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DIVISION
Environmental Services

Via email and certified mail
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January 10, 2014

Mr. Jacinto Soto
Project Manager, Brownfields and Environmental Restoration Program
Department of Toxic Substances Control
700 Heinz Ave., Suite 200
Berkeley, CA 94710-2737

Subject: Response to DTSC Comments on the Interim Corrective Measures Report for Controlling Migration of Contaminated Groundwater at the Former Building 51 Bevatron Site

Dear Mr. Soto:

The purpose of this letter is to respond to comments provided in your letter dated January 9, 2014 regarding the *Lawrence Berkeley National Laboratory (LBNL) Interim Corrective Measures (ICM) Report for Controlling Migration of Contaminated Groundwater at the Former Building 51 Bevatron Site*, dated October 2013. Your comments and LBNL's responses are provided below.

COMMENTS

Section 5.0, System Operation and Maintenance - Please provide a table summarizing the treatment system VOC mass removal rates per month as well as a cumulative total for the former Building 51 Bevatron site. The report should include a schedule of any upcoming (planned) work on the ICM groundwater extraction and treatment system and an estimate as to how long the system will be operated.

RESPONSE

VOC removal rates. The report has been revised to include a table in Section 5 (Table 1, page 19) that summarizes the monthly treatment system volatile organic compound (VOC) mass removal rates for the five months since the ICM was implemented (August through December 2013) as well as the cumulative VOC mass removed for the former Building 51 Bevatron site. As shown in the table, an estimated 30 grams of VOC mass have been removed from the groundwater since the start of the ICM. It should be noted that the purpose of the ICM is not to remove contaminant mass, but to control the migration of contaminated groundwater.

Planned work/system operation. There is no upcoming (planned) work on the ICM groundwater extraction and treatment system. The system will continue to operate until either the migration of contaminated groundwater is no longer a concern or a final corrective measure has been approved and implemented. The treatment system is a component of the DTSC-approved corrective measure for the Building 51/64 groundwater solvent plume and will continue to operate as such until the required Media

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Cleanup Standards (MCSs) for the Building 51/64 groundwater solvent plume are attained or until DTSC approves termination of the measure.

All of the information in this response has been incorporated into Section 5 of the attached revised ICM report. Please contact David Baskin (dabaskin@lbl.gov) at 510-486-5684 or me (ropauer@lbl.gov) at 510-486-7614 if you have any questions or require additional information.

Sincerely,

Ron Pauer
Environmental Manager

enclosure:

Interim Corrective Measures (ICM) Report for Controlling Migration of Contaminated Groundwater at the Former Building 51 Bevatron Site, January 2014

cc via email w/enclosure:

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INTERIM CORRECTIVE MEASURES REPORT

FOR CONTROLLING THE MIGRATION OF CONTAMINATED GROUNDWATER AT THE FORMER BUILDING 51 BEVATRON SITE

January 2014

Prepared by
Lawrence Berkeley National Laboratory
Environment / Health / Safety Division
Environmental Services Group
Environmental Restoration Program

This work was done at the Lawrence Berkeley National Laboratory, which is operated by the University of California for the U. S. Department of Energy under contract DE-AC02-05CH11231.

INTERIM CORRECTIVE MEASURES REPORT

For Controlling the Migration of Contaminated Groundwater at the Former Building 51 Bevatron Site

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Ron Pauer
LBNL Environmental Services Group Manager

Contents

List of Abbreviations

Bgs	below ground surface
Cal/EPA	California Environmental Protection Agency
CAP	Corrective Action Program
CHHSLs	California Human Health Screening Levels
DCA	Dichloroethane
DCE	Dichloroethene
DTSC	Cal-EPA Department of Toxic Substances Control
DWR	Department of Water Resources
DNAPL	Dense Non-Aqueous Phase Liquid
ERP	Environmental Restoration Program
ESL	Environmental Screening Level
GAC	Granular Activated Carbon
gpm	gallons per minute
LBNL	Lawrence Berkeley National Laboratory
ICM	Interim Corrective Measure
mg/kg	milligrams per kilogram
µg/L	micrograms per liter (10^{-6} grams per liter)
MIP	Membrane Interface Probe
msl	mean sea level
PCE	Tetrachloroethylene (Perchloroethene)
PID	Photoionization Detector
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RPM	Remedial Project Manager (meeting)
TCA	Trichloroethane
TCE	Trichloroethylene
VOCs	Volatile Organic Compounds
Water Board	San Francisco Bay Region of the Regional Water Quality Control Board

1.0 Introduction

1.1 Purpose and Scope

In April 2012, Lawrence Berkeley National Laboratory (LBNL) submitted a draft Interim Corrective Measure (ICM) workplan to the California Environmental Protection Agency Department of Toxic Substances Control (DTSC). The purpose of the workplan was to provide the rationale and establish the requirements for constructing and operating an ICM to control the migration of contaminated groundwater at the Bevatron Project demolition site.

On July 3, 2012, DTSC provided comments on the draft workplan that included a requirement that the workplan specify submittal of an ICM Report documenting the nature of the threat/contamination, the action taken, and the success in mitigating the threat. The workplan was revised to address DTSC's comments and resubmitted to DTSC on August 15, 2012 (LBNL, 2013). The revised workplan included the requirement that within 60 days following completion of ICM construction, LBNL would submit an ICM Report to the DTSC, which would provide the following information:

1. A summary of the nature of the threat
2. A description of the ICM as constructed, including as-built drawings
3. Results of any operational testing and/or monitoring indicating the estimated effectiveness of the system

This report has been prepared to comply with these requirements.

1.2 Background

LBNL Building 51, which housed the Bevatron, occupied approximately 2.25 acres in the west-central part of the LBNL main site. During its operation from 1954 until 1993, the Bevatron was among the world's leading particle accelerators. The Building 51 and Bevatron Demolition Project, which began in 2010, consisted of the demolition, deactivation, and disposal of the Building 51 structure and contents, including the shallow foundations, shield blocks, and the Bevatron accelerator housed within the building. Following demolition, the site was backfilled to grade with clean soil. These activities were completed in February 2012. Except for a limited area where the Vacuum Pump Room was located, the project area has been paved to provide parking.

The demolition project area is primarily referred to as Building 51 in this report, but is also referred to as the Bevatron Complex or simply as the Bevatron. The former location of the Bevatron is shown on Figure 1, which is an aerial photograph of the building area prior to demolition.

Between September 2010 and April 2011, LBNL conducted a preliminary investigation of potential subsurface contamination beneath the Building 51 demolition project area. This investigation was conducted in accordance with LBNL's standard practice of evaluating the potential presence of subsurface contamination at demolition/construction sites as part of a due diligence process. Requirements for the preliminary investigation were specified in the *Workplan for Initial Characterization of Subsurface Contamination - Demolition of Building 51 and the Bevatron* (LBNL, 2010). This workplan was provided to the DTSC, the Regional Water Quality Control Board (Water Board), and the City of Berkeley at a Remedial Project Managers (RPM) meeting held at the DTSC's Berkeley office on November 5, 2010.

During this preliminary Bevatron investigation, relatively high concentrations of volatile organic compounds (VOCs) were detected in the soil and groundwater under the Building 51 Vacuum Pump Room. In accordance with reporting requirements specified in LBNL's Hazardous Waste Handling Facility Permit, LBNL notified DTSC of this finding on June 6, 2011 by email and by telephone on June 7, 2011. Follow-up measurements of groundwater levels and VOC concentrations indicated that there was an imminent threat to the environment resulting from the migration of contaminated groundwater from the Vacuum Pump Room area into the clean backfill that had recently been placed in the Bevatron Air Duct shafts. LBNL therefore met with DTSC on August 16, 2011 to provide an update on the status of Building 51 investigations and submitted a workplan that included implementing an ICM to control contaminant migration.

1.3 ICM Chronology

A detailed chronology of the Building 51 Vacuum Pump Room investigations and ICM is provided in the following table.

Chronology of Building 51 Vacuum Pump Room Investigation and ICM[a]

June 6, 2011	LBNL receives analytical results showing relatively high concentrations of VOCs in the groundwater beneath the Vacuum Pump Room area. This finding is reported to DTSC by email.
June 7, 2011	LBNL follows up the June 6 email with telephone call to DTSC.
Aug 16, 2011	LBNL meets with DTSC to provide an update on the status of the Building 51 investigations and submits a workplan for investigation of the Vacuum Pump Room area and ICM.
Aug 25, 2011	DTSC requires ICM workplan to be submitted as a separate document.
Sept 8, 2011	LBNL submits a workplan for investigation of the Vacuum Pump Room area to DTSC.
Sept 22, 2011	DTSC provides comments on the workplan at a meeting in DTSC offices.
Oct 6, 2011	LBNL submits a revised workplan for investigation of the Vacuum Pump Room Area to DTSC (LBNL, 2011a).
Oct 10, 2011	DTSC approves the workplan for investigation of the Vacuum Pump Room area (DTSC, 2011).
Jan 24, 2012	LBNL submits a letter report to DTSC - *Status and Pending Tasks in Building 51A Area.*
Mar 14, 2012	LBNL submits a report to DTSC requesting approval for an ICM to control the migration of contaminated groundwater in the Vacuum Pump Room area (LBNL, 2012a).
Mar 27, 2012	DTSC requests a more detailed ICM workplan at a meeting in the DTSC offices.
April 18, 2012	LBNL submits detailed draft ICM workplan.
April 27, 2012	LBNL submits the report of investigation of Building 51A and Vacuum Pump Room areas to DTSC.
July 3, 2012	DTSC provides comments on both the draft ICM workplan and the Report of Environmental Investigations in Building 51A and Vacuum Pump Room areas.
Aug 6, 2012	LBNL submits a revised report of investigations of the Building 51A and Vacuum Pump Room areas to DTSC (LBNL, 2012b).
Aug 15, 2012	LBNL submits revised ICM workplan responding to DTSC comments (Berkley Lab, 2013).
Sept 18, 2012	DTSC approves the report of investigations of Building 51A and Vacuum Pump Room areas.
April 23, 2013	DTSC approves the draft ICM workplan.
May 1, 2013	LBNL, on behalf of the DTSC, distributes Community Notice of 30-day public comment period on the ICM workplan and Tiered Negative Declaration beginning on May 7, 2013.
July 2, 2013	DTSC prepares Responsiveness Summary addressing comments received during the public comment period.
July 12, 2013	LBNL submits the DTSC-approved *Final Interim Corrective Measures Workplan to Control the Migration of Contaminated Groundwater at the Bevatron Demolition Project Site* to the DTSC. The final document includes the draft ICM workplan, the Addendum to the Tiered Negative Declaration, and the DTSC Responsiveness Summary.
July 15, 2013	LBNL provides a presentation on the ICM at a Community Advisory Group (CAG) meeting in Berkeley.
July 29, 2013	ICM implementation starts (begin pumping from observation well OC51-11-1).
Aug 21, 2013	Groundwater extraction well EW51-13-1 installed in former Vacuum Pump Room.
Aug 28, 2013	ICM implementation completed. Groundwater extraction is started from groundwater extraction well EW51-13-1.

(a) LBNL reports are available online at http://www.lbl.gov/ehs/erp/html/documents.shtml, at the LBNL Information Repository at the Berkeley Public Library main branch; and at the DTSC Information Repository at 700 Heinz Street in Berkeley.

2.0 ICM Site Setting

2.1 Facility Description

The Bevatron was constructed inside Building 51 in 1950 and ceased operation in 1993. It was a large, weak-focusing synchrotron accelerator used for conducting experiments in nuclear physics. The original Building 51 was expanded with two high-bay additions, 51A and 51B, in the late 1950s and 1960s. The Vacuum Pump Room was located on the main floor of Building 51 at the eastern end of several large Air Ducts and equipment tunnels (Figure 2). The lower levels of the Bevatron, including the Air Duct shafts, were backfilled to grade (elevation 710 feet) as part of demolition project completion.

2.2 Site Geology and Hydrogeology

The physical setting of the Vacuum Pump Room area described in the following subsections is based primarily on information contained in LBNL's Resource Conservation and Recovery Act (RCRA) Facility Investigation Report (LBNL, 2000).

2.2.1 Physiography and Drainage

Prior to construction of the Bevatron, North Fork Strawberry Creek – which flows through Blackberry Canyon – passed between the current locations of Building 51 and Building 64. South of this area, a broader canyon containing an unnamed north-northwest-trending drainage passed through approximately the center of the present location of Building 51. Cut and fill activities during development of the Bevatron site significantly transformed the topography and surface runoff patterns. The hillside along the south and east edges of Building 51 was excavated, including the upper reaches of the unnamed northwest-trending drainage.

Storm drains were placed in the bottom of Blackberry Canyon northeast of Building 51 and along the unexcavated parts of the unnamed drainage prior to placing fill in the canyons. Since the hillside excavation intercepted the water table, various hillside drains, wells, and building subdrains were installed to convey intercepted groundwater to storm drains. The locations of the active subdrains that currently intercept groundwater are shown on Figure 2. The south perimeter subdrain lies adjacent to the retaining walls that formed the east and south walls of the Vacuum Pump Room. The Wind Tunnel subdrain lies approximately 60 feet west of the Vacuum Pump Room, and replaces a previously existing subdrain that was removed during demolition activities.

2.2.2 Geology

Two bedrock units – the Great Valley Group and the Orinda Formation – underlie the Bevatron Complex. Mudstones, sandstones, and shales of the Great Valley Group underlie the southwestern part of Building 51. The Orinda Formation, comprised primarily of clayey siltstones beneath the Bevatron Complex, overlies the Great Valley Group in the northeastern part of Building 51 including the Vacuum Pump Room area.

Colluvium several tens of feet thick is present in the former drainages that have been covered with artificial fill. The most extensive colluvial deposits lie along the former location of Blackberry Canyon. Colluvial deposits are also present within a former drainage course under the northwest portion of Building 51.

Artificial fill, consisting generally of gravelly, sandy, silty clay and clayey silt was used for cut and fill activities, including backfilling of the excavations surrounding the Air Duct shafts and Vacuum Pump Room retaining walls. Figure 3 is an historical photograph of the Bevatron construction site looking westwards from immediately southeast of the Vacuum Pump Room. The photograph shows the configuration of the bedrock surface prior to placement of backfill around the Air Duct shafts and behind the south perimeter wall and Vacuum Pump Room retaining walls.

2.2.3 Hydrogeology

Groundwater in the Building 51 area appears to flow mainly within the artificial fill. The underlying Orinda Formation generally has very low permeability and in most cases Orinda Formation rocks encountered in drilling throughout the Bevatron area appear dry, even when located beneath saturated overburden. Geological reports prepared before construction of Building 51 and geotechnical reports prepared during filling and compacting parts of Blackberry Canyon describe several springs at this site (Dames and Moore, 1949).

Groundwater flow beneath Building 51 had been controlled by the Bevatron subdrain systems prior to the demolition of Building 51 and parts of its internal subdrain system. Flow is still controlled to some extent by the remaining exterior components of the system, including the South Perimeter subdrain and hillside drains, and by the subdrain that was installed to replace the demolished Wind Tunnel subdrain system. The locations of the subdrains are shown on Figure 2.

A groundwater elevation contour map for the former Bevatron area is shown on Figure 4. Groundwater in areas uphill from the former Building 51 area flows generally northwards and westwards towards Building 51, where shallow groundwater is intercepted by the perimeter subdrains. Downhill from the perimeter subdrain groundwater is directed generally northwestwards towards the lower, unfilled portion of Blackberry Canyon to the northwest of the Building 51 area. As a result, groundwater is very shallow along the upslope perimeter of Building 51 and water frequently intruded into the basement area during the wet season particularly at the east end of the Air Duct shafts and in the southeast part of the Wind Tunnel, where it was captured by floor drains. Approximately 4,000 to 10,000 gallons of groundwater per day were captured by the drainage systems during the wet season.

2.3 Vacuum Pump Room Area Contamination

This section provides an overview and summary of the results of the environmental investigations conducted in the Vacuum Pump Room area. For a detailed discussion of the investigations and results refer to the *Report of Environmental Investigations in the Former Building 51 Vacuum Pump Room and Former Building 51A Areas* (LBNL 2012b). Results of the Vacuum Pump Room area investigations have also been reported in the LBNL Environmental Restoration Program (ERP) Progress Reports, which are submitted to the DTSC and provided to the Water Board and City of Berkeley. The Progress Reports are available on line at http://www.lbl.gov/ehs/erp/html/documents.shtml and at the main branch of the Berkeley Public Library.

2.3.1 Soil Contamination

The primary soil contaminant in the Vacuum Pump Room area is trichloroethylene (TCE), which was detected at a maximum concentration of 230 mg/kg at a depth of approximately 12 feet below the Vacuum Pump Room floor in SB51-11-9. Other chlorinated VOCs detected in the Vacuum Pump Room area included cis-1,2-dichloroethene (DCE), trans-1,2-DCE, 1,1-DCE, 1,1,1-trichloroethane (TCA), and 1,1-dichloroethane (DCA), all at relatively low concentrations. Soil boring locations and maximum concentrations of TCE detected in soil are shown on Figure 5. Note that the figure shows both the Vacuum Pump Room area and the former Cooling Tower area, located to the south of, and at 15 feet higher elevation than, the Vacuum Pump Room area. As shown on the figure, soil contamination is confined to a relatively small area beneath the southwest end of the Vacuum Pump Room and in the former Cooling Tower area immediately south of the Vacuum Pump Room retaining wall. The lateral extent of contamination is well defined by the non-detectable to low concentrations of VOCs in borings drilled around the periphery of the area (LBNL, 2012b). Except for SB51-11-9, where the maximum concentrations of VOCs were detected, the soil contamination appears to have been primarily limited to the fill areas adjacent to the Air Duct walls and southern wall of the Vacuum Pump Room. This is most likely due to the relatively permeable fill acting as a preferential migration pathway for contaminants. However, as discussed in Section 5, although SB51-11-9 appears to have been drilled entirely within the Orinda Formation (based on the boring log), the contaminated section of Orinda Formation in this boring has a hydraulic connection with the adjacent fill. The vertical extent of contamination is also well-defined, as shown on cross sections A-A' (Figure 6) and B-B' (Figure 7). The locations of the cross sections are shown on Figure 5.

2.3.2 Soil Vapor Contamination

Concentrations of total VOCs detected in soil vapor samples collected in the Vacuum Pump Room area and former Cooling Tower area are shown on Figure 8. The primary soil vapor contaminants detected consisted of TCE, vinyl chloride, cis-1,2-DCE, and 1,1-DCA. Of the five soil vapor sampling locations in the Vacuum Pump Room, four had relatively low concentrations of VOCs and the fifth, located at the south end of the room (SG51-10-34), had an elevated concentration of 51,770 $\mu g/m^3$. A second sampling site – SB51-11-9 – was later installed to sample the soil and groundwater at this location.

2.3.3 Groundwater Contamination

An isoconcentration contour map of total VOCs detected in groundwater in the Vacuum Pump Room area is shown on Figure 9. The primary contaminant detected has been TCE, with significantly lower concentrations of 1,1,1-TCA, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, and carbon tetrachloride (LBNL, 2012b). The maximum concentration of total VOCs detected was 132,960 µg/L in the initial sample collected from temporary groundwater sampling point SB51-11-9 shortly after it was installed. However, since this sample was collected from turbid water prior to well development, it is not considered representative of actual groundwater conditions. The initial post-development sample contained 34,476 µg/L total VOCs, which was likely more representative of actual groundwater conditions than the pre-development sample. A sheen was observed in this sample, indicating that dense non-aqueous phase liquid (DNAPL) was likely present. Groundwater samples collected from boreholes within several feet of SB51-11-9 contained total VOC concentrations that were orders of magnitude lower, with a maximum of 482 µg/L in SB51-11-24.

Subsequent groundwater samples collected from SB51-11-9 have shown a decreasing trend in concentrations, with TCE decreasing to 32,900 µg/L in July 2011, 17,500 µg/L in January 2012, and 4,450 µg/L in March 2013. The groundwater contamination appears to have been primarily limited to the fill areas adjacent to the Air Duct walls, except for near SB51-11-9, the sampling point that has contained the maximum concentrations of VOCs in both the soil and groundwater. However, as discussed in Section 4, although SB51-11-9 appears to have been drilled entirely within the Orinda Formation (based on the boring log), there is a hydraulic connection with the adjacent fill.

3.0 Contaminant Migration Extent and Risks

3.1 Contaminated Groundwater Migration

Prior to the demolition of the Bevatron, the difference in the hydraulic head (*i.e.* groundwater elevation) between the Vacuum Pump Room / Cooling Tower and Air Duct areas ranged from 5 to 10 feet. Any contaminated groundwater seeping through the concrete walls and floors of the Air Duct shafts and along the southeast edge of the Wind Tunnel was previously captured by the Air Duct and Wind Tunnel floor drain systems. The floor drain system was removed as part of the Bevatron Demolition Project, and a replacement Wind Tunnel subdrain was installed at approximately the same location and elevation as the original system to control the groundwater elevation in the former central Bevatron area. The effluent from this subdrain is routed to the Building 51 Motor Generator Room treatment system. The location of the replacement subdrain is shown on Figure 2.

Although the Demolition Project scope included completely removing all of the subgrade concrete walls and floors of the Air Duct shafts, the easternmost sections (approximately 10 to 25 feet) were left in place to help limit potential post-demolition migration of contaminated groundwater from the Vacuum Pump Room / Cooling Tower areas into the Air Duct shaft and Wind Tunnel backfill. After the Air Duct shafts were backfilled, the groundwater level in the backfill at the eastern end of the Air Duct shafts rose several feet (to the surface), as shown by water level measurements in observation well OC51-11-1, which was installed to monitor the water level in the backfill. The locations of OC51-11-1 and the remaining concrete Air Duct walls are shown on Figure 10. Figure 11 is a graph showing the variation in the groundwater elevation in OC51-11-1.

In December 2011, VOCs were detected at a total concentration of 264 µg/L in a grab groundwater sample collected from OC51-11-1. The primary VOCs detected were TCE (189 µg/L) and cis-1,2-DCE (52 µg/L). More recent samples collected in late 2012 and early 2013 contained VOCs at a total concentration of approximately 250 µg/L with cis-1,2-DCE (122 to 152 µg/L) and TCE (77 to 124 µg/L) the primary contaminants detected. The VOCs detected in the groundwater generally constituted the same suite of VOCs as has been detected in the adjacent Vacuum Pump Room and Cooling Tower areas. The most likely pathways for the migration of this contaminated groundwater are from the Vacuum Pump Room through the relatively permeable Air Duct shaft wall backfill and seepage of contaminated groundwater through the remaining concrete Air Duct shaft walls and floor slab.

3.2 Potential Risk to Human Health and the Environment

To assess potential risks to human health and the environment, detected concentrations of contaminants were compared to regulatory screening levels appropriate to an industrial land use scenario. Institutional (i.e. industrial) land use is the current and the reasonable and likely future land use at LBNL, and was therefore the land use scenario that was approved by DTSC to establish cleanup requirements for the entire LBNL site (LBNL, 2005).

3.2.1 Potential Risk to Human Health

Currently, there is no significant risk to human health associated with VOC contamination detected in the former Vacuum Pump Room area. The potential exposure pathways relevant to human health risks are inhalation due to vapor intrusion into indoor air, and direct contact with contaminated soil. VOCs have been detected in soil vapor and groundwater at concentrations well above California Human Health Screening Levels (CHHSLs) (Cal/EPA, 2005) and/or Water Board Environmental Screening Levels (ESLs) http://www.waterboards.ca.gov/rwqcb2/water_issues/programs/esl.shtml for potential risk to future indoor workers via the vapor intrusion pathway. However, there is no risk to current workers since there are no buildings in the areas where the screening levels are exceeded. The closest occupied building (Building 64) is approximately 300 feet from the areas of elevated soil vapor concentrations.

The exposure pathway that is currently potentially complete is dermal contact by outdoor workers with VOC-contaminated shallow soil, which is defined as soil at less than 10 feet depth. Concentrations of VOCs in shallow soil exceed the ESL for direct contact in SB51-11-31, where TCE was detected at a concentration of 32 mg/kg at a depth of three feet. This location has been posted with a warning sign requiring Hazardous Waste Operation (HAZWOPER) training for any worker handling soil in the posted area. Also, LBNL has in place an institutional process that requires a penetration permit for all soil disturbances. The permit process includes an assessment of potential subsurface contamination conducted by LBNL's Environmental Services Group.

Since the exposure pathways for risks to human health are not complete or are mitigated by institutional controls, the ICM did not address contamination associated with these pathways.

3.2.2 Potential Risk to the Environment

The former Building 51 site is within LBNL's main developed area. Potential exposure of wildlife to soil and groundwater contamination within the developed area was eliminated as a completed exposure pathway in the LBNL Ecological Risk Assessment (LBNL, 2002) because suitable habitat for wildlife is restricted to the natural areas along the site's perimeter, and is not present in the central developed area.

There is, however, a potential risk to groundwater. As described above, after the Air Duct shafts were backfilled, contaminated groundwater was detected migrating from the Former Vacuum Pump Room area into the clean Air Duct shaft backfill. This migration was impacting both the clean backfill and the clean downgradient groundwater, and was therefore identified as an imminent threat to the environment. Based on this determination, LBNL submitted a workplan to DTSC requesting approval to implement an ICM to mitigate the threat by controlling the migration of the contaminated groundwater (LBNL, 2013). The ICM is described in the following section.

4.0 ICM Description

4.1 ICM Objective

As described in Section 3.1 of this report, after demolition of the Bevatron was completed and prior to implementation of the ICM, the groundwater level in the eastern end of the backfilled Bevatron Air Duct shafts had risen several feet to near the surface. This groundwater was contaminated with the same suite of VOCs that had been detected in the adjacent Vacuum Pump Room and Cooling Tower areas. These observations indicated that since demolition of the Bevatron and backfilling of the Air Duct shafts, contaminated groundwater had been migrating from the former Vacuum Pump Room / Cooling Tower areas into the clean Air Duct backfill.

Although the downgradient contaminant migration would likely have been limited by the replacement subdrain that had been installed in the former Bevatron Wind Tunnel area, containment would not have occurred until a significant portion of the Bevatron backfill upgradient from the subdrain had become contaminated. In addition, if the subdrain did not successfully capture the migrating groundwater, potential impacts to clean groundwater (and potentially surface water) downgradient from the site could have occurred. The downgradient migration of contaminated groundwater therefore posed an imminent threat to the environment requiring mitigation.

The locations of the Vacuum Pump Room, Air Ducts, and replacement subdrain are shown on Figure 2. The most likely pathways for plume migration from the Vacuum Pump Room area are: 1) migration through the relatively permeable Air Duct shaft wall backfill and 2) seepage of contaminated groundwater through the remaining concrete Air Duct shaft walls and floor slab. The seepage is driven by the significant hydraulic head difference (i.e. groundwater elevation difference) between groundwater beneath the Vacuum Pump Room floor and groundwater within the former Air Ducts to the west. The ICM therefore focused on plume containment by extracting and treating groundwater both in the Vacuum Pump Room source area and in the Air Duct shaft backfill downgradient of the source area at observation well OC51-11-1. Containment at those locations should control the migration of contaminants through the Air Duct shaft backfill and reduce the hydraulic head difference that drives seepage through the former Air Duct walls and floor slab.

4.2 ICM Implementation

The ICM consisted of the construction of a groundwater extraction well in the former Vacuum Pump Room area, extraction of groundwater from this new well – EW51-13-1 – and the existing observation well OC51-11-11, and treatment of the extracted groundwater at the existing Building 51 Motor Generator Room Treatment System. ICM implementation is described below.

4.2.1 Groundwater Extraction Well EW51-13-1

On August 21, 2013, Hillside Drilling Inc. of Richmond, California first overdrilled and destroyed temporary groundwater sampling point SB51-11-9 in the Vacuum Pump Room using 24-inch-diameter augers and then installed a large-diameter groundwater extraction well at the same location. The well boring was drilled to a depth of 25 feet. In completing the well, all construction materials associated with the former temporary sampling point – which only reached a depth of 20 feet – were removed. Five-inch diameter Schedule-40 PVC casing was installed in the boring, with the bottom 15 feet consisting of 0.02-inch machine slotted screen.

To enhance the well yield, two additional contiguous large diameter borings (22-inch and 24-inch) were drilled to a depth of 20 feet to the west of the extraction well and backfilled with gravel. Multiple large-diameter borings were required for groundwater extraction due to the low hydraulic conductivity of both the artificial fill and the bedrock beneath the former Vacuum Pump Room location.

Drilling commenced as follows: The center boring of the three borings was drilled to a depth of 20 feet below ground surface (bgs) with 22-inch diameter augers. A 20-inch diameter steel temporary casing was then placed in the borehole to allow the simultaneous backfilling of all three borings with coarse drain rock without gravel caving into the adjacent boreholes during drilling. A 24-inch borehole was then drilled on the east side of the temporary casing to a depth of 25 feet bgs, and the groundwater extraction well casing and approximately 15 feet of gravel was installed into the borehole. A 24-inch boring was then drilled to a depth of 20 feet bgs on the west side of the temporary casing. The central and western borings were then backfilled with the drain rock to a depth of approximately 10 feet bgs and the temporary casing removed. All three borings were then backfilled with gravel to a depth of 3 feet bgs and covered with approximately 2 feet of hydrated bentonite chips. The locations of the three borings are shown on Figure 10 and in more detail on Figure 12. A geologic cross section through the extraction well locations is shown on Figure 13. The cross section location is shown on Figure 12.

Each of the borings first penetrated a few feet or clayey artificial fill and then siltstone of the Orinda Formation. Water was initially encountered at a depth of approximately 12 feet bgs. The groundwater extraction well was centered on SB51-11-9, which was located at the apparent center of the VOC-contaminated "hot spot" in the Vacuum Pump Room area. The well was installed to a depth of 25 feet to allow groundwater extraction and treatment from the entire depth of relatively high soil VOC concentrations. During drilling, relatively high photoionization detector (PID) (20 to 140 ppm) readings were briefly recorded in air adjacent to the borehole. This occurred during pulling of the augers between approximately the 12 foot and 16 foot depth horizons of the extraction well boring.

A submersible Grundfos pump equipped with level-sensor switches was installed in groundwater extraction well EW51-13-1 with the bottom of the pump approximately one foot above the bottom of the hole. The lower switch was set to turn the pump off when the groundwater level dropped to approximately 3 feet above the bottom of the hole, at an approximate elevation of 688 feet. The upper switch was located to turn the pump on when the groundwater elevation reached 12 feet bgs, at an elevation of approximately 698 feet. This promotes flushing of groundwater through the entire depth interval containing relatively high concentrations of VOCs in soil. Construction details for the EW51-13-1 are shown on Figure 14.

4.2.2 Observation Well OC51-11-1

Observation well OC51-11-1 was installed as part of the Bevatron Demolition Project to monitor the water level in the Air Duct backfill. The location of OC51-11-1 is shown on Figure 10 and Figure 12. Construction details are described below and shown on Figure 15.

Four-inch diameter Schedule-40 PVC casing (4 feet of screen and 8 feet of solid casing) was placed in a 2-foot-deep sump that had previously been excavated beneath the Air Duct shaft floor. The sump had been installed to lower the water table in order to allow soil sampling in the Air Duct shaft. The sump around the casing was filled with drain rock, and filter fabric was wrapped around the screen portion of the casing that extended above the drain rock. A 1.5-foot high containment berm was installed in the Air Duct shaft and the floor was covered with drain rock to a depth of about 1.5 feet. The Air Duct shafts were backfilled with clean soil and the soil compacted to 90 percent.

4.2.3 Groundwater Treatment System

LBNL previously installed the Building 51 Motor Generator Room granular activated carbon (GAC) system to treat extracted groundwater derived from the Building 51 drain system as part of an approved remedy under the RCRA Corrective Action Program (CAP). Clean effluent from the treatment system is either injected into the subsurface as part of the approved soil flushing remedy for the Building 51/64 Groundwater Solvent Plume, or discharged under permit to the sanitary sewer, depending on soil flushing system operational requirements. The system consists of two 1000-pound GAC canisters installed in series. This treatment configuration ensures that contamination will not be present at detectable concentrations in the post-treatment effluent.

Ancillary equipment includes: particulate filters; pressure gauges; flow totalizers; flow control, pressure relief, and back flow control valves; sampling ports; and electric power controls. The configuration of the above ground piping from groundwater extraction well EW51-13-1 to the treatment system is shown on Figure 10. A schematic diagram of water flow through the system is shown on Figure 16.

5.0 System Operation and Monitoring

5.1 ICM Operation

On July 29, 2013, after DTSC's approval of ICM implementation, extraction and treatment of contaminated groundwater from OC51-11-1 commenced. The yield on the first day was approximately 460 gallons, and on the following day it was approximately 1200 gallons. Intermittent manual pumping continued through August 19, 2013, with a total of approximately 6,300 gallons of groundwater extracted from the well. As a result of pumping, the water level dropped approximately 8.5 feet from near the surface to below the base of the compacted fill at the well location. Pumping was stopped due to the steep drawdown, which made extraction difficult. Figure 11 is a graph showing the variation in the groundwater elevations in OC51-11-1.

Pumping from EW51-13-1 started on August 28, 2013. The pumping rate has decreased from approximately 260 gallons per minute (gpm) in September 2013 to less than 50 gpm in October 2013. As a result of groundwater extraction from EW51-13-1, the water level in OC51-11-1 has remained near the base of the compacted fill, so pumping from OC51-11-1 has not been resumed.

At this time, there is no upcoming (planned) work on the ICM groundwater extraction and treatment system. The system will continue to operate until either the migration of contaminated groundwater is no longer a concern or a final corrective measure has been approved and implemented. The treatment system itself is a component of the DTSC-approved corrective measure for the Building 51/64 groundwater solvent plume and will continue to operate as such until the required MCSs for the Building 51/64 groundwater solvent plume are attained or DTSC approves termination of the measure.

5.2 ICM Effectiveness

5.2.1 Groundwater Flow

Hydrographs of Vacuum Pump Room area temporary groundwater sampling points (SB51-11-9, SB51-11-10, SB51-11-17, SB51-11-18, and SB51-11-19) are shown on Figure 17. The locations of the temporary groundwater sampling points are shown on Figure 12. As shown on Figure 17, the water level had risen to near the ground surface at all five locations in the period prior to groundwater extraction from OC 51-11-1. After pumping was started from OC51-11-1, the water level declined approximately 10 feet in SB51-11-9 and approximately two to four feet at the other four temporary groundwater sampling point locations.

Groundwater levels have continued to decline since groundwater extraction was started from EW51-13-1 (former SB51-11-9 location), with significant declines observed in SB51-11-10 (approximately 10 feet total) and SB51-11-17 (approximately 7 feet total). SB51-11-10 and SB51-11-17 were constructed with the upper portion of the screened intervals in fill (approximately 7.5 of fill at SB51-11-10 and 10 feet at SB51-11-17) and the lower portions in low permeability Orinda Formation bedrock. SB51-11-18 and SB51-11-19 are screened entirely in Orinda Formation bedrock. These results indicate a relatively good hydraulic connection through the fill. The significant drawdown observed in SB51-11-9 that resulted from pumping OC51-11-9, and the significant drawdowns observed in SB51-11-10 and SB51-11-17 that have been observed since groundwater extraction was started from EW51-13-1, suggests that the hydraulic connection between EW51-13-1 and the adjacent fill is good This indicates that the sampling point location is essentially connected to the fill or a zone of relatively high permeability is present within Orinda Formation bedrock at this location. This is the likely explanation for the presence of relatively high levels of contaminants in the low permeability Orinda Formation at the former SB51-11-9 location.

The effectiveness of the ICM in reducing groundwater seepage from the Vacuum Pump Room area into the Air Duct backfill and reducing the flow of contaminated groundwater through the Air Duct backfill is illustrated on Figure 13. This figure is a cross section through the Vacuum Pump Room area showing groundwater elevations on July 29, 2013 (prior to the start of groundwater extraction) and on September 25, 2013 (after groundwater extraction was started from EW51-13-1). Prior to the start of groundwater extraction, the water table was at an elevation of approximately 710 feet in the Vacuum Pump Room area and Air Duct backfill, and the entire section of the backfill was saturated. Given that the water table elevation in the center of the Bevatron area is typically at or below approximately 700 feet (as shown on Figure 4), the 10-foot head difference between these two areas would have driven flow downgradient through the Air Ducts toward the center of the Bevatron Area.

After extraction started, the water level was drawn down to the base of the Air Duct backfill and remains at that level, thus substantially reducing the westwards flow of groundwater through the Air Duct backfill. A similar relationship is illustrated on Figure 15, which shows groundwater elevations measured in OC51-11-1 on January 1, 2012 (shortly after installation), on July 29, 2013 (prior to the start of groundwater extraction) and on September 25, 2013 (after groundwater extraction was started from OC51-11-1). In addition, lowering of the water table at EW51-13-1 to approximately 698 feet elevation, as shown on Figure 13, would result in flow from the Air Ducts towards the well, thus reducing or eliminating seepage of contaminated groundwater westwards through the Air Duct walls.

Based on these observations, the ICM has been effective in mitigating the imminent threat to the environment, namely the downgradient migration of contaminated groundwater through the clean Air Duct backfill.

5.2.2 Groundwater VOC Concentrations

Groundwater samples collected from SB51-11-9 (subsequently converted to EW51-13-1) and OC51-11-1 were analyzed for VOCs by EPA Method 8260 both before and following implementation of the ICM. The locations of these wells are shown on Figure 12. Groundwater concentration trends for total VOCs detected in these wells are shown on Figure 18.

As described in Section 2, SB51-11-9 was located in the apparent center of the VOC-contaminated “hot spot” in the Vacuum Pump Room area. Concentrations of total VOCs in SB51-11-9 declined during the first year after its installation from approximately 35,000 µg/L to between approximately 5,000 and 10,000 µg/L. Samples collected from groundwater extraction well EW51-13-1, which was installed at the same location and sampled after approximately a month of groundwater extraction from the well, have been almost an order of magnitude lower – approximately 1,000 µg/L or less of total VOCs. The significant reduction in VOC concentrations observed since groundwater extraction was started is likely the result of two factors: flow of relatively uncontaminated groundwater toward the extraction well, and removal of some of the source area soil when overdrilling SB51-11-9 using large-diameter augers to install the extraction well.

As shown on Figure 18, the concentration of cis-1,2-DCE detected in OC51-11-1 was increasing while the concentration of TCE showed a comparable decrease prior to the start of groundwater extraction. During this same period the concentration of total VOCs remained relatively constant (Figure 18). These results may have been the effect of natural degradation processes, with TCE degrading to cis-1,2-DCE. Since groundwater extraction was started, there has been a significant decline in the concentrations of all VOCs detected, which is likely the result of the ICM effectively controlling the migration of contaminated groundwater from the Vacuum Pump Room area.

5.2.3 VOC Mass Removal Rate

Table 1 summarizes the monthly treatment system VOC mass removal rates for the five months since the ICM was implemented (August through December 2013) as well as the cumulative VOC mass removed for the former Building 51 Bevatron site. As shown in the table, an estimated 30 grams of VOC mass has been removed from the groundwater since the start of the ICM. It should be noted that the purpose of the ICM is not to remove contaminant mass but to control the migration of contaminated groundwater.

Table 1
Contaminant Mass Removal Rates Former Building 51 Bevatron Vacuum Pump Room Area

Date		Totalizer Reading (B51MRB-T5 93646572)	Gallons Treated/Month	Liters Treated/Month	Concentration of Total VOCs in Groundwater (ug/L)	VOC Mass Removal Rate (mg/month)
	August-2013		6300	23814	253	6025
9/2/2013		7,770				
9/10/2013		9,447				
9/13/2013		10,231				
9/17/2013		11,209				
9/20/2013		11,984				
9/23/2013		12,775				
9/27/2013		13,364				
9/30/2013	September-2013	13,757	5987	22631	763	17267
10/4/2013		14,163				
10/8/2013		14,371				
10/11/2013		14,407				
10/15/2013		14,407				
10/18/2013		14,618				
10/21/2013		14,721				
10/24/2013		14,803				
10/28/2013		14,833				
11/1/2013	October-2013	14,943	1186	4483	744	3335
11/4/2013		14,943				
11/8/2013		15,553				
11/12/2013		15,553				
11/15/2013		15,553				
11/19/2013		15,594				
11/22/2013		15,594				
11/25/2013		15,813				
11/27/2013	November-2013	15,813	870	3289	545	1792
12/2/2013		15,975				
12/6/2013		16,054				
12/10/2013		16,091				
12/13/2013		16,191				
12/16/2013		16,191				
12/20/2013		16,270				
12/24/2013		16,365				
12/26/2013		16,365				
12/31/2013	December-2013	16,365	552	2087	569	1187
1/2/2014		16,365				
Total Cotaminant Mass Removed						29607 mg 30 gms

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List of Figures

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Groundwater monitoring well

T SB51A-12-1

Temporary groundwater sampling point

Groundwater extraction well

OW51-11-1

Observation well

Soil boring

620

Groundwater elevation contour line (elevation in ft above mean sea level)

51A

Former building location

GAC GAC

Granular activated carbon
(GAC) treatment system

NOTES:
All other symbols used are explained on the figures.

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Key to Symbols Used on Figures.

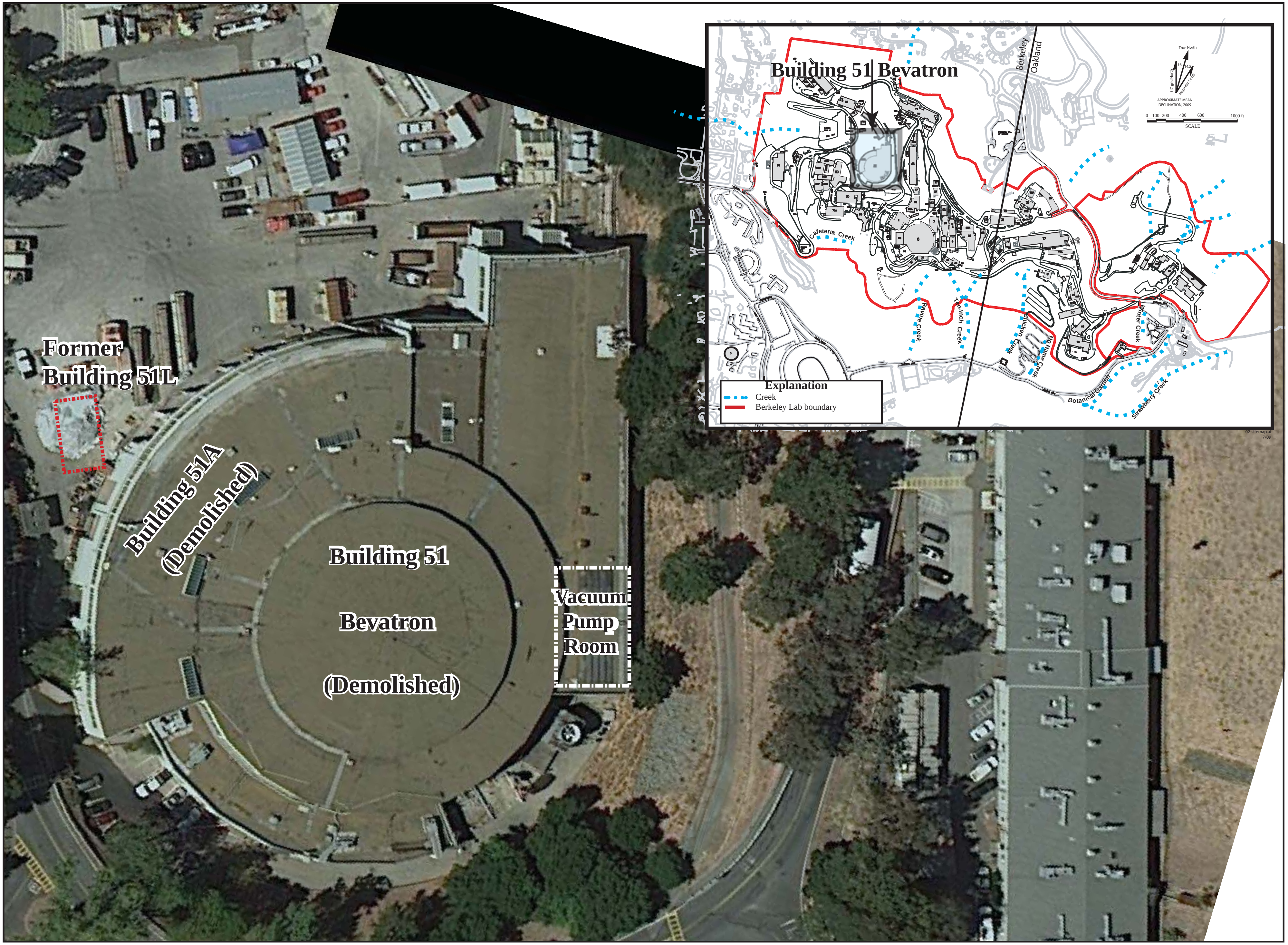

Figure 1. Location of Former Bevatron Site, Lawrence Berkeley National Laboratory.

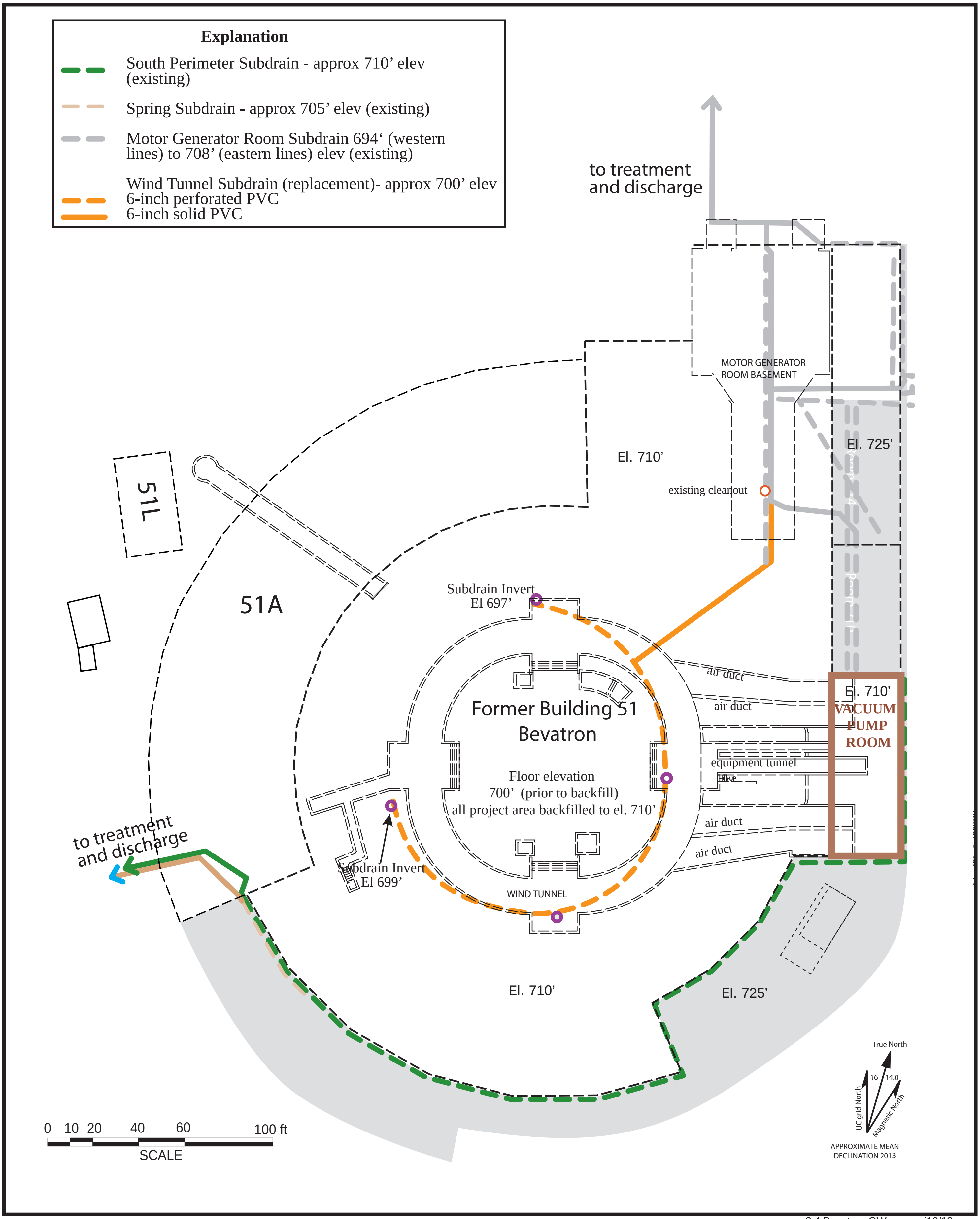

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Figure 2. Location of Vacuum Pump Room and Active Subdrain Systems, Former Building 51 Bevatron Site.

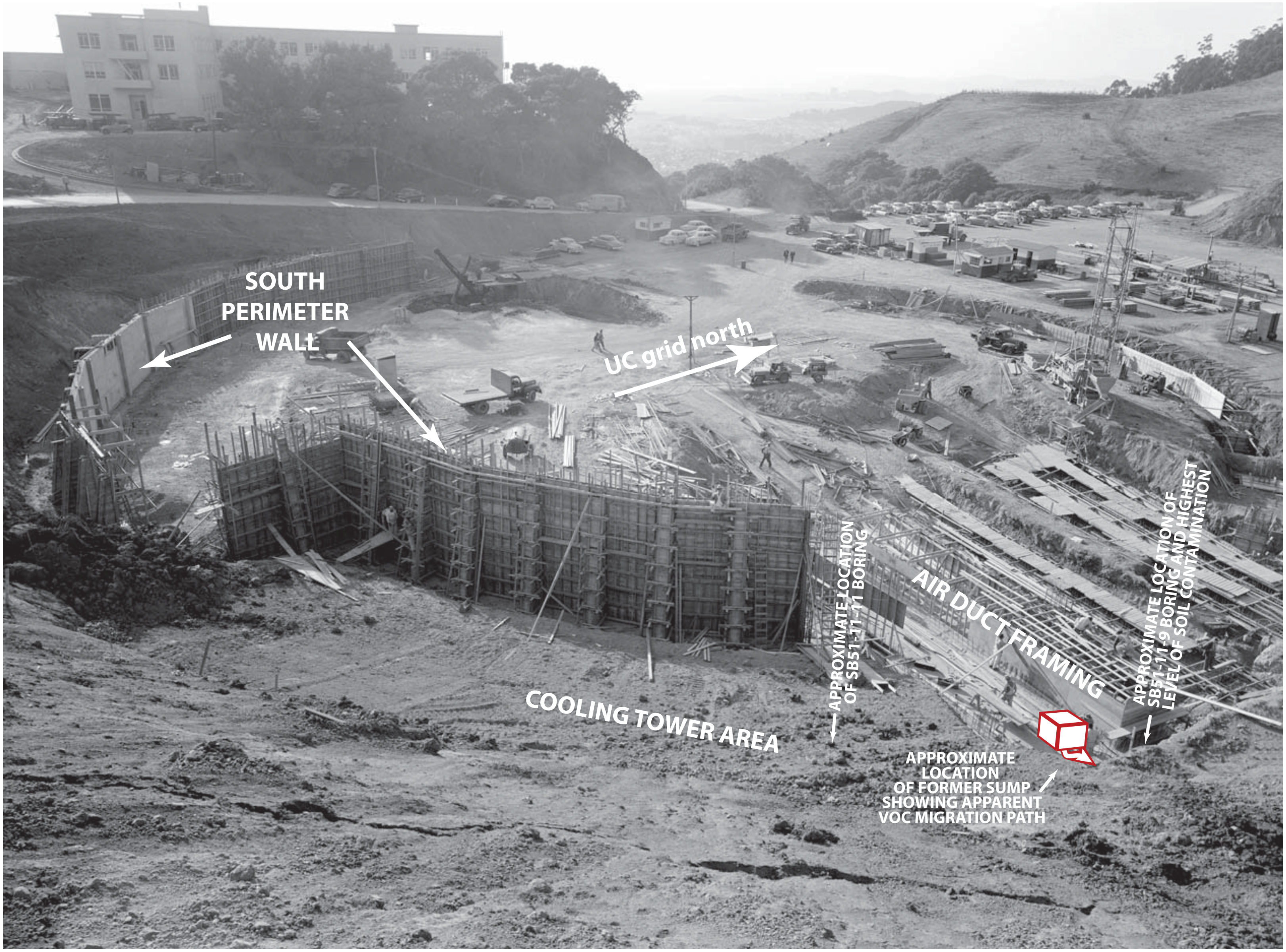

Figure 3. Bevatron Overview During Construction of Air Ducts and South Perimeter Wall.

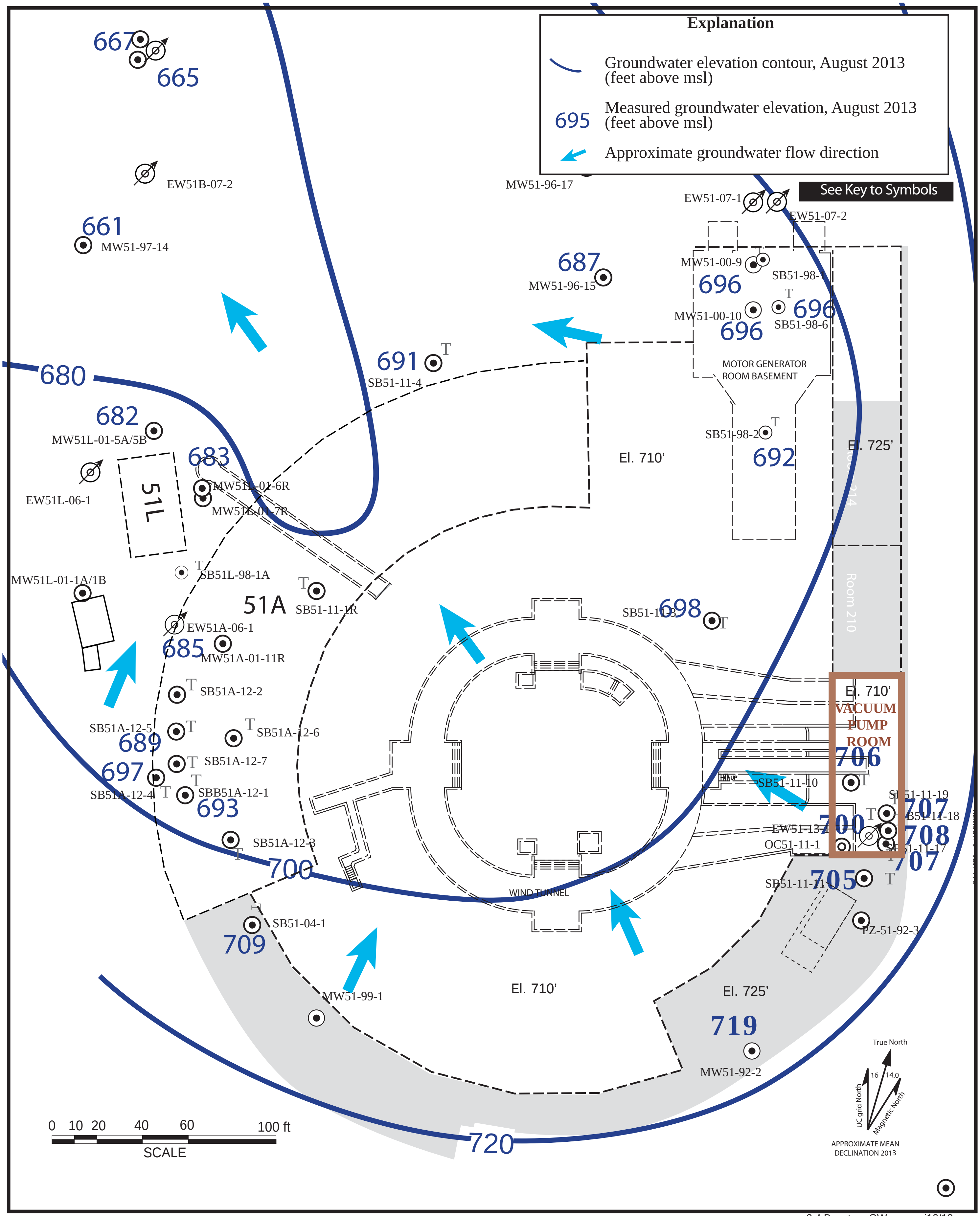

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Figure 4. Groundwater Elevation Map (August 2013) Showing Groundwater Flow Directions, Former Building 51 Site

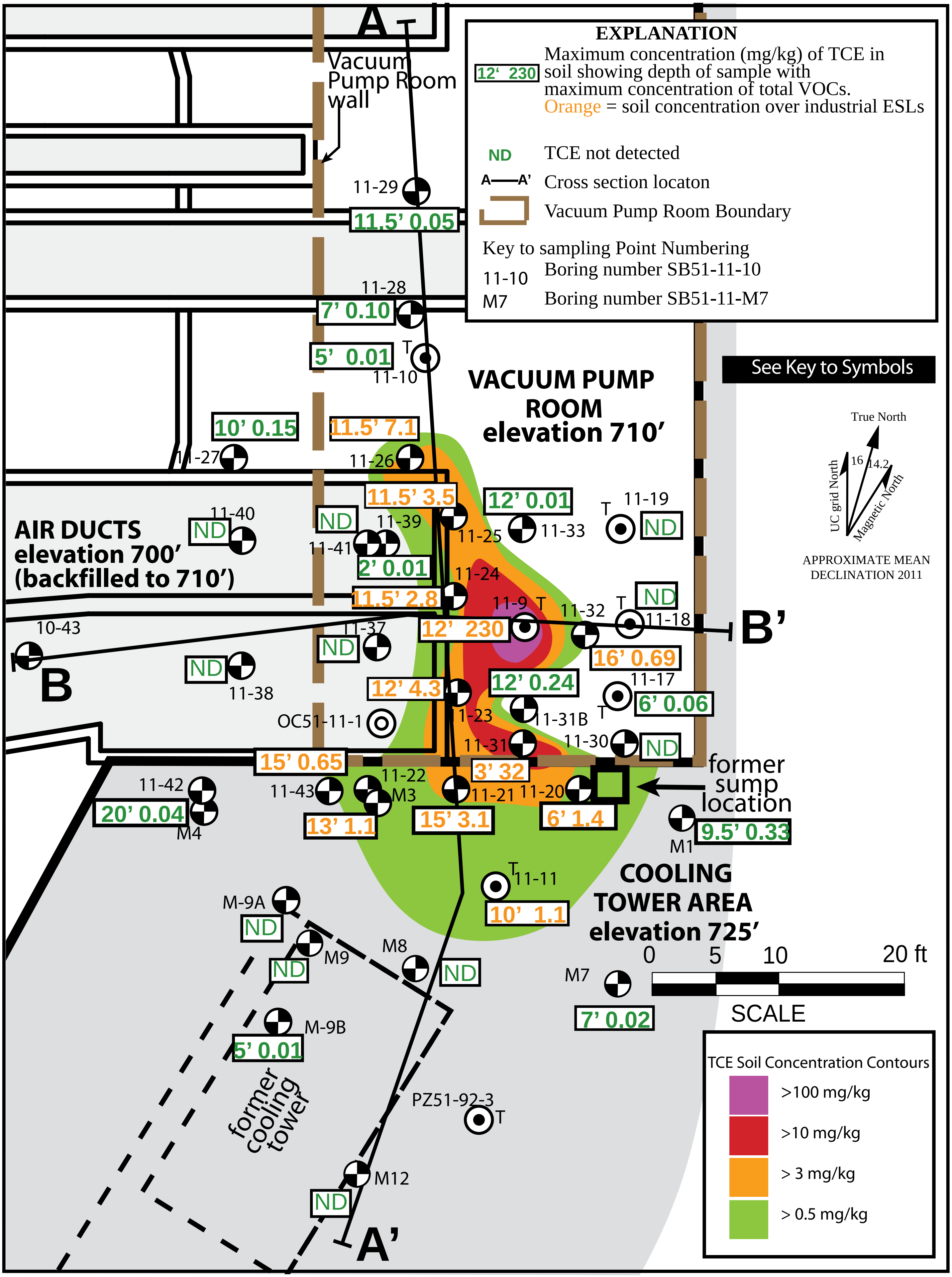


Figure 5. Maximum Concentrations of TCE Detected in Soil, Vacuum Pump Room and Cooling Tower Areas.

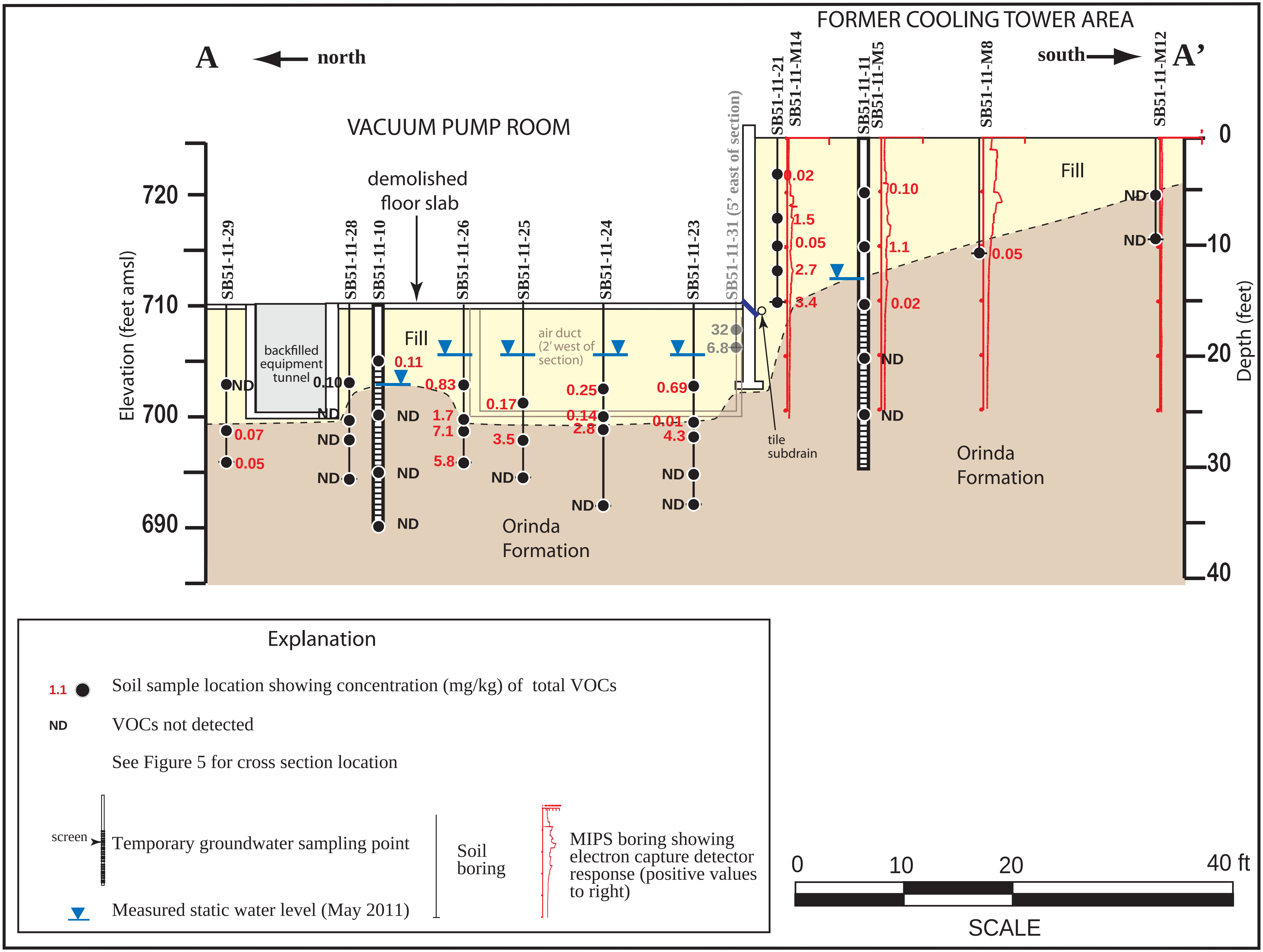


Figure 6. Geologic Cross Section A-A' Through Vacuum Pump Room Area Showing Total Concentrations of VOCs in Soil (mg/kg) and MIP ECD Responses.

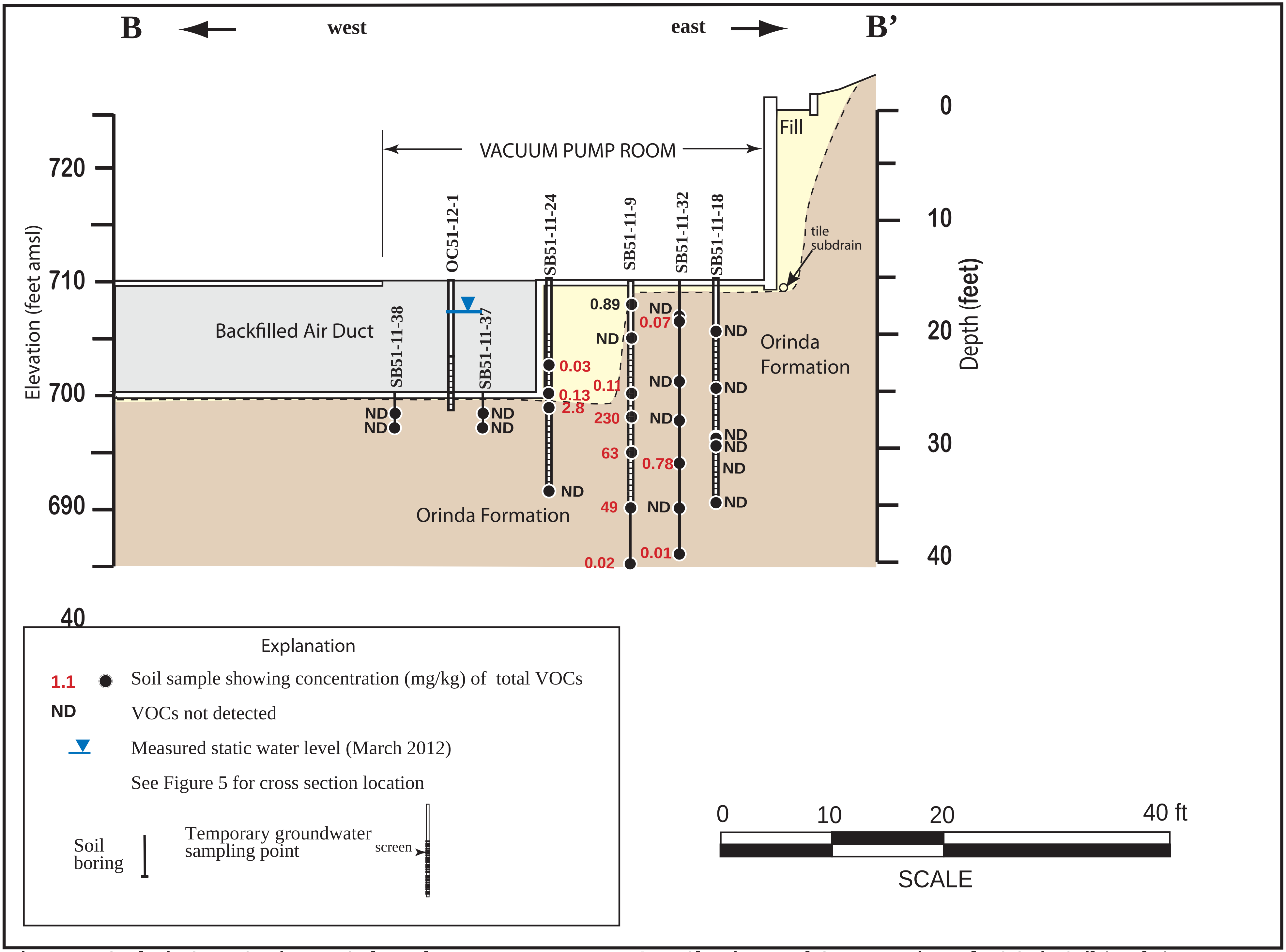


Figure 7. Geologic Cross Section B-B' Through Vacuum Pump Room Area Showing Total Concentrations of VOCs in Soil (mg/kg).

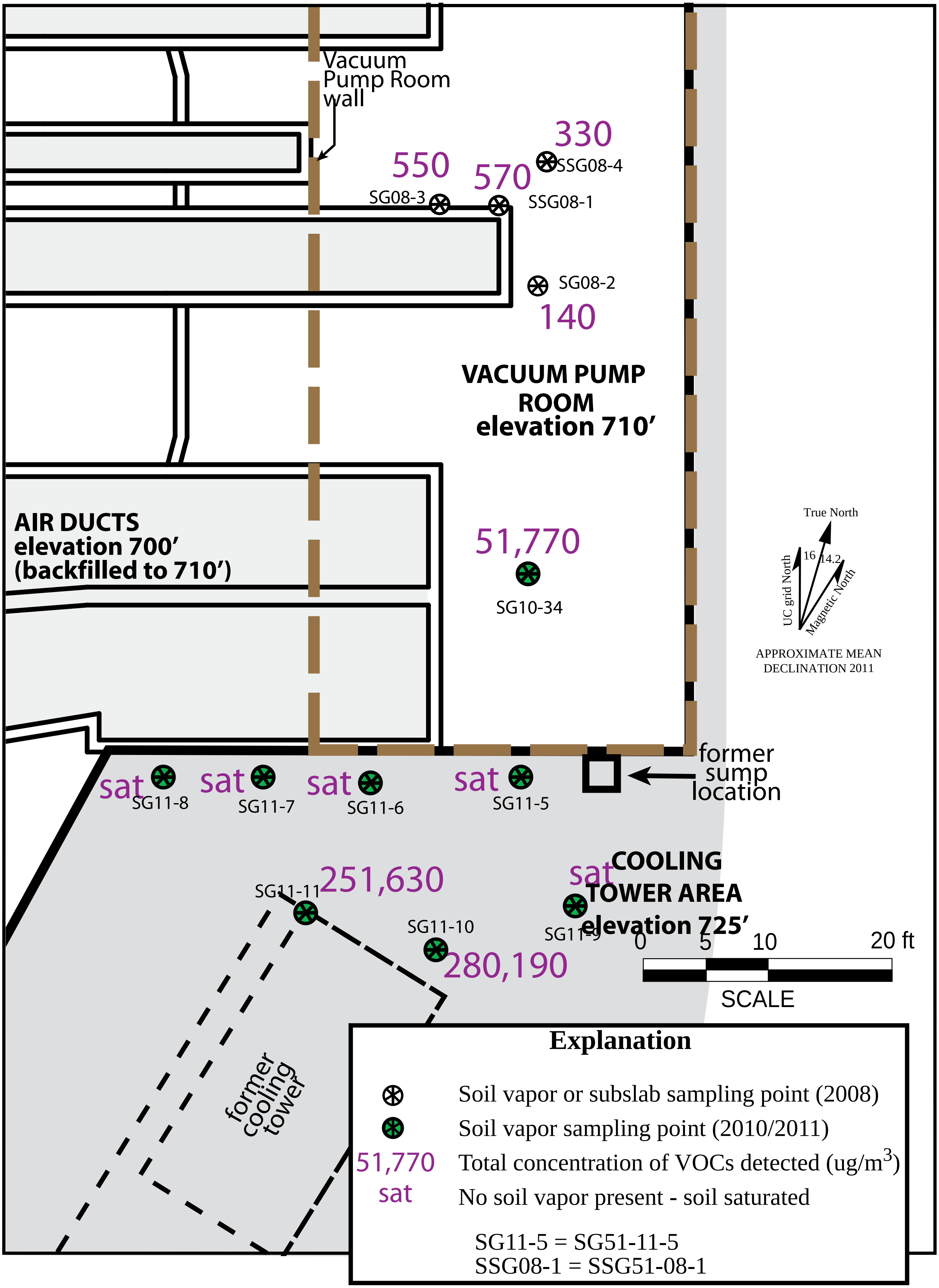


Figure 8. Total Volatile Organic Compounds in Soil Vapor and Subslab Vapor, Vacuum Pump Room Area.

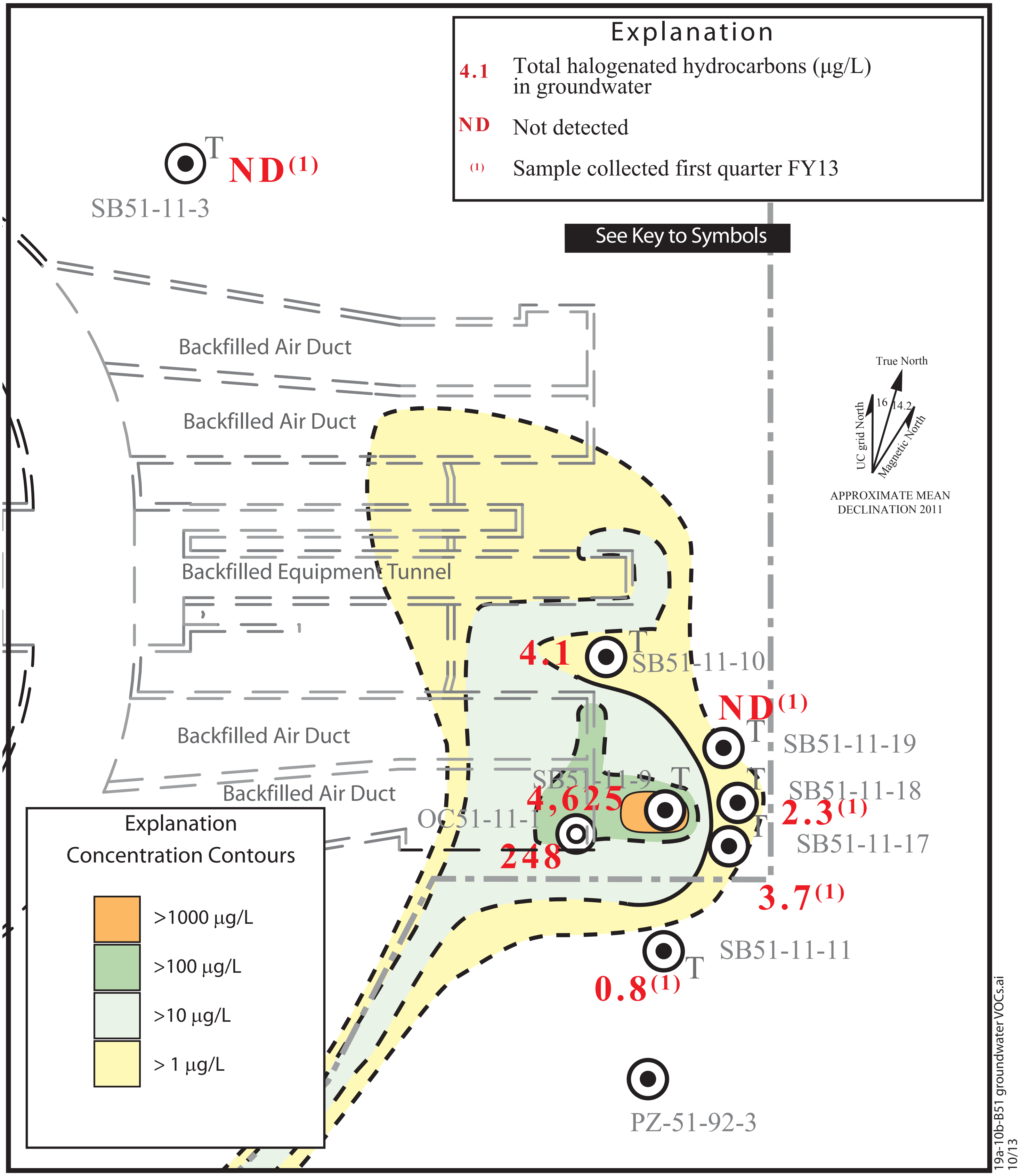


Figure 9. Isoconcentration Contour Map, Total Halogenated Hydrocarbons in Groundwater (µg/L) in the Building 51 Vacuum Pump Room Area, Second Quarter FY13.

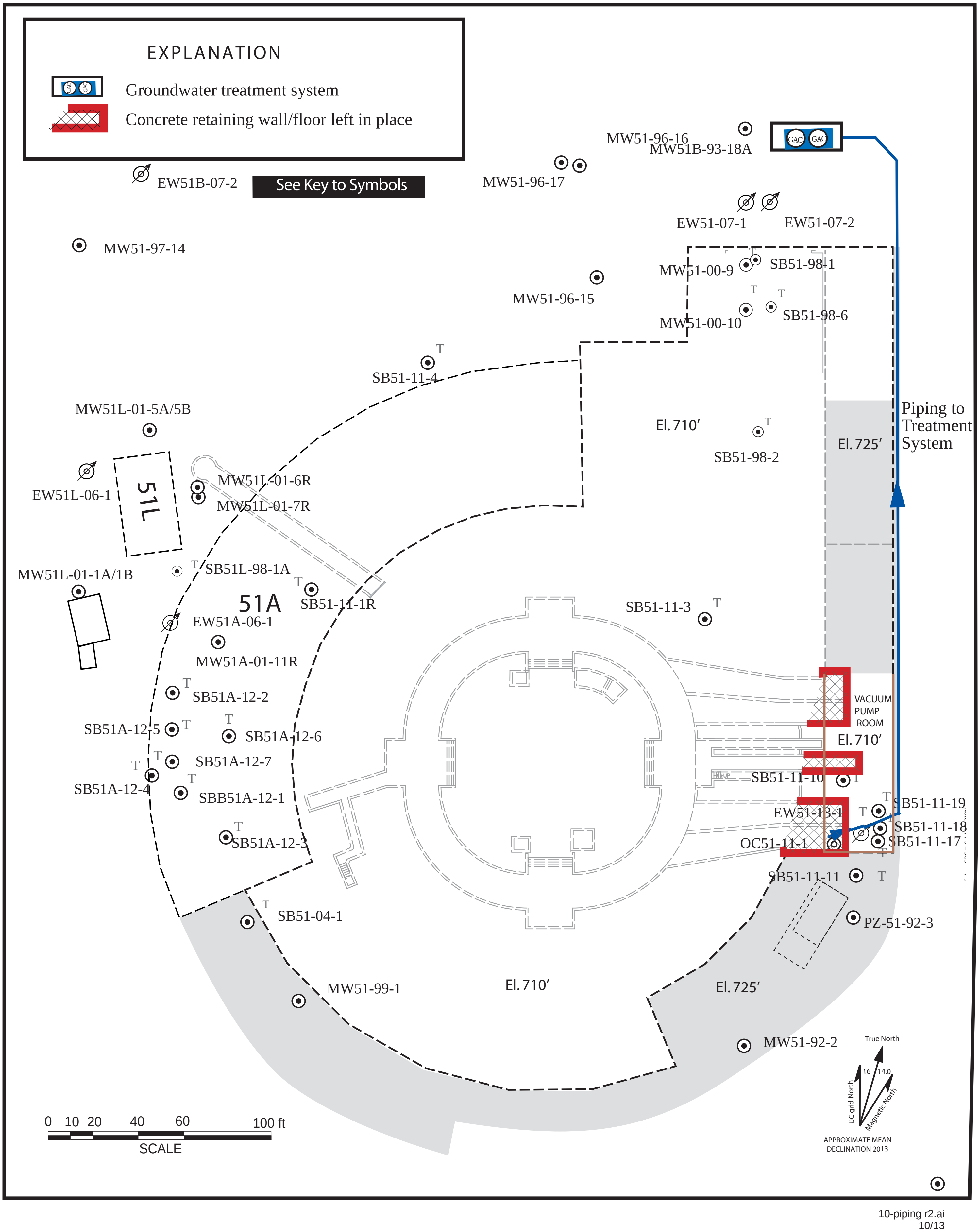
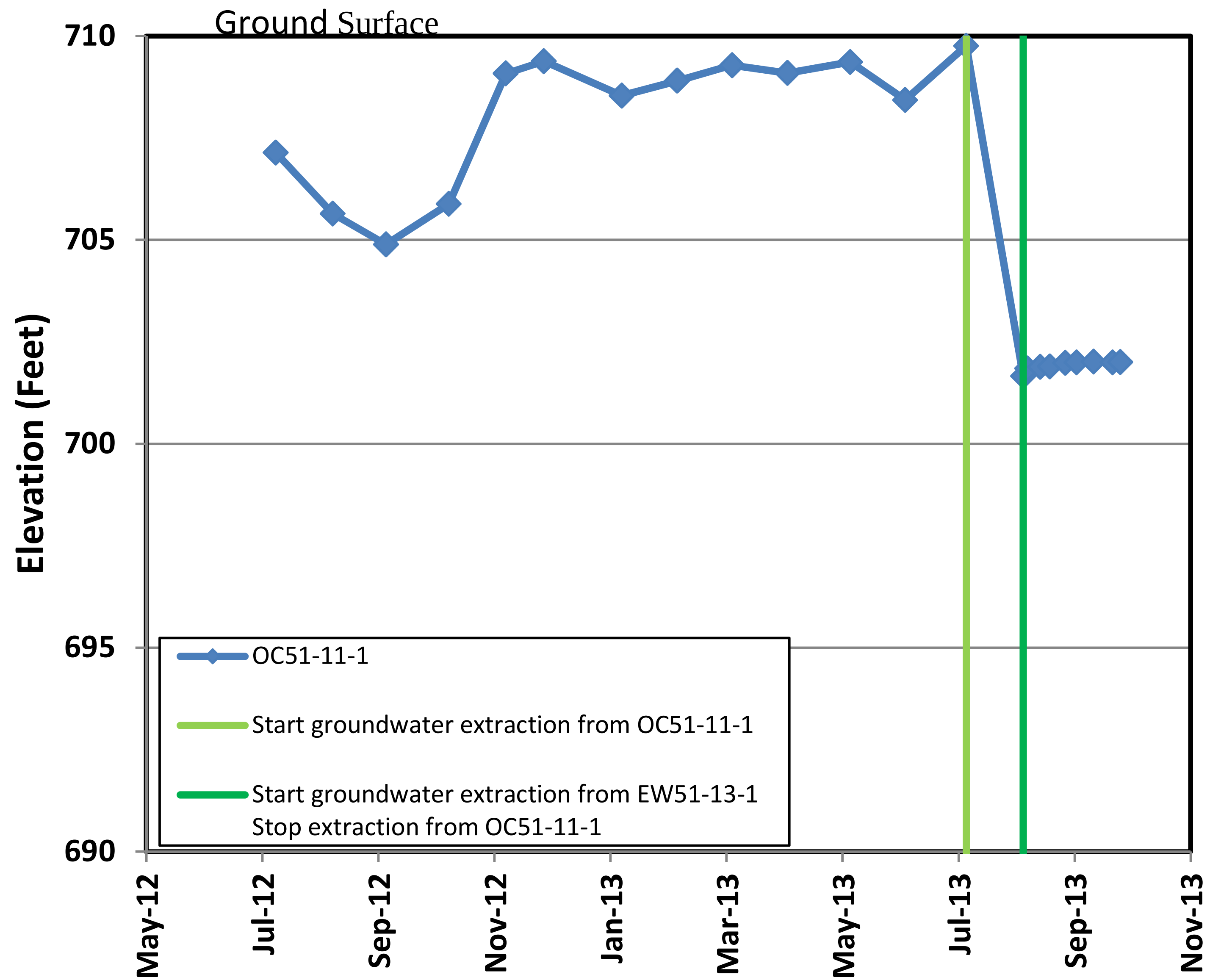


Figure 10. Configuration of Piping from Groundwater Extraction Well EW51-13-1 to Treatment System.

Figure 11. Hydrograph for OC51-11-1.



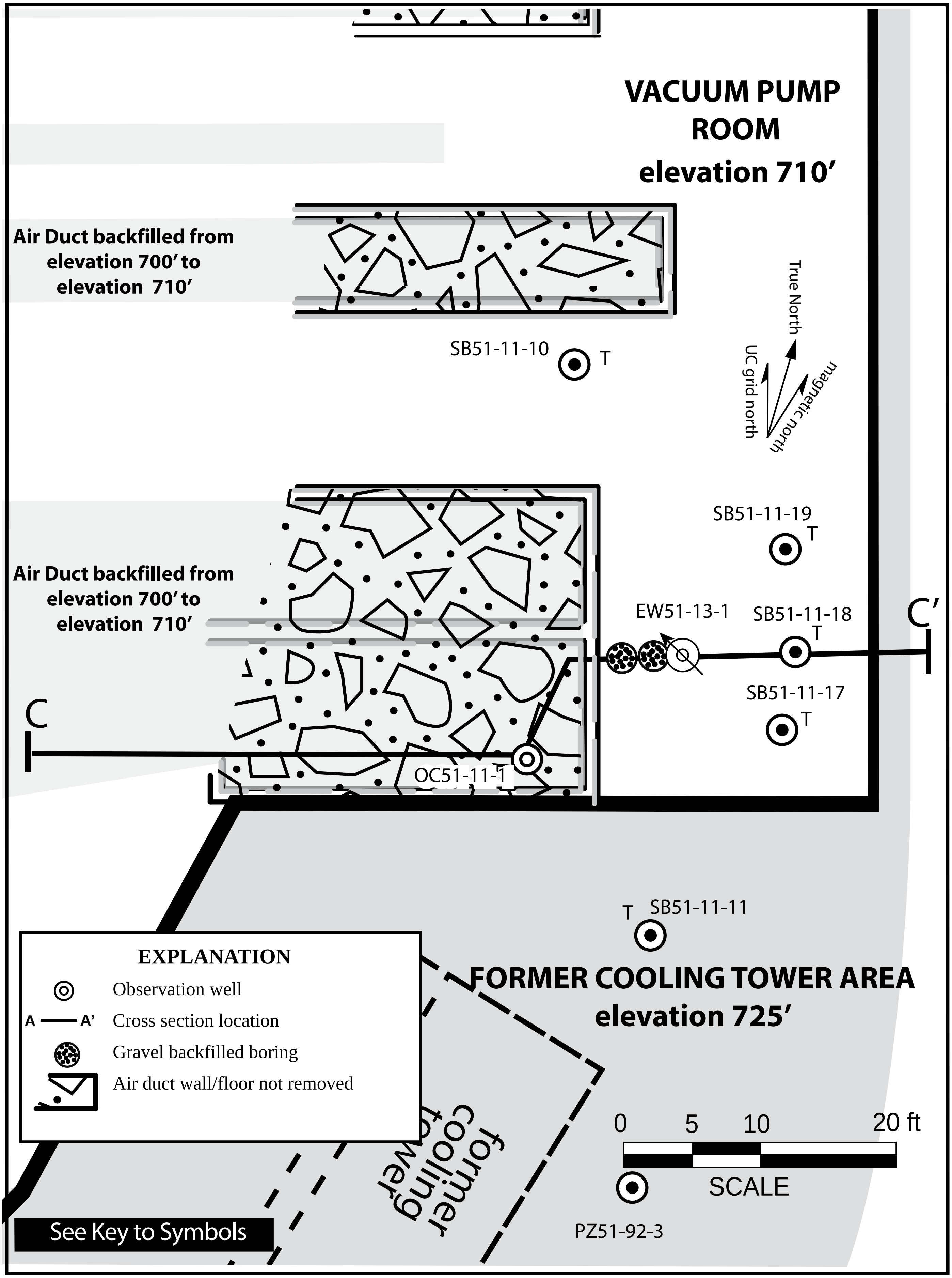


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Figure 12. Location of EW51-13-1, Vacuum Pump Room Area.

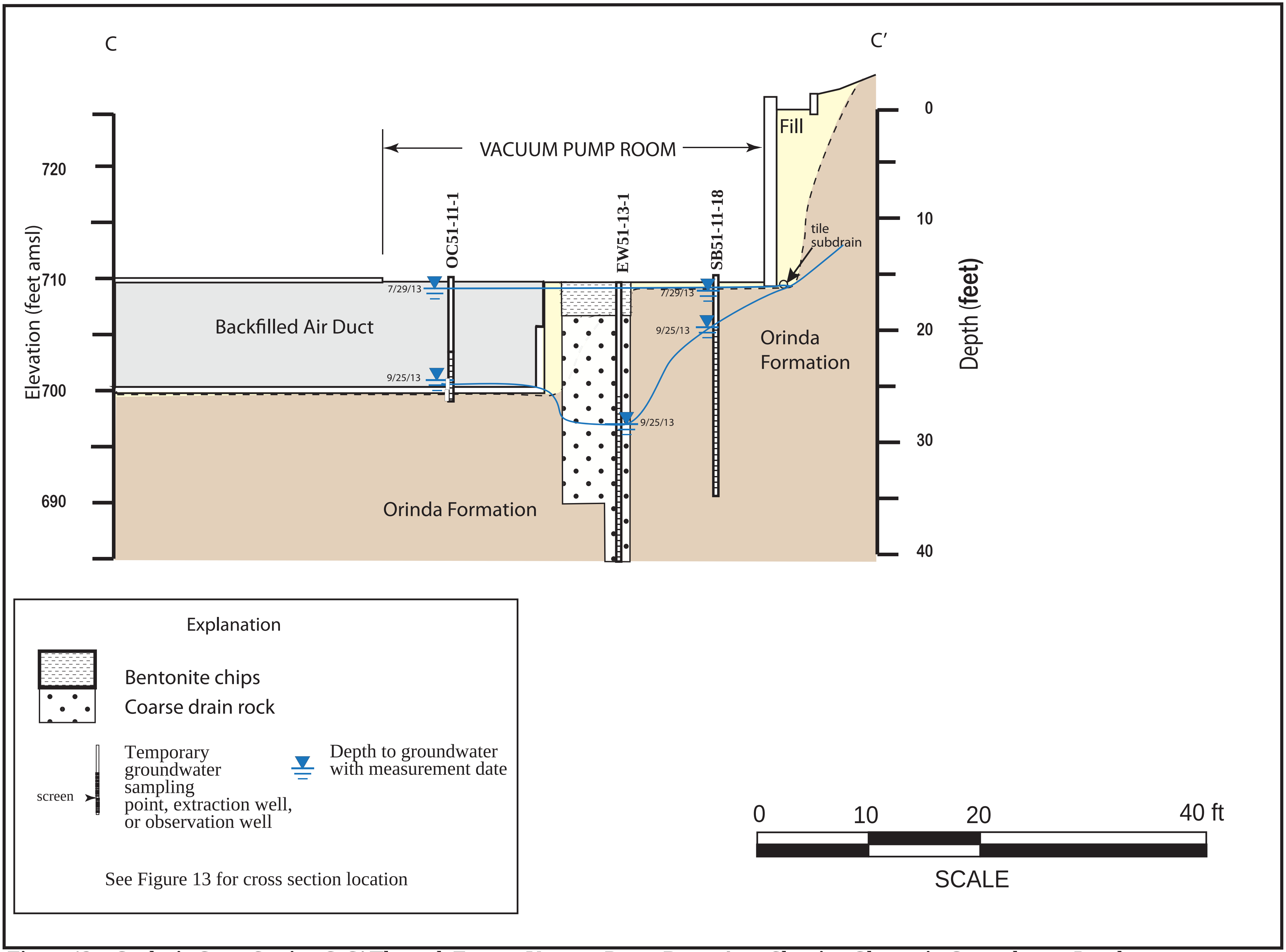

Figure 13. Geologic Cross Section C-C' Through Former Vacuum Pump Room Area Showing Change in Groundwater Level.

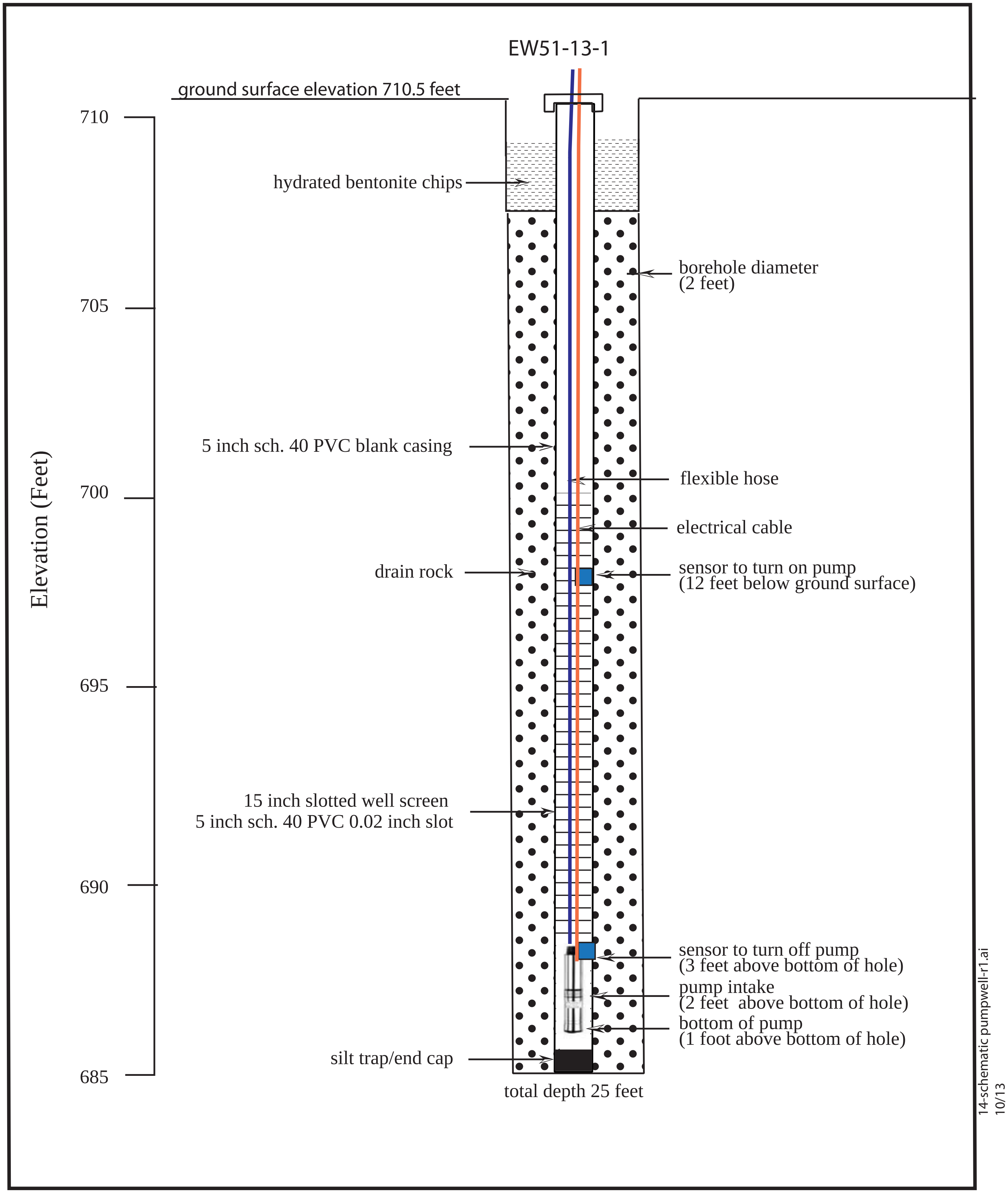

Figure 14. Groundwater Extraction Well EW51-13-1 Construction Details.

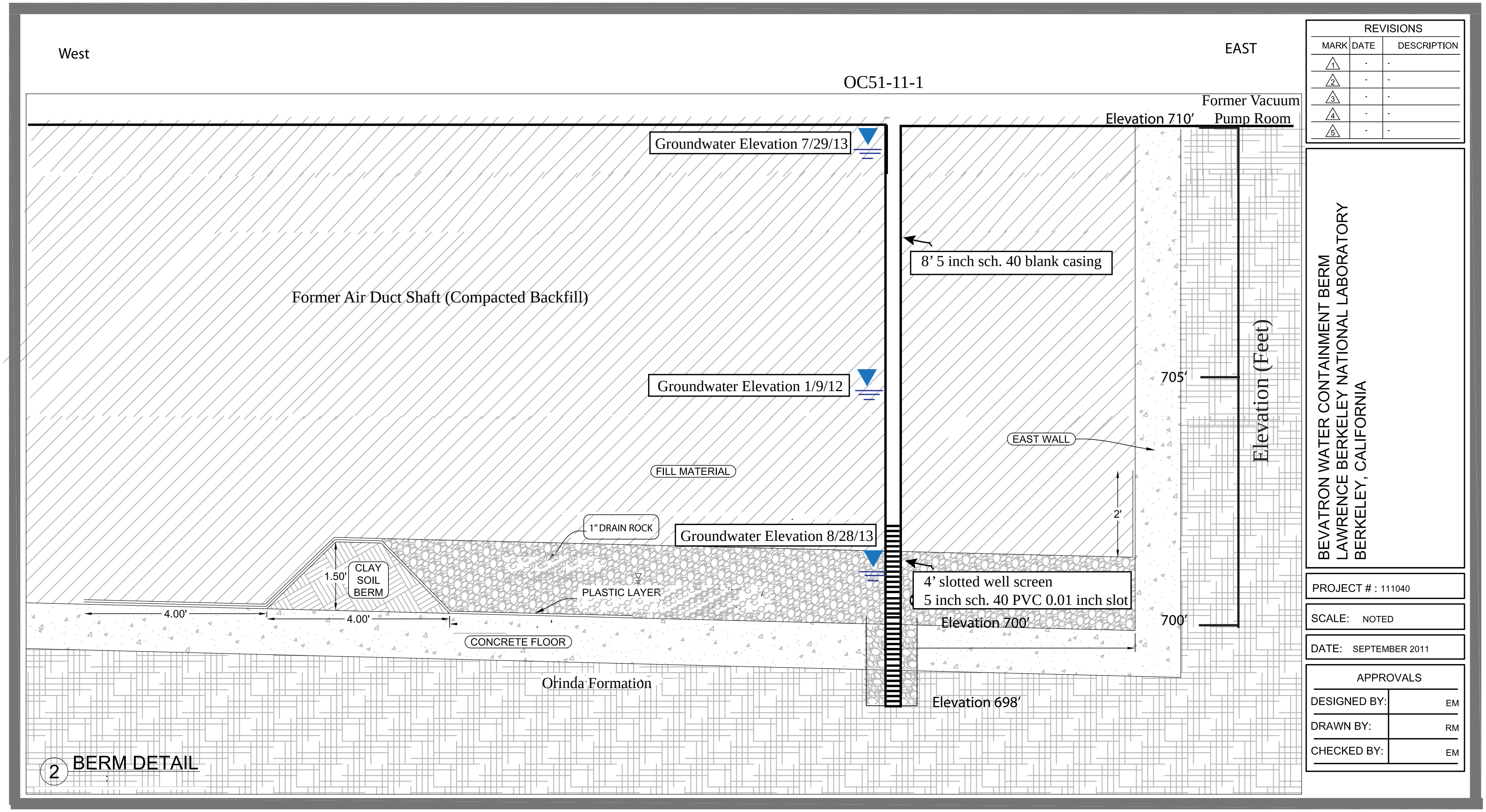

Figure 15. Construction Details and Groundwater Levels for Observation Well OC51-11-1.

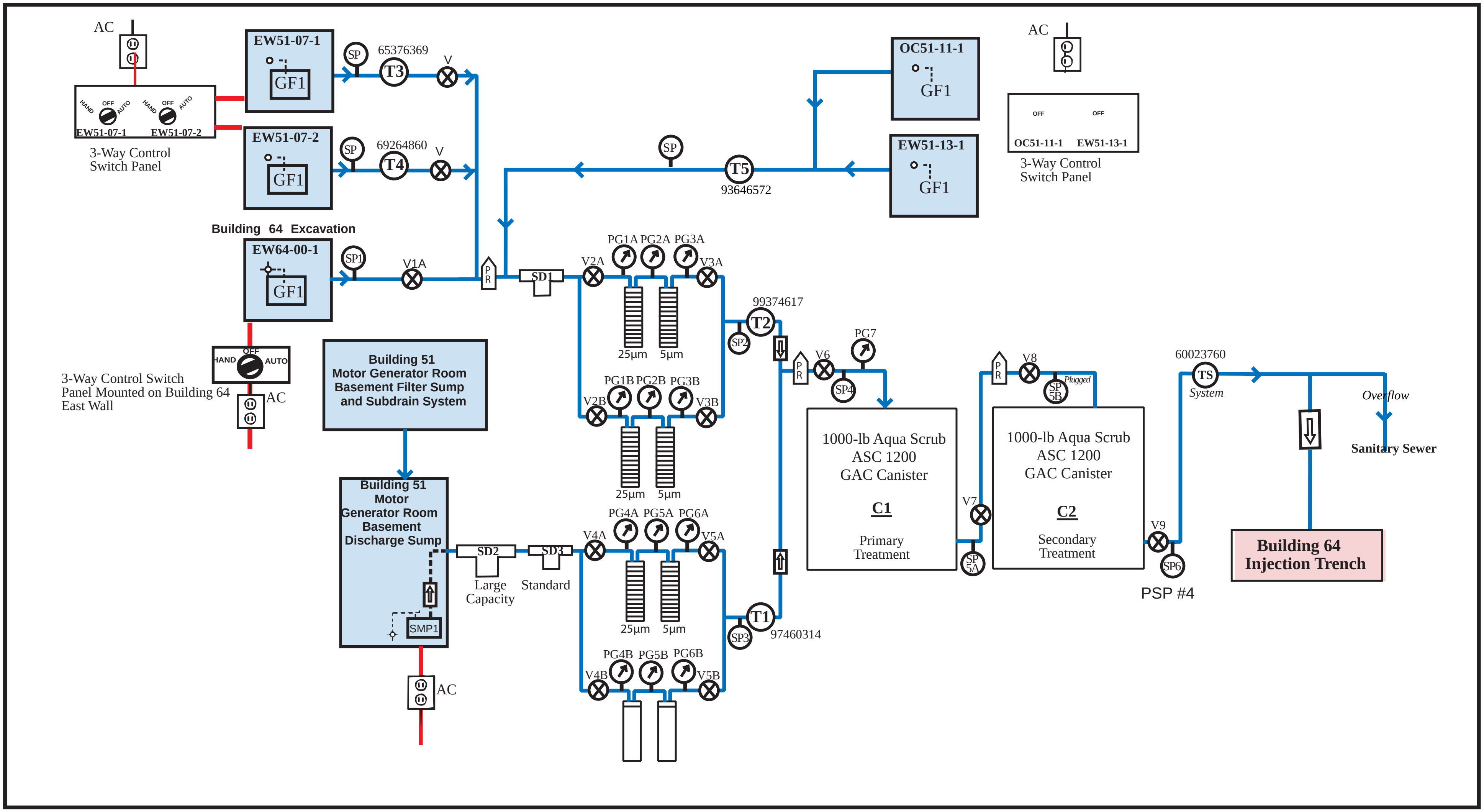

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Figure 16. Schematic Diagram of Building 51 Motor Generator Room Basement GAC Treatment System.

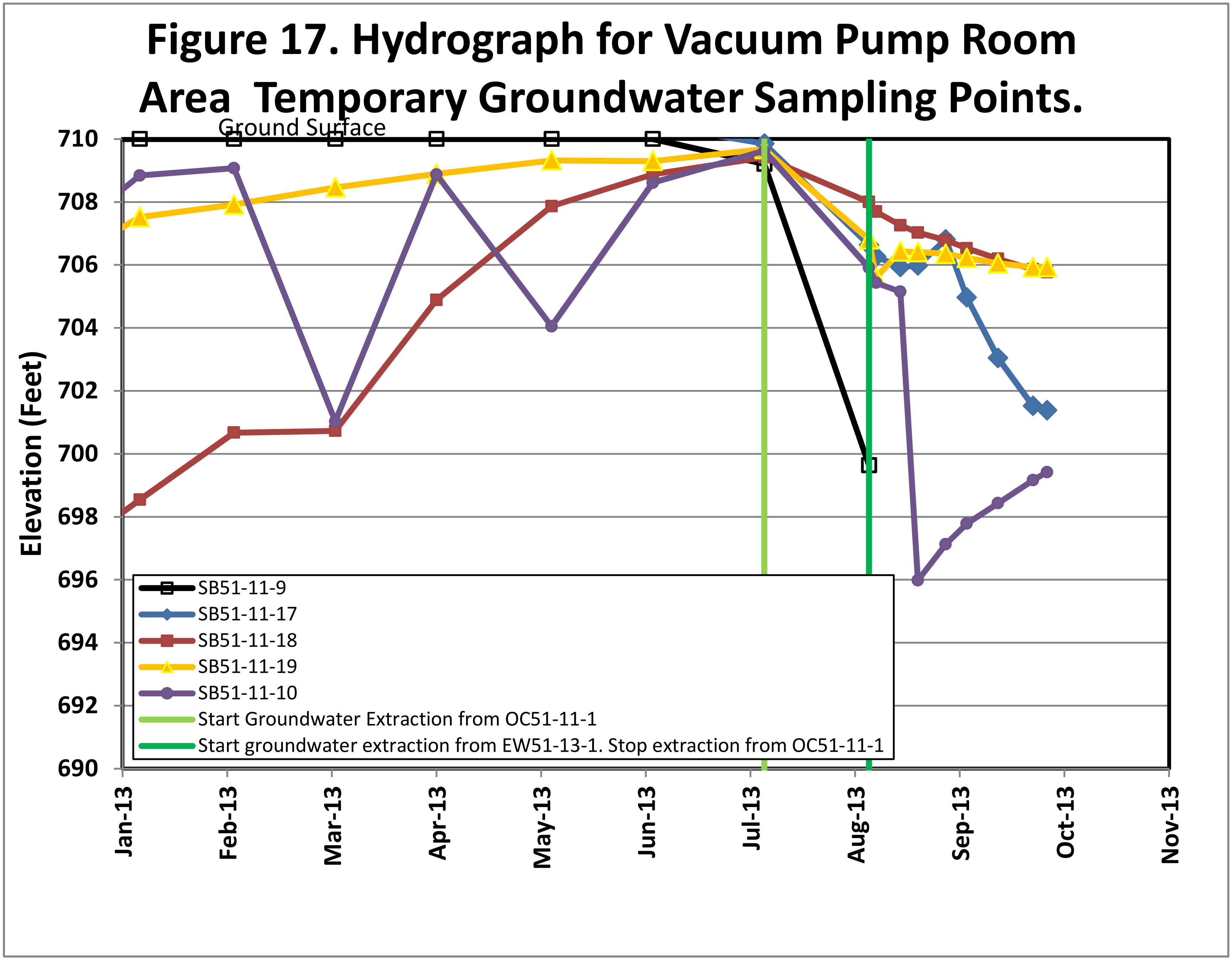

Figure 17. Hydrograph for Vacuum Pump Room Area Temporary Groundwater Sampling Points.
Ground Surface
Elevation (Feet)
710
708
706
704
702
700
698
696
694
692
690
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
SB51-11-9
SB51-11-17
SB51-11-18
SB51-11-19
SB51-11-10
Start Groundwater Extraction from OC51-11-1
Start groundwater extraction from EW51-13-1. Stop extraction from OC51-11-1

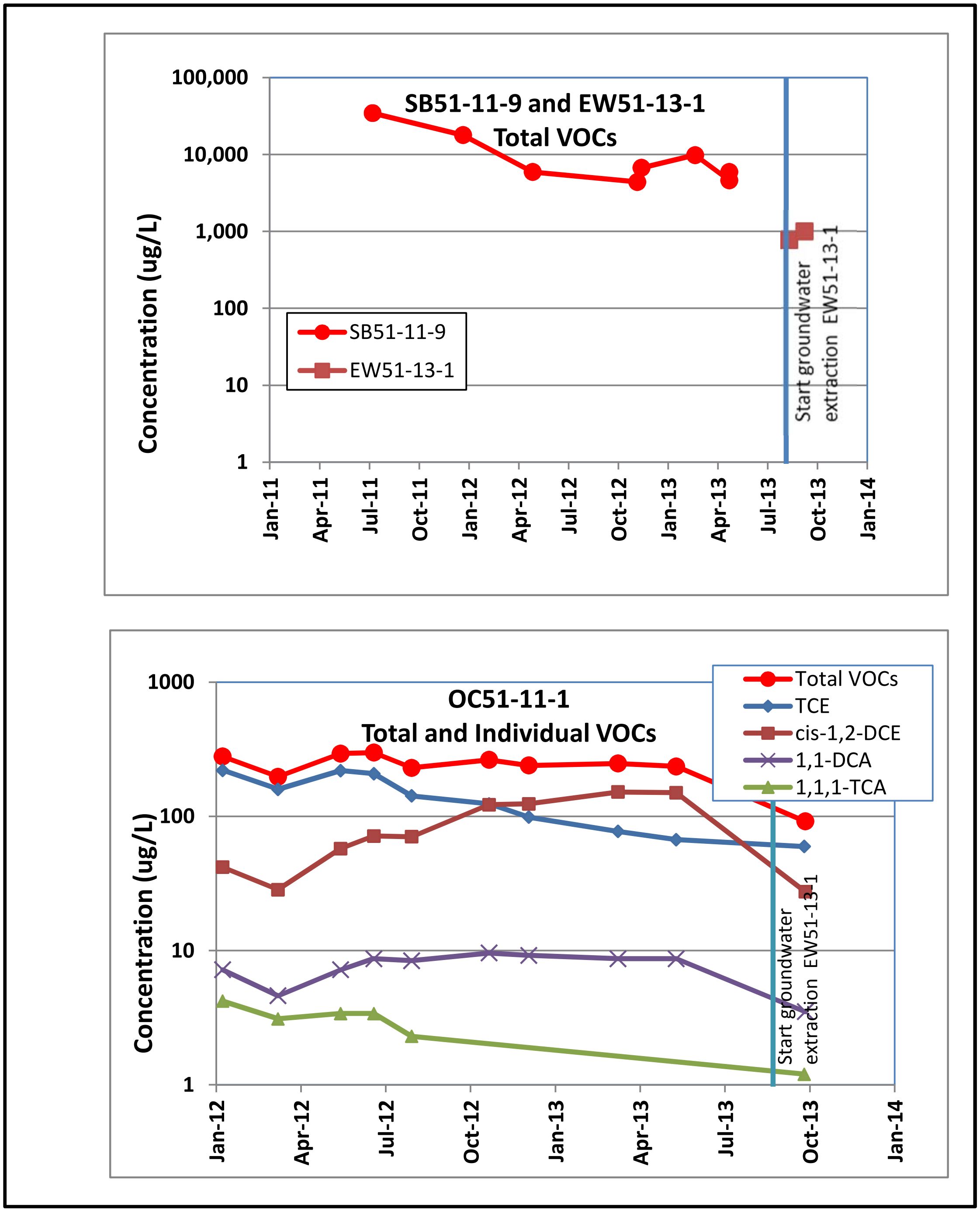

Figure 18. Concentration Trends for VOCs Detected in Groundwater-SB51-11-9, EW51-13-1, and OC51-11-1.