Office of the City Manager

November 17, 2025

To: Honorable Mayor and Members of the City Council

From: Paul Buddenhagen, City Manager

Re: Update on Additional Radiological Testing at Former Landfill at Cesar Chavez Park and Updated Radiation Health and Safety Plan

SUMMARY

This memo provides an update on the results of additional radiological testing at the former landfill at Cesar Chavez Park. The San Francisco Bay Regional Water Quality Control Board (RWQCB), in a letter dated January 28, 2025 (Attachment A), required additional tests to assess potential impacts from industrial waste materials delivered more than a half-century ago from a Richmond business, then known as Stauffer Chemical Company, to five former Bay Area landfills: Albany, Benicia, Berkeley, and two in Richmond.

The RWQCB letter dated January 28, 2025, was in response to the City of Berkeley's December 30, 2024 report, the results of which were discussed in an Off-Agenda Memo published on the same date[1]. The City's proposed additional testing was discussed in a June 5, 2025, Off-Agenda Memo[2]. The City submitted a revised Work Plan to the RWQCB on June 11, 2025 (Attachment B). The RWQCB approved this Work Plan on June 13, 2025. The additional radiological sampling has been completed, and the report was submitted to the RWQCB on November 14, 2025 (Attachment C). The City is awaiting review of the additional testing results by the RWQCB.

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[1] https://berkeleyca.gov/sites/default/files/documents/Results%20of%20Radiological%20Testing%20at%20Cesar%20Chavez%20Park.pdf.

[2] https://berkeleyca.gov/sites/default/files/documents/2025-06-05%20%20%20Environmental%20Compliance%20Updates%20at%20former%20Landfill%20at%20C%C3%A9sar%20Ch%C3%A1vez%20Park.pdf.

This memo also provides an update on modifications to select park activities to comply with permits that govern how the City manages and operates the park and capped landfill. The update to these modifications supersedes modifications provided in the June 5, 2025, Off-Agenda Memo and can be found in Table 1.

SUMMARY OF TESTING

Additional testing (Work Plan, Attachment B) included sampling and analysis of groundwater and leachate for radium-226 and radium-228 using different analytical testing methods from those previously employed and analysis of ambient air and landfill gas for radon, which is a decay product of radium-226.

Radon is a naturally occurring, cancer-causing radioactive gas. Not everyone exposed to radon will get lung cancer, but increased exposure increases risk. Lung cancer is the only health effect which has been definitively linked with radon exposure. (https://www.cdph.ca.gov/Programs/CEH/DRSEM/Pages/EMB/Radon/What-is-Radon.aspx).

SUMMARY OF RESULTS

Following are the additional sampling results (Report, Attachment C); given these results, public access to Cesar Chavez Park continues to be safe.

Groundwater and Leachate Samples

In the December 30, 2024 report, the City proposed additional sampling for radium-226 and radium-228 utilizing alternative methods to get more accurate results. Because the presence of radon in samples can interfere with the analysis method utilized in 2024, alternative methods, commonly used methods were used for the 2025 sampling to reduce radon interference and confirm results.

The additional samples required to perform the alternative analyses were collected during a routine semi-annual monitoring and sampling event on June 23 and 24, 2025. These results indicated significantly lower levels of radium-226 and radium-228 than previously reported in the December 30, 2024 report. Radon interference in the 2024 analyses appear likely, and the City's consultants consider the 2025 results using the alternative methods to be representative of radium activity within the groundwater and leachate. Currently the City does not plan to perform additional screening for radionuclides in groundwater and leachate based on these 2025 results and awaits RWQCB review of the results.

Ambient Air Samples

Samples were collected on June 17 and 18, 2025. Radon concentrations are presented in picocuries per Liter(pCi/L). Ambient air samples were collected with the air sample inlet height maintained at an estimated average adult's breathing zone (roughly 5.5 feet). Radon was detected in the ambient air samples at concentrations ranging from 0.01 pCi/L to 0.09 pCi/L. These concentrations are indicative of EPA stated average background levels for outdoor air, 0.4 pCi/L (https://www.epa.gov/radon/what-epas-action-level-radon-and-what-does-it-mean).

Landfill Gas (LFG) Samples

Samples were collected on June 17 and 18 from the LFG extraction wells (EW), which are connected to the subsurface gas collection and control system (GCCS) piping that are maintained under vacuum to convey LFG to the flare. Radon in subsurface LFG samples was detected at varying concentrations meaning the potential for LFG extraction system worker exposure to elevated radon during monitoring, maintenance, and/or repair activities is present. Health and safety procedures, including monitoring for radon during subsurface activities, are in place to control this potential risk.

While there is potential for LFG extraction system worker exposure to elevated radon during certain work activities, Cesar Chavez Park remains safe for members of the public. As stated above, the GCCS is a closed system that is maintained under vacuum, minimizing the risk of releases of radon to the surface, as made evident by the low levels detected in the ambient air sampling. When work occurs on the GCCS that has potential for radon exposure, workers will follow all applicable health and safety protocols and have radiation monitoring instruments for both area and individual monitoring.

RADIATION HEALTH AND SAFETY PLAN

The City tasked Geosyntec, an environmental engineering consultant, to prepare an updated Radiation Health and Safety Plan (RHASP) (Attachment D) with protocols for how all maintenance and repair work must be conducted at the capped landfill. According to the RHASP, significant disturbance of the surface soils at the closed Berkeley Landfill (Site) could breach the landfill cap. The June 5, 2025, Off-Agenda Memo informed Council that any work that disturbed the ground surface would require safety precautions. The updated RHASP has determined that safety precautions apply to any work that disturbs the ground surface at depths of one foot or deeper. As such, any current or proposed activities at the landfill that involve disturbance of the soils less than one foot in depth may proceed with no additional requirements, and any disturbance of the soils at depths of one foot or more must follow the RHASP.

The plan provides detailed instructions for the safe handling of media contaminated with low levels of radiological isotopes, including contamination in the soil, gas, and liquid within the Site and is intended for use by all employees and third parties working at the Site.

The RHASP applies to tasks performed at the Site that extend one foot or more below the existing ground surface including, but not limited to, trenching, underground utility work, re-grading, paving, and leachate, groundwater, and landfill gas monitoring or sampling.

MODIFICATIONS TO PARK USES

To ensure public safety, the City is modifying certain park uses in alignment with Berkeley Municipal Code Chapter 12.29.040 (Precautionary Principle). These adjustments are detailed in Table 1 on the following page.

Table 1 – Modifications to Park Uses	
Existing Use	**Modification**
Off-Leash Dog Area	Off-leash activity can still be allowed *only* if owners maintain control of their dogs and stop them from digging into the landfill cap (e.g., surface soils).
Volunteer Planting	Planting is permitted as long as soil disturbance does not extend one foot or greater below ground surface.
Routine Operations and maintenance by PRW staff (less than one foot below ground surface)	Operations and maintenance activities that involve penetrating the ground surface less than one foot in depth may be performed by City staff with no additional precautions.
Routine operations and maintenance by PRW staff (one foot or more below ground surface)	Operations and maintenance activities that involve penetrating the ground surface one foot or more in depth may be performed by City staff in accordance with the RHASP.
Landfill compliance activities and construction by City contractors	Contractors performing work related to compliance with regulatory requirements for the City's closed landfill will perform all work in accordance with the RHASP when said work penetrates the ground surface one foot or more below ground surface.
Rodent burrowing	The City will revisit existing policies on control of burrowing animal species at César Chávez Park in an effort to reduce ground penetrating burrows onsite.
Burrowing Owls	To be determined. Burrowing owls are present in the park generally from October to March and typically do not create their own burrows.
Trail Maintenance	Perimeter pathway maintenance will consist of mill and overlay of existing asphalt but cannot disturb the underlying soil one foot or more below ground surface.

The health and safety protocols for soil disturbance at César Chávez Park may be adjusted in the future, pending RWQCB review of the additional testing results and future guidance.

ATTACHMENT:

A. Water Board January 28, 2025 Letter – Concurrence with Investigation Completion Report and Requirement for Information Pursuant to Water Code Section 13267, Berkeley Landfill, Alameda County
B. Revised Work Plan – Response to Letter of Requirement for Information Pursuant to Water Code Section 13267, Berkeley Landfill, Alameda County
C. Report – Radiological Survey Results Closed Berkeley Landfill/Cesar Chavez Park, Berkeley, California
D. Radiation Health & Safety Plan – Berkeley Landfill Prepared by Geosyntec Consultants

cc: David White, Deputy City Manager
Terrance Davis, Public Works Director
Scott Ferris, Parks, Recreation, Waterfront Director
Jenny Wong, City Auditor
Farimah Brown, City Attorney
Mark Numainville, City Clerk
Matthai Chakko, Assistant to the City Manager

CALIFORNIA Water Boards

GAVIN NEWSOM
GOVERNOR

YANA GARCIA
SECRETARY FOR
ENVIRONMENTAL PROTECTION

San Francisco Bay Regional Water Quality Control Board

January 28, 2025
GeoTracker: L10006224883

City of Berkeley
Department of Public Works, Engineering Division
Attn: Daniel Akagi
1947 Center St., 4th Floor
Berkeley, CA 94704
Sent via email only: DAkagi@berkeleyca.gov

Subject: Concurrence with Investigation Completion Report and Requirement for Information Pursuant to Water Code Section 13267, Berkeley Landfill, Alameda County

Dear Daniel Akagi:

Regional Water Board staff has reviewed the City of Berkeley's December 30, 2024, *Completion Report - TENORM and OCP Health and Safety Survey* ("Report"), which was submitted in response to Regional Water Board's Section 13267 Order dated January 18, 2024, and in accordance with Berkeley's Revised Investigation Workplan, dated August 6, 2024, that the Regional Water Board approved on August 13, 2024.

This letter also requires the City of Berkeley to submit a technical report documenting the results of additional sampling and analysis of landfill leachate, groundwater, and landfill gas within 30 days of receiving analytical results. This requirement and its basis are explained below.

Concurrence with Investigation Completion Report

The Report concluded the following:

1. The drone flyover survey did not identify any appreciable spectral variability; no "hotspots" were identified that were statistically above expected natural background levels.

2. Analysis of leachate and groundwater samples collected from the landfill's groundwater monitoring well network did not identify any organochlorine pesticides; however, certain radionuclides were detected, including radium-226, which was detected in all liquid samples except one that had elevated detection limits. The radium results were obtained using analytical method Gamma Spectroscopy 901.1, and all radium-226 results appear to be above expected

background levels. Other radionuclides were detected at very low levels as follows: thorium-230 in two groundwater and three leachate samples; lead-210 in one leachate sample; and radium-228 in one groundwater sample. Most of the detected nuclides appear to be related, as thorium-230 decays to radium-226, which decays to lead-210.

The City of Berkeley has proposed collecting an additional round of groundwater and leachate samples and analyzing those samples using USEPA Method 903 (for radium-226) and Method 904 (for radium-228) to see if the radium detections are reproduced and/or confirmed. After consultation with California Department of Public Health staff about this approach, we concur with this proposed re-assessment of liquid samples. These methods are preferred because analysis of water samples using radiochemical methods such as Methods 903 and 904 can provide more reliable results with lower detection limits than gamma spectroscopy methods such as Method 901.1.

Requirement for Information

This letter requires the City of Berkeley to submit a technical report documenting the results of sampling and analysis of landfill leachate, groundwater, and landfill gas. In addition to the leachate and groundwater sampling proposed by the City of Berkeley described above, this letter requires the City of Berkeley to collect samples of landfill gas and analyze for radon, which is a decay product from radium-226. Additional investigation may be required depending upon the results of the water and landfill gas analyses. The City of Berkeley shall perform the required sampling as soon as possible and report the results to us within 30 days of receiving analytical results.

Basis for Requirement

This requirement for a report is made pursuant to Water Code section 13267, which allows the Water Board to require technical or monitoring program reports from any person who has discharged, discharges, proposes to discharge, or is suspected of discharging waste that could affect water quality. The burden, including costs, of the report bears a reasonable relationship to the need for the report and the benefits to be obtained from the report including determining whether subsurface contamination poses any immediate threats to human health or water quality. The attachment provides additional information about section 13267 requirements. Any extension to the above deadlines must be confirmed in writing by the Regional Water Board Executive Officer.

Electronic Reporting

The City of Berkeley is required to submit all reports and data in electronic format to the State Water Resources Control Board’s GeoTracker database, pursuant to California Code of Regulations, title 23, sections 3890–3895. See [Electronic Submittal of Information] for guidance on submitting documents to GeoTracker. This requirement includes all chemical data, monitoring well information (latitudes, longitudes, elevations, depth and length of screened interval, and water depth), site maps, and boring logs. Chemical data must be submitted in Electronic Deliverable Format (EDF) and be in accordance with the GeoTracker Guidance Letter on Reporting of Estimated Results in EDF.

If you have any questions, please contact Fangli Yin of my staff at (510) 622-2406 or fangli.yin@waterboards.ca.gov.

Sincerely,

Eileen M. White

Eileen M. White, P.E.
Executive Officer

Copy to:

Ian Utz, Department of Toxic Substances Control, Ian.Utz@dtsc.ca.gov
Bradley Loomis, California Department of Public Health, Bradley.Loomis@cdph.ca.gov

Attachment:

Water Code Section 13267 Fact Sheet

San Francisco Bay Regional Water Quality Control Board

Fact Sheet – Requirements for Submitting Technical Reports Under Section 13267 of the California Water Code

What does it mean when the Regional Water Board requires a technical report?

Section 13267[1] of the California Water Code provides that "…the regional board may require that any person who has discharged, discharges, or who is suspected of having discharged or discharging, or who proposes to discharge waste...that could affect the quality of waters...shall furnish, under penalty of perjury, technical or monitoring program reports which the regional board requires."

This requirement for a technical report seems to mean that I am guilty of something, or at least responsible for cleaning something up. What if that is not so?

The requirement for a technical report is a tool the Regional Water Board uses to investigate water quality issues or problems. The information provided can be used by the Regional Water Board to clarify whether a given party has responsibility.

Are there limits to what the Regional Water Board can ask for?

Yes. The information required must relate to an actual or suspected or proposed discharge of waste (including discharges of waste where the initial discharge occurred many years ago), and the burden of compliance must bear a reasonable relationship to the need for the report and the benefits obtained. The Regional Water Board is required to explain the reasons for its requirement.

What if I can provide the information, but not by the date specified?

A time extension may be given for good cause. Your request should be promptly submitted in writing, giving reasons.

Are there penalties if I don't comply?

Depending on the situation, the Regional Water Board can impose a fine of up to $5,000 per day, and a court can impose fines of up to $25,000 per day as well as criminal penalties. A person who submits false information or fails to comply with a requirement to submit a technical report may be found guilty of a misdemeanor. For some reports, submission of false information may be a felony.

Do I have to use a consultant or attorney to comply?

There is no legal requirement for this, but as a practical matter, in most cases the specialized nature of the information required makes use of a consultant and/or attorney advisable.

What if I disagree with the 13267 requirements and the Regional Water Board staff will not change the requirement and/or date to comply?

You may ask that the Regional Water Board reconsider the requirement, and/or submit a petition to the State Water Resources Control Board. See California Water Code sections 13320 and 13321 for details. A request for reconsideration to the Regional Water Board does not affect the 30-day deadline within which to file a petition to the State Water Resources Control Board.

If I have more questions, whom do I ask?

Requirements for technical reports include the name, telephone number, and email address of the Regional Water Board staff contact.

[1] Code sections can be found by searching the California Legislative Code Section search at http://leginfo.legislature.ca.gov/faces/codes.xhtml

rev: March 2014

Geosyntec consultants

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11 June 2025 (Revision 1)

Ms. Fangli Yin
San Francisco Bay Regional Water Quality Control Board (RWQCB)
1515 Clay Street, Suite 1400
Oakland, California 94612
via e-mail: fangli.yin@waterboard.ca.gov

Subject: Response to Letter of Requirement for Information Pursuant to Water Code Section 13267
Berkeley Landfill, Alameda County

Dear Ms. Yin:

As part of the on-call engineering support services provided to the City of Berkeley (City), Geosyntec Consultants, Inc. (Geosyntec) is transmitting this Work Plan (WP) in response to the San Francisco Regional Water Quality Control Board's (RWQCB) letter dated January 28, 2025. The letter, titled Concurrence with Investigation Completion Report and Requirement for Information Pursuant to Water Code Section 13267, Berkeley Landfill, Alameda County, requests the City to submit a technical report documenting the results of sampling and analysis of leachate and groundwater collected at the closed Berkeley Landfill/Cesar Chavez Park (Site) using different analytical testing methods than those previously used. In addition, the RWQCB's letter also requires the City to collect landfill gas samples and analyze them for radon, which is a decay product from Radium-226, one of the components encountered in leachate and groundwater samples reported by SCS Engineers (SCS) in the *Completion Report - TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill/Cesar Chavez Park, Berkeley, California* dated December 30, 2024 that SCS prepared on behalf of the City.

Background

On January 18, 2024, the RWQCB issued a letter to the City of Berkeley indicating that industrial waste materials containing certain radionuclides known as technologically enhanced naturally occurring materials (TENORM) may have been disposed at the Site. Therefore, the RWQCB required the City to prepare a work plan to conduct representative soil and groundwater sampling at the Site to assess potential TENORM contamination and document the results in a completion report.

In response to the January 18, 2024 RWQCB letter, SCS, the City's consultant, prepared a *Revised Work Plan for TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill, Berkeley, California,* which the City submitted to the RWQCB on August 6, 2024. The August 6, 2024 work plan was approved by the RWQCB on August 13, 2024. The approved work plan required the testing of leachate and groundwater samples for the following components using the test methods described below:

- Thorium-228, 230 and 232 and uranium-234, 235 and 238 by HASL-300 EML Radiological Manual Method A-01-R
- Radium-226 by Method Gamma Spec. 901.1
- Radium-228 by Method Gamma Spec. 901.1
- Lead-210 by Method LSC-Pb210
- Organochlorine Pesticides (OCPs) by EPA Method 8081.

Results of the soil, leachate and groundwater sampling and analysis were presented by SCS in the *Completion Report - TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill/Cesar Chavez Park, Berkeley, California,* dated December 30, 2024, and submitted to the RWQCB on the same day. The completion report showed that four radionuclides (Thorium-230, Radium-228, Radium-226 and Lead-210) were present in leachate and groundwater samples collected at the Site. SCS also reported that the Gamma Drone Survey (GDS) results indicated that all radiological activity detected at the ground surface and shallow subsurface was equal to or lower than typical background radiation levels expected in the ambient environment.

Current Scope of Work

In response to the RWQCB's letter dated January 28, 2025, the City proposes collecting leachate and groundwater samples following the "Liquids Sampling and Analysis" section of the RWQCB-approved WP dated August 6, 2024 except that as described in the RWQCB's letter dated January 28, 2025, USEPA Methods 903 and 904 will be used to test for Radium-226 and Radium-228, respectively. The objective of the testing using USEPA Methods 903 and 904 is to see if radium detections are reproduced and/or confirmed. This sampling and analysis will be performed by SCS for the City during the next routine monitoring and sampling event in June 2025.

In addition, because previous sample results did not detect the presence of OCPs in any of the liquid samples, the City requests that no additional testing of OCPs be performed. A copy of the RWQCB-approved 2024 WP is included in Attachment 1.

The approved 2024 WP did not require testing of landfill gas samples, therefore, as requested by the RWQCB in the January 28, 2025 letter, the City proposes collecting and testing landfill gas samples from 12 landfill gas extraction wells for radon. Figure 1 shows the proposed landfill gas extraction wells to be sampled. In the event that sampling is not viable from any of the proposed landfill gas extraction wells an alternate nearby well will be sampled. In addition, the City also proposes collecting 11 ambient air samples, from locations as shown in Figure 1.

To test for radon, the City proposes, following the procedures established by Dr. Doug Hammond, a professor of Earth Sciences at the University of Southern California (USC). Dr. Hammond is an expert in the field of radon analysis and radon sample collection. Attachment 2 includes a copy of *Protocols and Procedures used by D. Hammond for Analyses of Rn in Indoor Air and Soil Vapor,* prepared by Dr. Hammond to describe the instrumentation used in the analyses, the standardization applied, the method of handling background and blank samples, the quality assurance and quality control (QA/QC) procedures followed as part of the analyses, the protocols that are followed when samples arrived at the lab, and the method by which sample activity is calculated. Page 4 of the document included in Attachment 2 also includes sample collection instructions, including the sampling equipment to be used, the sample information required and specific sample collection instructions depending on whether ambient and room air samples or soil gas samples are to be collected. For the samples to be collected at the Site, the City proposes following the soil gas sample collection instructions developed by Dr. Hammond. Attachment 3 includes Dr. Hammond's resume. These samples would also be collected by SCS in June.

Technical Report

After sampling and laboratory testing have been completed in accordance with the above protocols, the City will submit a technical report. The report will be an addendum to the completion report previously prepared by SCS, on behalf of the City, and submitted to the RWQCB on 30 December 2024.

Closing

The City respectfully requests that the proposed WP be approved for implementation to be scheduled. If you have any questions, please contact Mr. Daniel Akagi at the City of Berkeley.

Sincerely,

Amy Padovani, P.E.
Principal

Attachments: Figure 1 – Sample Location Plan
Attachment 1 – Revised Work Plan for TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill, Berkeley, California
Attachment 2 – Protocol and Procedures Used by D. Hammond for Analysis of Rn in Indoor Air and Soil Vapor
Attachment 3 – Dr. Doug Hammond Resume

Legend:

- GROUNDWATER MONITORING WELL
- LEACHATE MONITORING WELL
- LMH-2 LIQUID COLLECTION SUMP
- EW-2 LFG EXTRACTION WELL
- CONCRETE DRAINAGE DITCH (V-ditch)
- GENERAL SITE BOUNDARY
- PROPOSED LANDFILL GAS EXTRACTION WELL SAMPLE LOCATION
- PROPOSED AMBIENT AIR SAMPLE LOCATION

Sample Location Plan

Berkeley Landfill
Alameda County, California

Geosyntec consultants

WG3542	June 2025	Figure 1

Attachment 1: Revised Work Plan for TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill, Berkeley, California (SCS, 2024)

August 6, 2024
File No. 01210112.03

Fangli Yin via email: Fangli.Yin@Waterboards.ca.gov
Regional Water Quality Control Board
Region 2
1515 Clay Street, Suite 1400
Oakland, California 94612
510-622-2406

Subject: Revised Work Plan for TENORM and OCP Health and Safety Survey
Closed Berkeley Landfill
Berkeley, California

Dear Fangli,

On behalf of the City of Berkeley (City), SCS Engineers (SCS) submits this Work Plan (WP) in response to the San Francisco Bay Regional Water Quality Control Board's (RWQCB) letter, dated January 18, 2024. The letter, titled *Berkeley Landfill, Berkeley, Alameda County - Requirement for Technical Reports Pursuant to Water Code Section 13267*, mandates the development of a WP to conduct a survey detailed herein at the closed Berkeley Landfill/Cesar Chavez Park (Site). The Site is located north of Spinnaker Way in Berkeley, California. Enclosed are a Site Location Map (Figure 1) and a Site Plan showing the primary features of the Site (Figure 2).

BACKGROUND

The January 18,2024 RWQCB letter indicates new evidence that industrial waste from the Zeneca Richmond Plant may have been disposed of at the Site between 1960 and 1971. Enclosed with the letter was a correspondence from March 28, 1980, by Stauffer Chemicals, identifying the Berkeley Landfill Company site as a recipient of the Richmond Plant's process waste. This waste reportedly included "alum mud," a byproduct of aluminum extraction from bauxite ore, which typically contains certain radionuclides known as "technologically enhanced naturally occurring radioactive material" (TENORM).

Neither the City nor the RWQCB was previously aware of the potential presence of TENORM at the Site. Consequently, the RWQCB requires the City to submit a work plan as this document provides. It should be noted that groundwater and leachate samples were analyzed at the Site for organophosphorus pesticides in 2013, 2018, and 2023, with no detections reported.

SITE DESCRIPTION

The Site spans approximately 90 acres on the western edge of the City. The Site forms the northern portion of a man-made peninsula, bounded by San Francisco Bay on the west, north, and east, and the Berkeley Marina on the south. The landfill is designated as Facility No. 01-AC-0001 in the State of California Solid Waste Information System (SWIS) database.

Initially permitted by the California Integrated Waste Management Board (CIWMB) in 1978, the landfill was authorized to receive up to 180 tons per day (67,000 tons per year) of residential and commercial refuse, plant debris, and demolition debris. Historical records indicate that waste placement began as early as 1961, comprising a mixture of municipal, commercial, and industrial solid wastes. This continued until 1983. Between 1983 and 1985, soil, asphalt, concrete, and materials containing a combination of subgrade soil, concrete and/or asphalt were also accepted as waste per RWQCB approval. After 1985 only, clean fill was imported as cover.

The landfill was formally closed in phases during the period 1981 through 1989 per the California Code of Regulations (CCR) Title 14 and 23 requirements in effect at the time. Today, the Site is developed as North Waterfront Park/Cesar Chavez Park and continues to be subject to post-closure monitoring and maintenance. Oversight of these activities is provided through various programs administered by the RWQCB, the California Department of Resources Recycling and Recovery (CalRecycle), and the Bay Area Air Quality Management District (AQMD).

The final cover system, which was installed in phases, varies in thickness from 3 to over 30 feet. The cover system was placed to contour the Site for use as a public park and to meet regulatory requirements in effect at the time of closure. The final cover system includes both general fill soils and a minimum 1-foot-thick layer of clay material with a hydraulic conductivity of 1×10^{-6} centimeters/second.

For additional information please refer to the *Updated WDRs for the Site (Order No. R2-2010-0064),* published by the RWQCB on April 19, 2010.

SCOPE OF WORK

This WP proposes a sequential survey approach which includes establishing background radiation levels through a pilot study using a drone, conducting an initial gamma radiation survey also using a drone, and performing additional water sampling and analysis from existing monitoring features.

The City has partnered with the University of California at Berkeley’s Nuclear Engineering Department (UCB) to perform the gamma drone survey (GDS). The purpose of the GDS is to identify sources of radiation on or near ground surface. The radionuclides of concern identified by the RWQCB emit gamma radiation, as well as alpha and beta radiation. Gama radiation is penetrating and can travel significant distances through air and soil making it easier to detect in the environment compared with alpha and beta radiation. The results of the GDS will assist in determining radiological risks to workers or members of the public from radioactive material potentially disposed of in the landfill and provide an estimate of the lateral extent of any surface radioactivity.

In addition, upcoming routine semi-annual monitoring is proposed to include additionally analyzing routinely collected samples for OCPs and additional parameters detailed below.

The proposed study includes the following:

- Establishment of Background Levels
- Surface Survey
- Follow-up Surface Survey (Based on results of Initial Survey)
- Liquids Sampling and Analysis
- Evaluation of Data and Report Preparation

Survey Instrumentation
This survey will employ a professional-grade drone with an advanced radiation detection system. The system features a 3 x 3 inch sodium iodide (NaI) spectrometer integrated with a GPS for sub-meter accuracy. The Theiss Validus Hex drone, battery-operated and able to carry up to 18 lbs, will carry the NaI(Tl) detector, which will operate in list mode with readout using an Ortec DigiBase. This readout method assigns time and energy to each detected gamma ray. Additionally, ground surface surveying with a SAM 945 Handheld Radiation Isotope Identifier (RIID) will be performed at select locations to validate drone data.

Survey Methodology
The GDS will involve the NaI detector suspended approximately 3 meters above the ground and with 6-meter line spacing. To enhance measurement sensitivity, the drone's speed will be limited to no more than 3 meters per second (m/s). Each 1-second measurement will cover an area of about 18 square meters (m^2).

The GDS aims to cover 100% of the accessible ground surface, providing a comprehensive assessment of the Site's radiological conditions. In areas where dense vegetation impedes the drone's flight path, the drone will fly at a safer height as determined by the pilot. If the understory is clear, surveyors will walk the understory with the NaI spectrometer to ensure thorough examination.

Background Establishment

Before surveying the entire Site, a preliminary survey was conducted in June 2024 to establish background levels in the northwest corner (Location A) as shown in Figure 2. This area was chosen because it contains only documented and confirmed clean soil or fill, with no landfill refuse present. Ground surface surveying was performed alongside the drone survey. For safety, the area was closed to the public while the drone operated at low altitudes. This preliminary survey was crucial for providing a baseline for comparison with subsequent surveys of the entire Site.

Analysis of the data collected during the background establishment survey (shown in Figure 3) revealed no significant spectral variations within the surveyed area, the gamma radiation detected was attributed to natural radioactivity found in all soils, with count rates remaining stable except when in proximity to or above water. The observed rates were compared with a handheld dosimeter near the background establishment effort launch point with readings of 7-10 microR/hr, which we associate with 200-285 counts per second (cps) in the spectrometer. Further investigation will be conducted in areas where readings exceed 3.5 sigma above the established local background. For example, in the area used to establish background, any reading above 345 cps will prompt further surveying. In regions closer to the shoreline, where typical readings of 200 cps were observed, the investigation threshold will be set at 250 cps. These count rate thresholds correspond to 1.25-2.0 microR/hr above the established background for triggering follow-up measurements.

Given the 3.5 sigma count rate threshold, approximately one false alarm per hour is anticipated due to statistical fluctuations. The initial approach for follow-up surveying will involve returning to the location of the anomalously high reading to check for reproducibility. If the elevated count rate is confirmed, handheld measurements with minute-scale dwell times will be conducted to further assess the anomaly. Based on these measurements, the existence and location of the anomaly will be reported, and further actions, such as soil sampling, will be considered.

Full Site Survey

With background levels established from the preliminary survey, the full Site survey will be conducted using the same drone and radiation detection system. The survey will be executed in phases due to the Site's size and public usage, ensuring minimal disruption. Each phase will require approximately 60 minutes of drone flight time, during which only limited areas will be closed to allow public access to other parts of the Site. Additionally, limited walking gamma surface surveys will be performed during each phase as previously described.

Data Evaluation

UCB will process the drone survey data, cross-checked with the ground surface survey data. A 3D map of the Site will be prepared to summarize all survey results. The map will use color to differentiate between results.

Additional Surveying

Survey results may results in follow up survey(s), to confirm initial data. The data will be processed and reported as described above.

Liquids Sampling and Analysis

During one future routine groundwater and leachate monitoring event, it is proposed to sample all Site groundwater and leachate monitoring well samples for the additional non-routine compounds listed below:

- Thorium-228, 230 and 232 and uranium-234, 235 and 238 by HASL-300 EML Radiological Manual Method A-01-R
- Radium-226 by Method Gamma Spec. 901.1
- Radium-228 by Method Gamma Spec. 901.1
- Lead-210 by Method LSC-Pb210
- Organochlorine Pesticides (OCPs) by EPA Method 8081

Liquid samples to be analyzed as listed above will be collected along with routine samples. For the groundwater samples, low-flow purging and sampling methodology, using existing dedicated bladder pumps will be used as routinely performed. Leachate samples will be collected using dedicated disposable plastic bailers, also as routinely performed. Samples will be collected in laboratory supplied, appropriate sample containers. Upon collection, samples will be labeled, logged, and placed in a chilled cooler prior to delivery or shipment to the analytical laboratory under proper chain-of-custody (COC) procedures. OCP samples will be delivered to McCampbell Analytical laboratory in Pittsburg, California for analysis. Remaining samples will be shipped to Eurofins Test America laboratory in Saint Louis, Missouri for analysis.

Completion Report and Additional Documents

A Completion Report will be prepared for submittal to the RWQCB following completion of the Survey and liquids sampling and analysis activities described above. The report will include a summary of performed activities, summary of data, 3D map summarizing Survey results, and copies of laboratory reports. The report will conclude whether additional data collection appears warranted at which time an addendum to this WP will be submitted to the RWQCB. The addendum will document possible additional survey activities and/or, if warranted, will provide proposed soil borings and soil sample collection and analysis to further evaluate the potential for TENORM at the Site

OCP results will be compared to current Environmental Screen Levels (ESLs) provided by the RWQCB.

CLOSING

With this submittal we respectfully seek your approval for the WP outlined herein. If you have any questions, please contact Mary Skramstad with the City of Berkeley.

Very truly yours,

Ted Sison
Senior Project Manager
SCS Engineers

Patrick Harms, PG
Project Manager
SCS Engineers

Attachments Figures 1, 2 and 3

cc: Mary Ellen Skramstad - City of Berkeley
Daniel Akagi - City of Berkeley
Ronald Nevels - City of Berkeley
Tony Svorinich – SCS Field Services
Melissa St. John – SCS Engineers
Brian Quiter – UC Berkeley
Kai Vetter – UC Berkeley

Figures

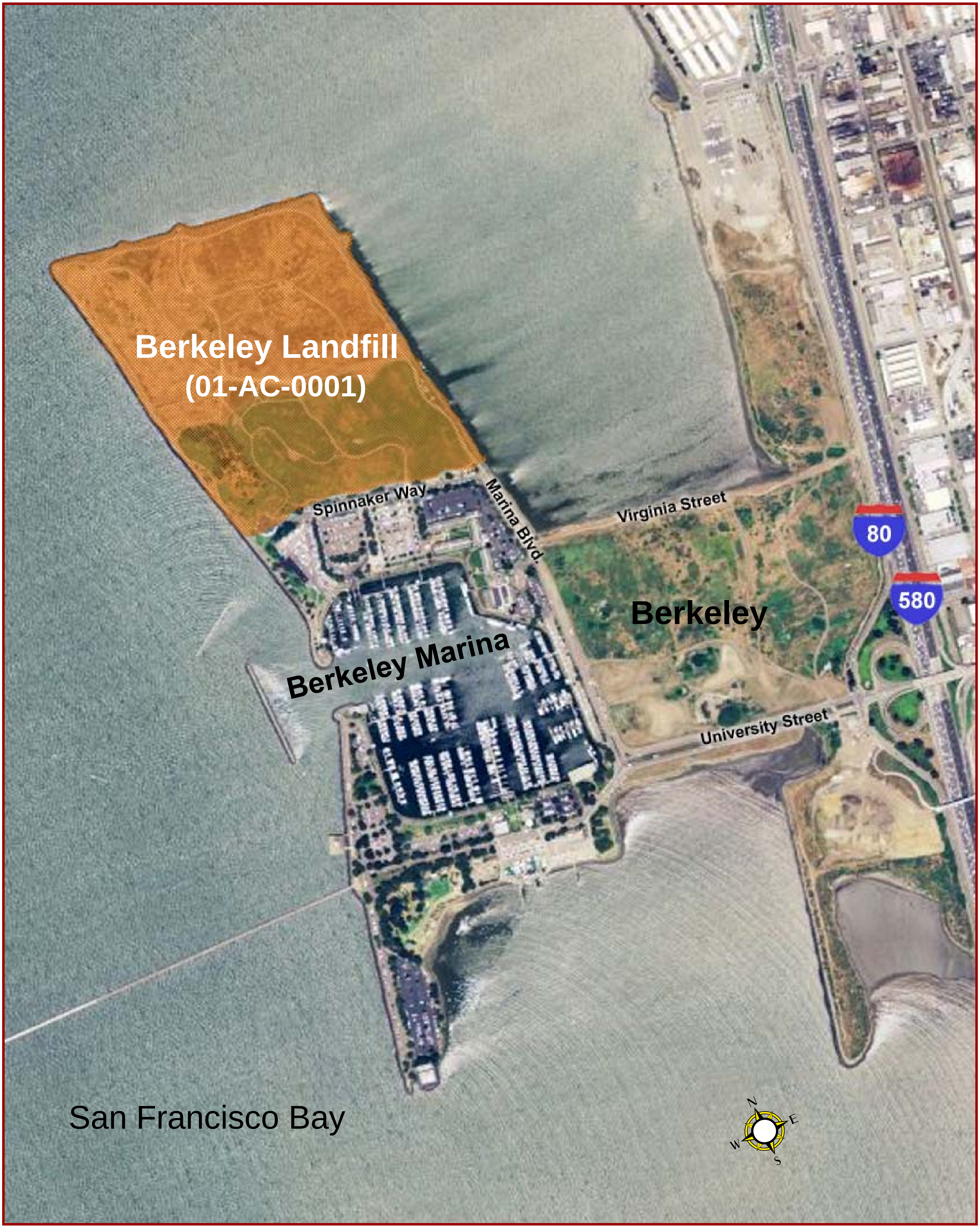


Figure 1: Berkeley Landfill Location Map

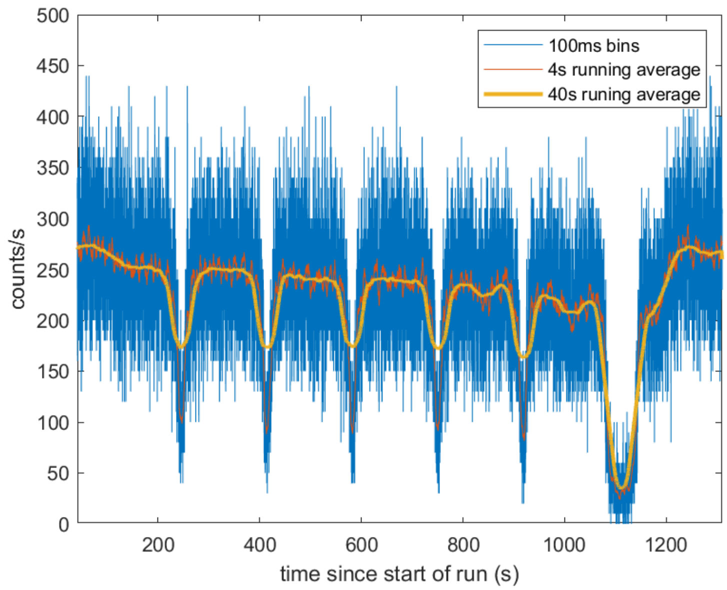
Figure 2

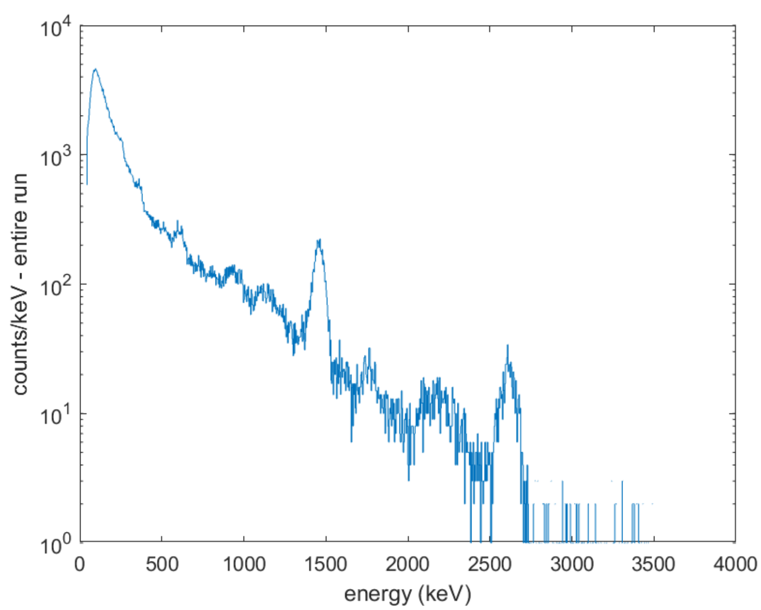
View with Site aerial photo from the drone planning software that shows the planned flight lines (in yellow), including Location A, which is circled in red on the zoomed-in right-hand figure. These lines were flown during the preliminary background survey.

Figure 3 - Data Summary from Background Study.

(top) Count-rate profiles from one of the two flights during the background establishment survey. The list-mode data collect modality allows for data to be converted into count-rate profiles at any time interval. Shorter intervals allow for sensitivity to fast anomalies, but are subject to greater statistical uncertainty, which is evident in the amount of jitter in the 100ms strip-chart, shown in blue. Longer intervals, such as the 40s running average, in yellow establish a mean rate over a wide area and can help to guide searches for anomalous activity.

(bottom) Gamma-ray spectrum obtained from the entirety of the corresponding flight, the prominent peaks at 2615 and 1460 keV are due to decay of thorium and potassium-40, respectively. The less prominent peak near 600 keV is due to both uranium radioactive decay (609 keV) and thorium decay (583 keV). The peak-like feature at low energy is due only to gamma-ray physics and is not indicative of any isotope in particular. Other visible peaks at 240,350, 910, 1120, 1760 and 2200 keV are also due to uranium and thorium decay.





Attachment 2: Protocol and Procedures Used by D. Hammond for Analysis of Rn in Indoor Air and Soil Vapor

Protocol and Procedures Used by D, Hammond for Analysis of Rn in Indoor Air and Soil Vapor (Updated 05/15/23)

SAMPLE COLLECTION INSTRUCTIONS: BE SURE YOU HAVE CONFIRMED WITH THE LAB THAT COUNTING TIME WILL BE AVAILABLE WHEN YOUR SAMPLES ARRIVE (contact info below)

Equipment needed

-Polypropylene Syringes with appropriate stopcocks for closing (60 cc is convenient). If syringe is disconnected from a soil gas probe and then transferred to a bag, the syringe should have a two way stopcock for closure while it is disconnected.

-Tedlar bags for each sample, 0.5 or 1 liter size. The design with polypropylene fittings is best (Bags from Cel or ESS have been most reliable. SKC Inc., Model 232-02 are OK, but have had slightly higher failure rates. **Do not use bags with metal fittings, as these valves have often leaked in the past.**

-Samples may also be collected with a lung box, but only if different tubing and fittings are used for subsurface and surface samples. **Once exposed to subsurface air, many plastics sorb sufficient Rn that they will contaminate low activity samples.**

Sampling information needed on COC or bag:

-**Sample ID and type** (sub-surface or above ground to indicate how hot it may be)
-Sampling date and time (within 10 minutes or so), using the local time zone.
-The approximate site location (so we can to correct results to ambient air pressure).
For our research, it is appreciated (but not required) if outdoor air samples are identified.

Sample Collection Procedures:

Overview: Samples are easily collected by syringe and transferred to the Tedlar bags. A small piece of tygon tubing (1/8" ID) is a convenient way to connect the syringe to the bag**. Use one syringe for 'cold' samples** (building or ambient air) **and a different one for 'hot' samples** (subsurface gas). **Handle bags with some care.** Some bags have developed pinhole leaks created by abrasion against rocks or other rough surfaces.

Volumes Needed: For subsurface samples, at least 250 cc should be collected. For room air or ambient air samples, at least 350 cc should be collected**. Bags should not be filled more than ~2/3 full**. Overfilling can lead to failure if they are exposed to low pressure during shipment.

Steps for Outdoor and Room Air Samples: Label bag. Fill syringe with air, connect to bag, open valve (1/2 to ¾ turn), and push gas into bag. Repeat until about 300-350 cc is collected. Close valve. **Gently squeeze bag to check for leaks (bag would deflate). Collect above-ground samples before purging subsurface lines to avoid adding Rn to the room air.**

Steps for Subsurface Soil gas: Be sure sampling path from soil probe tip to syringe has been flushed adequately. Connect sample syringe to probe. Draw sample into syringe and transfer to bag, as above. Holding time in the polypropylene syringe should be less than 1 hour. **Gently squeeze bag to check for leaks (bag would deflate).**

Ship samples, preferably specifying 8:30 am delivery within 2 days to:

Doug Hammond
1421 Bonnell Drive
Topanga, CA 90290
(tel. 310-490-7896)

A stiff cardboard box makes a satisfactory shipping container.
DO NOT USE STYROFOAM PEANUTS FOR PACKING.
Send email to dhammond90290@gmail.com to indicate that samples are on the way.

LAB ANALYSIS

Instrumentation:

Scintillation counters are used. Some were built by Applied Techniques (Model AC/DC-DRC-MK10-2), others have been assembled from components including Scientific Computer Inst. Pre-amp/HV (model 612) and Tennelec counter/timers (model 534). These systems use Lucas type counting cells that have been made by Guy Mathieu. Cells are either 120 cc or 240 cc volume. For sample analysis, a cell is evacuated and a plastic syringe is used to inject a sample of known volume directly into the cell, through a 5 cm long glass tube containing dririte ($CaSO4$) or indicating silica gel, coupled to a SWAGELOCK quick-connect fitting. For high activity (subsurface) samples, 40 cc gas is used in the 120 cc cells. Low activity samples (above ground), are analyzed in low background cells (0.09-0.15 cpm), using 60 in the smaller cells or 120 cc in a larger cell. Results are corrected for radioactive decay between collection and analysis, and for the difference in atmospheric pressure in the lab (elevation of 300 m and temperature of 10-32°C) and at the sampling site (based on altitude and an assumed temperature of 20°C). The pressure correction factor applies equally to surface and subsurface samples.

Laboratory Protocol:

Sample delivery within 2 days of collection is highly recommended. Storage tests have shown that the Tedlar bags are suitable for at least 10 days of storage without a detectable change in decay-corrected radon activity. However, it is desirable to complete sample analysis within one radon half-life (4 days), to minimize decay corrections and provide sufficient activity to obtain reasonable counting statistics. After arrival, the integrity of each sample container is checked by a simple pressure test of each bag to ensure that it does not leak. The bag label is compared to the COC information to be sure sample ID is consistent. Aliquots of gas are drawn from the tedlar bag to rinse a sampling syringe, then an aliquot of measured volume is drawn and injected through the drying trap, into an evacuated counting cell. One set of sampling syringes and drying traps is used for low activity samples, and a second for high activity samples, to avoid cross contamination. After using a cell, the sample is evacuated to remove its Rn. If it has had a high activity ("hot") sample, the cell is pumped a second time, about 1-2 hours later to completely remove the previous sample. Counting cells are allowed to "rest" for at least 4 hours before re-use to avoid influence of Rn daughters left in the cell from the previous sample. With this protocol, memory effects are insignificant. Samples are generally analyzed in the order listed on the COC, with hot samples run during day, as they usually need only 1-4 hours counting time, and low activity samples usually counted overnight, typically about 12 hours. As noted above, low background cells (0.05 to 0.15 cppm) are used for low activity samples. High background cells may have a background up to 1 cpm, and are only used for high activity samples.

Standardization:

Counting efficiency for cell/counter pairs has been determined by extracting radon from standard solutions containing 226Ra. These solutions were prepared from aliquots of a standard obtained from NBS (now NIST) during the GEOSECS program. Five of these standards are used regularly, and their relative activities have remained quite stable during the years they have been in use. Several cells are calibrated at least once per year using these standards to insure stability of the counting system. These cells are then used to determine Rn activities in large volume Tedlars that are used for intercalibrations of all cells. Subsequently, replicate analyses of selected samples are regularly run to be sure that this intercalibration remains valid.

In 2009, samples were run in an inter-laboratory calibration exercise for 226Ra analysis, and values consistent with other well-established University groups were obtained. An additional intercalibration of gas phase Rn was run with Dr. Phil Jenkins of Bowser-Morner in April, 2013, and results were in good agreement (better than the counting uncertainty of about 5%).

The effect of counting in a dry air matrix has been carefully evaluated, comparing results with values in the helium matrix in which cells are calibrated, to determine the small correction (1-5%) needed for the difference in counting gas matrix. Further experiments with CO2 and CH4 as a counting matrix indicate that their effects do not differ significantly from air. Results of these matrix evaluations have been published (McHugh et al., 2008) and eliminate the need for further evaluation of matrix effects.
Cells are internally inter-calibrated, using high activity subsurface samples that are run in replicates with other cells that have been calibrated with the standard 226Ra solutions. Cells with high backgrounds are inter-calibrated two or more times per year, and cells with low backgrounds are inter-calibrated about once per year. Experience has shown that the cell counting efficiencies change very little over many years, unless photomultiplier tubes (PMT) deteriorate. PMT performance is periodically checked (about twice per year) by measuring activity of an internal source of 241Am or 230Th mounted in a Lucas cell.

Backgrounds and blanks:
Cell backgrounds are checked at least 2-3 times per year. These are not very critical for most subsurface samples, but are very critical for low activity measurements. Consequently, the lowest background cells are used only for low activity samples. As a result, their backgrounds have remained very stable during the past 10 years, although these backgrounds are updated several times per year. The backgrounds used are averages of multiple (typically 5) background counts of long duration, as this reduces the background uncertainty. With this careful attention to backgrounds, values measured for aged air (stored in tedlar bags for more than one month) are within the counting uncertainty of zero. Consequently, we have determined that any blank beyond they cell background is negligible. Based on criteria defined by DOD (QSM Version 5.4 FINAL, 2021), the LOD calculated for a typical analysis (60 cc sample, 0.10 cpm counting background, 12 hour count, 2 days elapsed between collection and analysis, and 3 sigma times the counting uncertainty) is 0.20 pCi/L. In practice, lower values may be reported, along with their uncertainty (± 1 sample standard deviation), even if the observed value is lower than this LOD. For samples with very low activities, random fluctuations in background may result in lower count rates than the average background, as expected from the statistics of radioactive decay. In this case, a value of 0.001 cpm is arbitrarily assigned for observed activity during the count, along with the uncertainty for the analysis (see below).

Calculation of sample Activity and Uncertainty:
After the sample is drawn into the counting cell, the cell is placed in the counter. Typically, 3 readings are taken at intervals that depend on sample activity. The consistency of these readings allows detection of spurious electronic noise or operator error (both are rare). Background counts are subtracted from the total counts observed in each interval, based on the average cell background. Radon has 2 short-lived alpha emitting daughters (218Po and 214Po) that grow into secular equilibrium during the count. This ingrowth is considered by integrating the Bateman equations describing daughter ingrowth during each counting interval, to obtain the radon activity at the time the sample was introduced into the cell. Results (with associated counting uncertainty) for each interval are compared to ensure that this function is accurate, that the counting efficiencies for parent and daughter decays are identical, and that no spurious results were obtained. Results are averaged (weighted by duration of the counting interval) to obtain an average observed activity for the sample. If one interval differs from the other two by more than 3 standard deviations, it is rejected (this occurs less than 1% of the time). This weighted result is then corrected for cell counting efficiency, decay between sample collection and analysis, and the difference in atmospheric pressure and temperature between the lab and the sample site. We assume that the field temperature is 20°C, and the pressure difference is computed from the difference in elevation of the sample site

and the lab. A temperature difference of 10°C would make only a 3% difference in concentration, less than the stated analytical uncertainty. Uncertainty based on counting statistics is computed, considering uncertainty from both sample and background counts. An additional uncertainty of 5% from other factors is assumed, based on cell standardization (<3%) and sample volume used (~2%), with error propagation used to determine final concentration uncertainty.

QA/QC:

The sample volumes requested above provide sufficient gas to permit at least one replicate analysis, if needed. Typically, about one of every 8-10 samples is analyzed in duplicate, to ensure quality control and randomly check performance of cells and counting equipment. Usually a high activity sample is duplicated, but sometimes a low activity sample is used for replication. The average precision of high activity lab duplicates (±1 sample standard deviation) is typically about ±3%, slightly better than our typical expected uncertainty of ±5% which includes calibration uncertainty. For low activity samples, the analytical uncertainty depends primarily on the counting statistics, and the reported uncertainty for a single analysis may equal or exceed the reported value if activity is very low (less than the LOD described above). If the sample standard deviation of duplicates is greater than expected based on the calculated uncertainties (5% for high activity samples, but larger for low activity samples), the sample is re-analyzed. For low activity samples, the criterion for evaluating replicate analyses is to consider the difference (D) in two values. Error propagation predicts the uncertainty in this difference is sigD = sqrt(sx1^2 + sx2^2), where sx1 and sx2 are the uncertainties in the two analyses. If D/sigD >2 (95% confidence limit that the values differ), the analysis is re-run.

Additional details about analysis of standards and field samples can be found elsewhere:

Analysis of standards using solutions with 226Ra

Mathieu, G., P. Biscaye, R. Lupton, and D. E. Hammond, 1988, System for measurement of radon-222 at low levels in natural waters, Health Physics, 55, 989-992.

Analysis of soil gas

McHugh, T. E., D. E. Hammond, T. Nickels, B. Hartman (2008) Use of Radon measurements for evaluation of volatile organic compound (VOC) vapor intrusion: Method and application, Environmental Forensics, 9, 107-114, doi: 10.1080/15275920801888491.

Attachment 3: Dr. Doug Hammond Resume

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Current Position: Professor of Earth Sciences

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email: dhammond90290@gmail.com

Education:
B.A., Chemistry, University of Rochester, 1967
M.S., Geology, University of Rochester, 1970
Ph.D., Geology, Columbia University, 1975

Employment:
1967-1970 Teaching Assistant, University of Rochester
1970-1975 Research Assistant, Lamont-Doherty Geol. Obs.
1973 (Spring) Instructor, State University of New York at Purchase
1973 (Fall) Visiting Instructor, University of Rochester
1975-1981 Assistant Professor, University of Southern California
1982 (Spring) Visiting Scientist, Istituto di Geologia Marina, (CNR - Bologna, Italy)
1984-1987 (Summers) Visiting Res, Geologist, U. Calif. Riverside
1981-1989 Associate Professor, University of Southern California
1988-1989 Senior NATO Post-doctoral Fellow, Visiting Scientist, Istituto di Geologia Marina (CNR - Bologna, Italy)
1991-1994 Chairman, Department of Geological Sciences
Director, Center for Earth Sciences
1996 (Spring) Visiting Professor, Universita di Bologna
Visiting Scientist, Ist. Geol. Marina, (CNR-Bologna, Italy)
1996-2022 Director, Graduate Program in Ocean Sciences
1989- Professor, University of Southern California
2003 (Spring) Visiting Scientist, COAS, Oregon State Univ.
2008- Consultant, Radon Analysis for Vapor Intrusion
2016 (Fall) Visiting Scientist, Sch. of Oceanog., U. Washington

Honors:
1986: Best Lecturer, Earth Sciences (Sigma Gamma Epsilon)
1997: Golden Gneiss Award (Sigma Gamma Epsilon)
2005: General Education Teaching Award (USC College)

Professional Society Memberships:
American Geophysical Union
Geochemical Society (Life Memb.)
Sigma Xi (Life Memb.)
Soc. Economic Petrol. Mineral. (Life Memb.)

Research Interests: Aqueous Geochemistry, Sediment Diagenesis, Oceanography, Isotope Geochemistry, Groundwater Chemistry

Publications: 140

Revised 04/01/2025

PUBLICATIONS OF DOUGLAS E. HAMMOND: Refereed Articles and Books

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SCS ENGINEERS

Environmental Consulting & Contracting

November 14, 2025
Project No. 01210112.03

Ms. Fangli Yin via email: fangli.yin@waterboard.ca.gov
San Francisco Bay Regional Water Quality Control Board (RWQCB)
1515 Clay Street, Suite 1400
Oakland, California 94612

Subject: **Radiological Survey Results**
Closed Berkeley Landfill/Cesar Chavez Park
Berkeley, California

Dear Ms. Yin:

SCS Engineers (SCS) presents the results of recent radiological survey (Survey) of liquid and gas samples performed on behalf of the City of Berkeley (City) at the above-referenced site (Site).

This Survey included two tasks:

1. Evaluation of ambient air and landfill gas (LFG) extraction well (EW) vapor for radon.
2. Evaluation of groundwater and leachate monitoring well water for the presence of radium 226 and radium 228.

This Survey was performed in accordance with the *Response to Letter of Requirement for Information Pursuant to Water Code Section 13267* (Work Plan), prepared by Geosyntec Consultants, Inc. (Geosyntec) on June 11, 2025, which was approved by the RWQCB on June 13, 2025.

BACKGROUND

On January 18, 2024, the RWQCB issued a letter to the City indicating that industrial waste from the Stauffer Chemical Company Richmond Plant may have been disposed of at the Site between 1960 and 1971. Enclosed with the letter was correspondence from March 28, 1980, by Stauffer Chemical, identifying the Berkeley Landfill Company site as a recipient of some of the Richmond Plant's industrial waste. This waste reportedly included "alum mud," a byproduct of aluminum extraction from bauxite ore, which typically contains certain radionuclides known as "technologically enhanced naturally occurring radioactive material" (TENORM).

Neither the City nor the RWQCB was previously aware of the potential presence of TENORM at the Site.

In response to the January 18, 2024 letter from the RWQCB, SCS prepared a *Revised Work Plan for TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill, Berkeley, California*, which the City submitted to the RWQCB on August 6, 2024. The work plan (WP) was approved by the RWQCB on August 13, 2024.

The approved WP required the testing of leachate and groundwater monitoring well samples for the following constituents using the test methods described below:

- Thorium-228, 230, and 232 and uranium-234, 235, and 238 by HASL-300 EML Radiological Manual Method A-01-R.
- Radium-226 by Environmental Protection Agency (EPA) Method 901.1.
- Radium-228 by EPA Method 901.1.
- Lead-210 by Method LSC-Pb210.
- Organochlorine Pesticides (OCPs) by EPA Method 8081.

Results of the leachate and groundwater sampling and analysis were submitted to the RWQCB in the *Completion Report - TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill/Cesar Chavez Park, Berkeley, California* (SCS, December 30, 2024). The report stated that four radionuclides (thorium-230, radium-226, radium-228, and lead-210) were detected in leachate and groundwater monitoring well samples collected at the Site.

The work plan also called for a Gamma Drone Survey (GDS) to be performed along the surface of the landfill. GDS results indicated that all radiological activity detected at the ground surface and shallow subsurface was equal to or lower than typical background radiation levels expected in the ambient environment.

The City received a follow up letter from the RWQCB, dated January 28, 2025, requesting that the City submit a technical report documenting the results of additional sampling and analysis of landfill leachate, groundwater, and LFG. In response, Geosyntec prepared *Response to Letter of Requirement for Information Pursuant to Water Code Section 13267* (Work Plan), dated June 11, 2025, to address the methodologies and procedures to follow for collection of the additional requested samples. This letter presents the additional information requested by the RWQCB.

SCOPE OF WORK

RADON SURVEY

On June 17 and 18, 2025, SCS purged and collected samples from: (a) twelve LFG EWs, i.e., EW-6, EW-9, EW-11, EW-12, EW-21, EW-24, EW-30, EW-31, EW-32, EW-36, EW-37, and EW-38, and (b) eleven ambient air locations, i.e., A1 through A11, across the Site. A Site Plan with sample locations and a summary of measured radon results is provided in **Attachment A (Figure 1).**

Purging and sampling was performed using a 60-milliliter (ml) plastic syringe with a Luer Lock 3-way valve, and sections of polyethylene and silicone tubing comprising the sample train. Three sample trains were assembled and used in sequence between sample locations to allow for airing out of each between use and reduction of potential cross-contamination between sample locations.

Following sample collection, a Landtec GEM 5000 LFG monitoring device (GEM) was used to collect field readings at each sample location (EWs and ambient locations). The following field parameters were measured and recorded on field data sheets:

- Methane (CH_4) reported as percent by volume (%)
- Percent Lower Explosive Limit (%LEL) reported as %LEL
- Oxygen (O_2) reported as percent by volume (%)

- Carbon Dioxide (CO_2) reported as percent by volume (%)
- Balance gas (typically primarily nitrogen) reported as percent by volume (%)

Field data sheets are provided in **Attachment B**, and a summary of results is provided below.

Ambient Samples

On each day, ambient air samples were collected at the beginning of the day, when the wind was reduced, followed by the EW samples.

Purge and sample collection procedures included the following:

A one-liter Tedlar bag was connected to the sample train. One syringe of air was pulled through the sample train and expelled to the atmosphere (purge), followed by filling the Tedlar bag roughly ½ full with sampled ambient air using the syringe (sample). The air sample inlet height was maintained at an estimated average adult breathing zone height (roughly 5.5-feet) during ambient air sample collection. Each Tedlar bag was labelled, logged, and placed in a dark and cool location immediately following sample collection. Following sample collection, the GEM was used to collect field readings at each sample location.

A summary of field readings included the following:

CH_4 – 0.0 %
%LEL – 0.0
0_2 – 20.5 to 20.9%
CO_2 – 0.0 to 0.3%
Balance gas (typically primarily nitrogen) – 79.1 to 79.2%

EW Samples

The sample train was connected to the sample port at each EW location and a new Tedlar bag was attached. Two syringes of vapor were pulled through the sample train and expelled to the atmosphere (purge), followed by filling the Tedlar bag roughly ½ full with sampled vapor from each EW using the syringe (sample). Each Tedlar bag was labelled, logged, and placed in a dark and cool location immediately following sample collection.

The GEM was hooked up to each EW and field parameters were measured following each sample collection. A summary of field readings included the following:

CH_4 – 25.1 to 61.7%
%LEL – 502 to 1,234%
0_2 – 0.0 to 2.3%
CO_2 – 18.6 to 36%
Balance gas (typically primarily nitrogen) – 2.3 to 49.5%

Sample Handling

All samples were shipped via FedEx under proper chain-of-custody (COC) documentation to Mr. Doug Hammond at the Department of Earth Sciences at the University of Southern California (USC) for analysis.

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Analytical Results

All samples were analyzed for total radon by the USC laboratory. A Protocol and Procedures summary provided by Mr. Hammond is provided in **Attachment C.**

Ambient Samples - Radon was detected in the ambient air samples at concentrations ranging from 0.01 to 0.09 picocuries per liter (pCi/L).

EW Samples - Radon was detected in the EW vapor samples at concentrations ranging from 6.0 to 876 pCi/L. The lowest detection was from the EW-37 sample, and the highest detection was from the EW-9 sample.

The laboratory analytical report is included in **Attachment D.**

RADIUM 226 AND RADIUM 228 SURVEY

During routine semi-annual monitoring and sampling performed on June 23 and 24, 2025, SCS collected additional samples from the five groundwater monitoring wells - GW-1(a) and GW-2 through GW-5) and four leachate monitoring wells (L-4 through L-7) and submitted these additional samples to Eurofins Test America laboratory in Earth City, MO for analysis. Samples were analyzed for radium 226 (EPA Method 903.0) and radium 228 (EPA Method 904.0). The laboratory analytical report is included in **Attachment D.**

Sample analysis results are summarized below.

Well	Radium 226	Qualifiers	Radium 228	Qualifiers
	(pCi/L)		(pCi/L)	
GW-1(a)	0.195	U	0.568	U G
GW-2	1.83	--	3.87	--
GW-3	1.10	--	1.97	--
GW-4	0.169	U	0.396	U
GW-5	0.664	--	1.20	--
L-4	0.589	--	1.44	--
L-5	0.215	U	0.302	U
L-6	0.393	--	0.676	--
L-7	0.711	--	1.10	U G

Notes:
1. U = Results are above Minimum Detectable Concentration (MDC), but below Detection Limit.
2. G = The sample MDC is greater than the requested Reporting Limit.

Once previously in July 2024, samples from the same locations were analyzed for radium 226 and radium 228 by EPA Method 901.1.

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The previous sample analysis results from July 2024 are summarized below:

Well	Radium 226	Qualifiers	Radium 228	Qualifiers
	(pCi/L)		(pCi/L)	
GW-1(a)	30.6	--	13.2	U
GW-2	30.8	--	15.4	U
GW-3	79.5	--	16.7	U
GW-4	36.6	--	30.7	--
GW-5	88.8	--	26.3	U
L-4	-28.8	--	11.1	U
L-5	76.7	--	8.6	U
L-6	151	--	8.49	U
L-7	226	--	23.4	U

In the previous summary report (SCS, December 30, 2024), it was concluded there may be a potential for radon interference using analytical test method 901.1, therefore, the report's conclusions recommended additional sample collection and analysis using EPA Methods 903.0 and 904.0 in an attempt to: (1) reduce the potential for radon interference, and (2) confirm previous results.

A discrepancy does appear to be present between previous and current data results, therefore, radon interference in the previous data does appear likely, as the current 2025 results indicate significantly lower levels of radium 226 and 228 than previously reported. The current 2025 results are considered to be representative of radium activity within the groundwater and leachate.

SUMMARY AND CONCLUSIONS

This Survey represents the first-time radon has been evaluated at the Site, and the first-time groundwater and leachate monitoring well water has been analyzed for radium 226 and 228 using EPA Methods 903.0 and 904.0, respectively. The results of this Survey indicate the following:

- Radon was detected in all 11 ambient air samples at concentrations at or below 0.09 pCi/L. These concentrations are indicative of EPA stated average background levels of 0.4 pCi/L for outdoor air. Additional assessment appears to be unnecessary.
- Radon was detected in all 12 subsurface LFG EW vapor samples at concentrations ranging from 6.0 to 876 pCi/L. The potential for LFG extraction system worker exposure to elevated radon during monitoring, maintenance, and/or repair activities is present. Health and safety procedures, including monitoring for radon during subsurface activities, are in place to control this potential risk.
- Radium 226 was detected in groundwater monitoring well samples at concentrations ranging from 0.169 to 1.83 pCi/L and ranging from 0.215 to 0.711 pCi/L in the leachate monitoring well samples.
- Radium 228 was detected in groundwater monitoring well samples at concentrations ranging from 0.396 to 3.87 pCi/L, and ranging from 0.302 to 1.44 pCi/L in the leachate

monitoring well samples. Based on these results, future screening for radionuclides in groundwater and leachate appears to be unnecessary.

CLOSING

Please contact Thomas Bautista with the City to discuss this deliverable or the project.

Sincerely,

Ted Sison, REPA, CPSWQ, QSD
Senior Project Manager
SCS ENGINEERS

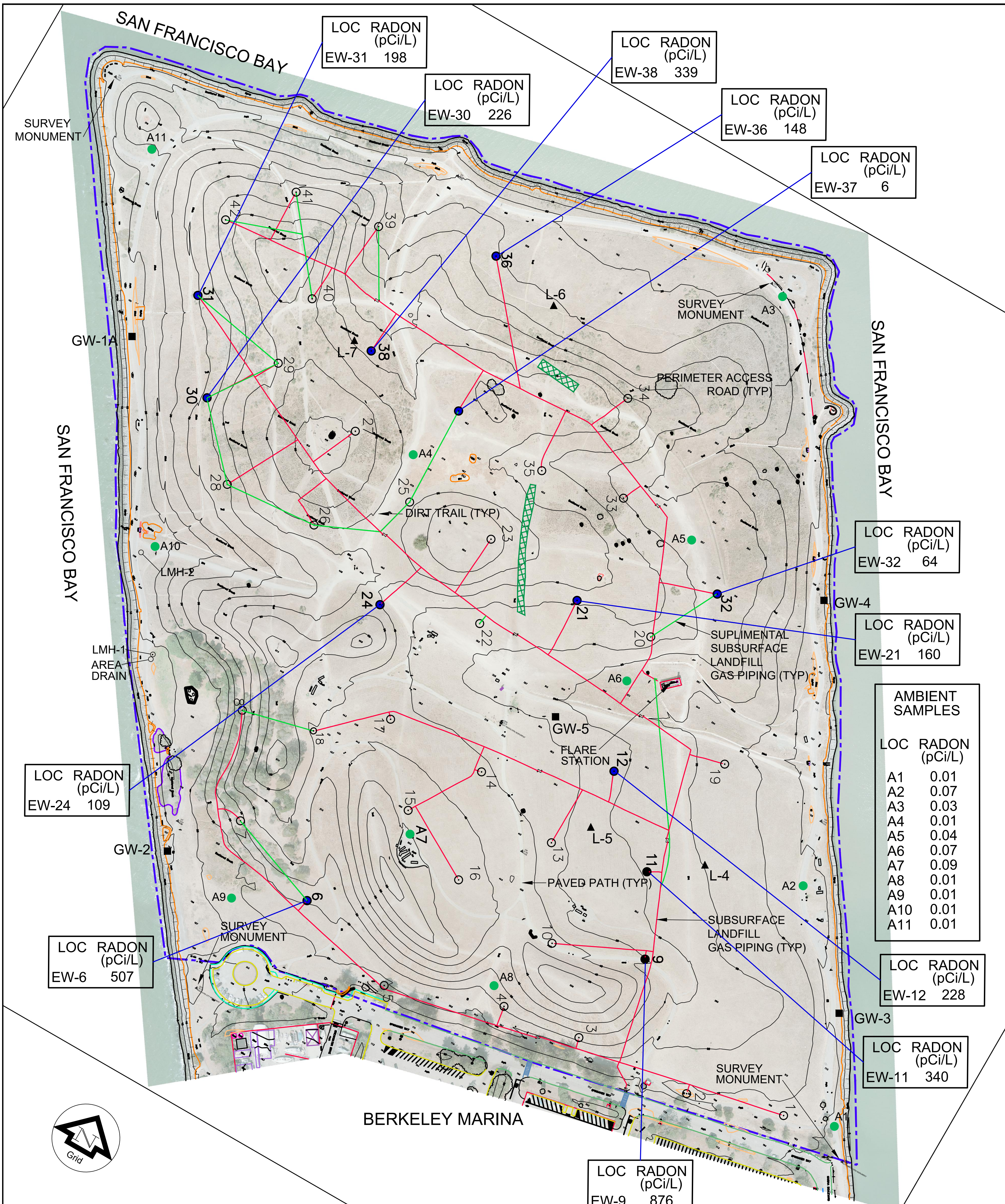
Patrick Harms, PG
Project Manager
SCS ENGINEERS

Attachments:

Attachment A – Figure 1 - Site Plan with Radon Sample Data
Attachment B – Field Data Sheets
Attachment C – Radon Testing Protocol and Procedures
Attachment D – Laboratory Analytical Reports and COCs

Attachment A

Figure 1 - Site Plan with Radon Sample Data



LEGEND

- GROUNDWATER MONITORING WELL
- LEACHATE MONITORING WELL
- LMH-2 LIQUIDS SUMP
- MAJOR CONTOURS RELATIVE TO MLLW
- LANDFILL GAS (LFG) EXTRACTION WELL (EW)
- 12 LFG EW SAMPLE LOCATION
- A1 AMBIENT AIR SAMPLE LOCATION
- RIP RAP ARMOR
- CONCRETE DRAINAGE DITCH (V-ditch)
- GENERAL SITE BOUNDARY
- WOOD MULCHED AREA

250 0 250

APPROXIMATE SCALE IN FEET

SCS ENGINEERS

ENVIRONMENTAL CONSULTANTS & CONTRACTORS

4683 CHABOT DRIVE, SUITE 200
PLEASANTON, CALIFORNIA 94588
PH. (925) 426-0080 FAX. (925) 426-0707

PROJ. NO. 01210112.03	DWN. BY: NM	ACAD FILE: F2.dwg	
DSN. BY: TMS	CHK. BY: TMS	APP. BY: TMS	

NOTES:
ORIGINAL TOPOGRAPHY BY AERIAL METHODS 2021. AERIAL PHOTOGRAPHY PERFORMED ON SEPTEMBER 24, 2021 BY TOWILL INC.

-VALUES ARE IN US SURVEY FOOT
-HORIZONTAL CONTROL IN GROUND VALUES USING AN ASSUMED ORIGIN
-VERTICAL CONTROL IN MLLW DATUM

SHEET TITLE: SITE PLAN WITH RADON SAMPLE RESULTS

PROJECT TITLE: CLOSED BERKELEY LANDFILL CITY OF BERKELEY

DATE: 9/22/2025

SCALE: AS SHOWN

FIGURE NO. 1

Attachment B

Field Data Sheets

FIELD MONITORING DATA SHEET

6/17/25

Client: City of Berkeley

Berkeley LF

Activity Being Monitored: Radon Sampling

Equipment Used: GEM

Other:

Location	Date	Time	GEM O2 %	GEM CO2 %	GEM LEL %	GEM CH4	GEM N %	GEM Balanace %
A-1	6/17/25	8:58	20.8	0.1	0	0.0		79.1
A-2		911	20.8	0.0	0	0.0		79.2
A-3		926	20.9	0.0	0	0.0		79.1
A-4		932	20.9	0.0	0	0.0		79.1
A-5		941	20.8	0.0	0	0.0		79.2
			0.0	36	1234.0	61.7		2.3
EW-32	6/17/25	1006	~~0.0~~	~~25.4~~	~~502.0~~	~~25.1~~		~~49.5~~
EW-21	6/17/25	1037	0.0	25.4	502.0	25.1		49.5
EW-24	6/17/25	1056	0.0	29.1	774.0	38.7		32.2
EW-37	6/17/25	1128	0.1	31.5	870	43.5		24.9
EW-38	6/17/25	1146	1.1	27.4	870	43.5		28
EW-36	6/17/25	1210	2.3	32.3	1066	53.3		12.1

Personnel ____________

FIELD MONITORING DATA SHEET

6/18/25

Client: City of Berkeley

Berkeley LF

Activity Being Monitored: Radon Sampling

Equipment Used: GEM

Other:

Location	Date	Time	GEM O2 %	CO2 %	LEL %	CH4	N %	Balanace %
A-10	6/18/25	8:30	20.5	0.3	0.0	0.0		79.2
A-9		8:40	20.7	0.1	0.0	0.0		79.2
A-6		8:45	20.8	0.0	0.0	0.0		79.2
A-7		8:51	20.8	0.0	0.0	0.0		79.2
A-8		8:57	20.9	0.0	0.0	0.0		79.1
A-11		904	20.8	0.0	0.0	0.0		79.2
EW-30		925	0.0	31.2	1036	51.8		17.0
EW-31		9:37	0.0	29.3	808	40.4		30.3
EW-6		9:53	0.0	18.6	1,086	54.3		27.1
EW-9		1008	0.0	21.0	714	35.7		43.3
EW-11		1021	0.0	24.6	1,020	51.0		24.4
EW-12		1032	0.0	23.4	1,032	51.6		25.0

Personnel ____________

Attachment C

Radon Testing Protocol and Procedures

Protocol and Procedures Used by D, Hammond for
Analysis of Rn in Indoor Air and Soil Vapor (Updated 05/15/23)

SAMPLE COLLECTION INSTRUCTIONS: BE SURE YOU HAVE CONFIRMED WITH THE LAB THAT COUNTING TIME WILL BE AVAILABLE WHEN YOUR SAMPLES ARRIVE (contact info below)

Equipment needed
-Polypropylene Syringes with appropriate stopcocks for closing (60 cc is convenient). If syringe is disconnected from a soil gas probe and then transferred to a bag, the syringe should have a two way stopcock for closure while it is disconnected.
-Tedlar bags for each sample, 0.5 or 1 liter size. The design with polypropylene fittings is best (Bags from Cel or ESS have been most reliable. SKC Inc., Model 232-02 are OK, but have had slightly higher failure rates. **Do not use bags with metal fittings, as these valves have often leaked in the past.**
-Samples may also be collected with a lung box, but only if different tubing and fittings are used for subsurface and surface samples. **Once exposed to subsurface air, many plastics sorb sufficient Rn that they will contaminate low activity samples.**

Sampling information needed on COC or bag:
-**Sample ID and type** (sub-surface or above ground to indicate how hot it may be)
-Sampling date and time (within 10 minutes or so), using the local time zone.
-The approximate site location (so we can to correct results to ambient air pressure).
For our research, it is appreciated (but not required) if outdoor air samples are identified.

Sample Collection Procedures:
Overview: Samples are easily collected by syringe and transferred to the Tedlar bags. A small piece of tygon tubing (1/8" ID) is a convenient way to connect the syringe to the bag**. Use one syringe for 'cold' samples** (building or ambient air) **and a different one for 'hot' samples** (subsurface gas). **Handle bags with some care.** Some bags have developed pinhole leaks created by abrasion against rocks or other rough surfaces.

Volumes Needed: For subsurface samples, at least 250 cc should be collected. For room air or ambient air samples, at least 350 cc should be collected**. Bags should not be filled more than ~2/3 full**. Overfilling can lead to failure if they are exposed to low pressure during shipment.

Steps for Outdoor and Room Air Samples: Label bag. Fill syringe with air, connect to bag, open valve (1/2 to ¾ turn), and push gas into bag. Repeat until about 300-350 cc is collected. Close valve. **Gently squeeze bag to check for leaks (bag would deflate). Collect above-ground samples before purging subsurface lines to avoid adding Rn to the room air.**

Steps for Subsurface Soil gas: Be sure sampling path from soil probe tip to syringe has been flushed adequately. Connect sample syringe to probe. Draw sample into syringe and transfer to bag, as above. Holding time in the polypropylene syringe should be less than 1 hour. **Gently squeeze bag to check for leaks (bag would deflate).**

Ship samples, preferably specifying 8:30 am delivery within 2 days to:
Doug Hammond
1421 Bonnell Drive
Topanga, CA 90290
(tel. 310-490-7896)

A stiff cardboard box makes a satisfactory shipping container.
DO NOT USE STYROFOAM PEANUTS FOR PACKING.
Send email to dhammond90290@gmail.com to indicate that samples are on the way.

LAB ANALYSIS

Instrumentation:

Scintillation counters are used. Some were built by Applied Techniques (Model AC/DC-DRC-MK10-2), others have been assembled from components including Scientific Computer Inst. Pre-amp/HV (model 612) and Tennelec counter/timers (model 534). These systems use Lucas type counting cells that have been made by Guy Mathieu. Cells are either 120 cc or 240 cc volume. For sample analysis, a cell is evacuated and a plastic syringe is used to inject a sample of known volume directly into the cell, through a 5 cm long glass tube containing dririte ($CaSO4$) or indicating silica gel, coupled to a SWAGELOCK quick-connect fitting. For high activity (subsurface) samples, 40 cc gas is used in the 120 cc cells. Low activity samples (above ground), are analyzed in low background cells (0.09-0.15 cpm), using 60 in the smaller cells or 120 cc in a larger cell. Results are corrected for radioactive decay between collection and analysis, and for the difference in atmospheric pressure in the lab (elevation of 300 m and temperature of 10-32°C) and at the sampling site (based on altitude and an assumed temperature of 20°C). The pressure correction factor applies equally to surface and subsurface samples.

Laboratory Protocol:

Sample delivery within 2 days of collection is highly recommended. Storage tests have shown that the Tedlar bags are suitable for at least 10 days of storage without a detectable change in decay-corrected radon activity. However, it is desirable to complete sample analysis within one radon half-life (4 days), to minimize decay corrections and provide sufficient activity to obtain reasonable counting statistics. After arrival, the integrity of each sample container is checked by a simple pressure test of each bag to ensure that it does not leak. The bag label is compared to the COC information to be sure sample ID is consistent. Aliquots of gas are drawn from the tedlar bag to rinse a sampling syringe, then an aliquot of measured volume is drawn and injected through the drying trap, into an evacuated counting cell. One set of sampling syringes and drying traps is used for low activity samples, and a second for high activity samples, to avoid cross contamination. After using a cell, the sample is evacuated to remove its Rn. If it has had a high activity ("hot") sample, the cell is pumped a second time, about 1-2 hours later to completely remove the previous sample. Counting cells are allowed to "rest" for at least 4 hours before re-use to avoid influence of Rn daughters left in the cell from the previous sample. With this protocol, memory effects are insignificant. Samples are generally analyzed in the order listed on the COC, with hot samples run during day, as they usually need only 1-4 hours counting time, and low activity samples usually counted overnight, typically about 12 hours. As noted above, low background cells (0.05 to 0.15 cppm) are used for low activity samples. High background cells may have a background up to 1 cpm, and are only used for high activity samples.

Standardization:

Counting efficiency for cell/counter pairs has been determined by extracting radon from standard solutions containing 226Ra. These solutions were prepared from aliquots of a standard obtained from NBS (now NIST) during the GEOSECS program. Five of these standards are used regularly, and their relative activities have remained quite stable during the years they have been in use. Several cells are calibrated at least once per year using these standards to insure stability of the counting system. These cells are then used to determine Rn activities in large volume Tedlars that are used for intercalibrations of all cells. Subsequently, replicate analyses of selected samples are regularly run to be sure that this intercalibration remains valid.

In 2009, samples were run in an inter-laboratory calibration exercise for 226Ra analysis, and values consistent with other well-established University groups were obtained. An additional intercalibration of gas phase Rn was run with Dr. Phil Jenkins of Bowser-Morner in April, 2013, and results were in good agreement (better than the counting uncertainty of about 5%).

The effect of counting in a dry air matrix has been carefully evaluated, comparing results with values in the helium matrix in which cells are calibrated, to determine the small correction (1-5%) needed for the difference in counting gas matrix. Further experiments with CO2 and CH4 as a counting matrix indicate that their effects do not differ significantly from air. Results of these matrix evaluations have been published (McHugh et al., 2008) and eliminate the need for further evaluation of matrix effects.
Cells are internally inter-calibrated, using high activity subsurface samples that are run in replicates with other cells that have been calibrated with the standard 226Ra solutions. Cells with high backgrounds are inter-calibrated two or more times per year, and cells with low backgrounds are inter-calibrated about once per year. Experience has shown that the cell counting efficiencies change very little over many years, unless photomultiplier tubes (PMT) deteriorate. PMT performance is periodically checked (about twice per year) by measuring activity of an internal source of 241Am or 230Th mounted in a Lucas cell.

Backgrounds and blanks:
Cell backgrounds are checked at least 2-3 times per year. These are not very critical for most subsurface samples, but are very critical for low activity measurements. Consequently, the lowest background cells are used only for low activity samples. As a result, their backgrounds have remained very stable during the past 10 years, although these backgrounds are updated several times per year. The backgrounds used are averages of multiple (typically 5) background counts of long duration, as this reduces the background uncertainty. With this careful attention to backgrounds, values measured for aged air (stored in tedlar bags for more than one month) are within the counting uncertainty of zero. Consequently, we have determined that any blank beyond they cell background is negligible. Based on criteria defined by DOD (QSM Version 5.4 FINAL, 2021), the LOD calculated for a typical analysis (60 cc sample, 0.10 cpm counting background, 12 hour count, 2 days elapsed between collection and analysis, and 3 sigma times the counting uncertainty) is 0.20 pCi/L. In practice, lower values may be reported, along with their uncertainty (± 1 sample standard deviation), even if the observed value is lower than this LOD. For samples with very low activities, random fluctuations in background may result in lower count rates than the average background, as expected from the statistics of radioactive decay. In this case, a value of 0.001 cpm is arbitrarily assigned for observed activity during the count, along with the uncertainty for the analysis (see below).

Calculation of sample Activity and Uncertainty:
After the sample is drawn into the counting cell, the cell is placed in the counter. Typically, 3 readings are taken at intervals that depend on sample activity. The consistency of these readings allows detection of spurious electronic noise or operator error (both are rare). Background counts are subtracted from the total counts observed in each interval, based on the average cell background. Radon has 2 short-lived alpha emitting daughters (218Po and 214Po) that grow into secular equilibrium during the count. This ingrowth is considered by integrating the Bateman equations describing daughter ingrowth during each counting interval, to obtain the radon activity at the time the sample was introduced into the cell. Results (with associated counting uncertainty) for each interval are compared to ensure that this function is accurate, that the counting efficiencies for parent and daughter decays are identical, and that no spurious results were obtained. Results are averaged (weighted by duration of the counting interval) to obtain an average observed activity for the sample. If one interval differs from the other two by more than 3 standard deviations, it is rejected (this occurs less than 1% of the time). This weighted result is then corrected for cell counting efficiency, decay between sample collection and analysis, and the difference in atmospheric pressure and temperature between the lab and the sample site. We assume that the field temperature is 20°C, and the pressure difference is computed from the difference in elevation of the sample site

and the lab. A temperature difference of 10°C would make only a 3% difference in concentration, less than the stated analytical uncertainty. Uncertainty based on counting statistics is computed, considering uncertainty from both sample and background counts. An additional uncertainty of 5% from other factors is assumed, based on cell standardization (<3%) and sample volume used (~2%), with error propagation used to determine final concentration uncertainty.

QA/QC:
The sample volumes requested above provide sufficient gas to permit at least one replicate analysis, if needed. Typically, about one of every 8-10 samples is analyzed in duplicate, to ensure quality control and randomly check performance of cells and counting equipment. Usually a high activity sample is duplicated, but sometimes a low activity sample is used for replication. The average precision of high activity lab duplicates (±1 sample standard deviation) is typically about ±3%, slightly better than our typical expected uncertainty of ±5% which includes calibration uncertainty. For low activity samples, the analytical uncertainty depends primarily on the counting statistics, and the reported uncertainty for a single analysis may equal or exceed the reported value if activity is very low (less than the LOD described above). If the sample standard deviation of duplicates is greater than expected based on the calculated uncertainties (5% for high activity samples, but larger for low activity samples), the sample is re-analyzed. For low activity samples, the criterion for evaluating replicate analyses is to consider the difference (D) in two values. Error propagation predicts the uncertainty in this difference is sigD = sqrt(sx1^2 + sx2^2), where sx1 and sx2 are the uncertainties in the two analyses. If D/sigD >2 (95% confidence limit that the values differ), the analysis is re-run.

Additional details about analysis of standards and field samples can be found elsewhere:

Analysis of standards using solutions with 226Ra
Mathieu, G., P. Biscaye, R. Lupton, and D. E. Hammond, 1988, System for measurement of radon-222 at low levels in natural waters, Health Physics, 55, 989-992.

Analysis of soil gas
McHugh, T. E., D. E. Hammond, T. Nickels, B. Hartman (2008) Use of Radon measurements for evaluation of volatile organic compound (VOC) vapor intrusion: Method and application, Environmental Forensics, 9, 107-114, doi: 10.1080/15275920801888491.

Attachment D

Laboratory Analytical Reports and COCs

Radon Analysis (EPA Method GS: Grab Sample/Scintillation Cell counting)

For SCS Engineers

Samplers: Adrian Delgadillo & N. Maranhas	Client Project Number: 01210112.03 Task 16
Sample containers: ESS Tedlar bags	Sample Dates: 6/17/25 and 6/18/25
Site: Berkeley Landfill (now Cesar Chavez Park) Berkeley, CA	Environmental Conditions: Elevation (ft) / Temp (°C) — Site: 18 / 20 (assumed T); Lab: 984 / 18 to 26
Analyst: Doug Hammond	Pressure Factor (Site/Lab) 1.03 adjust for each sample based on T
Phone: 310-490-7896	Time Zone adjustment: add to decay time 0 hours — Collect (PDT), Run (PDT)
email: dhammond90290@gmail.com	

Gas Sample Summary

	ID	Collection Date	Collection time (PDT)	Analysis Date	Analysis time (PDT)	Vol run (cc)	Conc. pCi/L	±1 sig pCi/L	Lab Duplicates mean pCi/L	Lab Duplicates ±1ssd pCi/L	Notes
Received 6/18/2025											
1	A-1	6/17/25	9:03	6/17/25	20:53	60	0.01	0.09			
2	A-2	6/17/25	9:10	6/17/25	20:55	60	0.07	0.08			
3	A-3	6/17/25	9:20	6/17/25	20:58	60	0.03	0.06			
4	A-4	6/17/25	9:31	6/17/25	21:00	60	0.01	0.08			
5	A-5	6/17/25	9:40	6/17/25	21:03	60	0.04	0.07			
Received 6/19/2025											
6	A-10	6/18/25	8:28	6/19/25	10:11	60	0.01	0.08			
7	A-9	6/18/25	8:38	6/19/25	14:50	60	0.01	0.09			
8	A-6	6/18/25	8:44	6/19/25	14:53	60	0.07	0.09			
9	A-7	6/18/25	8:50	6/19/25	14:55	60	0.09	0.07			
10	A-8	6/18/25	8:57	6/19/25	18:51	60	0.01	0.09			
11	A-11	6/18/25	9:03	6/19/25	18:54	60	0.01	0.06			
12	EW-32	6/17/25	10:00	6/19/25	10:39	40	64	4			
13	EW-21	6/17/25	10:34	6/19/25	10:41	40	160	9	161	1	
	Lab Duplicate	6/17/25	10:34	6/19/25	19:11	40	162	10			
14	EW-24	6/17/25	10:54	6/19/25	10:46	40	109	6			
15	EW-37	6/17/25	11:16	6/19/25	10:48	40	6	1			
16	EW-38	6/17/25	11:45	6/19/25	10:43	40	339	18	344	7	
	Lab Duplicate	6/17/25	11:45	6/19/25	19:08	40	349	19			
17	EW-36	6/17/25	12:08	6/19/25	18:59	40	148	8			
18	EW-30	6/18/25	9:24	6/20/25	9:16	40	226	13			
19	EW-31	6/18/25	9:35	6/21/25	9:00	40	198	12			
20	EW-6	6/18/25	9:50	6/19/25	19:03	40	507	27	512	6	
	Lab Duplicate	6/18/25	9:50	6/20/25	9:12	40	516	28			
21	EW-9	6/18/25	10:06	6/20/25	9:02	40	876	46			
22	EW-11	6/18/25	10:20	6/20/25	9:04	40	340	19			
23	EW-12	6/18/25	10:31	6/20/25	9:09	40	228	13			

Uncertainty given in pCi/liter is based on counting statistics and uncertainty for cell calibration and volume of ±5%.
The Lower Limit of Detection for Rn (95% confidence level as recommended by EPA 402-R-95-012, Oct. 97) is 0.20 pCi/liter.
Results are reported based on standardization with NIST-traceable radon sources.
Results corrected to in situ pressure and assumed T of 20°C based on P/Po = exp(-3.56e-5*(elevation - lab elevation))(273+Lab T)/(273+Site T)
These results are for application of naturally-occurring radon as a tracer of soil vapor intrusion, but are not intended for evaluation of radon hazards.
If cpm is less than the average cell background for that cell, a value of 0.001 obs dpm is assigned.
Note Details: None

Raw Data, Calculation factors, and Analytical Details

	Sample ID	Collection Date	Collection Time (PDT)	Analysis Date	Analysis Time (PDT)	Count in cell/ch	He eff	Air/He eff	Vol run (cc)	Press factor	obs dpm	sig dpm	Decay T (hours)	Decay factor	Concentration dpm/liter	Concentration pCi/liter	count stats pCi/liter ±1 sig	Notes
Received 6/18/2025																		
1	A-1	6/17/25	9:03	6/17/25	20:53	79/T1	0.730	0.94	60	1.05	0.001	0.007	11.8	1.094	0.03	0.01	0.09	
2	A-2	6/17/25	9:10	6/17/25	20:55	80/T2	0.872	0.94	60	1.05	0.007	0.008	11.8	1.093	0.16	0.07	0.08	
3	A-3	6/17/25	9:20	6/17/25	20:58	71/T3	0.870	0.94	60	1.05	0.003	0.006	11.6	1.092	0.07	0.03	0.06	
4	A-4	6/17/25	9:31	6/17/25	21:00	427/T4	0.945	0.94	60	1.05	0.001	0.008	11.5	1.091	0.02	0.01	0.08	
5	A-5	6/17/25	9:40	6/17/25	21:03	73/L1	0.850	0.94	60	1.05	0.004	0.007	11.4	1.090	0.10	0.04	0.07	
Received 6/19/2025																		
6	A-10	6/18/25	8:28	6/19/25	10:11	70/L1	0.935	0.94	60	1.04	0.001	0.007	25.7	1.214	0.02	0.01	0.08	
7	A-9	6/18/25	8:38	6/19/25	14:50	79/T1	0.730	0.94	60	1.06	0.001	0.006	30.2	1.256	0.03	0.01	0.09	
8	A-6	6/18/25	8:44	6/19/25	14:53	80/T2	0.872	0.94	60	1.06	0.006	0.007	30.2	1.256	0.16	0.07	0.09	
9	A-7	6/18/25	8:50	6/19/25	14:55	71/T3	0.870	0.94	60	1.06	0.007	0.006	30.1	1.255	0.19	0.09	0.07	
10	A-8	6/18/25	8:57	6/19/25	18:51	427/T4	0.945	0.94	60	1.06	0.001	0.008	33.9	1.292	0.03	0.01	0.09	
11	A-11	6/18/25	9:03	6/19/25	18:54	73/L1	0.850	0.94	60	1.06	0.001	0.005	33.9	1.291	0.03	0.01	0.06	
12	EW-32	6/17/25	10:00	6/19/25	10:39	91/T1	0.840	0.98	40	1.05	3.10	0.12	48.7	1.444	142	64	2	
13	EW-21	6/17/25	10:34	6/19/25	10:41	92/T2	0.880	0.98	40	1.05	8.17	0.20	48.1	1.438	356	160	4	
	Lab Duplicate	6/17/25	10:34	6/19/25	19:11	93/T3	0.870	0.98	40	1.06	7.59	0.26	56.6	1.534	361	162	6	
14	EW-24	6/17/25	10:54	6/19/25	10:46	93/T3	0.870	0.98	40	1.05	5.48	0.16	47.9	1.436	241	109	3	
15	EW-37	6/17/25	11:16	6/19/25	10:48	94/T4	0.855	0.98	40	1.05	0.29	0.03	47.5	1.432	13	6	1	
16	EW-38	6/17/25	11:45	6/19/25	10:43	Z12/R2	0.800	0.98	40	1.05	15.83	0.27	47.0	1.426	753	339	6	
	Lab Duplicate	6/17/25	11:45	6/19/25	19:08	92/T2	0.880	0.98	40	1.06	16.67	0.38	55.4	1.519	776	349	8	
17	EW-36	6/17/25	12:08	6/19/25	18:59	Z12/R2	0.800	0.98	40	1.06	6.45	0.18	54.9	1.513	329	148	4	
18	EW-30	6/18/25	9:24	6/20/25	9:16	94/T4	0.855	0.98	40	1.03	11.41	0.32	47.9	1.436	502	226	6	
19	EW-31	6/18/25	9:35	6/21/25	9:00	Z12/R2	0.800	0.98	40	1.03	7.81	0.23	71.4	1.715	441	198	6	
20	EW-6	6/18/25	9:50	6/19/25	19:03	91/T1	0.840	0.98	40	1.06	27.33	0.49	33.2	1.285	1127	507	9	
	Lab Duplicate	6/18/25	9:50	6/20/25	9:12	93/T3	0.870	0.98	40	1.03	26.60	0.49	47.4	1.430	1147	516	10	
21	EW-9	6/18/25	10:06	6/20/25	9:02	Z12/R2	0.800	0.98	40	1.03	41.62	0.62	46.9	1.426	1945	876	13	
22	EW-11	6/18/25	10:20	6/20/25	9:04	91/T1	0.840	0.98	40	1.03	17.01	0.39	46.7	1.423	756	340	8	
23	EW-12	6/18/25	10:31	6/20/25	9:09	92/T2	0.880	0.98	40	1.03	11.92	0.33	46.6	1.422	505	228	6	

Decay correctiions based on Rn decay constant of 0.1813 per day
Conversion from dpm based on 0.4504 pCi/dpm
Blanks are negligible.

Radon Conc = {(0.4504)(1000)(obs dpm)(decay factor)(Press factor)}/{(cc used)(He eff)(Air/He)} (in pCi/liter)

Definitions:

Cell/ch:	Counting cell and channel used	sig dpm	uncertainty (± 1 sig) in dpm based on counting statistics
He eff:	Cell and counter efficiency using helium matrix	Decay T:	time elapsed from sampling to analysis
Air/He:	Correction for matrix counting gas density	Decay factor:	Correction factor for decay from collection to analysis
Sample vol:	Volume analyzed at lab pressure (cc)	dpm/liter:	Radon concentration in disintigrations per minute per liter of sample
Press factor:	Correction to in situ pressure and 20°C based on collection altitude & lab P, T	pCi/liter:	Radon concentration in picoCuries per liter
obs dpm:	observed radon activity (disintigrations per minute) when analyzed	count stats:	uncertainty in observed radon based on counting statistics

Chain of Custody Record

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

Client Contact	Project Manager: Ted Sison	Site Contact: Ted Sison	Date: 6/17/25	COC No:
Name: SCS Engineers	Tel/Fax: 314-298-8566	Lab Contact: Doug Hammond	Carrier: fedex	1 of 1 COCs
Address:4683 Chabot Drive, suite 200	**Analysis Turnaround Time**			Sampler:
Zip: 94588	☐ CALENDAR DAYS ☐ WORKING DAYS			**For Lab Use Only:**
(925) 426-0080 Cell: 925-413-5813	TAT if different from Below standard			Walk-in Client:
(xxx) xxx-xxxx FAX	☐ 2 weeks			Lab Sampling:
Project Name: Berkeley LF	☐ 1 week			
Site:	☐ 2 days			Job / SDG No.:
P O #	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	Radon	Sample Specific Notes:
A-1	6/17/25	9:03	G	A	1			X	
A-2	↓	9:10	↓	↓	↓			X	
A-3	↓	9:20	↓	↓	↓			X	
A-4	↓	9:31	↓	↓	↓			X	
A-5	↓	9:40	↓	↓	↓			X	

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ______

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for ______ Months

Special Instructions/QC Requirements & Comments:

email report to: tsison@scsengineers.com

Custody Seals Intact: ☐ Yes ☐ No	Custody Seal No.:		Cooler Temp. (°C): Obs'd: ______ Corr'd: ______		Therm ID No.: ______
Relinquished by: N. Maranhas	Company: SCS	Date/Time: 6/17/25 1241	Received by: Doug Hammond	Company:	Date/Time: 6/18/25 2000
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:

Chain of Custody Record

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

Client Contact	Project Manager: Ted Sison	Site Contact: Ted Sison	Date: 6/18/25	COC No:
Name: SCS Engineers	Tel/Fax: 314-298-8566	Lab Contact: Doug Hammond	Carrier: FedEx	1 of 1 COCs
Address:4683 Chabot Drive, suite 200	**Analysis Turnaround Time**			Sampler:
Zip: 94588	☐ CALENDAR DAYS ☐ WORKING DAYS			**For Lab Use Only:**
(925) 426-0080 Cell: 925-413-5813	TAT if different from Below standard			Walk-in Client:
(xxx) xxx-xxxx FAX	☐ 2 weeks			Lab Sampling:
Project Name: Berkeley LF	☐ 1 week			
Site:	☐ 2 days			Job / SDG No.:
P O #	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	Radon	Sample Specific Notes:
A-10	6/18/25	8:28	G	A	1			X	
A-9	↓	8:38	↓	↓	↓			X	
A-6	↓	8:44	↓	↓	↓			X	
A-7	↓	8:50	↓	↓	↓			X	
A-8	↓	8:57	↓	↓	↓			X	
A-11	↓	9:03	↓	↓	↓			X	

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ____________

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

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Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for ________ Months

Special Instructions/QC Requirements & Comments:

email report to: tsison@scsengineers.com

Custody Seals Intact: ☐ Yes ☐ No	Custody Seal No.:	Cooler Temp. (°C): Obs'd: ______ Corr'd: ______	Therm ID No.: ______

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
N. Maranhas	SCS Engineers	6/18, 1100	Doug Hammond		6/19/25 945
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:

Form No. CA-C-WI-002, Rev. 4.3, dated 12/05/2013

Chain of Custody Record

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

Client Contact	Project Manager: Ted Sison	Site Contact: Ted Sison	Date: 6/17/25	COC No:
Name: SCS Engineers	Tel/Fax: 314-298-8566	Lab Contact: Doug Hammond	Carrier: FedEx	1 of 1 COCs
Address: 4683 Chabot Drive, suite 200	**Analysis Turnaround Time**			Sampler:
Zip: 94588	☐ CALENDAR DAYS ☐ WORKING DAYS			**For Lab Use Only:**
(925) 426-0080 Cell: 925-413-5813	TAT if different from Below standard			Walk-in Client:
(xxx) xxx-xxxx FAX	☐ 2 weeks			Lab Sampling:
Project Name: Berkeley LF	☐ 1 week			
Site:	☐ 2 days			Job / SDG No.:
P O #	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)		Radon	Sample Specific Notes:
EW-32	6/17/25	1000	G	A	1				X	
EW-21	6/17/25	1034	G	A	1				X	
EW-24	6/17/25	1054	G	A	1				X	
EW-37	6/17/25	1116	G	A	1				X	
EW-38	6/17/25	1145	G	A	1				X	
EW-36	6/17/25	1208	G	A	1				X	

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ____________

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for ________ Months

Special Instructions/QC Requirements & Comments:

email report to: tsison@scsengineers.com

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No.: | Cooler Temp. (°C): Obs'd: ________ Corr'd: ________ | Therm ID No.: ________

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Adrian Delgadillo			Doug Hammond		6/18/25 345
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:

Chain of Custody Record

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

Client Contact	Project Manager: Ted Sison	Site Contact: Ted Sison	Date: 6/18/25	COC No:
Name: SCS Engineers	Tel/Fax: 314-298-8566	Lab Contact: Doug Hammond	Carrier: FEDEX	1 of 1 COCs
Address:4683 Chabot Drive, suite 200	Analysis Turnaround Time			Sampler:
Zip: 94588	☐ CALENDAR DAYS ☐ WORKING DAYS			For Lab Use Only:
(925) 426-0080 Cell: 925-413-5813	TAT if different from Below standard			Walk-in Client:
(xxx) xxx-xxxx FAX	☐ 2 weeks			Lab Sampling:
Project Name: Berkeley LF	☐ 1 week			
Site:	☐ 2 days			Job / SDG No.:
P O #	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	Radon	Sample Specific Notes:
EW-3D	6/18/25	9:24	G	A	1			X	
EW- ~~3D~~ 3|		9:35						X	
EW-6		9:50						X	
EW-9		1006						X	
EW-11		1020						X	
EW-12		1031						X	

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ______

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☒ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for ______ Months

Special Instructions/QC Requirements & Comments:

email report to: tsison@scsengineers.com

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No.: | Cooler Temp. (°C): Obs'd: ______ Corr'd: ______ Therm ID No.: ______

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
N.Maranhas	SCS Engineers	6/18, 1040	Adrian Delgadillo	SCS	6-18 10:45
			Doug Hammond		6/19/25 945
			Received in Laboratory by:		

Form No. CA-C-WI-002, Rev. 4.3, dated 12/05/2013

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Environment Testing

ANALYTICAL REPORT

PREPARED FOR

Attn: Mr. Ted Sison
SCS Engineers
4683 Chabot Drive
Suite 200
Pleasanton, California 94588

Generated 7/22/2025 1:01:25 PM

JOB DESCRIPTION

Radiological Water Analysis

JOB NUMBER

160-58608-1

Eurofins St. Louis
13715 Rider Trail North
Earth City MO 63045

See page two for job notes and contact information.

Eurofins St. Louis

Job Notes

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Authorized for release by
Casey Robertson, Project Manager
Casey.Robertson@et.eurofinsus.com
(314)298-8566

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Job Narrative
160-58608-1

With the exceptions noted as flags or footnotes, standard analytical protocols were followed in the analysis of the samples and no problems were encountered or anomalies observed. In addition, all laboratory quality control samples were within established control limits, with any exceptions noted below. Each sample was analyzed to achieve the lowest possible reporting limit within the constraints of the method.

The test results in this report meet all NELAP requirements for parameters for which accreditation is required or available. Any exceptions to NELAP requirements are noted in this report.

Calculations are performed before rounding to avoid round-off errors in calculated results.

Any minimum detectable concentration (MDC), critical value (DLC), or Safe Drinking Water Act detection limit (SDWA DL) is sample-specific unless otherwise stated elsewhere in this narrative.

Radiochemistry sample results are reported with the count date/time applied as the Activity Reference Date.

This laboratory report is confidential and is intended for the sole use of Eurofins Environment Testing and its client.

Receipt
The samples were received on 6/25/2025 8:40 AM. Unless otherwise noted below, the samples arrived in good condition, and, where required, properly preserved. The temperature of the cooler at receipt time was 6.4°C.

Receipt Exceptions
The container label for the following sample did not match the information listed on the Chain-of-Custody (COC): GW-1(A) (160-58608-1). The container labe lists GW-1A, while the COC lists GW-1(A). This was logged to match the COC.

The reference method requires samples to be preserved to a pH of less than 2. The following samples were received with insufficient preservation at a pH of 8: GW-3 (160-58608-3), GW-4 (160-58608-4), GW-5 (160-58608-5), L-4 (160-58608-6) and L-7 (160-58608-9). The samples were preserved to the appropriate pH in the laboratory.

Method 903.0 - Radium-226 (GFPC)
Samples GW-1(A) (160-58608-1), GW-2 (160-58608-2), GW-3 (160-58608-3), GW-4 (160-58608-4), GW-5 (160-58608-5), L-4 (160-58608-6), L-5 (160-58608-7), L-6 (160-58608-8) and L-7 (160-58608-9) were analyzed for Radium-226 (GFPC). The samples were prepared on 6/27/2025 and analyzed on 7/21/2025.

Method 904.0 - Radium-228 (GFPC)
Samples GW-1(A) (160-58608-1), GW-2 (160-58608-2), GW-3 (160-58608-3), GW-4 (160-58608-4), GW-5 (160-58608-5), L-4 (160-58608-6), L-5 (160-58608-7), L-6 (160-58608-8) and L-7 (160-58608-9) were analyzed for Radium-228 (GFPC). The samples were prepared on 6/27/2025 and analyzed on 7/21/2025.

Radium-228 Prep Batch 724770:
The detection goal was not met for the following samples due to the reduced sample volume used in prep attributed to the presence of matrix interferences: GW-1(A) (160-58608-1) and L-7 (160-58608-9). Analytical results are reported with the detection limit achieved.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

TestAmerica St. Louis
13715 Rider Trail North
Earth City, MO 63045
phone 314.298.8566 fax

Chain of Custody Record

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

TestAmerica Laboratories, Inc.

Client Contact	Project Manager: Ted Sison	Site Contact: Ted Sison	Date:	COC No:
Name: SCS Engineers	Tel/Fax: 925-413-5813	Lab Contact: Casey Robertson	Carrier:	____ of ____ COCs
Address: 4683 Chabot Dr , Suite 200, Pleasanton, CA	Analysis Turnaround Time			Sampler:
Zip: 94588	☐ CALENDAR DAYS ☐ WORKING DAYS			For Lab Use Only:
(xxx) xxx-xxxx Phone 925-426-0080	TAT if different from Below __Normal______			Walk-in Client:
(xxx) xxx-xxxx FAX	☐ 2 weeks			Lab Sampling:
Project Name: Berkeley	☐ 1 week			
Site: 01210112.03 task 12	☐ 2 days			Job / SDG No.:
P O #	☐ 1 day			

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	EPA Method - 904.0	EPA Method 903.0	Sample Specific Notes:
GW-1 (A)	6-24-25	9:34	C	W				X	X	
GW-2		10:39						X	X	
GW-3		8:39						X	X	
GW-4		9:06						X	X	
GW-5		9:58						X	X	
L-4	6-23-25	11:11	G					X	X	
L-5		11:40						X	X	
L-6		10:45						X	X	
L-7		10:15						X	X	

160-58608 Chain of Custody

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ______

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☐ Disposal by Lab ☐ Archive for ________ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No	Custody Seal No.:		Cooler Temp. (°C): Obs'd: ______ Corr'd: ______		Therm ID No.: ______
Relinquished by:	Company: SCS-ES	Date/Time: 6-24-25 1100	Received by: Siena Worthington	Company: EASN	Date/Time: 6/25/25 0840
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:

Form No. CA-C-WI-002, Rev. 4.3, dated 12/05/2013

Login Sample Receipt Checklist

Client: SCS Engineers

Job Number: 160-58608-1

Login Number: 58608
List Number: 1
Creator: Worthington, Sierra M

List Source: Eurofins St. Louis

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	True	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	N/A	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	False	The samplers name is not listed on the COC.
There are no discrepancies between the containers received and the COC.	False	IDs on containers do not match the COC. Logged in per COC.
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	Sample 3, 4, 5, 6, 9 Preserved upn arrival
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Definitions/Glossary

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Qualifiers

Rad

Qualifier	Qualifier Description
G	The Sample MDC is greater than the requested RL.
U	Result is less than the sample detection limit.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
☼	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Method Summary

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Method	Method Description	Protocol	Laboratory
903.0	Radium-226 (GFPC)	EPA	EET SL
904.0	Radium-228 (GFPC)	EPA	EET SL
PrecSep_0	Preparation, Precipitate Separation	None	EET SL
PrecSep-21	Preparation, Precipitate Separation (21-Day In-Growth)	None	EET SL

Protocol References:

EPA = US Environmental Protection Agency

None = None

Laboratory References:

EET SL = Eurofins St. Louis, 13715 Rider Trail North, Earth City, MO 63045, TEL (314)298-8566

Sample Summary

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
160-58608-1	GW-1(A)	Water	06/24/25 09:34	06/25/25 08:40
160-58608-2	GW-2	Water	06/24/25 10:39	06/25/25 08:40
160-58608-3	GW-3	Water	06/24/25 08:39	06/25/25 08:40
160-58608-4	GW-4	Water	06/24/25 09:06	06/25/25 08:40
160-58608-5	GW-5	Water	06/24/25 09:58	06/25/25 08:40
160-58608-6	L-4	Water	06/23/25 11:11	06/25/25 08:40
160-58608-7	L-5	Water	06/23/25 11:40	06/25/25 08:40
160-58608-8	L-6	Water	06/23/25 10:45	06/25/25 08:40
160-58608-9	L-7	Water	06/23/25 10:15	06/25/25 08:40

Client Sample Results

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Client Sample ID: GW-1(A)

Lab Sample ID: 160-58608-1

Date Collected: 06/24/25 09:34

Matrix: Water

Date Received: 06/25/25 08:40

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	0.195	U	0.359	0.359	1.00	0.637	pCi/L	06/27/25 07:59	07/21/25 16:10	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*56.6*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:10*	*1*

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	0.568	U G	0.676	0.678	1.00	1.11	pCi/L	06/27/25 08:03	07/21/25 11:53	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*56.6*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:53*	*1*
Y Carrier	*84.1*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:53*	*1*

Client Sample ID: GW-2

Lab Sample ID: 160-58608-2

Date Collected: 06/24/25 10:39

Matrix: Water

Date Received: 06/25/25 08:40

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	**1.83**		0.519	0.544	1.00	0.430	pCi/L	06/27/25 07:59	07/21/25 16:10	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*86.5*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:10*	*1*

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	**3.87**		0.796	0.872	1.00	0.737	pCi/L	06/27/25 08:03	07/21/25 11:53	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*86.5*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:53*	*1*
Y Carrier	*82.6*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:53*	*1*

Client Sample ID: GW-3

Lab Sample ID: 160-58608-3

Date Collected: 06/24/25 08:39

Matrix: Water

Date Received: 06/25/25 08:40

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	**1.10**		0.421	0.433	1.00	0.445	pCi/L	06/27/25 07:59	07/21/25 16:10	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*90.7*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:10*	*1*

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Client Sample ID: GW-3

Date Collected: 06/24/25 08:39
Date Received: 06/25/25 08:40

Lab Sample ID: 160-58608-3
Matrix: Water

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	**1.97**		0.653	0.678	1.00	0.768	pCi/L	06/27/25 08:03	07/21/25 11:54	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*90.7*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*
Y Carrier	*73.3*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*

Client Sample ID: GW-4

Date Collected: 06/24/25 09:06
Date Received: 06/25/25 08:40

Lab Sample ID: 160-58608-4
Matrix: Water

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	0.169	U	0.232	0.233	1.00	0.392	pCi/L	06/27/25 07:59	07/21/25 16:10	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*87.0*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:10*	*1*

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	0.396	U	0.408	0.410	1.00	0.656	pCi/L	06/27/25 08:03	07/21/25 11:54	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*87.0*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*
Y Carrier	*77.4*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*

Client Sample ID: GW-5

Date Collected: 06/24/25 09:58
Date Received: 06/25/25 08:40

Lab Sample ID: 160-58608-5
Matrix: Water

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	**0.664**		0.368	0.372	1.00	0.465	pCi/L	06/27/25 07:59	07/21/25 16:10	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*84.7*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:10*	*1*

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	**1.20**		0.547	0.558	1.00	0.707	pCi/L	06/27/25 08:03	07/21/25 11:54	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*84.7*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*

Client Sample ID: GW-5

Lab Sample ID: 160-58608-5
Date Collected: 06/24/25 09:58
Matrix: Water
Date Received: 06/25/25 08:40

Method: EPA 904.0 - Radium-228 (GFPC) (Continued)

Carrier	%Yield	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Y Carrier	76.3		30 - 110	06/27/25 08:03	07/21/25 11:54	1

Client Sample ID: L-4

Lab Sample ID: 160-58608-6
Date Collected: 06/23/25 11:11
Matrix: Water
Date Received: 06/25/25 08:40

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	**0.589**		0.356	0.360	1.00	0.480	pCi/L	06/27/25 07:59	07/21/25 16:10	1

Carrier	%Yield	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Ba Carrier	90.7		30 - 110	06/27/25 07:59	07/21/25 16:10	1

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	**1.44**		0.567	0.582	1.00	0.720	pCi/L	06/27/25 08:03	07/21/25 11:54	1

Carrier	%Yield	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Ba Carrier	90.7		30 - 110	06/27/25 08:03	07/21/25 11:54	1
Y Carrier	78.9		30 - 110	06/27/25 08:03	07/21/25 11:54	1

Client Sample ID: L-5

Lab Sample ID: 160-58608-7
Date Collected: 06/23/25 11:40
Matrix: Water
Date Received: 06/25/25 08:40

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	0.215	U	0.249	0.250	1.00	0.403	pCi/L	06/27/25 07:59	07/21/25 16:11	1

Carrier	%Yield	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Ba Carrier	88.2		30 - 110	06/27/25 07:59	07/21/25 16:11	1

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	0.302	U	0.444	0.445	1.00	0.751	pCi/L	06/27/25 08:03	07/21/25 11:54	1

Carrier	%Yield	Qualifier	Limits	Prepared	Analyzed	Dil Fac
Ba Carrier	88.2		30 - 110	06/27/25 08:03	07/21/25 11:54	1
Y Carrier	80.7		30 - 110	06/27/25 08:03	07/21/25 11:54	1

Client Sample ID: L-6

Lab Sample ID: 160-58608-8

Date Collected: 06/23/25 10:45
Date Received: 06/25/25 08:40

Matrix: Water

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	**0.393**		0.234	0.236	1.00	0.301	pCi/L	06/27/25 07:59	07/21/25 16:11	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*92.7*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:11*	*1*

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	**0.676**		0.372	0.378	1.00	0.518	pCi/L	06/27/25 08:03	07/21/25 11:54	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*92.7*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*
Y Carrier	*74.4*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*

Client Sample ID: L-7

Lab Sample ID: 160-58608-9

Date Collected: 06/23/25 10:15
Date Received: 06/25/25 08:40

Matrix: Water

Method: EPA 903.0 - Radium-226 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	**0.711**		0.415	0.420	1.00	0.473	pCi/L	06/27/25 07:59	07/21/25 16:11	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*86.5*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:11*	*1*

Method: EPA 904.0 - Radium-228 (GFPC)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	1.10	U G	0.761	0.768	1.00	1.13	pCi/L	06/27/25 08:03	07/21/25 11:54	1

Carrier	*%Yield*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*86.5*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*
Y Carrier	*74.8*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:54*	*1*

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Method: 903.0 - Radium-226 (GFPC)

Lab Sample ID: MB 160-724767/1-A
Matrix: Water
Analysis Batch: 728174

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 724767

Analyte	MB Result	MB Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-226	-0.1312	U	0.158	0.159	1.00	0.382	pCi/L	06/27/25 07:59	07/21/25 16:09	1

Carrier	*MB %Yield*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*89.7*		*30 - 110*	*06/27/25 07:59*	*07/21/25 16:09*	*1*

Lab Sample ID: LCS 160-724767/2-A
Matrix: Water
Analysis Batch: 728174

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 724767

Analyte	Spike Added	LCS Result	LCS Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits
Radium-226	9.58	8.255		1.15	1.00	0.355	pCi/L	86	75 - 125

Carrier	*LCS %Yield*	*LCS Qualifier*	*Limits*
Ba Carrier	*89.7*		*30 - 110*

Method: 904.0 - Radium-228 (GFPC)

Lab Sample ID: MB 160-724770/1-A
Matrix: Water
Analysis Batch: 728146

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 724770

Analyte	MB Result	MB Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Radium-228	0.1016	U	0.337	0.337	1.00	0.599	pCi/L	06/27/25 08:03	07/21/25 11:53	1

Carrier	*MB %Yield*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Ba Carrier	*89.7*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:53*	*1*
Y Carrier	*82.2*		*30 - 110*	*06/27/25 08:03*	*07/21/25 11:53*	*1*

Lab Sample ID: LCS 160-724770/2-A
Matrix: Water
Analysis Batch: 728146

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 724770

Analyte	Spike Added	LCS Result	LCS Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits
Radium-228	9.24	11.06		1.46	1.00	0.580	pCi/L	120	75 - 125

Carrier	*LCS %Yield*	*LCS Qualifier*	*Limits*
Ba Carrier	*89.7*		*30 - 110*
Y Carrier	*83.0*		*30 - 110*

QC Association Summary

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Rad

Prep Batch: 724767

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
160-58608-1	GW-1(A)	Total/NA	Water	PrecSep-21	
160-58608-2	GW-2	Total/NA	Water	PrecSep-21	
160-58608-3	GW-3	Total/NA	Water	PrecSep-21	
160-58608-4	GW-4	Total/NA	Water	PrecSep-21	
160-58608-5	GW-5	Total/NA	Water	PrecSep-21	
160-58608-6	L-4	Total/NA	Water	PrecSep-21	
160-58608-7	L-5	Total/NA	Water	PrecSep-21	
160-58608-8	L-6	Total/NA	Water	PrecSep-21	
160-58608-9	L-7	Total/NA	Water	PrecSep-21	
MB 160-724767/1-A	Method Blank	Total/NA	Water	PrecSep-21	
LCS 160-724767/2-A	Lab Control Sample	Total/NA	Water	PrecSep-21	

Prep Batch: 724770

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
160-58608-1	GW-1(A)	Total/NA	Water	PrecSep_0	
160-58608-2	GW-2	Total/NA	Water	PrecSep_0	
160-58608-3	GW-3	Total/NA	Water	PrecSep_0	
160-58608-4	GW-4	Total/NA	Water	PrecSep_0	
160-58608-5	GW-5	Total/NA	Water	PrecSep_0	
160-58608-6	L-4	Total/NA	Water	PrecSep_0	
160-58608-7	L-5	Total/NA	Water	PrecSep_0	
160-58608-8	L-6	Total/NA	Water	PrecSep_0	
160-58608-9	L-7	Total/NA	Water	PrecSep_0	
MB 160-724770/1-A	Method Blank	Total/NA	Water	PrecSep_0	
LCS 160-724770/2-A	Lab Control Sample	Total/NA	Water	PrecSep_0	

Tracer/Carrier Summary

Client: SCS Engineers
Project/Site: Radiological Water Analysis

Job ID: 160-58608-1

Method: 903.0 - Radium-226 (GFPC)

Matrix: Water **Prep Type: Total/NA**

		Percent Yield (Acceptance Limits)
		Ba
Lab Sample ID	Client Sample ID	(30-110)
160-58608-1	GW-1(A)	56.6
160-58608-2	GW-2	86.5
160-58608-3	GW-3	90.7
160-58608-4	GW-4	87.0
160-58608-5	GW-5	84.7
160-58608-6	L-4	90.7
160-58608-7	L-5	88.2
160-58608-8	L-6	92.7
160-58608-9	L-7	86.5
LCS 160-724767/2-A	Lab Control Sample	89.7
MB 160-724767/1-A	Method Blank	89.7

Tracer/Carrier Legend

Ba = Ba Carrier

Method: 904.0 - Radium-228 (GFPC)

Matrix: Water **Prep Type: Total/NA**

		Percent Yield (Acceptance Limits)	
		Ba	Y
Lab Sample ID	Client Sample ID	(30-110)	(30-110)
160-58608-1	GW-1(A)	56.6	84.1
160-58608-2	GW-2	86.5	82.6
160-58608-3	GW-3	90.7	73.3
160-58608-4	GW-4	87.0	77.4
160-58608-5	GW-5	84.7	76.3
160-58608-6	L-4	90.7	78.9
160-58608-7	L-5	88.2	80.7
160-58608-8	L-6	92.7	74.4
160-58608-9	L-7	86.5	74.8
LCS 160-724770/2-A	Lab Control Sample	89.7	83.0
MB 160-724770/1-A	Method Blank	89.7	82.2

Tracer/Carrier Legend

Ba = Ba Carrier
Y = Y Carrier

RADIATION HEALTH & SAFETY PLAN - BERKELEY LANDFILL

Prepared by

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Prepared for

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August 2025

TABLE OF CONTENTS

LIST OF ACRONYMS

ALARA	As Low As Reasonably Achievable
ASTDR	Agency for Toxic Substances and Disease Registry
Cal/OSHA	California Occupational Safety and Health Administration
CPM	Counts per minute
DPM	Disintegrations per minute
EPA	United States Environmental Protection Agency
GDS	Gamma Drone Survey
MCL	Maximum Contaminant Level
MDA	Maximum Detectable Activity
mrem	Millirem
NRC	United States Nuclear Regulatory Commission
NORM	Naturally Occurring Radioactive Material
OEHHA	Office of Environmental Health Hazard Assessment
OSHA	United States Occupational Safety and Health Administration
pCi/g	Picocuries per gram
pCi/L	Picocuries per liter
PPE	Personal Protective Equipment
RHASP	Radiation Health and Safety Plan
RSO	Radiation Safety Officer
RWQCB	San Francisco Regional Water Quality Control Board
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material

SIGNATURES

Preparers and Reviewers

This RHASP must be maintained on-site when field work is being performed. The following individuals have prepared and reviewed this RHASP.

Prepared by:

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8/18/2025
Date

Reviewed by:

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8/18/2025
Date

Approved by:

Signed by:
David White
75878A0088CE471...

City of Berkeley Representative

9/16/2025
Date

1. INTRODUCTION

1.1 Purpose

This Radiation Health and Safety Plan (RHASP) provides detailed instructions for the safe handling of media contaminated with low levels of radiological isotopes, including contamination in the soil, gas and liquid within the closed Berkeley Landfill/Cesar Chavez Park (Site) owned by the City of Berkeley. This RHASP is intended for use by all employees and third parties working at the Site. This document is also intended to demonstrate compliance with applicable laws and regulations related to radiation protection and control of radioactive materials and to ensure that required controls are implemented to prevent exposures to workers, visitors, and the public, when work is performed at the Site. For the purposes of this RHASP, the term “radioactive materials” refers to materials that are either Naturally Occurring Radioactive Materials (NORM) or Technologically Enhanced Radioactive Materials (TENORM) due to the unknown origin of the radioactive materials at the Site.

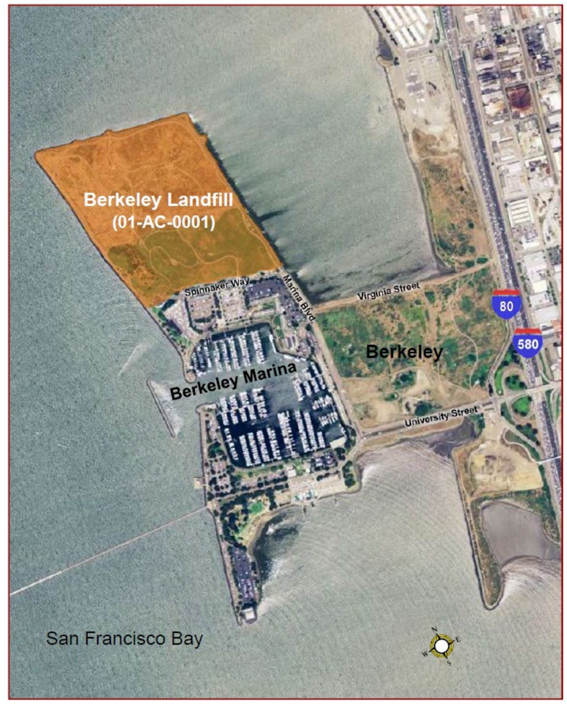
While the radioactive materials identified in this plan do not require formal permitting with any federal or state agency in California, OSHA and Cal/OSHA require employers to protect workers and the public from exposure to ionizing radiation sources. Thus, compliance with this RHASP is required of all workers and third parties who enter the Site to perform work, as described in this plan. The City of Berkeley is ultimately responsible for implementing this plan.

1.2 Site Background

The Site consists of an approximately 90 acre closed landfill along the northern portion of a man-made peninsula, bounded by the San Francisco Bay on the west, north, and east, and by the Berkeley marina along the south. Historical records indicate that waste placement at the Site began as early as 1961, comprising of a mixture of municipal, commercial, and industrial solid waste, and continued until 1983. A soil final cover system varying in thickness from 3 to 30 feet was installed in phases from 1981 through 1990, to contour the Site for use as a public park and to meet the regulatory requirements in effect at the time of closure. The site is currently undergoing post-closure monitoring and maintenance. A general vicinity map of the site is shown in Figure 1 below.

Figure 1 – General Vicinity Map of Berkeley Landfill

(*Taken from SCS 2024 Completion Report – TENORM and OCP H&S Survey Closed Berkeley Landfill/Cesar Chavez Park)*



In 2024, the San Francisco Regional Water Quality Control Board (RWQCB) issued a letter to the City of Berkeley indicating that industrial waste materials containing certain radionuclides known as TENORM may have been disposed at the Site. Therefore, the RWQCB required the City to prepare a work plan to conduct representative soil, leachate, and groundwater sampling at the Site to assess potential TENORM contamination and document the results in a completion report.

Results of the soil, leachate and groundwater sampling and analysis were presented by SCS in the *Completion Report - TENORM and OCP Health and Safety Survey, Closed Berkeley Landfill/Cesar Chavez Park, Berkeley, California,* dated December 30, 2024, and submitted to the RWQCB on the same day (completion report). The completion report showed that four radionuclides (Thorium-230, Radium-228, Radium-226, and Lead-210) were present in leachate and groundwater samples collected at the Site. SCS also reported that results from a Gamma Drone Survey (GDS) performed at the Site by the City, in collaboration with the University of California at Berkeley's Nuclear Engineering Department, indicated that all radiological activity detected at the ground surface and shallow subsurface was equal to or lower than typical background radiation levels expected in the environment. The completion report prepared by SCS also concluded that the current Health and Safety Plan (HASP) for the Site should be revised to include additional details and procedures to minimize exposure to radiation when City or third-party personnel are in contact with groundwater and leachate at the Site.

After reviewing SCS's December 2024 report, the RWQCB requested that additional sampling and analysis of landfill leachate and groundwater be performed, and that landfill gas (LFG) samples be tested for radon, which is a decay product from Radium-226, one of the components encountered in the leachate and groundwater samples previously collected at the Site. Results from the leachate and groundwater samples confirmed the presence of Radium-226 and Radium-228. In addition, all LFG samples showed radon concentrations higher than the United States Environmental Protection Agency's (EPA) established action level for radon of 4 pCi/L.

1.3 Description of Activities and Tasks

As previously stated, the tasks performed at the Site which relate to this RHASP given their potential for exposures to radiological materials include any excavation that extends one foot below the existing ground surface at the Site, including, but not limited to trenching, underground utility work, re-grading, paving, etc., and leachate, groundwater and LFG monitoring and/or sampling.

2. PERSONNEL RESPONSIBILITIES

The responsibilities of the City's personnel involved in the work activities performed at the Site are described below.

2.1 Radiation Safety Officer (RSO)

A Radiation Safety Officer (RSO) is a professional responsible for ensuring the safe use of radiation and radioactive materials and/or the safety of employees potentially exposed to radioactive materials. The RSO designated for the activities covered in this RHASP shall be selected by the City.

The RSO is required to complete a radiation safety officer training or by experience or education, be knowledgeable and trained in radiation safety as it pertains to radioactive materials at the Site. In general, the RSO will be responsible for the following:

- Maintaining this RHASP and applicable procedures.
- Periodic reviewing and updating this RHASP, as necessary.
- Reviewing new information as it relates to known, potential, or suspected exposures to radiation at the Site.
- Providing recommendations to the City regarding radiation exposures to workers at the Site.

2.2 City of Berkeley

The City of Berkeley is responsible for the implementation of this RHASP ensuring that all workers performing tasks described in Section 1.3 who may come in contact with soil, leachate, LFG, and groundwater at the Site are trained on the requirements specified within this RHASP. In addition, the City shall also be responsible for the following:

- Managing records from personal meters such as RaySafe i3 (https://www.raysafe.com/products/real-time-staff-dosimetry/raysafe-i3-real-time-radiation-dosimeter), Ludlum personal radiation monitor (https://ludlums.com/products/all-products/category/personal-radiation-meters) or an equivalent meter, in conjunction with the Authorized Worker's employer, if used.
- Reviewing results from pancake style Geiger-Muller detectors (https://ludlums.com/products/health-physics/product/model-2401-p-dose), friskers (https://ludlums.com/products/all-products/product/model-26), pocket-size meters(Pocket-Size Meters - Ludlum Measurements Inc.) or an approved equivalent detector, in conjunction with the Authorized Worker's employer, if used.
- Providing information to third-party workers and employers on RaySafe and/or Ludlum radiation detector meters and friskers.
- Determining if additional surveying is required upon an exposure event or as deemed necessary by a regulatory agency in conjunction with the RSO.

2.3 Authorized Workers

Onsite workers can be either employees of the City or third-party workers from entities, corporations, and/or businesses other than the City. All onsite workers who may come in contact with radiation are required to adhere to the requirements specified within this RHASP and follow the requirements deemed appropriate by the City. In general, workers onsite are responsible for the following:

- Understanding the requirements of this RHASP and applicable standards.
- Properly and continuously wearing personal meters when working within the Site.
- Following instructions provided by the City.
- Observing all warning signs and postings.
- Participating in training as required by the City.
- Reporting any known, potential, or suspected signs or symptoms of exposure immediately to their employer and the City's RSO.
- Completing and signing the "Authorized Worker Acknowledgement Form" attached with this RHASP and/or similar form provided by the City.

- Immediately reporting lost or stolen personal meters to their employer and the City's RSO.

3. HAZARDS AND ROUTES OF EXPOSURE TO RADIATION

It is important to understand the principles of radioactive decay and how exposures to radiation may occur. In addition, this section also provides information on the occupational hazards associated with radioactive materials exposure and associated health effects.

3.1 Principles of Radiation

Radium is a radioactive silvery-white metal, capable of emitting energy in the form of rays, waves, or particles. It is found in nature and can exist in several forms. Radium is formed naturally through the decay of uranium and thorium in the environment. During the decay series of both uranium and thorium, alpha radiation is emitted in the transition between some isotopes with beta and gamma radiation released in other steps of the decay process. The most common isotopes of radium are Ra-226 and Ra-228. When Radium-226 decays, it releases alpha particles to form Radon-222 while thorium produces Radium-228 that then releases beta particles to produce Actiminimum-228, with additional decay products as the decay chain continues. Radium decays to produce radon gas.

The United States Nuclear Regulatory Commission (NRC) defines half-life as the interval of time required for one-half of the atomic nuclei of a radioactive sample to decay or the time it takes for half of the radioactive atoms in a sample to decay into another isotope. This decay process is a natural phenomenon where unstable atomic nuclei emit radiation to become more stable. The half-life of Radium-228 is 5.75 years, while the half-life of Radium-226 is 1,600 years. Radium-226's decay to a more stable form through alpha emission occurs over a longer amount of time. Radium-228's decay to a more stable form through beta emission is faster than Radium-226's decay.

3.2 Health Effects

Low levels of radiation in nature are considered normal. Current scientific literature and data have not indicated that exposure to low levels of Radium-226 and Radium-228 is harmful to workers or the public. The EPA considers a low level of radium to be 5 pCi/L of Radium-226 and Radium-228 combined, which is also the Maximum contamination level (MCL). The MCL of 5 pCi/L for combined Radium-226 and Radium-228 in drinking water correlates to a maximum annual dose of 4 mrem, according to the EPA.

Moreover, pCi/L and pCi/g measures radioactivity, while mrem measures the absorbed dose of radiation that a radioactive source deposits in living tissue.

Radium isotopes have the potential to become harmful in high doses because the element's isotopes become unstable. Because of this instability, the element decays, and releases radiation in the form of alpha (Radium-226) and beta (Radium-228) particles and gamma rays. This radiation has been shown to cause bone, liver, and breast cancer in humans and animals at high concentrations, with the primary isotopes of radium being Radium-226 and Radium-228. Further, both isotopes of radium produce ionizing radiation and are classified as carcinogens, according to the Office of Environmental Health Hazard Assessment (OEHHA). Exposure to these isotopes has been associated with anemia, skin, and blood disorders, osteoporosis and other bone disorders, cataracts, kidney disease, and impairment of the immune system.

Routes of exposure to Radium-226 and Radium-228 can occur through inhalation and ingestion. It is important to highlight that nearly all humans are exposed to low levels of radium in the air and water. However, various industries such as the oil and gas industry, industrial factories, and waste disposal facilities may contain higher amounts of radium than what is considered normal and therefore, employees have the potential to be exposed to concentrations greater than background levels of radiation. The Agency for Toxic Substances and Disease Registry (ASTDR) published the "Toxicological Profile for Radium," which summarizes existing information on radium exposure and related health effects. Much of the information published cites health effects from oral and inhalation exposures, with limited information on dermal exposures. Thus, limited information relating to occupational exposures for workers involved in the handling of radium contaminated materials is available.

4. CONTROLLING EXPOSURES

As with many chemical, biological and radiological hazards in the workplace, it is generally emphasized that the "hierarchy of controls" be implemented and applied to prevent exposures with the highest protection being elimination, followed by substitution, engineering controls, administrative controls, and finally personal protective equipment (PPE). It is important to understand that no single control should be implemented as the sole means of protection, but rather a combination of all controls should be implemented to control exposure to radiation. Thus, a combination of the following controls shall be implemented and used to reduce exposures to radioactive materials at the Site:

- Engineering controls.
- Following as low as reasonably achievable (ALARA) principles.
- Monitoring and surveying for radiological exposures.

- Preparation and implementation of the guidelines and procedures identified in this RHASP.
- Providing training.
- Use of PPE.

4.1 Engineering Controls

Engineering controls mean preventing human exposure through construction equipment and systems which can be closed to prevent human exposures, such as shielding and physical barriers. As previously mentioned, exposures to radioactive materials onsite may occur through contact with leachate, LFG, and groundwater. Thus, the primary engineering control to be implemented for this work would include physical barriers such as gloves, long sleeve clothing, face shields, etc., to prevent exposure.

4.2 As Low As Reasonably Achievable (ALARA)

Authorized workers should reduce exposures when working on tasks and activities where potential exposures to radiation may occur. ALARA principles (time, distance, and shielding) shall be implemented by following the guidelines below:

- Limiting the amount of time spent working near radioactive materials, specifically within leachate, LFG, and groundwater monitoring wells.
- Working at the maximum possible distance away from the radioactive materials.
- Using shielding to contain radioactive materials (engineering controls mentioned above).
- Minimizing radioactive material's environmental impacts by handling materials that may contain radioactive materials carefully and avoiding personnel and equipment contact with radioactive materials.
- Ensuring appropriate decontamination is conducted when equipment or materials are in contact with radioactive materials, to prevent cross-contamination and unintentional worker exposures to radioactive materials.
- Utilizing secondary containment if handling any liquids contaminated with radioactive materials to prevent releases of radioactive materials to the environment and exposure to personnel.
- Avoiding activities that generate dust, such as grinding, cutting, polishing, etc. of materials that have been in contact with radioactive materials.
- Sealing or wrapping in plastic any openings on any contaminated equipment or materials.
- Minimizing work on contaminated equipment, such as cutting, grinding, sand-blasting, welding, drilling, or polishing.
- Performing work activities in well-ventilated areas.

4.3 Training

As previously mentioned, all Authorized Workers must be trained in the requirements of this RHASP. Protection from radiation exposure, from a health and safety standpoint, during normal day-to-day activities cannot be overemphasized. It is the responsibility of the City and RSO to ensure that individuals involved in the specific activities defined herein strictly adhere to the ALARA principles of time, distance, and shielding. Training shall emphasize that external radiation exposure can be minimized by decreasing the time of exposure, increasing the distance from the source whenever possible, and increasing the amount of shielding material. Training may be provided through procedures, safety-talks, online training through internal or third-party software, onsite/in-person, or other form of training which can communicate the hazards of radiation and the requirements specified in this RHASP. In general, training should include information on the following procedures:

- Responsibilities.
- Determining workers who require training.
- Hazards associated with Radium-226, Radium-228, and Radon.
- Exposure minimization procedures.
- PPE requirements.
- Signs and symptoms of exposure to contaminants.
- Recordkeeping.

4.4 Personal Protective Equipment (PPE)

While PPE cannot protect against all possible radiation hazards, the use of PPE will assist in preventing exposures when used in combination with the controls described in the subsections above. The following PPE is required for all work tasks performed where exposure to leachate, LFG, and groundwater contaminated with radioactive materials may occur:

- Disposable gloves (Nitrile or Latex are suitable).
- Long-sleeved and clothing that protects the arms and legs.
- Closed-toed work boots (steel toe or safety toe).
- Face shield, if working with leachate or groundwater.
- Tyvek arm covers, when working with liquids in large quantities (>1 Liter).

All PPE contaminated with radioactive materials shall be placed in double bags, sealed, and held for proper disposal as described below in Section 4.8 of this RHASP.

4.5 Universal Precautions

Universal precautions shall be implemented when working on the Site and where potential exposures to radioactive materials may occur, including:

- Minimize contact with contaminated materials to the extent feasible – if a worker is not required to handle materials or be within the area of material handling, vacate the area until work activities are completed.
- Avoid direct skin contact with materials contaminated with radioactive materials.
- Personnel and Authorized Workers are not permitted to eat, drink, or smoke in the work areas.
- If contamination of clothing occurs, remove any contaminated clothing prior to leaving the work area and follow the steps described below in Section 4.8 of this RHASP.
- Washing hands and any other portions of the skin, which may have been exposed with soap and water prior to leaving the restricted area, especially prior to eating or drinking, before leaving the work area, and at the end of the workday.
- Ensuring that any cuts, abrasions, or open wounds are covered appropriately to prevent exposure to radiological materials during work activities.
- Post warning signs and labels in areas and equipment where radioactive materials contamination is present to warn workers of the potential of radioactive materials exposure.
- Control and restrict access to the work area(s) where materials contaminated with radioactive materials may be present – do not let non-authorized workers or members of the public within the designated work area(s).

4.5.1 Disinfection of Non-Disposable Materials

All equipment which comes into direct contact with potentially contaminated soil, LFG, leachate, or groundwater shall be decontaminated prior to leaving the sampling location. Sampling equipment decontamination procedures will consist of the following:

- Physically remove packed dirt and debris with a stiff bristle long handle brush and water.
- Clean all potentially contaminated surface areas.
- Scrub all potentially contaminated surface areas with a water/industrial detergent soap solution.
- Rinse with clean, potable water to remove any soap.
- Apply a thorough final rinse of deionized water.
- Allow it to drip and air dry.

4.6 Pregnant Workers

Pregnant Authorized Workers are encouraged to report their pregnancy to the City and/or employer as early as possible. If the worker chooses to not declare the pregnancy to the City and/or employer, additional controls and monitoring for radiation exposure cannot be implemented.

Upon notification of the pregnancy, the City shall work with the RSO to provide instructions on the risks associated with radiation exposure to the embryo/fetus of the worker, evaluate the employee's radiation work environment, past exposure history, and potential for future exposure. Based on the information provided, additional recommendations or restrictions may be imposed regarding the employee's duties involving occupational radiation exposure.

4.7 Meters and Monitoring

As previously stated, leachate, LFG, and groundwater monitoring may present potential scenarios for exposure. The permissible public dose limit for Radium-226 and Radium-228 exposure is 100 mrem/year, while the occupational dose limit is 5,000 mrem/year. Occupational dose limits are different than public health dose limits in that the occupational dose is received over time by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or radioactive material.

Radiation monitoring instruments are used both for area monitoring and for individual monitoring. The instruments used for measuring radiation levels are referred to as area survey meters (or area monitors) and the instruments used for recording the equivalent doses received by individuals working with radiation are referred to as personal dosimeters (or individual dosimeters). Monitoring for radiation is conducted for the following reasons:

- To assess workplace conditions and individual exposures,
- To ensure acceptably safe and satisfactory radiological conditions in the workplace, and
- To keep records of monitoring.

All monitoring results and meteorological data (e.g., temperature range, wind speed, wind direction, etc.) will be recorded in the field notebook and will be transferred to Instrument Reading Logs. Instruments must be calibrated in terms of the appropriate quantities used in radiation protection. A Geiger–Müller (GM) counter or scintillation detector (ST) will be utilized to perform the monitoring (Ludlum Model 3, 2401-EW, 2401-P, 26 or equivalent). GM counters exhibit strong energy dependence at low photon energy and are considered indicators of radiation, whereas ionization chambers are used for measurements that are more precise. The Model 3, for example, is a portable radiation survey instrument with four linear ranges used with exposure rate or counts per minute (cpm) meter dials, or a combination of both exposure rate and count rate (referred to as "combo") meter face dials and can measure from 0 to 200 mrem/hr. To assure proper operation of the instrument and detectors(s) between calibrations, an instrument operational check including battery test and instrument test will be performed at least daily or prior to use, whichever is less frequent.

In addition, Authorized Workers are required to wear a personnel monitoring device such as RaySafe i3 or Ludlum personal radiation monitor, or equivalent devices during work activities at the Site. Dose readings from RaySafe i3 or Ludlum personal radiation monitors are collected either manually or automatically at a pre-determined frequency via a computer or Bluetooth capable mobile device for real-time tracking. When using RaySafe i3 badges or Ludlum personal radiation monitors, Authorized Workers will be responsible for reviewing their own exposures and reporting exceedances to the City and their employers, if third-party, immediately. The occupational dose limits are provided in Table 1 below, as set forth by OSHA and Cal/OSHA.

Table 1 – Occupational dose limits set forth by 10 Code of Federal Regulations 20.1201 & 1208

	Dose Limits for Adults (mrems/yr)	**Dose Limits during Pregnancy (mrems/yr)**
Total effective dose	5,000	500 (dose equivalent to embryo/fetus)
Sum of deep-dose equivalent and committed dose equivalent to any individual organ or tissue other than the lens of eye	50,000	
Lens dose	15,000	
Shallow-dose to skin of whole body or to skin of any extremity	50,000	

4.7.1 General Instructions

The following instructions shall be followed prior to use:

- Prior to using any instrument listed above, ensure that the instrument is calibrated and used by trained personnel within the manufacturer's specifications. Any equipment not operating within the required specifications shall not be used and shall be removed from service.
- Background readings are to be performed prior to use at the point of use.

- Verify that the Maximum Detectable Activity (MDA) has been calculated for background at the point to be used and is less than the applicable site release criteria.
- Lost or stolen RaySafe i3 or Ludlum badges shall be reported to the City and employer, if third party, immediately and a replacement badge shall be provided to the Authorized Worker(s) to whom the badge was assigned. These badges shall only be worn when working in the affected areas as described in Sections 1 and 2 of this RHASP during work activities to ensure that radiation exposures are correctly and sufficiently monitored. RaySafe i3 or Ludlum badges shall also be protected from inadvertent exposure to strong heat, light, or other forms of radiation during storage.

4.7.2 Direct Scans

For Direct Scans (scintillation detectors), the following instructions shall be followed:

- Surfaces shall be dry and cleaned prior to performing direct alpha, beta, or gamma measurements.
- All detectors should be placed within ¼-inch of the surface to be surveyed. Use caution to not contaminate or damage the detector's surface.
- Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on the surveyor's experience, or an item's use history. Typically, the scan frequency is a minimum of 10% of accessible surface areas, 100% in many cases.
- Typically, a scan survey will suffice to free-release an item or to perform personnel frisking, which is the scanning of hands, feet, and other parts of the body and clothing to ensure that no contamination resides on personnel upon contaminated material handling or equipment after contact with contaminated material. Documentation of the scan may be an indication that the entire surface scanned was less than a certain instrument count rate (ensure that the maximum count rate corresponds to a surface contamination level less than the release criteria). The action level for direct measurements is 1,000 cpm measured 0.5 cm above the surface.
- Record the measurement on the appropriate survey form(s). The use of diagrams or sketches is recommended. In simple cases, documentation could be a log notation that an item was checked and was less than (<) a certain reading.
- Measurement results should be recorded in units of disintegrations per minute, i.e., dpm, such as "dpm/100 cm^2" or "dpm/probe." However, raw cpm may be recorded if the proper action levels are listed corresponding to the release criteria.

4.7.3 Static Measurements

- Static measurements are those with the detector stationary over an area of interest either in scaler (count) mode or in rate mode held for time sufficient to obtain a stable meter reading.
- Surfaces shall be dry and cleaned, to the extent practicable, prior to performing direct alpha, beta, or gamma measurements.
- All detectors should be placed within ¼-inch of the surface to be surveyed. Use caution to not contaminate or damage the detector's surface.
- Static measurements may be used at locations with the highest potential for contamination or to investigate elevated scan readings. The number of survey points selected is subjective, based on the surveyor's experience or an item's use history.
- Static measurement count times shall be appropriate for desired MDAs. Typical count times are one minute for digital scalers and until a meter reading stabilizes for analog ratemeters.
- Record and identify all locations surveyed on the appropriate survey form(s), if provided, or using detailed diagrams or sketches.
- Measurement results should be recorded in units of "dpm," such as "dpm/100 cm^2" or "dpm/probe.". However, raw cpm may be recorded if the proper action levels are listed corresponding to the release criteria.

4.7.4 Personnel Monitoring (Frisking)

Personnel monitoring is normally performed by scanning the hands (both sides) and bottom of shoes (after PPE removal) using the GM or scintillation detector. Other areas of the body that may have contacted contamination, such as the head, knees, etc., should also be scanned. Any scan count rate above background is cause to perform a static measurement of the spot. If the static measurement confirms an "above background" reading, the item of clothing shall be removed and decontaminated or disposed as described in Section 4.8 of this RHASP. If the elevated reading is of exposed skin, then the skin shall be washed with soap and water and then re-scanned.

Contamination may be removed from personnel clothing by patting the affected area with tape and resurveying to determine if additional decontamination is necessary. If contamination cannot be reduced to levels below the applicable levels and ALARA, the clothing will be removed from service for disposal as low-level radioactive waste. Where radon progeny contamination (contamination from the decay of radon gas) is suspected, personnel may remove and secure the clothing to allow time to ventilate and decay, then re-survey at a later time to determine if contamination is below applicable levels and ALARA.

4.8 Waste Disposal Considerations

All materials that may be contaminated with radioactive materials shall be handled and disposed of appropriately. Gloves, plastic sleeves, tubing, and other disposable sampling equipment will be screened using appropriate instrumentation (Geiger-Muller Counter, and/or Scintillation Detectors, etc.) and visually examined. If clothing contamination is suspected, the clothing shall be surveyed for radiological contamination. Any items exhibiting visual, olfactory, or radionuclide evidence of contamination will be drummed for off-site disposal. Otherwise, it will be collected in contractor grade plastic bags and properly disposed of as municipal trash.

4.9. Exposure Response

When wearing the RaySafe i3 or Ludlum badges, the badge alerts wearers when a radiation dose parameter is exceeded, providing fast exposure reporting through visual and audible alarms on the monitor and for some of the meters automated email notifications. As previously mentioned, GM meters may detect levels of 0 mrem/hour to 1.0 rem/hr. The monitoring instruments are used to determine worker exposures and further decontamination procedures, if necessary.

Exposure to low levels of radium and radiation in the environment does not cause immediate health effects but can increase the overall risk of cancer. Further, physical signs and symptoms of acute or chronic exposure to Radium-226 and Radium-228 may include nausea, vomiting, diarrhea, headaches, and fatigue, and in severe cases hair loss and internal bleeding. Typically, physical signs and symptoms of exposure to radium will present itself within minutes to days at high exposures and hours to weeks at low exposures. Radium-228 has been shown to be more toxic than Radium-226 because Radium-228 emits beta rays. Thus, Radium-226 is considered less toxic because the isotope emits alpha rays, which while energetic, are also large and easily stopped by the skin.

If a worker determines or suspects that exposure to radioactive materials has occurred above background levels either by physical signs and symptoms of exposure or notification from the RaySafe i3 or Ludlum GM monitors, the City and the Authorized Worker's employer shall document the exposure. An investigation into the circumstances surrounding the exposure shall be conducted and an occupational health follow-up examination shall be completed by the employer's occupational health provider to determine if exposures have occurred and recommend treatment. The investigation of the exposure shall include name(s) of any witnesses, date and time of exposure, a statement from the affected worker, contributing factors, corrective actions, and any other relevant information applicable to the exposure event.

In addition, the worker may be required to follow the reporting and investigation procedures of the worker's employer and/or the City. The City shall determine if additional surveying is required at the time of the exposure event to determine if exposure to radiation has occurred with an appropriate radiation detector (Geiger-Muller Counter, Scintillation Detector, etc.).

5. AUTHORIZED WORKER ACKNOWLEDGEMENT FORM

I have read the City of Berkeley's Radiation Health and Safety Plan (RHASP) and understand the information presented as it pertains to radioactive material exposure associated with the work activities described within the RHASP.

Authorized Workers are required to strictly adhere to the safety guidelines contained in this RHASP. Any employee found to violate the procedures and requirements specified in the RHASP will be immediately suspended from work activities and provided additional training until the deficiency is corrected. By signing below, I hereby agree to comply with the provisions contained therein.

Employee Name	Employee Company	Signature

CITY OF BERKELEY:

____________________________ ____________________________

Signature Print Name

____

Date