (CWS-1). Figure 3 and Figure 4 show shallow groundwater isoconcentration contour maps for PCE and TCE, respectively. Figure 3 shows that MW-13 defines the downgradient extent of PCE while Figure 4 shows that MW-14C defines the downgradient extent of TCE in groundwater.

Looking at the Site area, the concentration trends nearest to the source area well MWS-6 show PCE concentrations have been consistent with previous results, while TCE concentrations have shown a decrease since Second Quarter 2019. Downgradient of the source area, the in situ remedial effects of the pilot test area (located near wells GMW 1 through GMW-4 where injections slurry-based amendment occurred in June 2017 [see Section 4.3 below]) have been observed in wells south and downgradient. Consistent PCE and TCE decreasing concentration trends have been observed in these downgradient wells, including CWS-1 through CWS-3; these decreasing trends reflect active biodegradation as a result of the pilot test. Further downgradient, the concentration trends for Offsite well MWS-9 have shown an overall reduction in contaminant concentrations, with PCE as stable to slightly decreasing, TCE is steadily decreasing, with the remaining degradation products as stable at low levels to non-detect. Based on these observations, it appears that degradation products are increasing in proximity to the pilot test area and stable to decreasing in downgradient due to natural attenuation processes, as would be expected.

### 3.3.3 Deep Groundwater

The deep groundwater zone is characterized based on three monitoring wells in the Site area and two borings in the Offsite area. Site wells MWD-4, MWD-5, and MWD-6 are collocated with shallow monitoring wells MWS-4, MWS-5, and MWS-6. The Offsite borings, GGD-1 and GGD-2 are located at west of 61st Street and T Street intersection and west of 61st Street and 2nd Street intersection, respectively.

The Additional Offsite Groundwater Assessment Report (BC, 2019b) described the deep groundwater zone to be greater than 46 ft bgs based on borings GGD-1 and GGD-2 in the Offsite area. The geologic observations indicate mostly very dense and stiff soil conditions, with only minor interbedded sandy silt to silty sand layers encountered (<2 feet thick), to a maximum depth of 85 ft bgs. This is unlike at the Site, where intervals of interbedded sands, silts, gravels, and clays to the maximum depth of 84 feet bgs were observed at boring/monitoring well locations MWD-4, MWD-5, and MWD-6.

PCE and TCE distribution in deep groundwater zone at the Site is delineated by three monitoring wells MWD-4, MWD-5, and MWD-6 which are screened between 69 and 81 feet (collectively). The latest PCE and TCE data for MWD-4, MWD-5, and MWD-6 in the December 2018 (BC, 2019a) did not exceed the maximum contaminant level of 5 μg/L. In the Offsite area, PCE and TCE groundwater impacts are defined by grab samples collected at various depths during the installation of the GGD-1 and GGD-2 borings in April 2019 (BC, 2019b). PCE and TCE in the deep groundwater zone were at the highest concentrations and above their maximum concentration limit (MCL) (5 μg/L) at sample location GGD-2. PCE concentrations from grab groundwater samples ranged from a maximum of 210 μg/L at GGD-2 (61-66 ft bgs) to a minimum of 2.0 μg/L at GGD-1 (78-83 ft bgs); TCE concentrations grab groundwater samples ranged from a maximum of 180 μg/L at GGD-2 (61-66 ft bgs) to a minimum of 0.20 μg/L at GGD-1 (78-83 ft bgs).

### 3.3.4 Site Soil Vapor

For the Site area, the CSR provides the latest collection of the PCE concentrations in soil vapor in the vadose zone. As reported in the CSR, elevated concentrations of PCE in soil vapor defining the source area are situated in the central and western portion of 1826 61st Street, the eastern portion of 1824 61st Street, and the southern portion of 1800 61st Street. At most sampling locations, the highest concentrations of PCE in soil vapor were reported in samples collected in the vadose zone between approximately 13 and 15 ft bgs. The highest concentration of PCE detected at the Site was reported for sample SG-15 with a concentration of 2,300 mg/L, or 2,300,000 micrograms per cubic meter (μg/m$^3$), at 15 ft bgs.

### 3.3.5 3D CSM Model for Offsite Soil Vapor

LeapFrog (by Seequent) is a 3D visualization software, that provides for enhanced interpretation and visualization of regional stratigraphy and geology, was used to depict Site and Offsite data as part of the visual CSM. LeapFrog is unique that it can provide rapid visual understanding of Project Site dynamics affecting contaminant migration. Use of 3D models helps illustrate how Project Site characteristics, such as geology or utility depths, can alter contaminant migration by inhibiting vertical migration or indicate likely preferential pathways. Developing a 3D Leap Frog CSM includes Project Site information not limited to soil boring logs, CVOCs present and their concentrations in groundwater and soil vapor, groundwater monitoring well information, soil gas (SG) well and sample point information, utilities present and depths, topography and potentiometric surface, and building type and construction information.

The overall footprint of the model is based on the extents of the groundwater monitoring well network. Upgradient areas start near the railroad track north of the Former Kramer Carton building and extend downgradient, across Highway 50, through the offsite residential neighborhood, and ending just south of Broadway Avenue. The uppermost layer generated in the 3D model is the ground surface. Publicly available elevation data is used to “drape” the aerial photographs across the Project Site at the corresponding elevation. A 10-times vertical exaggeration is used in the model to gain a better depiction of subsurface details (also in Figure 5); the average total thickness of the model is approximately 50 feet.

#### 3.3.5.1 Geologic Data

Development of the 3D geologic component of the model included incorporating information from geologic boring logs collected at the Project Site. Localized changes were made to stratigraphic thicknesses and depths, such that the model approximately matches available geologic data. The modeled vadose zone and shallow aquifer is part of the Laguna formation; sediments observed were grouped into three lithologic categories: Coarse grained sediments (sands and gravels), coarse with fines (sands with silts and clays), and fines (silts and clays). Both the Site and Offsite areas are underlain with a coarse with fines layer to the bottom of the model that becomes thinner to the south. An approximately 15-foot thick coarse-grained layer (at the northern extent; from 22 to 7 ft bgs) is depicted in the northern end of the model within the Site area, extending south while thinning, and pinching out just south of Highway 50 in the Offsite area. Surficial fines layers extending to 15 ft bgs are depicted below the Former Community Linen building in the Site area. In the Offsite area, the geologic information depicted is comprised of a 4-layer “layer cake” of surficial fines of approximately 15 feet, underlain by a coarse with fines layer 5- to 10- feet thick, underlain by another fines layer (10- to 20-feet thick), followed by another coarse with fines layer. The depicted lithologic data (Figure 6) shows lateral continuity of these four layers in the Offsite area south of Highway 50 to Broadway Avenue.

#### 3.3.5.2 Groundwater Data

Groundwater PCE concentration data was incorporated into the 3D model from both grab samples (typically collected with direct push drilling technology) and groundwater monitoring wells. The grab sample data is a point-in-time data set that has been collected under the various Project Site investigations. The Fourth Quarter 2019 PCE concentration data was included in the 3D model. The vertical thickness of the each of these data types corresponds to the sampler used for the direct push grab samples or the corresponding well screen. A gradation of magenta colors was used to depict the range of PCE concentration for the groundwater sample (as depicted as a cylinder in the model; Figure 7). The latest PCE groundwater plume is also included in the 3D model; the same gradation of magenta was used to depict the isocontours.

#### 3.3.5.3 Offsite Soil Vapor Data

Lastly, with respect to contaminant concentration data, recent PCE soil vapor data from the Offsite area (only) were incorporated into the model from samples that were collected from three intervals: 15-, 5-, and 2-ft bgs. On Figure 8, the 1-foot vertical sample interval is depicted as a cylinder in the model where soil vapor sample detections below the concentration 15 $\mu g/m^3$ are depicted as orange and concentrations of 15 $\mu g/m^3$ and greater are depicted as various shades of blue.

#### 3.3.5.4 Offsite Subsurface Utilities

The location, depth, and type of subsurface utilities is important for the development of an understanding of SG distribution and potential migration, as utilities and utility trenches which may act as preferential pathways for SG migration. Available utility location maps from utility purveyors in the area including the City of Sacramento, Sacramento County, SMUD, and any other applicable gas, telephone, and cable utilities were requested, and many were obtained. In addition, during the April 2020 soil vapor sampling event, an Offsite area walk along the public right of way was conducted to identify residential sewer connection pipes. Utility data collected for the Offsite area was incorporated into the 3D model. As shown on Figure 9, each type of subsurface utility is depicted as a different color; sanitary sewer is orange and storm sewer is green.

#### 3.3.5.5 Offsite Building Construction

Understanding the type of residential building construction in the Offsite area is another critical element in understanding the complete SG pathway. BC obtained publicly available information from the City of Sacramento Building Department relating to the construction of homes in the Offsite area during this investigation. The information gathered and incorporated into the 3D model includes:

- Foundation information (crawl space, slab on grade, etc.)
- Date constructed
- Presence of basement

As shown Figure 10, slab on grade and raised are types of residential foundations present in the Offsite area (building information is not available for all the properties in the Offsite area). No houses with basements were identified. Foundation types in the Offsite area included 17 residences with slab on grade construction (4 with a moisture barrier), and 41 homes with raised foundations.

## 3.4 Contaminant Fate and Transport

After release to surface or subsurface soils from the suspected source areas described in Section 3.2, contaminants migrated downward to or through the saturated Laguna formation to the shallow aquifer. It is likely that the previously mentioned source USTs were installed below the surficial clay layer. Releases from the Former Community Linen UST may have discharged directly to coarser sediments observed in the Site area, flowing downward fairly rapidly through to groundwater. The abundance of clay and silt layers in the Laguna formation likely account for the residual contamination near the assumed source area and are likely the source of CVOC impacted soil vapor in the Site area. Further fate and transport discussion about impacted soil vapor in the Offsite area can be found in Section 3.4.1 below.

As stated previously, PCE and to a lesser extent, TCE, show the highest reported values and are the most widespread CVOCs; these groundwater plumes in the shallow aquifer migrated through advection to the south. Based on the data available, the plumes are long and narrow indicating that dispersion is not a major contributor to plume distribution or attenuation has limited plume dispersion. Other degradation daughter products of PCE (i.e., cis-1,2DCE and VC) have been detected at the Site typically at lower concentrations than PCE and TCE). Transport from the release point to groundwater may include vadose zone soil vapor and water infiltration primarily within the approximately 10-foot-thick layer of sand to silty sand (from approximately 10 to 20 ft bgs). As discussed in the CSR, the Site is underlain by alluvial sediments where sands and gravels represent deposits from former river channels that may form preferential contaminant-flow paths along these features. Based on the Site data, these types of features are present within the vadose and saturated zones. These features appear to control movement of PCE and TCE generally in a northeast to southwest direction throughout the Site and north to south in the Offsite area.

### 3.4.1 Offsite Groundwater 3D Model Summary

The 3D model includes the PCE groundwater plume depicted as an isoconcentration contour based on the December 2019 groundwater monitoring isoconcentration contour map. Supporting the depiction are the various well screens (depicted as cylinders) and the associated PCE concentration (the color of the cylinder represents a concentration range). The vertical interval of the PCE groundwater plume is depicted from the groundwater table (also included in the model) to the deepest groundwater data point within the shallow aquifer.

The results of the 3D model confirmed our understanding of CVOC fate and transport in groundwater described above, showing the impacts have distributed in a long narrow plume shape likely largely due to subsurface lithology and groundwater flow patterns.

### 3.4.2 Offsite Soil Vapor 3D Model Summary

With respect to vapor intrusion in the Offsite area, a detailed review and evaluation of the 3D model identifies conditions that provide insight into the potential pathway of PCE impacted groundwater and soil vapor. As a basis of understanding, groundwater is the source of PCE impacted soil vapor in the Offsite area because no known activities or land uses are present; the PCE impacted groundwater plume within the Offsite area generally depicts the lateral extents of the Offsite investigation sample locations for evaluating impacted soil vapor. As depicted in the 3D model, for volatized PCE to reach the surface from groundwater, it would need to travel through two fine grained layers that “sandwich” a coarse with fines grained layer. This coarse with fines layer provides a conduit for lateral dispersion as well as an interval that acts as a reservoir for PCE vapors to gather. It should be noted that this layer is laterally continuous in the Offsite area. The surficial fines layer acts somewhat as a “cap” to reduce the flow of vapors to the surface; this layer is also understood to be continuous throughout the Offsite area. Additionally, the subsurface utilities are primarily found to reside within this surficial fines layer. This prevents the utilities and associated trenches and manholes from being a direct conduit from the coarse with fines layer but their presence still allows them to be a primary preferential pathway for vapors. The sanitary sewer connections to the residences is of interest as a preferential pathway.

The building foundation is the last component of the soil vapor pathway to be considered. The absence of basements in the Offsite residential area is advantageous in reducing preferential pathways since there are no foundation walls (with associated cracks) and floors in direct contact with subsurface sediments. Cracks and pipe chases are the primary pathway for slab on grade foundations and raised foundations provide the greatest disconnection from subsurface SG.

## Section 4

# Summary of Remedial Alternative Feasibility Testing

This section discusses feasibility testing previously performed to evaluate and select remedial alternatives to address CVOC impacts in the vadose zone soil and shallow groundwater at the Site and Offsite areas.

## 4.1 Remedial Alternative Feasibility Testing Overview

The following remedial alternatives feasibility testing were conducted to evaluate vadose zone soil and shallow groundwater impacts in the Site and Offsite areas. Associated Feasibility Reports are listed below each item.

- Site SVE pilot testing for the vadose zone soil treatment (described in detail in Section 4.2 below).
  - Soil Vapor Extraction Pilot Test Report 1800, 1824 and 1826 61st Street Sacramento, California (BC, 2016c)
- Shallow groundwater pump test activities and recirculation evaluation (described in detail in Section 4.3 below).
  - Addendum to the Groundwater Amendment Pilot Test Report Work Plan 1800, 1824 and 1826 61st Street Sacramento, California (BC, 2016d)
- GA Pilot Test using slurry-based amendment (EHC) for the shallow groundwater treatment (described in detail in Section 4.4 below).
  - Groundwater Amendment Pilot Test Work Plan 1800, 1824 and 1826 61st Street Sacramento, California (BC, 2016a)
  - Addendum to the Groundwater Amendment Pilot Test Report Work Plan 1800, 1824 and 1826 61st Street Sacramento, California (BC, 2016d)
  - Pilot Test Completion and 2017/2018 Annual Monitoring Report 1800, 1824, and 1826 61st Street (BC, 2018c)
- Bench-scale treatability testing using solution-based amendments for the shallow groundwater treatment and associated Focused Feasibility Study (described in detail in Section 4.4 below).
  - In-Situ Treatment Bench-Scale Treatability Study Report (BC, 2020a)
  - Addendum to the Groundwater Remedial Implementation Focused Feasibility Study (BC, 2020b)

## 4.2 Site Area Soil Vapor Extraction (SVE) Pilot Testing

SVE pilot test activities were performed in 2016 to evaluate its effectiveness on reducing CVOC mass in the high and moderately permeable (as described in Section 2.5 above) unsaturated zone soils beneath the Site. The basis of the design, described in the Soil Vapor Extraction Pilot Test Work Plan (BC, 2016a), was based on the extensive characterization work that has been conducted at the Site in accordance with the CSR. The results of the resulting Site characterization were reported in the SCR.

Before initiating SVE pilot testing, eight vapor extraction wells were installed at the Site as shown in Figure 11: four shallow wells (SVE-1S through SVE-4S) and four deeper wells (SVE-1D through SVE-4D). The shallow vapor extraction wells were screened from approximately 13 to 18 ft bgs and the deeper vapor extraction wells were screened from approximately 25 to 30 ft bgs.

Between July 18 and 19, 2016, step testing was performed using SVE-1S and SVE-1D (individually) for extraction. After this initial evaluation, a constant rate extraction test was performed between July 20 and 22, 2016 at well SVE-1S, for a period of approximately 55 hours. Only the shallow well was used for the test due to higher flow rates in the shallow zone during the step test and the inability of the deeper zone to propagate vacuum from SVE-1D to observation wells during the step tests. Tables summarizing the test results are provided in Appendix B.

The following summarizes the findings of the pilot testing:

- Influent PCE concentrations extracted from SVE-1S during the step test and constant rate extraction test ranged from 160,000 to 49,000 parts per billion by volume (ppbv) or approximately 1,100,000 to 330,000 $\mu g/m^3$.
- During the SVE-1D step test, PCE was detected at a concentration of 6,200 ppbv (approximately 43,000 $\mu g/m^3$).
- The shallow zone step test demonstrated acceptable vacuums present 46 feet from SVE-1S when the extraction flow rate was 8 cubic feet per minute (cfm).
- The radius of influence (ROI) around well SVE-1S (screened from 13 to 18 ft bgs) was at least 46 feet, with induced vacuum observed at wells SVE-2S, SVE-3S, and SVE-4S, at maximum levels of 14.8 inches of water column (in-WC), 44.2 in-WC, and 3.64 in-WC, respectively. During this single well test, a flow rate of approximately 55 to 60 cfm at SVE-1S was achieved.
- The ROI around deeper well SVE-1D (screened from 25 to 30 ft bgs), was inconclusive, but much smaller than the shallow zone. Induced vacuum was not observed at nearby wells SVE-2D and SVE-3D, however low levels of induced vacuum were observed at the more distant well SVE-4D (up to 1.0 in-WC).
- During the constant rate extraction test, total CVOCs were removed at rates ranging from 1.8 to 4.0 pounds per day, declining through the test. Over 95 percent of the total CVOC mass removed is estimated to be from PCE based on collected analytical data.

The result of the pilot test indicated that SVE is a viable remedial alternative for removal of contaminants in the shallow zone. The effectiveness of SVE in deeper zone contaminant removal is less certain, and less efficient due to lower permeability soils.

## 4.3 Shallow Groundwater Recirculation Evaluation

The CSR (BC, 2013) proposed remedial technology for groundwater impacts was in situ treatment using a groundwater recirculation system. The system was proposed because the technology can take advantage of permeable hydrogeology and can degrade PCE and TCE through enhanced anaerobic bioactivity. As described in the CSR, successful design of a groundwater recirculation system pilot test is dependent on the following two items: 1) Hydrogeologic properties such as sufficient thickness of upper permeable saturated sands, sufficient hydraulic conductivity, storage coefficients, and transmissivity, and 2) General mineral and nutrient analysis of existing groundwater conditions for use in designing the appropriate amendments for the groundwater recirculation system and assessing the potential for fouling of the recirculation wells.

Data collection efforts performed for the two items above were reported in the SCR (BC, 2015). The results were not conclusive that groundwater recirculation as proposed in the CSR would optimize an enhanced biodegradation approach. Specifically, further evaluation of the hydrogeologic properties was needed to determine if groundwater recirculation was feasible.

As described in the Addendum to the Groundwater Amendment Pilot Test Report Work Plan (BC, 2016d), a number of single well tests and one constant rate aquifer test were performed to quantify aquifer hydraulic properties, including transmissivity and hydraulic conductivity for the shallow portion of the groundwater aquifer. The single well tests were performed at wells CWS-2, CWS-3, and GMW-1 and the constant rate aquifer test was performed on well GMW-1.

In general, the wells tested responded quickly to pumping stress and achieved relatively stable drawdowns at pumping rates 4 gpm or less. After pumping, wells recovered quickly to pre-test levels, on the order of seconds to one minute. Based on standard aquifer test curve-matching techniques (such as Theis, 1935 and Cooper-Jacob, 1946), the quick responses to pumping and recovery are indicative of relatively lower aquifer transmissivity, while the stable drawdowns achieved during pumping are indicative of relatively higher transmissivities. Review of the pumping and response data from the single well tests and the constant rate test show that overall transmissivity estimates vary by an order of magnitude, depending upon whether drawdown or recovery is the basis of the estimate. This variation is likely due to the short-term nature of the tests, which likely affect only a limited amount of aquifer material in the direct vicinity of the well. The test deemed most representative of aquifer characteristics on a larger scale is the constant rate test, which produced stable drawdown in well GMW-1 at 4 gpm for 8 hours. As such, the transmissivity estimate from this test will be considered the most representative of Site aquifer characteristics, with analyses from the single well test providing secondary data.

Based on the aquifer testing performed, Site hydrogeologic conditions were not favorable for groundwater recirculation. Additionally, a recirculation system would require significant operation and maintenance activities. Injection well fouling and difficulty of amendment injection as a result were identified as some of the drawbacks of groundwater recirculation system requiring frequent biocide application and well rehabilitation. Further consideration was made to the fact that recirculation type amendment delivery is anticipated to be much costlier than the direct injection type amendment delivery. Because of the Site conditions, increased cost, numerous potential operational issues, and difficulty installing at the Site due to the buried charging station infrastructure, groundwater recirculation was not retained for further consideration.

## 4.4 Shallow Groundwater Amendment Pilot Test Using Slurry-Based Amendment (EHC)

The 2017 a proof-of-concept pilot test, the GA Pilot Test, was conducted to test enhanced biodegradation of dissolved CVOCs in shallow groundwater. The GA Pilot Test consisted of using a Permeable Reactive Zone (PRZ) placed downgradient of MWS-6 (suspected source) to reduce CVOCs in groundwater as they passed through the PRZ. The goals were to collect information on the injectant performance on degradation and injectate delivery mechanisms for use in the design of full-scale system.

A detailed GA Pilot Test design was provided in the addendum to the work plan (BC, 2016b). Essentially, the design consisted of a two row PRZ with six injection points per row, and spaced to cover the 5-foot ROI (Grid 1 with six points) and 7.5-foot ROI (Grid 2 with six points). The groundwater depth targeted for treatment was approximately from 30 to 42 ft bgs (vertical thickness of 12 feet). The amendment EHC® slurry and DHC culture were delivered into the groundwater at each injection point using GeoProbe® direct push points.

The results are provided in the GA Pilot Test report (BC, 2018a). In summary, reductive dechlorination of CVOCs was observed in both Grid 1 and Grid 2 treatment zone monitoring wells in response to EHC® injections leading up to the formation of innocuous end-products ethene and ethane without impacting the secondary water qualities. Although dechlorination was observed in both grids, the fact that EHC® injections were challenging requiring high pressure would limit the implementation of a 7.5-foot ROI design for full-scale as a larger ROI will require higher amounts of EHC® injection per unit depth interval. The EHC® could not be injected uniformly across all treatment depth intervals in Grid 2 whereas the Grid 1 injections required less pressure and more consistent delivery. Other results that supported limited ROI design for the EHC® slurry are: 1) Grid 1 had two orders of magnitude higher dechlorinating bacteria compared to Grid 2, and 2) compound specific isotope analysis (CSIA) revealed a greater degree of fractionation for PCE and TCE (i.e., degradation) in Grid 1 compared to Grid 2.

As part of lessons learned, other soluble organic carbon and iron reagents were considered as a potential replacement of EHC® amendment for the full-scale treatment. The lower viscosity of soluble type amendment would likely result in a lower injection pressure, higher injection volume, and better distribution in groundwater. Typically, the soluble reagents will not last long like EHC® (which has a ZVI component) and may require multiple injections, therefore EHC will be used in full scale remedial injections Onsite.

## 4.5 Shallow Groundwater Bench-Scale Treatability Testing Using Solution-Based Amendments

Based on the GA Pilot Test results and field observations, an FFS (as reported in the Groundwater Remedial Implementation Focused Feasibility Study Technical Memorandum [BC, 2019d]) was performed, that compared the performance and cost of injection of EHC slurry-type versus other soluble reagent-type amendments. This study resulted in identifying three solution-based amendments for additional bench-scale testing to select the most appropriate one for full-scale remedy given the slurry based in jection challenges from the GA Pilot Study. The amendments were: 1) EHC® Liquid (EHC-L), 2) GeoForm™ Soluble (GF Soluble), and 3) PlumeStop® Liquid Activated Carbon™ (PlumeStop®) plus S-MicroZVI™; collectively referred to as PlumeStop® + ZVI.

A detailed bench test design and effectiveness of the three amendments are provided in the FFS work plan (BC, 2019c). The overall scope was to test and identify the most appropriate soluble-based amendment for the in situ remediation of groundwater CVOCs. Specifically, the remedial objectives were to: 1) characterize the three amendments for defined constituents to meet the State requirements of General Order; 2) test the effectiveness of amendments to degrade the CVOCs in and groundwater; 3) evaluate the influence of the amendments on the secondary water quality (per the General Order). The three amendments were evaluated in the absence and presence of DHC culture.

The results of the testing are provided in the bench-scale treatability study report (BC, 2020a). In summary, the testing demonstrated that the solution-based low viscosity amendments EHC-L, GF Soluble, and PlumeStop® + ZVI, without and with DHC culture, were promising and could degrade the groundwater CVOCs (PCE and TCE). Although PlumeStop® + ZVI amendment resulted in most effective CVOCs reduction, this amendment required higher dosing in the bench-scale test compared to dosing provided for the FFS evaluation, increasing the actual remedy costs. Addition of the DHC culture was critical as the bacteria markedly enhanced CVOCs degradation in the EHC-L and GF Soluble tests and facilitated complete dechlorination to ethene. In the PlumeStop® + ZVI test, ZVI carried out the abiotic dechlorination of PCE and TCE directly to ethene and presence of DHC did not appear to contribute to the reduction, or the activity was masked by the ZVI presence. In terms of general minerals and metals, none of the amendments caused significant adverse effects on secondary water quality parameters. Based on these observations, EHC-L amendment with DHC culture was recommended for the full-scale remediation.

## Section 5

# Project Site Specific Health Risks

## 5.1 Introduction

Many risk assessment activities have been conducted since Project Site investigation activities commenced in 2009. References to Project Site human health and environmental risks have been made in previous Site reports, as well as meetings and other correspondence with the CVRWQCB. The results previous Project Site data has focused risk characterization and evaluation to the following media/areas:

- Site Area air impacts to a hypothetical utility/trench worker
- Offsite vapor intrusion of PCE/TCE into residences
- Groundwater beneficial use

An evaluation of current pathways for exposure is summarized in the following section.

### 5.1.1 Exposure Pathway Analysis

BC and SMUD have focused on three potential exposure pathways, as noted above. The table below summarizes two of the three evaluated pathways. Future groundwater beneficial use is not included on the table because no receptors have currently been identified (pathway is incomplete).

**Table 5-1. Summary of Exposure Pathways and Receptors**

| Receptor | Exposure Pathway |
|---|---|
| Site Area Construction/Trench Worker | • Inhalation of outdoor vapors volatilizing in manholes from soil or groundwater<br>• Incidental dermal contaminated contact with soil |
| Offsite Residence | • Inhalation of indoor vapors volatilizing from groundwater |

Potential future exposure to Site construction workers has not been evaluated and those risks have not been formally assessed. Currently, no subsurface work is ongoing on the Site property and risks will be characterized and mitigated prior to any such activities taking place. A risk evaluation for potential utility workers that may enter Site or near site vaults was performed in 2017, as described below.

## 5.2 Summary of Prior Human Health Risk Assessment Activities

### 5.2.1 2017 Site Area Vault Worker Evaluation

In 2017, BC collected air grab samples in several utility vaults on and near the Site and analyzed these samples for PCE and TCE. These samples were collected to evaluate the potential risks for exposure to utility workers that may enter these vaults. Based on the air sampling results of the subject Site vaults, levels of PCE and TCE (from a worker exposure perspective) were expected to be below California Division of Occupational Safety and Health (Cal/OSHA) permissible exposure levels (PELs). It was recommended that entry into these vaults should be done so using confined space practices including monitoring and ventilation. This procedure was determined to be protective of any potential exposure to a utility worker from PCE/TCE vapors. The results of the sampling were documented in BC's Vault VOC Mitigation Plan, dated January 19, 2018.

### 5.2.2 2017 Offsite Residence Soil Vapor Risk Assessment

In September 2017, BC conducted an additional soil vapor intrusion (SVI) risk evaluation (SVI Risk Evaluation; BC, 2017b) based on soil vapor sample data for the Offsite area south of the Highway 50. The risk evaluation included updating the Department of Toxic Substances Control (DTSC) Human and Ecological Risk Office (HERO; DTSC, 2011) model to include location specific soil-type data. The objective of the Offsite risk characterization was to evaluate the applicability of then current ESLs for the Offsite soil vapor sampling locations based on Project Site-specific data.

Based on this SVI Risk Evaluation and HERO model calculations, an Offsite area-specific screening level of 1000 µg/m$^3$ was determined to be protective of Offsite residences. BC and SMUD recommended to the CVRWQCB that this risk-based soil vapor screening level concentration value be used for PCE in the Offsite area since it is protective of the more sensitive human health endpoint in a residential setting.

In 2019, the DTSC, EPA, and the CVRWQCB changed the way risk was evaluated for SVI. Specifically, use of the HERO was determined to be no longer valid in most situations and instead an attenuation factor of 0.03 between subslab vapor samples and indoor air should be assumed, making the universal screening level for PCE in soil vapor, regardless of depth of soil type, 15 µg/m$^3$. Due to this change in risk evaluation by the agencies and the resulting screening level change, soil vapor samples collected from the Offsite area indicated a potential risk to Offsite residences. Data collected in this area to date indicate that VI risks to residential occupants in this area are unlikely. Additional investigation activities are planned to confirm the absence of significant VI risks in this area.

BC and SMUD are currently performing additional assessment and risk characterization activities in this area. The Additional Offsite Soil Gas Assessment Report (BC, 2020d) was submitted to the CVRWQCB on August 31, 2020. A work plan for additional evaluation of SVI in the Offsite area is currently underway and will be submitted to the CVRWQCB by November 30, 2020.

### 5.2.3 Groundwater Beneficial Use

Because water supply for drinking and commercial/industrial use at the Project Site and in the vicinity is imported by the City of Sacramento Water Agency, exposure pathways associated with use of Project Site groundwater were not considered complete and were not evaluated. A Sensitive Receptor Survey (SRS) was completed by SMUD (SMUD, 2018), and that SRS showed no municipal or domestic wells that would be potentially impacted by contaminated groundwater associated with the Project Site.

## 5.3 Approach for Future Risk Assessment

Currently identified potential risks from subsurface PCE/TCE impacts are being evaluated and addressed as work for the project is ongoing. The only immediate potential risk associated with the Offsite area are residences south of the Highway 50 freeway. As risk evaluation in this area progresses, an appropriate mitigation of SVI may be necessary. The source of the PCE/TCE impacts in the Offsite area is contaminants off-gassing from groundwater. The overall approach to risk management is to reduce the risk for SVI in the Offsite area by decreasing the concentrations of PCE and TCE in groundwater. The remedial approach, as summarized in this RAP, is intended to minimize and ultimately remove the risk from PCE and TCE off-gassing from groundwater into soil vapor, and ultimately potentially into indoor air. No indoor air impacts have been identified to date.

Future Site activities may include trenching, excavating, or other earthwork activities which may result in the potential exposure to contaminated soil. Risks associated with this type of future work are intended to be removed via the proposed Site SVE activities. Residual risks are unlikely, however any such risks associated with any such future work will be evaluated and addressed in a construction soil management plan.

Section 6

# Remedial Action Objectives and Proposed Corrective Measures

This section discusses the remedial action objectives for CVOC impacted soil, soil vapor, and shallow groundwater and appropriate full-scale proposed corrective measures to be implemented. The remediation performance criteria of the corrective measures are also described herein. As stated in previous sections, the CSR included proposed corrective measures to remediate impacted media at the Site. Subsequent evaluation and pilot testing confirmed the feasibility of the proposed corrective measures. The selected corrective measures are expected to be protective of human health and the environment, are permanent solutions, and are cost effective.

PCE and TCE are the primary CVOCs of concern and the proposed corrective measures focus on the remediation of these constituents. The other CVOCs will be remediated simultaneously with PCE and TCE and as such, specific monitoring and reporting for these constituents is unnecessary. Following completion of the PCE and TCE remedy, final monitoring will include the entire suite of CVOC constituents to verify the remedy is complete and that no residual risks from other CVOCs remain.

## 6.1 Remedial Action Objectives

The United States Environmental Protection Agency (USEPA) Region 9 Regional Screening Levels (RSL), DTSC Human Health Risk Assessment, and San Francisco Bay Regional Water Quality Control Board Environmental Screening Levels (ESLs) tables were reviewed to provide initial remedial objectives for commercial/industrial indoor air. The USEPA Region 9 RSLs were reviewed for commercial/industrial soil. State of California Environmental Protection Agency (CalEPA), DTSC, and California State Water Resources Control Board (SWRCB) Draft Supplemental guidance: Screening and Evaluating Vapor Intrusion (VI Guidance; SWRCB, 2020) was used to evaluate indoor air screening levels (SLs) with respect to soil vapor concentrations. California Division of Drinking Water Drinking Water Standards - MCLs and USEPA MCLs were used to evaluate PCE and TCE concentrations in groundwater. PCE and TCE in groundwater were further evaluated with respect to its potential impact to soil vapors and indoor air using the VI guidance.

### 6.1.1 Soil Vapor

The DTSC Screening Levelfor PCE and USEPA RSL TCE in commercial/industrial indoor air are 2 $\mu g/m^3$ and 3 $\mu g/m^3$ (respectively). The attenuation factor (AF) for a typical concrete slab building is 0.03. As such, the soil vapor concentration multiplied by 0.03 should be less than 2 $\mu g/m^3$, or the goal for PCE concentrations in the shallow zone vadose zone soil vapors is less than 66 $\mu g/m^3$. Similarly, for TCE, the soil vapor concentration multiplied by 0.03 should be less than 3 $\mu g/m^3$, or the goal for TCE concentrations in the shallow zone vadose zone soil vapors is less than 100 $\mu g/m^3$.

PCE: 66 $\mu g/m^3$ x 0.03 = 1.98 $\mu g/m^3$ (equal or less than DTSC screening level)

TCE: 100 $\mu g/m^3$ x 0.03 = 3 $\mu g/m^3$ (equal or less than USEPA RSL)

### 6.1.2 Soil

The proposed RAO's for soil are based on the PCE and TCE USEPA RSLs are protective of dermal contact exposure and will protect groundwater water quality standards. The USEPA RSL for concentrations in soils under a dermal contact exposure scenario are 100 mg/kg and 6 mg/kg, respectively. The USEPA RSL for PCE and TCE in soil to preserve groundwater quality are 0.0023 mg/kg and 0.0018 mg/kg respectively.

### 6.1.3 Groundwater

The RAO for PCE and TCE in groundwater is often considered to be the MCL of 5.0 µg/L. This is overly conservative because source area groundwater is shallow, there is a municipal water supply system in the vicinity, and other groundwater supply wells are located a considerable distance from the Site. As such, the remedial objectives for PCE in groundwater focuses on the potential of PCE volatilization into the soil vapor and subsequent potential exposure through the indoor air pathway. The RAO for Site and Offsite areas active groundwater remediation of ten times the MCL is proposed (50 µg/L for both PCE and TCE).

### 6.1.4 Summary

Based on the above, the following screening level remedial objectives will provide direction for the remedial system design:

**PCE:**

| | |
|---|---|
| Soil Vapor | 66 µg/m$^3$ in Site area shallow vadose zone |
| Soil | 0.0023 mg/kg |
| Groundwater | 50 µg/L in the Site and Offsite areas |

**TCE:**

| | |
|---|---|
| Soil Vapor | 100 µg/m$^3$ in Site area shallow vadose zone |
| Soil | 0.0018 mg/Kg |
| Groundwater | 50 µg/L in the Site and Offsite areas |

A source area site-specific Risk Assessment may be warranted in the future to define final cleanup goals that will define acceptable Site closure criteria.

## 6.2 Soil Excavation

If or when SMUD chooses to remove the Former Kramer Carton building foundation, soil excavation is the proposed corrective action for soils exceeding RAO's. Prior to removal of the foundation, a soil management plan will be prepared and submitted to the CVRWQCB. The plan will consider data from past investigations and identify appropriate management (handling and disposal) approach for potentially impacted soil.

As described is Section 3.3.1, primary CVOCs detected from soil samples collected at the Site near and at the Former Kramer Carton building exceeded commercial ESL's as did samples collected during the installation of the SVE pilot test wells (See Section 6.1.2). The full scale SVE system has been selected to address CVOCs retained in the vadose zone at the Site (see Section 6.3). In addition, institutional controls such as a deed restriction requiring the notification and CVRWQCB approval for any excavation activities at the 1800, 1824, and 1826 61st Street properties may be considered and potentially implemented as part of this RAP. Soil excavation is not proposed for these areas.

## 6.3 Soil Vapor Extraction

This RAP proposes to install an SVE system at the Site that will use a blower and GAC to remove and treat contaminants from the source area soils. The remediation system will be connected to a network of existing and new SVE wells. After Site treatment using GAC, the extracted air will be discharged to the atmosphere from a Sacramento Metropolitan Air Quality Management District (SMAQMD) permitted device. The proposed remedial approach is intended to reduce CVOC concentrations in soil vapor in the source area where the highest concentrations of PCE have been detected. Details associated with the proposed remedial action activities are described in Section 7.

## 6.4 In Situ Shallow Groundwater Remediation

Anaerobic bioremediation is a well-demonstrated remedial technology for the treatment of Project Site CVOCs. Amendments like an organic carbon (electron donor) can promote biotic dechlorination, iron-based reagents can promote abiotic dechlorination, and DHC culture can enhance the complete dechlorination of PCE and TCE to ethene. Generally, slurry-based amendments (such as EHC and granular ZVI) lasts longer compared to soluble amendments (such as lecithin, emulsified vegetable oil, and lactate) but the injection of slurry-based amendment requires a higher pressure and could be challenging at sites with a silty sand or silty clay subsurface lithology. Furthermore, slurry-based amendments generally exhibit a smaller ROI compared to solution-based amendment requiring a closer spacing and greater number of injection points.

The direct injections typically are designed as either a grid where injections cover higher concentration areas of the dissolved plume or a PRZ where injections are performed as a barrier perpendicular to groundwater flow. As impacted groundwater flows through the PRZ, CVOCs are degraded by taking advantage of the diffusion properties of the soluble amendments with the groundwater flow. Another advantage of the PRZ concept is the flexibility to relocate the gridded layout for the second injections, if necessary. Direct injection can be performed by introducing amendments through temporary or permanent wells or Direct Push Technology (DPT) drilling injection points. DPT is typically low cost, can be readily applied in unconsolidated materials and injection locations can be easily changed or added during application based on real time observations. In the event multiple injections are anticipated, delivery through injection wells may cost less compared to multiple DPT injections.

Based on the GA Pilot Test results and bench-scale test results, the conceptual in situ remedial approach to address shallow groundwater at the Site is direct injections in the form of a PRZ near the source and downgradient locations to collapse and shrink the plume. The solution-based amendments with a longevity of up to 3 years and with a design of multiple injections is expected to degrade the CVOCs significantly reducing the mass flux for polishing by natural processes to achieve the proposed remedial objective.

## 6.5 Performance Criteria

Monitoring required to evaluate SVE remedy performance on the vadose zone soil contamination reduction and monitoring required to evaluate in situ remediation performance on the shallow groundwater concentrations is described herein. Performance criteria for each corrective measure are described in terms of concentrations of primary CVOCs (PCE and TCE) in soil vapor and groundwater to determine if further remedial action is needed or the corrective measure is considered complete.

### 6.5.1 SVE

After the system start-up and system optimization, analytical testing of vapor samples will be collected from operating SVE wells and influent, mid-point, and effluent locations of the GAC treatment system. Using the resulting analytical data, the system will be optimized on an ongoing basis to maximize PCE mass removal rates to the extent practicable. As stated above, the ESL for PCE and TCE in commercial/industrial indoor air is 47 $\mu g/m^3$ and 3 $\mu g/m^3$ (respectively) and the goal for PCE and TCE concentrations in the shallow zone vadose zone soil vapors is less than 1,500 $\mu g/m^3$ and 100 $\mu g/m^3$.

Concentrations are anticipated to reach an asymptotic level within a few weeks after startup likely with soil vapor concentrations in surrounding monitoring points above performance criteria. In this case, system operation will continue to maintain constant diffusion rate and CVOC removal. If the extraction rate is relatively high, the asymptotic concentrations will be lower, but the mass removal will be about the same. Ideally, after a few months to a few years, it is expected that the extracted concentrations decline below the RAOs. On a quarterly basis, CVOC concentrations and vacuum readings will be evaluated to determine if adjustments or expanding the system are warranted. Once the CVOC concentrations in the SVE and SV monitoring wells are less than RAOs, rebound testing can be considered. Rebound testing would entail turning the system off for a month with subsequent monitoring. If SVE and SV monitoring wells are less than RAOs after on month, the system will continue to be shut down for another two months and progressing to four quarters of rebound testing. If the concentrations rebound, then turn on the SVE, vacuum out the accumulated VOCs, reestablish the new lower asymptotic level, and continue operating until the concentrations are equal or lower than when the previous rebound test was initiated. A detailed performance monitoring plan will be developed under the RDIP.

### 6.5.2 In Situ Groundwater Treatment

Performance monitoring for the in situ shallow groundwater treatment consists of analysis of parameters that will measure the effect of added amendments in terms of whether defined remedial objectives, compliance values, or operational end points have been achieved. With proper monitoring well network in place, suggested performance monitoring parameters are described below.

- Compare concentrations of Project Site CVOCs over time and with their dechlorination products (such as cis-1,2-DCE and VC), and ethene to determine dechlorination rate and extent and by-products potential stalling if any (not observed before and during the pilot test) and mineralization.
- Confirm that the observed ROI is consistent with designed ROI to ensure adequate distribution of the amendment by measuring field parameters such as conductivity and ferrous iron.
- Measure total organic carbon (TOC) to determine amendment (electron donor) longevity and TOC influence on biogeochemical activities such as sulfate reduction and methane production and growth of dechlorinating bacteria.
- Groundwater geochemistry measurement in terms of microbial respiratory substrates and products to support biodegradation (such as pH, dissolved oxygen [DO], oxidation-reduction potential [ORP], hydrogen sulfide, alkalinity, nitrate, iron, sulfate, and dissolved methane). For example, groundwater pH is an important parameter for the expression of dechlorination activity

with an optimal range of 6 to 8. The geochemistry provides information on the type of microbial process involved in contaminant degradation.

- Analyze samples for gene-specific dechlorinating bacteria such as DHC and their functional genes VC reductase that converts VC to ethene.
- To comply with Monitoring and Reporting Program for In Situ Groundwater Remediation and Discharge of Treated Groundwater to Land CVRWQCB Order No. R5-2015-0012 (Order No. R5-2015-0012) *Waste Discharge Requirements General Order for In situ Groundwater Remediation and Discharge of Treated Groundwater to Land*, required analytical data will be evaluated to identify whether there are any negative secondary impacts on groundwater quality due to amendment injections.

The above performance monitoring data can be compared with the detailed design criteria that will be developed after RAP approval to determine success of the in situ treatment.

The in situ shallow groundwater treatment performance goal is to restore the Project Site to pre-disposal conditions, to the extent feasible. At a minimum, the remedy selected shall eliminate or mitigate all significant threats to the public health and to the environment presented by CVOCs disposed at the Site through the proper application of scientific and engineering principles. Where Project Site restoration to pre-release conditions is not feasible, the CVRWQCB may approve alternative criteria based on the site-specific conditions.

Performance criteria of a reduction of groundwater PCE and TCE plume concentrations to 50 μg/L both onsite and offsite through the in situ remediation corrective measure is proposed. After reaching the 50 μg/L concentrations within the Site, no further active remediation (for example, amendment injections) is proposed. Further polishing and reduction of the residual 50 μg/L concentrations will be accomplished by natural processes (biodegradation and non-destructive mechanisms) to reach the MCL of 5 μg/L for PCE and TCE. For example, prior to the pilot test in 2017, natural processes was attenuating the plume wherein: 1) PCE concentrations decreased from 2,500 μg/L in MWS-6 (former source) to 120 μg/L in the directly downgradient well MWS-9 (400 ft away) and to about 3-15 μg/L as plume travelled further down by about 350 feet (MWS-11 and MWS-12); 2) TCE and cis-1,2-DCE were detected; 3) Ratio of TCE to PCE was low at the source and high near the downgradient area; and 4) no cis-1,2-DCE accumulation although VC was detected in trace or below detection limit suggesting likely additional route (aerobic degradation at microaerobic sites within mildly anaerobic groundwater) for PCE by-products concentration decrease.

## 6.6 Further Investigations

Further investigations of CVOC impacts to the deep groundwater zone and soil vapor in the Offsite area and therefore corrective measures for these media are not included in this RAP. As stated in the conclusions of the Additional Offsite Groundwater Assessment Report (BC, 2019b), further investigation of the geologic conditions and CVOC impacts to the deep groundwater zone are planned. On November 1, 2019 SMUD submitted a sampling plan providing additional details regarding how the investigation of the deep zone will be conducted and the CVRWQCB provided a letter of concurrence on November 1, 2019. Similarly, the Additional Offsite Soil Gas Investigation Report (BC, 2020d) proposed additional soil vapor sampling in the Offsite area and the CVRWQCB concurred with the recommendation in their September 16, 2020 letter. Subsequent to these investigations, corrective measures can be evaluated. If the results of these investigations suggest that additional remedial measures will be required to address soil vapor in the Offsite Area or deeper groundwater, an amendment to this RAP will be prepared. We do not recommend delaying implementation of the Site remedy, as any remedial efforts addressing source mass will aide in removing additional future source for these Offsite area media.

# Section 7

# Remedial Approach

The recommended remedial approach for the Site vadose zone soil and shallow groundwater and for the Offsite shallow groundwater are described in the following sections.

## 7.1 SVE Conceptual Design and Implementation Plan

SVE pilot test evaluation and design approach has been carried out by BC's teaming partner, Sierra West Consultants (Sierra West). Future system design, implementation, startup, and O&M will be carried out by Sierra West.

The source area (Figure 12) consists of areas where PCE concentrations in soil vapor exceed the remedial objective of 1,500 μg/m$^3$ in the shallow vadose zone. This section provides an overview of the SVE remedy, proposed layout, and sizing information.

### 7.1.1 SVE System Overview and Layout

The SVE Pilot Test (BC, 2016c) included step tests at SVE-1S where the soil vapor extraction flow rate was incrementally increased and performance data were collected at each step. Tests were conducted at the following flow rates with corresponding vacuum measurements collected 46 feet away at SVE-4S:

| Flow Rate (cfm) | Vacuum Reading (in-WC) |
|---|---|
| 8 | 0.3 |
| 25 | 2 |
| 45 | 5 |
| 55 | 6 |

A generally accepted lower limit vacuum reading to define the ROI for an SVE well is 0.1 in-WC. From a design perspective, eight cfm would be at the limit of acceptability to provide a 50-foot ROI. By extrapolating induced vacuum data collected during the SVE-1S pilot step testing, it is expected that extraction flow rates between 40 to 50 cfm per well will have an ROI of approximately 100 feet (Figure 13).

Three design criteria are evaluated to verify the adequacy of the design basis extraction rate and ROI (Appendix C):

- Minimum air flow velocity at outer extent of ROI (V > 3 to 30 feet per day [ft/day])
- Maximum travel time from outer extent of ROI to extraction well (t < 2 days)
- Air Exchange Rate (~500 pore volumes per year; 1,000 to 5,000 to achieve cleanup)

At an extraction flow rate of 50 cfm and an ROI of 100 feet, the air flow velocity at the perimeter is 76 ft/day and the calculated travel time is 0.65 days. The travel time is also the time required to remove one pore volume of soil gas. As such, approximately 1.5 pore volumes of soil vapor will be recovered per day and processed by the SVE system. This is approximately 550 pore volumes per year.

Using a 100-foot ROI, seven new shallow vadose zone SVE wells are proposed to operate with the existing wells from the pilot test (Figure 14). Given the substantial ROI, SVE-1S, -2S, -3S and -4S overlap, and it is recommended to operate only SVE-1S. With only SVE-1S utilized from the pilot test, the preliminary layout (Figure 14) identifies seven additional shallow zone SVE wells (SVE-5S through SVE-11S) that will be installed and utilized during full scale operation. One deep vadose zone SVE well (SVE-1D) will also operate to test the effectiveness of longer-term extraction in the deep zone. This layout will be refined during the final design with possibly another existing well connected to the system or slightly closer well spacing to provide a greater safety factor in areal coverage.

Four soil vapor monitoring probes will be included in potentially low-treatment areas between SVE wells and in areas surrounding the remediation area. These probes will provide monitoring data to evaluate induced vacuum from the SVE wells and to collect soil vapor samples to evaluate remediation progress.

The piping layout and equipment compound are shown on Figure 15. The SVE wellheads will be completed with isolation valves and connecting to two-inch diameter Schedule 80 polyvinyl chloride (PVC) piping to convey soil vapors from each well to the equipment compound. In travel areas, the piping will be buried in trenches approximately 30 inches in depth. After placing the piping in the trench, sand bedding material will be placed around and on top of the piping and compacted. The driving surface above the conveyance piping will be re-paved with asphalt or concrete to match the existing surface. In non-travel areas, such as across the remaining building foundation for 1800 61st Street, the piping will be installed above ground and anchored in place.

After transfer of soil vapors to the remediation area, GAC will be used to remove contaminants from the airstream. Regular analytical testing of the influent and effluent air stream will be conducted to verify the proper abatement of CVOCs, to estimate PCE and TCE mass removal rates, and to evaluate changeout intervals for the GAC. Chain link security fencing with tan colored slats will be installed around the remediation equipment to prevent unauthorized access.

### 7.1.2 SVE System Details

The SVE system will consist of a blower manifolded to each of the vapor extraction wells. Extracted vapors will be drawn through an air/water separator to remove condensed moisture, and then discharged through a heat exchanger and then GAC treatment vessels.

A 500-cfm blower would be the minimum sized system based on 50 cfm from each of nine wells and discharge with backpressure through the GAC vessels. The 500-cfm blower system includes a skid-mounted 25 Hp motor with the air/water separator, a small water transfer pump to remove collected water from the air/water separator, heat exchanger, and a control panel with automatic shutdown under critical alarm conditions. The control panel will have ON-OFF or ON-OFF-AUTO switches for the blower and transfer pump, hour display, and run condition lights. The control panel will also have an emergency off switch to shut down the system quickly as well as a disconnect switch for lockout/tagout purposes. An auto-dialer notification system will be included to alert operations personnel of an alarm condition. The system will require a 208/240 Volt, 3 Phase, 100 Amp electrical service.

Two 2,000-pound GAC vessels, in series, will treat the extracted vapors prior to discharge to the atmosphere as permitted by the SMAQMD. The discharge stack height will depend on requirements developed through the air quality permitting process.

A 500-gallon water storage tank will be provided to store collected water from the air/water separator. Depending on the volume generated by the SVE system, collected water can be managed offsite or onsite. If the volume is relatively small, the 500-gallon tank will fill every few months or a couple of times per year. In this case, a water-hauling and disposal service can remove the water and discharge under their licenses and permits. If substantial water is generated, then a small liquid-phase GAC vessel can be installed, and the water can be treated and discharged to a nearby sanitary sewer under a permit from the Sacramento Area Sewer District. It is recommended to begin operations anticipating that only a small amount of water will be generated based on the pilot test operations and groundwater being substantially deeper than the shallow vadose zone.

The following activities will be necessary to design, construct, and startup the SVE remediation system:

- Completion of design drawings
- Prefield and permitting
- Extraction and vapor monitoring well installation
- Equipment installation
- Piping installation
- System startup
- O&M
- Sampling
- Startup and routine reporting

Proposed details and specifications for the SVE system will be included in the RDIP to be completed after the public review and approval of this RAP. Figures 16 and 17 illustrate the proposed layout of the SVE system.

### 7.1.3 SVE System Performance Monitoring

Start-up and source testing for the remediation system will be conducted during the first days of system operation and as specified in the SMAQMD permit conditions. The exact scope of work for the source testing will be dependent on the requirements of the SMAQMD permit, once issued, and will be completed to satisfy the requests of the assigned SMAQMD caseworker/inspector. Typically, the SVE system is started and operated for an hour or two. Influent, mid-point, and effluent samples are collected from the GAC vapor treatment system and the system is shut down. The air samples will be forwarded to a state-certified laboratory for chemical analysis. The air samples will be analyzed on a 24-hour turnaround basis for CVOCs using USEPA Method TO-15. These analytical results will be used to evaluate system destruction efficiency and will be reported to SMAQMD. If the results are satisfactory, the SVE system will be turned on for fulltime operation.

Daily monitoring is expected for the first week of operation, followed by ongoing weekly monitoring while the SVE system is operating. The following parameters will be monitored and recorded on field data sheets during the system start-up and during routine monitoring thereafter:

- Vapor extraction flow rates from each SVE well and total flow into the GAC treatment vessels.
- Applied vacuum at each extraction well and induced vacuum at the vapor monitoring probes.
- Influent, mid-point, and effluent PID concentrations at the GAC treatment vessels.
- PID concentration readings at each operating SVE well.

After the system start-up and system optimization, a field technician will visit the Site weekly to monitor system operation, record performance data, and perform minor maintenance, if needed. Data collection will be as described above, with quarterly analytical testing of vapor samples collected from operating SVE wells and monthly analytical testing of the influent, mid-point, and effluent locations of the GAC treatment system. The air samples will be analyzed for CVOCs using USEPA Method TO-15.

Using weekly field data, monthly GAC influent analytical data, and quarterly soil vapor analytical data, the system will be optimized on an ongoing basis to maximize PCE mass removal rates to the extent practicable. Should substantial changes to the SVE system appear justified, SMUD will need to coordinate with the CVRWQCB to discuss potential changes prior to implementing proposed improvements.

# 7.2 Full-Scale Site Shallow Groundwater Remediation

Full-scale Site remedial technology proposed to address contamination in shallow groundwater is in situ anaerobic biotreatment. The proposed remedial strategy is described below.

## 7.2.1 EHC-L Injection In Situ Remediation

The GA Pilot Test activities have shown that after successfully treating high concentration zones within the core of the groundwater plume, CVOC plume concentrations surrounding the core will decrease (BC, 2018c). This decrease is often described as a “collapsing plume”. The conceptual remedial injection design for full scale remediation will follow this approach. Treating the Site will consist of focused source area amendment injections to reduce the >500 µg/L PCE plume footprint (Figure 16) and additional injections along the downgradient Site boundary to reduce CVOC concentrations of groundwater flowing to the Offsite area. Multiple injections in the proposed injection areas/PRZ over time will be undertaken until PCE groundwater concentrations reach 50 µg/L. The key elements of the in situ remediation are described herein.

### 7.2.1.1 Amendments

The solution-based electron donor amendment proposed for the injections is EHC-L, selected based on the results of the bench-scale testing. EHC-L is a cold-water soluble formulation that is designed to be emplaced via existing wells and/or hydraulic injection networks for the treatment of the Project Site CVOCs. The composition is a slow release carbon source (lecithin), an organo-iron compound and amino acids (all food-grade). A buffer (potassium bicarbonate) would be added to the EHC-L and then injected together as a mixture. The DHC culture will be also injected using anaerobic water (to protect the culture from exposure to oxygen). Anaerobic water will be prepared using regents that will result in DO concentration less than 0.5 milligrams per liter (mg/L) and ORP less than -75 millivolts (mV), which are favorable conditions for anaerobic remediation.

### 7.2.1.2 Permeable Reactive Zone Injection Design

Treatment of the >500 µg/L PCE plume footprint around and upgradient of MWS-6 is proposed consisting of 19 injection locations designed as two PRZs. These two PRZs, each consisting of two rows of injection points, are identified as PRZ-1 and PRZ-2 in Figure 17 (with TCE plume). PRZ-1 would consist of nine injection points and PRZ-2 will consist of ten injection points. The injection points within the row and between the row will be spaced at approximately 10-foot ROI (based on BC experience with standard injection methods in geologic conditions encountered in the Site and Offsite areas for solution-based amendments). The placement of the injection locations was selected accounting for access limitations of the Site area due to the existing parking lot infrastructure and subsurface utilities. However, these injection locations may change based on the field conditions. A focused treatment of the >500 µg/L PCE plume footprint is proposed since this is the area with the greatest amount of contaminant mass and the area of the assumed source (the former Community Linen boiler room heating oil underground storage tank). These injections will also treat a significant portion of the Site >50 µg/L TCE plume.

To reduce CVOC concentrations of groundwater flowing Offsite, 18 injection locations as two rows (nine injection points per row) are proposed along the downgradient Site boundary. This treatment zone is identified as PRZ-3 (Figures 16 and 17). These locations have been placed on each cross-gradient side of the 2017 GA pilot test (12 injection locations; BC, 2018c) to form a PRZ along the downgradient boundary. It is anticipated that the eastern group of proposed injection points will also treat the downgradient extent of the Site >500 µg/L PCE plume footprint (Figure 17).

#### 7.2.1.3 Treatment Interval and Delivery Method

The target treatment interval during the groundwater amendment pilot test was from 30 feet to 45 ft bgs. As designed amounts of EHC® could not be delivered within the deepest treatment interval from 41 to 45 ft bgs due to injections exhibiting the most resistance or refusal as a result of fine-grained sediments and potential cavity expansion. Therefore, the conceptual treatment zone for the Site full-scale remediation will be from 30 to 40 ft bgs.

The amendment delivery will be accomplished by the GeoProbe® enabled direct push points or through temporary injection wells. Following RAP approval, a detailed design will be performed and presented in the RDIP. This plan will include the result of comparing the efficiency and cost of these two delivery methods to determine the proposed method for field injections. It is likely that the number of injections points will be reduced if the delivery is by injection wells (rather than injection points) based on ROI that will be determined in the field (by measuring groundwater conductivity). The use of injection points verses injection wells will be addressed in the RDIP.

#### 7.2.1.4 Injection Volumes

Amendment EHC-L will be procured from the vendor as 25 percent or 100 percent strength. The final amendment strength in the injection volume will be between 1 percent and 5 percent achieved by dilution with water. The EHC-L concentrations will be up to 4,000 mg/L in groundwater based on the groundwater geochemistry that will be analyzed during baseline sampling. The injection volume per unit treatment interval will be equal to 10 percent to 20 percent of the formation pore volume, relying on diffusion and dispersion properties of the amendment to distribute across entire pore volume over time. It is assumed that the amendment injection rates will be up to 10 gpm, depending on the formation's capacity to accept. The daily post-injection report will document the amendment injection volumes, strength, flow rate, and injection pressure for all injections. Soils generated during boring preclearance activities and DPT injections (or injection wells construction) shall be placed in Department of Transportation (DOT)-approved drums for profiling and offsite disposal.

### 7.2.2 Full-Scale Site Area Shallow Groundwater Remediation

The amendments and injection approach to treat shallow groundwater Offsite will be similar to the design and approach proposed for the Site groundwater remediation. However, a significant data gap exists between the Site and Offsite areas under Highway 50. Although the CVOC groundwater plume is undefined in this area, it is likely that significant contaminant mass is present as supported by the concentrations detected in the Offsite well MWS-9. The proposed remedial injection designed to treat the influx of upgradient contaminant mass and higher Offsite CVOC concentrations at and downgradient MWS-9 is similar to the PRZ concept. It is anticipated that the Offsite PRZ injections will be performed as a separate mobilization.

To reduce the >50 µg/L CVOC plume (both PCE and TCE) and treat the influx of contaminated groundwater from under Highway 50, a PRZ (identified as PRZ-4) consisting of 22 injection locations are proposed along T street (Figures 16 and 17). Since the extent of the >50 µg/L CVOC plume is primarily within the Offsite area residential neighborhood, additional injection points are not proposed since access to private property is unlikely. Furthermore, T Street orientation is perpendicular to groundwater flow making it an optimal location to treat the influx of upgradient contaminated groundwater flowing under Highway 50. Due to the unknown CVOC mass in groundwater under Highway 50 and the known longevity of the solution-based amendments, a second injection event would be needed in approximately three years (depending on performance monitoring results) after the initial Offsite injections to maintain treatment of groundwater into the Offsite area until RAOs are achieved.

Based on the review of the Offsite boring logs, the fine-grained sediments are not present in the interval from 41 to 45 ft bgs (unlike the Site area near MWS-6). Because the depth to groundwater in the Offsite area is similar to the Site area (approximately 30 ft bgs), the conceptual Offsite area treatment interval will be 30 to 45 ft bgs. The daily post-injection report will document the amendment injection volumes, strength, flow rate, and injection pressure for all injections. Any investigative derived waste soils shall be placed in DOT-approved drums for offsite disposal.

### 7.2.3 Performance and Order Compliance Monitoring

Performance and compliance monitoring will be performed to determine the impact of in situ remediation on the shallow groundwater in reducing concentrations.

#### 7.2.3.1 Order Compliance Monitoring

To comply with Order no. R5-2015-0012 and evaluate the performance of the groundwater remedy, additional groundwater monitoring wells and samples are anticipated as part of the full-scale implementation. BC will use a similar groundwater monitoring approach for the full-scale remedy (with minor revisions) as described in the Addendum to the Groundwater Amendment Pilot Test Work Plan (BC, 2016d). The number of additional shallow groundwater wells needed at the Site to obtain California CVRWQCB approval and collect sufficient data to evaluate CVOC concentration trends and secondary water quality standards is 2 to 4. The number of additional shallow groundwater wells needed at the Offsite location to obtain CVRWQCB approval and collect sufficient data to evaluate CVOC concentration trends and secondary water quality standards is three to six.

First, the EHC-L amendment will be analyzed for the following to meet the requirements of the General Order: 1) VOCs; 2) General minerals (alkalinity, bicarbonate, potassium, chloride, sulfate, total hardness, nitrate, nitrite, ammonia); 3) Total and dissolved metals (arsenic, barium, cadmium, calcium, total chromium, copper, iron, lead, manganese, magnesium, mercury, molybdenum, nickel, selenium, and silica); 4) Total dissolved solids (TDS); 5) pH; and 6) Electrical conductivity (EC).

#### 7.2.3.2 Site Performance Monitoring

Second, to evaluate the effectiveness of EHC-L injections on the groundwater CVOCs, up to eight groundwater sampling events will be performed over a two-year period. The monitoring well network will be determined in the detailed design and will consist of existing wells CWS-1, CWS-2, CWS-3, GMW-1, GMW-2, GMW-3, GMW-4, MWS-6, MWS-7, and MWS-8; additional two to four new wells are proposed. Groundwater samples will be analyzed for the CVOCs, degradation end-products consisting of dissolved gases (methane, ethane, and ethene), geochemical parameters (alkalinity, total and dissolved iron, total and dissolved arsenic, nitrate, sulfate, chloride, total organic carbon [TOC]), microbial parameters (DHC culture), and field parameters (pH, DOORP, temperature, EC, ferrous iron, and sulfide). The CVOCs, geochemical, microbial, and field parameters data will help in the evaluation of in situ treatment performance.

#### 7.2.3.3 Offsite Performance Monitoring

Similar to the Site, to evaluate the effectiveness of EHC-L injections on the groundwater CVOCs, up to eight groundwater sampling events will be performed over a two-year period. The monitoring well network will be determined in the detailed design and will consist of existing wells MWS-9, MWS-10, and MWS-11; additional three to six new wells are proposed (see Figure 18). Groundwater samples will be analyzed for the CVOCs, degradation end-products, geochemical parameters, microbial parameters, and field parameters as described in Section 6.5.2 to assist in the evaluation of in situ treatment performance.

## 7.3 Sitewide Groundwater Plume Stability Analysis

Following the in situ remediation corrective measure, it is anticipated that the concentrations of CVOCs, primarily PCE and TCE, will be diminished and (as stated in Section 6.5.2) the in situ remediation corrective measure is considered successful when groundwater PCE and TCE plume concentrations have been reduced to 50 µg/L in the Site and Offsite areas. Once achieved, a long-term monitoring program (LTMP) will begin where semi-annual (initially) groundwater sampling will be performed to monitor CVOC concentrations and collect the data to evaluate the stability of the plume. Natural biodegradation and other processes are anticipated to decrease groundwater concentrations of PCE and TCE to the MCL of 5 µg/L within a reasonable timeframe and within 30 years to achieve closure.

### 7.3.1 Long Term Monitoring Program

Following the last quarterly sampling event associated with the shallow groundwater remediation corrective measure and the CVRWQCB concurrence that active remediation has achieved the proposed performance goals, the long term groundwater monitoring network (see wells listed in Sections 7.2.3.2 and 7.2.3.3) shown on Figure 18 will be sampled semi annually for four years. On an annual basis and following the first year, PCE and TCE concentrations over time will be evaluated using statistical analysis (Mann-Kendall and other tools) to determine the trend (increasing, stable, or decreasing). The evaluation will also include the determination of plume travel distance and time before reaching groundwater standard of 5 µg/L for PCE and TCE, and if any receptors are present and impacted before plume is attenuated to the groundwater standards. Based on the results of the analysis and where decreasing trends are observed, optimization of the LTMP well network will be proposed. Following the four years of semi-annual sampling, the frequency will be reduced to annual.

### 7.3.2 Shallow Groundwater Plume Closure Criteria

Once wells in the LTMP have decreased to a concentration below 20 µg/L and showing a decreasing trend that is predicted to decrease below the MCL in 5 years, then the sampling frequency will be reduced to biannually. Upon reaching the MCL, if concentration trends suggest that the resulting PCE or TCE concentration will decrease below the California Water Board - Office of Environmental Health Hazard Assessment public health goals (PHG) within five years then no further monitoring will be required.

It is expected that PCE and TCE concentrations in some of the Site LTMP wells may become stable below the active remediation goal of 50 µg/L and not decrease below 20 µg/L with a decreasing trend. In this case, and following the first five years of monitoring following active remediation, reassessment of risk to human health and the environment to determine if a viable threat exists if stable residual contamination remains in the source area.

## Section 8

# Schedule

The tasks and durations for the SVE and shallow groundwater corrective measures are provided in the following sections. These tasks follow the approval of this RAP and preparation, submittal, and approval of a RDIP. The RDIP is expected to take approximately one and a half to three months to prepare.

## 8.1 SVE Conceptual Design and Implementation Plan

Upon approval of the RDIP, a total duration of approximately two months is needed to install the SVE system. Once the drilling and building permits are obtained and electrical power has been arranged, installation of the vapor extraction wells will be scheduled. Approximately three to five weeks will be necessary to obtain the drilling permits and for a C-57 licensed driller to become available. The well installation reports will be submitted within approximately three weeks of completing the field activities.

Construction of the remediation system and connection of the remedial equipment to the electrical service will be performed shortly after installing the SVE wells. One to two weeks are anticipated to install the piping and remediation equipment. The electrical power connection schedule is dependent on coordinating the power drop with SMUD. Startup activities generally require one to two weeks, and the installation and startup report will be submitted within 45 days following acceptable startup testing.

**Table 8-1. Schedule for SVE Implementation**

| Task Name | Duration |
|---|---|
| Premobilization and permitting: Sacramento Air Resources Board, SVE well permitting, and other permits | 3-5 weeks |
| Installation of SVE test wells | 3 weeks |
| Installation and commissioning of SVE System and Piping | 2 months |
| Prepare and submit SVE Start-Up Report to CVRWQCB | 6 weeks |
| Obtain CVRWQCB approval of the SVE Start-Up Report | 4 weeks |
| Observation and Monitoring (O&M) - 1 year | 12 months |

## 8.2 Full Scale Project Site Shallow Groundwater Remediation

Upon approval of the RDIP, it is estimated that the General Order R5-2015-0012 Notice of Intent will be submitted to the CVRWQCB in one month. Following the receipt of the Notice of Applicability from the CVRWQCB, a duration of three months is needed to implement the full-scale shallow groundwater corrective measure. Following implementation, one year of performance monitoring is assumed.

| Table 8-2. Schedule for Full-Scale Groundwater Remedy | |
|---|---|
| **Task Name** | **Duration** |
| Prepare and submit Notice of Intent to the CVRWQCB for coverage under General Order R5-2015-0012 for proposed injections of amendments into groundwater | 1 month |
| CVRWQCB review of the Notice of Intent and preparation of the draft Notice of Applicability and Monitoring and Reporting Program for the in-situ General Order R5-2015-0012 | 2 months |
| Public Comment Period | 1 month |
| Obtain Notice of Applicability and the Monitoring and Reporting Program | 1 day |
| Field Operations - Premobilization, mobilization, injections, demobilization | 3 months |
| Quarterly Groundwater Monitoring | 12 months |
| Prepare and Submit full scale Groundwater Amendment (GA) Results Report | 2 months |
| Obtain CVRWQCB approval for the GA Results Report and Recommendations | 1 day |

## 8.3 Sitewide Groundwater Plume Stability Analysis

As stated in Section 6.5.2, after PCE and TCE plume concentrations reaching the 50 µg/L concentrations within the Site, no further active groundwater remediation will be required. Once achieved, the groundwater plume stability analysis described in Section 7.3 will be conducted as part of the annual monitoring program and will include recommended monitoring well network optimization recommendations based on the results.

Section 9

# Limitations

This document was prepared solely for SMUD in accordance with professional standards at the time the services were performed and in accordance with the contract between SMUD and BC dated September 26, 2019. This document is governed by the specific scope of work authorized by SMUD; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by SMUD as to the validity, completeness, or accuracy of such information.

Further, BC makes no warranties, express or implied, with respect to this document, except for those, if any, contained in the agreement pursuant to which the document was prepared. All data, drawings, documents, or information contained this report have been prepared exclusively for the person or entity to whom it was addressed and may not be relied upon by any other person or entity without the prior written consent of BC unless otherwise provided by the Agreement pursuant to which these services were provided.

Section 10

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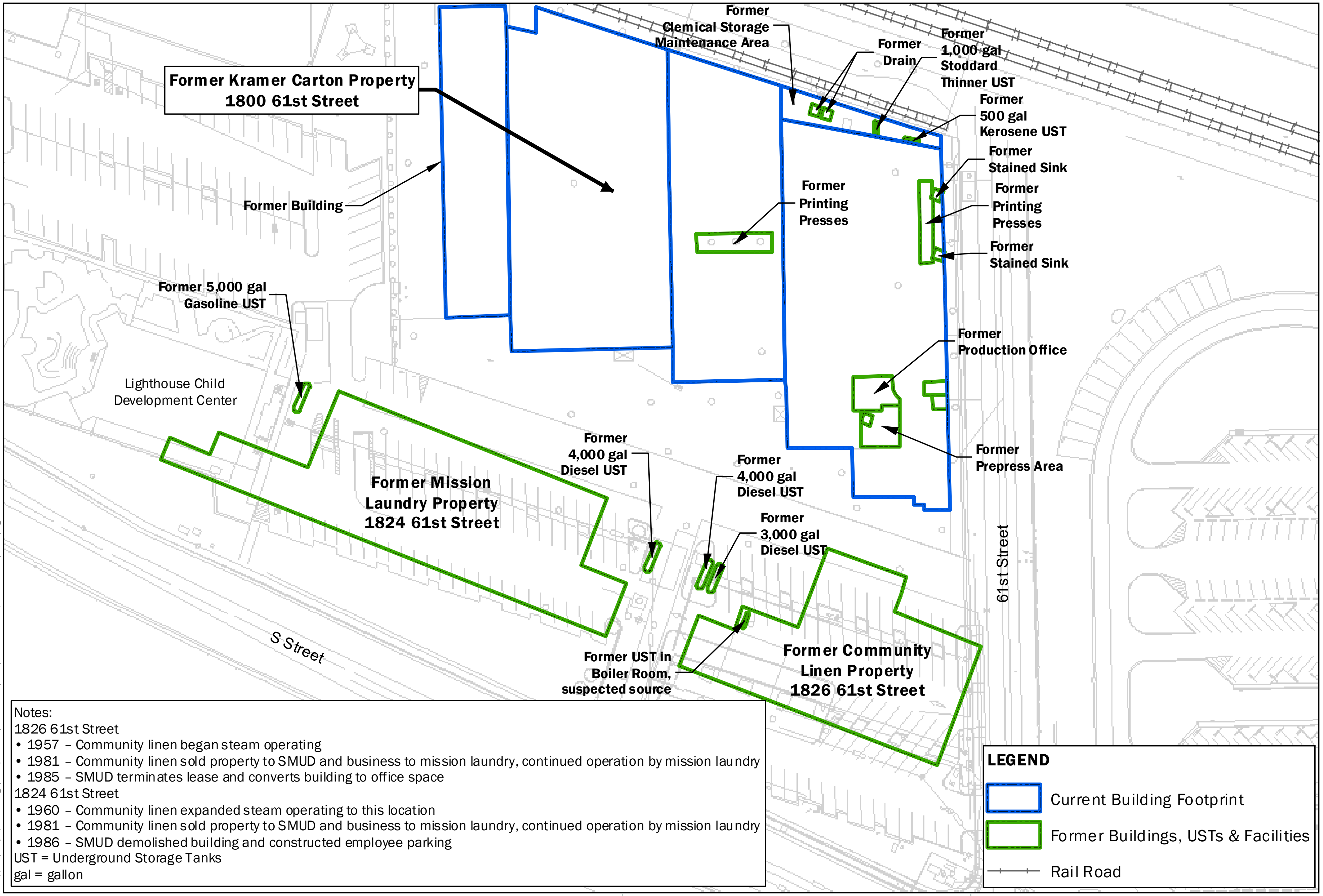
# Figures




Notes:
1826 61st Street
- 1957 – Community linen began steam operating
- 1981 – Community linen sold property to SMUD and business to mission laundry, continued operation by mission laundry
- 1985 – SMUD terminates lease and converts building to office space

1824 61st Street
- 1960 – Community linen expanded steam operating to this location
- 1981 – Community linen sold property to SMUD and business to mission laundry, continued operation by mission laundry
- 1986 – SMUD demolished building and constructed employee parking

UST = Underground Storage Tanks
gal = gallon

Brown AND Caldwell

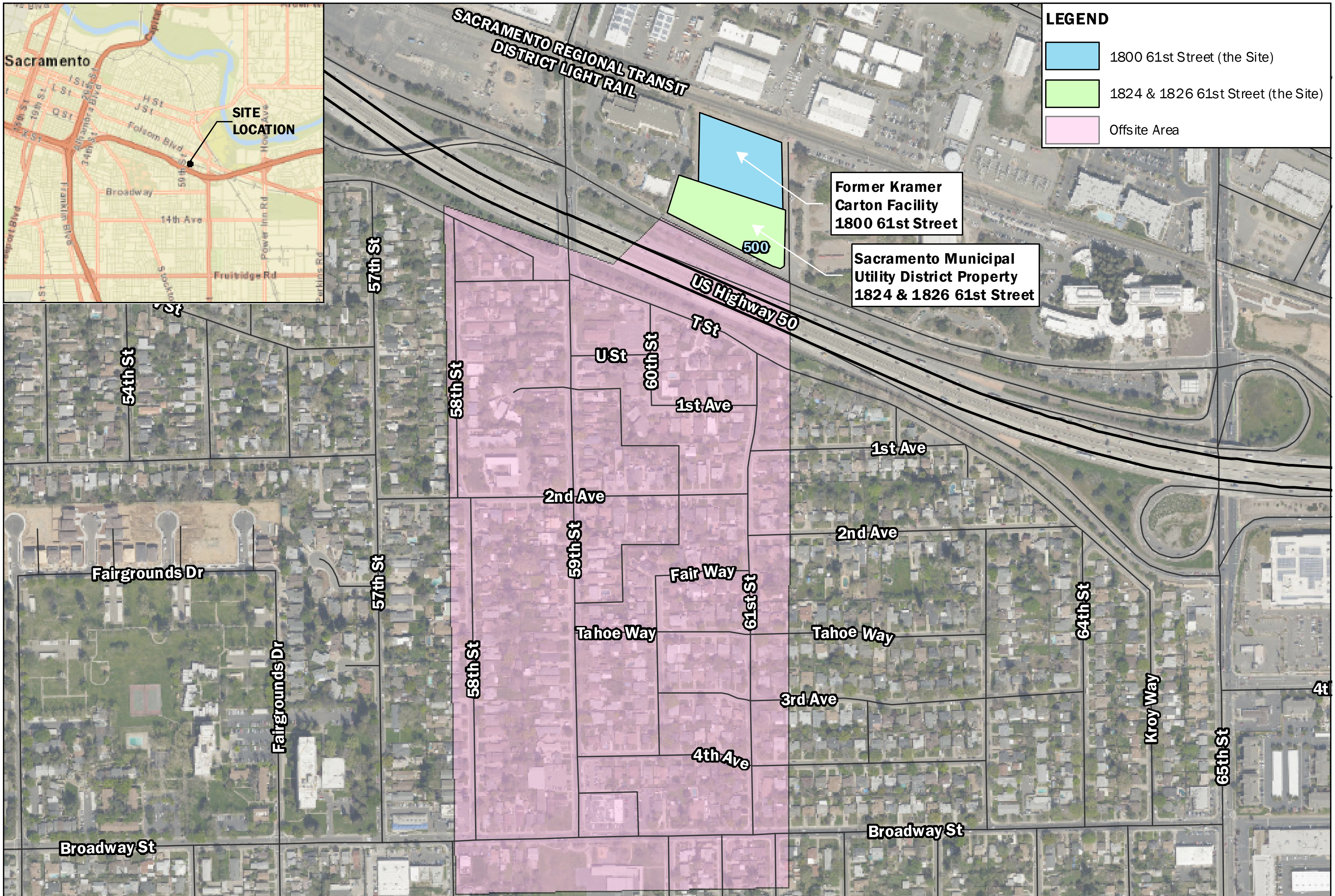
REMEDIAL ACTION WORK PLAN

FORMER COMMUNITY LINEN SITE

Date: OCTOBER 2020
Project: 153479

**FIGURE 1**

**SITE MAP WITH FORMER FEATURES**

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REMEDIAL ACTION WORK PLAN

FORMER COMMUNITY LINEN SITE

Date: OCTOBER 2020
Project: 153479

Sources:
Aerial photo: ESRI & Affiliates, 2018

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Feet

FIGURE 2

SITE LOCATION

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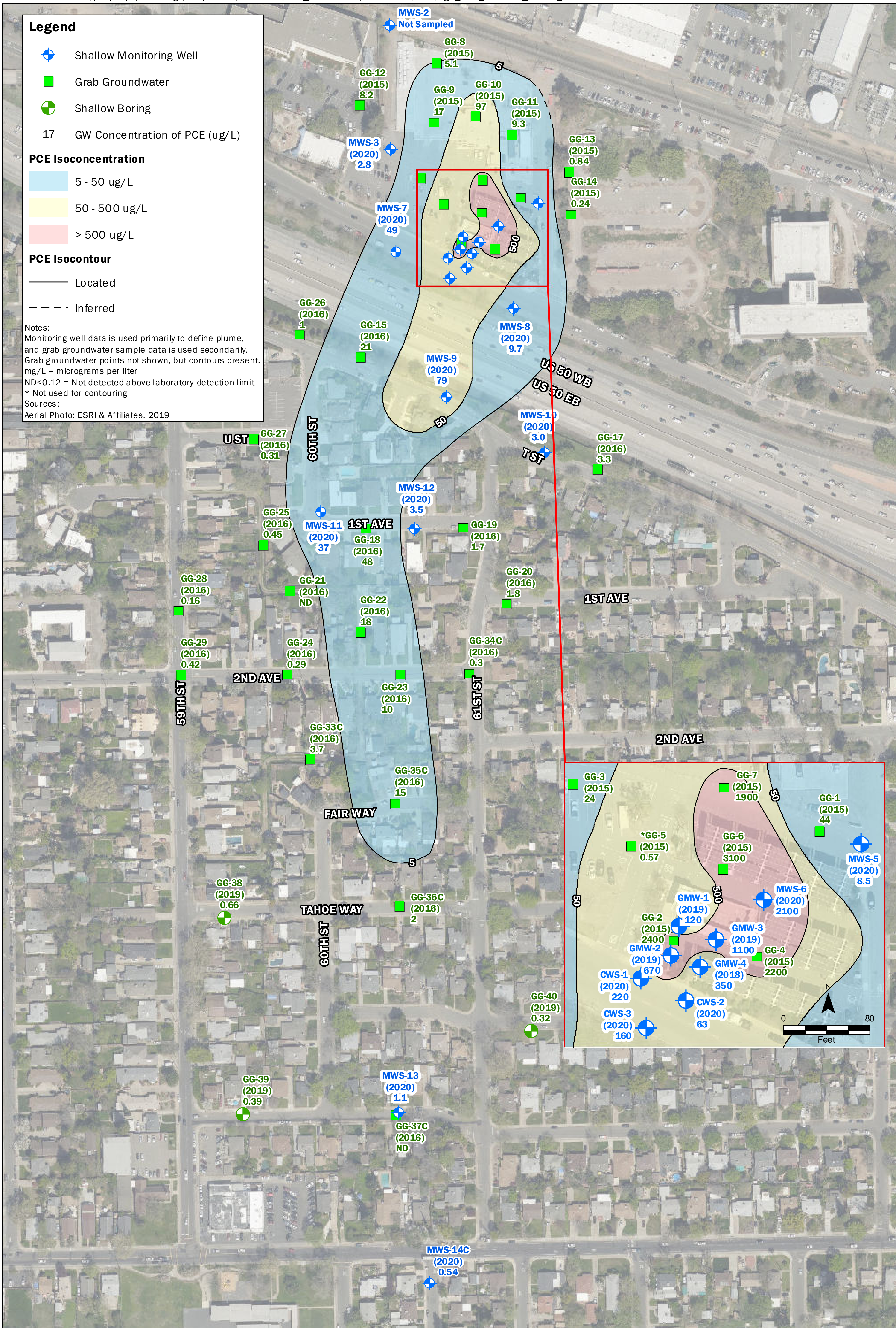


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FORMER COMMUNITY LINEN SITE

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Project: 153479

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Feet

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FIGURE 3

PCE SHALLOW GROUNDWATER ZONE ISOCONCENTRATION CONTOUR MAP JUNE 2020

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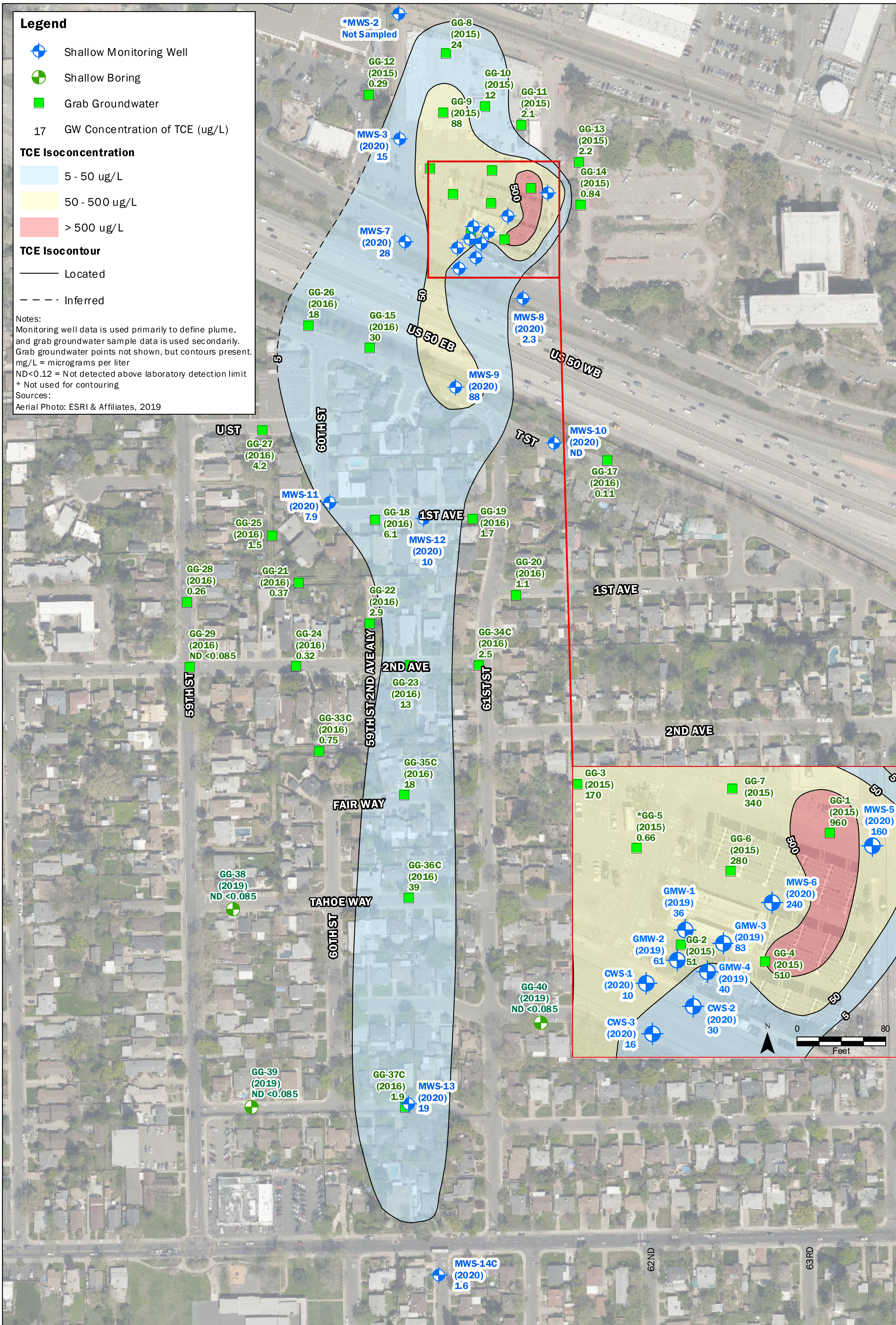


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REMEDIAL ACTION WORK PLAN

FORMER COMMUNITY LINEN SITE

Date: OCTOBER 2020
Project: 153479

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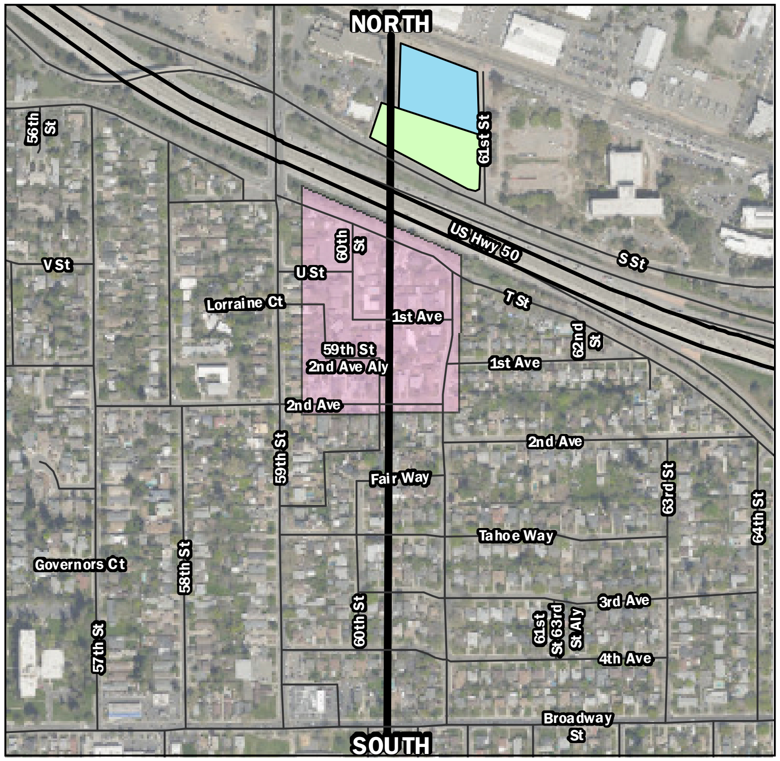
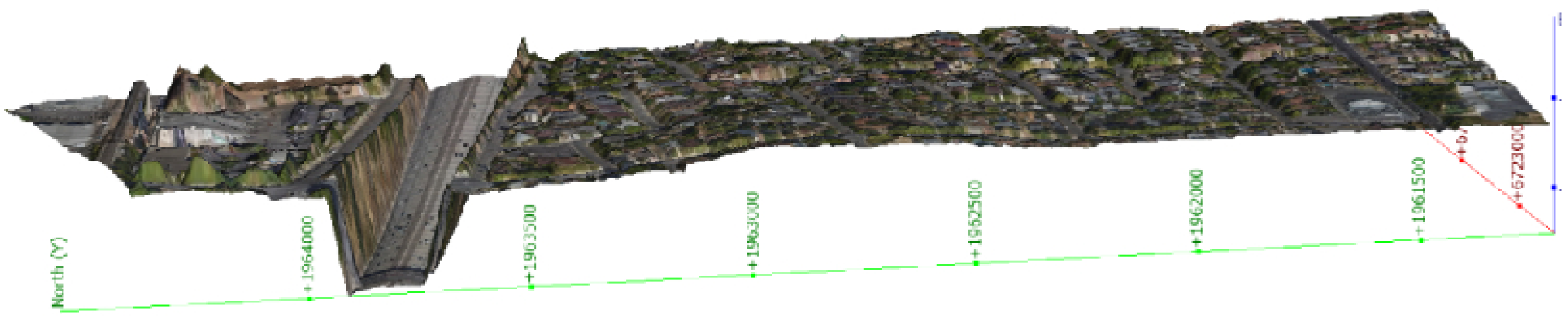
**FIGURE 4**

**TCE SHALLOW GROUNDWATER ZONE ISOCONCENTRATION CONTOUR MAP JUNE 2020**

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REMEDIAL ACTION WORK PLAN

FORMER COMMUNITY LINEN SITE

Date: OCTOBER 2020
Project: 153479

Sources:
Sewer and storm drain features, City of Sacramento
Aerial photo: ESRI & Affiliates, 2018

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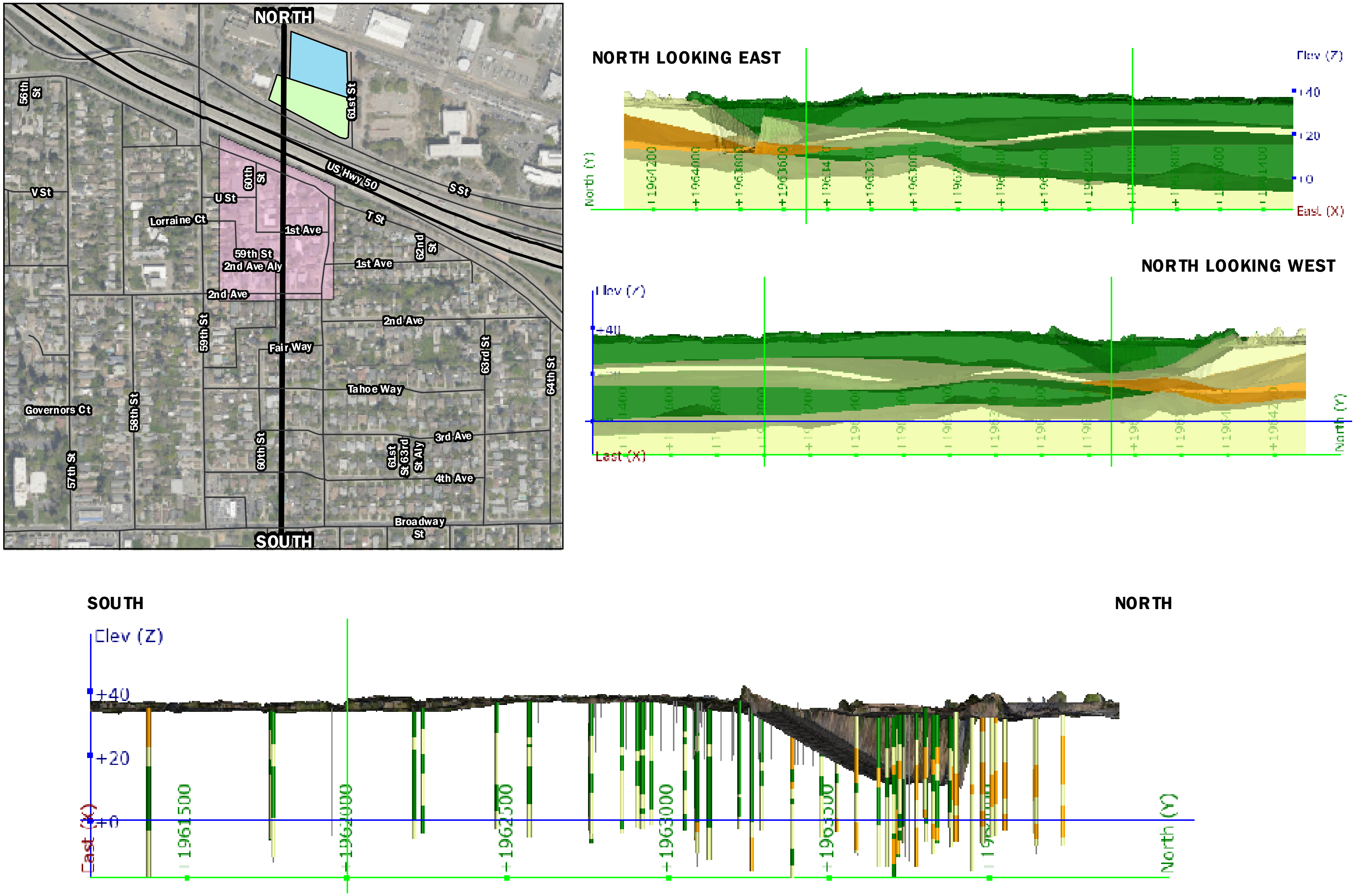
Feet

FIGURE 5

3D MODEL SUBSURFACE DETAILS

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REMEDIAL ACTION WORK PLAN

**FORMER COMMUNITY LINEN SITE**

Date: OCTOBER 2020
Project: 153479

Sources:
Sewer and storm drain features, City of Sacramento
Aerial photo: ESRI & Affiliates, 2018

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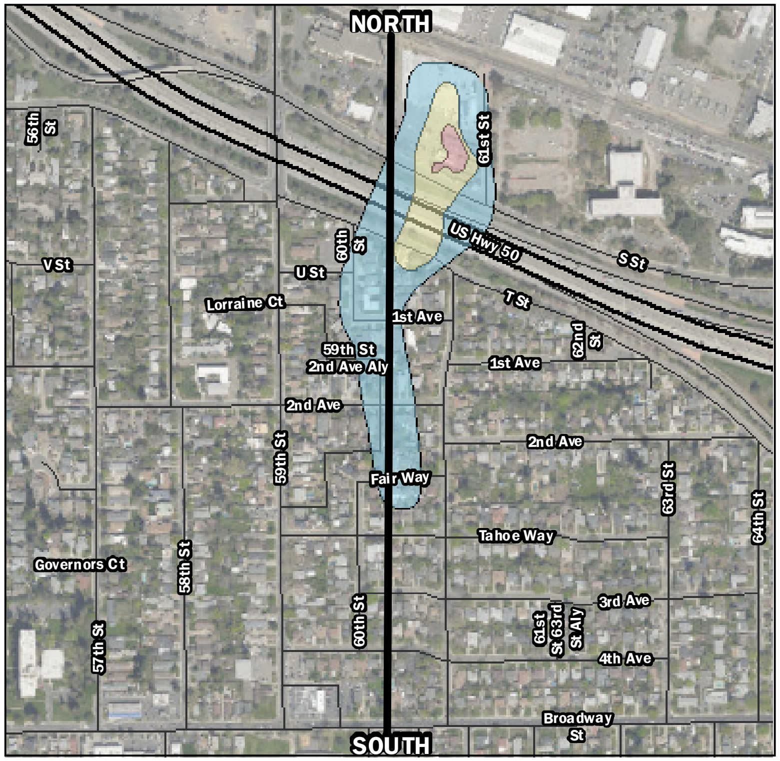
**FIGURE 6**

**3D MODEL LITHOLOGIC BORING DETAIL**



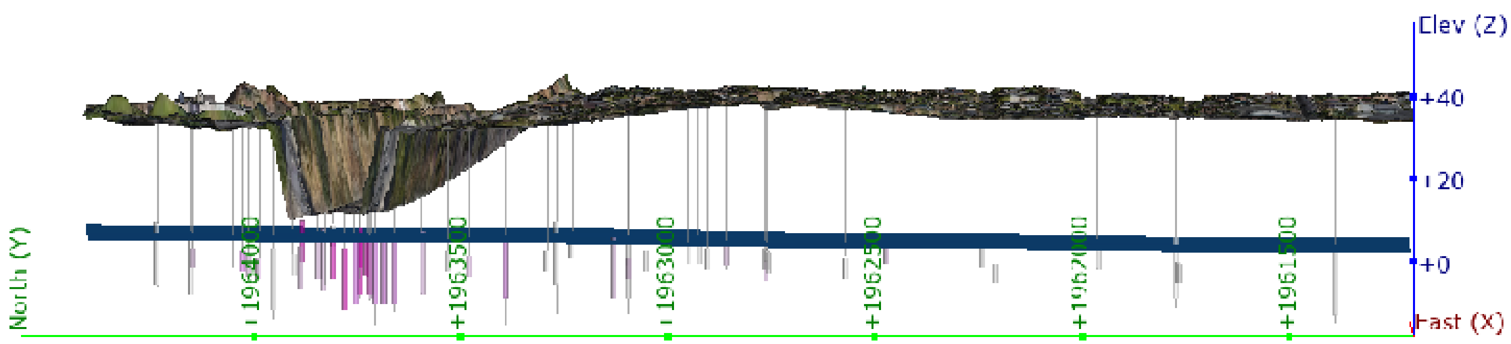

**LEGEND**

**PCE Isoconcentration**

- 5 - 50 ug/L
- 50 - 500 ug/L
- > 500 ug/L

**PCE Isocontour**

- Located
- Inferred

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REMEDIAL ACTION WORK PLAN

**FORMER COMMUNITY LINEN SITE**

Date: OCTOBER 2020
Project: 153479

Sources:
Sewer and storm drain features, City of Sacramento
Aerial photo: ESRI & Affiliates, 2018

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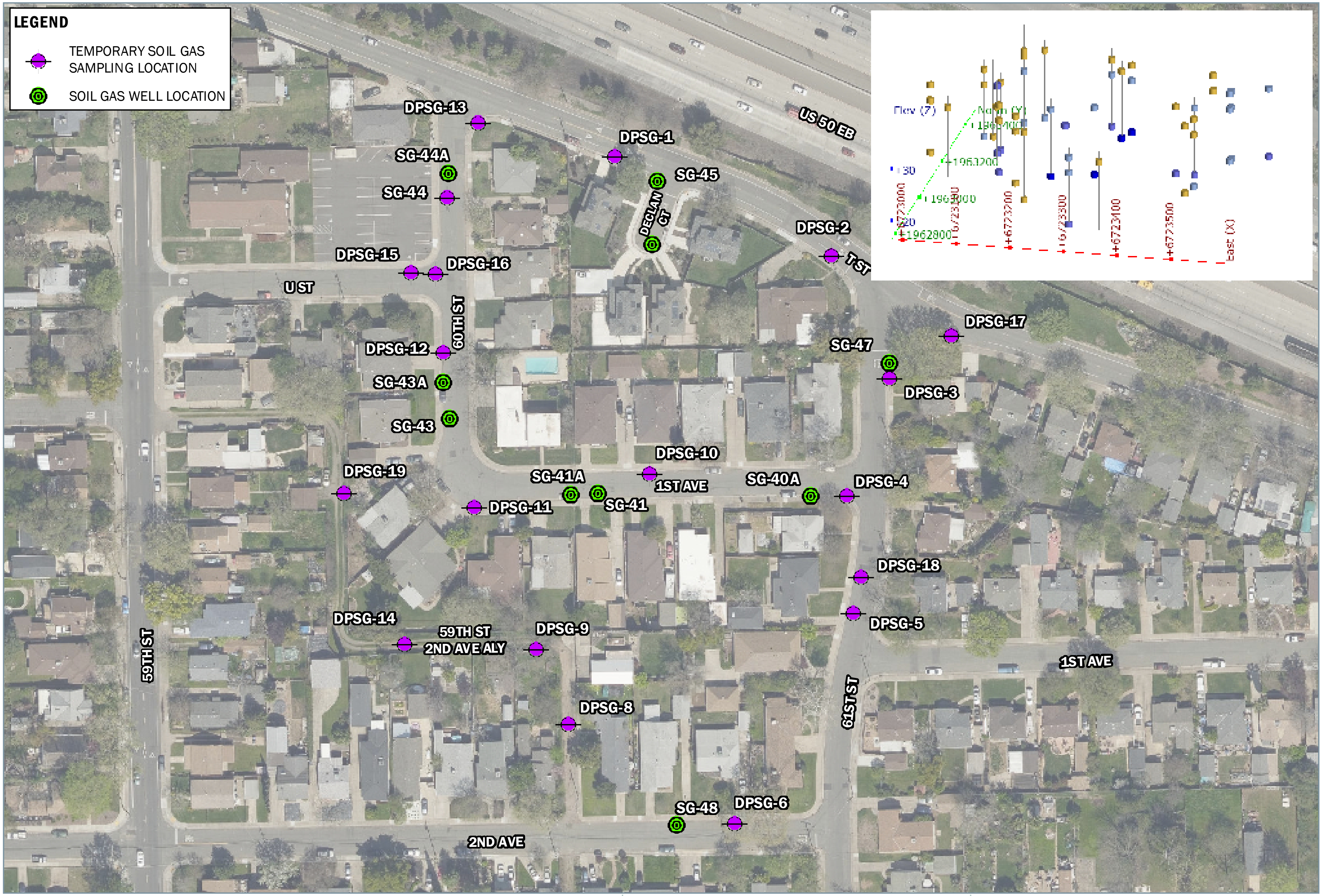
**FIGURE 7**

**3D MODEL PCE CONCENTRATIONS IN GROUNDWATER**




REMEDIAL ACTION WORK PLAN

**FORMER COMMUNITY LINEN SITE**

Date: OCTOBER 2020
Project: 153479

Sources:
Sewer and storm drain features, City of Sacramento
Aerial photo: ESRI & Affiliates, 2018

0 150
Feet
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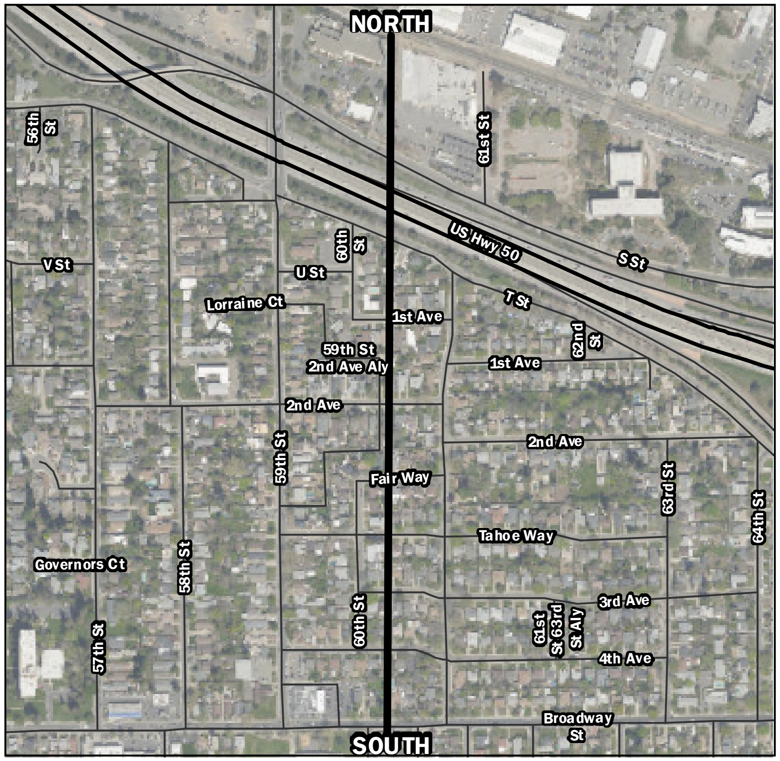
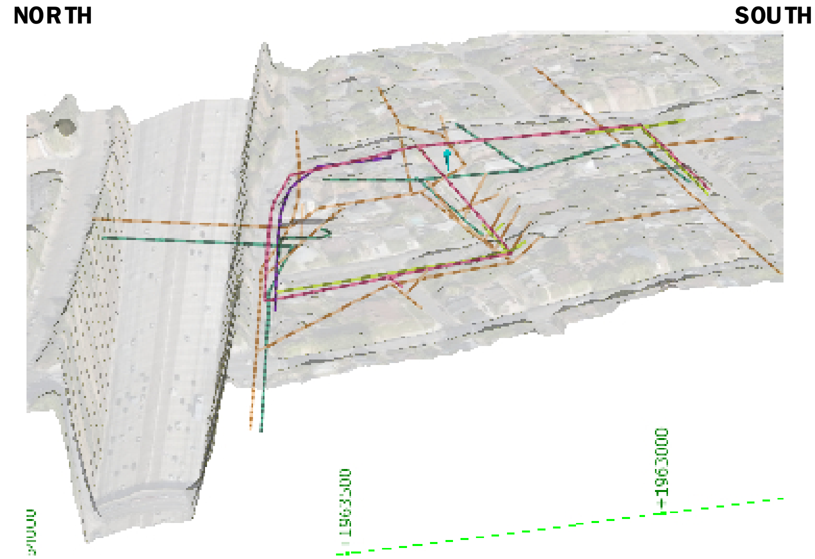
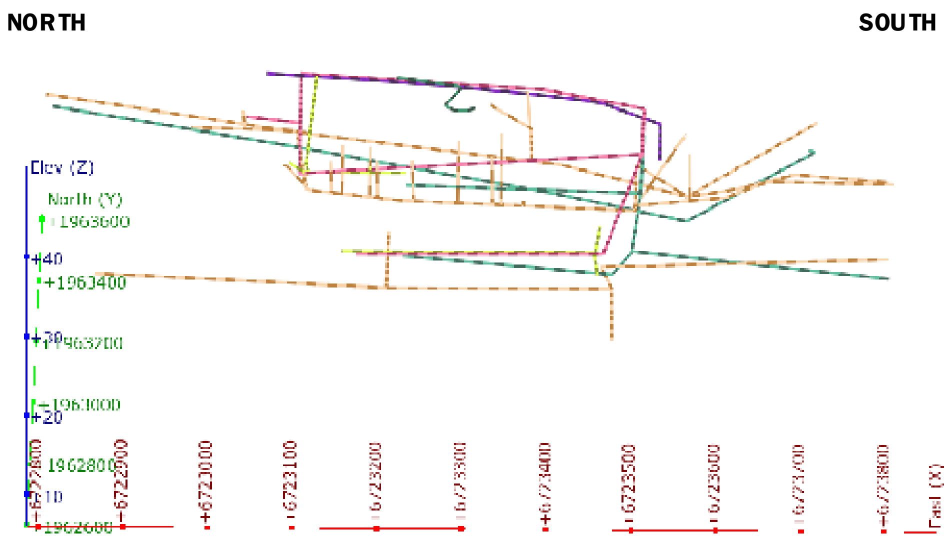
**FIGURE 8**

**3D MODEL PCE IN SOIL GAS**

[BCDENFP01]: \\bc\corp\Modeling\GIS\SMUD\KRAMER\GIS_MAPDOCS\WORKING\RAP\FIG9_SoilGasSampLoc_Cylinders_8x11P_20201015.mxd
tcrawford
Oct 15, 2020




REMEDIAL ACTION WORK PLAN

**FORMER COMMUNITY LINEN SITE**

Date: OCTOBER 2020
Project: 153479

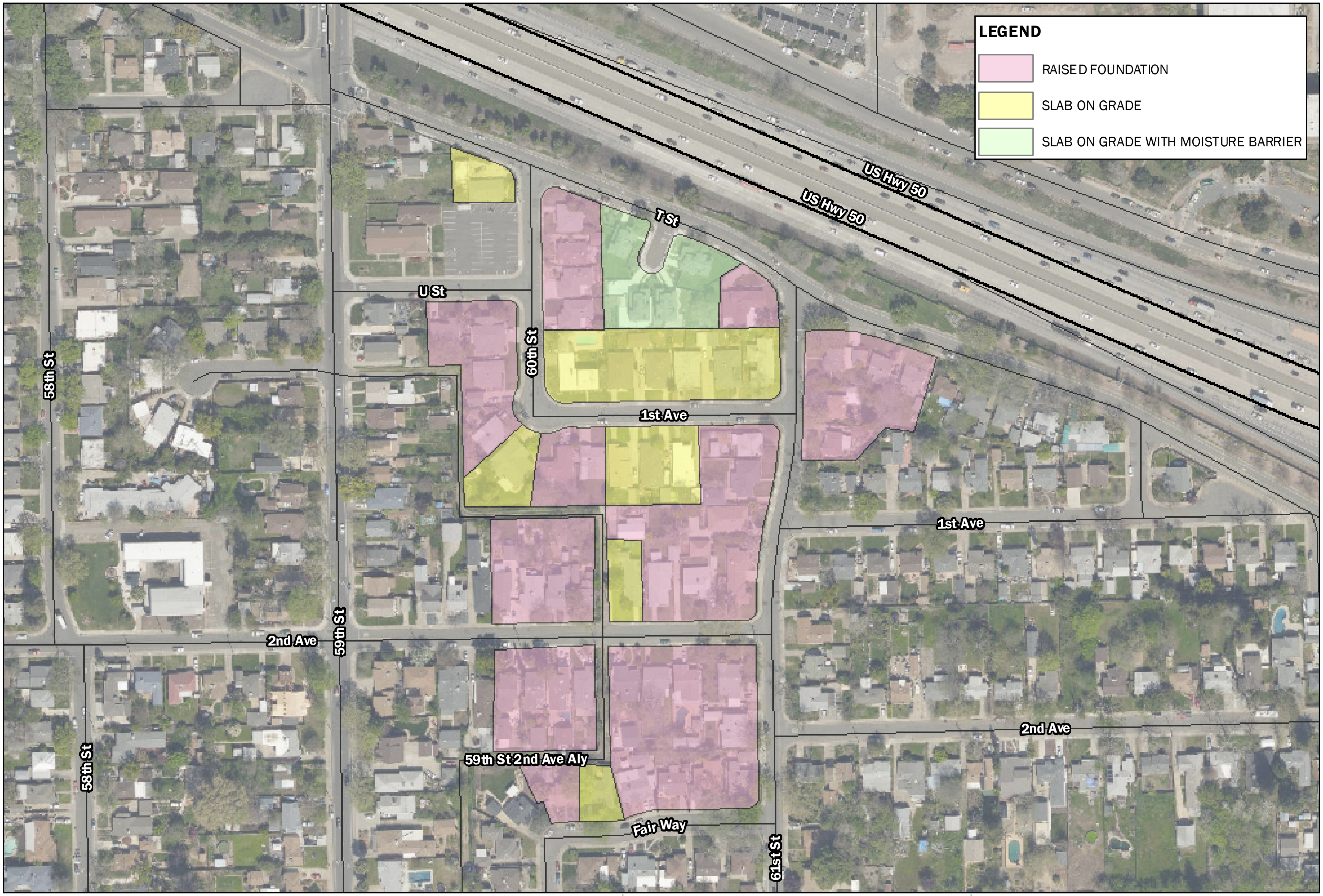
Sources:
Sewer and storm drain features, City of Sacramento
Aerial photo: ESRI & Affiliates, 2018

0 500
Feet

**FIGURE 9**

**3D SUBSURFACE UTILITIES**

[BCDENFP01]: \\bc\corp\Modeling\GIS\SMUD\KRAMER\GIS_MAPDOCS\WORKING\RAP\FIG10_SubsurfaceUtilities_8.5x11L_20201015.mxd

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REMEDIAL ACTION WORK PLAN

**FORMER COMMUNITY LINEN SITE**

Date: OCTOBER 2020
Project: 153479

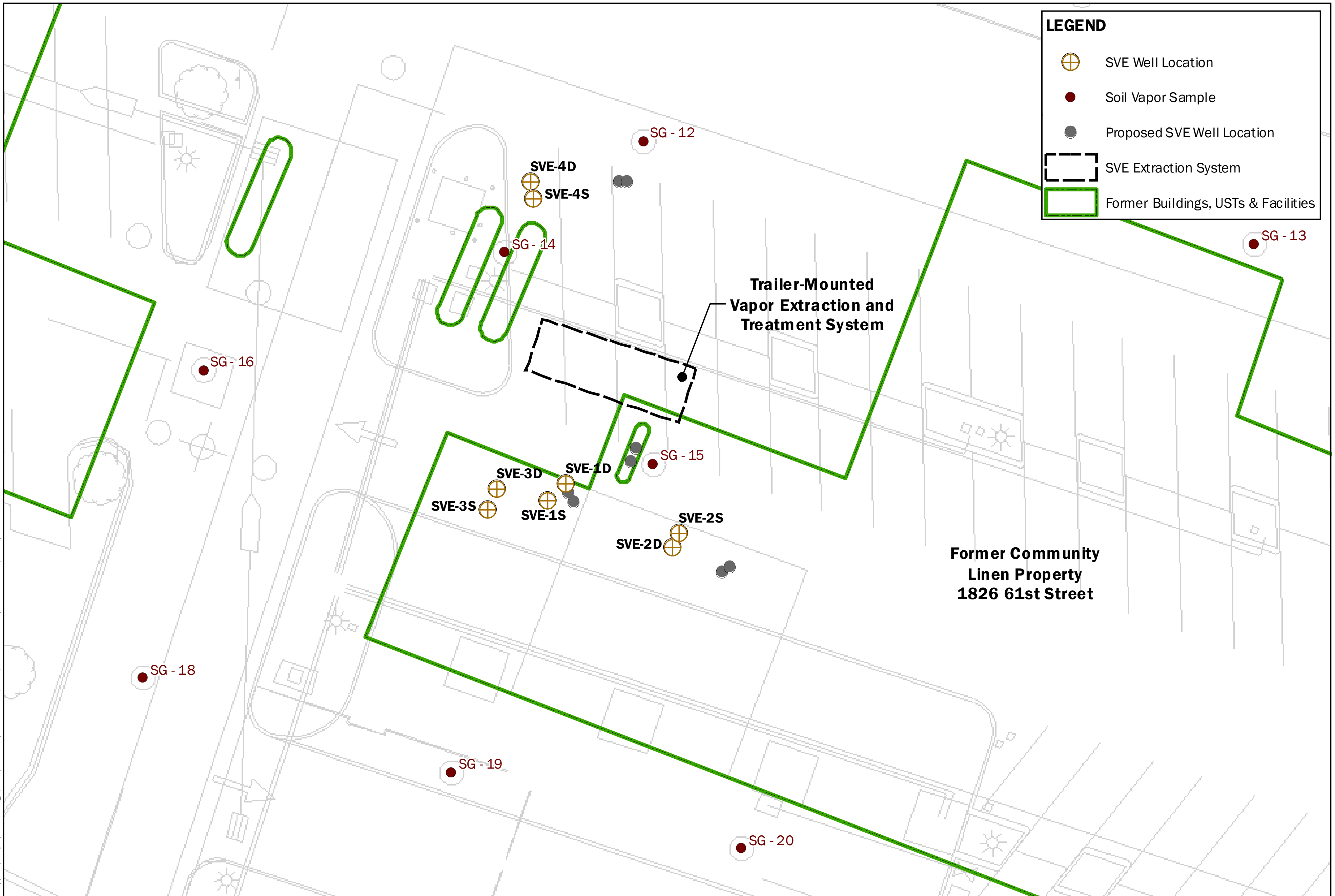
Sources:
Sewer and storm drain features, City of Sacramento
Aerial photo: ESRI & Affiliates, 2018

0 200
Feet

**FIGURE 10**

**3D MODEL HOME CONSTRUCTION TYPES**

[BCDENFP01]: \\bc\corp\Modeling\GIS\SMUD\KRAMER\GIS_MAPDOCS\WORKING\RAP\FIG11_Housing_8.5x11L_20201015.mxd

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FORMER COMMUNITY LINEN SITE

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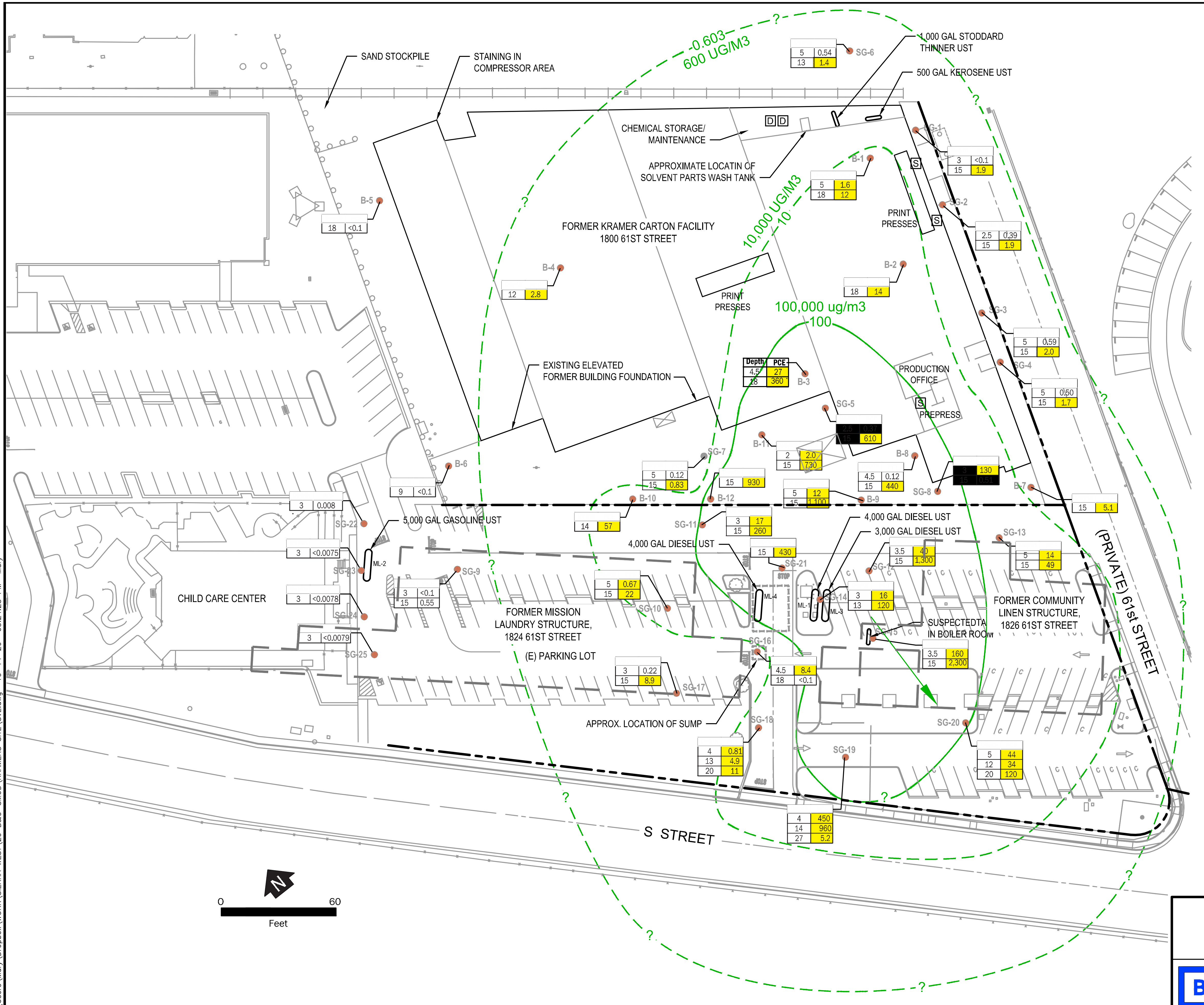
Project: 153479

**FIGURE 11**

**LOCATION OF SVE WELLS AND VAPOR EXTRACTION AND TREATMENT SYSTEM**




LEGEND

- PROPERTY BOUNDARY
- STRUCTURE
- APPROXIMATE LOCATION OF FORMER UST
- STAINED SINK
- DRAIN
- FORMER BUILDING
- FORMER EXCAVATION
- PCE, LINE OF EQUAL CONCENTRATION, DASHED WHERE INFERRED
- GROUNDWATER FLOW DIRECTION
- SOIL VAPOR SAMPLING LOCATION

NOTES:

1. Soil vapor samples at borings SG-1 through SG-15 were collected 8-26-2008 and 8-27-2008, SG-9 through SG 21 were collected 10-15-2012 to 10-29-2012, B-5 through B-15 were collected 3-18-2009 through 3-19-2009, and SG-22 through SG-25 were collected on 1-5-2013
2. Results are for the flow rate determined in the field at the beginning of each soil vapor investigation event.
3. Soil vapor concentrations in µg/L.

**Figure 12**

EXTENT OF PCE CONCENTRATIONS IN SOIL VAPOR

Brown AND Caldwell

1800, 1824, and 1826 61st Street
Sacramento, California

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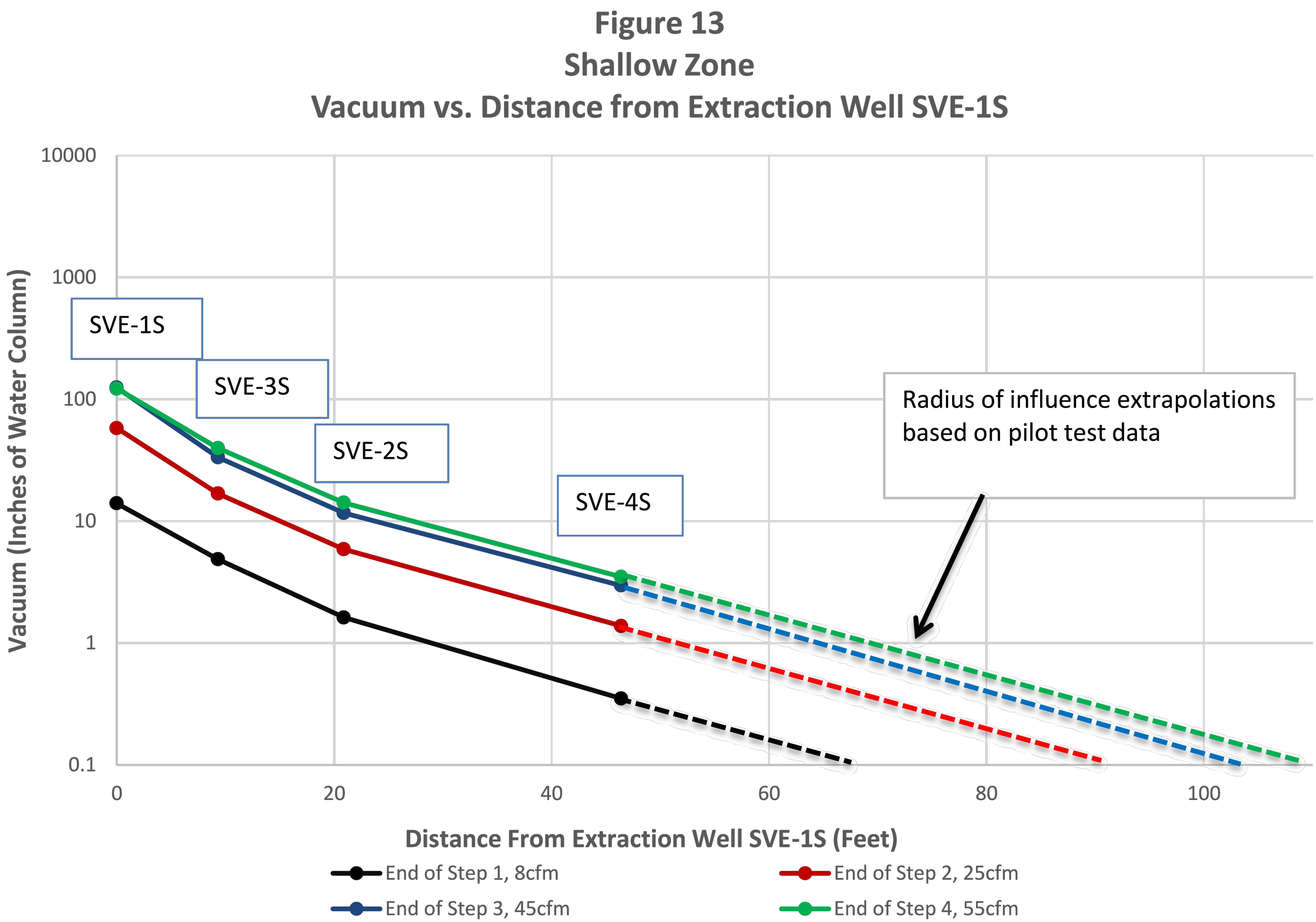


**Figure 13**

SHALLOW ZONE

VACUUM VS. DISTANCE FROM EXTRATION WELL SVE-1S

Brown AND Caldwell

1800, 1824, and 1826 61st Street
Sacramento, California

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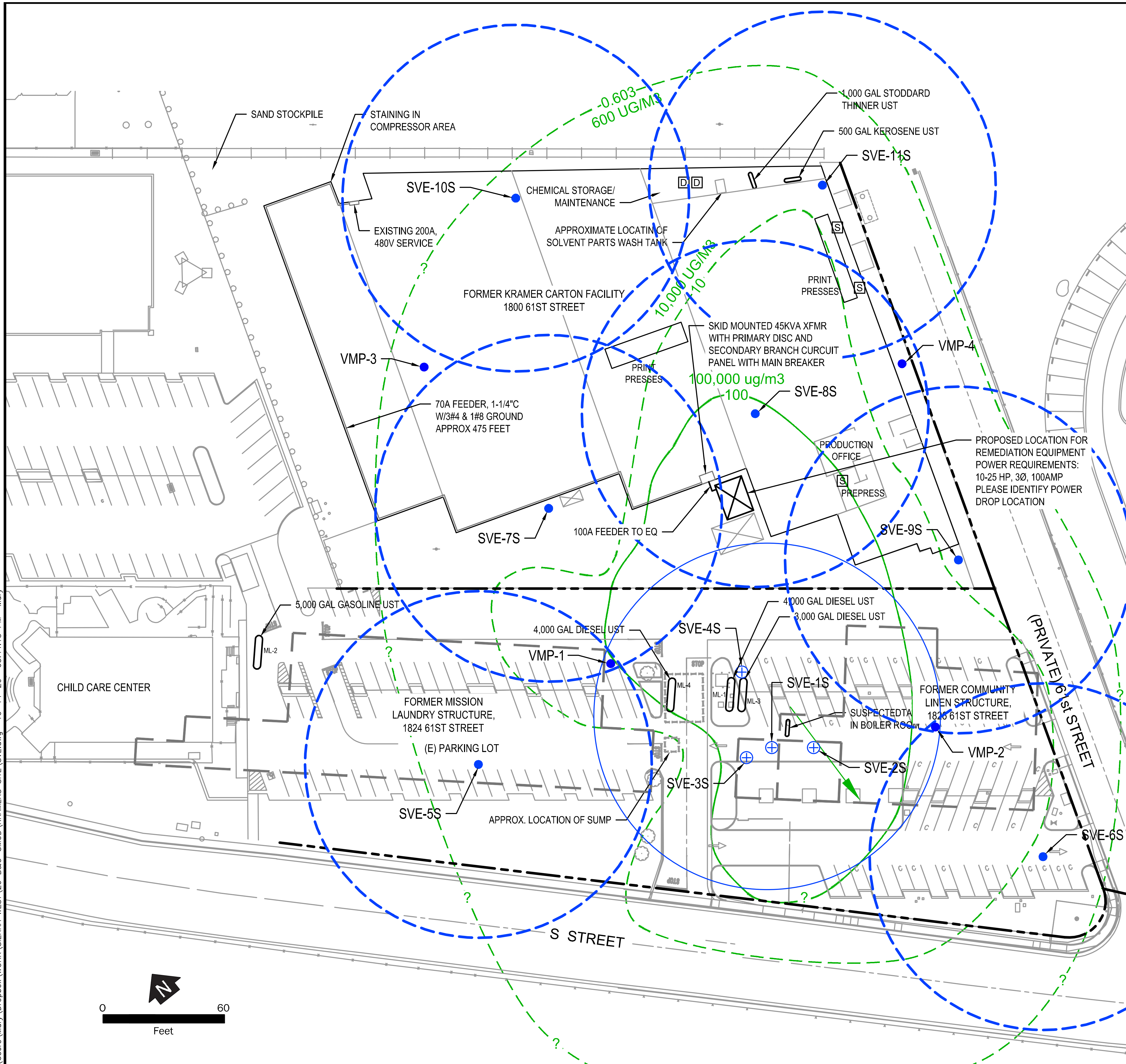



LEGEND

- PROPERTY BOUNDARY
- STRUCTURE
- ML-1 APPROXIMATE LOCATION OF FORMER UST
- S STAINED SINK
- D DRAIN
- FORMER BUILDING
- FORMER EXCAVATION
- 100 PCE, LINE OF EQUAL CONCENTRATION, DASHED WHERE INFERRED
- GROUNDWATER FLOW DIRECTION
- PROPOSED VAPOR MONITORING WELLS
- 1S EXISTING SVE WELLS (1S - 4S)
- PROPOSED SVE WELLS

NOTES:

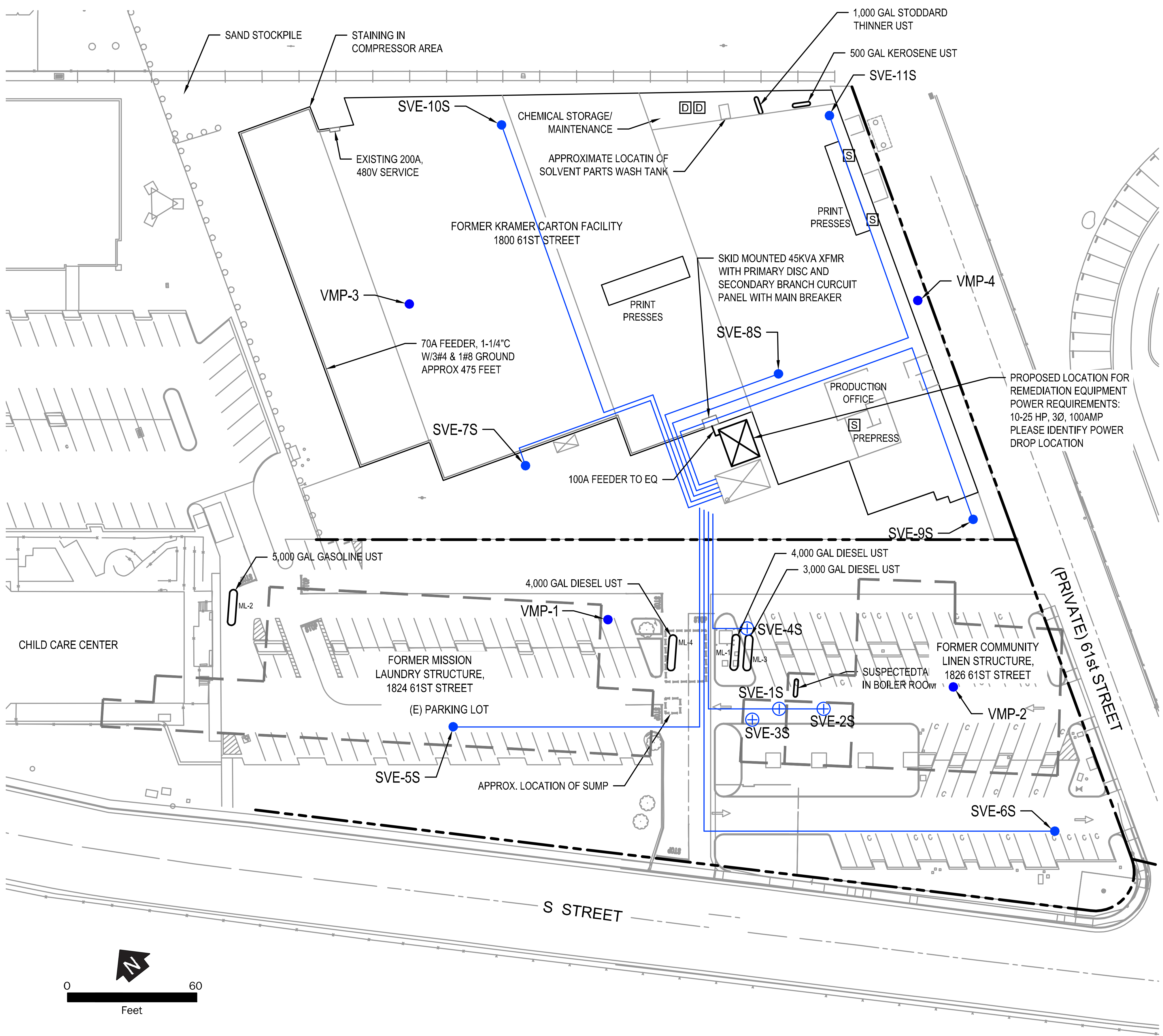
1. Soil vapor samples at borings SG-1 through SG-15 were collected 8-26-2008 and 8-27-2008, SG-9 through SG 21 were collected 10-15-2012 to 10-29-2012, B-5 through B-15 were collected 3-18-2009 through 3-19-2009, and SG-22 through SG-25 were collected on 1-5-2013
2. Results are for the flow rate determined in the field at the beginning of each soil vapor investigation event.
3. Soil vapor concentrations in µg/L.

**Figure 14**

ALTERNATIVE SVE WELL LAYOUT

Brown AND Caldwell

1800, 1824, and 1826 61st Street
Sacramento, California




LEGEND

- PROPERTY BOUNDARY
- STRUCTURE
- ML-1 APPROXIMATE LOCATION OF FORMER UST
- S STAINED SINK
- D DRAIN
- FORMER BUILDING
- FORMER EXCAVATION
- EXISTING SVE WELLS
- PROPOSED SVE WELLS
- PROPOSED VAPOR MONITORING PROBES (VMW)

**Figure 15**

ALTERNATIVE SVE SYSTEM PIPING LAYOUT

Brown AND Caldwell

1800, 1824, and 1826 61st Street
Sacramento, California

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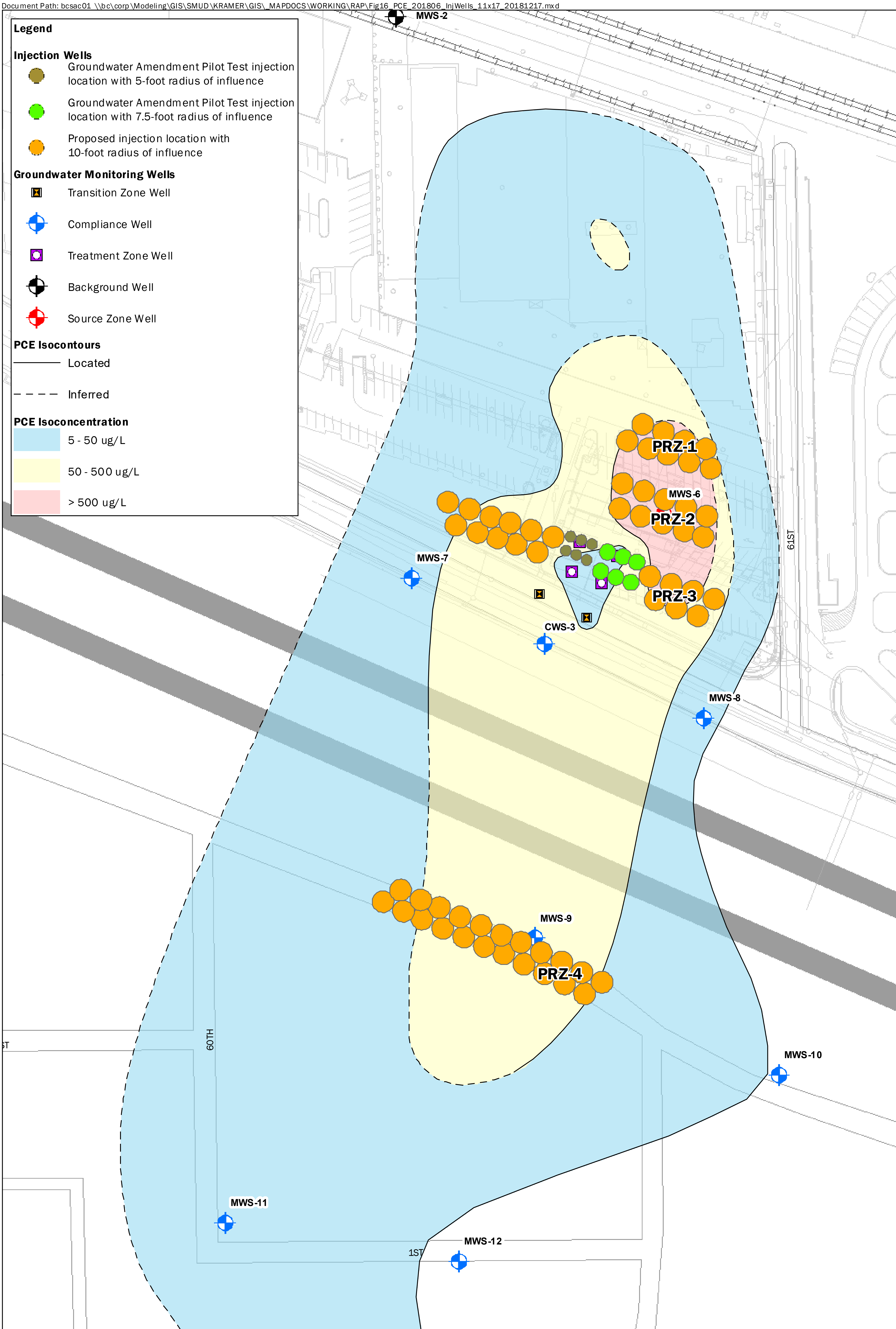


Brown AND Caldwell

REMEDIAL ACTION WORK PLAN

FORMER COMMUNITY LINEN SITE

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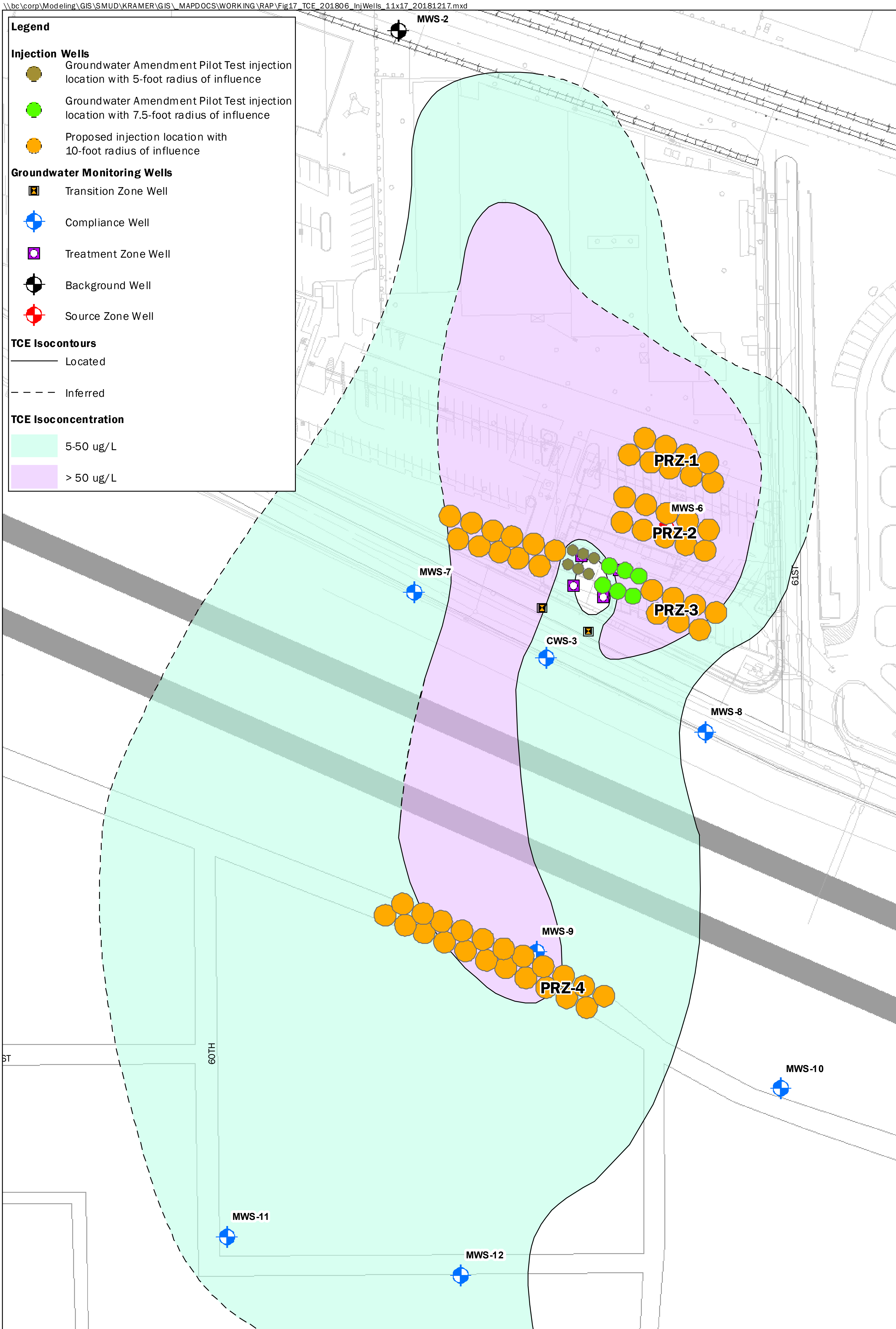
Project: 153479

0 80
Feet

N

FIGURE 16
PROPOSED FULL-SCALE GROUNDWATER REMEDIAL APPROACH IN-SITU INJECTION DESIGN
PCE SHALLOW GROUNDWATER ISOCONCENTRATION CONTOUR MAP - JUNE 2018

\\bc\corp\Modeling\GIS\SMUD\KRAMER\GIS_MAPDOCS\WORKING\RAP\Fig17_TCE_201806_InjWells_11x17_20181217.mxd




Brown AND Caldwell

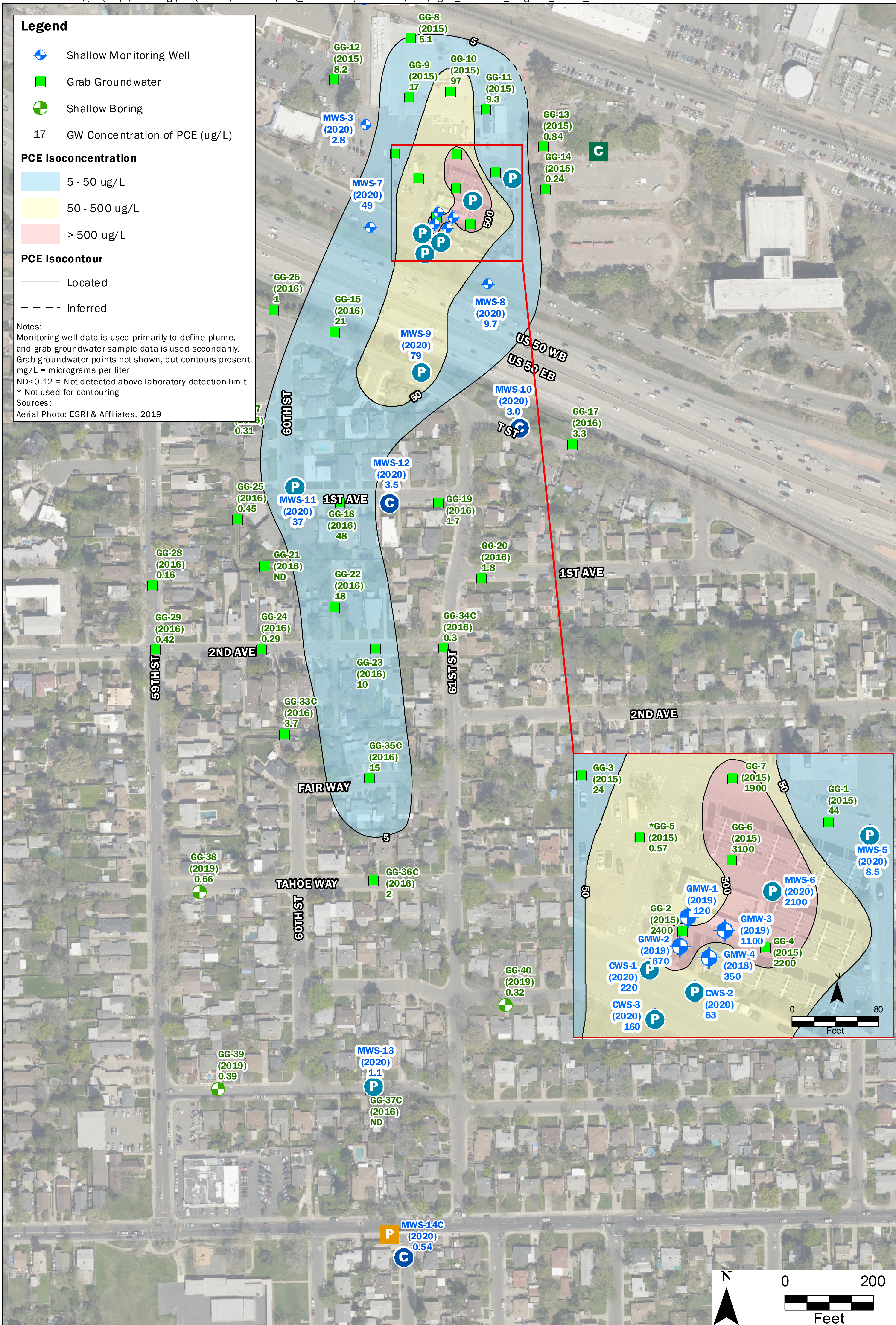
REMEDIAL ACTION WORK PLAN

FORMER COMMUNITY LINEN SITE

Date: OCTOBER 2020
Project: 153479

FIGURE 17
PROPOSED FULL-SCALE GROUNDWATER REMEDIAL APPROACH IN-SITU INJECTION DESIGN TCE SHALLOW GROUNDWATER ISOCONCENTRATION CONTOUR MAP - JUNE 2018

Document Path: \\bc\corp\Modeling\GIS\SMUD\KRAMER\GIS_MAPDOCS\WORKING\RAP\Fig18_Remedial_Progress_11x17_20201019.mxd




Brown AND Caldwell

REMEDIAL ACTION WORK PLAN

FORMER COMMUNITY LINEN SITE

Date: OCTOBER 2020
Project: 153479

0 200
Feet

N

FIGURE 18

REMEDIAL PROGRESS GROUNDWATER MONITORING NETWORK

# Appendix A: Source Area Soil Analytical Data

Table 4-1 SVE Pilot Test Report

**Table 4-1. Detected VOC Concentrations in Soil Samples**

| Sample ID | Sample Date | Sample Time | Sample Depth (feet bgs) | n-Butylbenzene | sec-Butylbenzene | cis-1,2-Dichloroethene | trans-1,2-Dichloroethene | Isopropylbenzene | n-Propylbenzene | Tetrachloroethene | Trichloroethene | 1,2,4-Trimethylbenzene | Vinyl chloride | o-Xylene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg | mg/kg |
| SVE-1D-8 | 6/21/2016 | 1515 | 7-8 | ND | ND | 0.0039 J | ND | ND | ND | 0.022 | 0.0013 J | ND | ND | ND |
| SVE-1D-14 | 6/21/2016 | 1510 | 14-15 | ND | ND | 0.003 J | ND | ND | ND | 0.023 | 0.0013 J | ND | ND | ND |
| SVE-1D-30 | 6/21/2016 | 1525 | 29-30 | ND | ND | 0.74 | 0.011 | ND | ND | 0.14 | 0.14 | ND | 0.036 | ND |
| SVE-2D-13 | 6/27/2016 | 1112 | 13-14 | ND | ND | ND | ND | ND | ND | 0.0072 | ND | ND | ND | ND |
| SVE-2D-29 | 6/27/2016 | 1110 | 29-30 | ND | ND | 0.014 | ND | ND | ND | 0.050 | 0.0034 J | ND | ND | ND |
| SVE-3D-13 | 6/23/2016 | 1020 | 12-13 | ND | ND | 0.096 | 0.0013 J | ND | ND | 0.41 | 0.031 | ND | ND | ND |
| SVE-3D-24 | 6/23/2016 | 1010 | 24-25 | 0.012 | 0.019 | 0.047 | ND | 0.0033 J | ND | 0.069 | 0.078 | ND | 0.0075 | ND |
| SVE-3D-Dup | 6/23/2016 | 1010 | 24-25 | 0.064 | 0.093 | 0.014 | ND | 0.016 | 0.0021 J | 0.063 | 0.042 | 0.12 | 0.0059 | 0.0018 J |
| SVE-4D-13 | 6/23/2016 | 1400 | 12-13 | ND | ND | 0.0072 | ND | ND | ND | 0.086 | 0.0091 | ND | ND | ND |
| SVE-4D-28 | 6/23/2016 | 1350 | 28-29 | ND | ND | 0.059 | 0.0019 J | ND | ND | 0.034 | 0.071 | ND | 0.0095 | ND |
| CHHLs = | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- | 2.80E-02 | 7.40E+02 |
| Commercial ESL = | | | | --- | --- | 9.00E+01 | 7.30E+02 | --- | --- | 2.70E+00 | 8.00E+00 | --- | 1.50E-01 | --- |

*Notes:*

** Only constituents that were detected in samples are shown above*

*ND = not detected above laboratory limits*

*J = detected above laboratory detection limit but below the reporting limit*

***Bold*** *detected above laboratory reporting limit*

*UNDERLINE Exceeds ESL*

*Highlighted ~~Exceeds CHHLs~~*

*Protective of GW, 0.0023 mg/Kg*

*mg/kg = milligram per kilogram*

*bgs = below ground surface*

*CHHL = 2016 California Human Health Screening Levels D = deep*

*Dup = duplicate*

*ESL = 2016 California Environmental screening levels, Water Board, SF Bay Region*

*SVE = soil vapor extraction*

*VOC = volatile organic compound*

# Appendix B: SVE Step Test Data and Soil Vapor Data

Tables 3-1 and 4-1 SVE Pilot Test Report

**Table 3-1. SVE Step Test**

SVE Pilot Test Report, 1800, 1824, and 1826 61st Street, Sacramento, California

| SVE Test Details | | | | | | | | Extraction Wells - Vacuum Applied | | | | | | Monitoring Wells - Passive Monitoring | | | | | | | | | | | | Treatment System Performance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Step No. | Test Well | Approx. Duration (minutes) | Time | Dilution Valve | Vent Well | Notes | SVE-1S (shallow) 13 to 18 feet bgs | | | SVE-1D (deep) 25 to 30 feet bgs | | | SVE-2S 13 to 18 feet bgs | | SVE-2D 25 to 30 feet bgs | | SVE-3S 13 to 18 feet bgs | | SVE-3D 24 to 29 ft bgs | | SVE-4S 12 to 17 feet bgs | | SVE-4D 25 to 30 feet bgs | | GAC (ppm) | | |
| | | | | | | | | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | Inf | Mid | Eff |
| 7/18/2016 | 1 | SVE-1S | 0 | 1220 | Full Open | Closed | -- | 6 | 4.6 | 270.0 | 0.00 | -- | -- | 0.68 | -- | 0.21 | -- | 2.07 | -- | 0.00 | -- | 0.16 | -- | 0.25 | -- | -- | -- | -- |
| | | | 2 | 1222 | 1/4 Closed | Closed | Begin applying vacuum to test well | 14 | 6.6 | 300.3 | 0.00 | -- | -- | 1.14 | -- | 0.00 | -- | 4.68 | -- | 0.00 | -- | 0.28 | -- | 0.13 | -- | -- | -- | -- |
| | | | 13 | 1233 | | | | 14 | 6.9 | 258.0 | 0.00 | -- | -- | 1.59 | -- | 0.11 | -- | 4.83 | -- | 0.00 | -- | 0.34 | -- | 0.11 | -- | -- | -- | -- |
| | | | 23 | 1243 | | | | 14 | 6.96 | 298.0 | 0.00 | -- | -- | 1.62 | -- | 0.10 | -- | 4.87 | -- | 0.00 | -- | 0.35 | -- | 0.10 | -- | -- | -- | -- |
| | 2 | | 0 | 1246 | 1/2 Closed | Closed | -- | 55 | 24.8 | 211.0 | 0.00 | -- | -- | 4.72 | -- | 0.00 | -- | 16.36 | -- | 0.00 | -- | 1.10 | -- | 0.18 | -- | -- | -- | -- |
| | | | 14 | 1300 | | | | 57 | 24.45 | 256.0 | 0.00 | -- | -- | 5.85 | -- | 0.00 | -- | 16.75 | -- | 0.00 | -- | 1.43 | -- | 0.17 | -- | -- | -- | -- |
| | | | 24 | 1310 | | | | 58 | 24.21 | 264.2 | 0.00 | -- | -- | 5.88 | -- | 0.00 | -- | 16.85 | -- | 0.00 | -- | 1.38 | -- | 0.10 | -- | -- | -- | -- |
| | 3 | | 0 | 1320 | 3/4 Closed | Closed | -- | 135 | 51.00 | Cannot draw a sample | 0.00 | -- | -- | 11.02 | -- | 0.00 | -- | 35.53 | -- | 0.00 | -- | 2.62 | -- | 0.09 | -- | -- | -- | -- |
| | | | 24 | 1344 | | | | 125 | 46.64 | | 0.00 | -- | -- | 11.67 | -- | 0.00 | -- | 33.45 | -- | 0.00 | -- | 2.96 | -- | 0.09 | -- | -- | -- | -- |
| | 4 | | 0 | 1350 | Closed | Closed | *1353 shut down and restarted due to breaker tripping | >150 | 64.80 | No sample | 0.00 | -- | -- | 14.80 | -- | 0.00 | -- | -- | -- | 0.00 | -- | -- | -- | -- | -- | -- | -- | -- |
| | | | 15 | 1405 | | | | 136 | 57.88 | 309.7 | 0.00 | -- | -- | 14.32 | -- | 0.00 | -- | 40.97 | -- | 0.00 | -- | 3.48 | -- | 0.10 | -- | -- | -- | -- |
| | | | 30 | 1420 | 3/4 Closed | | *1415 to 1445 3/4 Closed | 136 | 57.86 | 377.7 | 0.00 | -- | -- | 14.36 | -- | 0.00 | -- | 40.63 | -- | 0.00 | -- | 3.55 | -- | 0.09 | -- | -- | -- | -- |
| | | | 35 | 1425 | | | | 136 | 55.37 | 422.0 | 0.00 | -- | -- | 14.63 | -- | 0.00 | -- | 41.10 | -- | 0.00 | -- | 3.64 | -- | 0.00 | -- | -- | -- | -- |
| | | | 55 | 1445 | Closed | | Collected vapor sample SVE-1S at 1505 | 122 | 55.76 | 424.7 | 0.00 | -- | -- | 14.14 | -- | 0.00 | -- | 39.76 | -- | 0.00 | -- | 3.48 | -- | 0.00 | -- | 301 | 26.2 | 0.5 |
| | | | 90 | 1520 | Full Open | Closed | Allow time to reconfigure step test with deep well | 0.00 | -- | -- | 6.50 | -- | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | -- | -- | -- |
| | | | 120 | 1550 | | | | 0.00 | -- | -- | 6.50 | 4.96 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | -- | -- | -- |
| | 5 | SVE-1D | 0 | 1600 | 1/4 Closed | Closed | Begin applying vacuum to test well | 0.00 | -- | -- | 18.00 | 12.90 | 16.8 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 6.8 | 6.6 | 0.2 |
| | | | 15 | 1615 | | | | 0.00 | -- | -- | 18.00 | 12.75 | 5.9 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.11 | -- | -- | -- | -- |
| | | | 30 | 1630 | | | | 0.00 | -- | -- | 18.00 | 11.79 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.11 | -- | -- | -- | -- |
| | 6 | | 0 | 1633 | 1/2 Closed | Closed | -- | 0.00 | -- | -- | 96.00 | 33.83 | 1.2 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.14 | -- | 2.3 | 5.1 | 0.3 |
| | | | 17 | 1650 | | | | 0.00 | -- | -- | 75.00 | 26.33 | 1.0 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.12 | -- | -- | -- | -- |
| | 7 | | 0 | 1700 | 3/4 Closed | Closed | Vacuum pump at 12.5 in Hg max. at 1700 | 0.00 | -- | -- | 136.10 | 41.20 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | -- | -- | -- |
| | | | 20 | 1720 | | | | 0.00 | -- | -- | 136.10 | 41.40 | 1.6 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.26 | -- | 2.3 | 3.0 | 0.3 |
| | | | 40 | 1740 | | | -- | 0.00 | -- | -- | 156.50 | 43.25 | 1.0 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.44 | -- | -- | -- | -- |

**Table 3-1. SVE Step Test**

SVE Pilot Test Report, 1800, 1824, and 1826 61st Street, Sacramento, California

| SVE Test Details | | | | | | | | Extraction Wells - Vacuum Applied | | | | | | Monitoring Wells - Passive Monitoring | | | | | | | | | | | | Treatment System Performance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step No. | | Test Well | Approx. Duration (minutes) | Time | Dilution Valve | Vent Well | Notes | SVE-1S (shallow) 13 to 18 feet bgs | | | SVE-1D (deep) 25 to 30 feet bgs | | | SVE-2S 13 to 18 feet bgs | | SVE-2D 25 to 30 feet bgs | | SVE-3S 13 to 18 feet bgs | | SVE-3D 24 to 29 ft bgs | | SVE-4S 12 to 17 feet bgs | | SVE-4D 25 to 30 feet bgs | | GAC (ppm) | | |
| | | | | | | | | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | Inf | Mid | Eff |
| | 8 | | 0 | 1750 | Closed | Almost Fully Closed | Vacuum pump at 15.0 in Hg at beginning of test | 0.00 | -- | -- | 183.72 | 44.25 | 1.0 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.55 | -- | 5.7 | 1.2 | 0.5 |
| | | | 30 | 1820 | | | -- | 0.00 | -- | -- | 176.91 | 46.11 | 2.0 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.88 | -- | 9.4 | 2.1 | 0.7 |
| | | | 50 | 1840 | | | Collected vapor sample SVE-1D @ 1845 | 0.00 | -- | -- | 187.80 | 42.53 | 0.9 | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 0.00 | -- | 1.00 | -- | -- | -- | -- |
| 7/19/2016 | 9 | SVE-1S | 0 | 910 | 1/2 Closed | SVE-2S | Prior to test, allow time to reconfigure step test while venting (full open dilution valve and closed vent well) | 50.00 | 22.15 | 412.0 | -- | -- | -- | -- | 1.96 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | -- | -- |
| | | | 30 | 920 | | | | 51.00 | 20.80 | 412.7 | -- | -- | -- | -- | 2.12 | -- | | -- | | -- | | -- | | -- | | 70.4 | 13.3 | 5.1 |
| | | | 60 | 930 | | | | 52.00 to 53.00 | 28.85 | 421.1 | -- | -- | -- | -- | 1.93 | -- | | -- | | -- | | -- | | -- | | -- | -- | -- |
| | 10 | | 0 | 935 | 1/2 Closed | SVE-4S | -- | 51.00 to 52.00 | 20.10 | 485.0 | -- | -- | -- | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 3.02 | -- | Closed | 77.2 | 55.0 | 5.0 |
| | | | 10 | 945 | | | | 51.00 | 20.25 | 506.8 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | 2.60 | -- | | -- | -- | -- |
| | | | 15 | 950 | | | | 52.00 | 20.15 | 497.8 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | 2.30 | -- | | 76.8 | 5.2 | 4.5 |
| | 11 | | 0 | 1000 | 1/2 Closed | SVE-2D | -- | 51.00 | 19.90 | 465.9 | -- | -- | -- | -- | Closed | -- | 0.027 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | -- | -- |
| | | | 10 | 1010 | | | | 50.00 | 19.45 | 493.0 | -- | -- | -- | -- | | -- | 0.011 | -- | | -- | | -- | | -- | | -- | -- | -- |
| | | | 20 | 1020 | | | | 51.00 | 19.50 | 490.0 | -- | -- | -- | -- | | -- | 0.010 | -- | | -- | | -- | | -- | | 79.6 | 4.8 | 4.2 |
| | | | 28 | 1028 | | | | 51.00 | 19.80 | 499.2 | -- | -- | -- | -- | | -- | 0.0055 / 0.0000 | -- | | -- | | -- | | -- | | -- | -- | -- |
| | 12 | | 0 | 1035 | 1/2 Closed | SVE-4D | -- | 51.00 | 19.40 | 455.0 | -- | -- | -- | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 0.0100 | -- | -- | -- |
| | | | 5 | 1040 | | | | 50.00 | 19.30 | -- | -- | -- | -- | -- | | -- | | -- | | -- | | -- | | -- | 0.0055 / 0.0000 | 81.8 | 5.3 | 4.7 |
| | | | 15 | 1050 | | | _ | 51.00 | 19.48 | 446.3 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | | -- | 0.0055 / 0.0000 | -- | -- | -- |
| | 13 | | 0 | 1115 | Closed | SVE-2S | Vacuum on 0-150 magnehelic gauge is off scale as noted after step testing 12 at 1115 | 149.70 | 64.05 | 70.3 | -- | -- | -- | -- | 5.10 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | -- | -- |
| | | | 10 | 1125 | | | | 156.50 | 64.00 | 91.7 | -- | -- | -- | -- | 5.10 | -- | | 44.20 | | 3.44 | | -- | | -- | | 445.2 | 1.8 | 1.7 |
| | | | 20 | 1135 | | | | 156.50 | 64.12 | -- | -- | -- | -- | -- | 4.97 | -- | | -- | | -- | | -- | | -- | | -- | -- | -- |
| | | | 30 | 1145 | | | | 156.50 | 64.20 | 351.7 | -- | -- | -- | -- | 4.72 | -- | | -- | | -- | | -- | | -- | | 26.2 | 18.4 | 10.6 |

**Table 3-1. SVE Step Test**

SVE Pilot Test Report, 1800, 1824, and 1826 61st Street, Sacramento, California

| SVE Test Details | | | | | | | Extraction Wells - Vacuum Applied | | | | | | Monitoring Wells - Passive Monitoring | | | | | | | | | | | | Treatment System Performance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step No. | Test Well | Approx. Duration (minutes) | Time | Dilution Valve | Vent Well | Notes | SVE-1S (shallow) 13 to 18 feet bgs | | | SVE-1D (deep) 25 to 30 feet bgs | | | SVE-2S 13 to 18 feet bgs | | SVE-2D 25 to 30 feet bgs | | SVE-3S 13 to 18 feet bgs | | SVE-3D 24 to 29 ft bgs | | SVE-4S 12 to 17 feet bgs | | SVE-4D 25 to 30 feet bgs | | GAC (ppm) | | |
| | | | | | | | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | Inf | Mid | Eff |
| 14 | | 0 | 1150 | Closed | SVE-4S | -- | 156.50 | 63.00 | 357.2 | -- | -- | -- | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 7.60 | -- | Closed | -- | -- | -- |
| | | 10 | 1200 | | | | 161.94 | 64.32 | 145.3 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | 6.80 | -- | | 490.2 | 4.2 | 3.7 |
| | | 25 | 1215 | | | | 156.50 | 62.60 | 275.1 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | 6.95 | -- | | -- | -- | -- |
| | | 35 | 1225 | | | | 156.50 | 62.55 | -- | -- | -- | -- | -- | | -- | | -- | | -- | | -- | 6.50 | -- | | -- | -- | -- |
| 15 | | 0 | 1230 | Closed | SVE-2D | -- | 156.50 | 62.43 | 219.1 | -- | -- | -- | -- | Closed | -- | 0.0109 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | -- | -- |
| | | 15 | 1245 | | | | 156.50 | 62.46 | 327.0 | -- | -- | -- | -- | | -- | 0.0164 | -- | | -- | | -- | | -- | | 319 | 12.1 | 7.3 |
| | | 25 | 1255 | | | | 156.50 | 63.08 | 266.0 | -- | -- | -- | -- | | -- | 0.0055 / 0.0000 | -- | | -- | | -- | | -- | | -- | -- | -- |
| 16 | | 0 | 1305 | Closed | SVE-4D | -- | 156.50 | 62.10 | 239.0 | -- | -- | -- | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 0.0055 | -- | -- | -- |
| | | 10 | 1315 | | | | 156.50 | 61.53 | 165.7 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | | -- | 0.0055 / 0.0000 | -- | -- | -- |
| | | 20 | 1325 | | | | 156.50 | 61.75 | 62.5 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | | -- | 0.0055 / 0.0109 | 361.7 | 3.9 | 3.2 |
| | | 30 | 1335 | | | | 156.50 | 62.08 | 108.1 | -- | -- | -- | -- | | -- | | -- | | -- | | -- | | -- | 0.0055 / 0.0000 | -- | -- | -- |
| 17 | SVE-1D | 0 | 1400 | 1/2 Closed | SVE-2S | Prior to test, allow time to reconfigure step test while venting (full open dilution valve and closed vent well) | -- | -- | -- | 53.00 | 15.07 | 28.1 | -- | 0.0000 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | -- | -- |
| | | 10 | 1410 | | | | -- | -- | -- | 52.00 | 14.98 | 25.6 | -- | 0..0000 | -- | | -- | | -- | | -- | | -- | | 58.2 | 3.0 | 1.1 |
| | | 20 | 1420 | | | | -- | -- | -- | 53.00 | 16.60 | 36.8 | -- | 0.0000 | -- | | -- | | -- | | -- | | -- | | -- | -- | -- |
| 18 | | 0 | 1425 | 1/2 Closed | SVE-4S | -- | -- | -- | -- | 53.00 | 16.67 | 36.0 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 0.0710 | -- | Closed | -- | -- | -- |
| | | 10 | 1435 | | | | -- | -- | -- | 53.00 | 17.05 | 32.9 | -- | | -- | | -- | | -- | | -- | 0.0765 | -- | | 6.1 | 1.9 | 0.9 |
| | | 20 | 1445 | | | | -- | -- | -- | 53.00 | 21.46 | 34.5 | -- | | -- | | -- | | -- | | -- | 0.0218 | -- | | -- | -- | -- |
| | | 30 | 1455 | | | | -- | -- | -- | 53.00 | 22.28 | 33.5 | -- | | -- | | -- | | -- | | -- | 0.0273 | -- | | -- | -- | -- |
| 19 | | 0 | 1505 | 1/2 Closed | SVE-2D | -- | -- | -- | -- | 53.00 | 17.50 | 35.5 | -- | Closed | -- | 0.0000 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | -- | -- |
| | | 10 | 1515 | | | | -- | -- | -- | 52.00 | 16.90 | 36.5 | -- | | -- | 0.0000 | -- | | -- | | -- | | -- | | 5.0 | 2.2 | 1.1 |
| | | 20 | 1525 | | | | -- | -- | -- | 53.00 | 16.75 | -- | -- | | -- | 0.0000 | -- | | -- | | -- | | -- | | -- | -- | -- |
| 20 | | 0 | 1530 | 1/2 Closed | SVE-4D | -- | -- | -- | -- | 53.00 | 16.64 | 40.8 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 0.0000 | -- | -- | -- |

**Table 3-1. SVE Step Test**

SVE Pilot Test Report, 1800, 1824, and 1826 61st Street, Sacramento, California

| SVE Test Details | | | | | | | Extraction Wells - Vacuum Applied | | | | | | Monitoring Wells - Passive Monitoring | | | | | | | | | | | | Treatment System Performance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Step No. | Test Well | Approx. Duration (minutes) | Time | Dilution Valve | Vent Well | Notes | SVE-1S (shallow) 13 to 18 feet bgs | | | SVE-1D (deep) 25 to 30 feet bgs | | | SVE-2S 13 to 18 feet bgs | | SVE-2D 25 to 30 feet bgs | | SVE-3S 13 to 18 feet bgs | | SVE-3D 24 to 29 ft bgs | | SVE-4S 12 to 17 feet bgs | | SVE-4D 25 to 30 feet bgs | | GAC (ppm) | | |
| | | | | | | | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | PID (ppm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | V (in-WC) | Q (scfm) | Inf | Mid | Eff |
| | | 10 | 1540 | | | | -- | -- | -- | 53.00 | 17.06 | 41.1 | -- | | -- | | -- | | -- | | -- | | -- | 0.0000 | 3.6 | 1.9 | 1.2 |
| | | 20 | 1550 | | | -- | -- | -- | -- | 54.00 | 17.33 | 41.9 | -- | | -- | | -- | | -- | | -- | | -- | 0.0000 | -- | -- | -- |
| | | 0 | 1600 | | | | -- | -- | -- | 176.91 | 29.90 | 5.0 | -- | 0.0000 | -- | | -- | | -- | | -- | | -- | | -- | -- | -- |
| 21 | | 10 | 1610 | Closed | SVE-2S | -- | -- | -- | -- | 176.91 | 30.63 | -- | -- | 0.0000 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | 7.0 | -- | 1.0 |
| | | 20 | 1620 | | | | -- | -- | -- | 176.91 | 30.49 | 2.6 | -- | 0.0000 | -- | | -- | | -- | | -- | | -- | | -- | -- | -- |
| | | 30 | 1630 | | | | -- | -- | -- | 176.91 | 30.30 | -- | -- | 0.0000 | -- | | -- | | -- | | -- | | -- | | -- | -- | -- |
| | | 0 | 1635 | | | -- | -- | -- | -- | 176.91 | 30.40 | 1.6 | -- | | -- | | -- | | -- | | -- | 0.0164 | -- | | -- | -- | -- |
| 22 | | 10 | 1645 | Closed | SVE-4S | | -- | -- | -- | 176.91 | 30.80 | 1.7 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 0.0055 | -- | Closed | -- | -- | -- |
| | | 20 | 1655 | | | -- | -- | -- | -- | 163.30 | 30.02 | 1.0 | -- | | -- | | -- | | -- | | -- | 0.0109 | -- | | -- | -- | -- |
| | | 0 | 1710 | | | | -- | -- | -- | 176.91 | 30.88 | 1.5 | -- | | -- | 0.0000 | -- | | -- | | -- | | -- | | -- | -- | -- |
| 23 | | 10 | 1720 | Closed | SVE-2D | -- | -- | -- | -- | 176.91 | 29.72 | 1.1 | -- | Closed | -- | 0.0000 | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | -- | -- |
| | | 20 | 1730 | | | | -- | -- | -- | 176.91 | 30.28 | 1.4 | -- | | -- | 0.0000 | -- | | -- | | -- | | -- | | -- | -- | -- |
| | | 0 | 1740 | | | | -- | -- | -- | 176.91 | 31.30 | 1.2 | -- | | -- | | -- | | -- | | -- | | -- | 0.0000 | -- | -- | -- |
| | | 10 | 1750 | | | -- | -- | -- | -- | 176.91 | 31.11 | 1.2 | -- | | -- | | -- | | -- | | -- | | -- | 0.0000 | -- | -- | -- |
| 24 | | 20 | 1800 | Closed | SVE-4D | | -- | -- | -- | 176.91 | 29.82 | -- | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | Closed | -- | 0.0000 | -- | -- | -- |
| | | 25 | 1805 | | | | -- | -- | -- | 176.91 | 30.25 | -- | -- | | -- | | -- | | -- | | -- | | -- | -- | -- | -- | -- |
| | | 30 | 1810 | | | Shut Down System | -- | -- | -- | 176.91 | -- | -- | -- | | -- | | -- | | -- | | -- | | -- | -- | -- | -- | -- |

*Notes:*

*Measurements of flow and vacuum were made with VelociCalc Plus flow meters and a Dwyer Series 475 Mark III digital manometer, respectively. Several Magnehelic Series 2000 differential vacuum gauges were used to check digital manometer measurements. Vacuum was applied to extraction wells using a trailer mounted soil vapor extraction system (Model 250 CFM MKVES MV) equipped with a 10 hp motor, 250 SCFM rotary lobe blower/vacuum Dresser/Roots pump, a liquid separator tank and control system. Monitoring wells used for venting and extraction wells used for dilution as noted.*

*-- = not applicable; data not available*
*> = greater than*
*Approx. = approximate*
*bgs = below ground surface*
*D = deep*
*Eff = effluent*
*Extract. = extraction*
*GAC = granular activated carbon*
*Inf = influent*
*in Hg = inches of mercury*
*in-WC = inches of water column*
*max. = maximum*
*Mid = middle*
*No. = Number*
*PID = photoionization detector*
*ppm = parts per million*
*Q = flow rate*
*S = shallow*
*scfm = standard cubic feet per minute*
*V = vacuum*

**Table 4-2. Detected VOC Concentrations in Soil Vapor**

SVE Wells

| Sample Date | Time | Well ID | Acetone | Chloroform | cis-1,2-DCE | trans-1,2-DCE | PCE | TCE | Vinyl Chloride |
|---|---|---|---|---|---|---|---|---|---|
| 7/18/2016 | 1505 | SVE-1S | 620 | 49 J | 4,200 | 64 J | 160,000 | 3,700 | 120 |
| 7/18/2016 | 1845 | SVE-1D | 930 | ND | 2,800 | 67 | 6,200 | 1,800 | 300 |

GAC

| Sample Date | Time | GAC ID | Acetone | Dichloro-difluoromethane | cis-1,2-DCE | trans-1,2-DCE | 1,2-Dichloro-1,1,2,2-tetrafluoroethane | Styrene | PCE | TCE | Toluene | Vinyl Chloride |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/20/2016 | 1720 | GAC-Inf | **2,800** | **69 J** | **1,700** | ND | ND | ND | **110,000** | **2,500** | **210** | **140 J** |
| 7/20/2016 | 1725 | GAC-Inf-1 | **2,800** | ND | **2,200** | **60 J** | ND | ND | **140,000** | **3,400** | ND | **180** |
| 7/20/2016 | 1730 | GAC-Mid | **1,100** | **80** | **240** | ND | **33 J** | **33 J** | **3,600** | **170** | ND | **150** |
| 7/20/2016 | 1735 | GAC-Eff | ND | ND | ND | ND | ND | ND | **8** | ND | ND | ND |
| 7/21/2016 | 1710 | GAC-Inf | **1,300** | ND | **2,100** | **62 J** | ND | **30 J** | **90,000** | **3,800** | **39 J** | **110** |
| 7/21/2016 | 1706 | GAC-Mid | **1,900** | ND | **170** | ND | ND | ND | **5,300** | **220** | ND | **240** |
| 7/21/2016 | 1712 | GAC-Eff | **2,000** | ND | ND | ND | ND | ND | **670** | ND | ND | **190** |
| 7/22/2016 | 1457 | GAC-Inf | **2,400** | ND | **1,000** | ND | ND | ND | **49,000** | **1,800** | ND | ND |
| 7/22/2016 | 1458 | GAC-Mid | **2,000** | ND | **320** | ND | ND | ND | **12,000** | **490** | ND | **210** |
| 7/22/2016 | 1500 | GAC-Eff | **2,300** | ND | ND | ND | ND | ND | **390** | ND | ND | **240** |

*Notes:*

*Results are reported in parts per billion by volume*

*Constituents like Dichlorodifluoromethane and 1,2-Dichloro-1,1,2,2-tetrafluoroethane are likely from the GAC unit and not representative on actual site*

** = Only constituents that were detected in samples are shown above.*

***Bold** = detected above laboratory reporting limits*

*D = deep*

*DCE = dichloroethylene*

*Eff = effluent*

*GAC = granular activated carbon*

*Inf = influent*

*J = detected above laboratory detection limit but below the reporting limit*

*Mid = middle*

*ND = not detected above laboratory limits*

*PCE = tetrachloroethylene*

*S = shallow*

*SVE = soil vapor extraction*

*TCE = trichloroethylene*

*VOC = volatile organic compound*

# Appendix C: SVE Design Calculations

**SMUD Kramer Site - SVE Remedy**
**Source Area SVE System**
**Design Calculations**

SVE Pilot Test Results
See Attached Graph

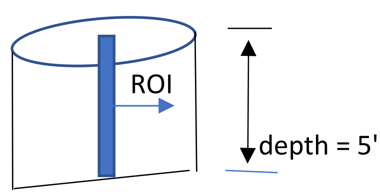
| | |
|---|---|
| 50 cfm/well | 100 ft ROI w/ vacuum > 0.1 inches of water column |
| 25 cfm/well | 90 ft ROI w/ vacuum > 0.1" w.c. |
| 25 cfm/well | 50 ft ROI w/ vacuum > 1.0" w.c. |
| 8 cfm/well | 50 ft ROI w/ vacuum > 0.1" w.c. |

Design Criteria: US Army Corps of Engineers, Engineering and Desing of
Soil Vapor Extraction and Bioventing, Engineering Manual
June 2002

| | |
|---|---|
| Min. air flow velocity at outer extent of ROI | V > 3 to 30 ft/day |
| Maximum travel time from outer extent to extraction well | t < 2 days |
| This is equivalent to time to remove one (1) Pore Volume | |
| Air Exchange Rate | ~ 500 PVs/year |
| Exchanges to Achieve Cleanup | 1,000 to 5,000 PVs |

Site specific. Goes up with higher initial concentrations and lower cleanup goals.
Kramer site has both of these.

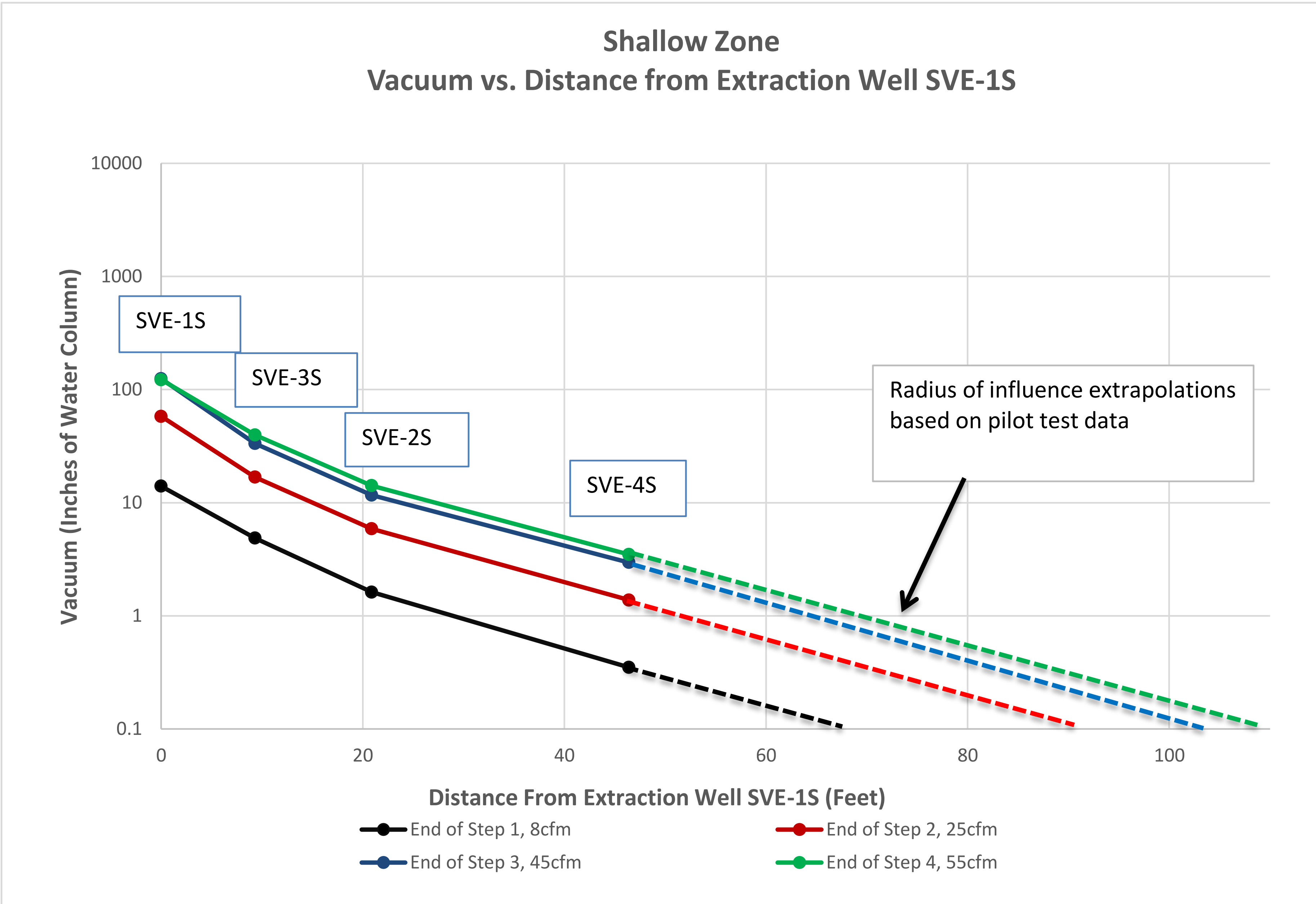
Calculation




Soil Porosity = 0.3 assumed value

Pore Volume = $PI*R^2*d*0.3$
Perimeter Area = 2*PI*R*d* 0.3
Travel Time = Time to Remove One PV = PV/Flow Rate
Minimum Air Flow Velocity = Flow Rate / PA

| Q (cfm) | R (ft) | d (ft) | p | Air Flow Velocity (ft/min) | Air Flow Velocity (ft/day) | Travel Time (minutes) | Travel Time (days) | Exchanges per Yr |
|---|---|---|---|---|---|---|---|---|
| 8 | 50 | 5 | 0.3 | 0.0170 | 24.4 | 1473 | 1.023 | 357 |
| 25 | 50 | 5 | 0.3 | 0.0531 | 76.4 | 471 | 0.327 | 1115 |
| 25 | 90 | 5 | 0.3 | 0.0295 | 42.4 | 1527 | 1.060 | 344 |
| 50 | 50 | 5 | 0.3 | 0.1061 | 152.8 | 236 | 0.164 | 2231 |
| 50 | 100 | 5 | 0.3 | 0.0531 | 76.4 | 942 | 0.654 | 558 |



Shallow Zone
Vacuum vs. Distance from Extraction Well SVE-1S
10000
1000
100
10
1
0.1
0
20
40
60
80
100
Vacuum (Inches of Water Column)
Distance From Extraction Well SVE-1S (Feet)
SVE-1S
SVE-3S
SVE-2S
SVE-4S
Radius of influence extrapolations based on pilot test data
End of Step 1, 8cfm
End of Step 2, 25cfm
End of Step 3, 45cfm
End of Step 4, 55cfm

(3) The design strategy for SVE systems is to promote the release of volatile compounds from the soil, NAPL, and water film covering the unsaturated soil so that they can be carried advectively under the influence of an applied vacuum to the surface for collection and treatment. For BV systems, the air movement provides a source of oxygen to diffuse into the water film, which promotes aerobic biodegradation of the contaminants dissolved in the water phase. In the subsurface, sufficient air movement is required to match the liberation rate from the soil and the microbial needs for oxygen.

(4) In an ideal SVE design, the rate of transfer of volatile contaminants from the soil and water into the soil air would match the rate of air movement to the surface, so contaminants in the air stream would remain as concentrated as possible. In practice, maximum contaminant concentrations occur shortly after start-up of the system, then decline from this concentration with time (unless there is an ongoing release). It is usually easy to provide a vacuum extraction system that will remove the existing contaminant vapors very quickly; but over time, due to diffusion or other constraints, the rate at which volatiles are removed from other "compartments" in the subsurface becomes increasingly independent of advection and increasingly dependent on diffusion, desorption, and other transport processes (paragraph 2-3*a*).

(5) The expected rate of transfer of volatile contaminants from the soil and water into the soil air needs to be considered prior to initiating the design of the subsurface venting system. Figure 5-2 presents a decision tree that outlines steps involved in carrying out these considerations. It should be noted that many of these steps may already have been considered during technology screening, but they need to be looked at again at the beginning of design so that new information (e.g., from laboratory- and/or pilot-scale testing) can be incorporated into the design process. Note that the process begins by reconsidering remedial goals relative to initial contaminant concentrations and the time available for cleanup. Next, the approximate number of pore volume exchanges required to achieve remedial goals within the available time frame, in the absence of mass transfer limitations, need to be selected. (The concepts of pore volume exchange rate and its reciprocal travel time, were introduced in paragraphs 4-5*f* (20) to (21). The required number of pore volume exchanges, divided by the available cleanup time, equals the limiting pore volume exchange rate.) There is a lack of agreement as to the total number of pore volume exchanges required for SVE. Some experts recommend as few as 200 to 400; others 2,000 to 5,000. Experience with similar sites and contaminants, column tests, or prolonged pilot tests have been suggested as predictive tools to estimate the required number of pore volume exchanges for a given site. Unless target cleanup goals are low or initial concentrations are very high, 1,000 to 1,500 pore volumes would be a good estimate of the required air exchanges. If the air exchange rates are too high, the removal of mass will be limited by diffusion kinetics. For BV, recommended pore volume exchange rates to meet microbial oxygen demand range from 1/4 to 1/2 $d^{-1}$. In other words, it is desirable to achieve pore-gas velocities in the treatment zone such that the maximum travel time is between 2 and 4 days from the edge of the treatment zone (where air contains high percentages of oxygen) to the extraction or injection wells. As discussed in section 5-3a(2), average pore-gas velocity is an alternate design criterion for developing an SVE/BV design. Current SVE research indicates that it is desirable to achieve pore-gas velocities throughout the treatment zone in excess of 0.001 cm/sec, or ~ 3 ft/day (DiGiulio and Ravi 1999). If performance specifications are to be used, the vacuums required at specific distances from the vent wells must be consistent with pressure gradients that yield adequate travel times or velocities. In summary, with either SVE or BV, potential rate limitations need to be reconsidered at this time, either quantitatively or qualitatively (Figure 5-2). Methods of doing so are described in the following four paragraphs.