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SITE INVESTIGATION REPORT

CATCH BASIN NUMBER 3 AREA
ALISO CANYON NATURAL GAS STORAGE FIELD
NORTHRIDGE, CALIFORNIA

Prepared for

Southern California Gas Company
555 W. Fifth Street, 2nd Floor
Los Angeles, California 90013

Prepared by

Geosyntec Consultants, Inc.
16644 West Bernardo Drive, Suite 301
San Diego, California 92127

Project Number: SC0766/50

18 September 2020

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INTRODUCTION

In October 2019, the Saddleridge Wildfire passed through the Aliso Canyon Natural Gas Storage Field (Facility). Following the wildfire, a small flame was observed on the steep hillside located northeast of Catch Basin No. 3 (CB3 area; site) where no visible fuel (wood, shrubs, etc.) was present. The flame was extinguished by the Los Angeles County Fire Department (LACFD) on 15 October 2019 with LA County Health-Hazardous Materials Division (HHMD), South Coast Air Quality Management District (SCAQMD), and California Geologic Energy Management Division (CalGEM; formerly referred to as The California Department of Conservation; Division of Oil, Gas, and Geothermal Resources [DOGGR]) representatives present.

Following notification by Southern California Gas Company (SoCalGas) to numerous local and regional regulatory agencies, Geosyntec Consultants, Inc. (Geosyntec) was engaged to support an investigation into the cause of the flame at the site. Initial observations at the site focused on delineation and characterization of discolored, odorous soil at the ground surface. Concentrations of methane detected in shallow soil vapor indicated that the methane in the subsurface was the likely cause for the flame observed at the CB3 area.

Following the identification of methane in shallow soil vapor, a Workplan was prepared to delineate and characterize soil gas at the site and identify potential sources of the gases observed [Geosyntec, 2019a]. CalGEM provided comments on the Workplan, which included specific requests for documentation and additional investigations [CalGEM, 2019]. SoCalGas also conducted additional investigation activities based on interactions and input from the agencies which are incorporated and addressed in this report (Table 1). Activities performed by Geosyntec and SoCalGas to address CalGEM and other agency requests and complete this investigation included the following:

- Characterization and delineation of impacts to shallow soil;
- Evaluation of historical aerial photography;
- Site reconnaissance and evaluation of surface and subsurface (faulting, top of formation depths) geologic conditions;
- Evaluation of gas well construction details (perforation data, directional data, wellbore data, and well header data) in close proximity to the site;
- Routine monitoring of ambient air and subsurface methane concentrations;
- Routine monitoring of the surface emissions using a high-resolution Forward-Looking Infrared (FLIR) camera throughout the site investigation activities;

- Characterization and analysis of stable isotopes in soil gas at the study area and gas in nearby Facility gas wells;
- Surface geophysical surveys;
- Subsurface investigation using hand-augered borings, tri-pod drilled borings, and hydro-excavations;
- Assessment of recovered historical metallic debris;
- Quantification of surface emissions at the study area;
- Temporary depressurization of SoCalGas buried pipe and pressurized well annuli within ¼ mile of the site and monitoring of surface emissions using FLIR technology;
- Assessment of abandoned wells within ¼ mile of the site; and
- Evaluation of the cumulative data collected during these studies and preparation of this Investigative Report.

CONCLUSIONS

Based on the results from the studies performed during this investigation we conclude the following:

- Isotopic analyses of gas samples collected from soil vapor probes indicates that subsurface gas at the site is not Storage Zone gas. Rather, data indicate that the methane detected in soil vapor probes is associated with Shallow Gas and also has similarities to the Pliocene Gas Sand (PGS).
- Methane was observed to be originating from a natural subsurface seep in native material at a depth of approximately 16 to 18 feet below ground surface (ft. bgs). This seep was identified beneath a wooden/gunite structure that covers an area of about 10 feet by 10 feet that is overlain by undifferentiated, disturbed soil.
- Surface emissions measured during weekly monitoring events and the results of flux testing have determined that surface methane emissions from the site are stable, minor in nature, limited to the area in close proximity to the subsurface wooden structure, and do not pose a risk to the public or Facility personnel.
- Piping was encountered in the subsurface, protruding from the top of the subsurface wooden structure and into the large-diameter vertical excavations. This piping was not connected to SoCalGas infrastructure and methane was not leaking from any subsurface pipes in the CB3 area.
- Depressurization of gas piping and pressurized well annuli within ¼ mile of the site showed no effect on surface emissions at the site based on FLIR monitoring performed by

SoCalGas. These data further support that SoCalGas's infrastructure in this area is not the source of methane observed at CB3.

- Records for abandoned wells within ¼ mile of the site were reviewed and confirmed that the abandonment activities were performed in compliance with regulations at the time the work was conducted.
- The absence of significant concentrations of combustible gas in the barholes sampled at abandoned wells within ¼ mile of the site indicate that shallow gas is not migrating up the wellbore to the surface. Based on these results there is no evidence to indicate that shallow gas is migrating from these abandoned well locations to the site.
- A graded pad on the slope above the site was observed in a 1944 aerial photograph. Aerial imagery indicates that the grading activity to construct the pad covered the wooden/gunite structure, because it is not visible in the 1944 aerial photograph.
- It is believed that burial of the structure beneath these overburden materials significantly decreased surface emissions. These activities (installation of the subsurface structure, pad grading to the northeast of the site, and subsequent burial of the structure) pre-date SoCalGas's acquisition and operation of the Facility.
- Evidence indicates the subsurface wooden/gunite structure was constructed at the site sometime before 1944. Based on the presence of the subsurface structure and orientation of piping observed protruding from the top of the structure and in the excavations in the vicinity of the structure, it is believed that this structure may have captured and conveyed methane seeping from native soil at the site for reuse during operations associated with the oil field. After the structure was covered during grading activities for the pad at the top of the slope, and subsequent landslide(s) occurred on the hillside, this underground seep location remained unidentified until the October 2019 Saddleridge Wildfire due to the relatively small area where measurable emissions have been documented, and its remote location in a generally inaccessible area on a steep hillside.
- The geophysical surveys identified a potential metallic line trace trending generally northwest-southeast at the site, which led to the advancement of hydro-excavations in this area. Geophysical surveys of the roadway above CB3 identified shallow abandoned buried pipes, though no evidence of pipelines or subsurface structures (e.g., well casings, vaults, or sumps) were identified on the pad above CB3.
- The impacted soil at the CB3 area was not the fuel for the flame observed in October 2019. The extent of impacted soil has been approximately defined and it does not pose a risk to the public or Facility personnel.

RECOMMENDATIONS

Oil and natural gas seeps are prevalent in areas of California proximal to underground oil and natural gas reservoirs. Likely the most well-known seep in the Los Angeles area is located at the La Brea Tar Pits in Hancock Park. At the La Brea Tar Pits, thermogenic gas is continuously emitted from the ground surface at a rate exceeding 180 metric tons per year[1] [Etiope, G. et. al, 2017].

There is no known precedent for mitigation of naturally occurring gas seeps in areas where no development has occurred or is planned. Based on the historical presence of the subsurface natural gas seep at the site, the absence of any buildings or planned construction in this area (due to its remote location on a historical landslide on very steep terrain), and the small volume of methane emissions from the ground surface, containment or capture scenarios appear unwarranted and infeasible.

Due to the ground disturbing investigation activities performed at the site to date, the known instability of the surrounding area, and the upcoming rainy season, we recommend the following actions:

- Restoring the site (backfill open excavations, remove shoring, and investigation-related equipment);
- Stabilizing the disturbed area (using traditional stormwater Best Management Practices [BMPs] including coconut-straw blanket, fiber rolls, and hydraulic mulch);
- Monitoring of site conditions for necessary BMP modifications/repairs through the rainy season; and
- Restricting site access by Facility personnel via institutional controls and signage.

[1] - Methane emission rates for the La Brea Tar Pits were measured at approximately 500 Kilograms per day; results were converted to metric tons per year by dividing the mass/time by 2.74.

1 INTRODUCTION AND OBJECTIVES

Geosyntec Consultants (Geosyntec) has prepared this Site Investigation Report (Report) on behalf of Southern California Gas Company (SoCalGas) to summarize activities conducted to evaluate the hillside east of the Catch Basin No. 3 area (CB3; site) at the Aliso Canyon Natural Gas Storage Field, located in Northridge, California (Figure1). This work was performed in accordance with the 25 October 2019, Site Characterization and Remediation Work Plan (Workplan, and subsequent addenda [Geosyntec, 2019a, 2019b, 2020a]).

Investigative activities performed at the site focused on identifying the source of fuel for a flame observed at the site following the Saddleridge Wildfire in October 2019. The Saddleridge Wildfire began on 10 October 2019 and burned vegetation across portions of the Facility. After the wildfire activity at the Facility had ceased, an area estimated to be approximately 15 to 20 square feet (sq. ft.) located on a steep hillside near CB3 continued to burn (herein referred to as the "former flame"; Figure 2). The flame did not have any visible fuels to sustain combustion, such as vegetation or woody debris, and no visible smoke could be observed.

SoCalGas notified the Los Angeles County Fire Department (LACFD), LA County Health-Hazardous Materials Division (HHMD), South Coast Air Quality Management District (SCAQMD), California Geologic Energy Management Division (CalGEM), the County of Los Angeles Department of Public Health (DPH), California Governor's Office of Emergency Services (CalOES), and the California Public Utilities Commission (CPUC). Various agencies mobilized personnel to observe site conditions near CB3 and conduct preliminary evaluations. The flame was subsequently extinguished by LACFD on 15 October 2019 using an estimated volume of less than 50 gallons of water. Since that time, no indications of reignition have been identified or reported.

Following extinguishment of the flame, SoCalGas submitted the initial investigation Workplan to various agencies for review [Geosyntec, 2019a]. CalGEM issued a letter to SoCalGas dated 5 November 2019, which included specific requests to support the evaluation of the site and safe implementation of the Workplan [CalGEM, 2019]. SoCalGas also conducted additional investigation activities based on interactions and input from the agencies which are incorporated and addressed in this report. A summary of these requests and the sections of the Report where information responding to these requests can be located is provided in Table 1.

The objective of this Report is to document the activities and findings from the investigations performed to evaluate the cause/source of the fuel for the former flame observed at the site. This Report has also been prepared to address the requests made by CalGEM to SoCalGas and to incorporate a summary of work performed directly by SoCalGas.

2 PRE-FIELD ACTIVITIES

2.1 AGENCY COORDINATION

Various agency personnel had a consistent onsite presence during the investigation. Geosyntec prepared weekly summaries documenting the activities from the prior week; forecasts for upcoming field activities; and included a schedule for implementation of the Workplan (and addenda). These summaries were submitted by SoCalGas to HHMD, CalGEM, DPH, CPUC, SCAQMD, and the California Air Resources Board (CARB) during the investigation and discussed during routine conference calls with the agencies.

2.2 WORKPLAN PREPARATION

On 25 October 2019, a Workplan for site evaluation was prepared while preliminary field assessments were ongoing [Geosyntec, 2019a]. Following initiation of the Workplan, and identification of elevated concentrations of methane in the subsurface, modifications to the scope of work were deemed warranted due to an evolving understanding of the conditions at the site. Addendum # 1 to the Workplan was prepared to outline the planned approach for delineation of soil and soil vapor impacts and submitted to SoCalGas on 14 November 2019 [Geosyntec, 2019b]. Based on the results of the initial soil, soil vapor, and ambient air sampling, Workplan Addendum # 2 was prepared to describe the procedures for conducting targeted excavation on the hillside and was submitted to SoCalGas on 25 February 2020 [Geosyntec, 2020a].

2.3 HEALTH AND SAFETY PLAN PREPARATION

Prior to commencing field activities, Geosyntec updated the existing site-specific health and safety plan (HASP) utilized for ongoing work at the facility so that site personnel were informed of the site-specific hazards, and to address the specific scope of work during various phases of investigation activities being conducted at the site [Geosyntec, 2019c]. CalGEM's 5 November 2019 letter to SoCalGas included a request for immediate implementation of site-specific safety procedures for the investigation and remediation phases of the Project. A revised HASP to address safety concerns throughout all potential activities performed during the investigative process was submitted to CalGEM on 13 December 2019 [Geosyntec, 2019d].

3 INVESTIGATIVE EFFORTS

A study was performed to determine historical site operations and evaluate suspected slope instability at the CB3 area in support of investigation activities. The study included reviewing readily available historical aerial photos, LiDAR Digital Elevation Model (DEM), processed hill shade imagery, and published geologic maps of the immediate site area. In addition to these activities SoCalGas also performed a review of records including an assessment of aerial surveys, well construction and abandonment details, and subsurface geology (including, but not limited to faulting, top of formations, etc.).

3.1 HISTORICAL FACILITY OPERATIONS

The area that is currently the Aliso Canyon Natural Gas Storage Field was originally developed for oil production in the 1930s and 1940s. In 1972, SoCalGas acquired and converted the Facility to natural gas storage.

Utilizing our understanding of historical site occupation and usage, an evaluation was performed to identify and assess historical activities in the vicinity of the CB3 area to assist in the evaluation and identification of potential source areas or potential causes for the former flame observed on the hillside. The evaluation included a review of online databases (such as CalGEM's online database "Well Finder"), documents provided by SoCalGas, geologic maps, and aerial photographs. Additionally, a field assessment of the surface geology in the immediate vicinity of CB3 was performed to assess potential preferential migration pathways and geohazards at the site.

3.2 HISTORICAL AERIAL PHOTOGRAPHY REVIEW

Geosyntec reviewed publicly available resources, including historical aerials of the site from 1930, 1938, 1944, 1956, 1960, and 1971 [UCSB, 2019]. Online aerials dated 1947, 1952, 1959, 1964, 1969, 1972, 1977, 1980, 1994, and annually from 2002 to 2019 were viewed on Google Earth™, and Historic Aerials.com [Google Earth™, 2019; Historic Aerials, 2019]. In addition to these resources, existing high-resolution aerial photography was also acquired for the site from Environmental Data Resources (EDR) and reviewed as part of this study [EDR, 2020]. Annotated historical aerials with depiction of key site features pertinent to this investigation are provided on Figures 3 through 5.

Based on review of the available aerial photographs, initial grading activities associated with early site development occurred within the immediate area between 1938 and 1944 to create a pad above the site along with associated access roads. The 1944 aerial photograph depicts a derrick situated on a graded pad at the top of the slope. The site appears devoid of vegetation with visible erosional rilling extending down slope across the current investigation area. Observations of the significant erosional rilling suggests that cut materials from the construction of the pad were likely pushed out onto the adjacent steep hillside and mechanized compaction of the slope material was unlikely. By 1956, aerial images indicate evidence of slope instability in the material placed over the hillside at the site. By 1959, a black rectangular feature (estimated to be approximately 55 ft. wide by 220 ft. long) appears on the pad (potentially a sump). The derrick and the potential sump are no longer visible in the 1964 aerial photograph. More recent aerials from the 2000's identify the pad as a soil stockpiling area.

Based on a geomorphic evaluation of the LiDAR hill shade from the available DEM data [USGS, 2018], the investigation area is underlain by an area of suspected slope instability that originated post-development of the pad at the top of the slope (Figure 6). Indications of pre-existing slope instability are not apparent on the 1930 aerial photograph; however, the post-1944 aerials, along with LiDAR imagery, indicate a large amphitheater-shaped scarp with hummocky surface conditions suggesting downslope movement of the fill material that was pushed out onto the slope.

3.3 GEOLOGY AND ENGINEERING HAZARDS REVIEW

On 20 December 2019, Geosyntec performed a visual reconnaissance of the site to evaluate the observed geomorphic slope features identified during the desktop evaluation (Figure 7). During the site reconnaissance, several large slump blocks were observed approximately 20 to 35 ft. downslope of the former pad area. Within the displaced blocks, sheared metal pipes and localized laterally continuous sections of an old, weathered asphalt surface were observed. It is presumed that this asphalt surface was at one point associated with prior activities on the pad at the top of the slope and suggests previous downslope movement of the loosely consolidated fill material along the southwestern edge of the pad.

Results from the geologic reconnaissance and study identified that the surficial geology at the site consists of the upper sandstone unit of the Miocene age Topanga Formation. Locally, this unit is associated with an anticlinal structure plunging generally to the east-southeast and abutted to the (younger) lower unit of the Modelo Formation (Monterey Shale), also of Miocene age. While the mapped surficial geology indicates an anticlinal structure, the occurrence of thrust faults surrounding the CB3 area and the presence of vertical and overturned bedding in the Modelo Formation south of the site suggest a more complex structure.

Previously mapped landslides within the immediate site area are not shown on the regional geologic map [Dibblee and Ehrenspeck, 1992] (Figure 8); however, based on data obtained during the evaluation and site reconnaissance, the site is underlain by areas of suspected slope instability which originated from the development of a graded pad at the top of the slope in the late 1930s or early 1940s. Historical aerial photographs and surficial slope conditions suggest cut materials from grading of the pad were pushed out onto the steep hillside, likely with minimal or no compaction. Sections of abandoned metal pipes and asphalt observed along the edges of the former pad were also found downslope in large displaced slump blocks indicating episodic downslope movement occurred following development of the pad.

Subsequent progressive erosion of the disturbed ground has resulted in a mantle of loose material blanketing the slope face and the formation of a fine talus deposit near the slope toe over time. Although evidence suggests recent slope instability occurred as a result of historical site activities, the current state of instability or rate of downslope movement at the site is unknown based on the available information at this time.

4 FIELD ACTIVITIES

4.1 AMBIENT AIR SAMPLING

Three air samples were collected at the site by Geosyntec personnel on 15 October 2019 from the CB3 area (Figure 9). Sample locations included the area of the former flame (collected 3-inches above the ground surface), at the base of the hill (downwind), and at the top of the hillside near the access road (upwind). The ambient air samples were collected in 1-liter Summa canisters using dedicated flow controllers calibrated by the analytical laboratory at a flow rate of 200 milliliters per minute (mL/min). Air samples were transported under standard chain-of-custody protocol to Eurofins Air Toxics Inc. (Eurofins) in Folsom, California for the following suite of analysis (Table 2):

- VOCs by United States Environmental Protection Agency (EPA) Method TO-15; and
- Fixed Gases by Modified American Society for Testing and Materials (ASTM) D-1946.

4.2 SOIL SAMPLING

Soil sample collection was initiated by Geosyntec in the vicinity of the former flame (following it being extinguished) on 16 October 2020. The shallow soil sampling was performed to assess the potential source of fuel for the former flame and identify COCs in the apparently impacted material (Figure 10).

On 16 and 22 October 2019, 4 and 5 November 2019, and 6 February 2020, Geosyntec personnel collected shallow soil samples at the site from the ground surface and at varying depths to define the lateral and vertical extent of the visually impacted material. Bedrock exposures are present both above and along the margins of the small drainage where impacted soils were identified. Use of field meters (photoionization detector [PID]), and visual and olfactory indicators of impacts were used to qualitatively assess the limits of the impacted soil. A total of 21 soil samples were analyzed for one or more of the following constituents (Table 3):

- VOCs by EPA Method 8260B;
- Extended range TPH (carbon range C6 to C44) by EPA Method 8015B;
- Semi-Volatile Organic Compounds (SVOCs) by EPA Method 8270C;
- Metals by EPA Methods 6010B/7471A;
- Polychlorinated Biphenyls (PCBs) by EPA Method 8082;
- Polycyclic Aromatic Hydrocarbons (PAHs) by EPA Method 8270SIM;
- Ignitability by EPA Method 1010A; and
- Dioxins and Furans (D&Fs) by EPA Method 8290.

4.3 SOIL VAPOR PROBE INSTALLATION AND SAMPLING

A total of 11 soil vapor probes (SVPs) were installed on the hillside to assess the source of methane and evaluate the subsurface concentrations of VOCs (Figure 11). SVPs were installed using a hand-auger or tri-pod drill rig and were constructed in accordance with the Department of Toxic Substances Control (DTSC) "Advisory for Active Soil Gas Investigations" dated July 2015 (Advisory). Soil vapor sampling and testing procedures were conducted in general accordance with the Advisory. SVP IDs and screened intervals are provided below:

Soil Vapor Probe ID	Screened Interval (ft. bgs)
SVP-1	4.5 to 6.0
SVP-1A	1.0 to 2.0
SVP-2	4.5 to 6.0
SVP-2A	1.0 to 2.0
SVP-3	4.5 to 6.0
SVP-4-2	1.0 to 2.0
SVP-4-5	3.5 to 5.0
SVP-5	9.0 to 10.5
SVP-6	16.0 to 17.5
SVP-7-12	10.5 to 12.0
SVP-7-21	19.5 to 21.0

During field screening, differential pressures in the probes were measured using a hand-held manometer followed by the purging of three "dead space" volumes from each probe using a Landtec GEM5000 gas analyzer prior to recording of field data. Following purging, oxygen, carbon dioxide, carbon monoxide, hydrogen sulfide and methane (using the gas analyzer) and VOC concentrations (using a PID) were recorded.

Soil vapor samples for laboratory analysis were collected in 1-liter Summa canisters, 1-liter flex foil®, or 1-liter Tedlar® air sample bags. In addition to the primary soil vapor samples, one equipment blank was collected, and a laboratory provided trip blank accompanied sample media throughout testing and submittal to the laboratory for analysis. Soil vapor samples were collected from probes SVP-1, SVP-2, SVP-3, SVP-4-5, SVP-5, and SVP-6 and submitted for the following analyses (Table 4):

- Hydrocarbon & Total Gaseous Non-Methane Organics by EPA Method TO-3 Modified;
- VOCs by EPA Method EPA TO-15;
- Fixed Gases by ASTM D 1946-90;
- Sulfur Compounds by ASTM D 5504-12; and
- Helium by EPA Method 3C Modified.

4.4 FACILITY GAS WELL SAMPLING

Between 22 October and 20 November 2019, 9 samples were collected from Facility gas wells for laboratory analysis[2]. These samples were collected to aid in identifying the potential source of methane detected in soil vapor probes in the CB3 area. The sample locations and zones which they represent is summarized below:

Sample Location	Representative Zone/Area
P-50B Tubing and FF38-ABC-WDHEADER	Storage Zone Gas
FF-11 Tubing	Shallow Zone Gas - Oil Production Zone
FF37-A2, FF32H-A1, FF32G-A1, and P50B-A1	Shallow Gas
P50A-TUBING	Pliocene Gas Sand (PGS)

The gas samples collected by Geosyntec and SoCalGas were analyzed for the following constituents (Table 4):

- Hydrocarbon & Total Gaseous Non-Methane Organics by EPA Method TO-3 Modified;
- VOCs by EPA Method EPA TO-15;
- Fixed Gases by ASTM D 1946-90;
- Sulfur compounds by ASTM D 5504-12; and
- Helium by EPA Method 3C Modified.

4.5 STABLE ISOTOPE ANALYSIS

On 20 November 2019, 9 gas samples were collected from the Aliso Canyon Gas Storage facility; three from the SVPs installed at CB3 and six from the well casings associated with depth-specific gas bearing formations (Figure 12). The locations selected for stable isotope analysis and their associated gas zones are provided below.

[2] Analytical results from the gas sample collected from Gathering Plant Tank T-15 is not presented herein because it is not a representative sample of Shallow Gas or Storage Zone gas.

Sample Location	Representative Zone/Area
SVP-1, SVP-2, and SVP-5	Shallow Soil Vapor Probes
FF38-ABC-WDHEADER	Storage Zone Gas
FF37-A2, FF32H-A1, FF32G-A1, and P50B-A1	Shallow Gas
P50A-TUBING	PGS

The gas samples were submitted to Isotech of Champaign, Illinois for air-free compositional analysis and stable isotope testing (Table 5).

4.6 HAND AUGER AND TRI-POD BORINGS

Twenty-four borings were advanced throughout the site to investigate the source of methane emissions in the area of the former flame (Figure 13). With exception of the borings advanced with the tri-pod auger rig (borings SB-1 and SB-2), the borings were advanced using a 3-inch hand auger to facilitate lithologic logging, soil sample collection, and characterization of visually impacted soil.

In early January 2020, tri-pod drilling equipment was mobilized to the site to advance a boring to a depth of up to 50 ft. bgs or refusal (whichever occurred first) to assist in the ongoing evaluation of the source of the subsurface gas at the site.

An obstruction was identified during the drilling of the first boring at approximately 12.5 ft. bgs. An industrial strength magnet and metal detector lowered down the open boring confirmed the subsurface feature was metallic.

To support delineation of this feature, hand auger borings were advanced on both the western (HA-1) and eastern (HA-2) sides of the drilled boring where the metallic object was originally identified. While the eastern hand auger boring (HA-2, 2 to 3 ft. away) did not encounter this feature, the hand auger boring advanced immediately west of the drilled boring (HA-1) did encounter refusal at a depth of approximately 12 ft. bgs and appeared to have more directly intercepted the buried object. Assessment with the metal detector again provided confirmation of a metallic feature.

Acrylonitrile-Butadiene-Styrene (ABS) pipe was installed in both borings where the buried object was encountered to maintain the integrity of the open hole and support the evaluation of the feature with an intrinsically safe push-camera. The hand auger boring that did not encounter this feature was backfilled with bentonite and hydrated. Based on the video surveys conducted, information on the characteristics and orientation of the subsurface object was not discernible; however, water in the bottom of the boring (added to clean off the boring sidewalls) was observed to bubble intermittently, indicating the presence of subsurface emissions.

Tri-pod drilling of a second-deep soil boring (SB-2) was attempted from 22 to 24 January 2020. Difficult drilling conditions were encountered at approximately 21.5 ft. bgs where more competent geologic material was encountered, causing refusal. There were no indications that refusal was being caused by a subsurface obstruction or metallic feature. A dual-nested SVP was installed in soil boring SB-2 on 24 January 2020 and re-named to SVP-7 with screened intervals at depths of 12 ft. bgs (SVP-7-12) and 21 ft. bgs (SVP-7-21).

ABS casings were installed in five hand auger borings (HA-1, HA-5, HA-7, HA-8, HA-9) where elevated methane or indications of low-pressure gas were observed. A summary of findings from advancement of the hand auger and tri-pod borings is provided in Table 6.

4.7 GEOPHYSICAL SURVEYS

An initial surface geophysical survey conducted at the site on 18 November 2019 was inconclusive in identifying features of interest in the immediate study area. In a localized area above the former flame, hand-auger borings encountered refusal at depths of approximately 9.5 to 12.5 ft. bgs on subsurface objects, some of which were metallic. Following identification of these features and in consultation with the geophysical contractor on their capabilities to connect to, and trace the subsurface metallic objects, a second geophysical survey was performed.

The geophysical subcontractor mobilized to the site on 27 January 2020 to perform a more comprehensive geophysical survey along the hillside at CB3 and the pad at the top of the slope. The 3-day supplemental geophysical survey was completed on 29 January 2020, and included the following:

- Line tracing of the metallic subsurface objects;
- A detailed magnetometer survey on the slope face; and
- A sting resistivity survey on the pad at the top of the slope.

Line tracing was performed by connecting to the metallic objects encountered in borings HA-1 and HA-3 and inducing a traceable signal, which provided preliminary indications of a linear metallic object traversing across the slope in a generally northwest/southeast trend (Figure 13). Though line tracing appeared successful in the immediate area, signals dissipated a short distance beyond the area of impacted soil to the southeast. The findings from the geophysical survey were utilized to enhance the understanding of subsurface conditions on the hillside and provide additional information for an appropriate location to advance the hydro-excavation shafts described below. Surveys conducted on the pad above CB3 did not identify evidence of a sump or subsurface well casing in that area. The comprehensive geophysical reports with interpretations by a licensed Professional Geophysicist are included as Appendix B of this Report.

4.8 HYDRO-EXCAVATION ACTIVITIES

Nine hydro-excavations (Figure 13) were advanced at the site by applying a waterjet to break up soil and a high-pressure vacuum from a guzzler truck to remove the soil and advance the excavation. The hydro-excavations were advanced utilizing Sonotube® form materials, or corrugated HDPE pipe, to stabilize the upper 4 to 6 ft. of the excavations, which ranged in diameter from 24 to 60 inches. A summary of the hydro-excavations and notable findings is provided below. Generalized logs for select excavations are depicted in Figures 14 through 18.

Location	Diameter (inches)	Total Depth (ft. bgs)	Findings
EX-1	36	15.25	The excavation was centered on locations B-1, HA-1, and HA-3, and the ABS piping installed at these locations was used to guide the excavation activities. Consistent with previous investigations in this focused area at the site, an obstruction that was observed as a wood/gunite structure was encountered at 11.0 ft. bgs. A Lunkenheimer 1-inch "union bonnet" valve, timber boards, and gunite were recovered from the excavation. Based on communication with Facility personnel, and subsequent research, the debris observed in the excavation appeared consistent with historical oilfield operations on the property.
EX-2	36	9.6	The excavation was advanced on the bench based on the depth of bubbles observed in EX-1. Consistent with previous hand auger and drilled borings, Abundant debris including wood, concrete, and a 2-inch steel pipe was encountered in EX-2. Audible and visual indications of bubbles were observed coming from the bottom of the excavation, though it was determined that gas was not emanating from the pipe observed in the excavation, rather the gas was emanating from the native formation beneath the debris. The extent of the subsurface seep was not fully delineated at this location.
EX-3	36	11.75	Wood debris and concrete were encountered at approximately 10 ft. bgs with strong bubbling observed in the west/northwest quadrant of the excavation. The bubbles appeared to be originating between EX-2 and EX-3. Attempts to break out and remove the subsurface debris to better view subsurface structure were largely unsuccessful. The extent of the subsurface seep was not fully delineated at this location.
EX-4	60	19.0	Small sections of 2-inch steel pipe, abundant wood and gunite materials were encountered at a depth interval of approximately 8 to 12 ft. bgs (Figure 14). Throughout excavation operations, water was added to the excavation to evaluate the presence and location of methane (as indicated by bubbles) emanating from the excavation sidewalls. Based on these observations, no bubbling was observed beyond a depth of approximately 17 ft. bgs, providing vertical delineation for the zone of emissions.

Location	Diameter (inches)	Total Depth (ft. bgs)	Findings
EX-5	24	11.0	EX-5 was advanced to a total depth of 11 ft. bgs in the area where the former flame was observed on the hillside. No methane, elevated VOCs, or anthropogenic debris was encountered at this location; therefore, no additional excavation was performed. This excavation provided delineation of the structure and emissions to the southwest of EX-4 (Figure 15).
EX-6	36	20.0	EX-6 was advanced to assist in delineating the subsurface structure/debris to the northwest of EX-4. No anthropogenic debris was encountered while excavating EX-6. A contact between "disturbed" surficial materials believed to be native-derived (Topanga Sandstone) and formational material (Monterey Shale) was encountered at a depth from 8.5 to 13.5 ft. bgs (Figure 16). Bubbling was observed at a maximum depth of approximately 18.5 ft. bgs and was not observed at 20.0 ft. bgs. These and EX-4 observations vertically delineate emissions at the site.
EX-7	36	8.6	EX-7 was excavated southeast of EX-4 to a total depth of approximately 8.6 ft. bgs. A wooden structure consisting of horizontal planks and a portion of metal pipe were identified at the bottom of the excavation. The orientation of the pipe observed was generally consistent with the pipe trending to the southeast in EX-4. No bubbling or elevated methane/VOCs were measured within the excavation, delineating emissions to the southeast of EX-4.
EX-8	36	9.5	EX-8 was excavated east-southeast of EX-7. Wooden and gunite materials that appeared to be an extension of those observed in EX-7 were encountered at approximately 7.2 ft. bgs (Figure 17). The orientation of the materials suggest that this was the terminating edge of the subsurface structure. No bubbling or elevated methane/VOCs were measured within the excavation. Data from EX-8 provided delineation of the structure to the southeast of EX-4.
EX-9	36	14.5	EX-9 was advanced east of EX-4 to a total depth of approximately 14.5 ft. bgs (Figure 18). No anthropogenic debris and/or structure was encountered, and no bubbling or elevated methane/VOCs were measured within the excavation. EX-9 provided delineation of the subsurface structure and emissions to the east.

Hydro-excavation backfill activities performed to date include the installation of a 4-inch diameter Schedule 80 polyvinyl chloride (PVC) pipe (centered in EX-4) with perforations from 9 ft. bgs to 19 ft. bgs (1/2-inch perforations at 3-inch spacing), and backfilling with ¾-inch crushed rock to a depth of approximately 5 ft. bgs.

While SoCalGas did not believe SCAQMD Rule 1166 (*Volatile Organic Compound Emissions from Decontamination of Soil)* notification and monitoring procedures were applicable, a SCAQMD

Rule 1166 Various Locations Compliance Plan (Compliance Plan) was prepared on SoCalGas's behalf and implemented during subsequent hydro-excavation activities [Geosyntec, 2020a].

Throughout hydro-excavation work, field screening at three monitoring locations (the active shaft-type excavation, Guzzler tank effluent, and roll-off bin) was performed in accordance with the Compliance Plan. No VOC concentrations recorded at any of the monitoring locations exceeded the 50 parts per million (ppm) threshold; therefore, no additional SCAQMD notifications, implementation of field methods to suppress vapors, or special handling of excavated materials were necessary. Soil and liquid wastes generated from hydro-excavation activities were subsequently characterized as non-hazardous, transported offsite, and disposed of at a SoCalGas-approved facility.

4.9 METALLIC OBJECTS RECOVERED FROM HYDRO-EXCAVATIONS

As mentioned previously, steel pipes (approximately 2-inches in diameter), trending in the southwest and southeast directions were identified protruding from the subsurface structure and from the sidewalls of hydro-excavation EX-4 (Figure 14). Within hydro-excavation EX-1 a brass valve connected to 1-inch piping were recovered. Following further evaluation, markings on the valve were observed showing "Lunkenheimer." The Lunkenheimer Cincinnati Valve Company (LCVC) is still in operation and was contacted to determine if they could assist in identifying and potentially dating the valve; however, LCVC was unable to aid in the identification or aging of the valve. Through the HathiTrust Digital Library [HathiTrust, 1906 and 1912] and the Internet Archive [Lunkenheimer, 1895; Fairbanks, 1914; Garth, 1926], Lunkenheimer catalogs dating from 1895, 1906, 1912, 1914, and 1926 were downloaded for comparative purposes (Figure 19). In addition, the Hagley Museum & Library [Hagley, 1925 and 1930] was contacted, and they provided digital scans of two Lunkenheimer publications in its catalog, dated from 1925 and 1930, respectively. Images reviewed from these catalogs identified valve designs similar to that of the recovered valve. Of specific note is the unique handle design consisting of what appear to consist of five to six "nubs."

In addition to the inquiry with the manufacturer and historical resources, three patent applications assigned to the Lunkenheimer Company pertaining to valves were acquired through Google Patents, dated 1923, 1934, and 1951, respectively. The patent applications, dated from 1934 and 1951, respectively, pertain to the valve stem and handle design. The patent for handle design includes a figure of the handle with four "nubs" rather than the six found on the excavated valve. While the handle design identified in these patent applications did not match exactly to the recovered valve, this design appears to be consistent with those manufactured from approximately the 1900s-1950s.

Requests were also made to the Cincinnati History Library & Archives for Lunkenheimer catalogs from 1953, 1960, 1966, 1971, and 1976. To date, the requested resources have not been provided.

Based on the historical research performed, the recovered valve is believed to be a Lunkenheimer "union bonnet" style globe valve with manufacture dates between 1920 and 1950. This timeframe is consistent with the timeline for construction of the pad above the site and the subsequent downslope movement of soil which would have buried the structure prior to 1944. These activities occurred prior to SoCalGas acquiring ownership or operating the Facility in the 1970s.

4.10 FLUX CHAMBER TESTING

In response to a request by CARB for the quantification of emissions from the site, a Standard Operating Procedure (SOP) flux chamber testing and quantification was prepared by CE Schmidt (2020b). The SOP was prepared in accordance with the United States Environmental Protection Agency's "Measurement of Gaseous Emission Rates from Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide" [USEPA, 1986]. The flux chamber testing performed on 11 June 2020 comprised collection of 8 primary and 4 quality assurance/quality control (QA/QC) samples (Figure 20):

Source	Location	Sample ID
EX-4 Excavation	EX-4 Excavation	Flux-EX4-200611
EX-4 Excavation	EX-4 Excavation	Flux-EX4-200611-Dup
Soil Surface	Ground surface adjacent to EX-4 Excavation	Flux-EX4A-200611
Soil Surface	Approximately 6 ft. west/southwest of SVP-4-2/-5	Flux-01-200611
Soil Surface	Approximately 3 ft. west of SVP-7-12/-21	Flux-02-200611
Soil Surface	Between probes SVP-1 and SVP-1A	Flux-03-200611
Soil Surface	Approximately 2 ft. northwest of SVP-2	Flux-04-200611
Soil Surface	Approximately 2 ft. northwest of EX-5 (former flame area)	Flux-05-200611
Soil Surface	Approximately 3 ft. southwest of SVP-3	Flux-06-200611
Background	Dirt Parking Area southwest of CB3 (adjacent to access road)	Flux-BKGC-200611
Sweep Gas (media blank)	CB3 Staging Area	Flux-Blank-200611
Plastic Sheeting (media blank)	CB3 Staging Area	Flux-PC-200611

Air samples were submitted to ALS Laboratories, Inc. of Simi Valley, California for analysis of fixed gases by ASTM Method D 1946-90 (hydrogen, oxygen, nitrogen, carbon monoxide, methane, and carbon dioxide) and VOCs by EPA Method TO-15 (Table 7).

4.11 ROUTINE FIELD MONITORING AND REPORTING

Weekly monitoring of accessible soil vapor probes, ABS casings, and surface locations was performed to evaluate temporal changes in the subsurface concentrations of COCs. Weekly summary reports were provided to SoCalGas to document site conditions, field screening data, provide updates on findings from ongoing investigation activities and status of the schedule for Workplan implementation. Weekly reports were submitted to the agencies throughout the investigation, to supplement the ongoing cooperative effort, which also included a regular onsite presence by agency inspectors, coordination for independent sampling and analysis by agency representatives, and routine agency meetings. A summary of historical data collected throughout routine monitoring of these locations is provided in Tables 8 and 9.

4.12 SITE SURVEYS

An initial survey of the site and surrounding area was conducted on 6 February 2020 by Geosyntec (utilizing a subcontracted licensed surveyor) and SoCalGas personnel to perform high definition surveying and Unmanned Aerial Vehicle (UAV) based mapping (respectively). The objective of the surveying was to obtain detailed topography and accurately locate features to better understand the distribution of impacted soil/elevated methane and support the planning of future activities at the site.

Following the completion of hydro-excavation activities at the site, a supplemental survey (using 3D LiDAR scanning equipment) was performed on 15 July 2020 in the immediate work zone. The purpose of the supplemental survey was to allow more accurate correlation of surficial and subsurface data/features, compare data from before and after completion of the hydro-excavations, and obtain a more detailed and current topographic surface for subsequent site evaluations.

4.13 DEPRESSURIZATION STUDY

In August 2020, Aliso Canyon operations personnel conducted two depressurization tests of certain infrastructure within ¼ mile of the site followed by monitoring of the surface emissions using a high-resolution FLIR camera [SoCalGas, 2020a]. Testing included the following:

- Depressurization of piping in the vicinity of the site commenced on 6 August 2020 and was conducted for a period of 48 hours. Infrastructure involved in this test included fuel lines at Porter Gathering Plant and Dehy 3, water disposal lines to wells FF-36 & FF-37, and the high-pressure header at the Porter Gathering Plant.[3] Monitoring of the site using a

[3] Note that the header at the Porter Gathering Plan was reduced to 20 pounds per square inch gauge (psig) instead of zero due to the operational effects/risks of complete depressurization of these systems.

FLIR camera was conducted prior to the pressure reduction and twice per day during the testing period.

- Depressurization of pressurized well annuli in the vicinity of the site was initiated on 8 August 2020 and was conducted for a period of 48 hours. Wells included in this test included FF-32H-A1, FF-32G-A1, FF-32A-A1, FF-32B-A1, FF-32F-A1, FF-37-A2, P-50B-A1, P-72B-A1. Monitoring of the site using a FLIR camera was conducted prior to the pressure reduction and twice per day during the testing period.
- No noticeable variations to the surface emissions at the site were observed while conducting the FLIR monitoring during the test period.

4.14 ABANDONED WELL ASSESSMENT

Historical data from abandoned wells within ¼-mile of the site were evaluated to assess the potential for upward migration of Shallow Gas [SoCalGas, 2020b]. Former wells evaluated during these activities include FF-12, P-11, P-12A, P-50A, P-59, and P-72 (Figure 12). With exception of P-50A (abandonment currently in progress) an evaluation summary for each location was prepared by SoCalGas (Appendix E) [SoCalGas, 2020b].

On 31 August 2020, SoCalGas advanced barholes (small diameter borings driven with a steel rod) at the former well sites to facilitate gas sample collection and analysis [SoCalGas, 2020c]. Three barholes were advanced at each of the six abandoned well locations near the site at depths ranging from 17 to 35 inches bgs. These barholes were plugged at the surface for approximately 48 hours prior to sample collection to allow the locations to equilibrate. At each barhole, a sampling probe was lowered, and using a suction bulb and tubing, gas was extracted for screening using a combustible gas meter and for analysis of methane, ethane and propane (in parts per million [ppm]) and air, carbon dioxide, helium, hydrogen, and isotopic ratio analysis. Details on the results of the barhole survey are provided in the memorandum prepared by SoCalGas included in Appendix E [SoCalGas, 2020c].

5 ANALYTICAL RESULTS

5.1 AMBIENT AIR SAMPLING

5.1.1 Ambient Air Analytical Results

Laboratory analytical results for air samples collected on 15 October 2019 indicated localized detections of methane up to 1.1% by volume from the ground surface adjacent to the former flame and VOCs commonly associated with petroleum hydrocarbons (e.g., benzene, toluene, ethylbenzene, and xylene [BTEX] constituents) from historical oil field operations. A summary of the ambient air analytical results is presented in Table 2, sample locations are presented on Figure 9, and the laboratory analytical report is included as Appendix A. Similar to methane, concentrations of VOCs were highest in the area where the former flame was observed (CB3-SA-191015).

Helium, a typical trace indicator of storage gas, was not detected in any of the three air samples analyzed, and mercaptan (or other natural gas odorant) odors were not noted during reconnaissance and air sampling. The laboratory analytical results for the three air samples collected on 15 October 2019 demonstrated that detectable concentrations of methane and VOCs were localized near the location of the former flame (CB3-SA-191015) and that these concentrations attenuate significantly in the upslope (CB3-UH-191015) and downslope (CB3-DH-191015) directions. The detected concentrations of methane and VOCs in air in this localized area do not represent a risk to the community and Facility personnel.

5.1.2 Surface Screening

Field screening (through a shroud) at the ground surface adjacent to each accessible SVP location (Figure 11) was performed on a weekly basis. Ambient air monitoring in the worker's breathing zone was also performed continuously during onsite activities for health and safety purposes. Concentrations of methane at the surface screening locations typically ranged from 0.0% (non-detect) to less than 1% at the surface monitoring locations, with rare intermittent detections greater than 1%, and a maximum surface methane concentration of 4.4% measured near SVP-1 on 5 November 2019. A summary of field screening data for ambient air collected during weekly monitoring is provided in Table 8.

To further evaluate surface concentrations of methane (in parts per million by volume [ppmv]) at the site a ground surface survey of methane gas was conducted on 14 July 2020 using a Flame Ionization Detector (FID). The ground surface survey consisted of measuring methane in ambient air three inches above ground surface at three-foot intervals along eleven northwest-southeast trending transects of varying lengths. The FID was held in place for approximately one minute to allow the reading to stabilize. In some areas FID screening was not feasible due to lack of accessibility; therefore, the number of monitoring locations on each transect varies.

The results from the surface survey adequately delineated methane at the surface (greater than 500 ppmv) with the highest detections (greater than 10,000 ppmv; 1%) located in the immediate vicinity of the EX-4 and EX-6 hydro-excavations (Figure 21). Significant reductions were documented in all directions surrounding these locations. It is believed that the preferential pathways at EX-4 and EX-6 artificially elevated surface data and that ambient air monitoring (through the shroud) best characterized methane at the surface until such a time that all hydro-excavations are backfilled.

5.2 SOIL

Soil samples were collected during five sampling events from 16 October 2019 to 6 February 2020 (Figures 10 and 13). The soil samples were collected from the ground surface to depths of up to approximately 10.5 ft. bgs at the site. The soil samples contained relatively low concentrations of TPH, VOCs, and SVOCs that are commonly associated with petroleum hydrocarbons from former oil field operations (Table 3). Low-level PAHs and D&Fs were also detected in soil samples, which are commonly associated with incinerated organic matter and are generally ubiquitous. Concentrations of metals were generally low and not at levels significant enough for evaluation of leachability potential for waste characterization. Analysis of ignitability in select samples determined that the shallow soils at the site were not ignitable and confirmed that the former flame at the site could not be attributable to the constituents detected in soil.

Based on the results from the laboratory analysis of soil samples collected on the hillside adjacent to CB3, the relatively minor soil impacts are of limited extent covering an area of approximately 40 ft. by 15 ft. This soil is located in an area not readily accessible to onsite workers. Further, the concentrations of residual constituents in this localized area do not represent a threat to the public or facility personnel.

5.3 SOIL VAPOR

5.3.1 Soil Vapor Probe Samples

Samples from the soil vapor probes at the site were collected on 11 and 12 November 2019. The soil vapor samples contained constituents that are commonly associated with natural gas and oil production, including methane and BTEX constituents. Sulfur compounds were largely not detected in samples collected from SVPs; however, detectable concentrations of dimethyl disulfide and dimethyl sulfide were reported in select soil vapor probe samples. Common natural gas odorants such as mercaptans and tetrahydrothiophene were not detected above laboratory reporting limits in any of the soil vapor samples collected from the site.

Analytical results from the SVPs are summarized in Table 4, and the methane to ethane ratios and total hydrocarbons (C2-C6+) comparisons with Facility gas well samples are presented on Figures 22 and 23, respectively. Copies of the laboratory analytical reports are provided in Appendix A.

5.3.2 Screening of Soil Vapor Probes and ABS Casings

Field screening of the accessible SVPs and ABS casings was performed on a daily to weekly basis to evaluate temporal changes in the subsurface concentrations of COCs. Prior to the start of hydro-excavation activities, concentrations of methane in the subsurface were stable (Figure 24).

Following the completion of hydro-excavations EX-4 and EX-6, where the greatest indications of subsurface emissions were observed, concentrations of methane detected in the soil vapor probes decreased by an order of magnitude or greater. Currently only one monitoring probe, SVP-1, consistently has detectable concentrations of methane; however, the observed concentrations are currently below the Lower Explosive Limit (LEL) for methane (5%) at a depth of approximately

5 ft. bgs. Subsurface methane concentrations have attenuated to non-detectable concentrations in co-located probe SVP-1A screened to a total depth of 2 ft. bgs. The SVP locations are depicted on Figure 11 and field screening results are presented in Tables 8 and 9.

5.4 FACILITY GAS WELL SAMPLING

Samples from the Facility Gas Wells in close proximity to the site, shown on Figure 12, were collected at the respective well-head casings or tubing on 24 October and 20 November 2019 to aid in determining the potential source of methane detected in the CB3 soil vapor probes. The results of the gas sample analysis confirmed elevated concentrations of methane, as well as the presence of detectable concentrations of sulfur compounds in each Facility gas well sampled. Common natural gas odorants such as mercaptans and tetrahydrothiophene were also detected in the majority samples analyzed from the collected Facility well sampling.

Analytical results from Facility Gas Well analyses are summarized in Table 4. Methane to ethane ratios and total hydrocarbons (C2-C6+) derived from the gas well analysis were compared with data from the SVPs and are presented on Figures 22 and 23, respectively[4]. Copies of the laboratory analytical reports are provided as Appendix A.

5.5 STABLE ISOTOPE INTERPRETATION

Following completion of analytical testing and data evaluation, an interpretive report summarizing the results of the isotopic analysis and a comparison of data from the SVPs and Facility Gas Wells was prepared by Isotech (Appendix C) [Isotech, 2020]. Findings from these evaluations confirm that methane detected at the site is not from the Storage Gas zone. Isotopically, data from the SVPs are consistent with Shallow Gas and PGS.

Isotech concluded the following:

- The soil gas samples showed hydrocarbon concentrations and helium results similar to that observed for the surface casing gas samples from FF32H-A1 and FF37-A2.
- The stable isotope results for the soil gas samples were indicative of thermogenic origin and most similar to the surface casing gas sample from FF32H-A1.
- The stable isotope results of the CO_2 for the soil gas samples were similar to that observed in samples collected from the PGS.
- The two shallower soil gas samples contained lower concentrations of the heavier hydrocarbons (including propane through hexanes+) compared to the deeper soil gas

samples suggesting the heavier hydrocarbons were stripped off by various process including oxidation as the gas migrated up through the vadose zone.

- The compositional and isotopic results for the samples collected from the surface casings screened in the Shallow Gas and PGS showed significant differences compared to the Storage Gas zone sample, concluding that isotopically, they are different sources of gas.

5.6 EMISSIONS QUANTIFICATION

Laboratory analytical results from the flux chamber analysis were provided to the flux testing subcontractor for calculation of flux emissions from each test location [CE Schmidt, 2020a]. A summary of laboratory analytical results and flux rates for VOCs and methane at each test location is provided in Appendix A and below. A tabular summary of flux rates and estimated emissions from the ground surface and from the open excavation at EX-4 are provided in Tables 10 and 11, respectively.

5.6.1 VOCs

VOCs were detected in the flux chamber samples analyzed during this effort (Table 7; Appendix A). Concentrations of VOCs from samples Flux-01 and Flux-06 were below background levels and adequately delineate the lateral extent of emissions in the CB3 area. A brief summary of VOC flux rates for samples collected at the ground surface is provided below and in Table 10. Calculated flux rates from Excavation EX-4 are provided in Table 11 and in Appendix D.

- Flux emission rates for VOCs at the ground surface ranged from 0.12 $\mu g/m^2$,min (micrograms per square meters per minute) up to approximately 4 $\mu g/m^2$,min.
- Flux emission rates for VOCs from EX-4 ranged from 116 $\mu g/m^2$,min to approximately 10,780 $\mu g/m^2$,min, respectively. This flux emission rate is not directly comparable to the results from testing at the surrounding ground surface sample locations.
- EX-4 was a 5-foot diameter open excavation to a depth of approximately 20 ft. bgs, located in the immediate vicinity of the apparent source of subsurface methane. This sample is not representative of surface emissions from soil because it was collected over an “open tube” and not surface soil.

5.6.2 Methane

- Surface methane was not detected in samples collected at the ground surface at test locations Flux-01, -02, -04, and -06 (Figure 25). These data effectively delineate the limits of methane emissions in the northeast, northwest, and southwest portions of the CB3 area.
- Surface methane flux emission rates from test locations Flux-03, -04A and -05 ranged from approximately 47 milligrams per square meter per minute (mg/m^2,min) in sample Flux-05 to approximately 238 mg/m^2,min in sample Flux-EX4A.

- The flux emission rate from open excavation EX-4 (Flux-EX4) was approximately 60,900 mg/m^2, min. This flux emission rate is not directly comparable to the results from testing at the surrounding ground surface sample locations. EX-4 was a 5-foot diameter open excavation to a depth of approximately 20 ft. bgs, located in the immediate vicinity of the apparent source of subsurface methane. This sample is not representative of surface emissions from soil because it was collected over an "open tube" and not surface soil.

5.6.3 Emissions Estimates

To calculate estimated emissions from ground surface at the site, the area (square meters; m^2) of emissions was estimated using the limits of detectable (and non-detect) concentrations of methane in the surface flux samples in the northeast, northwest, and southwest portions of the study area and the data from SVPs previously used to define the approximate extent of the CB3 area (Figures 11 and 25). Based on these data, the footprint of the area of apparent emissions was estimated to be approximately 350 square ft. (ft^2); or 32.5 m^2. To calculate the range and average emission rate across this zone, the flux emission rates are multiplied by the area (32.5 m^2), resulting in an emission rate in units of mass/time (micrograms per minute [μg/min] for VOCs or milligrams per minute [mg/min] for fixed gases).

- Based on the calculated flux data, the estimated emission rate for methane ranges from approximately 1 ton/year to 4 metric tons/year, with an average emission rate of approximately 2 metric tons/year, equivalent to the greenhouse gas emissions from 11 passenger cars in one year.
- Of the VOCs detected in the flux chamber samples, no emissions were estimated to exceed 1 lb/year and are considered de minimis.

The flux emission rate for the EX-4 excavation (5-foot diameter) was multiplied by the area of the excavation (approximately 19.6 ft^2 diameter; approximately 1.82 m^2). The average methane emission rate for methane from EX-4 was approximately 59 metric tons/year. Of the VOCs detected in EX-4, no VOC emissions exceeded 0.01 metric tons/year[5] with the highest emission rate of 23 pounds per year (lbs./year)[6]. A summary of estimated emission rates for methane and VOCs is provided below and tabulated in Tables 10 and 11.

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[5] mg/min emissions rates converted by multiplying the mass/time value by a factor of 1.159 (lbs./year) or dividing the by a factor of 1903 (metric tons/year).

[6] ug/min emissions rates converted by dividing the mass/time value by a factor of 863 (lbs./year) or dividing the by a factor of 1.903e+6 (metric tons/year).

5.7 DATA QUALITY ASSURANCE/QUALITY CONTROL

Select analytical data packages were reviewed for basic analytical QA/QC adherence based on QC guidance in the USEPA Contract Laboratory Program National Functional Guidelines [USEPA, 2017a and 2017b], as well as pertinent methods referenced in the data packages, and professional judgment. Data packages were reviewed for chain of custody discrepancies; adherence to sample holding times; evaluation of matrix spike/matrix spike duplicates (MS/MSD) and laboratory control samples/laboratory control sample duplicates (LCS/LCSD); method blanks and QC blanks (where collected).

Review of the analytical data packages indicated QA/QC parameters and criteria were met, with the exceptions noted in the data validation summaries presented with the laboratory analytical reports presented in Appendix A. Based on the validation results, the data are usable for meeting project objectives as qualified.

6 SUMMARY OF FINDINGS

6.1.1 Geologic Conditions

Results from geologic reconnaissance and study identified that the surficial geology at the site consists of the Miocene age upper sandstone unit of the Topanga Formation. Locally, this unit is associated with an anticlinal structure plunging generally to the east-southeast and abutted to the (younger) lower unit of the Modelo Formation (Monterey Shale), also of Miocene age. The site is located on the margins of a landslide primarily comprised of disturbed materials, originating from the grading of a work pad between 1938 and 1944, northeast and upslope of CB3. Available historical aerial imagery from 1944 provided evidence of a derrick on the graded pad upslope of the site. The earliest indications of movement of these native-derived materials (landslide) placed on the hillside was observed in aerial imagery from 1956. Subsequent aerial photos in the period after 1956 document a localized “bare spot” on the hillside above CB3 in the general vicinity of the site.

6.1.2 Soil Impacts

Discolored soil at the site was analyzed for various constituents, including Volatile Organic Compounds (VOCs) and Total Petroleum Hydrocarbons (TPH). Relatively low concentrations of these constituents were detected at concentrations below ignitable levels across an area of approximately 550 sq. ft. (Figure 11). Based on these data, impacted soils at the site were eliminated from further consideration as the potential fuel source for the former flame. Further, these soils were determined to be non-hazardous and do not pose a threat to the public or facility personnel.

6.1.3 Nature and Extent of Methane in the Subsurface

Soil vapor probes installed to evaluate the lateral extent of elevated subsurface methane confirmed that the area with elevated subsurface methane concentrations was limited to an area of approximately 250 square feet (ft.) in the area upslope of the location of the former flame (Figure 24). Over 65 monitoring events of the soil vapor probes have been conducted and document consistent localized subsurface methane concentrations exceeding 90% methane, and surface methane concentrations averaging significantly less than 1% methane. Based on the data obtained and the absence of facility infrastructure or operations at the site, both surficial and subsurface concentrations of methane detected at the site do not pose a risk to onsite workers, facility personnel, or the community.

6.1.4 Geophysical Survey

To evaluate the presence of buried pipes or casings that could serve as a source of methane, two surface geophysical surveys were performed at the site. Geophysical surveys performed along the hillside near the prior flame identified a potential metallic line trace, trending generally northwest-southeast at the site. These data were correlated with observations from the advancement of hand auger borings and used to focus investigations to further refine the lateral limits of vertical explorations and the apparent source area. Surveys conducted on the pad above CB3 did not identify evidence of a sump or subsurface well casing in that area.

6.1.5 Isotopic Testing of Methane

To investigate the source of the localized subsurface methane, gas samples were collected from select soil vapor probes and Facility gas wells in the vicinity of the site and submitted for laboratory analysis including, but not limited to, gas composition and stable isotope analysis. Gas wells were selected based on their proximity to the site and specific casings within these wells were sampled to provide data to various depth-specific gas producing zones. Stable isotope signatures of soil vapor samples were determined to correlate well with gas samples collected from surface casings screened in the Shallow Gas and from the PGS. Isotopically, samples collected from the soil vapor probes are dissimilar from the samples collected from wells screened in the Storage Gas zone.

6.1.6 Subsurface Structure

Twenty-four borings and nine large diameter hydro-excavations were advanced to investigate the source of subsurface methane emissions in the study area. These explorations encountered localized buried gunite, wood and sections of metal pipe in the subsurface at depths ranging from approximately 7 ft. bgs to 12 ft. bgs. Materials extracted and observations made during hydro-excavation activities identified the structure as being man-made. This structure appears to be overlain by native-derived sandstone material (Section 3) that migrated downslope because of grading of the pad upslope from the site sometime prior to 1944 as inferred by historical aerial photographs. Based on historical imagery, this area was subject to instability sometime between 1944 and 1956. The subsurface structure was comprised of a wooden plank structure encased with a gunite (or similar) cementitious material. The subsurface structure was identified at the contact between the overburden/landslide materials and the underlying native shale materials.

6.1.7 Subsurface Metallic Features

Steel pipes (approximately 2-inches in diameter), trending in the southwest and southeast directions were identified protruding from the subsurface structure and from the sidewalls of select hydro-excavations. No evidence was identified to indicate that the pipes observed in the hydro-excavations were connected to any piping utilized by SoCalGas. Historical research of a brass Lunkenheimer “union bonnet” style valve recovered from one excavation indicates the valve is believed to have been manufactured between 1920 and 1950. This timeframe is consistent with the timeline for construction of the pad above the site and the subsequent downslope movement of soil which would have buried the structure prior to 1944. These activities occurred prior to SoCalGas acquiring ownership or operating the Facility in the 1970s.

6.1.8 Observed Methane Emissions

Bubbling in the subsurface was observed and subsequently used to delineate the location of emissions in the various vertical explorations. Following the removal of the subsurface structure material encountered in hydro-excavations EX-4 and EX-6, emissions were identified in the depth interval of approximately 16 to 18 ft. bgs over an area of approximately 10 feet by 10 feet.

The presence of emissions from the native formational materials indicates that the source of the methane at the site is a natural sub-surface seep. The identification of the man-made structure and piping (created sometime prior to 1944) constructed directly above the subsurface seep suggests that the structure may have captured and conveyed methane from the site. While no other infrastructure was encountered to confirm the purpose of the structure, the likely beneficial uses for the captured methane would have been for applications such as heating and lighting at the oil field. Following completion of hydro-excavations EX-4 and EX-6 focused in the area of the subsurface emissions, concentrations of elevated methane in the subsurface surrounding the area have significantly decreased in concentration and lateral distribution, further confirming that the source zone for methane at the site has been identified and adequately delineated.

Flux chamber testing was performed at the ground surface to quantify the flux of emissions from the site. Flux data was utilized to calculate the emissions for the area of the site where elevated methane has been identified in the subsurface and at the open excavation at EX-4. The flux chamber results indicate that the average methane emissions from the ground surface was approximately 2 metric tons/year, with the open excavation having potential for emissions of approximately 59 metric tons/year. However, EX-4 has since been backfilled and these emissions estimates are not representative of ongoing emissions from the site.

Based on the EPA's Greenhouse Gas Equivalencies Calculator[7], the emissions measured at the ground surface are equivalent to greenhouse gas emissions from 11 passenger cars over the course of one year. The emissions from the ground surface are representative of static conditions at the site at the time of testing.

In comparison, the La Brea Tar Pits in located Los Angeles continuously emit thermogenic gas (consisting of greater than 80% methane) from the ground surface at a rate exceeding 180 metric tons per year[8] [Etiope, G. et. al, 2017]. The EPA Greenhouse Gas Equivalencies Calculator indicates that these emissions would be equivalent to emissions from greater than 970 passenger cars over the course of a year.

6.1.9 Depressurization Study

From 6 August to 10 August 2020, Aliso Canyon operations personnel conducted two depressurization tests of certain infrastructure within ¼ mile of the site. Initial testing included depressurization of buried piping associated with fuel lines at Porter Gathering Plant and Dehy 3, water disposal lines to wells FF-36 & FF-37, and the high-pressure header at the Porter Gathering Plant. Secondary testing was performed on well annuli associated with wells FF-32H-A1, FF-32G-A1, FF-32A-A1, FF-32B-A1, FF-32F-A1, FF-37-A2, P-50B-A1, P-72B-A1.

During implementation of each test, monitoring of the site using a FLIR camera was conducted prior to the pressure reductions and twice per day during the testing period. Based on information provided by operations personnel, SoCalGas concluded that no noticeable variations to the surface emissions at the site were observed while conducting the FLIR monitoring during the depressurization of the buried piping and well annuli tested, indicating that this infrastructure is not the source of the gas at CB3 [SoCalGas, 2020a].

6.1.10 Abandoned Well Assessment

SoCalGas evaluated six former well sites penetrating the PGS located within a ¼-mile radius from CB3. Based on their evaluation, it was confirmed that the abandonment of five wells between 1955 and 1993 (FF-12, P-11, P-12A, P-59, and P-72) was performed in compliance with regulations at the time the work was performed. Each well was abandoned with intervals of 9.6 pounds per gallon (ppg) mud and finished with surface cement plugs ranging from 30' to 60' in length. The sixth well (P-50A) is currently in the process of being abandoned. It will be completed

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[7] EPA Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[8] - Methane emission rates for the La Brea Tar Pits were measured at approximately 500 Kilograms per day; results were converted to metric tons per year by dividing the mass/time by 2.74.

in compliance with the current regulations utilizing a series of cement plugs and cement retainers placed throughout the entire wellbore [SoCalGas, 2020b].

Following advancement of the barholes and collection of samples from the area surrounding the former well sites it was determined that insufficient concentrations of combustible gas was detected at each location to test for hydrocarbons, fixed gases, and isotopic ratio analysis. A minimum concentration of 0.5% or 5,000 ppm of combustible gas is needed to accurately analyze and quantify aforementioned analytes; therefore, this testing was not performed. Concentrations of combustible gases ranged from 20 ppm to 1,900 ppm in barholes advanced at abandoned well sites P-12 and P-72, respectively [SoCalGas, 2020c].

The absence of significant concentrations of combustible gas at any of 18 barholes sampled indicate that gas is not migrating up the wellbore to the surface. Based on these results there is no evidence to indicate that methane is migrating from these abandoned well locations to the site. A tabular summary of combustible gas concentrations at each of the six well sites evaluated during the barhole survey is provided in Table 12. Details related to the barhole survey performed by SoCalGas are provided in Appendix E [SoCalGas, 2020c].

7 CONCLUSIONS

Based on the results from the studies performed during this investigation we conclude the following:

- Isotopic analyses of gas samples collected from soil vapor probes indicates that subsurface gas at the site is not Storage Zone gas. Rather, data indicate that the methane detected in soil vapor probes is associated with Shallow Gas and also has similarities to the Pliocene Gas Sand (PGS).
- Methane was observed to be originating from a natural subsurface seep in native material at a depth of approximately 16 to 18 feet below ground surface (ft. bgs). This seep was identified beneath a wooden/gunite structure that covers an area of about 10 feet by 10 feet that is overlain by undifferentiated, disturbed soil.
- Surface emissions measured during weekly monitoring events and the results of flux testing have determined that surface methane emissions from the site are stable, minor in nature, limited to the area in close proximity to the subsurface wooden structure, and do not pose a risk to the public or Facility personnel.
- Piping was encountered in the subsurface, protruding from the top of the subsurface wooden structure and into the large-diameter vertical excavations. This piping was not connected to SoCalGas infrastructure and methane was not leaking from any subsurface pipes in the CB3 area.

- Depressurization of gas piping and pressurized well annuli within ¼ mile of the site showed no effect on surface emissions at the site based on FLIR monitoring performed by SoCalGas. These data further support that SoCalGas's infrastructure in this area is not the source of methane observed at CB3.
- Records for abandoned wells within ¼ mile of the site were reviewed and confirmed that the abandonment activities were performed in compliance with regulations at the time the work was conducted.
- The absence of significant concentrations of combustible gas in the barholes sampled at abandoned wells within ¼ mile of the site indicate that shallow gas is not migrating up the wellbore to the surface. Based on these results there is no evidence to indicate that shallow gas is migrating from these abandoned well locations to the site.
- A graded pad on the slope above the site was observed in a 1944 aerial photograph. Aerial imagery indicates that the grading activity to construct the pad covered the wooden/gunite structure, because it is not visible in the 1944 aerial photograph.
- It is believed that burial of the structure beneath these overburden materials significantly decreased surface emissions. These activities (installation of the subsurface structure, pad grading to the northeast of the site, and subsequent burial of the structure) pre-date SoCalGas's acquisition and operation of the Facility.
- Evidence indicates the subsurface wooden/gunite structure was constructed at the site sometime before 1944. Based on the presence of the subsurface structure and orientation of piping observed protruding from the top of the structure and in the excavations in the vicinity of the structure, it is believed that this structure may have captured and conveyed methane seeping from native soil at the site for reuse during operations associated with the oil field. After the structure was covered during grading activities for the pad at the top of the slope, and subsequent landslide(s) occurred on the hillside, this underground seep location remained unidentified until the October 2019 Saddleridge Wildfire due to the relatively small area where measurable emissions have been documented, and its remote location in a generally inaccessible area on a steep hillside.
- The geophysical surveys identified a potential metallic line trace trending generally northwest-southeast at the site, which led to the advancement of hydro-excavations in this area. Geophysical surveys of the roadway above CB3 identified shallow abandoned buried pipes, though no evidence of pipelines or subsurface structures (e.g., well casings, vaults, or sumps) were identified on the pad above CB3.
- The impacted soil at the CB3 area was not the fuel for the flame observed in October 2019. The extent of impacted soil has been approximately defined and it does not pose a risk to the public or Facility personnel.

8 RECOMMENDATIONS

Oil and natural gas seeps are prevalent in areas of California proximal to underground oil and natural gas reservoirs. Likely the most well-known seep in the Los Angeles area is located at the La Brea Tar Pits in Hancock Park. At the La Brea Tar Pits, thermogenic gas is continuously emitted from the ground surface at a rate exceeding 180 metric tons per year[9] [Etiope, G. et. al, 2017].

There is no known precedent for mitigation of naturally occurring gas seeps in areas where no development has occurred or is planned. Based on the historical presence of the subsurface natural gas seep at the site, the absence of any buildings or planned construction in this area (due to its remote location on a historical landslide on very steep terrain), and the small volume of methane emissions from the ground surface, containment or capture scenarios appear unwarranted and infeasible.

Due to the ground disturbing investigation activities performed at the site to date, the known instability of the surrounding area, and the upcoming rainy season, we recommend the following actions:

- Restoring the site (backfill open excavations, remove shoring, and investigation-related equipment);
- Stabilizing the disturbed area (using traditional stormwater Best Management Practices [BMPs] including coconut-straw blanket, fiber rolls, and hydraulic mulch);
- Monitoring of site conditions for necessary BMP modifications/repairs through the rainy season; and
- Restricting site access by Facility personnel via institutional controls and signage.

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TABLES

Table 1
Summary CalGEM Requests - 5 November 2019
Catch Basin No. 3 Area
Aliso Canyon Natural Gas Storage Field

Geosyntec consultants

Deliverable Description	Location in this Report/Response
Weekly updates and revised timeline for investigation and remediation of site, along with any sampling data results	Weekly Summary Reports have been prepared by Geosyntec and submitted to CalGEM (and other pertinent Agencies) from October 2019 to present.
FLIR camera high resolution documentation before, during, and after fire along with qualitative and quantitative analysis from a certified Optical Gas Imaging (OGI) Thermographer	SoCalGas directly uploaded FLIR videos to CalGEM's online interface; Email notification and documentation of upload provided to CalGEM on 15 February 2020.
Site-specific safety procedures for the investigation and remediation phase, to address concerns regarding slope conditions and workers' safety	Initial project-specific Health and Safety Plan (HASP) and Task Hazard Analysis (THA) prepared in November 2019; Amended HASP and THA submitted to CalGEM on December 2019.
Additional gas sample data representative of what is observed leaking from the site, including map of sampling locations	Investigation Report; Sections 4 and 5; Tables 4, 5, and 10; Figures 11, 20, 21, and 25
Soil-gas sample data, including map of sampling locations	Investigation Report; Sections 4 and 5; Tables 4, 5, and 10; Figures 11, 20, 21, and 25
Root Cause Analysis - historical conditions	Investigation Report; Section 3; Figures 3, 4, 5, 6, and 27
Root Cause Analysis - comparisons of known gas samples from storage reservoir, any upper known gas zones, well annulus gas within 1/4 mile of site, and biogenic gas	Investigation Report; Sections 4, 5, and 6; Tables 4 and 5; Figures 11, 12, 23, and 24
Root Cause Analysis - analysis of gas and oil samples from oilfield	Investigation Report; Sections 4, 5, and 6; Tables 4 and 5; Figures 11, 12, 23, and 24 (Note: no oil samples were collected for analysis following identification of elevated subsurface methane)
Root Cause Analysis - comparisons of known gas and oil samples with that of samples obtained at the fire site	Investigation Report; Sections 4, 5, and 6; Tables 4 and 5; Figures 11, 12, 23, and 24 (Note: no oil samples were collected for analysis following identification of elevated subsurface methane)
Root Cause Analysis - summary conclusion on the source and pathway of the hydrocarbons from their origin to the fire site, or if the conclusion is that this is from historic operations, documentation of that operation	Investigation Report; Sections 6 and 7, Figures 4, 5, 6, 15, 16, and 27
3D modeling of wellbore paths, formation tops, and faulting within 1/4 radius of the site in Geographix format. Wellbore paths shall identify the length of any uncemented casing and any perforations in the casing open or cemented. Wells and Wellbore paths should include all plugged and abandoned, idle, and active wells.	SoCalGas submitted tabulated well data (Top of Formations; Perforations Data, Directional Data, Wellbore Data; and Wellheader Data) to CalGEM via email on 19 November 2019
History of the change in the localized topography at the site i.e. has any soil been excavated or removed from the site	Investigation Report; Section 3, Figures 3, 4, 5, and 6 (Note: no soil has been removed from the site other than that associated with the hydro-excavations.)
Details on how the shut-in test of the gas transmission pipelines within 1/4 mile of the site was conducted and a summary of results	Investigation Report; Sections 4.13 and 6.1.9
Evaluation of well construction, cementing, and well integrity of abandoned wells within 1/4 mile of the site	Investigation Report; Sections 4.14 and 6.1.10, Table 12 and Figure 12, Appendix E

Notes:
California Geologic Energy Management Division (CalGEM) former called Division of Oil, Gas and Geothermal Resources (DOGGR).