HNF-56300 -FP
Revision 0, Draft

Radiological Assessment for the Removal of Legacy BPA Power Lines that Crossed the Hanford Site - 14039

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

P.O. Box 650
Richland, Washington 99352

HNF-56300 -FP
Revision 0, Draft

Radiological Assessment for the Removal of Legacy BPA Power Lines that Crossed the Hanford Site - 14039

W. J. Millsap
Mission Support Alliance

D. J. Brush
Mission Support Alliance

Date Published
November 2013

To be Presented at
WM 2014 Conference

Waste Management Symposium
Phoenix, Arizona

03/02/2014 - 03/06/2014

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728

P.O. Box 650
Richland, Washington 99352

Printed in the United States of America

Radiological Assessment for the Removal of Legacy BPA Power Lines that Crossed the Hanford Site – 14039 (Draft)

William J. Millsap *, Daniel J. Brush *
* Mission Support Alliance

ABSTRACT

This paper discusses some radiological field monitoring and assessment methods used to assess the components of an old electrical power transmission line that ran across the Hanford Site between the production reactors area (100 Area) and the chemical processing area (200 Area). This task was complicated by the presence of radon daughters—both beta and alpha emitters—residing on the surfaces, particularly on the surfaces of weathered metals and metals that had been electrically-charged. In many cases, these activities were high compared to the DOE *Surface Contamination Guidelines*, which were used as guides for the assessment. These methods included the use of the Toulmin model of argument—represented using Toulmin diagrams-- to represent the combined force of several strands of evidences, rather than a single measurement of activity, to demonstrate beyond a reasonable doubt that no or very little Hanford activity was present and mixed with the natural activity. A number of forms of evidence were used: the overall chance of Hanford contamination; measurements of removable activity, beta and alpha; 1-minute scaler counts of total surface activity, beta and alpha, using "background makers"; the beta activity to alpha activity ratios; measured contamination on nearby components; NaI gamma spectral measurements to compare uncontaminated and potentially-contaminated spectra, as well as measurements for the sentinel radionuclides, Am-241 and Cs-137 on conducting wire; comparative statistical analyses; and *in-situ* measurements of alpha spectra on conducting wire showing that the alpha activity was natural Po-210, as well as to compare uncontaminated and potentially-contaminated spectra.

INTRODUCTION

Bonneville Power Administration (BPA) owned an electrical transmission line with several conductors that crossed the Hanford Site and which had been in operation for seven decades. See Figure 1 for a map of the transmission line. This transmission line was being replaced with a new line following a somewhat different routing across the site. BPA wished to dispose of many of the components of the old transmission line as uncontaminated material, and, in particular, it wished to recycle the metal, especially the large amount of valuable bare, copper conductor. There were about 30 miles of three-phase copper conducting wire and about 10 miles of three-phase aluminum wire. The metal was estimated to be worth about $1.5 million. To support this plan, BPA asked the Mission Support Alliance (MSA), a Hanford contractor, to assess the likelihood that the components of the transmission line were contaminated with radionuclides from Hanford, and if so, was the contamination likely to exceed the DOE *Surface Contamination Guidelines*.

MSA planned and implemented a detailed survey of the components of the transmission line. The following components were surveyed: wooden poles (two per structure); the cross arms that braced the two poles for each structure; the electrical insulators; and the conductors. Figure 2 shows a photograph of typical poles, a cross arm and insulators. The types of surveys performed were alpha radioactivity and beta-gamma radioactivity scan surveys; 1-minute scaler counts for both alpha and beta-gamma radioactivity (these measure the actual count in one minute, rather than a count rate); removable radioactivity surveys for both alpha and beta-gamma radioactivity; *in-situ* alpha spectrometry on the conducting wire; and *in-situ* gamma spectroscopy on the conducting wire. Conducting wire samples were cut into short pieces, laid side-by-side on a wooden board to form "wire sheets." Radiological measurements were taken of these wire sheets. These measurements are discussed further below.

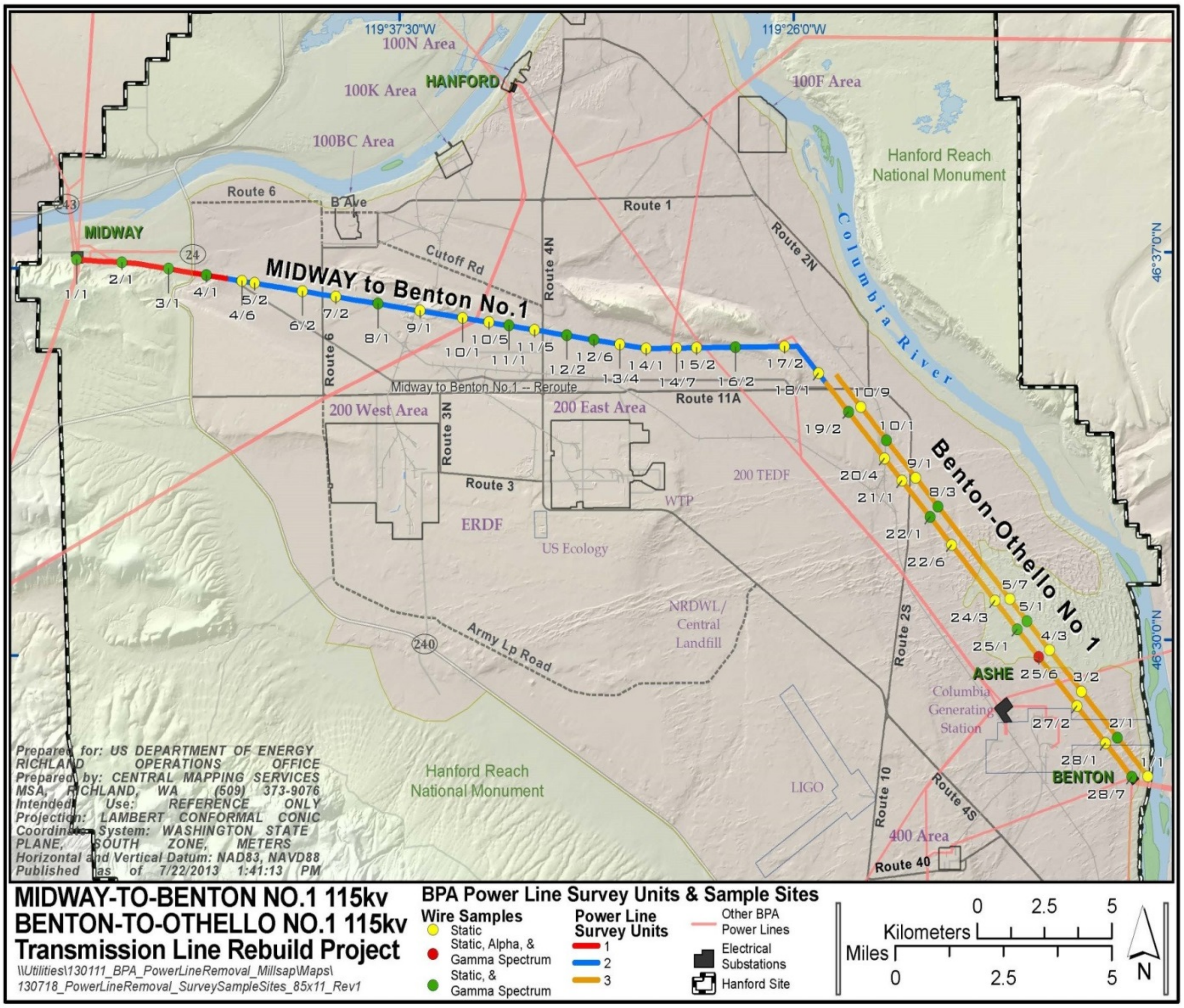


Fig. 1 Map Showing Power Lines, Survey Units, and Sample Sites

Fig. 2 Photo Showing Poles, Cross Arm and Insulators

BACKGROUND

In order to make the discussion of methods and techniques below understandable, it is first necessary to review some background information.

Natural Radioactivity on Surfaces

Many surfaces at Hanford, particularly weathered, metal surfaces and surfaces of material and equipment that have been electrically charged, exhibit natural beta and alpha radioactivity from the U-238 decay chain. The levels of these activities, particularly fixed alpha activities, are often greater than the default limits for the clearance of personal property used by MSA and, historically, at Hanford. The default values used are the most restrictive ones from the DOE *Surface Contamination Guidelines*: For alpha, these are 20 dpm/100cm^2, removable, and 100 dpm/100cm^2, total, and for beta 1,000 dpm/100cm^2, removable, and 5,000 dpm/100cm^2, total. Personal property with surface activity greater than any of these values is held until it can be shown that the activity is natural and not man-made. This has resulted in a large amount of personal property, particularly property that has previously been electrically charged, being held on-site, because there has been no practical, cost-effective means to demonstrate that the activity is natural and not Hanford-made.

Some explanation of the natural radioactivity found is in order. Evans (Evan 1980) notes "A typical value for the flow of radon from ordinary surface soils into the atmosphere is 10E-16 Ci/sec-cm^2, or about 0.1 microCi/day per square yard. This radon is diluted in the atmosphere so that typical values for the radon concentration in outdoor air are in the domain 0.1-1 pCi per liter of air." Evans further notes in Table 1 of his paper that the number of atoms for 100 pCi of Rn-222 is 1,770,000. Thus, we can estimate that the number of atoms of Rn-222 per liter of air is about 10,000 atoms/liter of air. Assuming that there are about as many charged radon daughters as radon in the air, there are about 10,000 atoms of charged radon daughters per liter of air around bare conducting wire and other surfaces. These atoms are being continuously resupplied from the U-238 in the soil.

Many of these charged atoms apparently attach to dust particles, which are then electrically attached to the wire. The bright copper wire is, after years of service, a shiny black, which is likely the buildup of dust particles and chemical compounds on the surface of the wire. See the photo in Figure 5, below. When wire is immediately de-energized, there is a lot of surface activity that decays very quickly (early radon daughters) leaving activity that decays slowly. The early, short-lived radon daughters decay quickly to lead-210, which has a 22.2 year half-life. Lead-210 beta decays to bismuth-210 (5 day half-life), which in turn beta decays to polonium-210. Polonium-210 has a 138 day half-life and alpha decays to stable lead-206. Since lead-210 has a half-life of 22.2 years, the activity on the wire decays very slowly and will remain for many decades.

Similarly, uncharged, weathered metal, particularly rusted metal, also, apparently by chemical attraction, accumulates natural alpha activity, although not to the level found on electrical wire. The alpha activity has been found to be Po-210, and there is also an energetic beta component present. This is also believed to be due to the sequence Pb-210, Bi-210 and Po-210 to stable Pb-206.

This explanation is consistent with field observations, since bare conducting wire collected years ago from a background area is still radioactive, and activity on weathered metal is also long-lived. Also, the alpha radioactivity measured on the wire has been shown to be due to polonium-210. The alpha detector is also sensitive to high energy beta particles from bismuth-210 that are present in the spectra measured. See Figure 8, below, and the associated discussion.

Thus, in summary, the partial radon decay chain believed to be causing the natural activity is

	22.2 y		5 d		138 d	
Pb-210	→	Bi-210	→	Po-210	→	Pb-206 (stable)
	low-energy beta		1.16 MeV beta 100%		5.3 MeV alpha 100%	

The overall decay rate is determined by Pb-210 at 22.2 years; the observed high-energy beta particle is supplied by Bi-210; and the alpha particle is supplied by Po-210.

Hanford Inter-Facility Area Contamination Guidelines

Hanford is a large site and much of it is at some distance from contaminated facilities. Within these areas that are not near a facility, referred to as the inter-facility area, it is possible to conservatively estimate the relative proportions of natural and Hanford-made activity generally present. The proportion of gross alpha activity generally measured that is of Hanford origin is unlikely to exceed 10% in the inter-facility area. Also, since beta activity is not normally limiting, the proportion of natural beta activity to Hanford-made beta activity is not normally estimated, and all beta activity is assumed to be from Hanford. Furthermore, 10% of the beta activity is assumed to be hard-to-detect, that is, not readily detectable with commonly-used field survey instruments.

Based on this conservative assessments of the amount of natural, alpha radioactivity present in the inter-facility area and the amount of hard-to-detect, beta-gamma radioactivity present, inter-facility gross activity guideline values have been established:

Total alpha surface radioactivity: 1,000 dpm/100 cm^2

Removable alpha surface radioactivity: 200 dpm/100 cm^2

Total beta-gamma surface radioactivity: 4,500 dpm/100 cm^2

Removable beta-gamma surface radioactivity: 900 dpm/100 cm^2

The inter-facility values cannot usually be applied to electrified wire, because the inter-facility values weren't derived for such an environment. The electromagnetic attraction of charge radon daughters over decades results in the long-term buildup of natural radioactive material on the wire. This is discussed further below.

Potential Means of Contamination and Radionuclides of Concern

The means of contamination are wind transport and biological transport. The wind could have blown airborne activity from the many facilities and burial grounds. A common biological vector is bird droppings on poles from birds that have become contaminated with radioactive material. Contaminated bird nests are an occasional occurrence. Contaminated coyote urine on the bases of poles is another potential vector.

Given the many possible sources of contamination, it is practical to consider a set of widely dispersed radionuclides, rather than every possible radionuclide. The radionuclides of concern were Cs-137, Sr-90, Co-60, U-234, U-235, U-238, Pu-239/240 and Am-241. Sr-90 is an easily-detectable beta emitter; Cs-137 and Co-60 are easily-detectable gamma emitters; and U-234, U-235, U-238, Pu-239/240 and Am-241 are all easily-detectable alpha emitters.

Cs-137 serves as a sentinel radionuclide for fission products—signaling the potential presence of other fission products—because it is the most abundant photon-emitter in the inter-facility area and has an easily-detectable 662 keV photon. Am-241 is the most abundant transuranic in the inter-facility area and has a relatively easy to detect 60 keV photon; it is used as a sentinel radionuclide for transuranics in the inter-facility area.

Survey Units

The BPA transmission lines were divided into three survey units for two reasons: (1) To set aside a part of the transmission line that has a particularly low chance of contamination as a background reference area; and (2) to divide the part of the line that runs across the site between the 100 Area and the 200 Area from the part that runs roughly parallel to the Columbia River, since they have different potentials for contamination. The background area to the west is called Survey Unit 1; the part that runs across the site is Survey Unit 2; and the part that runs roughly parallel to the river is Survey Unit 3. See Figure 1; *Map Showing Power Lines, Survey Units, and Sample Sites*.

METHODS AND TECHNIQUES USED TO ASSESS SURFACE RADIOACTIVITY

This section individually describes the methods and techniques used to assess the surface radioactivity on the components of the electrical transmission lines. The integrating idea, the Toulmin model of argument, is used to combine the other methods and techniques into an overall assessment of the likelihood of Hanford-made activity on the components. Examples of Toulmin diagrams, used to represent Toulmin's model of argument, are shown in the next section.

Toulmin Model of Argument

In 1958 Stephen Toulmin[1], then Chair of the Department of Philosophy at the University of Leeds, published *The Uses of Argument* (Toulmin 2003), a work in epistemology. In it Toulmin argued that the discipline of logic had become so narrow in its focus that it was essentially useless for any actual problems that exist in day-to-day life. That is, this model of arguments requires such clarity and simplicity that it is unsuitable for many actual problems that are not clear and simple. Toulmin concluded that the more general and procedural model of jurisprudence would serve practical decision-making better than the more narrow confines of mathematics. From the model given by jurisprudence, he derived a single model of argument.

Toulmin diagrams are used to summarize the arguments why the available evidence justifies the conclusions that the surface contamination levels on the personal property are less than the DOE *Surface Contamination Guidelines*. Since the DOE *Surface Contamination Guidelines* are often small compared to the levels of natural activity present, particularly on electrical equipment, simple, direct measurements of surface activity cannot always be used to assess the presence of Hanford radioactivity. To do this, several different strands of information have to be pulled together to make the case whether or not Hanford activity is present beyond the DOE *Surface Contamination Guidelines*.

The basic structure of the Toulmin model has three components: the *claim* that is being advanced (asserted), the *data* or *information* that supports the claim, and the *warrant* (basis) that allows one to draw the desired conclusion (claim) from the data or information given. See Figure 3, *Toulmin's Basic Model of Argument*, for a schematic representation.

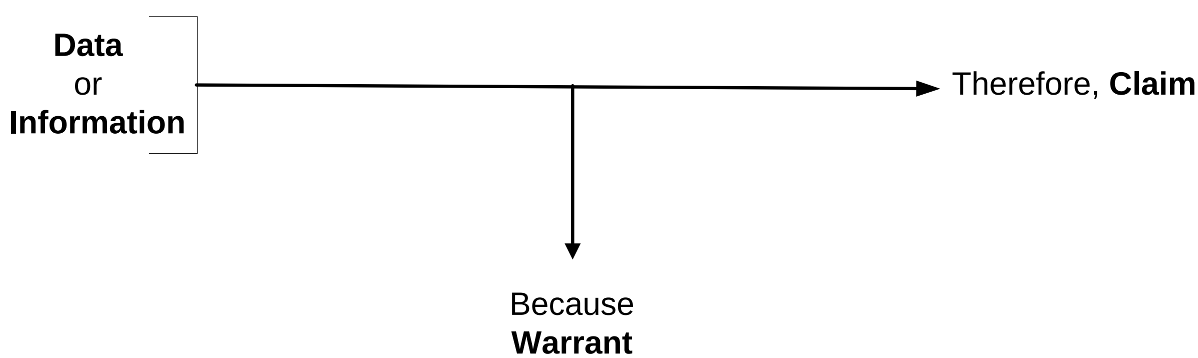


Fig. 3 ~~Toulmin' s~~Toulmin's Basic Model of Argument

In Figure 3, the claim that we are trying to establish is shown to the right of the arrow; the data or information that we are using to show that the claim is true shown to the left of the arrow; and the reason that allows us to say that the data or information establishes the claim, the warrant, is shown underneath the arrow, after the word Because. Thus, the data or information allows us to conclude that a certain claim is true, because certain facts, the warrant, are true.

[1] Stephen Toulmin (1922-2009) was born in London, England. He was educated at Cambridge, earning a PhD in philosophy in 1950. His philosophical work primarily analyzed moral reasoning. He is perhaps best known for the Toulmin model of argument. He taught at Cambridge, Leeds and a number of American universities, including Columbia, Stanford, Chicago and Southern California.

In the case of the clearance of personal property, the claims, the things that are claimed to be true, are often the regulatory requirements that have to be met for an item to be cleared from DOE radiological control. The data or information, such as radioactive contamination measurements and process knowledge, are the things that the claims are based on. Finally, there are the facts, often the regulations, which allow us to logically get from the data or information to the claim we wish to support. An example makes it easy to see.

Suppose we have a piece of metal that we wish to clear from DOE radiological control, and we believe that the metal is not contaminated with radioactivity of Hanford origin beyond the values of DOE O 5400.5, Figure IV-1[2]. Suppose further, for the sake of the example, that we know that the potential contaminants are all beta-gamma emitters subject to the beta-gamma row in DOE O 5400.5, Fig. IV-1. We take some surface measurements and determine that the highest total contamination value is 3500 dpm/100 cm^2, and no removable contamination is found down to a detection limit of 100 dpm/100 cm^2. Using this information, the argument for clearance can be represented by Figure 4, *Example Showing Toulmin' s Basic Model of Argument*.

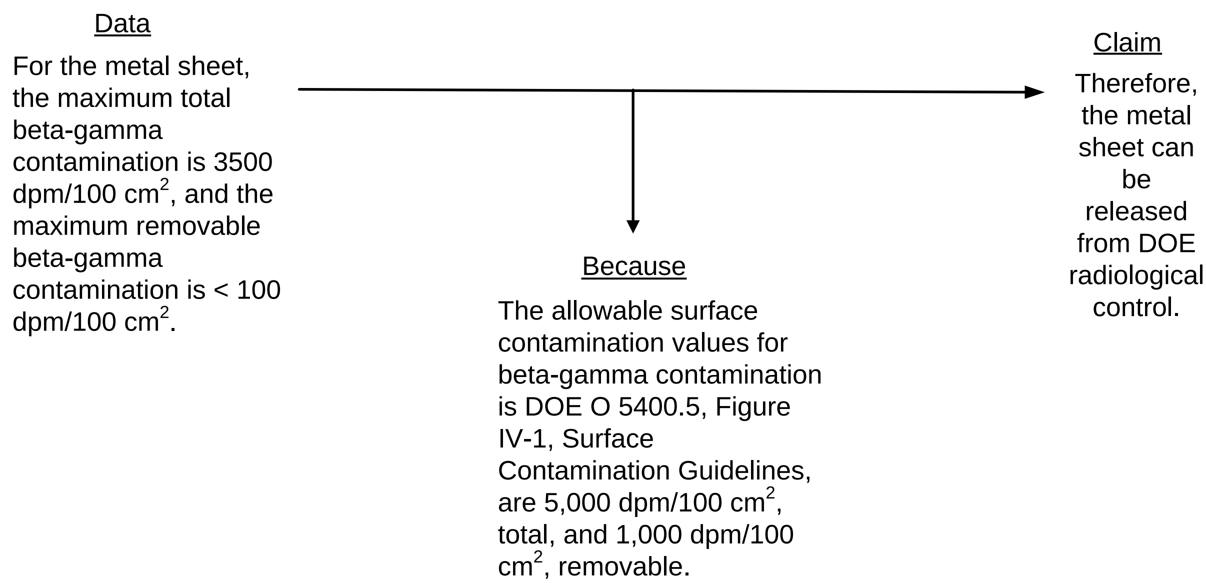


Fig. 4 Example Showing Toulmin's Basic Model of Argument

In some arguments, the claim is established not by a single line of argument, but by several lines of arguments that collectively establish the claim beyond a reasonable doubt. In this case, the diagram shows several arrows going into a single claim. This was done in this work, as discussed below and shown in Figures 10 and 11. It should be noted that there are three additional optional components to the Toulmin model that are not used here; these components provide for qualifiers, rebuttals and backing; see Toulmin' s book (Toulmin 2003) for further information. Another discussion of the Toulmin model is given by Zarefsky (Zarefsky 2005).

Assessment of the Overall Likelihood of Hanford-Made Contamination

In each case, a qualitative (judgmental) assessment was made of the overall likelihood of Hanford-made activity on the components. In all cases, since the power transmission lines were in the inter-facility area, the likelihood of Hanford-made contamination was judged to be

---

[2]*These values are acceptable under the present order, DOE O 458.1.*

low. As discussed above, these power transmission lines had been in the presence of charged radon daughters for decades. In contrast, Hanford man-made activity would have been, at most, sporadically present. Thus, one would expect a low level of risk.

Scan Surveys

Scan surveys were performed with commonly-used beta survey instruments (end-window GM detectors) and alpha survey instruments (ZnS scintillators). They were performed mainly to detect potential contamination from biological vectors, such as contaminated bird droppings and coyote urine.

Removable Surface Contamination

Removable surface contamination was assessed using smear paper.

Total Surface Contamination

Total surface contamination was assessed using 1-minute scaler counts using an end-window GM detector for beta activity and a ZnS scintillator for alpha activity. In almost all cases, the background activity was assessed using a "background maker," which is an uncontaminated piece of material as close to the material being measured as could be found. This sometimes makes a substantial difference for beta activity, but significantly less for alpha activity.

Beta Activity to Alpha Activity Ratios

Beta activity to alpha activity ratios were assessed as indicators of the presence of Hanford-made radioactivity. Based on technical studies, the beta activity to alpha activity ratios at Hanford are significantly greater for Hanford-made activity than for natural activity. For Hanford-made activity, the ratios are generally on the order of one to a few hundred, while for natural activity the ratios are generally less than 10 to 20, usually less than 10. These ratios were assessed by type of component within survey units using the mean values for surface activity for the component and survey unit.

Descriptive Statistics of Activity

For each type of component and for each survey unit, descriptive statistical values were calculated using JMP statistical software from SAS Institute, Inc (SAS 2008). These statistical values were reviewed by an analyst to see if there were any indications of marked, unexplained differences between survey units. Since Survey Unit 1 was essentially background, if there were not unusual differences between the statistical values in a given survey unit and Survey Unit 1, it was taken as evidence that there was no Hanford-made activity in the given survey unit, since significant differences should show up in the distribution or other descriptive statistical values.

Measured Activity on Co-Located Components

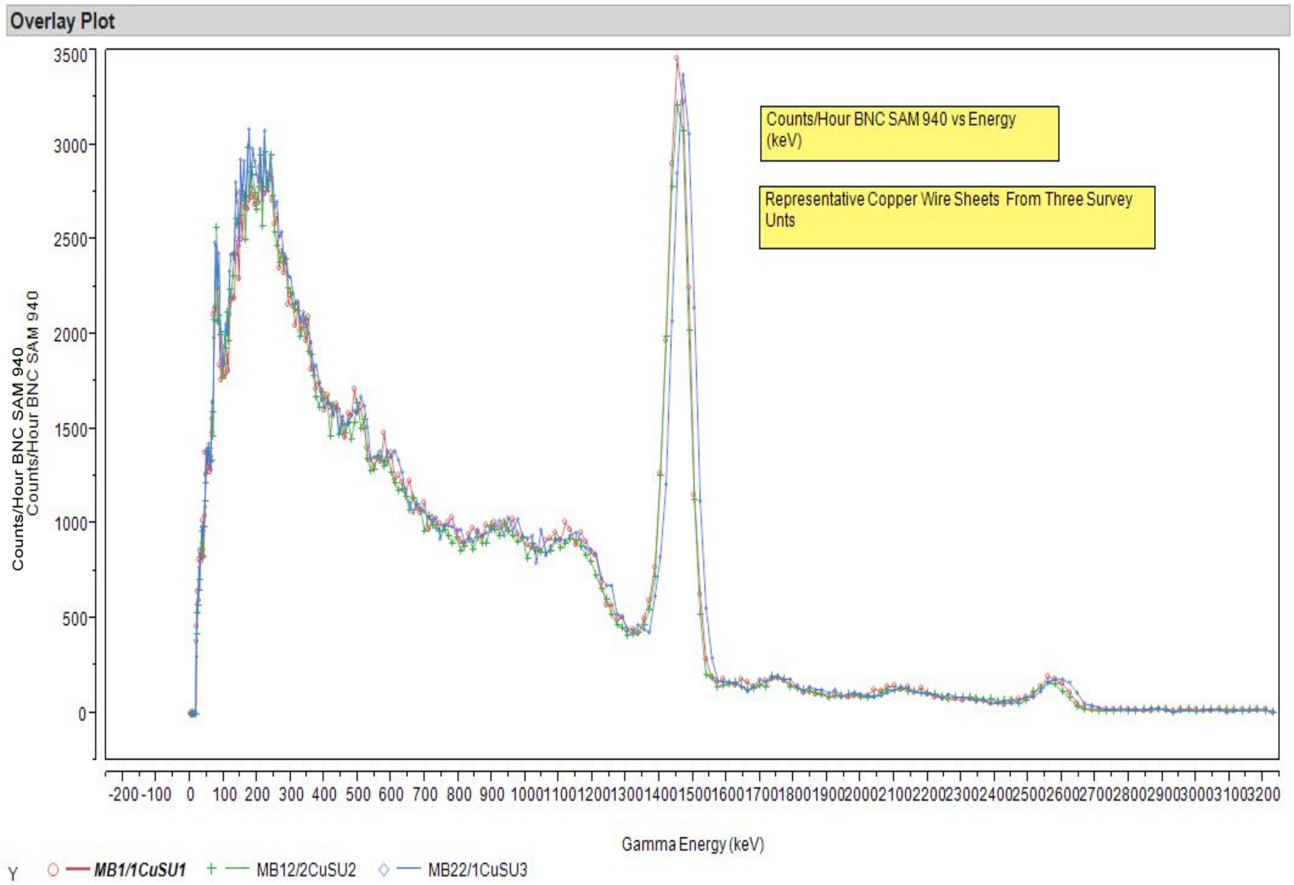
If a set of co-located components (say, metal beams) had been analyzed and found to be contaminated to a high degree of certainty only with natural activity, then this is taken as some evidence that other components (say, ceramic insulators) are also likely to be free from Hanford activity.

In-situ Gamma Spectral Measurements for Sentinel Radionuclides on Conducting Cable

As mentioned above, the inter-facility limits cannot be used with the bare, conducting cable, since the inter-facility values were not derived for conditions where strong electromagnetic fields were attracting radon daughters. Thus, to further investigate the activity on the conducting cable, the photon spectra from the "wire sheets" made from wire samples were taken from Survey Units 2 and 3 (potentially contaminated conducting cable) and compared to that from the background survey unit, Survey Unit 1. See Figure 5.

Fig. 5 Photo Showing Wire Sample

Photon spectra were taken from the cable samples (wire sheets) using a Berkeley Nucleonics Corporation SAM-940 3-Inch NaI detector, and the spectra analyzed using Los Alamos National Laboratory's *PeakEasy* spectrum analysis software (LANL, 2012). A direct comparison to the background survey unit, Survey Unit 1, was made by overlaying wire sheet spectra from Survey Units 2 & 3 using JMP. As an example, see Figure 6, which shows 1-hour counts using the Berkeley Nucleonics Corporation SAM-940. Backgrounds in the counting area were taken with a wire sheet constructed with unused copper cable. Note that the spectra from the three survey units essentially overlay each other.



Y Fig. 6 Overlay Plot of Gamma Spectra from Copper Wire Sheets from Survey Units 1, 2 & 3

Also, as discussed above, Cs-137 and Am-241 serve as easy-to-detect, photon-emitting sentinel radionuclides for fission products and transuranic radionuclides. Each photon spectrum from the wire sheets was analyzed, and no hints of Cs-137 or Am-241 were found. In doing these analyses, photon spectra from Cs-137 and Am-241 sources traceable to the National Institute of Standards and Technology were directly measured using the Berkeley Nucleonics Corporation SAM-940 and these spectra were used to locate the Cs-137 and Am-241 areas in *PeakEasy*. No indication of Cs-137 and Am-241, sentinel radionuclides for fission product and transuranics, were found on any wire sheet samples.

In-Situ Alpha Spectral Measurements (with a Beta Component) on Conducting Cable

The conducting cable shows high alpha surface activity, as expected from previous measurements at Hanford and from the natural contamination model (Pb-210, Bi-210, Po-210) discussed above. The intent here is to show that the activity is all or essentially all natural. This is done using two approaches: (1) The alpha activity is measured with an alpha spectrometer to determine if it displays the characteristic spectra shown by the detector and natural activity and the count rates in the "channels of interest;" and (2) direct comparisons between the measured alpha spectra from the background Survey Unit 1 to the alpha spectra from samples in the two suspect Survey Units 2 & 3.

The *in-situ* alpha spectrometry system was designed and build by Mr. Dave Balmer, now of MSA; it has been described elsewhere (Millsap 2010 & Millsap 2011), but a brief explanation is given here. See Figure 7, Field Spectrometer. The commonly-used alpha detector, and the one used here, is a 2-inch Canberra PIPS (Passive Implanted Planar Silicon) detector wired to an SE International URSA II Universal Radiation Spectrum Analyzer. This detector is sensitive to alpha particles in the energy range found at Hanford, as well as high-energy beta particles. The 2-inch PIPS detector module is show in Figure 7 at the bottom center of the page; the spectrometer is shown in the lower left.

Fig. 7 Field Spectrometer

Figure 8 shows the typical *in-situ* alpha spectrum found during this investigation, as well as previous investigations. Alpha particles are shown in the spectrum from about channel 100 up. The alpha spectrum intersects the x-axis (channel number) at about channel 540, which corresponds to an alpha emission energy of about 5.3 MeV, the emission energy of Po-210. In this case, the alpha spectra were taken from wire sheets taken from samples along the transmission line. Another essential feature of the spectra measured by this detector is the peak below about channel 100 to near zero. (The needle-like peak at channel 0 is electronic noise.) This peak (referred to as the “beta tail”) is due to high-energy beta particles and is believed to be due to the 1.16 MeV beta from Bi-210. This shape is consistent with the model of natural contamination discussed above. For the expected Hanford radionuclide distribution, Pu-239 has an alpha energy immediately below Po-210, and Am-241 has an alpha energy immediately above Po-210. In practice, alpha counts are continued until it is clear that the intersection point of the curve is about 5.3 MeV. Pu-239, Po-210 and Am-241 alpha sources traceable to the National Institute for Standards and Technology are used in practice to show that the intersection point is above Pu-239 and below Am-241. Also, based on a technical argument, it has been shown that if the inter-facility area radionuclide distribution were present at the DOE *Surface Contamination Guideline* values, one would expect about 8 counts per hour in the approximately 21 channels between Po-210’s end-point channel and Am-241’s end-point channel. For a routine 6-hour count, this would be 48 counts.

In summary, in practice, the end-point alpha energies are checked against Pu-239, Po-210 and Am-241 alpha standards; the shape of the curve is reviewed; and the number of counts in the “indicator channels” is checked. If these indications are met, the spectrum is taken to be Po-210 and the activity natural. Table 1 summarizes the review of the in-situ alpha spectra of the “wire sheet” samples.

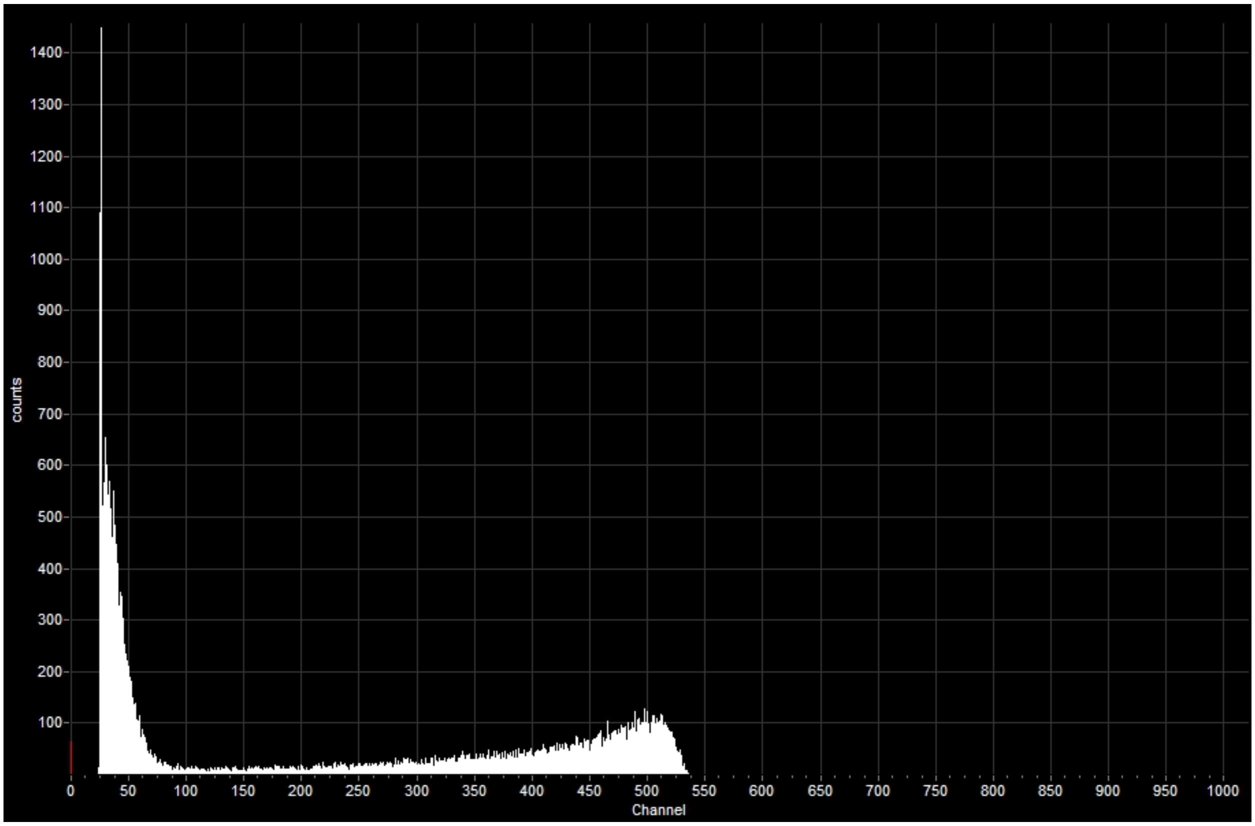


Fig. 8 Representative Po-210 In-Situ Spectrum

Table I Summary of Information from Alpha Spectrometry Analyses of Wire Sheets

(Notes: “Po-210 Endpoint Within Range” means maximum energy of the alpha particles measured was greater than that of Pu-239 and less than that of Am-241, as it should be. “Counts in Range (8/hr) mean the number of counts recorded in the 21 spectrometer channels above the maximum energy of the alpha particles from Po-210. Eight counts per hour, or for a 6 hour count, 48 counts, mean that man-made surface contamination at the DOE *Surface Contamination Guideline*s levels would be present; fewer counts mean that man-made activity, if present at all, is less than the DOE *Surface Contamination Guidelines*.)

Location	Survey Unit	Metal	Count Time (Hr)	Po-210 Endpoint Within Range	Counts in Range (8/hr)	Comment
MB 1/1	1	Copper	6	Yes	4	Typical Po-210 curve.
MB 2/1	1	Copper	6	Yes	4	Typical Po-210 curve.

MB 3/1	1	Copper	6	Yes	7	Typical Po-210 curve.
MB 4/1	1	Copper	6	Yes	6	Typical Po-210 curve.
MB 8/1	2	Copper	6	Yes	11	Typical Po-210 curve.
MB 11/1	2	Copper	6	Yes	7	Typical Po-210 curve.
MB 12/2	2	Copper	6	Yes	1	Typical Po-210 curve.
MB 12/6	2	Copper	6	Yes	5	Typical Po-210 curve.
MB 16/2	2	Copper	6	Yes	2	Typical Po-210 curve.
MB 19/2	3	Copper	2	Yes	1	Typical Po-210 curve.
MB 22/1	3	Copper	2	Yes	2	Typical Po-210 curve.
MB 25/1	3	Copper	6	Yes	12	Typical Po-210 curve.
MB 28/7	3	Copper	3	Yes	2	Typical Po-210 curve.
BO 2/1	3	Aluminum	6	Yes	6	Typical Po-210 curve.
BO 5/1	3	Aluminum	6	Yes	6	Typical Po-210 curve.
BO 8/3	3	Aluminum	6	Yes	0	Typical Po-210 curve.
BO 10/1	3	Aluminum	6	Yes	5	Typical Po-210 curve.

Figure 9 shows alpha spectra at four representative locations in Survey Units 2 and 3 (green) overlaid onto an alpha spectrum from Survey Unit 1 (white); Survey Unit 1 is the background area. Note that the spectra are identical except for slight differences in intensity. In all four cases, the end-point energies are the same and the shapes of the curves are the same. This is taken as evidence that the spectra are from the same radionuclide, which is known to be Po-210 for the background case.

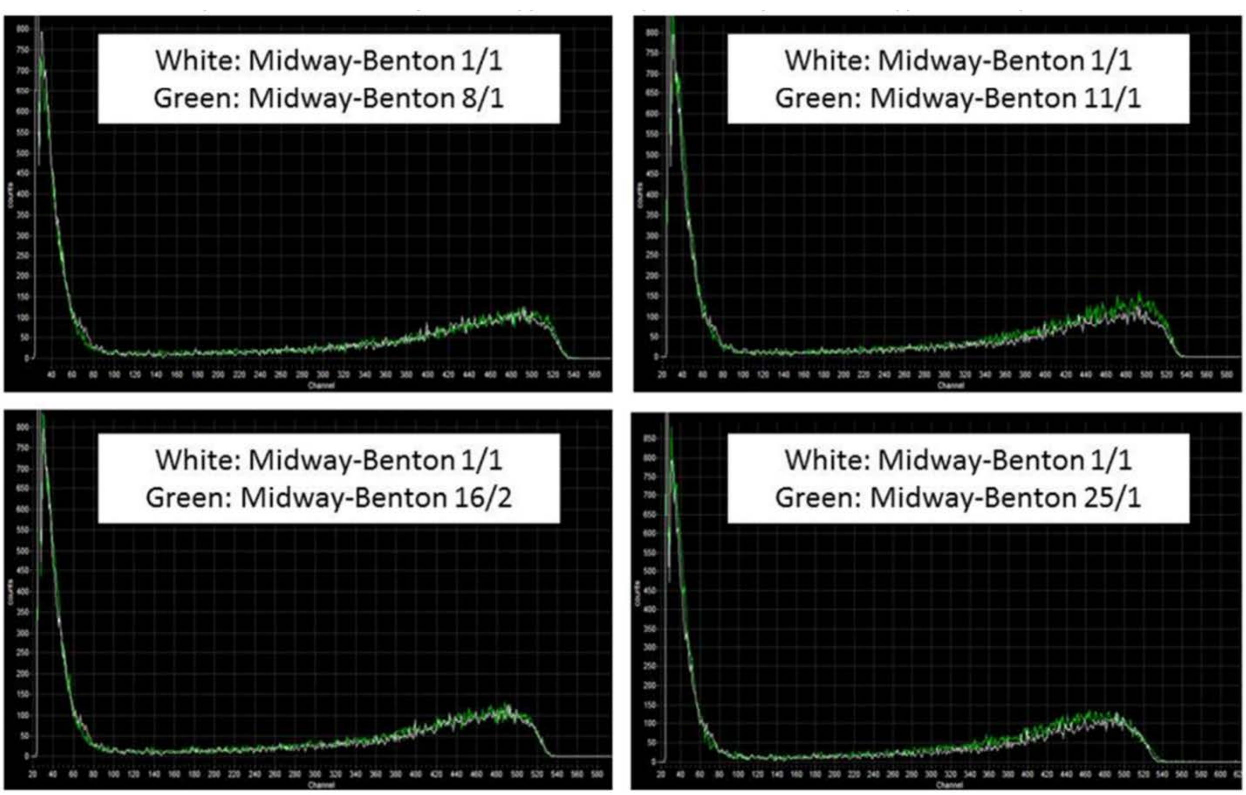


Fig. 9 Four Plots Showing Alpha Spectra from Copper Wire from Survey Units 2 & 3 Overlaid on a Spectrum from Survey Unit 1, Midway-Benton 1/1

SOME REPRESENTATIVE RESULTS USING TOULMIN DIAGRAMS

This section reproduces and discusses two representative Toulmin diagrams as examples of their use. These diagrams, using only the basic elements of the Toulmin model of argument, summarize the arguments why the electrical insulators and copper wire are contaminated with natural radioactivity and not Hanford activity, at least to any significant degree. These two diagrams are taken directly from the original internal report, and the references in them are to sections of the original report. These sections generally provide more detailed technical explanation supporting the data or information parts of the diagrams.

Figure 10 gives the argument for the ceramic insulators. Note that the 1-minute scaler counts showed that both the total alpha and the total beta surface activities are below the inter-facility limits, as well as the removable activities. The scan activities were also below the inter-facility limits. These results alone demonstrate that the surface contamination is below the DOE *Surface Contamination Guideline* values. However, the addition of the facts that the probability of Hanford contamination was very low to begin with and that the beta activity to alpha activity ratios are low further supports the overall argument that the insulators are free of any significant Hanford contamination.

Figure 11 shows the overall argument for the copper wire. This argument is different from that for the insulators, since the inter-facility limits do not apply and since the alpha activity on the wire is quite high, up to nearly 2,500 dpm/100 cm^2. Again, the potential for Hanford contamination is low to begin with. It is again true that the beta activity to alpha activity ratios is small, indicating natural activity. Furthermore, analyses made on co-located components of the power lines—poles, cross arms and insulators—showed only natural activity. Finally, gamma spectroscopy analyses showed that the wire from Survey Units 2 and 3 were essentially indistinguishable from Survey Unit 1 (background) and that there were no indications of the sentinel radionuclides, Cs-137 and Am-241. Alpha spectrometry analyses showed that the alpha spectra from wire samples from Survey Units 2 and 3 were the same as those from Survey Unit 1 and that all of them showed the characteristic spectra from Po-210. Taken together, these strands of evidence strongly support the conclusion that the activity on the wire is natural and not Hanford-made.

Figure 10 Toulmin Diagram Demonstrating That the Total & Removable Alpha & Beta-Gamma Surface Contamination on All Ceramic Insulators Are Within the Allowable Limits

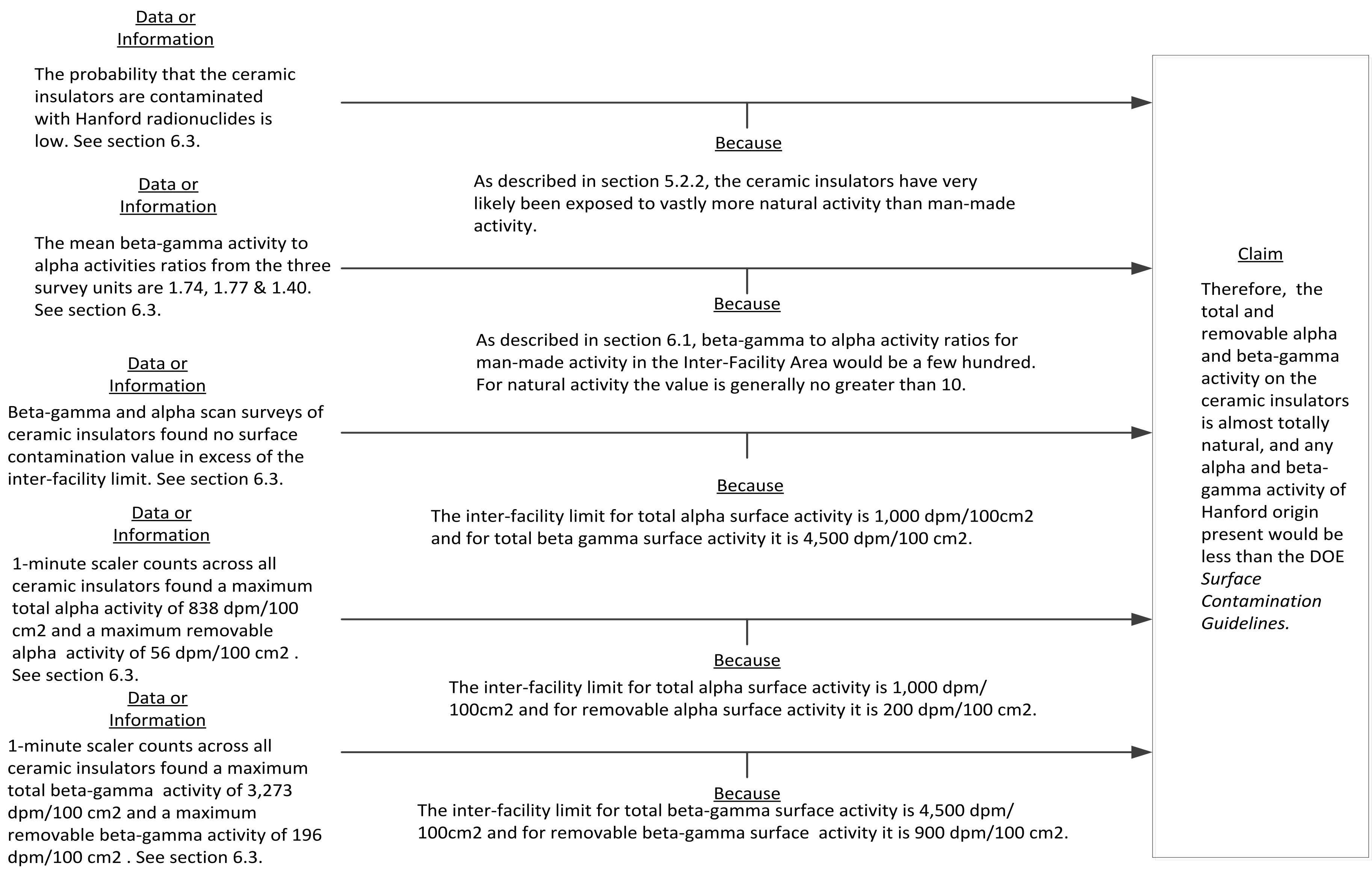


Figure 11 Toulmin Diagram Demonstrating That the Total & Removable Alpha & Beta-Gamma Surface Contamination on All Copper Wire Are Within the Allowable Limits

Data or Information

The probability that the copper wire is contaminated with Hanford radionuclides is low. See section 8.5.

Because

As described in section 5.2.2, the copper wire has very likely been exposed to vastly more natural activity than man-made activity and electrified wire is known to build up a coating of radon daughters.

Data or Information

The mean beta-gamma activity to alpha activities ratios from the copper wire is 2.18. See section 8.5.

Because

As described in section 8.5, beta-gamma to alpha activity ratios for man-made activity in the Inter-Facility Area would be a few hundred. For natural activity the value is generally no greater than 10.

Data or Information

The radioactivity on other components of the transmission lines –insulators, cross arms, and poles—has been shown to be primarily natural with any Man-made activity likely below the DOE SCG. See section 8.5.

Because

If the radioactivity on all other components of the transmission line is natural, then it is highly unlikely that the wire itself would be substantially contaminated with man-made radioactivity.

Data or Information

As shown in Figure 10 below, the radioactivity on the wire in Survey Units 2 & 3 is essentially indistinguishable from that on the wire in Survey Unit 1. See section 8.5.

Because

Since the radioactivity on the wire in Survey Unit 1 is at essentially background levels, if the wire in Survey Units 2 & 3 are essentially indistinguishable for it, they, too, are likely at background levels.

Claim

Therefore, the total and removable alpha and beta-gamma activity on the copper is almost totally natural, and any alpha and beta-gamma activity of Hanford origin present would be less than the DOE *Surface Contamination Guidelines.*

CONCLUSION

Based on the discussion above, it is concluded that the Toulmin model of argument, when integrating the radiological methods and techniques discussed, is adequate to determine if activity on the surfaces of personal property is natural or man-made.

REFERENCES

(Evans 1980) Evans, Robley D., *Engineers' Guide to the Elementary Behavior of Radon Daughters*, Health Physics, Vol. 38 (June), pp. 1173-1197, Pergamon Press Ltd., 1980.

(LANL, 2012) *PeakEasy*. Version 4.27 Los Alamos National Laboratory, Los Alamos, NM, 2012.

(Millsap 2010) Millsap, W.J. *et al*. *Development of a Portable, Field, Alpha Particle & Photon Spectrometer for the Clearance of Property with Surface Contamination.* Presentation at Health Physics Society Annual Meeting 2010.

(Millsap 2011) Millsap, W.J. and D.J. Brush, *Field Experience with a Portable, Field, Alpha and Photon Spectrometer for the Clearance of Property with Contaminated Surfaces.* Presentation at Health Physics Society Midyear Meeting 2011.

(SAS 2008) *JMP 10 User Guide*, SAS Institute, Inc., Cary, NC, 2008

(Toulmin 2003) Stephen E. Toulmin, *The Uses of Argument*, Cambridge University Press, 1958. Updated edition, 2003.

(Zarefsky 2005) Zarefsky, David, *Argumentation: The Study of Effective Reasoning*, Northwestern University. Published by The Teaching Company, 2005.