APPENDIX L
GAMMA LIBRARY

THIS PAGE INTENTIONALLY LEFT BLANK.

Science Applications International Corporation
An Employee-Owned Company

Date: 4/21/2005

To: Steve Passig, CHP

Cc: Martin Swanson, RI Field Manager

From: Steven Howard, SAIC Analytical Laboratory Manager

RE: Gamma Spectroscopy Library and RCOPC Assessment
Westinghouse/Hematite Remedial Investigation

Purpose:

The initial Westinghouse Hematite site characterization and background soil results contain data for several radionuclides that have no basis for being present at the facility, and have half-lives that rule out current existence. Provided below is an evaluation of these gamma spectroscopy results, primarily addressing false positive (Type-I error) results due to spectral interferences and the standard system report template. The objectives of this document are to provide technical justification for removing these radionuclides from future consideration as Radiological Constituents of Potential Concern (RCOPC) and to provide recommendations for a revised gamma library.

Basis of Review:

Characterization samples were submitted to Paragon Analytics for analysis of radionuclides by gamma spectroscopy – this method allows for quantification of multiple nuclides simultaneously, without chemical separation. As with other commercial laboratories, a broad isotopic gamma library was utilized when conducting the analyses. In gamma spectroscopy, the instrument's software compares detected/observed gamma rays with the known energy listed in the library, enabling the "identification" or quantification of nuclides present in the sample.

However, due to the lack of chemical separation, all nuclides within the sample will contribute their respective disintegration(s) to the spectrum. The software will attempt to identify and quantify all the isotopes that are listed in the gamma library – the Paragon library contained over 40 isotopes. If two isotopes have the same or similar gamma emission energies, the system will likely report a false positive for one or both of the nuclides. This is especially true when a sample comes from a site containing elevated levels of thorium, radium or uranium. These nuclides may lead one to falsely conclude that the site is contaminated with unrelated radioactivity or believe that there is an excessive amount of naturally occurring radioactive material (NORM) or technologically enhanced NORM (TENORM).

Often laboratories will address these issues with data qualifiers and/or in the case narrative. However, when data are processed or transmitted electronically, often the results are imported without qualifiers and accompanying documentation from the case narrative(s).

There are algorithms available in most spectroscopy software that can adjust for spectral interference and correct one or both isotopes accordingly. However, the variance in background, gamma-ray yield, number of emissions per isotope, gamma-ray energies, contaminant levels, detector sensitivity, and other variables prohibit the ability to consistently and accurately rely on the correction by the software without data verification. In some cases, the spectroscopist or the software will flag the sample data with qualifiers, in this case 'SI', to note that there was spectral interference in the respective energy region.

Another situation that can occur when using a broad scope gamma library is the "forced reporting" of isotopic concentrations when there was no identified peak. The system selects the energy region where the listed isotope's gamma-ray (primary key line) would be detected. If there are insufficient counts to statistically determine that a peak is present, then the software will simply report the activity observed in that area. Due to a standard library (for all clients) with a tandem report, an isotopic concentration will still be reported, though not detected/identified. Though the data can be flagged, in this case 'TI', as being tentatively identified, count statistics and the addition of other activity result in "positive" values, just above minimum detectable concentrations. Further complicating matters, these isotopes' gamma lines/energies often have high abundance or yields, which drive down the detection limit. As with the spectral interference example, the values can be falsely carried into the reporting process and be considered as potential contaminants.

<u>False Positives – Spectral Interference (SI):</u>

The following table lists the nuclides that were frequently reported as positive as a result of spectral interference. The naturally occurring and/or known site RCOPCs that would cause the spectral interference is provided to substantiate the removal of the isotope from consideration.

TYPE I Error Radionuclide	*Primary Gamma Ray Energy (keV) at % yield*	*RCOPC or NORM Isotope interfering*	*Primary Energy of Interferer (keV)*	*Routine Lab Qualifier*	*Historical Basis for Site Presence?*
Cd-109	88.04 @ 3.6%	Pb-212, 214 (U series)*	87.2*	SI	No
Eu-155	86.5 @ 30.9%	Pb-212, 214 (U series)*	87.2*	SI	No
Eu-155	105.3 @ 20.67%	Ac-228	105.0	SI	No
Mn-54	834.8 @ 99.98%	Ac-228	835.6	SI	No
Nb-95	765.8 @ 99.8%	Pa-234m (U daughter)	766	SI	No

* Between approximately 70-90 keV excess X-rays, especially in higher activity level samples, negatively impacts detector discrimination.

No Peak Identification and/or Short Half-life with No Source Material

The table below provides a listing of the nuclides that were NOT identified but generated frequent false positives. The associated half-life is also provided along with a determination if potential source material is present at the site.

TYPE I Error Radionuclide	*Primary Gamma Ray Energy (keV) at % yield*	*Lab Qualifier*	*Isotope Half Life*	*Source Material Present?*	*Historical Basis for Site Presence?*
Co-56	846.8 @ 100%	TI (no peak)	77 days	No	No
Co-57	122 @ 85.6%	TI (no peak)	271 days	No	No
Co-58	810.78 @ 99%	TI (no peak)	71 days	No	No
Cr-51	320.08 @ 10%	TI (no peak)	28 days	No	No
Cs-134	604.7 @ 97%	TI (no peak)	747 days	No	No
	795.9 @ 86%	TI (no peak)	747 days	No	No
Ag-110m	657.8 @ 94%	TI (no peak)	250 days	No	No
Al-26*	1808.6 @ 99%	TI (no peak)	717k years	No	No
Be-7	477.6 @ 105%	TI (no peak)	53 days	Yes**	Yes**
Eu-152	121.8 @ 28.6%	TI (no peak)	13.5 years	No	No
	344.29 @ 26.5%	TI (no peak)	13.5 years	No	No
	1408.0 @ 21.0%	TI (no peak)	13.5 years	No	No
Eu-154	123 @ 40%	TI (no peak)	8.8 years	No	No
	1274.5 @ 35%	TI (no peak)	8.8 years	No	No
Fe-59	1099.3 @ 56.5%	TI (no peak)	45 days	No	No
	1291.6 @ 43.2%	TI (no peak)	45 days	No	No
Na-22	1274.5 @ 99.9%	TI (no peak)	2.6 years	No	No
Ru-106	511.9 @ 20.6%	TI (no peak)	374 days	No	No
Sb-124	602.7 @ 97.9%	TI (no peak)	60 days	No	No
Sc-46	889.3 @ 99.9%	TI (no peak)	84 days	No	No
	1120.5 @ 99.9%	TI (no peak)	84 days	No	No
Zn-65	1115.5 @ 50.6%	TI (no peak)	244 days	No	No

* High yield of line results in a low MDC for isotope, increases likelihood of false positive.

** Naturally occurring radioactive material.

Recommended Library Modification:

Provided below is the library used during the remedial investigation at the Hematite site. Included are the recommended modifications for consideration in future analyses to avoid these Type-I errors. Using the information provided above, along with eliminating isotopes that were reported with no detectable concentrations – shaded isotopes should be removed.

Radionuclide	*Comment*
Actinium-228	
Aluminum-26	No peak identification, TI, no source material
Americium-241	
Antimony-124	Not detected
Antimony-125	Not detected
Beryllium-7	Not detected, recommend maintaining as NORM marker.
Bismuth-212	Maintain as confirmation of other RCOPCs
Bismuth-214	Maintain as confirmation of other RCOPCs
Cadmium-109	Spectral Interference, no source material
Cerium-139	Not detected
Cerium-144	Not detected
Cesium-134	No peak identification, TI, no source material
Cesium-137	Maintain as appropriate indicator of fission products.
Chromium-51	No peak identification, TI, no source material
Cobalt-56	No peak identification, TI, no source material
Cobalt-57	No peak identification, TI, no source material
Cobalt-58	No peak identification, TI, no source material
Cobalt-60	Maintain as appropriate indicator of fission products.
Europium-152	No peak identification, TI, no source material
Europium-154	No peak identification, TI, no source material
Europium-155	Spectral Interference, no source material
Iodine-131	Not detected
Iron-59	No peak identification, TI, no source material
Lead-212	Maintain as confirmation of other RCOPCs
Lead-214	Maintain as confirmation of other RCOPCs
Manganese-54	Spectral Interference, no source material
Neptunium-237	
Niobium-94	Not detected, no source material
Niobium-95	Spectral Interference, no source material
Potassium-40	Not detected, recommend maintaining as NORM marker.
Protactinium-234	
Ruthenium-106	No peak identification, TI, no source material
Scandium 46	No peak identification, TI, no source material
Silver-110	No peak identification, TI, no source material
Sodium-22	No peak identification, TI, no source material
Thallium-208	Not detected
Thorium-227	
Thorium-234	
Uranium-235	
Zinc-65	No peak identification, TI, no source material