



Energy Technology Engineering Center (ETEC) Remediation Support

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REVIEWS AND APPROVALS

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Executive Summary

The Santa Susana Field Laboratory (SSFL) is divided into four administrative areas (Areas I, II, III and IV), bounded on the north and the south by contiguous buffer zones. Areas I, III and IV, as well as the buffer zones on the north and south are owned by Boeing. Area II is federally owned and administered by the National Aeronautics and Space Administration (NASA). While not a landowner in SSFL, the U.S. Department of Energy (DOE) is responsible for cleanup of soils and groundwater in Area IV and the Northern Buffer Zone (NBZ). The former Energy Technology Engineering Center (ETEC) is located at the SSFL in area IV and planning for cleanup of that land is underway.

DOE entered into an Administrative Order of Consent (AOC) with the California State Department of Toxic Substances Control (DTSC) in 2010 that established a new framework for soil characterization and cleanup processes in Area IV and the NBZ. For the soil cleanup, the 2010 AOC stipulated that the soil cleanup standard would be based on Look-Up Table (LUT) values, which are: (1) for chemicals, local background concentrations or method detection limits for those chemicals whose method detection limits exceed local background concentrations, and (2) for radionuclides, local background concentrations or minimum detection limits for radionuclides whose detection limits exceed local background concentrations. However, evaluation of the AOC standard has highlighted some potential issues associated with its implementation; particularly with the established LUT values.

DOE Office of Environmental Management (EM) requested support from the Network of National Laboratories for Environmental Management and Stewardship (NNLEMS) to identify options for paths forward in soil remediation at the Energy Technology Engineering Center (ETEC) that are potentially acceptable to all parties involved in the clean-up, as well as technically achievable.

As prescribed in the AOC, establishing acceptance criteria for evaluating soil at the site is to be determined by the most current laboratory analytical limits of detection rather than a dose, disposal, or health risk assessment approach. Addressed in this report are the technical challenges of implementing cleanup to the AOC's criteria, focusing on establishing technically achievable analytical results (which are not necessarily the LUT values as proposed in the AOC), as well as evaluating backfill material with regards to false positive and false negative rates associated with laboratory analytical methods. Both factors contribute to the ability to evaluate suitable backfill material, which is addressed in this report as well. The following bullets summarize our conclusions:

- The (provisional) LUT values selected by DTSC may not be technically achievable, particularly for radionuclides of interest.
- A transition from the AOC criteria to that of a risk-based approach (e.g., risk assessment for a 'resident with garden') is supported because it could improve false positive detections of contaminants and lessen the volume of soil removed from the site. Lessening the rate of false positives would ultimately reduce the use of limited resources during cleanup actions, as well as lower cleanup costs by preventing the diversion of resources to unnecessary actions.
- If a risk-based approach is not pursued, use of the practical quantification limit (PQL) in place of the method detection limit (MDL) or method reporting limit (MRL) for establishing LUT values may improve the statistical robustness and ease of implementing these LUT values.

- Backfill availability and technically achievable and defensible detection limits for background discrimination of contaminants of concern (COCs) act as guardrails to implementing cleanup under the current AOC. These guardrails must be considered in the remedial approach.

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Acronyms and Abbreviations

AOC	Administrative Order of Consent
BTV	background threshold value
COC	Contaminants of Concern
DTSC	California State Department of Toxic Substances Control
DOE	U.S. Department of Energy
DOE-EM	U.S. Department of Energy, Office of Environmental Management
DOECAP	Department of Energy, Consolidated Audit Program
EFCOG	Energy Facility Contractors Group
EFH	extractable fuel hydrocarbons
EPA	U.S. Environmental Protection Agency
ETEC	Energy Technology Engineering Center
LUT	Look-Up Table
MCPA	2-methyl-4-chlorophenoxyacetic acid (herbicide)
MCPP	Mercoprop (herbicide)
MDC	minimum detectable concentration
MDL	method detection limit
MRL	method reporting limit
NASA	Administrative Order of Consent
NNLEMS	Network of National Laboratories for Environmental Management and Stewardship
NBZ	Northern Buffer Zone
PCE	Tetrachloroethylene
PQL	practical quantification limit
QAPP	Quality Assurance Project Plan
RBSL	risk-based screening level
RCRA	Resource Conservation and Recovery Act
SRS	Savannah River Site
SSFL	Santa Susana Field Laboratory
TCE	Trichloroethylene
TEQ	toxicity equivalent
TPH	total petroleum hydrocarbons
VOC	volatile organic carbon compounds

Introduction

The Santa Susana Field Laboratory (SSFL) is divided into four administrative areas (Areas I, II, III and IV), bounded on the north and the south by contiguous buffer zones. Areas I, III and IV, as well as the buffer zones on the north and south are owned by Boeing. Area II is federally owned and administered by the National Aeronautics and Space Administration (NASA). While not a landowner in SSFL, the U.S. Department of Energy (DOE) is responsible for cleanup of soils and groundwater in Area IV and the Northern Buffer Zone (NBZ). The former Energy Technology Engineering Center (ETEC) is located at the SSFL in area IV and planning for cleanup of that land is underway.

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DOE Office of Environmental Management (DOE-EM) requested support from the Network of National Laboratories for Environmental Management and Stewardship (NNLEMS) to identify options for paths forward in soil remediation at the Energy Technology Engineering Center (ETEC) that are potentially acceptable to all parties involved in the clean-up, as well as technically achievable.

Purpose and Objectives

DOE-EM requested support from the NNLEMS to perform a technical support activity related to an AOC that DOE entered into with DTSC in 2010 for cleanup of Area IV of the SSFL. As prescribed by the agreement, establishing acceptance criteria for evaluating material for cleanup determinations at the site is to be determined by the most current laboratory analytical limits of detection rather than a dose, disposal, or health risk assessment approach. This report illustrates the technical challenges of implementing cleanup to the AOC's criteria focusing on establishing technically achievable analytical results for quantifying contaminants of concern (COCs) (which are not necessarily the LUT values as proposed in the AOC), as well as issues in evaluation of material with regards to false positive and false negative rates associated with laboratory analytical methods. Both factors will contribute to the ability to evaluate suitable backfill material, which is addressed in this report as well. Additionally, the Appendix provides a glossary of terms that are commonly used in this report.

Technical Topics

The topics discussed in the following subsections are: 1) background discrimination - establishment of limits of detection; and 2) backfill availability.

Background Discrimination - Establishment of Limits of Detection

In 2010, DTSC entered into an AOC with DOE that requires cleanup to background. The AOC presents the chemical soil LUT values developed by DTSC from their background study, including background values for 130 naturally occurring chemicals and analytical detection limits for man-made chemicals (DTSC, 2013a). For radionuclides, provisional LUT values were determined through a multi-lab analysis study (DTSC, 2013b). In pursuing a non-risk-based assessment model, the LUT is entirely dependent on laboratory analytical detection capabilities which vary as methods and instrumentation improve over time.

Under the AOC, any soil exceeding the AOC LUT value for even one constituent would require remediation, therefore accurate and technically attainable LUT values are crucial to effective cleanup at the SSFL. For compounds that do not have background concentrations, method reporting limits (MRL)¹ were used for establishing LUT values. The AOC defines the MRL as the detection limit, or "the lowest concentration at which an analyte can be confidently detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision" (DTSC, 2010). However, the non-risk-based approach of pushing detection limits as low as possible blurs the line between the MRL and method detection limit (MDL) and increases the probability of reporting false positives (actionable COC concentrations) because analytical uncertainty becomes more impactful as the MRL and MDL approach each other. The MDL is simply a threshold where compounds are able to be detected with an instrument or method, but the concentration cannot accurately be determined; therefore, values under the MRL

¹ AOC defines "detection limits" for chemical contaminants as equivalent to method reporting limit (MRL) and for radiological contaminants as equivalent to minimum detectable activity (MDA). The differences in the terminology relate to the analytical and instrumentation differences for chemicals and radionuclides. Glossary contains more information on definitions.

(like MDL values) should be considered as estimates. Estimated results can be considered when using risk-based approaches because elevated analytical uncertainty is addressed, but cleanup decisions based on LUT values do not include those evaluations, so the use of sample results reported at or greater than the MRL is required to ensure the data generated is defensible (DTSC, 2017).

Cleanup efforts are more traditionally based on risk-based approaches (e.g., EPA, 1989 and related DTSC rulemaking and guidance (DTSC, 2022a and 2023)). As part of these approaches, screening values are established. Areas with concentrations of contaminants below these screening values represent sites where no remediation is needed because they do not pose a threat to human health or the environment. The US Environmental Protection Agency (EPA) has provided guidance for this method, as well as risk-based soil screening levels for common COC. However, some states have elected to modify these values, including California. California EPA has established these values for a number of chemicals, including metals, volatile organic carbon (VOC) compounds, etc. (California EPA, 2005). Since risk-based values are generally higher than MRLs/MDLs, a transition from the AOC criteria to that of a risk-based approach would reduce false positive detections of contaminants and lessen the volume of soil removed from the site. Lessening the rate of false positives would ultimately reduce the use of limited resources during cleanup actions, as well as lower cleanup costs by preventing the diversion of resources to unnecessary actions.

This risk-based approach is used in the 2022 Boeing Settlement Agreement for soil cleanup at the SSFL. California DTSC and Boeing agreed to this risk assessment process based on a 'resident with garden' scenario, though no future residential land use is expected (DTSC, 2022a). Though criteria for this agreement are not as restrictive as the AOC criteria, the Boeing Settlement Agreement presents an extremely aggressive soil cleanup process. The residual risk and estimated soil volume for Area IV cleanup with application of the Boeing Settlement Agreement criterion has been assessed (CDM Smith, 2022). Under these criteria, most soils are expected to be classified as 'non-waste soils' where chemical concentrations are greater than the AOC LUT values, but less than both the risk-based screening levels. Applying the Boeing Settlement Agreement criteria, the radionuclide concentrations are expected to be below provisional AOC LUT values (DOE EM, 2018).

If transition to a risk-based approach like the Boeing Settlement Agreement is not viable, alternative LUT values, particularly those values currently based on the detection limits for radionuclides and chemicals (e.g., MDLs/MRLs), would be an alternative approach to establishing technically achievable cleanup values. One alternative to MRLs that improves the statistical robustness of these values is the practical quantification limit (PQL). PQL values represent the lowest concentration of an analyte that can be quantified with a statistical degree of confidence (Ohio EPA, 2007). "The PQLs are the lowest matrix-specific concentrations that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions" (DTSC, 2018). DTSC has previously used this statistic as a criterion for cleanup at another California facility. Cleanup near the Exide Facility in Vernon California (DTSC, 2018) used PQLs to support risk-based criteria and achieve design quality objectives. PQLs were also used to establish field accuracy and ensure appropriate analytical methods were employed during cleanup (DTSC, 2018). For example, field accuracy was assessed through analysis of field equipment

blanks and comparison to PQL values for each constituent. DTSC states in their Quality Assurance Project Plan (QAPP) that the use of these values contributed to the representativeness of their data. Further, the intended land use for the Exide Facility site after cleanup is 'sensitive land use', which includes residential properties, schools, parks, day care centers, and childcare facilities. Clean up to garden standard, as required in the 2022 Boeing Settlement Agreement for soil cleanup, is the expected threshold for remediation regardless of future land use in the area (DTSC, 2022a). If LUT values remain the path forward for clean up under the AOC, the use of PQLs is an option to address analytical uncertainty and conservativeness related to future land use.

PQLs may also be used to establish evaluation criteria for background in place of those determined using the MRL for the method. This would allow some LUT values to be changed without affecting the overall DTSC background process. Since the driver in a non-risk assessment evaluation of the site depends on laboratory analytical capability, the use of PQL ensures evaluation of any contaminant of interest – introduced by DOE or naturally occurring – that is within current practices for analytical laboratories and currently being used for analyses accepted at many DOE facilities.

Provisional LUT values were determined by DTSC for radionuclides of interest (DTSC, 2013b). A 2011 assessment by EPA determined the majority of the man-made radionuclides detected at Area IV were Sr-90 and Cs-137 (EPA, 2011). Therefore, it is expected that these constituents will be the primary drivers for determining the need for remediation of radionuclides. Following EPA's recommendation to select one analytical lab for radionuclide analysis and use that laboratory's detection limits as the LUT values, we have compared the provisional LUT values for all radionuclides identified by DTSC with currently achievable MDLs and PQLs used for environmental restoration and monitoring activities being completed at the Savannah River Site (SRS) (see Table 1) (SRNS, 2007) to provide context for the state of the art in analytical radiochemistry. [Note: while the list of analytical methods has not changed, e.g., the SRNL 2007 reference, the instrument detection limits have been lowered over time due to better electronics, shielding, software, etc.] These values are used for site monitoring and compliance activities, so based on our technical opinion they represent values that are technically achievable and defensible with current analytical methods. In addition, these values have been developed using the quality requirements established in accordance with *Definition and Procedure for the Determination of the Method Detection Limit* (EPA, 2016) as required by the DOE's Consolidated Audit Program² (DOECAP) and in association with recommendation by the Energy Facility Contractors Group (EFCOG). Detection limits in radiochemistry are heavily dependent on count time, sample size, and counting method so MDLs and PQLs for SRS establish a reasonable expectation for detection limits and would be comparable to expected detection limits at other DOE-EM sites. A review of laboratories that are

² DOE's Consolidated Audit Program (DOECAP) is an audit program managed by the Office of Sustainable Environmental Stewardship. The DOECAP seeks to reduce DOE's Environmental Program management risk and assist DOE Program Offices and contractors by providing the conduct of audits and assessments that are designed to assure commercial environmental analytical laboratories and treatment, storage, and disposal facilities (TSDFs) used by DOE entities are operating in compliance with applicable federal, state and local environmental, safety and health, and transportation regulations (see: <https://www.energy.gov/ehss/analytical-services-program>).

certified through the DOECAP Accreditation Program can lead to contacts to address the lab's ability to meet the analytical and capacity needs of ETEC in the future.

MDLs for the following radionuclides were above LUT values: Co-60, Eu-152, Eu-155, and Ni-59. All others were comparable, or MDL values were less than LUT values, suggesting analytical capabilities may have been improved since the LUT value initial determinations. The current analytical capabilities, compared to the EPA preliminary assessment and site investigation (EPA, 2007a), show that some background values can be quantified to better reflect naturally occurring concentrations without affecting the overall DTSC background process. However, the background study used to establish the provisional LUT values may need to be repeated to better reflect current technological capabilities and advancements made since the original studies were completed.

It should be noted that neither Cs-137 nor Sr-90 SRS MDL values exceeded that of the provisional LUT values. The LUT value and SRS MDL for Sr-90 were approximately the same (~ 0.12 pCi/g), while the LUT value for Cs-137 exceeded the SRS MDL by more than 0.1 pCi/g. The PQL for Sr-90 is more than double the MDL (and LUT value), however. Because these two constituents made up most of the detected radioactive contamination found at Area IV, the importance of accurate cleanup values for those constituents is further highlighted.

Use of a non-risk-based assessment for radionuclides at environmental levels presents a particular challenge given the inherent variability in radioanalytical techniques. As shown in Table 1, the state of the art in radiochemistry has advanced to drive minimum detectable concentration (MDC³) values lower; additionally, determination of the MDC in radiochemical analysis is highly dependent on count time on nuclear counting instrumentation. The MDC is typically an *a priori* calculation, which differs from the MDL or MRL which are determined experimentally based on the performance of the analytical instrument (MARSSIM 2000; NUREG-1507). Since a non-risk-based approach depends on MDC for evaluation, the selection of an analytical laboratory with the ability to handle the large number of samples along with low MDCs and reasonable turn-around-times will be critical in the project's success. The selection of laboratory services that meet the latest DOECAP and accreditation requirements can ensure quality assurance across DOE facilities.

³ Guidance and regulations for radionuclide quantification use both the terminology of minimum detectable concentration (as in MARSSIM 2000; NUREG-1507) and minimum detectable activity (as in the AOC definition).

Table 1. Comparison of radionuclide provisional LUT values and currently achievable detection limits.

Radionuclide	Background Threshold Values (BTV; (pCi/g))	Provisional LUT basis	EPA Lab A (pCi/g)	EPA Lab B (pCi/g) ^a	SRS MDL (pCi/g) ^b	SRS PQL (pCi/g) ^b	SRS method ^b
Am-241	0.0162	MDC ^c	0.0815	0.039	~ 0.004	~ 0.008	L3.21-10005(Alpha Spectrometry)
Co-60	0.00556	MDC	0.04	0.0363	~ 0.03	~ 0.07	L3.21-10021(Gamma Analysis)
Cs-137	0.193	BTV ^d	0.225	0.225	~ 0.04	~ 0.1	L3.21-10021(Gamma Analysis)
Eu-152	0.0169	MDC	0.105	0.0739	~ 0.25	~ 0.6	RADA-013
Eu-154	0.0251	MDC	0.217	0.198	~ 0.08	~ 0.1	RADA-013
Eu-155	0.198	MDC	0.253	0.231	~ 0.3	~ 0.8	RADA-013
Ni-59	0.344	MDC	10.9	0.875	~ 3	~ 6.2	RADA-022
Pu-238	0.00425	MDC	0.122	0.0254	~ 0.003	~ 0.006	L3.21-10005(Alpha Spectrometry)
Pu-239/240	0.0142	MDC	0.115	0.023	~ 0.002	~ 0.006	L3.21-10005(Alpha Spectrometry)
Sr-90	0.075	MDC	1.02	0.117	~ 0.12	~ 0.3	L3.21-10008 (low background alpha-beta counters)
Th-228	3.67	BTV	4.27	4.27	~ 0.3	~ 1.4	RADA-038
Th-230	2.04	BTV	2.38	2.38	~ 0.3	~ 1.4	RADA-038
Th-232	2.95	BTV	3.44	3.44	~ 0.3	~ 1.4	RADA-038
U-233/234	1.87	BTV	2.18	2.18	~ 0.02	~ 0.25	L3.21-10005(Alpha Spectrometry)
U-235	0.13	MDC	0.249	0.152	~ 0.02	~ 0.08	L3.21-10005(Alpha Spectrometry)
U-238	1.68	BTV	1.96	1.96	~ 0.02	~ 0.25	L3.21-10005(Alpha Spectrometry)

MDC – minimum detectable concentration

BTV – background threshold value

LUT – Look-Up Table

SRS – Savannah River

^a Values from Lab B will be applied by DTSC if AOC criteria are applied. Source for values: (DTSC, 2013)

^b SRS values and methods taken from the SRS *Environmental Restoration Data Management System*

^c The MDC is an estimate of the detection capabilities of a method or protocol and differs from the MDL or MRL, which are determined experimentally based on the performance of the analytical instrument (MARSSIM 2000; NUREG-1507). Only MDC values were reported by DTSC for these analytes.

^d Background threshold values (BTV) are meant to represent the amount of a constituent in 'clean' soil. This value takes into consideration the variation in concentrations across California soils.

LUT values were also determined for over 120 different chemical contaminants. A similar comparison for chemicals is included in Table 2. We have compared the chemical LUT values with currently achievable MDLs and PQLs used for environmental restoration and monitoring activities being completed at SRS and standard method MDLs (Table 2) (SRNS, 2007; EPA, 1992, 1994a, b, 1996a, b, c, d, 1998, 2003, 2007a, b, c, d, and 2017). As an illustration, a subset of the chemicals under consideration by ETEC are included in this comparison based on availability of data for each analyte.

A significant factor in determination of site sampling for clean-up is the false positive issue faced in a non-risk-based assessment. Due to the inherent uncertainty of detection for an analysis and the large number of Constituents of Concern (COC's) in the LUT, there are inherent statistical reasons why the majority of backfill material tested will be rejected due to false positives. The LUT incorporates a 5% false positive rate for each constituent, based on either BTV or MDL/MDC, and assumes the backfill material is free of COC prior to any analytical testing (DTSC, 2010). While this appears to give a level of certainty for any one individual analysis, the compounded false positive rate for the 100+ COC's being tested will reject multiple lots because any single COC exceeding the LUT leads to disqualification of the material. Even assuming that testing can identify whether each COC is within limits 99% of the time, testing 100 constituents will result in a false positive for at least one COC 63% of the time by compounding false positives. The LUT's dependence on MDL or MDC values, which are already near analytical capabilities, will bias the evaluation of clean up sampling towards being rejected, from a statistical basis.

Quantification of most analytes in the LUT seem achievable using presently available instrumentation and methodology. A particular challenge of using a non-risk-based approach for remediation, however, means that establishing LUT values set below MDL or PQL values will have inherent quality issues and false positive assumptions; i.e., the method cannot reliably meet measurement objectives and the method uncertainty at the limit of quantification affects confidence in the results. In this case, following the AOC guidelines, any soil with concentrations that exceed these ultra-low values will be treated as hotspots with an assumed removal radius of five feet. This would likely result in extensive removal of soil that was not contaminated. For example, LUT values for dioxins, are far below any MDL or PQL reported by the sources we surveyed. The LUT/background value for dioxin toxicity equivalent (TEQ) is 0.912 pg/g (0.000912 ug/kg) and the resident with garden risk-based screening level (RBSL) is even lower at 0.156 pg/g (0.000156 ug/kg) (CDM Smith, 2022). This discrepancy would likely lead to extensive soil removal as a result of false positive detections above the LUT values and/or measurement inaccuracy from trying to measure below the MDL/PQL.

Table 2. Comparison of chemical LUT values and currently achievable detection limits.

Analyte name	Analytical method	MDL (µg/kg)	PQL (µg/kg)	LUT value (µg/kg)	LUT method
Alcohols					
Ethanol	EPA Method 8015B	3000		700	EPA Method 8015B
Methanol	EPA Method 8015B	3000		700	EPA Method 8015B
Dioxin-Furans					
1,2,3,4,6,7,8-HpCDD	EPA Method 1613 (MDL)/ EPA Method 1613B (PQL)	0.005	0.01	0.912 pg/g^a	EPA Method 1613B
1,2,3,4,6,7,8-HpCDF	EPA Method 1613 (MDL)/ EPA Method 1613B (PQL)	0.005	0.01	0.912 pg/g	EPA Method 1613B
1,2,3,4,7,8,9-HpCDF	EPA Method 1613 (MDL)/ EPA Method 1613B (PQL)	0.005	0.01	0.912 pg/g	EPA Method 1613B
1,2,3,4,7,8-HxCDD	EPA Method 1613	0.005		0.912 pg/g	EPA Method 1613B
1,2,3,4,7,8-HxCDF	EPA Method 1613	0.005		0.912 pg/g	EPA Method 1613B
1,2,3,6,7,8-HxCDD	EPA Method 1613	0.005		0.912 pg/g	EPA Method 1613B
1,2,3,6,7,8-HxCDF	EPA Method 1613	0.005		0.912 pg/g	EPA Method 1613B
1,2,3,7,8,9-HxCDD	EPA Method 1613	0.005		0.912 pg/g	EPA Method 1613B
1,2,3,7,8,9-HxCDF	EPA Method 1613	0.005		0.912 pg/g	EPA Method 1613B
2,3,4,6,7,8-HxCDF	EPA Method 1613	0.005		0.912 pg/g	EPA Method 1613B
OCDD	EPA Method 1613	0.01		0.912 pg/g	EPA Method 1613B
OCDF	EPA Method 1613	0.01		0.912 pg/g	EPA Method 1613B
Formaldehyde					
Formaldehyde	EPA Method 8315A	20		1,870	EPA Method 8315A
Metals					
Aluminum	EPA 6010D	9240	27200	58,600,000	EPA Methods 6010B/6020A

Analyte name	Analytical method	MDL (µg/kg)	PQL (µg/kg)	LUT value (µg/kg)	LUT method
Antimony	EPA 6010D	448	2720	860	EPA Methods 6010B/6020A
Arsenic	EPA 6010D	680	4080	46000	EPA Methods 6010B/6020A
Barium	EPA 6010D	136	680	371,000	EPA Methods 6010B/6020A
Beryllium	EPA 6010D	136	680	2,200	EPA Methods 6010B/6020A
Cadmium	EPA 6010D	136	680	700	EPA Methods 6010B/6020A
Chromium	EPA 6010D	204	1360	94,000	EPA Methods 6010B/6020A
Cobalt	EPA 6010D	204	680	44,000	EPA Methods 6010B/6020A
Copper	EPA 6010D	408	2720	119,000	EPA Methods 6010B/6020A
Lead	EPA 6010D	448	2720	49,000	EPA Methods 6010B/6020A
Manganese	EPA 6010D	272	1360	1,120,000	EPA Methods 6010B/6020A
Nickel	EPA 6010D	204	680	132,000	EPA Methods 6010B/6020A
Potassium	EPA 6010D	8700	34000	14,400,000	EPA Methods 6010B/6020A
Sodium	EPA 6010D	9510	34000	1,780,000	EPA Methods 6010B/6020A
Hexavalent chromium					
Hexavalent chromium	EPA 7196A	0.215	0.538	2,000	EPA Methods 7199/7196
Mercury					
Mercury	EPA 7471B	10.6	31.7	130	EPA Methods 7471A/7470A
PCBs/PCTs					
Aroclor 1016	EPA 8082	6.59	35	17	EPA Method 8082
Aroclor 1221	EPA 8082	6.05	35	33	EPA Method 8082
Aroclor 1232	EPA 8082	15.7	35	17	EPA Method 8082
Aroclor 1242	EPA 8082	14	35	17	EPA Method 8082
Aroclor 1248	EPA 8082	10.1	35	17	EPA Method 8082
Aroclor 1254	EPA 8082	9.73	35	17	EPA Method 8082
Aroclor 1260	EPA 8082	8.17	35	17	EPA Method 8082
Herbicides					
Dalapon	EPA Method 8151A	0.12		12.5	EPA Method 8151A

Analyte name	Analytical method	MDL (µg/kg)	PQL (µg/kg)	LUT value (µg/kg)	LUT method
MCPA	EPA Method 8151A	43		761	EPA Method 8151A
MCPP (Mecoprop)	EPA Method 8151A	66		377	EPA Method 8151A
Pentachlorophenol	EPA 8270C	0.16		170	EPA Method 8151A
2,4-Dichlorophenoxyacetic acid (2,4-D)	EPA 8151A	1.17	20	5.8	EPA Method 8151A
Dinoseb	EPA 8151A	0.0384	20	3.3	EPA Method 8151A
2,4,5-TP (SILVEX)	EPA 8151A	0.795	20	0.63	EPA Method 8151A
2,4,5-T	EPA 8151A	0.69	20	1.2	EPA Method 8151A
VOCs					
1,1-Dichloroethane	EPA 8260B	0.402	1.03	5	EPA Method 8260
2-Hexanone	EPA 8260B	1.45	5.16	10	EPA Method 8260
Acetone	EPA 8260B	1.27	10.3	20	EPA Method 8260
Benzene	EPA 8260B	0.495	1.03	5	EPA Method 8260
Toluene	EPA 8260B	0.485	1.03	5	EPA Method 8260
Tetrachloroethylene (PCE)	EPA 8260B	0.866	1.03	5	EPA Method 8260
Trichloroethylene (TCE)	EPA 8260B	0.743	1.03	5	EPA Method 8260
Hexachlorobutadiene	EPA 8270C	108	700	5	EPA Method 8260
1,4-Dioxane	EPA 8270C	224.8	2060	10	EPA Method 8260 (SIM)
TPH					
TPH EFH (C15-C20)	EPA Method 8015B	5,000 (gasoline headspace) or 10,000 (gasoline purge and trap and diesel)		5,000	EPA Method 8015

Note: Cells highlighted in blue represent LUT based on MRLs. Green highlighted values given by contract analytical laboratory who analyzed samples for SRS; other values from online search/literature review. Blank cells denote that those values were not available. Compounds for where there are LUT values but no MDL or PQL available are not included in this comparison table.

Backfill availability

When contaminated soil is removed from Area IV, proper backfill will be needed to replace what was excavated. Identifying appropriate backfill soil is critical for successful site restoration following contaminated soil removal. It lessens the impact to native vegetation and limits the threat to local habitats caused by bringing in foreign soil. However, the availability of 'clean' backfill is contingent upon

appropriate background and LUT value determinations. DOE and NASA investigations have determined that available backfill soil fails to meet the cleanup values if current LUT are applied (Jones, 2016; Mathias, 2022). For example, DOE evaluated soil from three potential local borrow sites, as well as two soils acquired from local home improvement stores, and none satisfied the currently established LUT values (Jones, 2016). This study prompted DOE to request further evaluation of backfill requirements and highlights the inability to locate soils that qualify as usable backfill based on current criteria. Boeing also appears to have a similar issue with its soil remediation (DTSC, 2022a). The need for identification and characterization of backfill for site restoration is further supported in a recent directive from DTSC to ETEC, Boeing, and NASA representatives (Mathias, 2022). In this directive, DTSC identifies backfill as one of the “two most time sensitive decision-critical issues” that must be evaluated in cleanup work plans from all three responsible parties (Mathias, 2022). Even ‘clean’ soil in Area IV fails to satisfy AOC criteria for all constituents of concern.

A significant factor in the failure to find backfill material is the false positive issue faced in a non-risk-based assessment. Similar to the discussion in site sampling, there can be issues with false positives with dioxins and other COCs in the LUT for backfill material. The LUT’s dependence on MDL or MDC values, which are already near analytical capabilities, will bias the evaluation of backfill towards being rejected, from a statistical basis.

One alternative to identifying borrow sites (i.e., sites to source backfill material from) involves engineering a backfill that meets the necessary criteria. However, the processes (like soil washing; Field et al., 1993) used to remove the unwanted contaminants also removes those compounds necessary to sustain plant life. Alternative methods for removal, like phytoremediation, are not effective within this type of environment where the soil is limited in carbon, nitrogen, and phosphorus sources and natural precipitation is limited. The Hanford Site has had limited success with revegetation of some remediated areas because of the lack of remaining compounds (e.g., nutrients in the form of nitrogen, phosphorus, etc.) in the soil needed for sustained plant growth (Field et al., 1993). Similarly, alternative techniques like bioremediation or microbial bio-stimulation require these same compounds to be successful. Increases in these nutrients not only supports revegetation, but also improves performance of microbial degradation of contaminants.

DTSC has published advisory criteria for identifying appropriate fill material (DTSC, 2021). The fill material criterion presented by DTSC was used to identify fill materials in the same Exide Facility cleanup activities (DTSC, 2018) as previously mentioned. As with the screening levels, a risk-based approach was used to evaluate fill material for the site. DTSC advises use of its *Preliminary Endangerment Assessment (PEA) Guidance Manual* for evaluating detectable amounts of compounds of concern within the fill material (DTSC, 2021; DTSC, 2022b). This is superseded, however, by any California Screening Levels established by DTSC. DTSC has modified these screening levels within the last year (DTSC, 2022b).

Conclusions

There are several conclusions for this evaluation of background discrimination and backfill availability. The following bullets summarize our conclusions:

- The (provisional) LUT values selected by DTSC may not be technically achievable, particularly for radionuclides of interest. Therefore, a transition from the AOC criteria to that of a risk-based approach (e.g., risk assessment for a 'resident with garden') is supported. It could improve false positive detections of contaminants and lessen the volume of soil removed from the site without increasing risk.
- If a risk-based approach is not pursued, use of the PQL in place of the MDL or MRL for establishing LUT values may improve the statistical robustness of these LUT values.
- Backfill availability and technically achievable and defensible detection limits act as guardrails to implementing cleanup under the current AOC. These guardrails must be considered in the remedial approach.

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Appendix: Glossary

Term	Definition
Detection Limit	The method reporting limit (or MRL) that is the lowest concentration at which an analyte can be confidently detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision. (DTSC 2010, §1.8.3; DOE, 2018)
Minimum Detectable Activity (MDA)	From the AOC, for radiological contaminants: “the smallest amount of activity that can be quantified for comparison with regulatory limits.” The MDA is the “detection limit” for radiological contaminants. (DTSC, 2010, §1.8.3.2)
Minimum Detectable Concentration (MDC)	The MDC is the minimum concentration that gives a 95% probability of detection when the detection criteria are chosen to give only a 5% probability of false detection in a blank sample. (EPA 2022) The MDC is an a priori estimate of the capability for detecting an activity concentration with a specific measurement system... As such, this estimate is valuable for planning and designing radiation surveys. (MARSSIM, 2000)
Method Detection Limit (MDL)	“The minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR 136, Appendix B).” (MARLAP, 2004)
Method Reporting Limit (MRL)	From the AOC, for chemical contaminants: “lowest concentrations at which an analyte can be confidently detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision” The MRL is the “detection limit” for chemical contaminants. (DTSC, 2010, §1.8.3.1)
Practical Quantification Limit (PQL)	The lowest concentration that can be reliably measured within specified limits of precision and accuracy for a specific laboratory analytical method during routine laboratory operating conditions. (EPA Enterprise Vocabulary)

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