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:

Radionuclides with one BTV for all results: 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).

Radionuclides with statistically different surface and subsurface soil BTVs: 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.

Radionuclides with statistically different BTVs based on geologic formations: 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).

Radionuclides with statistically different BTVs for RBRAs: 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).

Radionuclides with statistically different BTVs for datasets: 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

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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
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**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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								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