December 5, 2012

Jared Blumenfeld
Regional Administrator
Region 9
US Environmental Protection Agency
75 Hawthorne
San Francisco, CA

by email blumenfeld.jared@epa.gov

Dear Administrator Blumenfeld:

As you know, the EPA Regional 9 office received a grant from the American Recovery and Reinvest Act to perform certain specified radiological studies of contamination at the Santa Susana Field Laboratory (SSFL), site of a partial reactor meltdown and other nuclear accidents and spills.

Until now, the community advocates had looked to EPA and this process to buttress the clean-up agreements made by DOE and DTSC. Unfortunately, the final work product has been hastily released and we are deeply concerned with the flawed results. You can well imagine how disappointed we are with the look-up tables and formulas used to determine background contamination levels. We see this new action as a deeply disappointing breach of trust, given EPA's excellent performance on clean-up efforts thus far.

We urge you to personally take immediate steps to fix these problems and ensure that the EPA SSFL report complies with the work EPA agreed to do. It can be done. There is a small window of opportunity before the meeting scheduled for December 12 to release the final results to the general public, news media, and elected officials.

As you know, the 2010 clean-up agreement for the SSFL requires cleaning Area IV and the Northern Buffer Zone to background levels. In essence, any soil must be cleaned up if radioactivity was detected above background levels. According to the agreement, and the stimulus fund grant, EPA is to determine background levels, and prepare a "look-up table" setting them out as clean-up targets. For radionuclides detected in the EPA background study, the measured values were to be the background level; for radionuclides not detected, the detection limit for the background study was supposed to be the background value.

It was to be very simple: EPA was to prepare a table of background levels (Background Threshold Values or BTVs) for each radionuclide. It would measure SSFL soil. When the SSFL soil measurements exceeded the look-up table background value, it was supposed to get cleaned up.

Until the last few weeks, EPA was living up to its commitments. The background study was completed, BTVs were established, soil measurements were made, and numerous samples had radionuclides above the BTVs.

However, in the last days, EPA issued its recommendations for the look-up table in final form, with no draft and no opportunity for public comment. That report -- prepared by a contractor -- recommended that the BTVs not be the table (as the clean-up agreement required). Instead, the contractor recommended a convoluted process to come up with look-up tables that would generally be considerably higher than the BTVs.

The final report didn't provide background values to be used as a look-up table nor did it identify all soils in which radionuclides were detected above background levels. Therefore, the final recommendations breach the fundamental requirement of the cleanup, proposing much of the contamination found should be abandoned and not cleaned up.

The report also contains another breach of EPA's commitment: the agency promised to perform all step-out measurements, confirmatory measurements, and measurements of replacement fill. Now it is talking of having DTSC approve laboratories that would do the measurements for the RPs, violating the central premise of the agreements that EPA would do that work.

Before the public release on December 12, we ask you to have the reports and associated materials revised, to comply with the clean-up agreements and EPA's tasks for the stimulus funds. In particular, we ask that you:

1. Withdraw the non-compliant look-up table memorandum, and replace it, as required, with the BTVs that EPA established in its background study. In the attached EPA's BTV table, the column marked "Selected BTVs" was supposed to be the look-up table values. It should be issued as the recommended table. (Note that it already contains the higher of detected background or minimum detection limits that EPA found in the background study).

2. Make necessary changes to the Final Soil report to conform with the above, and identify the soil samples where radionuclides were detected above the BTVs, as required. (It currently compares the measured values to "Field Action Levels" that are generally significantly higher than the BTVs.) Change related language that asserts that exceedances do not indicate contamination or areas that are to be remediated. By definition, anything above background levels indicate contamination and are to be remediated, according to the agreement.

3. Finally, make clear that EPA will carry out its commitments to do step-out and confirmatory measurements and measurements of fill, if given the funds to do so.

Please see the attached memo with a bit more detail on this matter and highlighted excerpts from the key documents identifying what EPA was supposed to do, what it had been doing, and the most recent documents that break those commitments.

We, the following individuals and organizations, hope very much that this matter can be rapidly and fully resolved. Please let me know if you have questions.

Sincerely,

Martha Dina Arguello, Physicians for Social Responsibility-Los Angele

Denise Duffield, Physicians for Social Responsibility-Los Angeles

Dan Hirsch, Committee to Bridge the Gap

Marie Mason, Rocketdyne Cleanup Coalition

Barbara Johnson, Rocketdyne Cleanup Coalition

Dawn Kowalski, Rocketdyne Cleanup Coalition

Holly Huff, Rocketdyne Cleanup Coalition

Cindi Gortner, Rocketdyne Cleanup Coalition

Davis Gortner, Teens Against Toxins

William Preston Bowling, Aerospace Contamination Museum of Education-LA

Bradley Angel, Greenaction for Health and Environmental Justice

Cynthia Babich, Del Amo Action Committee

Caroline Farrell, Center on Race, Poverty & the Environment

Rubina Suwol, California Safe Schools

Dorothy Wigmore, Worksafe Coalition

# Key Points Regarding
# EPA Final Technical Memorandum Look-Up Table Recommendations

1. The SSFL cleanup agreement requires all soil with radionuclide concentrations detected above background to be cleaned up, and for USEPA to determine background, those values to become the Lookup Table of the cleanup standards, and for USEPA to determine where soil exceeds local background:

> Per the final agreement, USEPA, in the course of conducting its radioactive contaminant background study, will determine local background levels and detection limits. Upon completion of the USEPA Radiological Background Study, a table of the radiological background levels will be prepared by USEPA, which will include both local background concentrations as well as minimum detection limits for specific contaminants whose minimum detection limits exceed local background concentrations. DTSC will use USEPA's radiological background levels as the "Look-up" Table values for the radiological cleanup levels.

And:

> U.S.EPA, in the course of conducting its radioactive contaminant survey, will determine where onsite levels exceed local background within Area IV and Northern Buffer Zone.

Thus, USEPA was to perform a Radiological Background Study that identified background levels; for those radionuclides where minimum detection limits exceeded background, the detection limit established by USEPA in the Background Study would be used as the background value. Those values were to become the Lookup Table; USEPA was to identify all soil over those values; and that soil was to be cleaned up.

2. EPA did precisely as required, up until the last few days. EPA measured background for dozens of radionuclides. For a few, where the minimum detection limit exceeded local background concentrations, the minimum detection limit of the background study for those radionuclides was used as the background number, as required. EPA issued a Final Background Study report, with tables for the background values and those minimum detection limits, called Background Threshold Values, or BTVs. The values in the surface soil BTV's column were recommended to be used as the BTVs for the lookup table. Key pages, with passages highlighted, are attached here. EPA decided to use the surface BTVs as the background values.

So far, so good.

3. In the Draft Final Soil report, which is being released as final on the 12th despite a comment period that ends thereafter, an appendix on the BTVs is included, which we have attached here with key sections highlighted. It accurately identifies the BTVs, as the upper background levels or minimum detection limits if higher than background. See particularly the last two pages, which has a column marked "Selected BTV." Those accurately show the background values USEPA found in the background study, and that were supposed to end up as the cleanup levels in the Lookup Table. Again, so far, so good.

4. THEN, IN THE LAST FEW DAYS, EVERYTHING WENT AWRY. USEPA's contractor prepared, and USEPA released, after virtually no time for internal USEPA review, and with no draft and no public comment, the FINAL Lookup Table Recommendation. These explicitly say that it would be "inappropriate" to use the BTVs for the lookup table, which is precisely what the AOC requires and what EPA agreed to do when it took the stimulus funds. We have attached the report with highlighted sections, which is to be released December 5 at a stakeholders meeting with no advance notice and no opportunity to comment, since it is final,.

On the very first page it says EPA prepared Background Threshold Values (BTVs) in its Background study, but that "BTVs alone are neither appropriate nor recommended for LUT (Look-Up Table) values." We want to reinforce this point: the AOC requires those BTVs be the Lookup Table Values, EPA agreed to prepare them in its stimulus grant, and at the very last minute EPA is saying the cleanup should not be to background, the very core of the cleanup agreement. Instead, the report proposes the BTVs be jettisoned as the lookup table values and replaced with something they are calling DL's, Decision Levels, and says, "DTSC should develop new DLs as LUT values." (p. 2) The entire cleanup agreement says cleanup is to be to background, that EPA's background values will be the Lookup Table values, and here an EPA contractor, speaking for EPA, says throw the entire agreement out and have new, non-background levels developed sometime in the future, by DTSC. There is nothing left of the cleanup agreement if this happens.

Page 4 of the report again says EPA recommends abandoning the requirement to have the background values be the cleanup levels in the lookup table. Page 5 says USEPA, "exercising independent technical judgment [sic], as identified in Section 5.2 of the AOC," pushes for "an adjustment" to the requirement to base the cleanup on BTVs and minimal detection limits. They misrepresent the AOC passage, which says that USEPA shall use independent judgment *in carrying out its obligations to determine background, create a lookup table of background, and measure soil samples against background*. ["The parties acknowledge that USEPA should exercise its independent technical judgment in performing the technical work identified for EPA in the AIP (Attachment B) and in the "Confirmation Protocol; 'Not to Exceed'; Background Cleanup Standard for Soils" (Attachment C). "] It doesn't authorize USEPA to break out of those obligations, but rather to use independent judgment in how to carry them out (e.g., which lab to use, which detection technique). And then there is a very troubling footnote which says there is a dispute resolution process if someone tries to reinterpret the agreement; yes, the AOC sets up a process whereby a party can go to court if the other party breaches it.

Note that the AOC expressly bars the use of uncertainty, error bars—one is required to compare the measured soil value to background, without adding or subtracting uncertainty.

> Look-up Table Comparisons
> The concentrations of radiological and chemical contaminants of concern observed in the confirmation samples will be compared directly to the concentrations listed in the "Look-up" Tables of radiological and chemical cleanup levels. The "Look-up" levels cannot be exceeded by any sample. The analytical result level shall be the number that the laboratory reports, not including (i.e. not adding or subtracting) the standard deviation (analytical error)[1].

[1] Federal Register/Vol. 65. No. 236/Thursday, December 7, 2000/Rules and Regulations, page 76727 paragraph 5 (Interpretation of Analytical Results).

In other words one compares the sample's measured value against background without adding or subtracting the uncertainty.

This was actually written by USEPA into the AOC. This last-minute paper on the Lookup Tables says to breach this requirement, written by USEPA itself, and do precisely the opposite of what is required by the AOC--ignore the measured value and pile on so large a multiple of uncertainty that you won't clean up large amounts of soil that USEPA has found to be above background.

p. 10 says do not use the BTV as the lookup table value, but puts forward a complicated and indefensible formula that in most cases would result in a far higher, and less protective cleanup standard. In other words, USEPA in this last minute paper is saying, break the AOC, don't clean up to background as found by USEPA, leave much of the contaminated soil uncleaned up, despite the AOC requirement to the contrary.

Table 3 of the paper, on p. 21 of the file, puts forward a set of complicated and technically indefensible formulas to substitute for the requirement that background be the lookup table values. You can see that even by their example, for cobalt-60, their proposal would raise the cleanup level for cobalt-60 from a BTV of 0.00556 to 0.0387, a seven-fold increase. For others, it will end up much higher than that. In short, the paper would breach the agreements and USEPA's commitment and create a Lookup Table for cleanup that is far less protective than the background values USEPA found and that the agreements require.

And lastly, the last page of the LookUp Table report shows a bizarre and complex decision tree to replace the Lookup Table. The whole premise of the cleanup agreement was that it was to be simple--take a measurement of soil, compare its reported value, without futzing with uncertainty, against the background value in the LookUp Table, and if it is over, clean it up. But now there is a convoluted process so complex it can never be sensibly carried out, if adopted.

The specific approach they are putting forward is technically indefensible and shows their pure bias. The background value already is heavily inflated so that if you are over it, there is only about a 1% chance or less you are not really over background. USEPA proposed not to use a traditional 95% confidence level but a non-traditional measure, the Upper Simultaneous Level, that pushes the estimated background far above the 95% traditional limit. That means that just below the background value, when you don't have to clean up, your chances that you are really over background are something like 45 to 1. Now USEPA is proposing another set of statistics on top of that, setting the chance of cleaning something up that is in fact not above background at something like 1 in a thousand or less when combined with the background statistics, which means the chances are something like 1000 to 1 that you are going to leave a lot of stuff that is in fact contaminated not cleaned up. The bias is solely in the direction of the polluter.

SEPA is saying, even though it found the soil to be above what it found to be background, break the requirement to clean it up.

To do this, very misleading language is used. The LookUp Table paper repeats that the AOC says the LookUp Table should be come from USEPA's background study:  the values measured for background in that study and the minimum detection limits for those radionuclides where the MDL exceeded the background value. Those are precisely the numbers USEPA put together as its BTVs in its final background study. Now this contractor is proposing that those numbers be jettisoned and replaced with numbers that are higher, often very much higher (and thus more lax). This is to be based not on the measurements and labs used by USEPA study for the $40+ million study, but rather on labs to be identified sometime in the future and detection limits not yet determined for those labs, and then indefensible statistics to inflate even those detection limits far above their central value. Thus, even when USEPA found contamination at SSFL above the background it had determined, and above the detection limits for the sample USEPA had taken, this memo says throw the value out and don't clean it up.

It is important to recognize that that the requirement that the Lookup Table be the values USEPA determined for background and for detection limits when those are above background was met in the USEPA background study, which includes measured background and the detection limits, whichever is higher. This paper is suggesting throwing out the detection limits and replacing them with hugely inflated detection limits that were not those USEPA determined in that background study.

Additionally, the paper says DTSC will pick labs for the RPs to do the remaining sampling. However, the AOC requires USEPA to perform all the radioactive sampling at the site, including stepouts, confirmatory sampling, and clearance of replacement fill. It appears that these commitments by USEPA are also being contemplated to be breached.

SUMMARY:  The deal was simple. The site would be cleaned up to background.  USEPA would determine background (BTV) and soil above background; if it detected contamination above background, it would be cleaned up. USEPA now proposes that lots of soil it itself has found to be above the background level it itself established should not be cleaned up. No simple lookup table would be produced, but rather a convoluted set of formulas and decision trees, all of which result in not cleaning up to background but leaving lots of contamination not cleaned up. The AOC breached--and at the last minute.

This was snuck in; never discussed in all the years of stakeholder meetings; no draft sent out for comment; just issued in final form without notice at the very end. When an agency wants to do something not quite kosher, it tries to ram it through at the last minute. But there is still time for USEPA to fix things before the release on December 12.

# FINAL RADIOLOGICAL BACKGROUND STUDY REPORT
# SANTA SUSANA FIELD LABORATORY
# VENTURA COUNTY, CALIFORNIA

**EPA Contract No.: EP-S3-07-05**
**Work Assignment Number: 021TATA09QL**

**Prepared for:**

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**October 2011**

# 8.0 DETERMINATION OF BACKGROUND THRESHOLD VALUES

Once it was determined that the radiological background reference areas (RBRA) represent unimpacted background locations (after removing identified outliers), background threshold values (BTV) were calculated using analytical data collected from all the RBRAs. No distance test location (DTL) analytical data were used in the determination of BTVs.

BTVs were estimated based on established background data collected from unimpacted background locations represented by the RBRAs. The details of the statistical procedures used to establish defensible background data sets are described in Appendix B. The analytical data from the RBRAs has been determined to be an established background dataset by:

- Conducting exhaustive research on the RBRAs to ensure that they were unimpacted areas, including site visits, aerial photograph interpretation, and historical research;
- Removing statistical outliers from the dataset; and
- Comparing the RBRA analytical data to the DTL data.

## 8.1 APPROPRIATE STATISTIC TO ESTIMATE BACKGROUND THRESHOLD VALUES

Because BTVs are computed based upon an established background data set, and multiple on-site observations are to be compared with the BTVs, an appropriate statistic that maintains the proper balance between false positives and false negatives should be used. This is especially warranted for this study because many on-site observations will be compared with their respective BTVs for many radionuclides.

At many sites, the U.S. Environmental Protection Agency (EPA) uses the 95$^{th}$ percentile or a 95% upper prediction limit to establish BTVs, because risk assessments and professional judgments can be used when it is determined that some on-site sample results above the BTVs may be false positives. However, for this study, the Administrative Order on Consent (AOC) asserts that any on-site sample that exceeds the BTV must be resampled, and the soil remediated, if the analytical results are reproducible. Therefore, care must be taken to limit the amount of false positives in on-site samples for this study.

Four different statistical limits were evaluated as potential statistics to determine BTVs:

1. 95$^{th}$ Percentile
2. 95% Upper Prediction Limit (UPL95)
3. 95%-95% Upper Tolerance Limit (UTL95-95)
4. 95% Upper Simultaneous Limit (USL95)

A brief description of each of these statistics are included the following sections.

UTL represented by a higher order statistic (for example, the largest value or the second largest value) can be used as an estimate of BTV. When sample size is large (such as 500), UTL95-95 approaches the 95$^{th}$ percentile.

### 8.1.4 95% Upper Simultaneous Limit (USL95)

A USL95 represents that statistic such that all observations, not some proportion or percentile, from the established background data set will be less than or equal to USL95 with a confidence coefficient (CC) of 95%. It is expected that *all* potential observations (present and future) coming from the background population will be less than or equal to USL95 with a 95% CC.

For each radionuclide, the false positive error rate does not change with the number of comparisons, as USL95 is meant to perform many comparisons simultaneously. A parametric USL95 takes variability of the background dataset into account. When the dataset does not follow a discernable distribution, a nonparametric USL represented by the largest value in the dataset can be used as an estimate of BTV.

### 8.1.5 Determination of Appropriate Statistic

Based on the analytical results and the uniqueness of the on-site investigation, it was determined that the USL95 was the best statistic to estimate background threshold values (BTV). The USL95 was used to determine BTVs for the SSFL Background Study because:

- Exhaustive research on the RBRAs (site visits, aerial photograph interpretation, historical research) to ensure that they were unimpacted areas;
- Comparison of the RBRA analytical data to the DTL data confirms that the RBRA locations have not been impacted by any activities at the SSFL;
- The analytical data is very consistent;
- There are few outliers in the analytical data which are not being included in the statistical evaluation; and
- The Administrative Order on Consent (AOC) requires that any on-site sample that exceeds the BTV must be retested for reproducibility or remediated; therefore, care must be taken to limit the number of false positives in on-site samples for this study so that resources can be directed toward cleaning up sites where contamination is present.

## 8.2 CALCULATING BACKGROUND THRESHOLD VALUES FOR EACH RADIONUCLIDE

### 8.2.1 Radionuclides with Fewer than Five Detections

Eleven radionuclides analyzed for the SSFL Background Study exhibited fewer than five detections (Table 8.1). Due to the low number of detections, no meaningful and defensible statistical analysis may be performed on such a data set consisting mostly of nondetects (ND). In addition, any detection in a dataset consisting mostly of NDs must also be evaluated with caution.

Based on an overall evaluation of these 11 radionuclides, it can be determined that these radionuclides are not present at the background locations. However, a value needs to be determined to compare to on-site sample results. Therefore, the maximum ND value for each radionuclide is presented as the BTV, as shown in Table 8.1. In other words, the highest recorded value for each radionuclide that is considered to be a ND is the BTV. For data sets with fewer than five NDs, the approach described above is the most appropriate approach to establish estimates of BTVs.

### 8.2.2 Radionuclides with Five or More Detections

Fifty-three radionuclides analyzed for the SSFL Background Study exhibited five or more detections. Because five detections are enough to conduct a defendable statistical analysis, BTVs were calculated for these radionuclides using the USL95. These radionuclides are exhibited in Table 8.2.

As shown in Table 8.2, the gamma spectroscopy results for barium-133, californium-249, silver-108, and silver-108m were rejected due to spectral interference from naturally occurring radionuclides. This interference was observed in all soil samples collected from the RBRAs. It is unlikely that any of these radionuclides will be of any concern in the soil samples results from the SSFL based on former investigations and site history. However, if any of these radionuclides become an issue during the on-site investigation, archived samples will be reanalyzed to attempt to determine BTVs.

BTV calculation details for all the radionuclides with five or more detections are included in Appendix A. There were six individual datasets that were evaluated for each radionuclide:

1. Lang Ranch RBRA Surface Soils (Chatsworth Formation)
2. Lang Ranch RBRA Subsurface Soils (Chatsworth Formation)
3. Rocky Peak RBRA Surface Soils (Chatsworth Formation)
4. Rocky Peak RBRA Subsurface Soils (Chatsworth Formation)
5. Bridle Path RBRA Surface Soils (Santa Susana Formation)
6. Bridle Path RBRA Subsurface Soils (Santa Susana Formation)

For each radionuclide, each of these datasets was statistically compared to each other to determine if they were similar enough to be merged. After these comparisons, the radionuclide BTV calculations fell into five main categories, which are presented in the tables noted in parentheses:

1. Radionuclides with One BTV for all Results (Table 8.3)
2. Radionuclides with Surface Soil and Subsurface Soil BTVs (Table 8.4)
3. Radionuclides with BTVs based on Geologic Formations (Table 8.5)
4. Radionuclides with BTVs based on RBRAs (Table 8.6)
5. Radionuclides with BTVs based on Individual Datasets (Table 8.7)

## 9.0 USE OF BACKGROUND THREHOLD VALUES WHEN DEVELOPING CLEANUP NUMBERS

At the time this study was planned, California Law (Article 5.5 in Chapter 6.8 of Division 20 of the Health and Safety Code [SB 990]) dictated that that radiological contamination at the Santa Susana Field Laboratory (SSFL) should ultimately be remediated to the U.S. Environmental Protection Agency's (EPA's) agricultural preliminary remediation goals (PRG). Since that time, the State of California Department of Toxic Substances Control (DTSC) and the Department of Energy (DOE) signed the Administrative Order on Consent (AOC) on December 6, 2010, which requires cleanup of radioactive contaminants to local background concentrations in SSFL Area IV and the Northern Buffer Zone.

The AOC states that the EPA will determine local background levels through this SSFL Background Study Report. Once this report has been finalized, a Look-Up Table of the radiological cleanup levels will be developed by DTSC in consultation with EPA. The requirements of the AOC state that the Look-Up Table values will be based on the background threshold values (BTV) exhibited in this report. For the investigation at the SSFL, these Look-Up Table values will be compared to individual discrete soil samples collected on site. The AOC asserts that any on-site sample that exceeds the BTV must be resampled, and if the analytical results are reproducible the soil must be remediated.

EPA will consult with DTSC to produce a Look-Up Table. Although the Look-Up Table values will be based on the BTVs, they will also incorporate management decisions to facilitate the cleanup of the SSFL. The following sections discuss management decisions that may be considered for the Look-Up Table.

### 9.1 USE OF PRELIMINARY REMEDIATION GOALS WHEN THEY ARE HIGHER THAN THE BACKGROUND THRESHOLD VALUE

For some radionuclides, the associated agricultural PRG is greater than the estimated BTV. In these instances, one option that should be considered is to select the agricultural PRG (included for each radionuclide in Tables 8.1 to 8.7) as the Clean-Up Value in the Look-Up Table.

### 9.2 USE OF THE HIGHEST BACKGROUND THRESHOLD VALUE WHEN SEPARATE VALUES WERE CALCULATED FOR SURFACE AND SUBSURFACE SOILS

Some radionuclides exhibited results that were statistically similar among all the datasets (Table 8.3). In these instances, all the analytical data were combined to calculate one BTV. However, some radionuclides exhibited statistically significant differences between datasets. In these instances, management decisions will need to be made to facilitate the cleanup at the SSFL.

For some radionuclides, separate BTVs were calculated for surface soils and subsurface soils (Table 8.4). However, because of the soil disturbances that have occurred at the SSFL (such as construction, demolition, remediation, etc.), it may be difficult to distinguish surface from subsurface soil on site. Therefore, one option that should be considered when developing the

**Table 8.1 - Radionuclides With Fewer Than Five Detections**

| Radionuclide | Detects/ Samples | Maximum Detected Value(1) (pCi/g) | Maximum Non-Detect Value (pCi/g) | Agricultural $10^{-6}$ PRG (pCi/g) | Recommended BTV (pCi/g) | Recommended BTV Determination |
|---|---|---|---|---|---|---|
| americium-243+D | 0/149 | No Detects | 1.34E-02 | 1.11E-02 | **1.34E-02** | Maximum Non-Detect Value |
| cobalt-60 | 1/141 | 1.26E-02 | 5.56E-03 | 9.01E-04 | **5.56E-03** | Maximum Non-Detect Value |
| curium-243/244 | 2/149 | 2.37E-02 | 1.47E-02 | 1.27E-01 | **1.47E-02** | Maximum Non-Detect Value |
| curium-248 | 0/149 | No Detects | 2.34E-02 | 1.43E-03 | **2.34E-02** | Maximum Non-Detect Value |
| neptunium-239 | 1/149 | 7.27E-02 | 4.27E-02 | 2.26E+01 | **4.27E-02** | Maximum Non-Detect Value |
| nickel-59 | 5/146(2) | 5.20E-01 | 3.44E-01 | 2.15E+00 | **3.44E-01** | Maximum Non-Detect Value |
| nickel-63 | 3/148 | 5.06E-01 | 4.52E-01 | 1.01E+00 | **4.52E-01** | Maximum Non-Detect Value |
| plutonium-241 | 1/149 | 4.37E-01 | 3.49E-01 | 1.05E+00 | **3.49E-01** | Maximum Non-Detect Value |
| thulium-171 | 0/144 | No Detects | 6.59E+01 | 1.25E+03 | **6.59E+01** | Maximum Non-Detect Value |
| tin-126 | 0/146 | No Detects | 4.90E-03 | 7.11E-01 | **4.90E-03** | Maximum Non-Detect Value |
| uranium-232 | 1/149 | 4.17E-01 | 5.65E-02 | 5.90E-04 | **5.65E-02** | Maximum Non-Detect Value |

**Notes:**

pCi/g - Picocuries per gram of dry soil. Analyses for H-3, C-14, Tc-99, and I-129 are reported in units of pCi per gram of "as-received" soil.

PRG - Preliminary Remediation Goal

BTV - Background Threshold Value

(1) - The Maximum Detected Value excludes outliers that were removed during the statistical analysis

(2) - Although nickel-59 results exhibited 5 detections, 2 detections were removed as outliers during the statistical evluation (See Appendix A)

**Table 8.2 - Radionuclides With Five or More Detections**

**Radionuclides With Five or More Detections**

| Radionuclide | Detects/ Samples | Maximum Detected Value* (pCi/g) | Maximum Non-Detect Value (pCi/g) | Agricultural $10^{-6}$ PRG (pCi/g) | Recommended BTV Determination | Recommended BTV |
|---|---|---|---|---|---|---|
| actinium-227+D | 40/149 | 1.24E-01 | 6.78E-02 | 8.31E-02 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| actinium-228 | 149/149 | 2.30E+00 | No Non-Detects | 7.31E+02 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| americium-241 | 5/149 | 2.39E-02 | 1.77E-02 | 1.32E-02 | USL95 | One BTV - See Table 8.3 |
| antimony-125+D | 143/144 | 2.63E-01 | 1.57E-01 | 4.60E-01 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| barium-137m | 117/148 | 1.71E-01 | 3.03E-03 | 1.78E+05 | USL95 | Multiple BTVs due to Differences in Surface vs. Subsurface Soil - See Table 8.4 |
| bismuth-212 | 149/149 | 2.04E+00 | No Non-Detects | 2.24E+04 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| bismuth-214 | 149/149 | 1.57E+00 | No Non-Detects | 8.19E+03 | USL95 | Multiple BTVs based on Individual Datasets - See Table 8.7 |
| cadmium-113m | 5/149 | 4.32E+03 | 1.73E+03 | 5.26E-03 | USL95 | One BTV - See Table 8.3 |
| carbon-14 | 6/149 | 3.26E+00 | 2.22E+00 | 5.63E-05 | USL95 | One BTV - See Table 8.3 |
| cesium-134 | 123/131 | 2.61E-02 | 4.80E-03 | 7.47E-03 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| cesium-137+D | 117/148 | 1.80E-01 | 3.21E-03 | 1.20E-03 | USL95 | Multiple BTVs due to Differences in Surface vs. Subsurface Soil - See Table 8.4 |
| curium-245/246 | 6/149 | 2.20E-02 | 1.79E-02 | 9.22E-02 | USL95 | One BTV - See Table 8.3 |
| europium-152 | 17/149 | 2.53E-02 | 3.06E-02 | 3.76E-02 | USL95 | One BTV - See Table 8.3 |
| europium-154 | 8/148 | 2.91E-02 | 1.70E-02 | 4.72E-02 | USL95 | One BTV - See Table 8.3 |
| europium-155 | 147/149 | 1.71E-01 | 1.46E-02 | 3.74E+00 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| holmium-166m | 56/149 | 3.87E-02 | 9.28E-03 | 1.10E-02 | USL95 | One BTV - See Table 8.3 |
| iodine-129 | 12/149 | 2.22E+00 | 2.08E+00 | 2.76E-05 | USL95 | Multiple BTVs due to Differences in Surface vs. Subsurface Soil - See Table 8.4 |
| iron-55 | 10/120 | 7.15E+00 | 7.31E+00 | 8.21E-01 | USL95 | One BTV - See Table 8.3 |
| lead-210+D (bismuth-210) | 148/148 | 2.17E+00 | No Non-Detects | 6.42E-05 | USL95 | One BTV - See Table 8.3 |
| lead-212 | 149/149 | 2.67E+00 | No Non-Detects | 8.00E+01 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| lead-214 | 149/149 | 1.68E+00 | No Non-Detects | 3.49E+04 | USL95 | Multiple BTVs based on Individual Datasets - See Table 8.7 |
| neptunium-236 | 47/149 | 3.80E-02 | 2.13E-02 | 2.81E-03 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| neptunium-237+D | 7/149 | 2.25E-02 | 6.21E-03 | 4.48E-04 | USL95 | One BTV - See Table 8.3 |
| niobium-94 | 99/149 | 1.63E-02 | 5.09E-03 | 1.15E-02 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| plutonium-236 | 10/149 | 2.57E-02 | 2.26E-02 | 1.04E-01 | USL95 | One BTV - See Table 8.3 |
| plutonium-238 | 27/139 | 5.36E-03 | 3.38E-03 | 7.31E-03 | USL95 | One BTV - See Table 8.3 |
| plutonium-239/240 | 93/149 | 1.71E-02 | 3.44E-03 | 6.09E-03 | USL95 | Multiple BTVs due to Differences in Surface vs. Subsurface Soil - See Table 8.4 |
| plutonium-242 | 9/147 | 4.65E-03 | 5.87E-03 | 6.42E-03 | USL95 | One BTV - See Table 8.3 |
| plutonium-244+D | 5/149 | 2.43E-03 | 1.31E-03 | 5.06E-03 | USL95 | One BTV - See Table 8.3 |
| polonium-210 | 149/149 | 1.98E+00 | No Non-Detects | 1.94E+01 | USL95 | One BTV - See Table 8.3 |
| potassium-40 | 149/149 | 3.05E+01 | No Non-Detects | 4.45E-02 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| promethium-147 | 10/149 | 6.35E+00 | 3.28E+00 | 6.69E+02 | USL95 | Multiple BTVs due to Differences in Surface vs. Subsurface Soil - See Table 8.4 |
| protactinium-231 | 7/149 | 1.77E+00 | 2.07E-01 | 2.10E-01 | USL95 | One BTV - See Table 8.3 |
| radium-226+D | 149/149 | 1.88E+00 | No Non-Detects | 6.32E-04 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| radium-228+D | 149/149 | 2.30E+00 | No Non-Detects | 1.16E-03 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| radon-220 | 149/149 | 2.27E+00 | No Non-Detects | 7.74E+08 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| radon-222+D | 149/149 | 1.61E+00 | No Non-Detects | 1.27E+05 | USL95 | Multiple BTVs based on Individual Datasets - See Table 8.7 |
| sodium-22 | 11/144 | 9.54E-03 | 6.47E-03 | 8.52E-02 | USL95 | One BTV - See Table 8.3 |
| strontium-90+D (yttrium-90) | 109/148 | 8.36E-02 | 1.07E-02 | 1.39E-03 | USL95 | Multiple BTVs due to Differences in Surface vs. Subsurface Soil - See Table 8.4 |
| technetium-99 | 40/149 | 3.64E-01 | 2.92E-01 | 5.57E-03 | USL95 | One BTV - See Table 8.3 |
| tellurium-125m | 143/144 | 6.07E-02 | 3.62E-02 | 3.20E+01 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| thallium-208 | 149/149 | 9.23E-01 | No Non-Detects | 2.26E+04 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| thorium-228+D | 149/149 | 3.55E+00 | No Non-Detects | 3.38E-02 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| thorium-229+D | 80/149 | 4.50E-02 | 2.20E-02 | 1.71E-03 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| thorium-230 | 149/149 | 2.04E+00 | No Non-Detects | 1.05E-02 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| thorium-231 | 145/149 | 1.20E-01 | 3.79E-02 | 3.31E+03 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| thorium-232 | 149/149 | 2.87E+00 | No Non-Detects | 9.42E-03 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| thorium-234 | 148/149 | 2.45E+00 | 1.41E+00 | 1.53E+01 | USL95 | Multiple BTVs based on RBRAs - See Table 8.6 |
| tritium (H-3) organic | 16/149 | 7.27E+00 | 4.99E+00 | 1.60E-01 | USL95 | Multiple BTVs due to Differences in Surface vs. Subsurface Soil - See Table 8.4 |
| uranium-233/234 | 149/149 | 1.71E+00 | No Non-Detects | 1.84E-03 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| uranium-235+D/236 | 145/149 | 1.20E-01 | 3.79E-02 | 1.81E-03 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| uranium-238+D | 149/149 | 1.68E+00 | No Non-Detects | 1.47E-03 | USL95 | Mutiple BTVs based on Geologic Formations - See Table 8.5 |
| uranium-240 | 5/149 | 2.43E-03 | 1.31E-03 | 2.98E+02 | USL95 | One BTV - See Table 8.3 |

**Rejected Results**

| | |
|---|---|
| barium-133 | Rejected due to Spectral Interference |
| californium-249 | Rejected due to Spectral Interference |
| silver-108 | Rejected due to Spectral Interference |
| silver-108m | Rejected due to Spectral Interference |

**Notes:**

pCi/g - Picocuries per gram of dry soil. Analyses for H-3, C-14, Tc-99, and I-129 are reported in units of pCi per gram of "as-received" soil.

PRG - Preliminary Remediation Goal

BTV - Background Threshold Value

RBRAs - Radiological Background Reference Areas

USL95 - 95% Upper Simultaneous Limit

* - The Maximum Detected Value excludes outliers that were removed during the statistical analysis

## Table 8.3 - Radionuclides With One BTV for All Results

| Radionuclide | Detects/ Samples | Maximum Detected Value* (pCi/g) | Maximum Non-Detect Value (pCi/g) | Agricultural $10^{-6}$ PRG (pCi/g) | Recommended BTV Determination | Calculated BTV (pCi/g) |
|---|---|---|---|---|---|---|
| americium-241 | 5/149 | 2.39E-02 | 1.77E-02 | 1.32E-02 | USL95 | **1.62E-02** |
| cadmium-113m | 5/149 | 4.32E+03 | 1.73E+03 | 5.26E-03 | USL95 | **2.95E+03** |
| carbon-14 | 6/149 | 3.26E+00 | 2.22E+00 | 5.63E-05 | USL95 | **2.54E+00** |
| curium-245/246 | 6/149 | 2.20E-02 | 1.79E-02 | 9.22E-02 | USL95 | **1.62E-02** |
| europium-152 | 17/149 | 2.53E-02 | 3.06E-02 | 3.76E-02 | USL95 | **1.69E-02** |
| europium-154 | 8/148 | 2.91E-02 | 1.70E-02 | 4.72E-02 | USL95 | **2.51E-02** |
| holmium-166m | 56/149 | 3.87E-02 | 9.28E-03 | 1.10E-02 | USL95 | **3.65E-02** |
| iron-55 | 10/120 | 7.15E+00 | 7.31E+00 | 8.21E-01 | USL95 | **5.08E+00** |
| lead-210+D (bismuth-210) | 148/148 | 2.17E+00 | No Non-Detects | 6.42E-05 | USL95 | **2.07E+00** |
| neptunium-237+D | 7/149 | 2.25E-02 | 6.21E-03 | 4.48E-04 | USL95 | **1.09E-02** |
| plutonium-236 | 10/149 | 2.57E-02 | 2.26E-02 | 1.04E-01 | USL95 | **1.84E-02** |
| plutonium-238 | 27/139 | 5.36E-03 | 3.38E-03 | 7.31E-03 | USL95 | **4.25E-03** |
| plutonium-242 | 9/147 | 4.65E-03 | 5.87E-03 | 6.42E-03 | USL95 | **2.46E-03** |
| plutonium-244+D | 5/149 | 2.43E-03 | 1.31E-03 | 5.06E-03 | USL95 | **1.56E-03** |
| polonium-210 | 149/149 | 1.98E+00 | No Non-Detects | 1.94E+01 | USL95 | **2.09E+00** |
| protactinium-231 | 7/149 | 1.77E+00 | 2.07E-01 | 2.10E-01 | USL95 | **7.91E-01** |
| sodium-22 | 11/144 | 9.54E-03 | 6.47E-03 | 8.52E-02 | USL95 | **7.87E-03** |
| technetium-99 | 40/149 | 3.64E-01 | 2.92E-01 | 5.57E-03 | USL95 | **3.68E-01** |
| uranium-240 | 5/149 | 2.43E-03 | 1.31E-03 | 2.98E+02 | USL95 | **1.56E-03** |

**Notes:**

pCi/g - Picocuries per gram of dry soil. Analyses for H-3, C-14, Tc-99, and I-129 are reported in units of pCi per gram of "as-received" soil.

PRG - Preliminary Remediation Goal

BTV - Background Threshold Value

USL95 - 95% Upper Simultaneous Limit

* - The Maximum Detected Value excludes outliers that were removed during the statistical analysis

## Table 8.4 - Radionuclides With Surface Soil and Subsurface Soil BTVs

| Radionuclide | Detects/ Samples | Maximum Detected Value* (pCi/g) | Agricultural $10^{-6}$ PRG (pCi/g) | Recommended BTV Determination | Surface Soil BTV (pCi/g) | Subsurface Soil BTV (pCi/g) | Calculated BTV Combining All Data (pCi/g) |
|---|---|---|---|---|---|---|---|
| barium-137m | 117/148 | 1.71E-01 | 1.78E+05 | USL95 | **1.83E-01** | **1.05E-02** | **2.11E-01** |
| cesium-137+D | 117/148 | 1.80E-01 | 1.20E-03 | USL95 | **1.93E-01** | **8.03E-03** | **2.29E-01** |
| iodine-129 | 12/149 | 2.22E+00 | 2.76E-05 | USL95 | **1.60E+00** | **2.08E+00** | **1.54E+00** |
| plutonium-239/240 | 93/149 | 1.71E-02 | 6.09E-03 | USL95 | **1.42E-02** | **2.09E-03** | **1.34E-02** |
| promethium-147 | 10/149 | 6.35E+00 | 6.69E+02 | USL95 | **4.96E+00** | **3.28E+00** | **4.60E+00** |
| strontium-90+D (yttrium-90) | 109/148 | 8.36E-02 | 1.39E-03 | USL95 | **7.50E-02** | **1.31E-02** | **7.35E-02** |
| tritium (H-3) organic | 16/149 | 7.27E+00 | 1.60E-01 | USL95 | **3.75E+00** | **7.38E+00** | **5.86E+00** |

**Notes:**

pCi/g - Picocuries per gram of dry soil. Analyses for H-3, C-14, Tc-99, and I-129 are reported in units of pCi per gram of "as-received" soil.

PRG - Preliminary Remediation Goal

BTV - Background Threshold Value

USL95 - 95% Upper Simultaneous Limit

* - The Maximum Detected Value excludes outliers that were removed during the statistical analysis

# BACKGROUND THRESHOLD VALUE AND RADIONUCLIDE SELECTION RATIONALE SANTA SUSANA FIELD LABORATORY AREA IV RADIOLOGICAL STUDY

The background threshold values (BTV) for radionuclides included in the investigation of Area IV and the Northern Buffer Zone (NBZ) at the Santa Susana Field Laboratory (SSFL) were determined in the SSFL Background Study Report (HGL, 2011). Background threshold values were based on data from soil samples collected from three unaffected locations outside the SSFL represented by the radiological background reference areas (RBRA).

## 1.0 FINALIZATION AND REDUCTION OF RADIONUCLIDE LIST FOR BACKGROUND STUDY

At the beginning of the project, there were multiple discussions and meetings with the Background Study Technical Group to determine the radionuclides to include in the Radiological Background Study. These meetings narrowed the list to a total of 70 radionuclides.

During the background study, an additional six radionuclides were removed from the analytical suite, thus reducing the list to 64 radionuclides. The radionuclides removed were as follows:

- Chlorine-36 and selenium-79: removed from consideration during the background study as a result of the lack of approved, validated methods in the laboratory and the low likelihood of use at SSFL (HGL, 2010).
- Barium-133, californium-249, silver-108, and silver-108m: gamma spectrometry results were rejected because of inconsistent and unpredictable spectral interference from naturally occurring radionuclides (HGL, 2011).

It was unlikely that any of these radionuclides would be of concern in the soil samples collected at SSFL based on former investigations and site history. Therefore, no BTVs were calculated for these six radionuclides.

## 2.0 CALCULATING BACKGROUND THRESHOLD VALUES FOR EACH RADIONUCLIDE

Background threshold values were calculated for the 64 radionuclides. Based on analytical results and to establish limits that would include the majority of background activity levels, the 95 percent Upper Simultaneous Limit (USL95) was the statistic used as the BTV (HGL, 2011), except where datasets were too small to statically evaluate, as noted below. All BTVs are summarized in Attachment A.

### 2.1 Radionuclides with Fewer than Five Detections

Eleven radionuclides analyzed exhibited fewer than five detections. Based on an overall evaluation of these 11 radionuclides, it was determined that these radionuclides were not present at background locations. However, a value was needed to compare to on-site sample results. Therefore, the maximum nondetect value for each radionuclide was presented as the BTV, rather than the USL95 (HGL, 2011). These results are presented in Attachment A.

### 2.2 Radionuclides with Five or More Detections

Fifty-three radionuclides analyzed for the SSFL Background Study exhibited five or more detections. Five detections were determined to be a sufficient dataset to conduct a defensible statistical analysis, and BTVs were calculated for these radionuclides using the USL95.

For the 53 radionuclides, each of the following six datasets was statistically compared to the others to determine if they were similar enough to be merged:

- Lang Ranch RBRA Surface Soils (Chatsworth Formation)
- Lang Ranch RBRA Subsurface Soils (Chatsworth Formation)
- Rocky Peak RBRA Surface Soils (Chatsworth Formation)
- Rocky Peak RBRA Subsurface Soils (Chatsworth Formation)
- Bridle Path RBRA Surface Soils (Santa Susana Formation)
- Bridle Path RBRA Subsurface Soils (Santa Susana Formation)

After these comparisons, the radionuclide BTV calculations fell into the following five main categories:

<u>Radionuclides with one BTV for all results:</u> this group included 19 radionuclides exhibiting analytical results that were statistically similar among all datasets. In these instances, all the analytical data was combined to calculate one recommended BTV (Attachment A).

<u>Radionuclides with statistically different surface and subsurface soil BTVs:</u> this group included seven radionuclides with separate BTVs calculated for surface and subsurface soils. The analytical results for these radionuclides did not exhibit statistically significant differences between geologic formations or RBRAs (Attachment A). However, because of the soil disturbances that have occurred at the SSFL (such as construction, demolition, remediation, and similar changes), it would be difficult to distinguish surface from subsurface soil on site. As an example, these soil disturbances may have caused surface soil affected by fallout radionuclides (that is, cesium-137 and strontium-90) to be reworked into the subsurface soils (HGL, 2011).

Per Section 9.2 of the SSFL Radiological Background Study Report (HGL, 2011), it was recommended "to select the higher value between the surface soil BTV and the subsurface soil BTV as a Clean-Up Value."

The analytical results for five radionuclides exhibited a higher surface soil BTV. This value was consistent with fallout radionuclides (HGL, 2011).

In the case of iodine (I)-129 and tritium (H-3), the observation that the subsurface BTV was the higher of the two is consistent with the physical properties of iodine and hydrogen. Specifically, both are volatile at relatively low temperatures in their common chemical forms. That volatility would result in the depletion of those vaporous analytes in the surface soils and the retention of the same analytes in the subsurface soils (HGL, 2011).

In the original calculation of radiological trigger levels, the BTV selected in the calculation of I-129 radionuclide reference concentration was the surface BTV of 1.60 picocuries per gram (pCi/g). The subsurface value of 2.08 pCi/g should have been selected.

<u>Radionuclides with statistically different BTVs based on geologic formations:</u> this group included 10 radionuclides with separate BTVs calculated for the Chatsworth Formation and Santa Susana Formation soils. The analytical results for these radionuclides did not exhibit statistically significant differences between RBRAs or sample depth (Attachment A). In addition to calculating separate BTVs for the Chatsworth Formation and the Santa Susana Formation, a BTV also was calculated using all results.

U.S. Environmental Protection Agency (USEPA) recommended using the BTV calculated using all the results. This recommendation was based on the difficulty in determining whether specific soil sample locations in Area IV and the NBZ were in the Chatsworth or Santa Susanna Formations, for reasons such as the mixing of soils and import of non-native soils at SSFL (HGL, 2011).

<u>Radionuclides with statistically different BTVs for RBRAs:</u> this group included 14 radionuclides, with separate BTVs calculated for each of the three RBRAs. The analytical results for these radionuclides did not exhibit statistically significant differences between geologic formations or sample depth. In addition to calculating separate BTVs for each RBRA, a BTV was calculated using all the results (Attachment A). During the investigation it was not possible to correlate Area IV and NBZ samples to a specific RBRA. USEPA recommended the use of the BTV calculated from the combined results (HGL, 2011).

<u>Radionuclides with statistically different BTVs for datasets:</u> this group included three radionuclides, and separate BTVs were calculated for each dataset. In addition, a BTV was calculated using all the results. As with the radionuclides with statistically different BTVs for RBRAs, it was not possible to correlate Area IV and NBZ sample locations to the specific datasets. Based on the groupings shown in Attachment A, USEPA recommended the use of the BTV calculated from the combined results (HGL, 2011).

## 3.0 RADIONUCLIDES REMOVED FROM THE ANALYTICAL SUITE AFTER BACKGROUND THRESHOLD VALUES WERE DETERMINED

Twelve radionuclides analyzed during the Radiological Background Study were not included in the default or site-specific analytical suites for the SSFL investigation. These radionuclides were removed at various times during the development of the Look-up Table. Some radionuclides were assumed to be in a state of secular equilibrium with other radionuclides that were also reported and evaluated. The activity concentrations of these radionuclides are calculated directly from the reported parent or progeny activity and any additional assessment is redundant. Other radionuclides were removed for reasons such as low likelihood of use or production at SSFL or short radioactive half-life. The following is a list of the radionuclides that were removed from the analytical suites and the reason for their removal:

- Barium-137m was removed during the development of the Field Sampling Plan (FSP) for soil sampling (HGL, 2012) because it is assumed to be in a state of secular equilibrium with cesium-137 and results are redundant.
- Iron-55 was removed during the September 23, 2010, stakeholder meeting. Iron-55 is an activation product with a 2.7 year half-life. It was not expected to be present in significant quantities in soil because of radioactive decay and low water solubility (HGL, 2010).
- Lead-210 and polonium-210 were removed during the September 23, 2010, stakeholder meeting. Lead-210 and its progeny polonium-210 are naturally occurring radionuclides that are part of the uranium decay series. Naturally occurring concentrations of lead-210 and polonium-210 are found in secular equilibrium with their gamma-emitting lead-214 and bismuth-214 precursors, both of which are reported and evaluated separately. As a result of the low likelihood of observing unsupported lead-210 at SSFL, lead-210 and its polonium-210 progeny were removed from consideration (HGL, 2010).
- Plutonium-242 was removed because it was used as a tracer radionuclide by both laboratories for quality control of the alpha spectroscopy data. Thus, a separate analysis would be required to determine the concentrations of plutonium-242. Additionally plutonium-242 had a low likelihood of use at SSFL.
- Radium-228 was removed during the September 23, 2010, stakeholder meeting, because it is assumed to be in a state of secular equilibrium with actinium-228, and results are redundant (HGL, 2010).
- Radon-220 was removed during the development of the FSP for soil sampling (HGL, 2012) because it is assumed to be in a state of secular equilibrium with lead-212 and bismuth-212, and results are redundant.
- Radon-222 was removed during the development of the FSP for Soil Sampling (HGL, 2012) because it is assumed to be in a state of secular equilibrium with lead-214 and bismuth-214, and results are redundant.
- Tellurium-125m was removed during the development of the FSP for Soil Sampling (HGL, 2012), because it is assumed to be in a state of secular equilibrium with antimony-125, and results are redundant.

- Thorium-231 was removed during the September 23, 2010, stakeholder meeting because it is assumed to be in a state of secular equilibrium with uranium-235, and results are redundant (HGL, 2010).
- Uranium-232 was removed during the September 23, 2010, stakeholder meeting because it was not used in reactor fuels and there was no known use of it at SSFL (HGL, 2010).
- Uranium-240 was removed during the September 23, 2010, stakeholder meeting because it is assumed to be in a state of secular equilibrium with plutonium-244, and results are redundant (HGL, 2010).

## 4.0 REFERENCES

HydroGeoLogic, Inc. (HGL), 2010. Santa Susana Field Laboratory Site; Area IV and NBZ Radiological Characterization Study, 9-23-2010 Technical Stakeholder Meeting Notes/Action Items. September.

HGL, 2011. Final Radiological Background Study Report Santa Susana Field Laboratory, Ventura County, California. October.

HGL, 2012. Final Field Sampling Plan for Soil Sampling, Area IV Radiological Study, Santa Susana Field Laboratory Site, Ventura County, California. March.

## ATTACHMENT LIST

Attachment A Summary of Calculated and Selected Background Threshold Values

# ATTACHMENT A

Summary of Calculated and Selected Background Threshold Values

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## Attachment A
## Summary of Calculated and Selected Background Threshold Values

| Radionuclides | Symbol | Selected BTV (pCi/g) | Less than Five Detections (pCi/g) | One BTV for all data (pCi/g) | Surface and Subsurface Soil BTVs (pCi/g) | | | Geologic Formations with Different BTVs (pCi/g) | | | RBRAs with Different BTVs (pCi/g) | | | | Individual Datasets with Different BTVs (pCi/g) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Surface | Subsurface | All Data | Formation | | All Data | Bridal Path RBRA | Lang Ranch RBRA | Rocky Peak RBRA | All Data | Bridal Path RBRA | | Lang Ranch RBRA[1] | | Rocky Peak RBRA[1] | | All Data |
| | | | | | | | | Santa Susana | Chatsworth | | | | | | Surface | Subsurface | Surface | Subsurface | Surface | Subsurface | |
| Actinium-227 | Ac-227 | 1.27E-01 | -- | -- | -- | -- | -- | 1.34E-01 | 9.76E-02 | **1.27E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Actinium-228 | Ac-228 | 2.30E+00 | -- | -- | -- | -- | -- | -- | -- | -- | 2.45E+00 | 1.82E+00 | 1.31E+00 | **2.30E+00** | -- | -- | -- | -- | -- | -- | -- |
| Americium-241 | Am-241 | 1.62E-02 | -- | **1.62E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Americium-243 | Am-243 | 1.34E-02 | **1.34E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Antimony-125 | Sb-125 | 3.21E-01 | -- | -- | -- | -- | -- | -- | -- | -- | 3.45E-01 | 2.29E-01 | 1.59E-01 | **3.21E-01** | -- | -- | -- | -- | -- | -- | -- |
| Barium-137m | Ba-137m | 1.83E-01 | -- | -- | **1.83E-01** | 1.05E-02 | 2.11E-01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Bismuth-212 | Bi-212 | 2.04E+00 | -- | -- | -- | -- | -- | -- | -- | -- | 1.93E+00 | 2.04E+00 | 1.15E+00 | **2.04E+00** | -- | -- | -- | -- | -- | -- | -- |
| Bismuth-214 | Bi-214 | 1.57E+00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1.83E+00 | 9.14E-01 | 1.31E+00 | | 9.06E-01 | | **1.57E+00** |
| Cadmium-113m | Cd-113m | 2.95E+03 | -- | **2.95E+03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Carbon-14 | C-14 | 2.54E+00 | -- | **2.54E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Cesium-134 | Cs-134 | 3.00E-02 | -- | -- | -- | -- | -- | -- | -- | -- | 2.94E-02 | 2.13E-02 | 1.84E-02 | **3.00E-02** | -- | -- | -- | -- | -- | -- | -- |
| Cesium-137 | Cs-137 | 1.93E-01 | -- | -- | **1.93E-01** | 8.03E-03 | 2.29E-01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Cobalt-60 | Co-60 | 5.56E-03 | **5.56E-03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Curium-243/244 | Cm-243/244 | 1.47E-02 | **1.47E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Curium-245/246 | Cm-245/246 | 1.62E-02 | -- | **1.62E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Curium-248 | Cm-247/248 | 2.34E-02 | **2.34E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Europium-152 | Eu-152 | 1.69E-02 | -- | **1.69E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Europium-154 | Eu-154 | 2.51E-02 | -- | **2.51E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Europium-155 | Eu-155 | 1.98E-01 | -- | -- | -- | -- | -- | -- | -- | -- | 1.97E-01 | 1.54E-01 | 1.20E-01 | **1.98E-01** | -- | -- | -- | -- | -- | -- | -- |
| Holmium-166m | Ho-166m | 3.65E-02 | -- | **3.65E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Iodine-129 | I-129 | 2.08E+00 | -- | -- | 1.60E+00 | **2.08E+00** | 1.54E+00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Iron-55 | Fe-55 | 5.08E+00 | -- | **5.08E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lead-210 | Pb-210 | 2.07E+00 | -- | **2.07E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lead-212 | Pb-212 | 2.67E+00 | -- | -- | -- | -- | -- | -- | -- | -- | 2.81E+00 | 2.43E+00 | 1.80E+00 | **2.67E+00** | -- | -- | -- | -- | -- | -- | -- |
| Lead-214 | Pb-214 | 1.68E+00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1.93E+00 | 1.39E+00 | 1.40E+00 | | 9.80E+00 | | **1.68E+00** |
| Neptunium-236 | Np-236 | 3.14E-02 | -- | -- | -- | -- | -- | 3.54E-02 | 2.13E-02 | **3.14E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Neptunium-237 | Np-237 | 1.09E-02 | -- | **1.09E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Neptunium-239 | Np-239 | 4.27E-02 | **4.27E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel-59 | Ni-59 | 3.44E-01 | **3.44E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel-63 | Ni-63 | 4.52E-01 | **4.52E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Niobium-94 | Nb-94 | 1.65E-02 | -- | -- | -- | -- | -- | -- | -- | -- | 1.66E-02 | 1.53E-02 | 1.08E-02 | **1.65E-02** | -- | -- | -- | -- | -- | -- | -- |
| Plutonium-236 | Pu-236 | 1.84E-02 | -- | **1.84E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Plutonium-238 | Pu-238 | 4.25E-03 | -- | **4.25E-03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Plutonium-239/240 | Pu-239/240 | 1.42E-02 | -- | -- | **1.42E-02** | 2.09E-03 | 1.34E-02 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Plutonium-241 | Pu-241 | 3.49E-01 | **3.49E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Plutonium-242 | Pu-242 | 2.46E-03 | -- | **2.46E-03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Plutonium-244 | Pu-244 | 1.56E-03 | -- | **1.56E-03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

## Attachment A
## Summary of Calculated and Selected Background Threshold Values

| Radionuclides | Symbol | Selected BTV (pCi/g) | Less than Five Detections (pCi/g) | One BTV for all data (pCi/g) | Surface and Subsurface Soil BTVs (pCi/g) | | | Geologic Formations with Different BTVs (pCi/g) | | | RBRAs with Different BTVs (pCi/g) | | | | Individual Datasets with Different BTVs (pCi/g) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Formation | | | | | | | Bridal Path RBRA | | Lang Ranch RBRA[1] | | Rocky Peak RBRA[1] | | |
| | | | | | Surface | Subsurface | All Data | Santa Susana | Chatsworth | All Data | Bridal Path RBRA | Lang Ranch RBRA | Rocky Peak RBRA | All Data | Surface | Subsurface | Surface | Subsurface | Surface | Subsurface | All Data |
| Polonium-210 | Po-210 | 2.09E+00 | -- | **2.09E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Potassium-40 | K-40 | 3.05E+01 | -- | -- | -- | -- | -- | -- | -- | -- | 2.15E+01 | 3.05E+01 | 2.50E+01 | **3.05E+01** | -- | -- | -- | -- | -- | -- | -- |
| Promethium-147 | Pm-147 | 4.96E+00 | -- | -- | **4.96E+00** | 3.28E+00 | 4.60E+00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Protactinium-231 | Pa-231 | 7.91E-01 | -- | **7.91E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Radium-226 | Ra-226 | 1.88E+00 | -- | -- | -- | -- | -- | -- | -- | -- | 1.88E+00 | 1.56E+00 | 1.15E+00 | **1.88E+00** | -- | -- | -- | -- | -- | -- | -- |
| Radium-228 | Ra-228 | 2.30E+00 | -- | -- | -- | -- | -- | -- | -- | -- | 2.45E+00 | 1.82E+00 | 1.31E+00 | **2.30E+00** | -- | -- | -- | -- | -- | -- | -- |
| Radon-220 | Rn-220 | 2.27E+00 | -- | -- | -- | -- | -- | -- | -- | -- | 2.34E+00 | 2.04E+00 | 1.48E+00 | **2.27E+00** | -- | -- | -- | -- | -- | -- | -- |
| Radon-222 | Rn-222 | 1.61E+00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1.61E+00 | 1.36E+00 | 1.34E+00 | 1.30E+00 | 9.14E-01 | 8.87E-01 | **1.61E+00** |
| Sodium-22 | Na-22 | 7.87E-03 | -- | **7.87E-03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Strontium-90/ Yttrium-90 | Sr-90 | 7.50E-02 | -- | -- | **7.50E-02** | 1.31E-02 | 7.35E-02 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Technetium-99 | Tc-99 | 3.68E-01 | -- | **3.68E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tellurium-125m | Te-125m | 7.61E-02 | -- | -- | -- | -- | -- | -- | -- | -- | 7.97E-02 | 5.29E-02 | 3.51E-02 | **7.61E-02** | -- | -- | -- | -- | -- | -- | -- |
| Thallium-208 | Tl-208 | 9.23E-01 | -- | -- | -- | -- | -- | -- | -- | -- | 9.39E-01 | 7.98E-01 | 5.49E-01 | **9.23E-01** | -- | -- | -- | -- | -- | -- | -- |
| Thorium-228 | Th-228 | 3.67E+00 | -- | -- | -- | -- | -- | 3.55E+00 | 3.29E+00 | **3.67E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Thorium-229 | Th-229 | 4.62E-02 | -- | -- | -- | -- | -- | 4.45E-02 | 4.02E-02 | **4.62E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Thorium-230 | Th-230 | 2.04E+00 | -- | -- | -- | -- | -- | 1.88E+00 | 2.04E+00 | **2.04E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Thorium-231 | Th-231 | 1.30E-01 | -- | -- | -- | -- | -- | 1.22E-01 | 1.25E-01 | **1.30E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Thorium-232 | Th-232 | 2.95E+00 | -- | -- | -- | -- | -- | 3.19E+00 | 2.29E+00 | **2.95E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Thorium-234 | Th-234 | 3.04E+00 | -- | -- | -- | -- | -- | -- | -- | -- | 2.45E+00 | 1.92E+00 | 1.26E+00 | **3.04E+00** | -- | -- | -- | -- | -- | -- | -- |
| Thulium-171 | Tm-171 | 6.59E+01 | **6.59E+01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tin-126 | Sn-126 | 4.90E-03 | **4.90E-03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tritium | H-3 | 7.38E+00 | -- | -- | 3.75E+00 | **7.38E+00** | 5.86E+00 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Uranium-232 | U-232 | 5.65E-02 | **5.65E-02** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Uranium-233/234 | U-233/234 | 1.87E+00 | -- | -- | -- | -- | -- | 1.77E+00 | 1.73E+00 | **1.87E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Uranium-235/236 | U-235/236 | 1.30E-01 | -- | -- | -- | -- | -- | 1.22E-01 | 1.25E-01 | **1.30E-01** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Uranium-238 | U-238 | 1.68E+00 | -- | -- | -- | -- | -- | 1.74E+00 | 1.65E+00 | **1.68E+00** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Uranium-240 | U-240 | 1.56E-03 | -- | **1.56E-03** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Notes:**

Data from Section 8 Tables, *Final SSFL Radiological Background Study Report, HGL, 2011*

Bold values indicate selected BTV

Shaded rows indicate radionuclide removed from analytical suites after background study.

[1]Bi-214 and Pb-214 Lang Ranch and Rocky Peak RBRA surface and subsurface are combined values

-- No BTV calculated

BTV - background threshold value

RBRA - Radiological Background Reference Area

pCi/g - picocuries per gram

# FINAL
# TECHNICAL MEMORANDUM
# LOOK-UP TABLE RECOMMENDATIONS
# SANTA SUSANA FIELD LABORATORY
# AREA IV RADIOLOGICAL STUDY

| | |
|---|---|
| **TO:** | Andrew Bain, EPA Region 9 RPM |
| **FROM:** | L. Steven Vaughn, R.G., HGL Project Manager |
| **CC:** | Mary Aycock, EPA Region 9 RPM |
| | Shiann-Jang Chern, Ph.D., P.E., EPA Region 9 RPM |
| | Gregg Dempsey, Technical Advisor |
| **DATE:** | November 27, 2012 |
| **SUBJECT:** | Look-up Table Recommendations |
| | |
| **CONTRACT NO:** | EP-S7-05-05 |
| **TASK ORDER NO:** | 0038 |

## EXECUTIVE SUMMARY

Pursuant to an interagency agreement between the U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (USEPA), the USEPA has conducted a Radiological Background Study to determine the background levels for radionuclides in surface and subsurface soils associated with Area IV and the Northern Buffer Zone (Area IV Study Area[1]) of the Santa Susana Field Laboratory (SSFL), located in Ventura County, California. In addition, the USEPA is currently conducting a radiological characterization of the Area IV Study Area to identify areas that exhibit radionuclide concentrations in surface and subsurface soil and sediment above background levels (herein, "soil" shall mean surface and subsurface soil as well as surface and subsurface sediment unless otherwise specified).

This technical memorandum provides USEPA's recommendations to the State of California's Department of Toxic Substances Control (DTSC) regarding the future development of Look-up Table (LUT) values. LUT values are a metric against which analytical sample results will be compared to determine if a sample contains or does not contain contamination requiring remediation. In addition, guidance is provided for the implementation and application of these LUT values, and for addressing potential challenges in the procurement and use of analytical laboratory data. USEPA recommends the use of Background Threshold Values[2] (BTV) as the basis for development of LUT values for radiological contamination; for the reasons described herein, BTVs alone are neither appropriate nor recommended for use as the LUT values. BTVs were established during the USEPA's Radiological Background Study as summarized in Table 1 (Attachment 1).

[1]The "Area IV Study Area" is defined as the property including Area IV and the Northern Buffer Zone.
[2]BTVs are the upper limit of background activity for individual radionuclides.

**BTVs are the basis for developing future LUT values.**

USEPA recommends in cases where it is not practically or technologically feasible for the radioanalytical laboratory to provide data of a quality that supports the use of a specific BTV, the laboratory's detection limit[3] should be used as the acceptable alternative. This document includes recommendations on the selection of either BTVs or laboratory detection limits as cleanup levels[4] for soils in the Area IV Study Area.

USEPA recommends that DTSC establish decision criteria for comparison of laboratory results to the cleanup levels, which will assist in determining whether the cleanup levels have been exceeded. These decision criteria, called decision levels (DL), should take into account the quality of the laboratory's analytical data and DTSC's tolerance for errors in the decision making process. While DLs (called Radiological Trigger Levels [RTL] during USEPA's Area IV Radiological Study) have been developed for the USEPA's radiological investigation of the Area IV Study Area, those DLs are based on the quality of data procured specifically for that investigation and USEPA does not recommend the use of those DLs for future phases of the project. Rather, new DLs should be calculated based on the expected quality of future laboratory data. This document provides guidance for DTSC to calculate new DLs, hereafter called LUT values, after the procurement of future analytical laboratory services; therefore, these LUT values will be developed after the procurement.

**USEPA's RTLs are not LUT values and should not be used by DTSC.**

**DTSC should develop new DLs as the LUT values.**

USEPA provides the following recommendations for implementation of operational efficiencies during the remediation and site closure phases, based on outcomes and "lessons learned" from the Area IV Radiological Study:

- Focus on the comprehensive list of BTVs summarized in Table 1 on Priority One radionuclides (Section I of Table 1 and 2) that were detected in the Area IV Radiological Study at concentrations above USEPA's Radionuclide Reference Concentrations (RRC). See the explanation of the development and purpose of the RRCs in an appendix of the Final Radiological Characterization of Soils, which was in development when this technical memorandum was completed. This effort is expected to reduce analytical costs, accelerate the delivery of analytical data, and optimize

[3] Per the Administrative Order on Consent (AOC), detection limit means the minimum detectable activity. In all cases, minimum detectable activity is synonymous with minimum detectable concentration and the terms may be used interchangeably with detection limit.
[4] The BTVs are called "cleanup levels" after comparison to laboratory detection limits to distinguish the two step process of establishing LUT values.

overall data quality while achieving a cleanup level closer to the BTVs in compliance with the AOC.

**Focus procurement of an analytical laboratory on Priority One radionuclides.**

- Follow "best practices" in the procurement and management of laboratory services, including the specification of measurement quality objectives (MQO), optimizing method performance, and streamlining the data evaluation and decision making process.

## 1.0 INTRODUCTION

This technical memorandum provides USEPA's recommendations to DTSC regarding development of LUT values for radiological contamination in SSFL Area IV Study Area soil samples during further investigation, remediation and closure phases. The Administrative Order on Consent (AOC), an agreement between DOE and DTSC, is briefly discussed as the basis for the development of LUT values. The memorandum also includes recommendations regarding the lessons learned from the USEPA's Area IV Radiological Study regarding the use of cleanup levels, the selection of analytical laboratories, and the use of laboratory data. Finally, recommendations are included for the development of LUT values as criteria for comparison to future laboratory data.

### 1.1 ADMINISTRATIVE ORDER ON CONSENT

The AOC was issued under the regulatory authority of the DTSC and is a principal guiding document in the development of the Area IV Study Area remediation standards. The AOC is an agreement between DTSC and DOE. USEPA is not a party to the AOC, but has agreed to assist with limited activities pending funding from DOE. USEPA agreed to provide DTSC assistance on the development of LUT values. DTSC has the authority and responsibility to develop and approve final LUT values.

### 1.2 DEVELOPMENT OF BACKGROUND THRESHOLD VALUES

BTVs were determined during USEPA's SSFL Radiological Background Study. A detailed analysis of the development of the BTVs is included in the Final Radiological Background Study Report (HGL, 2011).

The background study included analyses of 149 surface and subsurface soil samples from areas that were not affected by SSFL site operations, and were representative of SSFL soil in geology and other physical characteristics. From the analytical data and extensive statistical analyses, BTVs were calculated as the 95 percent Upper Simultaneous Limit for 64 radionuclides of concern. The BTVs describe an upper limit of the level of radioactivity expected to be encountered in a background sample. This limit incorporates observed variability in the background radioactivity for each radionuclide, as well as the variability in the sampling and measurement processes used to characterize the background samples.

After the removal of 12 radionuclides for which the results were either redundant or otherwise technically problematic, 52 BTVs remain as the basis for calculating LUT values. The BTVs are summarized in Table 1 and, while they are the starting point for the calculation of LUT values, they are not appropriate for use by themselves as LUT values.

**BTVs alone are not appropriate for use as LUT values.**

## 1.3 THE DECISION MAKING PROCESS

In establishing statistical criteria for determining whether a BTV has been exceeded[5], it is important to formulate the null hypothesis in a manner that accurately reflects the quality of the available data. If the null hypothesis is that "the sample is assumed to exceed the BTV until it is shown to be otherwise" then Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Scenario A defines the appropriate calculation for the LUT value. Alternately, if the null hypothesis is that "the sample is assumed not to exceed the BTV until it is shown to be otherwise", MARLAP Scenario B defines the appropriate calculation for the LUT value.

For this project data generally falls into one of two categories:

- Radionuclides for which the BTV is derived from background samples with no measurable activity. In this case there is no way to statistically distinguish a "clean" sample from the background samples that were used to derive the BTVs. Therefore, under the expected analytical conditions, no sample could be reliably determined to meet the acceptance criteria applicable to Scenario A, even after remediation.
- Radionuclides for which the BTV is derived from background samples with measurable activity. For these radionuclides, the BTVs are determined from the upper limit of a population of background results. Establishing a decision level below the BTV, as prescribed in Scenario A calculations, would result in a decision error rate that significantly exceeds the Scenario A design parameter.

For both cases described above, MARLAP Scenario B is applicable and the BTV is assumed not to have been exceeded until the analytical results exceeds the BTV by a margin that reflects the method uncertainty ($U_M$) at the BTV.

**The decision making process requires the use of MARLAP Scenario B.**

Regardless of the selection of Scenario A or Scenario B, the goal of the decision process remains the same; to determine whether the BTV, i.e. the cleanup level, has been exceeded. The selection of Scenario B is a necessary outcome of the project goal, which is to establish clean up levels that are equal to "background" levels.

[5]Data users who are unfamiliar with radiological data or with the MARLAP Manual (MARLAP; USEPA, 2004) Directed Planning and Data Quality Objectives Processes, which are reflected in this document and in the Area IV Radiological Study Quality Assurance Project Plan (HGL, 2012b), may benefit from a review of MARLAP, Appendix B, as well as Chapters 2 and 19.

### 1.3.1 The Impact of Method Uncertainty on the Decision Making Process

All measurements have some degree of inherent uncertainty. All radioanalytical methods should be evaluated to determine all significant sources of uncertainty. The cumulative effect of those uncertainty sources is $U_M$. $U_M$ describes the range of true values that might be represented by a given laboratory result. $U_M$ is an unavoidable aspect of the analytical method, is specific to the sampling and measurement processes used to characterize the Area IV samples, and is *independent* of the variability in the background results reflected in the development of BTVs.

For any given sample, a laboratory result that is equal to the BTV represents a range of possible true values for that sample; some of which are less than the BTV and some of which are greater than the BTV. Whether that result represents a true sample value that actually exceeds the BTV is purely a matter of chance; a decision that the BTV has been exceeded would be incorrect 50 percent of the time. Establishing a decision criterion, without considering the impact of $U_M$, would result in a potential situation in which the release of uncontaminated background-level material would not be assured, but would instead be randomly determined, similar to a coin toss.

### 1.3.2 The Impact of the AOC on the Decision Making Process

The AOC states, in pertinent part:

- The LUT will describe radiological cleanup levels that include local background concentrations as well as minimum detection limits, where appropriate and as described in Section 2.2 below.
- The analytical result, not adding or subtracting the analytical error, will be compared directly to the LUT values.

While DTSC may select LUT values that are equal to the cleanup levels, it is USEPA's understanding that the extraordinarily high decision error rate for laboratory results at or near those cleanup levels is believed to be unacceptable. In exercising independent technical judgement, as identified in Section 5.2 of the AOC, USEPA recommends an adjustment to the BTVs and minimum detectable concentrations (MDC) to include appropriate consideration for $U_M$ to ensure an acceptably low decision error rate of approximately 5 percent. This adjustment is not believed by USEPA to be contrary to the AOC requirement that LUT values incorporate BTVs and laboratory MDCs[6]. Individual sample results would not be adjusted by adding or subtracting the reported sample-specific uncertainty, in keeping with the AOC requirements.

[6]The AOC is subject to interpretation and includes specific provision for DTSC and DOE to resolve any potential disputes in that interpretation.

### 1.3.3 Limiting $U_M$ in the Laboratory Analytical Methods

To ensure that $U_M$ is adequately restricted to provide meaningful decisions at the cleanup level, $U_M$ must be constrained to a level that will support a pre-defined acceptable decision error rate. USEPA recommends a decision error rate of no more than 5 percent, which requires that the maximum $U_M$ not exceed 10percent at the cleanup level.

Limiting $U_M$ to a maximum level, in this case 10 percent, is accomplished by establishing a maximum required method uncertainty ($U_{MR}$) as an MQO, incorporated into the laboratory's statement of work (SOW). The nature of radioanalytical uncertainty requires that $U_{MR}$ be defined in two parts; a maximum required *absolute* method uncertainty, $U_{MR}$, below a specified activity level and a maximum required *relative* method uncertainty ($\phi_{MR}$), above the specified activity level.

The primary MQO applicable to the decision making process is that the $U_{MR}$ should not exceed 10 percent of the BTV, for results at or below the BTV. For results above the BTV, the $\phi_{MR}$ should not exceed 10 percent of the result. In keeping with the requirements of the AOC, if laboratory MDCs exceed the BTV for a given radionuclide, the MDC is used in place of the BTV. The development of LUT values, described in Section 2.3, incorporates this rationale.

## 2.0 INTERPRETATION OF ANALYTICAL LABORATORY DATA

The use of BTVs as the basis for LUT values and the effective comparison of those LUT values to subsequent laboratory sample results, depends heavily on laboratory data of a known and predictable quality that optimizes both precision and sensitivity. USEPA recommends ensuring laboratory data meets the requirements of the project and is produced in a reliable and defensible manner.

For each radionuclide, DTSC should specify a required $U_{MR}$; see Section 2.1.1 for additional information. The $U_{MR}$ is the primary MQO used to establish decision criteria (the LUT values) for determining if a sample result has exceeded a BTV[7]. When a laboratory result exceeds the corresponding LUT value, data evaluation may conclude within a specified confidence interval that the actual soil activity concentration has exceeded the BTV, therefore requiring remediation. The recommended decision criteria are based on the MQO that results at or above the BTV will have a $U_{MR}$ of no more than 10 percent. This primary MQO, as well as contingency conditions when the primary MQO cannot be met, and other considerations in the procurement and use of laboratory data, are discussed in more detail below.

| |
|---|
| **A specific $U_{MR}$ is the primary MQO to develop a DL.** |

[7]Other MQOs, such as quality control sample acceptance criteria, are described in the Area IV Radiological Study QAPP (HGL, 2012b) and are intended to support the project data quality objectives.

## 2.1 LABORATORY SELECTION AND MEASUREMENT QUALITY OBJECTIVES

Before soliciting laboratory services, USEPA recommends that DTSC and DOE form an agreement on the potential scope of the project, including:

- overall remediation schedule
- number and expected collection rate of soil samples for analyses
- radionuclides to be reported (optimally based on USEPA's recommended Priority One radionuclides)
- period of laboratory performance
- expected turnaround-time for analysis and reporting of data in acceptable data packages
- establish achievable MQOs that result in consistent LUT values for the remainder of the project; i.e., remediation and closure phases

In addition, the agreement should include any other parameters that may affect the selection of the laboratory, impact the laboratory's ability to perform, or influence the negotiation of laboratory MQOs. These issues should be discussed in the context of the potential impact on field operations, such as excavation, confirmation sampling, backfilling, and closure, with the goal of establishing coordinated and consistent contracting of laboratory services that minimizes any disparity of data quality or MQOs among laboratories or organizations.

The laboratory selection process should include a thorough review of the laboratory's capabilities to perform the requested analyses, achieve the project MQOs, and deliver the data in a pre-defined format, within a specified schedule. Pre-qualification laboratory audits, and a review of independent performance evaluation results and analyst proficiency reports, are significant proactive steps recommended to ensure the retention of qualified laboratory services.

In all cases, and for all methods and radionuclides, the laboratory should provide a verifiable demonstration of its analytical proficiency prior to the award of a contract. This demonstration should include, at a minimum, the analysis of performance evaluation samples supplied by DTSC, to be analyzed at the project-required MQOs, and to be reported within a specified time frame in the project-required format, including electronic data deliverables, if required.

USEPA recommends selecting a single laboratory that best meets the project requirements, specifically, that meets the MQOs for the Priority One radionuclides to avoid having multiple MDCs. This laboratory is recommended to be used for the analyses of all samples collected during all future phases of investigations, remediation, and closure.

**Procurement of a single analytical laboratory should focus on meeting the MQOs for the Priority One radionuclides and on avoiding having multiple MDCs.**

Recommendations for establishing MQOs that support the project cleanup goals are discussed in the following sections.

### 2.1.1 Required Method Uncertainty

In specifying project MQOs, USEPA recommends that the laboratory establish Laboratory Action Levels (LAL) at which the following $U_{MR}$ criteria for each requested radionuclide can be met:

- For results at or below the LAL, the method uncertainty, expressed as a one sigma (1σ) combined standard uncertainty (CSU), should not exceed 10 percent of the LAL.
- For results above the LAL, the CSU should not exceed 10 percent of the reported result.

The preferred LAL is equal to the BTV.

The ability to accurately predict the $U_M$ at the cleanup level is a key principle in the development of LUT values and requires a reliable determination of the LAL.

**The analytical Statement of Work should require laboratories to establish an LAL, which is critical to developing LUT values.**

The LAL is the activity concentration at which the associated CSU is less than or equal to 10 percent. Results greater than the LAL will have a required relative CSU ($\phi_{MR}$) of not more than 10 percent of the result. Results less than or equal to the LAL will have a required CSU ($U_{MR}$), expressed in activity units, of not more than 10 percent of the LAL. This uncertainty requirement of 10 percent at the LAL should be an MQO that is formally incorporated into the laboratory analytical statements of work. In addition, the laboratory should be required to verify its ability to meet this MQO by performing a method validation study, as described below, prior to performing analyses on project samples.

**The MQOs in the analytical SOW should be:**

- **Sample results greater than the LAL shall have a relative CSU of no more than 10 percent.**
- **Sample results less than or equal to the LAL shall have a required CSU of not more than 10 percent of the LAL.**

The method validation study should incorporate the principles described in MARLAP, Chapter 6, Section 6.6, and should be performed at Levels C, D, or E, as applicable to the laboratory, to ensure that at least five replicates are prepared at each activity level of interest. Level A and B validation studies should not be accepted, as performance to the SOW itself may be considered a "New Application". In addition, the three activity concentration levels should be equal to the LAL, one-half the LAL, and twice the LAL. Finally, all results provided in the method validation report should be evaluated against the MQO to ensure that each result meets the method uncertainty requirements, $\phi_{MR}$ or $U_{MR}$, as applicable.

This MQO is based on the expectation that LUT values will be calculated and used as exceedance decision criteria, for which the decision error rate does not exceed 5 percent. The laboratory should ensure that all significant sources of uncertainty are accounted for in their reported uncertainty estimates. MARLAP, Chapter 19 has further details related to estimating laboratory uncertainty (USEPA, 2004).

The 10 percent requirement for method uncertainty may require negotiations with the laboratory for extended count times, large sample volumes, or other non-routine method modifications. In all cases, these modifications should be demonstrated to be effective and achievable before finalizing the procurement of laboratory services.

There may be cases in which the 10 percent uncertainty requirement is not practically or technologically achievable at the BTV. In these cases the laboratory should provide an activity level at which it can achieve the 10 percent uncertainty requirement, with the understanding that this activity level will be greater than the BTV. The laboratory should be expected to meet the uncertainty requirement, either at the BTV or at the alternate activity level, in all subsequent results. Failure to do so should be viewed as cause for rejection of the result and reanalysis of the sample.

### 2.1.2 Minimum Detectable Concentration

As the AOC allows for consideration of the method MDC, as discussed below, the laboratory should declare their method MDCs in advance and those values should be incorporated into the laboratory services agreement. For consistency among laboratories and for comparability of results, the formula for calculating the MDC should be explicitly described in the request for proposals to the prospective laboratories and should be incorporated into the contract for laboratory services.

For each requested radionuclide, and for the analytical conditions under which the $U_{MR}$ requirement is achieved, the laboratory should provide a method MDC that can reasonably be expected to be achieved in subsequent sample analyses.

As discussed above, the method MDC should be effectively demonstrated prior to awarding a contract for laboratory services. This method MDC should be incorporated into the contract for laboratory services and subsequent sample-specific MDCs should generally conform to the overall method MDC.

The analytical SOW should require the laboratory to specify actual method MDCs achieved under the analytical conditions that meet the MQOs; i.e., the $U_{MR}$ requirement before the project commences

## 2.2 USE OF MINIMUM DETECTABLE CONCENTRATIONS IN PLACE OF BACKGROUND THRESHOLD VALUES

When the laboratory is unable to achieve the $U_{MR}$ requirement of 10 percent at the BTV, alternate decision criteria may become necessary. In cases where the method MDC exceeds the established BTV, the MDC is used in place of the BTV, in compliance with the AOC.

**If the laboratory cannot meet the MQO of 10 percent required CSU ($U_{MR}$) at the BTV, and the laboratory method MDC is greater than the BTV, then the method MDC may be used as the alternate cleanup level.**

For purposes of this technical memorandum, and for the appropriate use of BTVs, it is important to note that the MDC is <u>not</u> used as a <u>detection</u> decision criterion. Rather, the MDC is understood to represent a level of activity at which the associated uncertainty becomes predictably constrained to a level that is useful for defining a substitute cleanup value when the BTV is not practically or technologically supported by the laboratory data. The use of the MDC in this case, defined as "the smallest amount of activity that can be quantified for comparison with regulatory limits," is consistent with the AOC requirements and definitions.

## 2.3 DEVELOPMENT AND USE OF DECISION LEVELS

Decisions regarding the exceedance of the established cleanup levels, whether they are BTVs or method MDCs, should take into account the overall uncertainty of the analytical method, as well as the data user's tolerance for making decision errors. These parameters influence the likelihood that a particular laboratory result is consistent with the true sample concentration (which is impossible to know with 100 percent certainty) in which the BTV has been exceeded.

USEPA understands that LUT values are the limits for reported laboratory results, above which action is required and recommends that LUT values are calculated as follows:

$$\text{LUT value} = \text{Cleanup Level} + 1.645 * U_M$$

Where:

| | | |
|---|---|---|
| Cleanup Level | = | the greater of the BTV or the laboratory's method MDC |
| $U_M$ | = | the laboratory's method uncertainty for results at the Cleanup Level |
| 1.645 | = | the normal distribution quantile consistent with 5 percent Type I and Type II decision errors (see MARLAP for additional information) |

Attachment 2 contains a flow chart to illustrate the development of LUT values. It is noted that $U_M$ is to be evaluated for each method and for each radionuclide at the established Cleanup Level. The $U_M$ does not include consideration of individual sample-specific uncertainties, which would allow for incorrect decisions to be made based on poor quality data, such as that due to matrix interference or instrument performance problems.

**Use the flow chart in Attachment 2 to guide development of DLs as the LUT values.**

The USEPA recommends that the correct use of the LUT values is that laboratory results above the LUT values are likely, at the 95 percent confidence interval, to represent an exceedance of the cleanup level. The response to laboratory results above a LUT value is governed by the AOC; that is, the reanalysis of the sample at a longer count time to verify accuracy or remediation followed by confirmation sampling and analysis.

## 3.0 USE OF THE LOOK-UP TABLE

Table 1 summarizes the results of the background study with the BTVs for the radionuclides of concern. USEPA recommends that DTSC develop the future LUT values required by the AOC using the process outlined in Sections 1 and 2 of this memorandum.

Table 1 is divided into two sections. Section I (Priority One radionuclides) includes only those radionuclides that, during the Area IV Radiological Study, were detected at concentrations exceeding the project RRCs. The RRCs were calculated from sample results obtained from the two contracted production laboratories. The two sigma (97.7 percent confidence level of the standard normal cumulative probability) upper confidence limit (UCL) MDCs calculated from these laboratories are summarized in Table 2 to provide DTSC with a reference point for a reasonable limit for commercially available MDCs.

**USEPA recommends that DTSC should contract a laboratory that can meet the MQOs for LUT values equal to or less than the RRCs. RRCs are not appropriate for use as LUT values.**

**USEPA recommends that DTSC should contract a laboratory that can achieve the lower of the two sigma UCL MDCs presented in Table 2.**

Section II (Priority Two radionuclides) includes those radionuclides that were not detected at concentrations exceeding the RRCs. Some of these radionuclides are Naturally Occurring Radioactive Material (NORM). During the USEPA's Area IV Radiological Study most of the analytical results that exceeded the DLs for NORM radionuclides of concern were evaluated and determined as not attributable to site-related activities. However, several NORM radionuclides were suspected as potential site-related activities and are included in Section I. Future results that exceed an LUT value for NORM will require careful evaluation to determine if the result is attributable to site-related activities.

USEPA recommends focusing analytical efforts on the radionuclides in Section I (Priority One radionuclides). This is expected to reduce analytical costs, accelerate the delivery of analytical data, and optimize overall data quality while achieving a cleanup closer to the BTVs by allowing the laboratory to focus its analytical resources on the most important radionuclides of concern. The method MDCs and the LUT values in Table 1 cannot be determined until after the final procurement of laboratory services. Table 3 provides a more detailed worksheet, including the formula for calculating LUT values using values derived from a hypothetical contract laboratory, and the required inputs from the laboratory procurement effort, which may be helpful in completing Table 1.

The BTVs in the LUT are displayed to three significant figures, which is consistent with the American National Standards Institute (ANSI) N42.23 recommendations for significant figures, and is believed to be generally appropriate for the quality of data generated in the background study (ANSI, 1996). A review of the process used to develop DLs indicates that three significant figures are appropriate for those values as well. USEPA recommends reporting the LUT values to three significant figures, after they are calculated.

In the decision making process of comparing sample results obtained during future investigations, remediation, and closure to the LUT values, USEPA recommends that LUT values are established as described in this memorandum. Once the LUT values are established by DTSC then individual sample results can be compared to the respective LUT values. If the individual sample result is equal to or greater than the LUT values then the sample is considered contaminated, thus requiring remediation, else the sample is considered not contaminated, thus not requiring remediation. Direct comparison of sample results to the BTVs, RTLs or RRCs is inappropriate. USEPA recommends that DTSC develop LUT values by following the process outlined in this memorandum.

**A sample is only considered contaminated if the sample result is equal to or greater than the respective LUT value, which DTSC will develop after procurement of laboratory services.**

**Comparing sample results to BTVs, RTLs, or RRCs is NOT appropriate because those values do not represent applicable LUT values.**

## 4.0 RECOMMENDATIONS

USEPA recommends using the BTVs in the development of LUT values for all future phases of investigation, remediation, and closure of the Area IV Study Area. In cases where the laboratory analytical data does not support the use of BTVs in the decision making process, specifically where the laboratory's MDC is greater than the BTV, that MDC should be used as an alternate cleanup level.

USEPA recommends establishing LUT values, to be used as decision-making criteria to determine whether the laboratory result supports a conclusion that the BTV has been exceeded for each radionuclide of concern.

USEPA recommends focusing the list of radionuclides analyzed by the laboratory to those that have been detected at concentrations above the respective RRCs in the Area IV Radiological Study (Priority One radionuclides).

USEPA recommends that a single laboratory is used for the development of the LUT values to avoid multiple MDCs and for analyses of all samples collected from all future phases of investigation, remediation, and closure of the Area IV Study Area.

Finally, USEPA recommends that a rigorous procurement process to obtain a single high quality analytical laboratory services may have advantages as summarized in this technical memorandum. As the majority of contamination is either cesium-137 or strontium-90, the analytical services contract should clearly state that the evaluation score will be weighted higher for responses that provide evidence of meeting the MQOs at or closest to the BTV value for those radionuclides. In addition, higher scores may be given to the strontium-90 analysis, since achieving the MQOs near the BTV is more technically challenging.

## 5.0 REFERENCES

American National Standards Institute (ANSI) N42.23-American National Standard Measurement and Associated Instrument Quality Assurance for Radioassay Laboratories, 1996, IEEE, New York, New York. August

Department of Toxic Substances Control (DTSC), 2010. Administrative Order On Consent For Remedial Action, Santa Susana Field Laboratory, Simi Hills, Ventura County, California. December.

HydroGeoLogic, Inc. (HGL), 2011. Final Radiological Background Study Report, Santa Susana Field Laboratory, Ventura County, California. October.

HGL, 2012b, Final Quality Assurance Project Plan for Soil Sampling, Area IV Radiological Study, Santa Susana Field Laboratory, Ventura County, California, Revision 01. March.

U.S. Environmental Protection Agency (USEPA), et. al., 2004, Multi-Agency Radiological Laboratory Analytical Protocols Manual, EPA-402-B-04-001A. July.

**ATTACHMENT 1**

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**Table 1**
**Example Lookup Table**

| Radionuclide | Symbol | BTV | Method MDC | LUT Values |
|---|---|---|---|---|
| ***Section I: Priority One Radionuclides*** (1) | | | | |
| actinium-228 | Ac-228 | 2.30 | (2) | (2) |
| bismuth-212 | Bi-212 | 2.04 | (2) | (2) |
| bismuth-214 | Bi-214 | 1.57 | (2) | (2) |
| cesium-137+D | Cs-137 | 0.193 | (2) | (2) |
| cobalt-60 | Co-60 | 0.00556 | (2) | (2) |
| europium-152 | Eu-152 | 0.0169 | (2) | (2) |
| lead-212 | Pb-212 | 2.67 | (2) | (2) |
| lead-214 | Pb-214 | 1.68 | (2) | (2) |
| nickel-59 | Ni-59 | 0.344 | (2) | (2) |
| plutonium-239/240 | Pu-239/Pu-240 | 0.0142 | (2) | (2) |
| strontium-90+D (Y-90) | Sr-90 | 0.0750 | (2) | (2) |
| thallium-208 | Tl-208 | 0.923 | (2) | (2) |
| thorium-230 | Th-230 | 2.04 | (2) | (2) |
| thorium-234 | Th-234 | 3.04 | (2) | (2) |
| uranium-233/234 | U-233/U-234 | 1.87 | (2) | (2) |
| uranium-235+D/236 | U-235/U-236 | 0.130 | (2) | (2) |
| uranium-238+D | U-238 | 1.68 | (2) | (2) |
| ***Section II: Priority Two Radionuclides*** (1) | | | | |
| actinium-227+D | Ac-227 | 0.127 | (2) | (2) |
| americium-241 | Am-241 | 0.0162 | (2) | (2) |
| americium-243+D | Am-243 | 0.0134 | (2) | (2) |
| antimony-125+D | Sb-125 | 0.321 | (2) | (2) |
| cadmium-113m | Cd-113m | 2,950 | (2) | (2) |
| carbon-14 | C-14 | 2.54 | (2) | (2) |
| cesium-134 | Cs-134 | 0.0300 | (2) | (2) |
| curium-243/244 | Cm-243/Cm-244 | 0.0147 | (2) | (2) |
| curium-245/246 | Cm-245/Cm-246 | 0.0162 | (2) | (2) |
| curium-247/248 | Cm-247/Cm-248 | 0.0234 | (2) | (2) |
| europium-154 | Eu-154 | 0.0251 | (2) | (2) |
| europium-155 | Eu-155 | 0.198 | (2) | (2) |
| holmium-166m | Ho-166m | 0.0365 | (2) | (2) |
| iodine-129 | I-129 | 2.08 | (2) | (2) |
| neptunium-236 | Np-236 | 0.0314 | (2) | (2) |
| neptunium-237+D | Np-237 | 0.0109 | (2) | (2) |
| neptunium-239 | Np-239 | 0.0427 | (2) | (2) |

**Table 1**
**Example Lookup Table (Continued)**

| Radionuclide | Symbol | BTV | Method MDC | LUT Values |
|---|---|---|---|---|
| ***Section II: Priority Two Radionuclides[1] (Continued)*** | | | | |
| nickel-63 | Ni-63 | 0.452 | (2) | (2) |
| niobium-94 | Nb-94 | 0.0165 | (2) | (2) |
| plutonium-236 | Pu-236 | 0.0184 | (2) | (2) |
| plutonium-238 | Pu-238 | 0.00425 | (2) | (2) |
| plutonium-241 | Pu-241 | 0.349 | (2) | (2) |
| plutonium-244+D | Pu-244 | 0.00156 | (2) | (2) |
| potassium-40 | K-40 | 30.5 | (2) | (2) |
| promethium-147 | Pm-147 | 4.96 | (2) | (2) |
| protactinium-231 | Pa-231 | 0.791 | (2) | (2) |
| radium-226+D | Ra-226 | 1.88 | (2) | (2) |
| sodium-22 | Na-22 | 0.00787 | (2) | (2) |
| technetium-99 | Tc-99 | 0.368 | (2) | (2) |
| thorium-228+D | Th-228 | 3.67 | (2) | (2) |
| thorium-229+D | Th-229 | 0.0462 | (2) | (2) |
| thorium-232 | Th-232 | 2.95 | (2) | (2) |
| thulium-171 | Tm-171 | 65.9 | (2) | (2) |
| tin-126 | Sn-126 | 0.00490 | (2) | (2) |
| tritium (H-3) organic | H-3 | 7.38 | (2) | (2) |

**Notes:**
[1]Determined during USEPA's Area IV Radiological Study based on comparison to the project Radiological Reference Concentrations.
[2]To be entered after laboratory procurement is completed.
All units reported in picocuries per gram.
BTV – background threshold value
+D – plus daughters
LUT – look-up table
MDC – minimum detectable concentration

**Table 2**
**Background Threshold Values and Two Sigma Upper Confidence Level Minimum Detectable Concentrations of USEPA's Contract Laboratories**

| Radionuclide | Symbol | BTV | Laboratory A Two Sigma UCL MDC(1) | Laboratory B Two Sigma UCL MDC(1) |
|---|---|---|---|---|
| ***Section I: Priority One Radionuclides(2)*** | | | | |
| actinium-228 | Ac-228 | 2.30 | 0.135 | 0.108 |
| bismuth-212 | Bi-212 | 2.04 | 0.220 | 0.163 |
| bismuth-214 | Bi-214 | 1.57 | 0.0419 | 0.0315 |
| cesium-137+D | Cs-137 | 0.193 | 0.0251 | 0.0198 |
| cobalt-60 | Co-60 | 0.00556 | 0.0252 | 0.0228 |
| europium-152 | Eu-152 | 0.0169 | 0.0670 | 0.0459 |
| lead-212 | Pb-212 | 2.67 | 0.0497 | 0.0319 |
| lead-214 | Pb-214 | 1.68 | 0.0479 | 0.0317 |
| nickel-59 | Ni-59 | 0.344 | 7.24 | 0.648 |
| plutonium-239/240 | Pu-239/Pu-240 | 0.0142 | 0.0369 | 0.00664 |
| strontium-90+D (Y-90) | Sr-90 | 0.0750 | 0.387 | 0.0677 |
| thallium-208 | Tl-208 | 0.923 | 0.0255 | 0.0213 |
| thorium-230 | Th-230 | 2.04 | 0.123 | 0.0156 |
| thorium-234 | Th-234 | 3.04 | 0.426 | 0.222 |
| uranium-233/234 | U-233/U-234 | 1.87 | 0.0997 | 0.0172 |
| uranium-235+D/236 | U-235/U-236 | 0.130 | 0.0751 | 0.0149 |
| uranium-238+D | U-238 | 1.68 | 0.0718 | 0.0143 |
| ***Section II: Priority Two Radionuclides(2)*** | | | | |
| actinium-227+D | Ac-227 | 0.127 | 0.267 | 0.169 |
| americium-241 | Am-241 | 0.0162 | 0.0410 | 0.0141 |
| americium-243+D | Am-243 | 0.0134 | 0.0372 | 0.00686 |
| antimony-125+D | Sb-125 | 0.321 | 0.0695 | 0.0502 |
| cadmium-113m | Cd-113m | 2,950 | 178 | 47.5 |
| carbon-14 | C-14 | 2.54 | 0.998 | 0.0983 |
| cesium-134 | Cs-134 | 0.0300 | 0.0231 | 0.0688 |
| curium-243/244 | Cm-243/Cm-244 | 0.0147 | 0.0466 | 0.0162 |
| curium-245/246 | Cm-245/Cm-246 | 0.0162 | No Data | 0.0123 |
| curium-247/248 | Cm-248 | 0.0234 | No Data | 0.0110 |
| europium-154 | Eu-154 | 0.0251 | 0.136 | 0.125 |
| europium-155 | Eu-155 | 0.198 | 0.0949 | 0.0438 |
| holmium-166m | Ho-166m | 0.0365 | 0.0362 | 0.0302 |
| iodine-129 | I-129 | 2.08 | 0.525 | No Data |
| neptunium-236 | Np-236 | 0.0314 | 0.0495 | 0.0368 |
| neptunium-237+D | Np-237 | 0.0109 | 0.0542 | No Data |

## Table 2
## Background Threshold Values and Mean Minimum Detectable Concentrations of USEPA's Contract Laboratories (Continued)

| Radionuclide | Symbol | BTV | Laboratory A Two Sigma UCL MDC(1) | Laboratory B Two Sigma UCL MDC(1) |
|---|---|---|---|---|
| ***Section II: Priority Two Radionuclides(2) Continued*** | | | | |
| neptunium-239 | Np-239 | 0.0427 | 0.177 | 0.102 |
| nickel-63 | Ni-63 | 0.452 | 1.78 | 0.843 |
| niobium-94 | Nb-94 | 0.0165 | 0.0213 | 0.0172 |
| plutonium-236 | Pu-236 | 0.0184 | 0.0510 | 0.0107 |
| plutonium-238 | Pu-238 | 0.00425 | 0.0480 | 0.00921 |
| plutonium-241 | Pu-241 | 0.349 | 3.73 | No Data |
| plutonium-244+D | Pu-244 | 0.00156 | 0.0259 | 0.00526 |
| potassium-40 | K-40 | 30.5 | 0.213 | 0.186 |
| promethium-147 | Pm-147 | 4.96 | 8.62 | No Data |
| protactinium-231 | Pa-231 | 0.791 | 1.11 | 0.693 |
| radium-226+D | Ra-226 | 1.88 | 0.151 | No Data |
| sodium-22 | Na-22 | 0.00787 | 0.0306 | 0.0295 |
| technetium-99 | Tc-99 | 0.368 | 1.75 | 0.387 |
| thorium-228+D | Th-228 | 3.67 | 0.183 | 0.0300 |
| thorium-229+D | Th-229 | 0.0462 | 0.135 | 0.0165 |
| thorium-232 | Th-232 | 2.95 | 0.0877 | 0.0139 |
| thulium-171 | Tm-171 | 65.9 | 23.0 | 7.63 |
| tin-126 | Sn-126 | 0.00490 | 0.0233 | 0.0195 |
| tritium (H-3) organic | H-3 | 7.38 | 9.99 | 0.284 |

**Notes:**
(1)Two Sigma UCL MDCs represent a benchmark for expected limits of achievable MDCs by commercial laboratories. Two Sigma UCL MDCs were calculated from 3,772 sample results from USEPA's Area IV Radiological Study. Datasets for calculating the two sigma UCL MDCs ranged from 14 to 2,464 samples, depending on the radionuclide and laboratory.
(2)Determined during USEPA's Area IV Radiological Study based on comparison to the project Radiological Reference Concentrations.
(3)Less than 50 results were used in the calculation of the two sigma UCL MDCs, thus use of this value warrants caution.
All units reported in picocuries per gram.
BTV – background threshold value
+D – plus daughters
MDC – minimum detectable concentration
Two Sigma UCL – two sigma (97.7 percent confidence level of the standard normal cumulative probability) upper confidence limit (UCL)

# Table 3
## Example Worksheet for Determining Project Decision Levels

| Background Study[1] | | | Example Laboratory Contract[2] | | Development of Example LUT Levels[3] | | |
|---|---|---|---|---|---|---|---|
| **Radionuclide** | **Symbol** | **BTV** | **Laboratory Activity Meeting a 10% Uncertainty[4]** | **Laboratory Method MDC** | **Cleanup Level** | **Estimated Uncertainty at Cleanup Level** | **Example LUT Values** |
| | Column: | C | D | E | F | G | H |
| | Equation: | | | | =MAX(C,E)[5] | =IF(F>D,0.1*F,0.1*D)[5] | =F+(1.645*G)[5] |
| cesium-137+D | Cs-137 | 0.193 | 0.0727 | less than BTV | 0.193 | 0.0193 | 0.225 |
| cobalt-60 | Co-60 | 0.00556 | 0.0889 | 0.0240 | 0.0240 | 0.00889 | 0.0387 |

**Notes:**
[1]Values derived from the USEPA's Radiological Background Study.
[2]Values represent example values derived from a hypothetical contract laboratory and provided for illustrative purposes only. These values must be replaced with actual values from the contracted laboratory.
[3]Example LUT values are derived from the example values of the hypothetical laboratory. These values are calculated automatically after updated values are entered in the "Example Laboratory Contract" columns.
[4]Uncertainty is defined as the one sigma combined standard uncertainty. Uncertainty requirement is 10 percent when a value is equal to the BTV.
[5]Equations represent a formula to be entered into the rows below. Letters denote the respective column to be used in the formula.
All units reported in picocuries per gram.
BTV – background threshold value
+D – plus daughters
LUT – look-up table
MDC – minimum detectable concentration

**ATTACHMENT 2**

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## Development of Lookup Table Decision Levels