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Soil Screening and Management Plan - June 2021

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Environmental Functional Area

Environment, Safety & Health

Lawrence Livermore National Laboratory

Soils Screening and Management Plan

June 2021

FINAL

Revision 1

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Soil Screening and Management Plan Review Log

Revision No.	Date	Change Description
0	February 2019	Initial Version
1	April 2019	Editorial changes for clarity, updated Table 4-1
1	September 2020	Significant revisions, updated Tables and Figures, added acronyms and abbreviations page
1	June 2021	Corrected typographical mistakes and addressed DTSC comments

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List of Acronyms and Abbreviations

BTV	Background Threshold Value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CoC	Chain of Custody
COC	Constituent(s) of Concern
DOE	U.S. Department of Energy
DOHS	Department of Health Services
DQI	Data Quality Indicator
DQO	Data Quality Objective
DTSC	Department of Toxic Substances Control
EA	Environmental Analyst
EDO	Environmental Duty Officer
EFA	Environmental Functional Area
EMRL	Environmental Monitoring Radiation Laboratory
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Difference
ESL	Environmental Screening Level
ERD	Environmental Restoration Department
ES&H	Environment, Safety & Health
FFA	Federal Facilities Act
HAZWOPER	Hazardous Waste Operations and Emergency Response
HP	Health Physicist
HERO	Human and Ecological Risk Office
IH	Industrial Hygienist
ISMS	Integrated Safety Management System
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security, LLC
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MUSD	Maintenance and Utility Services Department
NAVY	U.S. Department of Navy
NPL	National Priorities List
OU	Operable Unit
PMO	Project Management Office
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RHWM	Radioactive and Hazardous Waste Management
RPM	Remedial Project Manager
RL	Reporting Limit
REV	Representative Elemental Volume
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
ROWD	Report of Waste Discharge
RSL	Regional Screening Level

RWQCB	Regional Water Quality Control Board
S300	Site 300
SAP	Sampling and Analysis Plan
SIA	Source Investigation Area
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SL	Screening Level
SSL	Soils Screening Level
SSMP	Soils Screening and Management Plan
SSP	Site Safety Plan
STLC	Soluble Threshold Limit Concentration
SWPPP	Stormwater Pollution Prevention Plan
TCLP	Toxicity Characteristic Leaching Procedure
TTLC	Total Threshold Limit Concentration
VOC	Volatile Organic Compound(s)
VSP	Visual Sampling Plan
WAMA	Water, Air, Monitoring and Analysis
WCP	Work Control Process

1,1-DCE	1,1-Dichloroethene, 1,1-Dichloroetheylene
HMX	High Melting Explosive, Cyclotetramethylene-Tetranitramine, Octogen
PCE	Perchloroethene, Tetrachloroethene, Tetrachloroethylene
PCBs	Polychlorinated Biphenyls
RDX	Royal Demolition Explosive, 1,3,5-trinitro-1,3,5-triazine
TCE	Trichloroethene, Trichloroethylene
TNT	2,4,6-Trinitrotoluene, Trinitrotoluene
TPH	Total Petroleum Hydrocarbons

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ft	foot or feet
mg/kg	milligrams per kilogram
pCi/g	picocuries per gram
yd^3	cubic yard or yards

1 Introduction

The purpose of this Soil Screening and Management Plan (SSMP) is to outline requirements for managing soil excavated at the Lawrence Livermore National Laboratory (LLNL) Livermore Site and Experimental Test Site 300 (S300). This SSMP provides processes to minimize waste generation through beneficial reuse of excess soils, when appropriate, and proper management of soils with residual contamination. This SSMP describes a screening process, combining historical and current activity due diligence, data collection, and data review to determine if soils may be reused on-site. Although related to the processes outlined in this SSMP, criteria for waste management and characterization of locations with contaminated soils are not addressed. LLNL Radioactive and Hazardous Waste Management (RHWM) should be contacted for waste management requirements and the Environmental Restoration Department (ERD) for characterization of contaminated locations managed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This SSMP does not apply to projects under other regulatory framework, such as CERCLA and the Resource Conservation and Recovery Act (RCRA).

1.2 Background

The LLNL Livermore Site and S300 are owned by the U.S. Department of Energy (DOE), and operated by DOE and Lawrence Livermore National Security, LLC (LLNS). Both sites are listed on the National Priorities List (NPL) under CERCLA.

1.2.1 Livermore Site

The LLNL Livermore Site occupies approximately one square mile in the eastern portion of the City of Livermore. The Livermore Site is bounded to the north by Patterson Pass Road, to the south by East Avenue, to the east by Greenville Road, and to the west by South Vasco Road.

Property records show the first use of the property, other than for grazing, was by the U.S. Department of Navy (NAVY) in 1943 as a naval air station. After the NAVY ceased operations, the southwest portion of the property was used by Standard Oil Company of California as a bulk fuel storage facility. LLNL was established on the property in 1952 as a national security laboratory and is responsible for ensuring that the nation's nuclear weapons remain safe, secure, and reliable. The Laboratory also meets other pressing national security needs, including countering the proliferation of weapons of mass destruction and strengthening homeland security, and conducts major research in atmospheric, earth, and energy sciences; bioscience and biotechnology; and engineering, basic science, and advanced technology. Historical NAVY and LLNL operations resulted in soil contamination on the LLNL Livermore Site.

LLNL has been actively operating the Livermore Site under CERCLA since finalization of the Federal Facilities Agreement (FFA) between DOE, the U.S. Environmental Protection Agency (EPA) Region 9, the California Department of Health Services (DOHS) (currently Department of Toxic Substances Control [DTSC]), and the San Francisco Regional Water Quality Control Board (RWQCB) in 1988 (LLNL, 1988). Constituents of concern (COC) identified in the

Record of Decision (ROD) for the Livermore Site include: volatile organic compounds (VOCs) (*e.g*., trichloroethene (TCE), perchloroethene (PCE), chloroform, 1,1-dichloroethene (1,1-DCE), and carbon tetrachloride), inorganic substances (*e.g*., chromium and lead), gasoline constituents in a limited area (*e.g*., benzene, toluene, ethylbenzene, and xylene(s)), and radioactive constituents (*e.g*., tritium) (LLNL, 1992a).

1.2.2 Site 300

Site 300 is located off Corral Hollow Road, roughly 15 miles southeast of Livermore, and four miles southwest of the City of Tracy, California. About one-sixth of S300 is in Alameda County, the remainder in San Joaquin County. Site 300 comprises approximately 7,000 acres of largely undeveloped land. The Site consists of seven designated areas, including the West and East Firing Areas (indoor and outdoor remote explosives testing facilities), Chemistry Area, Process Area, Engineering Test Area, Maintenance Facilities, General Services Area, and a Small Firearms Training Facility.

LLNL established S300 in 1955 to provide a remote site to conduct outdoor tests of explosives. Currently, S300 is primarily a nonnuclear explosives and other nonnuclear weapons component test facility. LLNL has been operating S300 under CERCLA since finalization of the FFA between DOE, EPA Region 9, the California DOHS and the San Joaquin Valley RWQCB in 1992 (LLNL, 1992b). Potential COC listed in the ROD depend on specific location (*i.e*., Operable Unit [OU]), and may include: VOCs, high explosives compounds, perchlorate, tritium, uranium, nitrate, polychlorinated biphenyls (PCBs), dioxins and furans, silicone oils, and metals (LLNL, 2008).

1.3 Soil Reuse Programs at LLNL

Legacy contamination at the Livermore Site led to environmental management activities managed under the CERCLA program per the ROD and associated Explanation of Significant Difference (ESD) documents (LLNL, 2014). Soils at the Livermore Site may either be appropriate for beneficial reuse or alternatively have the potential to contain COC in concentrations that may require management as waste.

To promote waste minimization (avoid excessive disposal of soils), LLNL established the Beneficial Soil Reuse Program in 1992 that is protective of the environment and groundwater quality, while allowing reuse of soils containing *de minimus* COC concentrations. This program was submitted to the San Francisco RWQCB as a Report of Waste Discharge (ROWD) and approval was received for reuse of soils containing VOCs (Christian, 1994). In the ROWD, LLNL also proposed the beneficial reuse of soils containing below background concentrations or levels of metals and radioactivity, where background screening levels were established using an upper confidence limit approach (Fisher, 1997; Folks, 1997). The San Francisco RWQCB decided not to proceed with formal permitting, but verbally concurred with the proposed background Soils Screening Levels (SSLs) (documented in a Record of Communication, 1997).

The Central Valley RWQCB provided guidance that allowed for reuse of soils at S300 that were at or below established background levels for specific COC. Background screening levels for metals and radioactivity have been periodically reviewed and revised based on available data (Blake, 2006; Gallegos, 2008; LLNL, 2019). Background radioactivity values were presented to the DOE Livermore Field Office most recently in 2011 and approved by DOE as compliant with DOE Order 458.1 Section 4k(6)(f) (Hill, 2011).

Plans for projects involving soil excavation must include plans for the management and disposition of soils within the project scope. LLNL prefers to beneficially reuse soils on-site, when possible, to be consistent with waste minimization goals and to avoid unnecessary project costs. This SSMP provides requirements and guidance on when soils may be reused and when alternative management through RHWM or ERD may be necessary. Management alternatives include reuse onsite, disposal at a municipal landfill, or disposal at a hazardous or radiological waste management facility (Institutional Procedure PRO-2725 – *Management of Soil and Debris*). Soils shall be managed in accordance with all applicable local, state, and federal regulations. Receiving facilities must be properly authorized, and soils sent offsite must meet the receiving facility's acceptance criteria.

This SSMP supersedes the existing Beneficial Soil Reuse Program. However, the waste minimization and environmental protection objectives of LLNL's Beneficial Soil Reuse Program remain relevant. Historically, the program has primarily been implemented on small to moderate sized excavation projects. This SSMP is derived from and extends LLNL's Beneficial Soil Reuse Program. Institutional soil management procedures were reviewed to ensure they could be scaled up to accommodate excavation activities required for upcoming projects. This internal review provided the opportunity to benchmark LLNL's soil management program with similar DOE facilities and relevant regulatory guidance.

This program review confirmed that LLNL has adequate soil management procedures in place, but also identified opportunities to enhance guidance and align LLNL's existing SSLs with established approaches, consistent with regulatory requirements. LLNL has elected to modify its SSLs to be comparable with regulatory guidance while continuing to be protective of human health and the environment. The modified SSLs use Background Threshold Values (BTVs) or regulatory-approved SSLs, whichever is greater (**Section 4.1**).

1.4 Institutional Procedures

Institutional Procedure PRO 2725 is followed for management of soils at LLNL. PRO 2725 implementation is supported by internal instruction documents that address details of a project site evaluation process. The eight Instructions related to this SSMP are listed below and may be obtained via the Environmental Functional Area (EFA) Administrative Assistant:

Document	Title
ESP-04, Instruction 00	Site Evaluation Procedure
ESP-04, Instruction 01	Completing a Review Checklist for Soil, Asphalt, and/or Concrete
ESP-04, Instruction 02	Performing a Low-Level Gamma and X-Radiation Meter Survey of Asphalt/ Concrete
ESP-04, Instruction 03	Preparing a Sampling/Surveying Plan

Document	Title
ESP-04, Instruction 04	Collecting Surface and Subsurface Soil; and, asphalt and/or Concrete Samples
ESP-04, Instruction 06	Collecting Samples from Material Stockpiles
ESP-04, Instruction 07	Submitting Samples to the Analytical Laboratory
ESP-04, Instruction 08	Data Review and Management

Note: ESP-04, Instruction 05 has been integrated into ESP-4, Instruction 04.

Operations described in this SSMP must comply with the local, state, and federal government requirements, and LLNL policies contained in latest versions of documents listed below:

- For air quality compliance, Institutional Program Description, Non-radiological Air Quality Compliance, DES 2645.

- For storm water management, Institutional Program Description, LLNL Storm Water Management, DES 2685, and the Livermore Site and S300 Stormwater Pollution Prevention Plans (SWPPPs). This includes the requirements for permit coverage under the construction general permit for projects larger than one acre.

- Construction dewatering may be considered a non-stormwater discharge and may require additional permitting, contact the EFA stormwater Subject Matter Expert (SME). Dewatering wet soil generated from activities such as excavation of storm water impacted areas or potholing must occur in containers or contained areas lined with plastic. Contact the LLNL stormwater SME for management of runoff resulting from dewatering activities, if any.

2 Soil Management Program

All projects must evaluate excavated soils, either before or after excavation (stockpile sampling), to determine proper management. Sampling frequency is determined by the historical use of the property, i.e., Due Diligence Tier. An initial due diligence review must also be performed per existing procedures using historical information and current available soil sampling results per ESP-04, Instruction 00.

LLNL's soil management program has evolved to include comprehensive risk-based approaches that:

- Clarify the program applicability and due diligence standards.
- Improve decision trees to clarify when and why specific due diligence and sampling activities are necessary.
- Provide improved guidance for project planning to meet soil management requirements, including expectations for large projects.
- Ensure consistent application of standard regulatory screening approaches applying appropriate soil screening values or site-specific background, whichever is greater.

- Promote consistency in documenting standard statistical sampling designs, as appropriate, that are risk-based and consistent with guidance like the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (MARSSIM, 2000).

Each of these components will be discussed in more detail in the following sections.

2.1 Program Organization

Planning for soil disposition as an element of overall project planning begins with the engagement of EFA and an Environment, Safety and Health (ES&H) Team Environmental Analyst (EA). This should take place early during project scoping. A detailed discussion of roles and responsibilities is provided in LLNL Institutional Procedure PRO 2725 and the above referenced internal instruction documents, available on the EFA Bookshelf Portal. The effort required in project planning and implementation scales with project size, location, and timing as discussed below.

2.2 Data Quality Objectives

LLNL's SSMP has been organized to be consistent with EPA guidance on the Data Quality Objectives (DQO) process (EPA, 2006).

> *"The DQO Process is used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO Process leads to efficient and effective expenditure of resources; consensus on the type, quality, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project."* (EPA, 2006, pg. iii)

The EPA suggests the following steps for developing data quality objectives:

1- State the problem.
2- Identify the Goal of the Study.
3- Identify Information Inputs.
4- Define the Boundaries of the Study.
5- Develop the Analytic Approach.
6- Specify Performance or Acceptance Criteria.
7- Develop the Detailed Plan for Obtaining Data.

The following sections provide the components of the DQO Process, specifically identifying and defining LLNL's soils management program, boundaries, and limitations for the decisions to be made using due diligence and data collection, data requirements and methods, as well as criteria for decisions on soil disposition. As stated in the introduction, this SSMP provides guidance on the acceptable and appropriate reuse of excavated soils at the Livermore Site and at S300.

The disposition of soils may be determined either before or after excavation, using representative data that is enough to reach defensible conclusions. Representative data is key to any disposition determination. Such data may include:

- Due diligence reviews (Historical Site Assessment) of historical activities that assess the potential for the presence of any COC, spill records, and current activities. The ES&H Team EA will determine the chemical analyses to be performed on collected soil samples, based on the results of the due diligence.
- Pre-existing soils data from historical samples that meet Quality Assurance/Quality Control (QA/QC) requirements and that may indicate the potential for the presence of any COC in excavated soils.
- Collecting pre-excavation soils analytical data (*in situ* sampling) using statistical and/or judgmental sampling approaches that may indicate the presence or absence of COC.
- Collecting of post-excavation soils analytical data (*ex situ* sampling) from soil stockpiles that may indicate the presence or absence of COC.

Each of these sources of information, independently or in combination, may be appropriate depending on the project site conditions, project design, and schedule constraints.

Due diligence reviews must include evaluating LLNL ERD and EFA historical documentation, *e.g.*, Dreicer (1985) or spill logs. Due diligence requirements outlined in PRO 2725 shall be followed.

Soils may be sampled and analyzed *in situ* or *ex situ* in post-excavation stockpiles. For larger projects (e.g., projects excavating 100 cubic yards [yd^3] or more of soil), a Sampling and Analysis Plan (SAP) and a Quality Assurance Project Plan (QAPP) are required prior to sampling activities (**Appendix A**).

LLNL has established analytical suites with state-certified analytical laboratories to quantify the COC in soil samples. Data Quality Indicators (DQIs) in addition to representativeness are addressed through a Quality Assurance/Quality Control (QA/QC) program specified in contracts with the analytical laboratories and reviewed by LLNL upon data delivery. Other QA/QC elements are addressed in the project specific SAPs (**Section 3**).

Data completeness will be reviewed by an LLNL ES&H Team EA and/or EFA SME. If analytical data is collected by RHWM or ERD, then data validation will be performed through the processes established in those departments, which are comparable to this SSMP (LLNL, 2018; RHWM Procedure WIC 125). Laboratory analyses must have Method Detection Limits (MDLs) and Reporting Limits (RLs) appropriate for comparison to the LLNL SSLs.

Data provided to LLNL by the analytical laboratories is processed through a Quality Assurance (QA) verification review, and the verified data is compared to LLNL SSLs. If all analytical results from a sample are less than their associated SSLs, then the soil for which that sample is considered representative is available for beneficial reuse on the site. Additional aspects of the DQO Process are addressed in the sections that follow.

2.3 Applicability

This SSMP applies to soil excavation activities at the LLNL Livermore Site and S300, except for exclusions outlined below. This SSMP addresses only specific LLNL expectations for determining the final disposition of excavated soils. Disposition options for a project include reuse within the project area, beneficial reuse at another location on- site, or disposal off-site as a waste. Soil with COC concentrations above Federal and California hazardous waste standards, and with radiological constituents above current DOE and LLNL reuse levels will not be reused. Additional requirements may apply for regulated wastes.

2.3.1 Exclusions

LLNL soil reuse requirements apply to all projects that include soil excavation, except for the limited exclusions discussed in this section. These exclusions may require other soils management activities depending on the situation. Additional review beyond due diligence review will not be required when excavation projects are:

- Generating 3 yd^3 of soil or less in areas outside locations with known contamination (**Section 2.5.1**).
- Roadway, fire trail, or other minor grading or resurfacing where the average line/grade is not changed by more than one foot with the purpose of maintenance or utilities work, landscaping, or fire protection.
- Limited emergency excavation activities (**Section 2.3.1.1**).
- Specific RCRA-related activities (**Section 2.3.1.2**).
- Specific CERCLA-related activities, and activities conducted under regulatory agency or agencies' oversight having jurisdiction over soil handling requirements (**Section 2.3.1.2**).

The applicability of the SSMP activities are summarized in the decision tree in **Figure 2-1**. The project due diligence tiers are described in detail in **Section 2.5**.

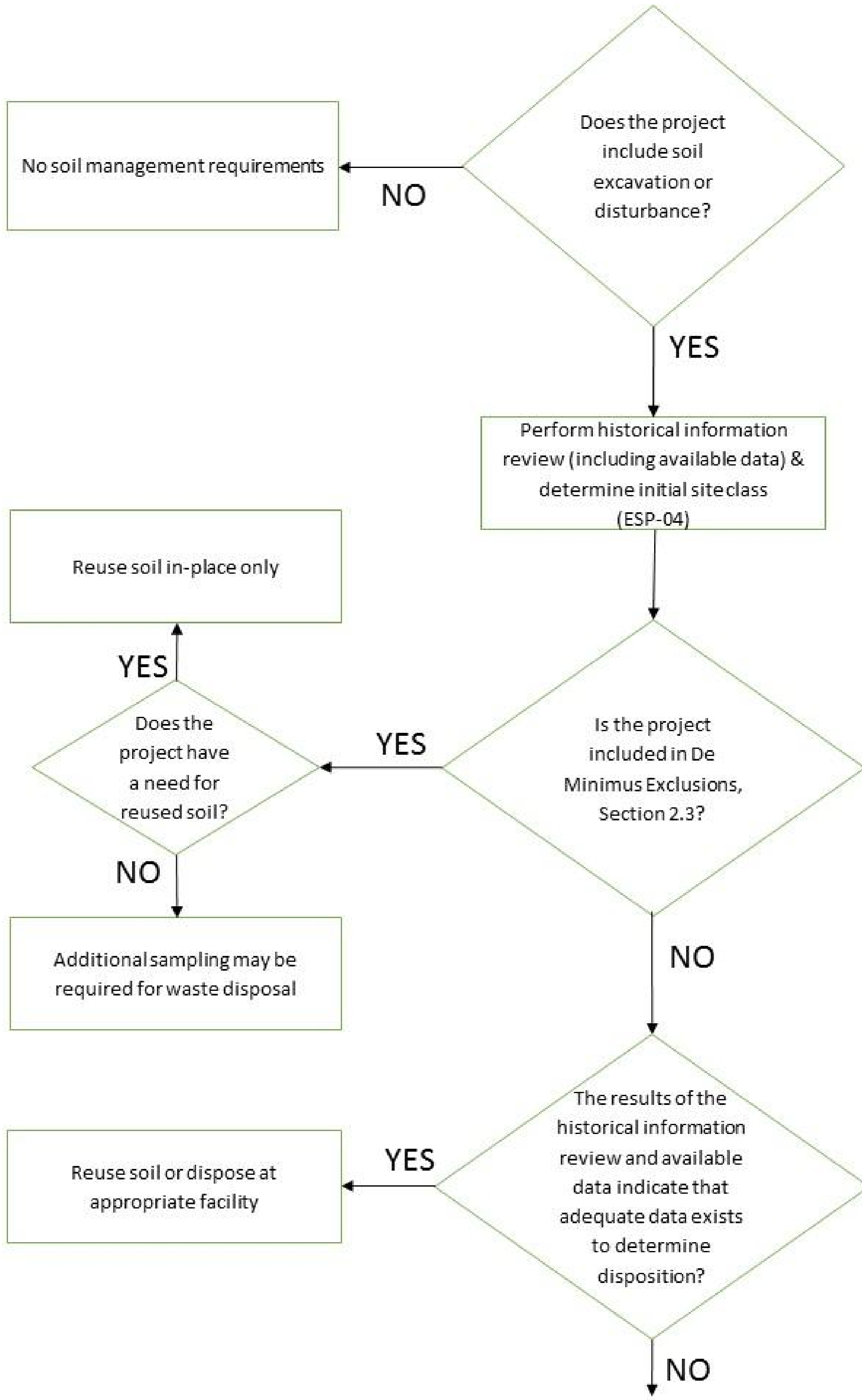
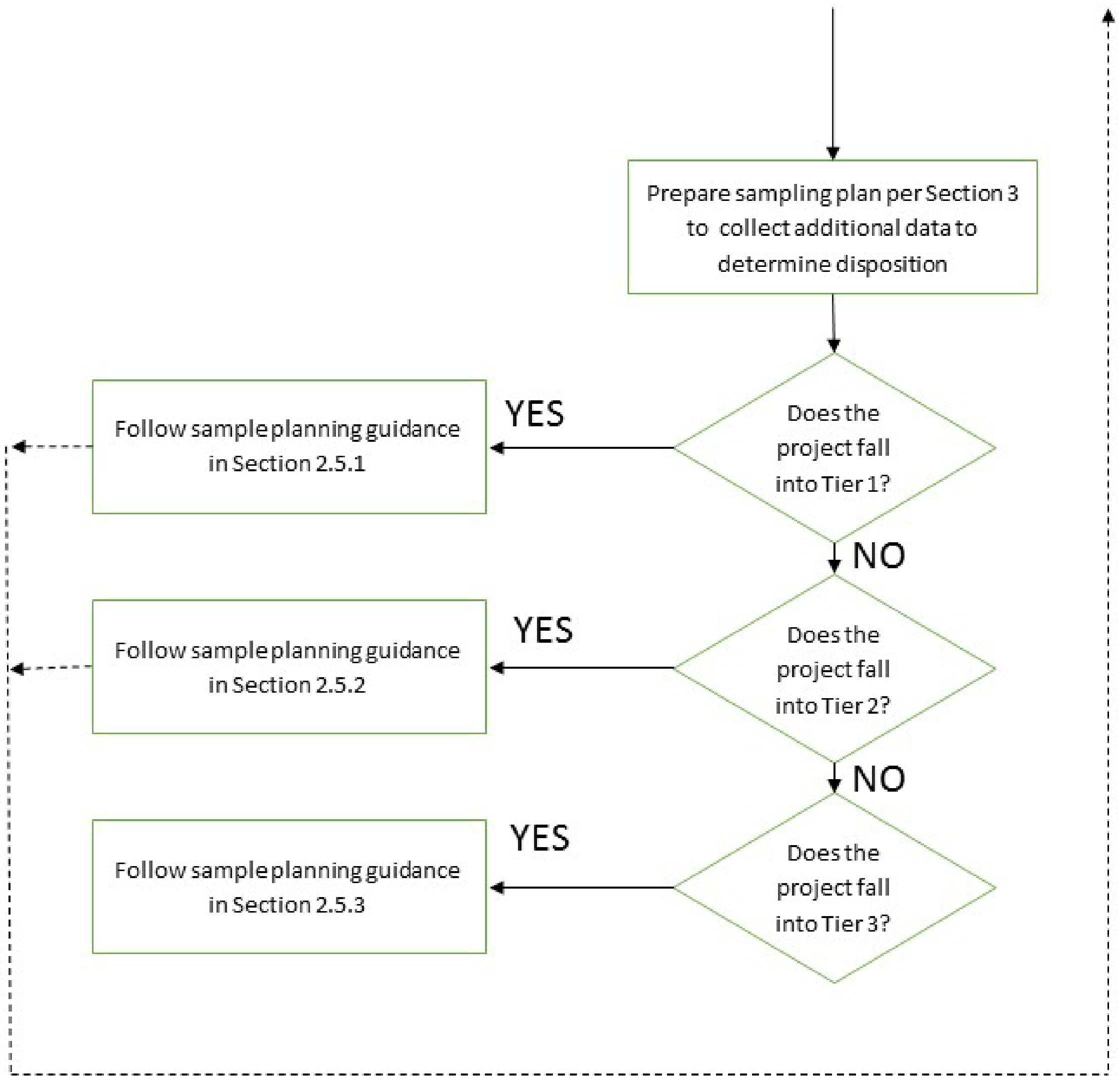

Does the project include soil excavation or disturbance?
NO
No soil management requirements
YES
Perform historical information review (including available data) & determine initial site class (ESP-04)
Is the project included in De Minimus Exclusions, Section 2.3?
YES
Does the project have a need for reused soil?
YES
Reuse soil in-place only
NO
Additional sampling may be required for waste disposal
NO
The results of the historical information review and available data indicate that adequate data exists to determine disposition?
YES
Reuse soil or dispose at appropriate facility
NO

Figure 2-1. Decision tree for soil reuse applicability.

Note: Refer to **Section 2.5.1**, **Section 2.5.2**, and **Section 2.5.3** for the rationale on how the Tier 1, Tier 2 and Tier 3 determination was made.



2.3.1.1 *De Minimis* Exclusion

After performing due diligence, and if **all** the following criteria below are met, then the project may reuse or locally spread excavated soils as part of the project.

1. Except as noted in No. 2, the project is located outside of known contamination areas (**Section 2**; and **Figure 2-6** and **Figure 2-7**).
   a. Exception is granted; if the project is located within a known contamination area (Due Diligence Tier 1 Area), but quantifiable soil analytical data is present within

55 feet (see **Section 2.4.1** and **Appendix C**) of the excavation showing that soils meet LLNL's SSLs **(Table 2-2)**.

2. The project purpose is for maintenance or utilities work, landscaping, or fire protection.
3. The total excavated volume of soil will be less than three yd^3.
4. All excavated soil can be returned to the disturbed area.

Emergency excavation activities (*e.g.* emergency water line repair) generating less than 20 yd^3 of soil; and roadway and fire trail grading, or resurfacing (**Section 2.3.1**) are also excluded.

Note: Any excavated soils that cannot be returned to the disturbed area must be characterized for disposition.

2.3.1.2 CERCLA/RCRA Activities

This SSMP is designed to screen LLNL soils for reuse, however projects potentially requiring regulatory cleanup under CERCLA or RCRA may require actions above and beyond those addressed in this SSMP.

At the Livermore Site, Source Investigation Areas (SIAs) have been established where vadose zone contamination is or was a likely source for impact to groundwater; and, which are currently undergoing remediation per the Site ROD. In addition, areas with specific VOC contamination have been identified, where if soil is excavated, the soil could potentially meet the definition as an F-listed hazardous waste (**Figure 2-6**).

For S300, **Figure 2-7** shows the approximate locations of known release areas and CERCLA OUs from the Site-Wide ROD (LLNL, 2008).

Additional information on CERCLA actions at the Livermore Site and at S300 can be obtained from ERD.

2.3.1.3 Hazardous Waste Management Facilities

LLNL operates hazardous waste management facilities at the Livermore Site and S300 under permits issued by the DTSC. Any changes to facilities covered under the DTSC permits, including modification, closure and demolition, or projects under other regulatory framework are expected to be outside the scope of this SSMP. Similarly, CERCLA activities performed under the site-specific RODs are also outside of the scope of this SSMP. Components of this SSMP may be used in discussions with outside agencies, but the actual requirements may differ based upon the agencies involved and specific attributes of the project. Contact the ES&H Team EA to determine if a project falls into this category.

2.3.2 Project Size and Scope

Consistent with responsibilities discussed in the CERCLA document "*Explanation of Significant Differences for Land Use Controls*" (LLNL, 2014), this SSMP has been designed to address soil excavation projects of all scopes, and sizes exceeding three yd^3 (**Table 2-1**).

- Small Projects: (> 3 to ≤ 10 yd^3) can be managed by the ES&H Team EA, normally in cooperation with EFA. In these cases, a written SAP may not be necessary and resources for soil sampling and analysis will likely be managed internally by LLNL.
- Medium Projects: (> 10 - ≤ 100 yd^3) may require a SAP, but the necessary plan and resources will be established through review by the ES&H Team EA and EFA.
- Large Projects: (> 100 yd^3) Larger projects must include the ES&H Team EA, the EFA Water, Air, Monitoring and Analysis (WAMA) Group Leader and EFA Manager. Additional resources may be required using either internal staff or available sub-contract support to prepare and implement the required SAP.

All projects involving excavation shall require due diligence reviews; and all projects involving more than five samples shall require a written SAP/QAPP. The ES&H Team EA or EFA WAMA EA may use professional judgement to determine if a project involving five or fewer samples, would need a written SAP/QAPP.

Table 2-1. Excavation size and scope considerations for soils management planning[1].

Potential Excavation Volume	Minimum Prior Notification	Level of Notification	Sampling & Analysis Plan
> 3 to ≤ 10 yd^3	60 days	Team EA	Not necessary (optional)
> 10 to ≤ 100 yd^3	120 days	Team EA & EFA WAMA EA	Recommended or Required per Team EA
> 100 yd^3	> 120 days *(depends on number of soil samples & stockpiling vs. pre-excavation disposition requirements)*	Team EA & EFA WAMA Group Leader	Required

[1.] The ES&H Team EA or EFA WAMA EA Manager may use professional judgement to determine if a project involving five or fewer samples, will need a written SAP/QAPP.

Large projects may be divided into sub-areas for waste minimization and efficiency. This will allow for managing soils from discrete locations according to their final characterization. The following sections explain the sampling design and rationale for *in situ* and stockpile (*ex situ*) soils.

2.4 Sampling Design

Sampling design refers to the selection of locations at which to collect soil samples. The overall goal for a sampling design is to be representative of the entire volume of soil for which management decisions must be made, so that management decisions can be based on sample results. Representative sampling reduces the likelihood of mismanaging non-sampled soil.

Sampling may include *in situ* (before excavation) sampling to determine soil COC concentrations prior to project initiation, *ex situ* (post excavation) sampling of stockpiled soils, or some combination that meets the project schedule and objectives. Sampling designs explained in this section are the minimum requirements. Any areas requiring further investigation, as a result of due diligence or elevated levels of COC, will be investigated.

Two major design methods are available to determine sampling locations: judgmental and statistical (probability-based) methods.

- Judgmental sampling uses professional judgment in combination with a site conceptual model (based on knowledge of the history of site activities and due diligence reviews) to select representative locations. Judgmental sampling is recommended for small to moderate projects (*e.g.*, projects excavating less than 100 yd^3 of soil). It can also be appropriate for larger projects if substantial information is available to indicate where unacceptable soil, if any, is located.
- Statistical sampling controls approximate the probability of failing to discover the presence of soil with COC concentrations exceeding SSLs. Statistical sampling is recommended for large (*e.g.*, projects excavating 100 yd^3 or more of soil) projects, especially when there is insufficient information to support decisions based on judgmental sampling.

2.4.1 *In situ* Characterization

Grid sampling is a standard sampling design that ensures even coverage of sampling locations across a site. Grid sampling makes sense when soils with COC concentrations exceeding reuse SSLs are expected to be found in one or more (large) contiguous areas within the project area. For LLNL (for both the Livermore Site and S300) projects, hexagonal or triangular spacing are recommended.

Random sampling design layouts may be preferred when: (a) soils with COC concentrations exceeding SSLs are expected to be found in (many) scattered small areas which together make up a significant portion of the project area; and, (b) it is important to have a known statistical probability that sampling will find soils that exceed SSLs.

This SSMP establishes standard sampling approaches that are tiered based on the potential for COC in soil to be present exceeding SSLs. The Due Diligence Tiers are assigned based on the reviews described in **Section 2.2**. The Due Diligence Tiers are similar in concept to the Tiers used in MARSSIM (MARSSIM, 2000). Sampling designs for areas with a greater potential for soil COC to exceed SSLs will include more samples at a greater density, *(i.e.*, smaller grid spacing between sampling points).

Table 2-2 presents the standard sampling designs that will be employed for LLNL projects under this SSMP. The grid spacings are calculated to have a 95% probability that at least one grid location will be placed within a "target" area of the specified size within the project area, assuming the grid is placed at random. A "target" area is a circular shaped area, all of which exceeds an SSL. This methodology is available in Visual Sample Plan (VSP) software (Matzke *et al.*, 2014).

Table 2-2. Standard sampling grids for LLNL projects involving excavation.

Project Size*	Project Due Diligence Tier	Target Surface Area (ft^2)	Sampling design and grid spacing
Small	All	n/a	Best Professional Judgment
Medium and Large	1 [High potential to exceed SSLs]	10,000	Hexagonal grid, 109 ft spacing (55-foot radius)
	2 [Moderate potential to exceed SSLs]	25,000	Hexagonal grid, 172 ft spacing (86-foot radius)
	3 [Low potential to exceed SSLs]	50,000	Hexagonal grid, 244 ft spacing (122-foot radius)

*If a relatively small area of contamination is suspected, closer spacing may be warranted based on the professional judgement of the EFA SME.

Figure 2-2 and Figure 2-3 illustrate the target surface areas relative to the size of the Livermore Site and S300, respectively. **Appendix C** compares these grid spacings to the CERCLA-identified SIAs at the Livermore Site. A project specific grid will be generated for each SAP.

This SSMP also recognizes that there may be project-specific needs that result in deviation from these standards. If deviation is required, it must be documented in a project-specific SAP explaining the:

- Reason for the deviation from the standard.
- Selected sampling design.
- Justification that the design is more representative or appropriate for the project.

For *in situ* samples collected using bore hole or coring methods, a vertical depth composite sample may be collected at each identified location. Except for samples collected for VOC analyses, vertical composite samples will be obtained by taking subsamples from the top, middle and bottom of boreholes at no more than three feet apart. Samples collected for VOC analyses will be non-composite, or single point samples, and will be collected using a Terra-Core©, or similar sampling device. Horizontal composite samples will not be collected across boreholes. Depth composites are an acceptable approach to obtain representative results for a soil profile at the depths of excavation planned for specific projects.

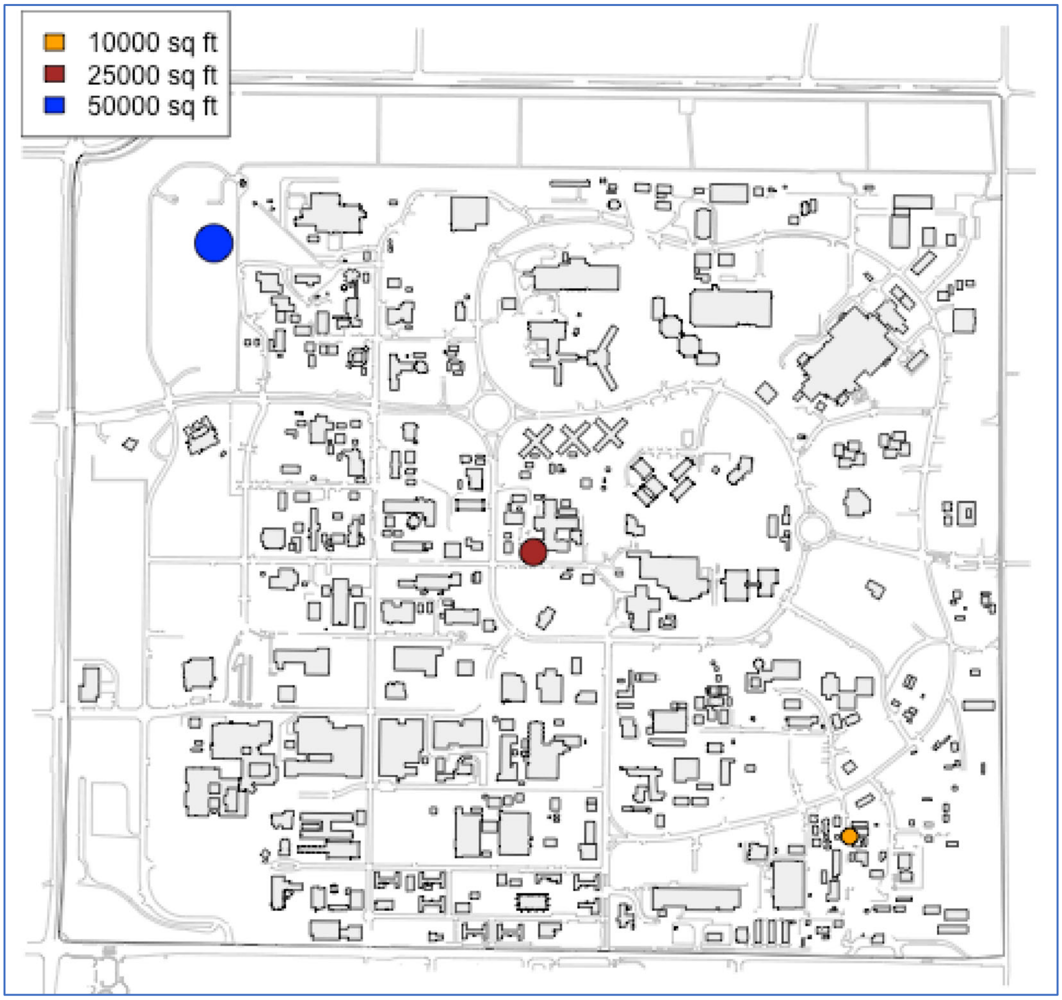


Figure 2-2. Example target surface area sizes employed for grid sampling designs at the Livermore Site (yellow - 10,000 ft^2, red - 25,000 ft^2, and blue - 50,000 ft^2).

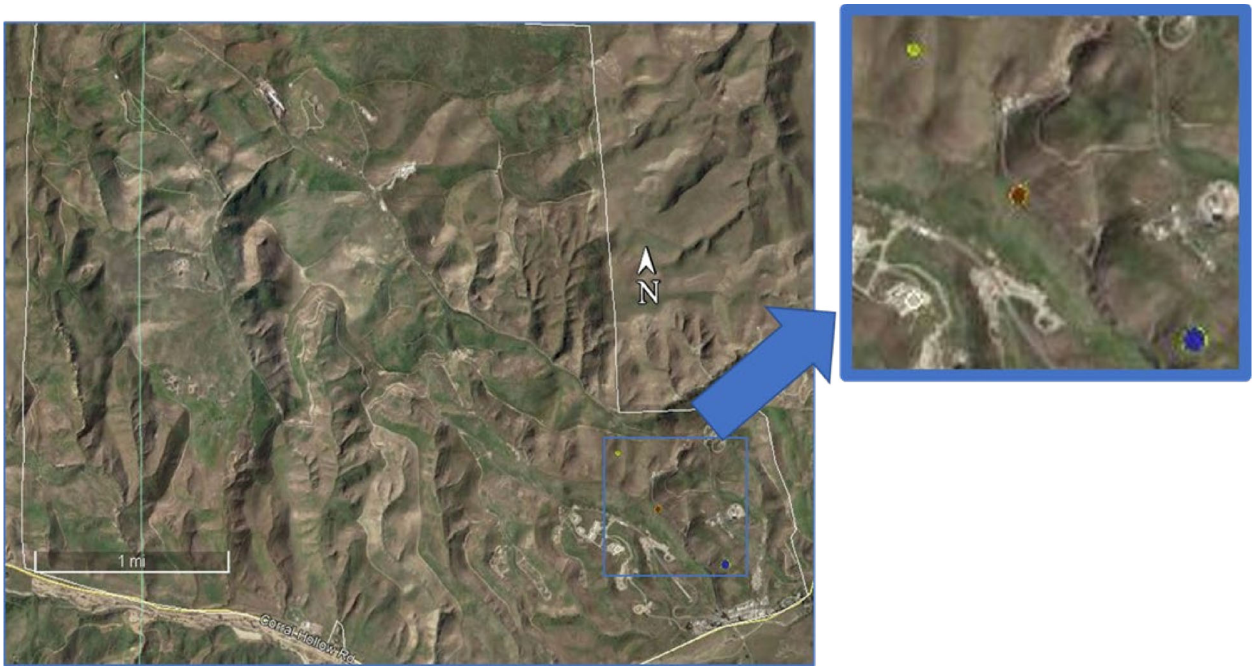


Figure 2-3. Example target surface area sizes employed for grid sampling designs at S300 (yellow - 10,000 ft^2, red - 25,000 ft^2, and blue - 50,000 ft^2).

2.4.2 Stockpile Sampling

Sampling soil stockpiles following excavation may be appropriate for some projects. The decision to sample after excavation or sample before excavation is based on professional judgement and on project specific design. Project specific SAPs will outline sampling decisions. Sampling of soil stockpiles following excavation may be performed to determine both soil reuse and soil disposal. Sampling of soils stockpiles is addressed in EFA ESP-04, Instruction 06 and is consistent with the EPA guidance "*Preparation of Soil Sampling Protocols, Sampling Techniques, and Strategies*" (EPA, 1992).

For soil stockpiles, LLNL uses a systematic sampling design consistent with EPA (1992), that applies a two-dimensional grid over a stockpile. Composite sampling is performed within grids of the stockpile. Systematic sampling involves collecting samples at preset intervals (in space in this case) and using randomly selected locations as the first sampling point (EPA, 1992). For soil piles, LLNL will apply the approach spatially over two dimensions as illustrated in **Figure 2-4**, where the first illustration is a horizontal view from ground level and the second is a plan view from above the pile. The figure is provided as an illustration example of how the systematic sampling design will be applied in a stratified fashion across the pile, with each initial sampling point selected randomly. Systematic sampling may be considered a type of stratified sampling as described in EPA (1992). This sampling design is appropriate to assess the mean concentration of constituents within soil grid areas, but still allows for identification of areas of potential elevated concentrations.

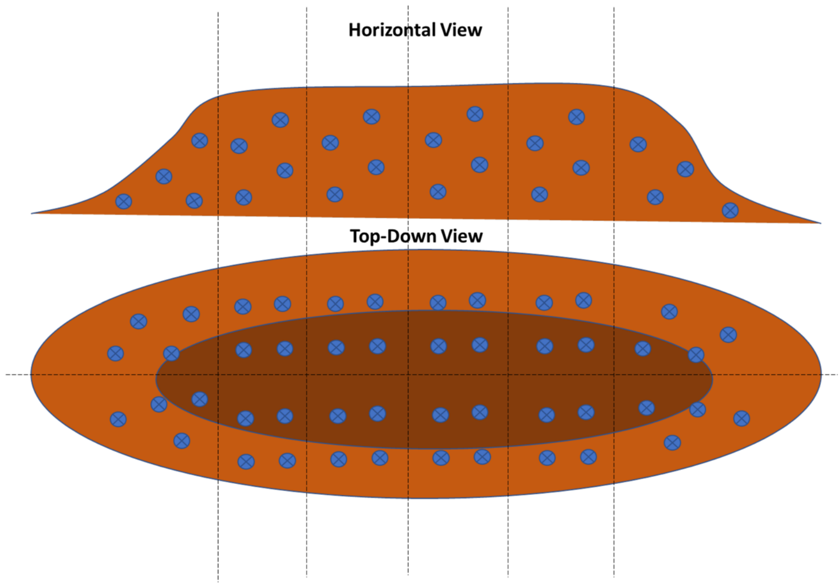


Figure 2-4. Illustration of systematic stratified stockpile sampling design to be applied in this SSMP.

The size of the grid and number of subsamples per composite will depend on the size and geometry of the specific soil stockpile. At a minimum, however, one subsample for every 20 yd^3 of stockpiled soil will be collected for Due Diligence Tier 1 Area projects. The objective of the design is to ensure that samples have been collected in a manner that appropriately represents the statistical population in question, so that results may be considered representative of that population. Soils are structured and require sampling designs that recognize heterogeneity and stratification to capture a Representative Elemental Volume (REV) as summarized by Campbell and Garrido (2005). For this SSMP, a conservative minimum representative volume for stockpile sampling was selected based on published waste management guidance, benchmarking similar plans, and through comparison of the statistically based target surface areas for *in situ* sampling designs. Based on this REV the total volume of soil represented by stockpile composite samples for each of the Due Diligence Tiers would be less than the total volume represented through *in situ* sampling.

Stockpile sampling will use composites to increase representativeness, with each composite consisting of a combination of subsamples (usually four). At least one sample will be required per "unit volume" for each of the different site Due Diligence Tiers (**Table 2-3**). Project SAPs will specify whether composite subsampling locations will be random or systematic.

> **Note:** Samples collected for VOC analyses from stockpiled soils will be non-composite, or single point samples, and will be collected using a Terra-Core©, or similar sampling device.

Table 2-3. Standard soil stockpile sampling designs for LLNL projects involving excavation.

Project Size	Project Due Diligence Tier	Minimum Subsample Unit volume (yd^3)
Small	All	*Use best judgement for piles <20 yd^3*
Medium and Large	1 [High potential to exceed SSLs]	20
	2 [Moderate potential to exceed SSLs]	30
	3 [Low potential to exceed SSLs]	40

There are advantages to stockpile sampling following excavation that include more accessible soils for sampling, and no specialized coring/boring equipment required. Some disadvantages include large areas required for soil storage and lengthened project schedules while waiting for data for final disposition.

Compositing is a widely accepted and applied soil sampling technique that is appropriate for screening activities such as those presented in this SSMP (EPA, 1995). Composite sampling of stockpiles involves collection of multiple sub-samples that are combined into a single sample for analyses as illustrated in **Figure 2-5** (EPA, 2002b). One concern with compositing is that information regarding variability may be lost, but when appropriately designed, the population mean (or median) should be representative. However, as variability is scale dependent in soil sampling it is necessary to collect representative samples at the appropriate spatial scale for the question being asked (Campbell and Garrido, 2005). This is consistent with the EPA DQO process (EPA, 2006) and appropriate for effective decision making. This means that compositing must be appropriately considered to ensure the sampling plans are obtaining representative data.

Considerations for collecting composite soil samples is provided in Section 5 of EPA's *Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies* (EPA, 1992) and have been applied in this SSMP. Composites samples generally include between two and ten subsamples, with recommendations to generally avoid exceeding ten subsamples. Guidance in RCRA SW-846 Chapter 9 provides an approach to select soil sample composites and comparing the results to action levels (EPA, 1986). Based on that guidance, LLNL reviewed historical soil data that contained few results below detection limits to examine the relationship between variability, minimum number of samples, and the potential for compositing. As a result of this analysis, LLNL selected a conservative upper limit of four subsamples per composite to ensure that any potential contamination in a sample would be appropriately identified.

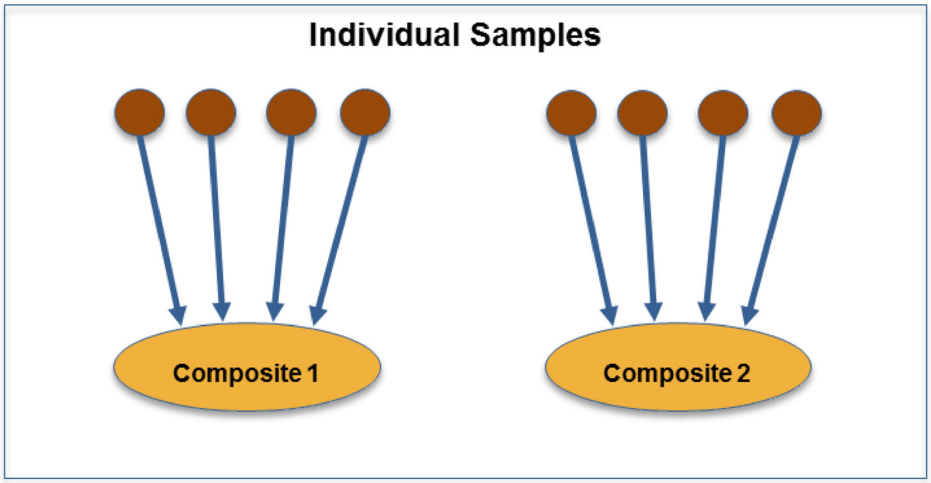


Figure 2-5. Conceptual example of soil composites and subsamples.

2.5 Project Due Diligence Tiers

This SSMP establishes Project Due Diligence Tiers to clarify expectations, and to assign appropriate levels of review in categories that take historical land use into account - using a Historical Site Assessment and sample data approach consistent with the MARSSIM Manual (MARSSIM, 2000) but applied as a screening tool instead of a contamination characterization approach. This approach causes areas with known impact to be managed with more scrutiny and a subsequent greater sampling density than areas with potential but unconfirmed impacts, or those with no known impacts.

2.5.1 Tier 1 - High Potential to Exceed SSLs

Due Diligence Tier 1 Areas are those areas where LLNL has data demonstrating elevated levels of COC in soil. Alternatively, these may be OU locations under CERCLA; or, areas with confirmed records of disposal or other historical contaminating activities. See **Figure 2-6** for the Livermore Site and **Figure 2-7** for S300.

The sampling design objective in Due Diligence Tier 1 Areas is to identify if soil COC are present at levels requiring management other than on-site soil reuse (**Table 2-2** [in-situ] and **Table 2-3** [stockpiled]). The sampling design has not been developed for the purpose of mapping/characterizing the extent of contamination, or for other RCRA or CERCLA requirements. The sampling design can be used for disposal purposes, however.

Unless LLNL has analytical data within 55 feet (grid point radius) of a proposed excavation showing that soils meet SSLs, LLNL will provide pre-notification (via e-mail) to all CERCLA Remedial Project Managers (RPMs) that excavation activities will be initiated in a Due Diligence Tier 1 Area. The pre-notification email will include the following information:

- Project name and purpose;
- Location of the excavation; and,
- Date or dates of planned excavation.

For all projects in Due Diligence Tier 1 Areas where pre-notification has been made, a Soil Disposition Memo will be prepared, per PRO 2725, based on sampling results and will include a summary and disposition of the excavated soil. The Soil Disposition Memo, or multiple memos for different project areas and/or stockpiles if applicable to the project, will be compiled and provided to the RPMs at the conclusion of each soil excavation project. The analytical laboratory data packages supporting the Soil Disposition Memo(s) will not be provided but will be available for review and/or provided upon request.

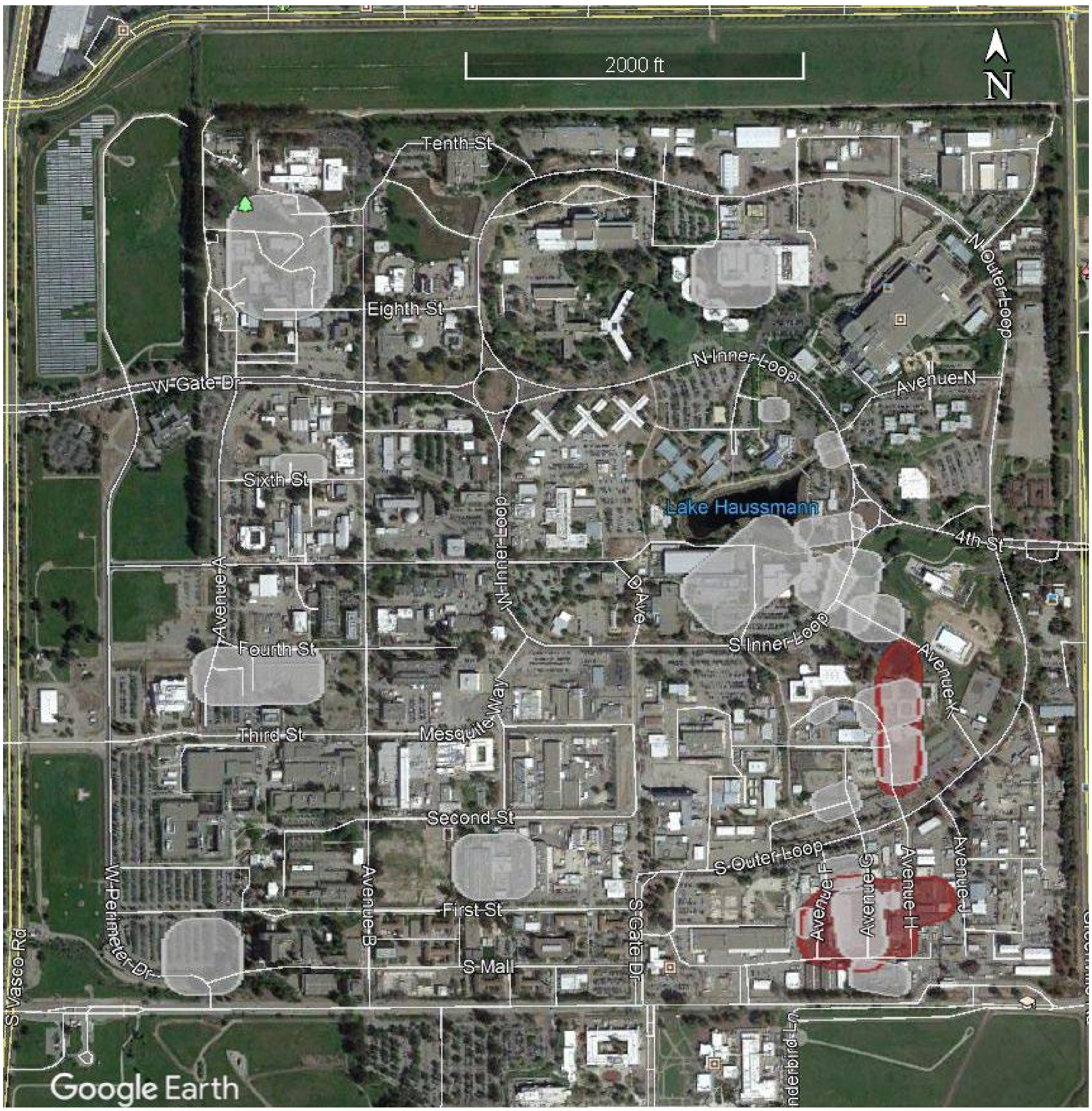


Figure 2-6. LLNL Livermore Site Google Earth image with CERCLA Source Investigation Areas (white polygons) and potential F-Listed Areas for soils (red polygons) identified.

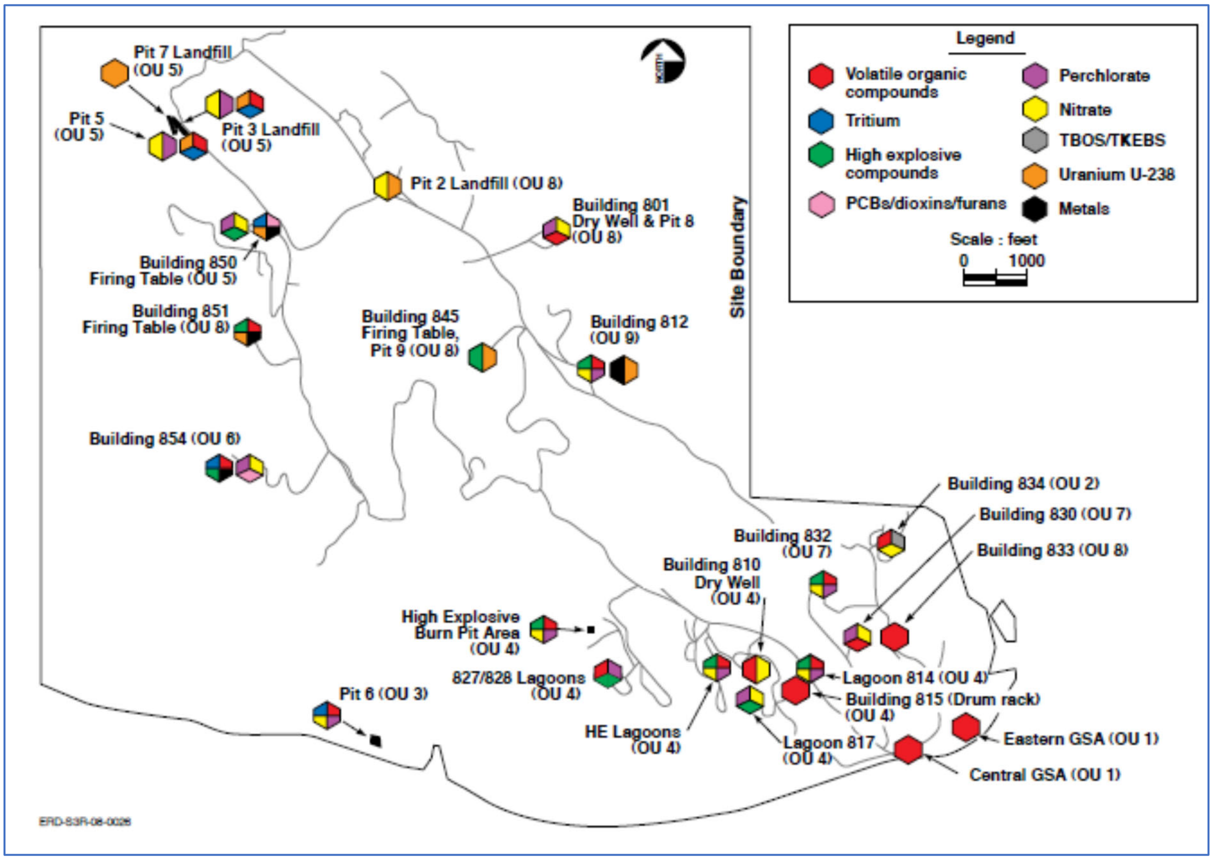


Figure 2-7. LLNL Site 300 release sites and Operable Units (OUs) (*from S300 Site-Wide ROD Figure 2.4-1*, LLNL, 2008).

2.5.2 Tier 2: Moderate potential to exceed SSLs

Due Diligence Tier 2 Areas are those areas where industrial activities have occurred historically, but there is no known record of contamination in the area. In these areas sampling will be designed to determine if there is evidence that any of the activities have resulted in COC in soil exceeding SSLs. Any sampling required for a Due Diligence Tier 2 Area shall be designed as specified in **Table 2-2** or **Table 2-3** unless an acceptable alternative approach is specifically documented.

2.5.3 Tier 3: Low potential to exceed SSLs

Due Diligence Tier 3 Areas are those areas with no known impact and relatively low potential for historic industrial impacts, and where land use has been limited to office buildings or a similar historic use. Sampling in Due Diligence Tier 3 Areas provides a backup to the due diligence assessment that soil exceeding SSLs is unlikely to be present. Any sampling required for a Due Diligence Tier 3 Area shall be designed as specified in **Table 2-2** or **Table 2-3** unless an acceptable alternative approach is specifically documented.

3 Sampling and Analysis Planning

Soils must be characterized based on prior knowledge (previous valid analytical data) or new soil analytical data before final disposition per **Section 2**. A project-specific SAP/QAPP may also be necessary or required as stated in **Section 2.3.2**. A template SAP/QAPP for LLNL soil projects is provided in **Appendix A**. When a project specific SAP/QAPP is required, it will follow EPA DQO process and contain project specific information including:

- Due diligence summary(ies) and the identified Project Tier.
- Conceptual site model based on due diligence.
- Sampling and analysis design based on project size and pre or post excavation sampling.
- SSLs that will be applied and disposition decision criteria.
- Specific sampling requirements with QA/QC specifications.
- Roles and responsibilities for SAP implementation.
- Guidance on field safety planning.

3.1 Quality Assurance/Quality Control

QA/QC requirements apply for all data collected during project soil sampling. For projects with 10 or more samples, 10% duplicate (co-located) sampling (one duplicate sample for every 10 samples) will be completed. For projects with less than 10 samples, 10% duplicate sampling will occur based on the cumulative number of samples collected in a calendar year at each site. For example, if 19 samples had been collected at the Livermore Site for the year and a project has four samples, one duplicate sample would be collected as the cumulative number of samples collected for the year would be 23.

One trip blank sample will be placed in each cooler of samples sent to off-site laboratory. Strict sample Chain of Custody (CoC) and sample control requirements shall be followed as specified in LLNL EMP-QA-DM - *Data Management*, and these are consistent with EPA guidance (EPA, 2002b).

Data review and management are addressed in ESP-04, Instruction 08 and will include 100% review of all QA/QC results from the analytical laboratories. The laboratory QC analyses will include at minimum: calibration standards, blanks, matrix spikes, and matrix spike duplicates.

Specific details regarding sample analyses will be included in the project SAP/QAPP. For projects not requiring a SAP/QAPP, sample analyses will be selected from the following list. There may some instances, however, for projects not requiring a SAP/QAPP where the analyses listed below will need to augmented.

- Polychlorinated Biphenyls (PCBs).
- Total Threshold Limit Concentration (TTLC) VOCs.
- Toxic Characteristic Leaching Procedure (TCLP) VOCs.
- Soluble Threshold Limit Concentration (STLC) VOCs.
- STLC Metals.
- TTLC Metals.

- TCLP Metals.
- Total Petroleum Hydrocarbons (TPH) – as Gasoline, Diesel, and/or Oil
- Explosives, *e.g.*, TNT, HMX and RDX.
- Nitrates and/or Perchlorates.
- Gross Alpha and Gross Beta Activity.
- Tritium.
- Specific Radioactive Isotopes.

Sample bottle requirements and hold-times are specified by the analytical laboratories and are consistent with Code of Federal Regulations Title 40, Chapter 1, Subchapter D, Part 36 (CFR 40-136).

All analyses will be performed under contract with certified analytical laboratories. Sub-contract support may be required for data verification and validation on larger projects due the volume of QA/QC results to review. The use of subcontract labor, when required, will be specified in the project SAP/QAPP.

All field tracking forms, any field observations, CoC forms, and other records will be maintained in accordance with EFA or ERD (as appropriate) and LLNL and DOE record retention policies.

3.1.1 Confirmatory Analyses for Unexpected Results

When unexpected or questionable results are identified during data QA/QC, the QA/QC Chemist will first confirm the initial validity of the result based on the laboratory reported data. He/she will then contact the analytical laboratory to determine if there was anything unusual about the result or analyses performed. The laboratory may either confirm the validity of the analyses or initiate an investigation to determine the potential for error or sample contamination. In some circumstances additional sample collection and analysis may be required to ensure confidence in results. The QA/QC Chemist will work with the analytical laboratory to finalize results, including corrections if any, prior to release of the data for comparison to the SSMP SSLs.

Given the potential variability in radiological data, when a suspect or unexpected result is identified the ES&H Team EA or EFA WAMA SME can request a recount of the originally prepared sample. If the recount result is like the original result, LLNL may request two separate preparations from the same submitted soil to be performed and analyzed by the laboratory. If either of the two re-analyses produces a result like the first, then the initial data is confirmed. If both re-analyses are like each other and do not agree with the initial result, then the initial reported result will be rejected and the results of either of the two re-analyses will be used.

4 Soil Management Guidelines

All soils whether stockpiled or collected directly into vessels for transport will be managed in accordance with regulatory requirements as specified in this SSMP and LLNL policies and procedures. Soil stockpiles shall be managed in accordance with requirements outlined in PRO 2725.

4.1 LLNL Soil Screening Levels

LLNL has established SSLs based upon regulatory agency generated Environmental Screening Levels (ESLs), Regional Screening Levels (RSLs) or Screening Levels (SLs), and site-specific background data, as outlined below. LLNL's SSL selection process is shown in **Figure 4-1** and is discussed further below.

1. San Francisco Bay Regional Water Quality Control Board Tier 2 Environmental Screening Levels (ESLs), July 2019.
2. DTSC Human Health and Ecological Risk Office (HERO) Human Health Risk Assessment (HHRA) Note 3, Recommended Screening Levels for Residential and Commercial/Industrial Soil, June 2020.
3. US EPA Regional Screening Levels (RSLs) (TR=1E-06, HQ=1), Residential and Industrial Soil, May 2021.
4. LLNL site-specific background threshold values calculated using an upper confidence limit approach (Fisher, 1997; Folks, 1997).
5. Gallegos, G. *Background Values of Gross Alpha and Gross Beta in Soil for Lawrence Livermore National Laboratory*, LLNL-TR-402360, March 2008.

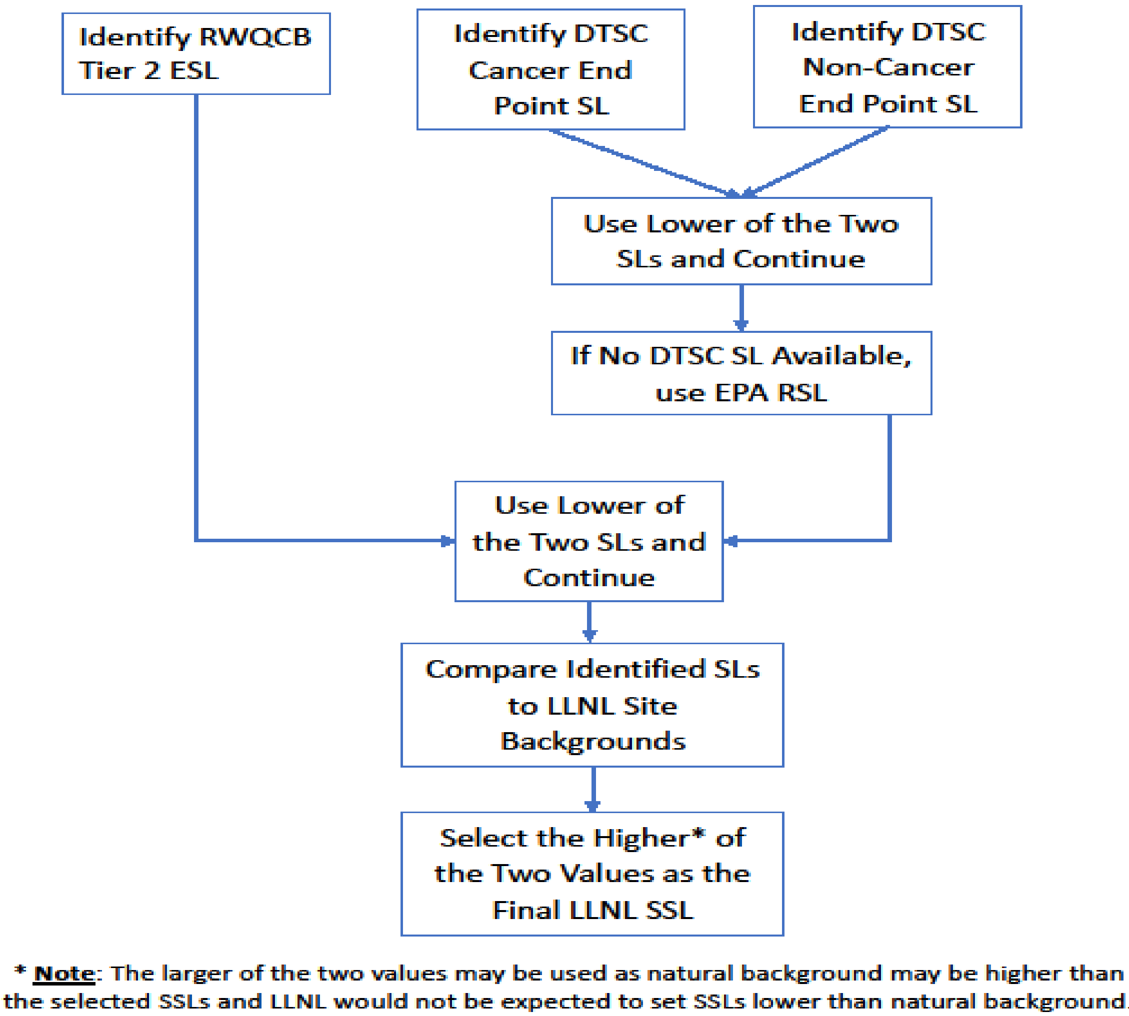


Figure 4-1. LLNL process for SSL selection from established regulatory screening levels.

RWQCB Tier 2 ESLs were calculated using the following:

- Land Use: Commercial or Industrial.
- Vegetation Level: Minimal.
- Groundwater Use: Drinking Water Resource.
- Maximum Contaminant Level (MCL) Priority over Risk-Based: Yes.
- Discharge to Surface Water: No Discharge Expected.
- Soil Contamination Depth: Shallow Soil.

In cases where RWQCB Tier 2 ESLs do not exist, a concentration for the constituent was determined by choosing the lowest value from the DTSC SLs for commercial/industrial soil, cancer end point and noncancer end point (where available), and the EPA residential soil RSL (where available). Except for arsenic and vanadium, the resulting metals concentrations (RWQCB ESLs, DTSC SLs or EPA RSLs) were compared with the Livermore Site and S300 background concentrations. The higher concentration resulting from the comparison was chosen as the SSL, as soils would not require clean up at levels below background concentrations. LLNL established site-specific background values for arsenic and vanadium, using data from non-impacted soils on and off the Livermore Site and S300. Background screening levels were calculated using a 1 in 200 exceedance-rate prediction interval.

Background screening levels for gross alpha and gross beta were calculated using a 95% confidence/95% detection of non-parametric upper tolerance limit (EPA, 2015). The most recent background screening levels were published in Gallegos (2008). The radiological screening values for soils were reviewed and approved by the DOE Livermore Field Office, consistent with DOE Order 458.1 (Hill, 2011). Final determination of S300 background values is pending completion of additional investigations. This SSMP will be revised, pending RPM approval, once the final background values are available.

LLNL's SSLs are shown in **Table 4-1**. The SSLs are based on unrestricted reuse levels. Current SSLs in place at the beginning of a project will be applicable to the entire project for soil management activities including disposal. SSLs will not be applied retroactively.

LLNL is also planning to prepare site-specific SSLs based upon modeling incorporating localized conditions to assess the potential for groundwater contamination. As these site-specific SSLs are developed, they will be added to this SSMP. The site-specific SSLs will either focus on potential groundwater impact and replace the ESLs in **Table 4-1**, or the modeling will appropriately include exposure and health concerns. The approach and models used to establish site-specific SSLs will be discussed with the RPMs to ensure regulatory acceptance.

The SSMP will be revised annually and will incorporated the most recent COC concentration updates that are available from the agencies and will include the Characterization of Background Concentrations of Metals Study when it is completed at S300.

The current SSLs are maintained on the EFA WAMA server and available from the EFA WAMA soil SME.

Table 4-1. Soil Screening Levels.

Constituent	CAS Number	Screening Level (mg/kg[7], unless specified)
1,1,1-Trichloroethane	71-55-6	7.0 [1]
1,1,2,2-Tetrachloroethane	79-34-5	0.018 [1]
1,1,2-Trichloroethane	79-00-5	0.076 [1]
1,1,2-Trichlorotrifluoroethane (Freon 113)	76-13-1	6,700 [3]
1,1-Dichloroethane	75-34-3	0.20 [1]
1,1-Dichloroethene	75-35-4	0.54 [1]
1,2-Dichlorobenzene	95-50-1	1.0 [1]
1,2-Dichloroethane	107-06-2	0.007 [1]
1,2-Dichloropropane	78-87-5	0.065 [1]
1,3-Dichlorobenzene	541-73-1	7.4 [1]
1,3-Dichloropropene	542-75-6	0.017 [1]
1,4-Dichlorobenzene	106-46-7	0.20 [1]
Acetone	67-64-1	0.92 [1]
Benzene	71-43-2	0.025 [1]
Bromodichloromethane	75-27-4	0.016 [1]
Bromoform (Tribromomethane)	75-25-2	0.69 [1]
Carbon Tetrachloride	56-23-5	0.076 [1]
cis-1,2-Dichloroethene	156-59-2	0.19 [1]
Chlorobenzene	108-90-7	1.4 [1]
Chlorodibromomethane	124-48-1	4.1 [2]
Chloroform	67-66-3	0.023 [1]
Dichlorodifluoromethane (Freon 12)	75-71-8	87 [3]
Ethylbenzene	100-41-4	0.43 [1]
Methylene Chloride	75-09-2	0.12 [1]
Methyl Ethyl Ketone (2-Butanone)	78-93-3	6.1 [1]
Methyl tert-butyl ether (MTBE)	1634-04-4	0.028 [1]
Styrene	100-42-5	0.92 [1]
Tetrachloroethene	127-18-4	0.08 [1]
Toluene	108-88-3	3.2 [1]

Constituent	CAS Number	Screening Level (mg/kg[7], unless specified)
trans-1,2-Dichloroethene	156-60-5	0.65 [1]
Trichloroethylene	79-01-6	0.085 [1]
Trichlorofluoromethane (Freon 11)	75-69-4	5,400 [2]
Xylenes, total	1330-20-7	2.1 [1]
Diesel oil/Kerosene (TPH diesel)	68334-30-5	260 [1]
Antimony	7440-36-0	50 [1]
Arsenic	7440-38-2	8.51 [4] 9.24 [5]
Barium	7440-39-3	670 [1]
Beryllium	7440-41-7	10 [1]
Cadmium	7440-43-9	1.9 [1]
Chromium (total)	7440-47-3	160 [1]
Chromium (VI)	18540-29-9	2.8 [1]
Cobalt	7440-48-4	28 [1]
Copper	7440-50-8	300 [1]
Lead and Compounds	7439-92-1	32 [1]
Mercury (elemental)	7439-97-6	20 [1]
Molybdenum	7439-98-7	40 [1]
Nickel	7440-02-0	86 [1]
Selenium	7782-49-2	5.5 [1]
Silver	7440-22-4	50 [1]
Thallium	7440-28-0	3.5 [1]
Vanadium	7440-62-2	65.2 [4] 97.5 [5]
Zinc	7440-66-6	340 [1]
PCBs (total) *	1336-36-3	0.58 [2]
HMX (Octogen)	2691-41-0	3,900 [3]
RDX (Cyclonite)	121-82-4	8.3 [3]
TNT (2,4,6-Trinitrotoluene)	118-96-7	21 [3]
Nitrate	14797-55-8	130,000 [3]
Perchlorate and Perchlorate Salts	14797-73-0	55 [3]
Gross Alpha	12587-46-1	6.5 pCi/g [4] [9] 11 pCi/g [5] [9]

Constituent	CAS Number	Screening Level (mg/kg(7), unless specified)
Gross Beta	12587-47-2	11 pCi/g (4) (8) 21 pCi/g (5) 8)
Tritium	10028-17-8	5 pCi/g (6) (8)

Note: * Total PCBs are provided by the analytical laboratory used, by summing the concentration values of detected aroclors (isomers), *e.g*., 1016, 1221, 1232, 1242, 1248, 1254 and 1260.

(1) RWQCB Tier 2 ESLs – Commercial or Industrial Soil, July 2019, https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/esl.html
(2) DTSC HERO HHRA Note 3, Recommended Screening Levels for Commercial/Industrial Soil - Cancer and Noncancer Endpoint, June 2020 - https://dtsc.ca.gov/wp-content/uploads/sites/31/2019/04/HHRA-Note-3-June-2020-A.pdf
(3) EPA RSLs (TR=1E-06, HQ=1), Residential Soil, May 2021 – https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
(4) Livermore Site Background Levels
(5) Site 300 Background levels for metals. Stated radionuclide values are interim values, based on research by Gallegos (2008)..Final determination of radionuclide background values is pending completion of additional investigations.
(6) LLNL background levels established based on historical detection limits
(7) mg/kg milligrams per kilogram
(8) pCi/g picocuries per gram

There are two areas at the Livermore Site where waste soils can potentially be identified as F-Listed (**Figure 2-6**). Trichloroethylene, tetrachloroethylene, carbon tetrachloride and methylene chloride were used in these areas for their solvent properties and portions of the releases to the environment may contain these solvents. The DTSC, in their April 6, 2017, letter, provided health-based exit levels (delist the areas) for the contained-in determination for the contaminated environmental media (DTSC, 2017). The respective exit level concentrations for the F-Listing determination are:

- trichloroethylene (trichloroethene)– 0.94 mg/kg;
- tetrachloroethylene (tetrachloroethene) – 0.60 mg/kg;
- carbon tetrachloride – 0.10 mg/kg; and,
- methylene chloride – 1.90 mg/kg.

Analytical results from over 10,000 soil samples collected at the Livermore Site in the past 30 years have not shown contaminant concentrations exceeding the above exit levels. LLNL will continue to compare the results of all samples collected in these areas to the referenced exit level concentrations and dispose of waste soil following DTSC's direction.

4.2 Pre-Construction and Construction Soils Management

4.2.1 Geotechnical Soil Samples

All soil sampled for geotechnical analysis must be determined to be acceptable for handling and testing by the geotechnical laboratories, *i.e*., no radiological constituents detected above background levels before being sent offsite. EFA will have any samples collected during *in-situ* testing, *e.g.*, exploratory borings, tested for radiological constituents. EFA will compare the resulting analytical data with site background levels and determine if the geotechnical samples can be released. Contact the ES&H Team EA for sample requirements and coordination of geotechnical sample release.

4.2.2 Pothole and Utility Clearance Soils

During pre-construction actions, the upper portion of a boring may be excavated, or subsurface utilities exposed (daylighted) using dry (air knife) or wet (hydro-excavator) methods. The generated soil or soil-water mixture is generally placed into a plastic-lined roll-off bin or a plastic-lined containment area for temporary storage/to dry out. Because of the time frame involved for the soil to dry out the soil is not normally reused on the project where it was generated. As such, the *de minimus* exclusion for small quantities of generated soil does not apply (**Section 2.3.1.1**). The soils may be reused at/on another project as long as previous soil analytical data is present within the distances outlined in **Table 2-2** showing that the soils meet reuse criteria **(Table 4-1)**.

4.2.3 Soil Segregation and Stockpile Management

Stockpile segregation is essential to appropriate soil disposition. Soil samples must be directly connected, or related, in a traceable manner to specific sections of the stockpiles. Failure to maintain control over segregated stockpiles results in samples that may not be representative of the soil pile. This may require additional sample collection or disposal of larger volumes of soil if elevated COC concentrations are identified in sampling results. The increased costs associated with additional sampling or excess soil disposal may be prevented through good stockpile management practices.

Stockpile management must also meet all requirements of the Livermore Site's or S300's SWPPPs to ensure appropriate protection of storm water runoff and receiving water quality. Storm Water Pollution Prevention requirements are outlined in DES-2685 and PRO 2725, and the Livermore Site and S300 SWPPPs.

4.2.4 Imported Fill Material

LLNL requires that any soil brought on to the Livermore Site or S300 for use as backfill be characterized to ensure that the soil meets soil reuse criteria (**Table 4-1**). It is the responsibility of the PMO PM to ensure that any fill material brought on to the Livermore Site or S300 for use as backfill on their project be characterized to ensure that the soil meets soil reuse criteria. Failure to ensure that imported fill meets LLNL SSLs, could result in a need for additional unplanned excavation and soil disposal.

The DTSC has provided guidance on sampling soil for use as import material for construction projects (DTSC, 2001). Section 01 35 43, Part 1.10 of LLNL's SNAP/MTA Division 01 Specifications (MAS-CON-0004) further discusses the requirements to bring fill material on to the Livermore Site or S300.

4.3 Waste Management

This SSMP specifically addresses soil reuse determination, however, in many cases leaching analyses (STLC and TCLP) may be added to a SAP to allow for comparison to waste acceptance requirements for local nonhazardous (Class II or Class III) landfills. The decision to include the additional analyses will need to be made by the ES&H Team EA based upon project timing and resources. If initial analytical results indicate that soils contain hazardous COC concentrations or radioactivity distinguishable from background, then additional sampling and analyses may be required to prepare profiles for proper disposal, and to confirm that the soil is not characterized as a hazardous and/or radioactive waste. Sampling and analyses in these situations should be coordinated with RHWM.

4.4 Project Management

Pre-planning is critical for successful implementation of soil sampling during larger projects. Important scheduling considerations for planning soil sampling and analyses as part of a construction project are provided in **Appendix B**. Early engagement and notification of EFA, clear roles and responsibilities, and appropriate scheduling are key to good planning.

4.4.1 Roles and Responsibilities

Key roles and responsibilities for soils and debris management may be found in project specific SAPs and PRO 2725.

If unexpected, contaminated soil and debris or suspect items (e.g., drums, boxes, cans, bottles, or discolored, malodourous, or otherwise suspected contaminated soil and debris) are encountered during excavation or sampling activities, stop all work in the affected area and immediately notify the ES&H Team EA. The ES&H Team EA will subsequently notify EFA, an ES&H Industrial Hygienist (IH) and Health Physicist (HP), ERD, and the Environmental Duty Officer (EDO), as conditions warrant. A new contamination discovery could trigger CERCLA or other regulatory requirements.

Additional roles and responsibilities are depicted in **Figure 4-2**, below.

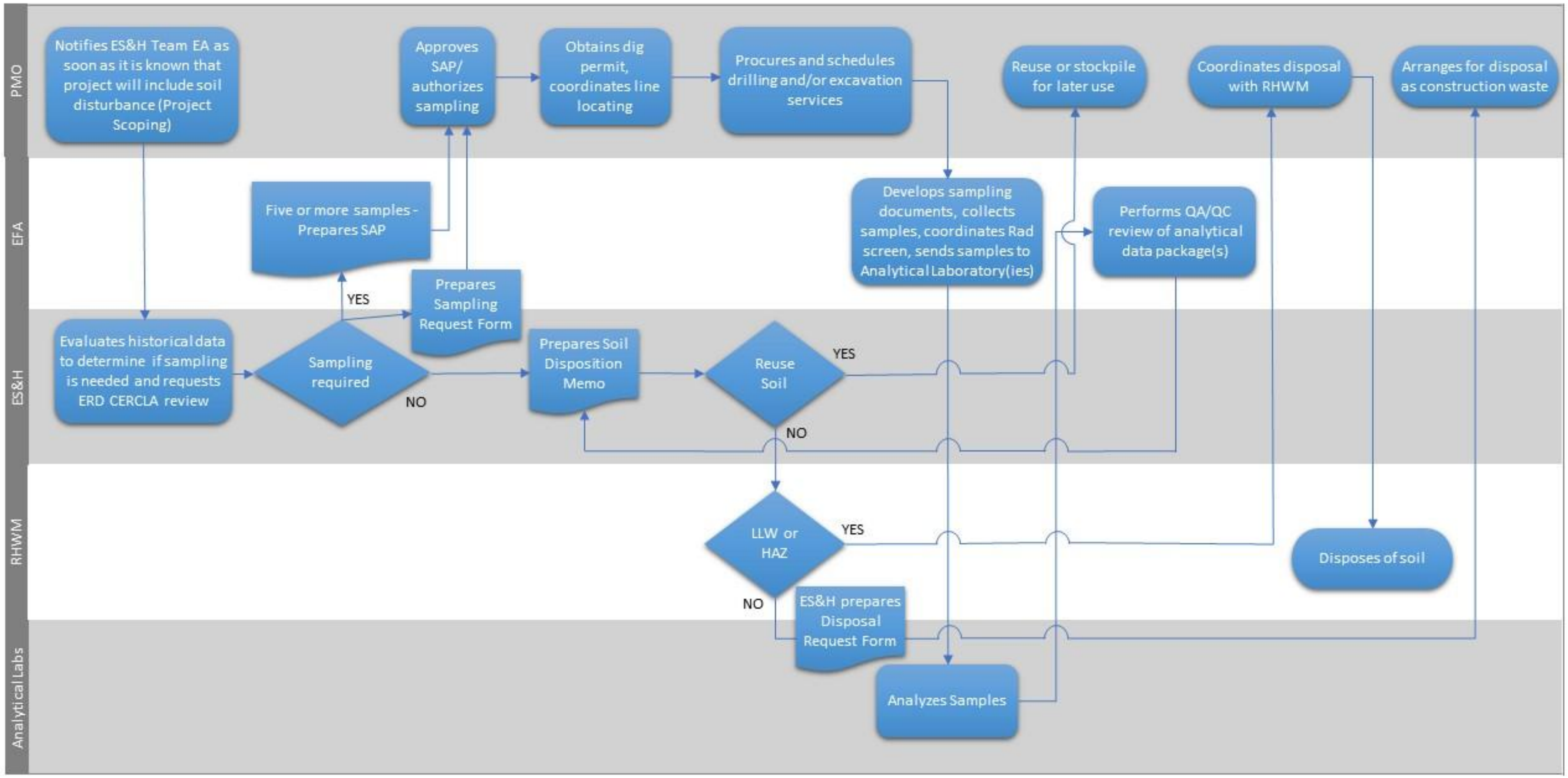


Figure 4-2. Clarification of roles and responsibilities for implementing LLNL's SSMP.

<u>Note</u>: If unexpected, contaminated soil and debris or suspect items (e.g., drums, boxes, cans, bottles, or discolored, malodourous, or otherwise suspected contaminated soul and debris) is encountered during excavation or sampling activities, stop all work in the affected area and notify the ES&H Team EA. The ES&H Team EA will make further notifications as needed, *e.g.*, ERD, EDO, etc.

4.4.2 Site Safety Plan

A Site Safety Plan (SSP) related specifically to soil sampling activities will be included in a project SAP/QAPP. This SSP will also specify the need for security escorts, which are required for many areas at LLNL and must be scheduled well in advance of field activities. In general, the SSP will include the following requirements:

- All work will be performed under LLNL's Integrated Safety Management System (ISMS) (DOE, 2006). The ISMS is the structure used at LLNL for performing work safely and protecting the environment.
- Work will be coordinated through the institutional Work Control Process (WCP) and ES&H. All subcontractors will be included in the process and may require additional training.

The ISMS involves establishing a scope of work, analyzing hazards of the work, developing and implementing hazard controls, documenting the authorization and release of work; and, providing feedback for improvement. The process involves incorporating and addressing hazards associated with the specific tasks to be performed and the equipment and tools to be used as part of an activity, work location area hazards, and the environment, and other aspects of the work that could pose a hazard needing controls.

Only trained personnel shall be permitted to perform demolition, surveying, or sampling. ES&H will determine the need for staff to have current Hazardous Waste Operations and Emergency Response (HAZWOPER) training, and any other training required to conduct the work of their assigned role. At a minimum, field staff will have completed LLNL's General Employee Radiation Training. The sampling team will also need to be trained in fall hazards, and excavation safety. Training requirements will be included in project specific SAPs.

All personnel are authorized to pause or stop work at any time when needed to address a safety concern or issue. Prior to commencing field work all project personnel must demonstrate they are up to date on any required training. Daily safety meetings will be held at the beginning of each field workday to review safety hazards and controls, radiological controls, and any location- or weather-specific hazards[1] for the day, as well as to discuss any work or safety-related issues and worker feedback.

In some areas, *i.e.*, Tier 1 Due Diligence Areas, and OUNs at S300, equipment, *e.g.*, tires, sample core barrels, excavator bucket, etc., may need to be inspected and screened for release prior to leaving the project area (MAN-2050 - *Lawrence Livermore National Laboratory Radiological Control Manual*). Contamination control procedures will be specified by ES&H and followed to prevent contamination of facilities and personnel. Decontamination procedures will be conducted in accordance with EFA and ES&H procedures for personnel, tools and

[1] OSHA Heat Safety Tool app is available to field personnel who possess a mobile device. Available at: https://play.google.com/store/apps/details?id=gov.dol.heatindex&hl=en for android or https://itunes.apple.com/us/app/osha-heat-safety-tool/id469229784?mt=8 for iPhone

equipment, and personal protective equipment (PPE) decontamination. Generally, for radiological decontamination ES&H Health & Safety Technicians will survey and, if contamination is found, the ES&H Health Physicist (HP) will be notified to determine the extent of contamination and direct/supervise appropriate decontamination. The subcontractor working on the project will be responsible to decontaminate their equipment and have the equipment resurveyed by ES&H prior to removal from the decontamination area.

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5 References

Blake, R.G. (2006) Review of Methodology for Beneficial Reuse of Soils at the Lawrence Livermore National Laboratory. Memo to Joy Hirabayshi-Dethier, LLNL WGMG06:017, February 9, 2006.

Brausch, R. (2017). *Contained-in Determination for Drilling Mud, Excess Soil, and Other Contaminated Environmental Media*. Letter to Brian Perkins from CA Department of Toxic Substances Control, April 6, 2017.

Campbell, C.G. and F. Garrido. (2005). *Spatial and temporal variability of soil processes: Implications for method selection and characterization*, Chapter 2 in: Soil-water-solute process characterization: an integrated approach. J. Álvarez Benedí and R. Muñoz Carpena editors, CRC Press, NY, NY, LBNL-53569.

Christian, V. (1994) *Using Soils Containing Trace Levels for Contaminants as Fill*. Letter to William Isherwood from San Francisco Bay Area Regional Water Quality Control Board. File 2199.9026, December 8, 1994.

DES 2685 *LLNL Storm Water Management.* Lawrence Livermore National Laboratory Procedures. https://policiesprocedures.llnl.gov/portal/page/portal/MYLLNL/ITEMS/DOCUMENTS/BOOKSHELF/env.html.

DOE (2006) *Integrated Safety Management System Manual*. U.S. Department of Energy, DOE M 450.4-1. November 1.

Dreicer, M. (1985) *Preliminary Report of the Past and Present Uses, Storage, and Disposal of Hazardous Materials at the Lawrence Livermore National Laboratory*. December 1985.

DTSC (2001) *Information Advisory Clean Imported Fill Material*, CA Department of Toxic Substances Control, October 2001.

DTSC (2017) *Contained-In-Determination for Drilling Mud, Excess Soil, and Other Contaminated Media*, April 6, 2017.

DTSC (2020) Human and Ecological Risk Office, *HUMAN HEALTH RISK ASSESSMENT GUIDANCE (HHRA) Note 3.* https://dtsc.ca.gov/wp-content/uploads/sites/31/2019/04/HHRA-Note-3-June-2020-A.pdf.

EPA (1986) *The SW-846 Compendium, Chapter 9 Sampling Plan*. https://www.epa.gov/hw-sw846/sw-846-compendium.

EPA (1992) *Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies*, EPA/600/R-92/128, July 1992.

EPA (1995) Agency, *EPA Observational Economy Series, Volume 1: Composite sampling*, EPA-230-R-95-005. August 1995.

EPA (2002a) *RCRA Waste Sampling Draft Technical Guidance, Planning Implementation, and Assessment*, EPA 530-D-02-002, August 2002.

EPA (2002b) *Guidance on Choosing a Sampling Design for Environmental Data Collection*, EPA QA/G-5S, EPA/240/R-02/005, December 2002.

EPA (2006) *Guidance on Systematic Planning Using the Data Quality Objectives Process*. U.S. Environmental Protection Agency, EPA QA/G-4, EPA/240/B-06/001, February 2006.

EPA (2015) *ProUCL Version 5.1 Technical Guide Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations.* U.S. Environmental Protection Agency, EPA/600/R-07/041, October 2015.

EPA (2021) *Regional Screening Levels (RSLs) - Generic Tables.*

https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

Fisher, D. (1997) *Report of Waste Discharge for Beneficial Reuse of Soil at the Lawrence Livermore National Laboratory, Livermore Site*. Letter/Application to SFBARWQCB. LLNL. WGMG97:97, April 7, 1997.

Folks, K. (1997) Technical Report Supporting LLNL Report of Waste Discharge for Beneficial Reuse of Soil at the Livermore Site. LLNL UCRL-AR-126943. April 1997.

Gallegos, G. (2008) *Background Values of Gross Alpha and Gross Beta in Soil for Lawrence Livermore National Laboratory*, LLNL-TR-402360, March 2008.

Hill, Phillip (2011) *Livermore Site Office Approval of Lawrence Livermore National Laboratory Documentation Demonstrating Compliance with Department of Energy Order 458.1*, Letter to Reginal Gaylord from USDOE/NNSA. COR-ESH-6/6/2011-356050, June 6, 2011.

LLNL (1988) *Lawrence Livermore National Laboratory (Main Site) Federal Facility Agreement Under CERCLA Section 120,* November 1, 1988.

LLNL (1992a) *Record of Decision for the Lawrence Livermore National Laboratory*. UCRL-AR-109105.

LLNL (1992b) *Lawrence Livermore National Laboratory Site 300 Federal Facility Agreement*, June 1992.

LLNL (2008) *Site-Wide Record of Decision Lawrence Livermore National Laboratory Site 300***,** LLNL, UCRL-AR-236665, July 2008.

LLNL (2013) *Distinguishable from Background (DFB) Radioactivity Determination for Waste*, LLNL-MI-654907, August 2013.

LLNL (2014) *Final Explanation of Significant Differences for Land Use Controls Lawrence Livermore National Laboratory, Livermore Site*, LLNL-AR-640345-Final, September 2014.

LLNL (2018) *Quality Assurance Project Plan Lawrence Livermore National Laboratory Livermore Site and Site 300 Environmental Restoration Projects*, UCRL-AR-103160-REV3, September 2018.

LLNL (2020) *Lawrence Livermore National Laboratory Radiological Control Manual*, MAN-2050, Rev. 00, ttps://policiesprocedures.llnl.gov/portal/page/portal/MYLLNL/ITEMS/DOCUMENTS/BOOKSHELF/MAN-2050.pdf.

MARSSIM (2000) *Multi-Agency Radiation Survey and Site Investigation Manual Revision 1*, NUREG-1575, Rev.1, EPA-402-R-97-016, Rev. 1, DOE/EH-0624, Rev. 1.

MAS-CON-0004, *SNAP/MTA Division 01 Specifications*, Lawrence Livermore National Laboratory Procedures, LL-OB-2011-038207, REV 0, June 2016. https://ucm.llnl.gov/urm/groups/ucmllnl/@public/@ob_public_fi/@ob_admin/documents/document/mdaw/mdu4/~edisp/ll-ob-2011-038207.pdf.

Matzke, B.D., J.E. Wilson, L.L. Newburn, S.T. Dowson, J.E. Hathaway, L.H. Sego L.M., Bramer, and B.A. Pulsipher. (2014). *Visual Sample Plan Version 7.0 User's Guide*. PNNL-23211, Pacific Northwest National Laboratory, Richland, Washington.

PRO 2725, *Management of Soil and Debris*, Lawrence Livermore National Laboratory Procedures. https://policiesprocedures.llnl.gov/portal/page/portal/MYLLNL/ITEMS/DOCUMENTS/BOOKSHELF/env.html.

PRO 2686, *Monitoring and Reporting for Non-Industrial Storm Water Runoff.* Lawrence Livermore National Laboratory Procedures. https://policiesprocedures.llnl.gov/portal/page/portal/MYLLNL/ITEMS/DOCUMENTS/BOOKSHELF/env.html.

SFRWQCB (2019) Environmental Screening Levels. https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/esl.html.

APPENDICIES

APPENDIX A

Soil Sampling and Management Plan and Quality Assurance Project Plan Template

Environmental Functional Area

Environment, Safety & Health

Lawrence Livermore National Laboratory

(Project Name)

SOIL SAMPLING AND ANALYSIS PLAN

QUALITY ASSURANCE Project PLAN

(Date)

Preparer Signature: ______________________________

Preparer Date

Review Signature: ______________________________

WAMA Group Leader Date

Approval Signature: ______________________________

PMO Project Manager Date

Approval Signature: ______________________________

EFA Manager Date

Lawrence Livermore National Laboratory

Table of Contents

List of Figures

List of Attachments

Purpose and Need

Provide a brief description and the need for the project.

Due Diligence

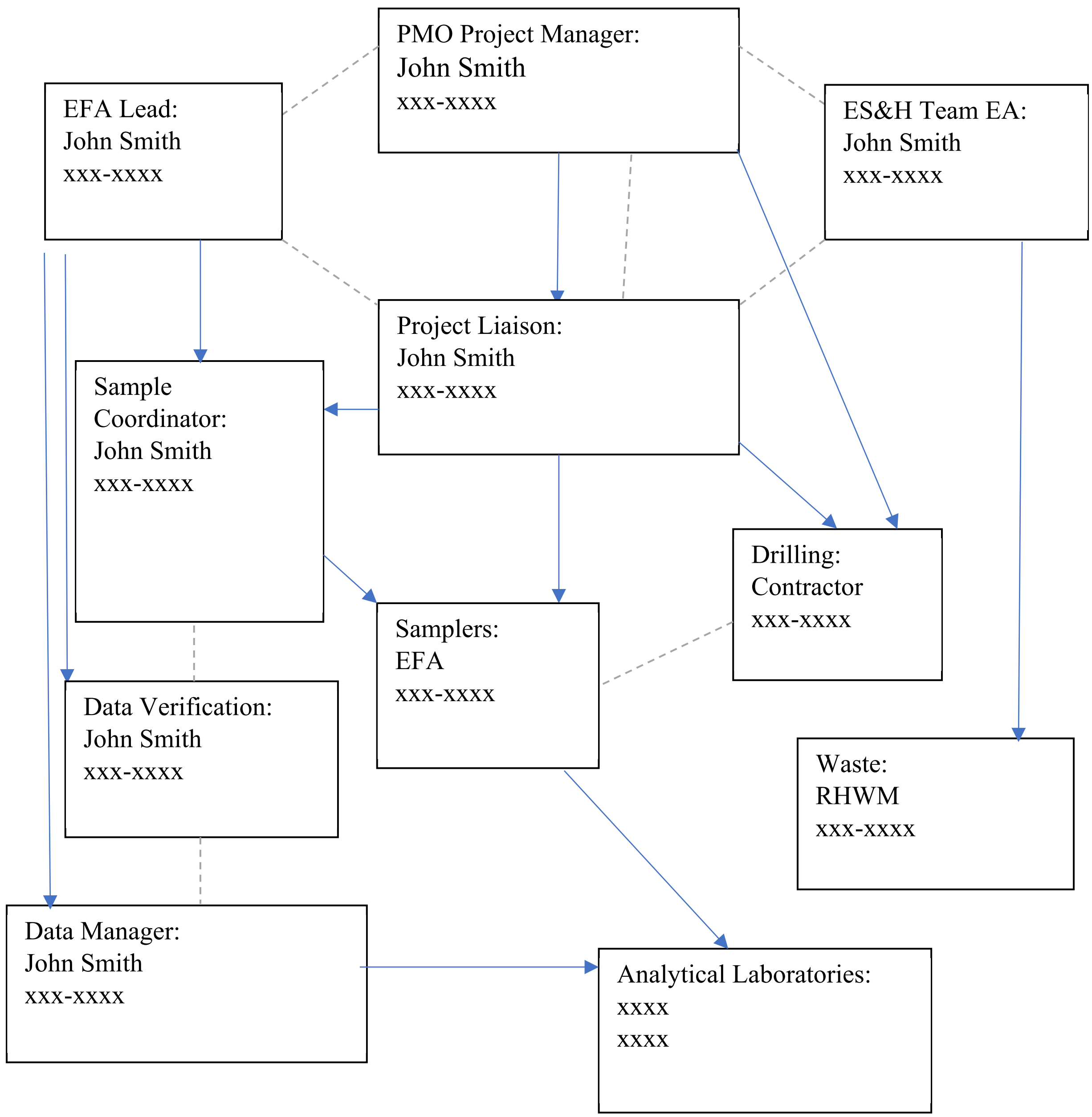
Perform due diligence as described in the SSMP. Describe the result of visual inspection and any significant issues noticed. List documents reviewed, and any personnel interviewed.

Conceptual Site Model

Briefly describe site history and results of the due diligence. Describe key aspects of the project and available information that will influence the project quality objectives. Describe the uncertainties associated with the conceptual site model. The information in this section should be on a graded approach and would depend on the complexity of the project. The format for this section could vary; use text, graphs, sketches as needed.

Organizational Chart

Provide an organizational chart with key personnel name, title, role and contact information. Provide lines of responsibility and communication. Here is an example.



Personnel Responsibilities

Identify key personnel and specific responsibilities, such as arrange for line locators, GPS, etc.

Title/Role	Organization	Responsibilities

Notes:

Training Requirements

Identify training requirements for different tasks, as needed.

Project role	Training

Notes:

SAP Distribution List

Determine individuals who need a copy of the SAP. Distribute the SAP electronically when possible.

Name and title	Organization

Notes:

Tasks Summaries and Schedule

Provide a general overview for each task. Examples include:

- Site Access and Security
- Line Locating
- Dig Permit
- Reporting Incidents
- Sampling
- Sample Location ID/Numbering
- Sample Location Marking
- Radiological Screening
- Shipping
- Data Verification
- Data Management

Sampling Design and Rationale

Describe the tier based on due diligence and the rationale for choosing the sampling approach

Sampling Methods

Describe sample collection methods.

Sampling Locations

Identify sample locations. Use figures, maps as needed.

Location-Specific Sampling Information

Identify the coordinate system used for the coordinates (longitude/latitude, CA State Plane, etc.)

List project samples.

Sample ID/Location	**Depth**	**Analytical Group**	**Coordinates**	
			East	**North**

Notes:

Sample Requirements

Indicate field sample requirements. Specify minimum sample volume or mass requirements if it differs from the container volume.

Analytical Group	**Analytical Method**	**Sample Volume**	**Containers (number, size and type)**	**Preservation Requirements**	**Maximum Holding Time**

Notes:

Reporting Limits

Identify constituents of concern and the reporting limits

Analytical Group:

Analyte	CAS No.	Reporting Limit (unit)

Include LLNL requested analysis code, which includes a listing of analytes and reporting limits. Requested analysis codes are defined as part of the analytical contract "bid package".

Notes:

Project Documents and Records

Identify the documents and records that will be generated for the project.

Document	Where Maintained

Notes:

References

APPENDIX B

General Project Soil Sampling and Analyses Planning Steps

General Project Soil Sampling and Analyses Planning Steps

Pre-sampling versus real-time sampling (Prior to excavations versus during excavations):

- The analytical suite options:
  - limited analyses suite (covers re-use or disposal at local landfill) or,
  - Analytical suite to address disposition options. (results exceed radioactive backgrounds or hazardous thresholds, additional sampling will be required to demonstrate acceptability for disposal site acceptance (Low-level Radiological or Hazardous Waste Landfill, etc.).

Information Needs for planning resources and sampling strategy:

- Location, dimensions and volume of soil to be excavated (i.e., trench excavation route, dimensions, design drawings, CAD files, etc.).
- Planned pothole locations if to be used for pre-sampling.
- Number and location of any geotechnical samples to be collected.

On-going Coordination Actions:

- Coordinate master schedule of concurrent soil-related projects.
- Coordinate on geotechnical sampling for radiochemical analyses prior to off-site release to Geotech contractor.
- Establish sampling design (# samples, location, identifiers, …).
- Set up procurement for Sampling and Analysis Plan (SAP) preparation.
- Set up the database with location IDs and analytical suites
- Prepare the SAP, including LLNL internal review (PMO, ERD, EFA, ES&H Teams).
- Determining sampling support resource needs. Sampling and data review subcontracts will be required for large projects. Subcontract employees may need to be trained and brought up to speed prior to deployment.
- Establish subcontract task and schedule for sampling personnel.
- Coordinate and subcontract task for any drilling that may be needed for sample collection if hand sampling of potholes is infeasible.
- Coordinate with analytical laboratory(ies) to understand turnaround time and total capacity.
- Identify QA/QC Chemist resources needed for data review and establish subcontract as needed.
- Coordinate the sampling events per the SAP.
- Perform the QA/QC and data review.
- Establish disposition in coordination with ES&H Team EAs and EFA, depending on project size.

Potential soil sampling coordination and bottleneck issues:

- Priorities for multiple projects occurring at the same time.
- Radiological analyses capacity for geotechnical cores (could review using external labs).
- Review time on the SAP.
- Trained subcontract samplers – new individuals may need to be trained
- If hand-auger sampling method is employed, additional resources will need to be brought in to help.
- Coordinated with drilling subcontractor – if needed, it will cost time.
- Laboratory capacity – If the analytical labs have other big projects at the same time the throughput could be reduced. In general, be careful to use only one lab for each area where data needs to be compared.
- If additional QA/QC resources are unavailable, data review will be delayed.

APPENDIX C

Basis for Sampling Grid Selection at the Livermore Site

Basis for Sampling Grid Selection at the Livermore Site
Version 1, April 9, 2018

Introduction

LLNL selected soil sampling grid design spacing options using the same methods as are provided in Visual Sampling Plan (VSP) software that provided a 95% confidence to detect a result exceeding a Soil Screening Level (SSL), if 5% or more of a selected detection area exceeds the SSL. The approach is appropriate to apply for the soil reuse program at LLNL, which focuses on identification of soil constituents that exceed the SSLs for reuse of the soils on site. Exceeding an SSL does not mean the soil is contaminated or hazardous, only that an SSL or SSLs were exceeded so that unrestricted reuse may not be immediately approved.

Based upon the objectives of the Soils Screening and Management Plan (SSMP), LLNL needed to establish a basis for the soil sampling grid design that would target an appropriate "detection area". LLNL decided to establish and apply standard detection areas to ensure consistency and comparability between soil sampling projects. Three proposed grid spacings were identified based on the potential to detect Source Investigation Areas (SIAs) established for the site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program.

This appendix helps illustrate the performance of three proposed grid spacings selected: 109 feet, 172 feet, and 244 feet a(ft), respectively, that correspond to detection areas of 10,000 square feet, 25,000 square feet, and 50,000 square feet (ft^2), respectively.

Discussion

Suppose that one wishes to "detect" a target area of elevated (above some threshold) contaminant of concern concentrations within the LLNL site perimeter using a random start hexagonal grid of samples placed across the entire site.

The following figures and the table that follows them illustrate the "detection" capability of the three grid spacings shown in the next table, relative to 22 CERCLA-identified SIAs. The CERCLA-identified SIAs are shown on a Google Earth image in **Figure 1**.

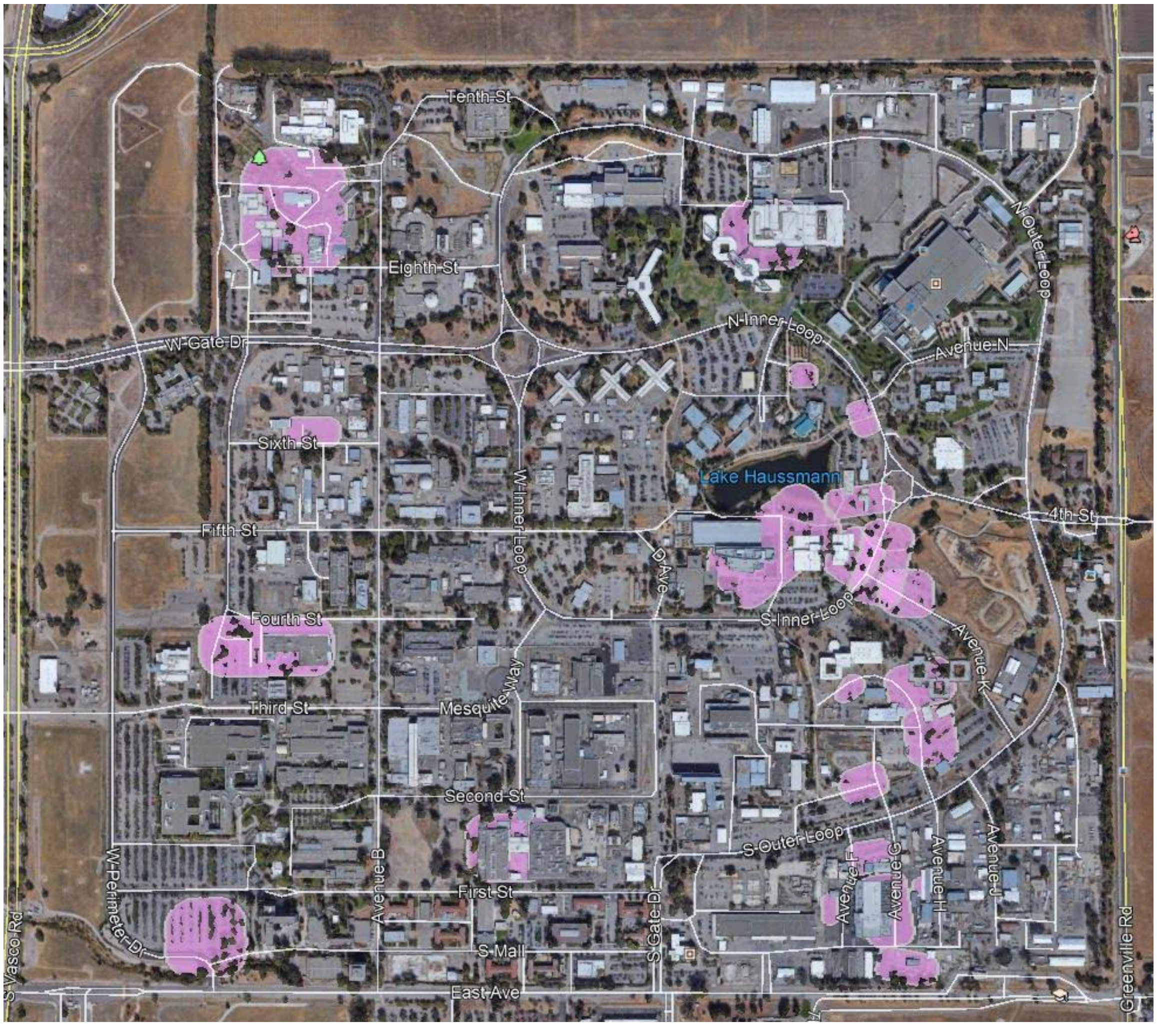


Figure 1. The 22 CERCLA-identified Source Investigation Areas (pink highlighted areas) at the LLNL Livermore Site.

The grid spacing for different detection areas are provided in **Table 1**. The sizes of these areas were selected to maximize the probability of detecting an area where soil analytical results could potentially exceed SSLs for reuse.

Table 1. Example circular target areas and grid spacings

Circular Target Area (Square Feet)	Hexagonal Grid Spacing (Feet)
10,000	109
25,000	172
50,000	244

Figures 2, **3**, and **4** display the three proposed grid spacings for each of the three detection areas. Note that when applying the 109 ft spacing, 22 of the 22 SIAs were intersected by at least one sample location (**Figure 2**). As the grid spacing increases, the probability that the sampling design will intersect every SIA decreases.

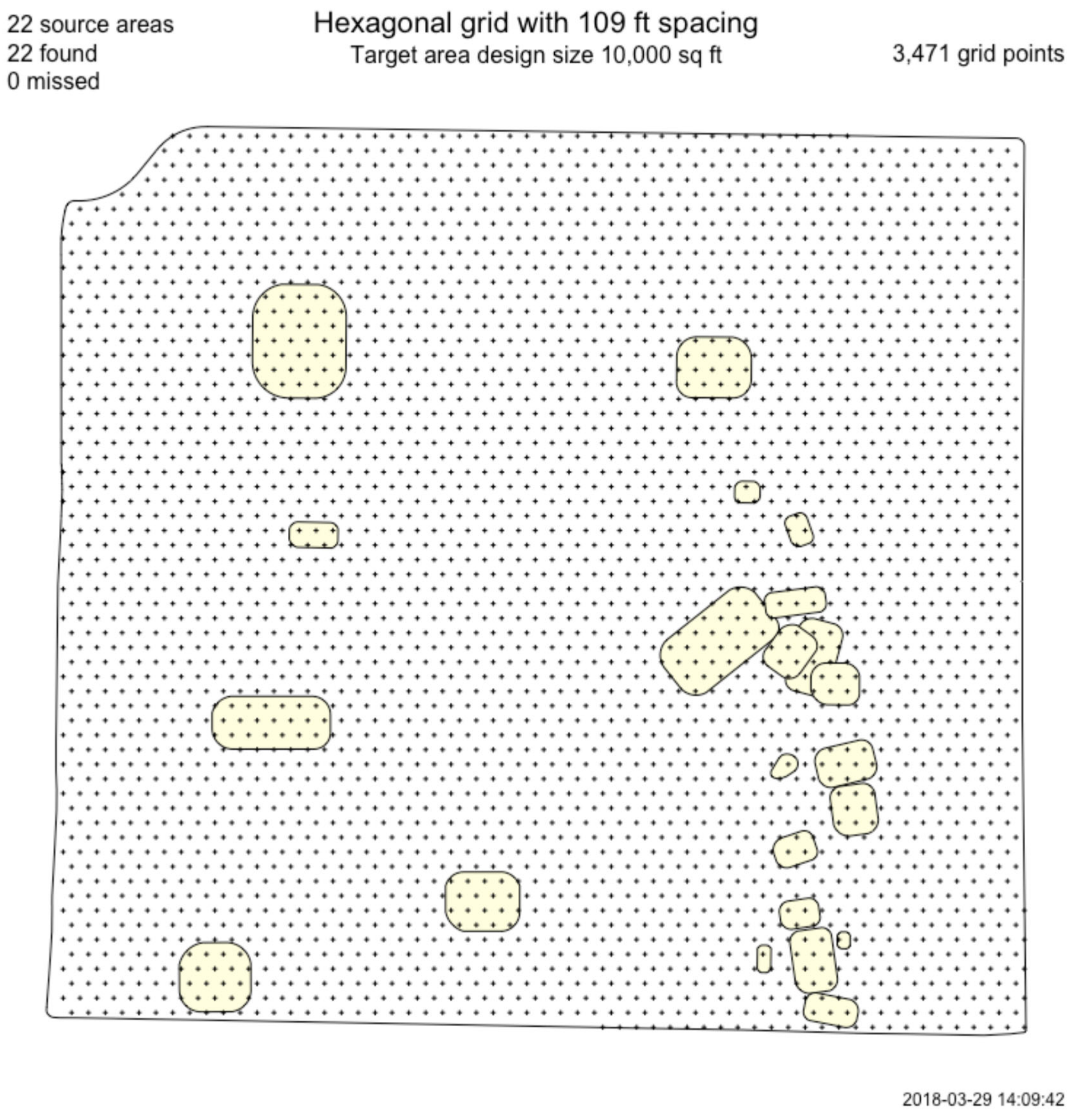


Figure 2. The 109 ft hexagonal grid spacing in comparison with the 22 CERCLA-identified Source Investigation Areas (yellow highlighted areas) at the LLNL Livermore Site.

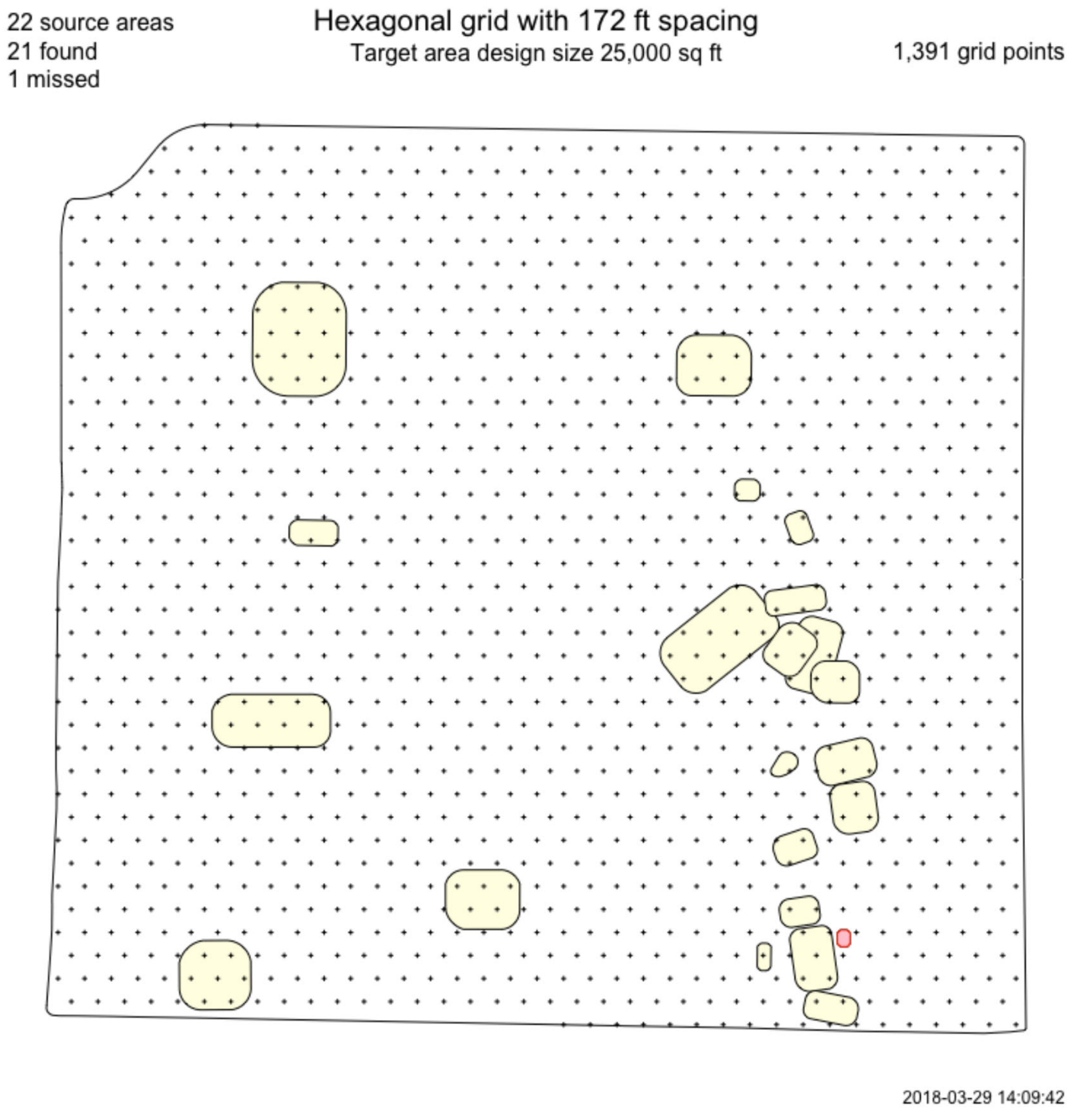


Figure 3. The 172 ft hexagonal grid spacing in comparison with the 22 CERCLA-identified Source Investigation Areas (yellow highlighted areas) at the LLNL Livermore Site.

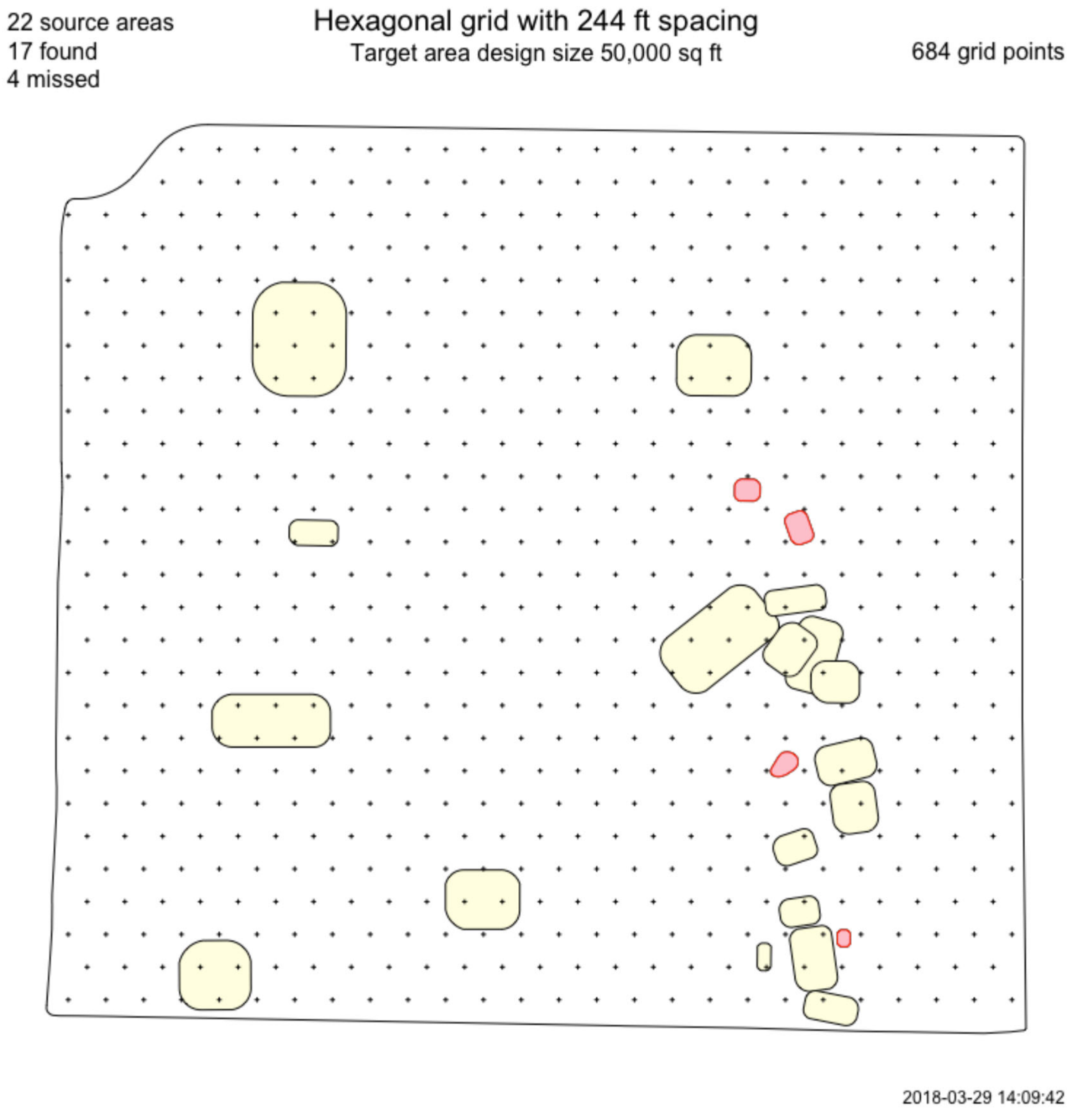


Figure 4. The 244 ft hexagonal grid spacing in comparison with the 22 CERCLA-identified Source Investigation Areas (yellow highlighted areas) at the LLNL Livermore Site.

The probabilities of intersecting the 22 source areas have the detection for each grid spacing are shown in the following **Table 2**. It is clear that the 109 ft spacing adequately intersects the SIAs in mostly all cases. The larger spacing, selected based on the assumption that due diligence information can be used to establish the potential for soil analyses to exceed SSLs, as described in the SSMP.

Table 2. Source area detection probabilities

Source Area (Square Feet)	109 Foot Grid	170 Foot Grid	244 Foot Grid
8,201	0.8	0.32	0.16
4,618	1.0	0.57	0.28
19,115	1.0	0.74	0.37
21,035	1.0	0.82	0.41
28,668	1.0	0.99	0.56
43,544	1.0	1.00	0.85
48,929	1.0	1.00	0.94
50,107	1.0	1.00	0.95
60,234	1.0	1.00	1.00
62,451	1.0	1.00	1.00
76,752	1.0	1.00	1.00
81,298	1.0	1.00	1.00
88,421	1.0	1.00	1.00
93,399	1.0	1.00	1.00
107,055	1.0	1.00	1.00
134,356	1.0	1.00	1.00
169,936	1.0	1.00	1.00
176,694	1.0	1.00	1.00
186,730	1.0	1.00	1.00
247,744	1.0	1.00	1.00
309,764	1.0	1.00	1.00
404,342	1.0	1.00	1.00

Application to S300

A SIA map has not been developed for Site 300 (S300), so LLNL has elected to apply the sampling grid designs developed for the Livermore Site to S300. **Figure 5** provides an illustration of the grids applied at S300 in the vicinity of the General Services Area.

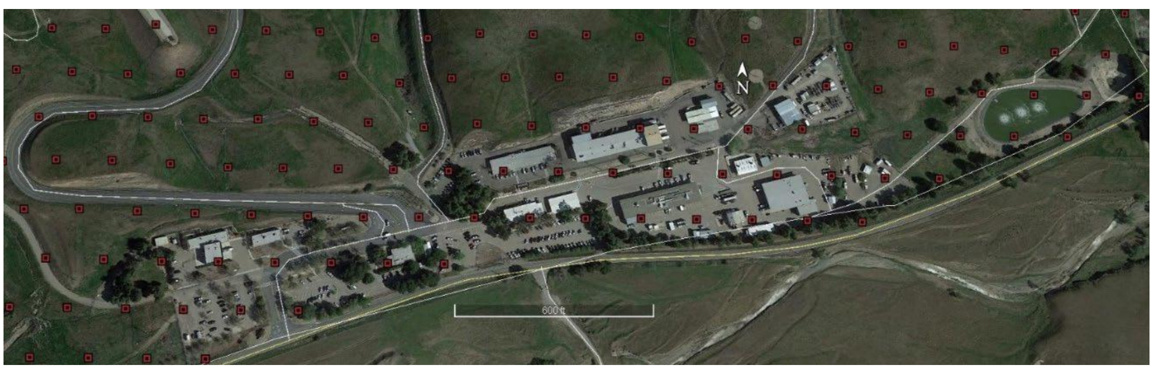
The application of the Livermore site approach to S300 can be considered a conservative approach for the following reasons:

- S300 covers more than ten times the area as the Livermore Site.
- Historical activities at the site would generally be expected to occur over larger area at S300.
- CERCLA Operating Units (OUs) at S300 cover large areas, but not the entire site compared to the designation of the entire Livermore Site as a single OU.

Until additional review and analysis is completed, the SSMP will apply to the Livermore Site Due Diligence Tiers and associated sampling grids at S300.

a) 109 ft spacing

b) 172 ft spacing



c) 244 ft spacing

Figure 5. Example hexagonal grid spacing displayed in the vicinity of the S300 General Services Area for: a) 109 ft spacing, b) 172 ft spacing, and c) 244 ft spacing.

Summary & Conclusion

LLNL has selected target detection areas for statistical design grids for soil reuse sampling at the Livermore Site. Grid sizing was proposed based upon the area of historical SIAs established at the site under CERCLA activities. This approach provides the basis for establishing the three grid spacing standards in the SSMP displayed in **Table 2**. This analysis demonstrated that a 109 ft spacing would be expected to reasonably capture a sampling location within the SIAs. This spacing is therefore appropriate for detection of areas of known potential for results that exceed SSLs. Larger grid spacings were selected to provide reasonable certainty that other areas defined by due diligence to not be suspect for analytical results that could exceed SSL, have been adequately examined. The level of that examination depends upon the due diligence determination.

Script Information

The working directory is /Users/macqueen1/Documents/EPD/Soil-projects/Soil-Management-Plan-2018/scripts.

Grid spacing calculated using methods from:

- Singer, D.A., 1972, ELIPGRID, a FORTRAN IV program for calculating the probability of success in locating elliptical targets with square, rectangular and hexagonal grids: Geocom Programs, v.4, 16p.

These are the same methods as used in VSP software; the software used for this produces the same results as VSP, given the same inputs.