Addressing Beryllium Health and Safety at the Luckey FUSRAP Site – 14647

Karen Keil, Stephen Buechi, Stephen Bousquet, and John Busse.
U.S. Army Corps of Engineers, Buffalo District

ABSTRACT

The Luckey FUSRAP Site in Troy Township, Ohio, was a former beryllium production plant operated under contract to the Atomic Energy Commission from 1949 to 1958. During site operations process waste was discharged to three lagoons on site; and at the close of operations a disposal area was created in a portion of the site in which lagoon sludges and other waste were disposed of. The operations and eventual closeout of the site resulted in widespread contamination of site soils with beryllium, with maximum detected levels over ten thousand milligrams per kilogram (mg/kg), or over one percent, in concentration. The U.S. Army Corps of Engineers has completed CERCLA investigation process for the Luckey Site, and has issued Records of Decision, establishing the cleanup goals for beryllium and other FUSRAP constituents in site soils and groundwater. Excavation and off-site disposal have been chosen as the remedy for FUSRAP-contaminated soils, and groundwater will be addressed via monitored natural attenuation. As preparations recently began for the site remediation, the Corps' awareness of the potential adverse health effects of beryllium exposure became heightened, and the uniqueness of the beryllium contamination situation at the Luckey Site became apparent, with such widespread high-level beryllium contamination of soils in an open environment being atypical of other FUSRAP sites and Department of Energy and industrial facilities. This paper will discuss the challenges the Corps of Engineers is experiencing in addressing the potential beryllium health and safety issues related to the upcoming site remediation effort; including incorporating beryllium safety practices into existing Corps of Engineers safety and health policies and procedures; assessing the potential beryllium exposure and resulting hazard for differing site activities; developing monitoring programs; and identifying and implementing beryllium exposure reduction and minimization actions, so that remediation can occur in a manner that is protective of the workers and surrounding community.

INTRODUCTION

Beryllium is a naturally occurring element found in soil and rock, with several properties that make it desirable for use in a number of industries, notably including the atomic energy and defense industry. Beryllium in its natural form or final manufactured form poses a low potential health risk; however, exposure to beryllium dust or fumes, particularly through inhalation, poses a high health risk, which can cause an allergic-type reaction known as beryllium sensitization. Further exposure of sensitized individuals can lead to development of chronic beryllium disease (CBD), also known as berylliosis, which is a chronic, incurable, debilitating lung disorder. Certain studies have shown that inhaling even small amounts of beryllium dust or fumes can cause beryllium sensitization and CBD. The Occupational Safety and Health Administration has recent information suggesting that their current permissible exposure limit for beryllium in the workplace may not be protective enough to prevent CBD among exposed workers [1]; and the DOE has promulgated a Chronic Beryllium Disease Prevention Program (CBDPP) to address the

unique health and safety considerations for its facilities with the potential for worker exposure to beryllium [2].

However, the DOE's CBDPP was developed for protection of workers manipulating beryllium metal in a manufacturing facility. The Luckey FUSRAP site is the first beryllium environmental cleanup performed by a federal government entity to our knowledge.

In following the CERCLA process for investigation and remediation of FUSRAP sites, the USACE determined that beryllium contamination in Luckey site soil and groundwater warrants remediation in order to be protective of human health and the environment. The Baseline Risk Assessment was published in 2000 and indicated that for the then current use and conditions at the site, risks for exposure to beryllium and FUSRAP radionuclides (radium, thorium, and uranium) were within the EPA's acceptable risk range, although risk from exposure to lead (another FUSRAP related constituent) may be unacceptable [3]. In addition, if the site were to be redeveloped in the future or returned to use commensurate with the surrounding land use (i.e., agriculture), then risks to potential future users of the site (including residents and farmers) due to exposure to FUSRAP contaminated soil and groundwater could exceed EPA's acceptable risk range. A CERCLA risk-based cleanup goal of 131 mg/kg beryllium was established for site soils in the Soil Record of Decision (ROD) [4, 5]. This cleanup goal was established using EPA toxicity criteria and the Risk Assessment Guidance for Superfund protocols [6]. Since that ROD was signed, the facilities are no longer being used for active industrial processes and the new owner of the site is interested in reclaiming building materials for scrap metal value. The USACE has been monitoring the contamination in the groundwater (which includes beryllium, lead, and uranium) to ensure that the contamination does not reach the potable deeper groundwater wells used by the surrounding community. Removal of contaminated soils should help ensure long term protection of groundwater resources [7].

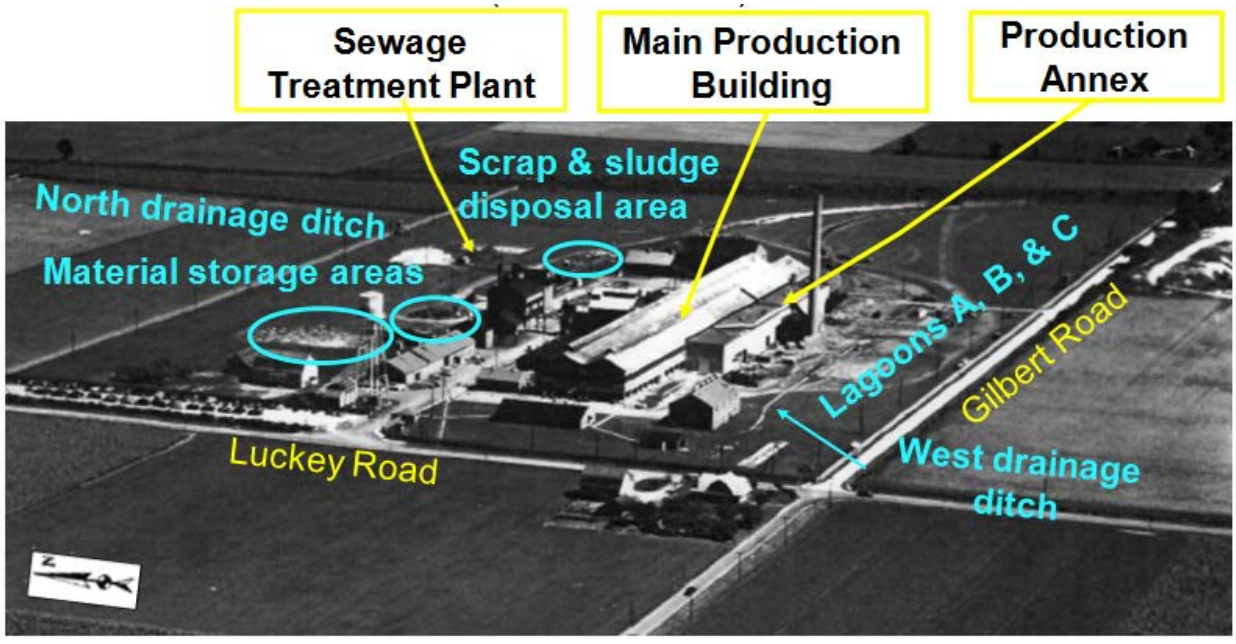

Figure 1. Luckey Site features (oblique aerial photograph, probably circa 1950's)

METHODS

We are utilizing three main approaches to addressing beryllium health and safety at the Luckey site during soil remediation.

- Creation of a comprehensive and proactive Chronic Beryllium Disease Prevention Program, which would apply to Buffalo District Corps Employees who would encounter beryllium at one of our FUSRAP sites,
- A beryllium inventory for the Luckey site, and
- Air monitoring data from soil remediations at other FUSRAP sites.

Chronic Beryllium Disease Prevention Program

Using guidance provided for the U.S. Air Force [8] as well as the example provided by the Department of Energy in 10 CFR 850 [2], the Buffalo District Corps of Engineers created its own Chronic Beryllium Disease Prevention Program. This was drafted in the Fall of 2013 primarily by the Buffalo District Safety Officer, who coordinated input from the Luckey Site project industrial hygienist, environmental toxicologist, environmental engineering team, management team, office of counsel, human resources specialist, and employee union representative. It was sent out to the US Army Corps of Engineers (USACE) Environmental and Munitions Center of Expertise in Omaha, Nebraska, for review by the Certified Industrial Hygienist there, and was also reviewed and approved by the USACE Headquarters Safety Officer.

The beryllium inventory for the Luckey Site

The beryllium inventory includes sampling and analysis of soils, sediments, surface water, groundwater, and building dust and surfaces for the presence of beryllium (and other hazardous substances). In addition, air sample results from personal breathing zone and ambient air monitoring are available for some of the investigative activities. Sampling began when the Army Corps of Engineers was directed to implement the Formerly Utilized Sites Remedial Action Program in 1997. In addition to the Remedial Investigation Report published in 2000, further characterization efforts have ensued, including additional sampling of site soils [9], and annual groundwater monitoring events [10, 11, 12, 13]. Sample results have been entered into a project database and a geographic information system (GIS) has been developed for project data.

Air monitoring data from soil remediations at other FUSRAP sites

Two other FUSRAP sites that have recently undergone soil remediation have extensive air monitoring data available from those remediation efforts. The air monitoring data from the Painesville, Ohio Site [14] as well as the Maywood, New Jersey site [15] were reviewed to evaluate ranges of airborne dust concentrations that are typically generated when excavating contaminated soil from a FUSRAP site, using standard dust suppression techniques. Dust levels were measured in real time on a 60 second or 10 second interval for the Maywood and Painesville sites, respectively.

RESULTS

Highlights of the Buffalo District CBDPP

The Buffalo District Corps of Engineers Chronic Beryllium Disease Prevention Program contains the following general requirements:

- Integrate safety, health, training, medical monitoring, counseling and work planning to minimize human contact with, and the uptake of, beryllium
- Minimize the spread of beryllium contamination
- Minimize the number of workers exposed to beryllium through hazards assessment, work planning, and engineering controls
- Establish exposure reduction and minimization goals below the Occupational Exposure Level (OEL) that would be applicable to the specific task
- Reduce exposure by applying engineering controls, whenever feasible, as well as using administrative control measures and Personal Protective Equipment (PPE)

Occupational Exposure Level:

The USACE default OEL for any airborne contaminant is the lower of the OSHA PEL and the ACGIH TLV [16, 17]. The Buffalo District Corps of Engineers obtained a headquarters-approved waiver allowing the OEL to be set to 0.2 $\mu g/m^3$ beryllium (total fraction) at the Luckey Site, with an action level of one-half this concentration.

Mandatory Medical Surveillance:

Under this CBDPP, USACE employees that will be doing work at the site that involves beryllium exposure are required to submit to medical surveillance. If the employee declines the option of the testing, they will be precluded from further participation in the medical program and from work at USACE LRB beryllium controlled projects until they agree to medical monitoring. Prior to being assigned to work at a USACE LRB beryllium controlled project, all designated beryllium workers will receive a prescribed physical and be deemed fit-for-duty by the Occupational Health Provider. While designated as a beryllium worker, the physical will be conducted annually with the beryllium lymphocyte proliferation test (BeLPT) will be conducted every six (6) months unless the Occupational Health Provider recommends a different interval. Components of the physical can include but are not limited to: physically able to wear a respirator, respirator fit test, negative (-) BeLPT, free of any symptoms of beryllium exposure. An employee cannot be designated as a beryllium worker until the individual's medical results have been completed and received by the Occupational Health Provider, including determination that he/she is medically cleared by the Occupational Health Provider for work in beryllium locations and that the employee has received the appropriate training.

Mandatory Medical Removal:

When the Occupational Health Provider recommends that a beryllium affected worker should be temporarily or permanently removed from exposure to beryllium, the employee's Supervisor must advise the beryllium affected worker of the determination that medical removal is necessary to protect the worker's health. The Supervisor will provide the beryllium affected worker with information they deem necessary regarding the risks of continued exposure to beryllium and the benefits of removal. When a beryllium-affected worker is temporarily removed from beryllium exposure pursuant to the CBDPP, USACE LRB will transfer the worker

to a comparable project or other duties for which the worker is qualified (or for which the worker can be trained in a short period).

Luckey Beryllium Inventory

The nature and extent of beryllium contamination in Luckey site soils, groundwater, surface water, and sediment was established in a 2000 Remedial Investigation Report [3], and later refined with further focused sampling of environmental media. As presented in Figure 2, most of the surface soil sampling locations contained beryllium above the naturally occurring level in area soils, which was established to be 1.1 mg/kg (parts per million, ppm). Large areas of the site also contain beryllium soil concentrations above 131 ppm, which was established as the risk-based remedial goal. Soil in the northeastern corner of the site, which was used for disposal of sludges dredged from waste lagoons, contains the greatest concentration of beryllium, over 10,000 ppm (over 1%).

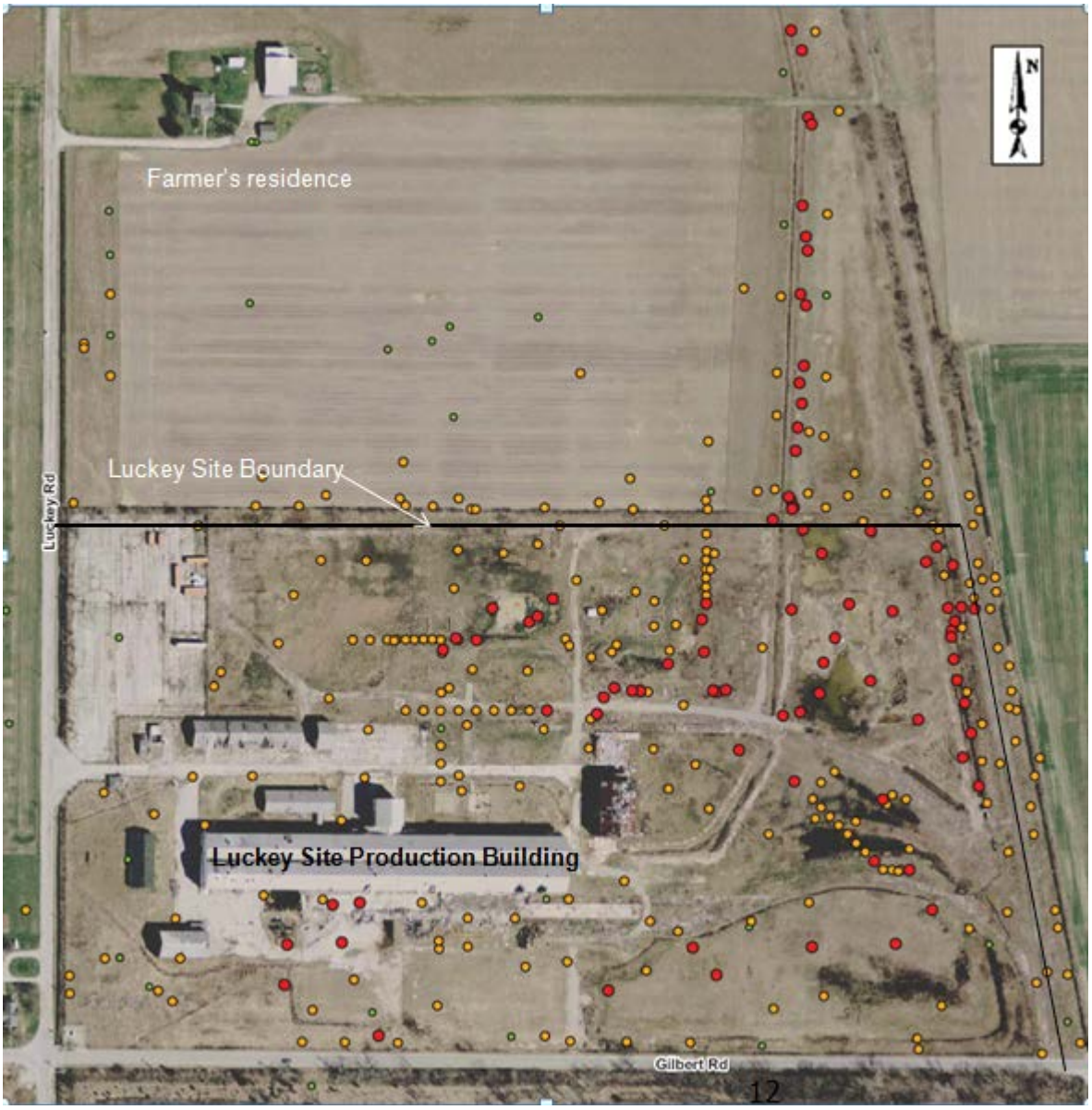

Figure 2. Concentrations of beryllium in surface soil at the Luckey Site.

Green dots: Locations of beryllium comparable to background concentrations (1.1 ppm)
Yellow dots: Concentrations of beryllium between background and USACE CERCLA risk-based remedial goal (between 1.1 and 131 ppm)
Red dots: Concentrations of beryllium above USACE CERCLA risk-based remedial goal (above 131 ppm)

Because beryllium is primarily an inhalation hazard, during many of the sampling events, personal breathing zone and ambient air samples were collected and analyzed for beryllium. Table 1 presents a summary of the beryllium concentrations in these air and breathing zone samples.

Table 1 Summary of Luckey Beryllium Air Monitoring Data, 1998 - 2010, $\mu g/m^3$

IA/Location	# AA/PBZ	# AA detections	# PBZ detections	AA MDL range	PBZ MDL range	AA min detect	PBZ min detect	AA average (detect only)	PBZ average (detect only)	AA max	PBZ max
OUTDOOR SAMPLES											
IA01	55/1	34	0	0.0002 - 0.2	0.006	0.0004	ND	0.0704	ND	1.0008	ND
IA02	21/2	1	2	0.05	0.05	0.1	0.0086	0.1000	0.00885	0.0500	0.0091
IA03	5/0	2	0	0.007 - 0.02	ND	0.01	ND	0.0200	ND	0.0200	ND
IA04	1/0	0	0	0.02	ND	ND	ND	ND	ND	ND	ND
IA05	4/1	1	0	0.03 - 0.02	0.006	0.06	ND	0.0600	ND	0.0300	ND
IA07	22/3	2	0	0 - 0.04	0.006	0.00079	ND	0.0504	ND	0.1000	ND
IA08	42/2	2	0	0.0059	0.006	0.0007	ND	0.0012	ND	0.0016	ND
IA10	4/4	1	0	0.02	0.0058	0.02	ND	0.02	ND	0.0200	ND
INSIDE FACILITY BUILDING SAMPLES											
Annex	0/27	0	12	ND	0 - 0.2	ND	0.01	ND	0.2342	ND	0.9800
Production Bldg	6/8	0	2	0.00031	0 - 0.04	ND	0.01	ND	0.0300	ND	0.0500
Main Office	6/0	0	0	0.00031	ND	ND	ND	ND	ND	ND	ND
Maintenace Bldg	0/4	0	1	ND	0.02	ND	0.05	ND	0.0500	ND	0.0500
West Well House	0/1	0	0	ND	0.006	ND	ND	ND	ND	ND	ND
PBZ SAMPLES DURING VOLUME UNCERTAINTY SAMPLING											
Trench Excavation	0/6	0	2	ND	0.0128 - 0.05	ND	0.0600	ND	0.0721	ND	0.0842
ChopHouse	0/24	0	7	ND	0.033	ND	0.0186	ND	0.9951	ND	2.2800
PigeonHole	0/5	0	4	ND	0.028	ND	0.0389	ND	0.1160	ND	0.2680
Manhole	0/3	0	0	ND	0.0178	ND	ND	ND	ND	ND	ND
Lab	0/11	0	1	ND	0.0417	ND	0.0134	ND	0.0134	ND	0.0134
Drill1	0/5	0	0	ND	0.0255	ND	ND	ND	ND	ND	ND
Drill2	0/8	0	2	ND	0.0323	ND	0.0157	ND	0.0237	ND	0.0316
Connex	0/4	0	3	ND	0.435	ND	0.1400	ND	0.3543	ND	0.5890
WastePack	0/3	0	2	ND	0.0429	ND	0.0516	ND	0.0748	ND	0.0979

Notes:
AA Ambient Air
PBZ Personal Breathing Zone
MDL Method detection limit
ND Non-detect

These air sample results show a wide range of beryllium concentrations. The greatest concentrations of beryllium were detected in samples obtained within buildings or temporary structures, such as the Connex box used for handling soil samples during the Volume Uncertainty Sampling event. The production annex was probably the building with the greatest beryllium surficial contamination. Although the outdoor air samples generally had lower concentrations of beryllium, at least one ambient air (AA) sample obtained outdoors in the IA01 area, which is in the northeast corner of the site, had an elevated beryllium concentration (above

1 microgram per cubic meter). The vast majority of outdoor air samples had low or non-detectable concentrations of beryllium.

Luckey Remediation Beryllium Hazard Assessment

The excavation of radiologically contaminated soils from the Maywood and Painesville sites generated highly variable concentrations of airborne dust, which was monitored continuously during remedial action at these two sites. The average dust concentrations ranged from less than 0.02 mg/m^3, to over 1.5 mg/m^3, a range of almost two orders of magnitude. The majority of the dust concentrations were less than approximately 0.15 mg/m^3, with only occasional spikes in dust concentrations above these levels.

DISCUSSION

Airborne dust concentrations generated during remediation of FUSRAP sites were compared to potential total dust loading limits which would meet different airborne beryllium concentrations, assuming high levels of beryllium soil contamination was present.

When measuring beryllium airborne concentrations, 2 different limits must be met during remediation:
(1) For worker protection in the breathing zone, 0.1 μg/m3 (0.0001 mg/m3) beryllium is the USACE LRB action limit (based on an occupational exposure limit of 0.2 μg/m3)
(2) For protection of public health in the air outside the site, 0.01μg/m3 (0.0001 mg/m3) beryllium is the EPA NESHAPS limit, which must be met as a 30 day average.

From these air limits, three different airborne particulate concentrations are used for comparison to these particulate concentrations:
(i) 0.0075 mg/m3, which is the inhalable dust limit that must be met at the fenceline in order to meet the NESHAPS level, if the maximum concentration of beryllium measured in the soils (13,300 mg/kg) is airborne. This represents a worst case scenario; where the maximum soil contamination level must still stay within the most stringent air limit. This hypothetical airborne dust limit is presented as a red line on Figure 3.

(ii) 0.075 mg/m3, which is the inhalable dust limit that must be met at the fenceline to meet NESHAPS if the concentration of beryllium in airborne soil is the same as the cleanup goal (131 mg/kg). It is also the inhalable dust limit that must be met in the worker's breathing zone if the maximum concentration of beryllium measured in the soils (13,300 mg/kg) is airborne. This hypothetical airborne dust limit is presented as a green line on Figure 3.

(iii) 0.75 mg/m3, which is the inhalable dust limit that must be met in the worker's breathing zone if the concentration of beryllium in airborne soil is the same as the cleanup goal (131 mg/kg). This hypothetical airborne dust limit is presented as a black line on Figure 3.

Figure 3 presents an evaluation of the range of total dust generated during remediation of two different FUSRAP sites, compared to the three different hypothetical dust loading limits needed to meet beryllium air standards protective of workers and the public.

When excavating highly beryllium contaminated soils, standard dust suppression techniques will probably be adequate for the majority of the time. However, it is evident that these dust suppression methods were not adequate 100% of the time, since there were some occasional dust levels that were elevated enough to result in potentially unacceptable airborne concentrations of beryllium, based on exceedances of the hypothetical dust loading limits presented above.

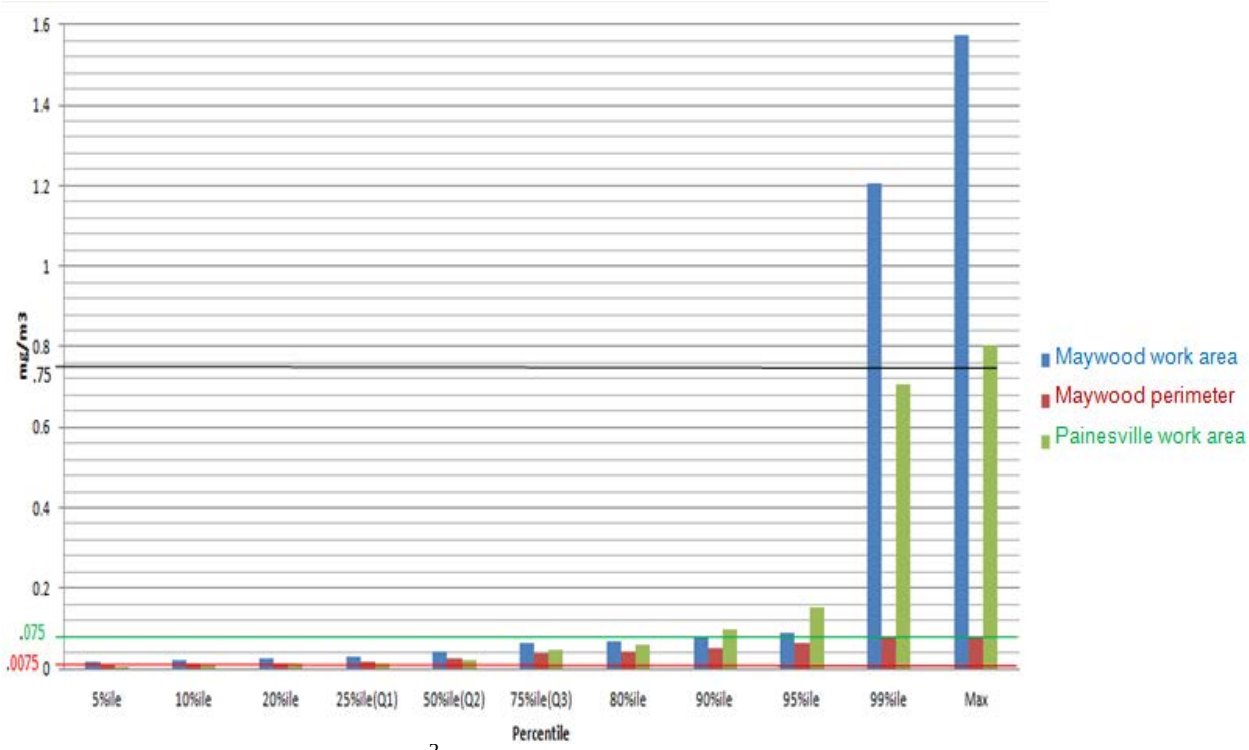

Figure 3 Total particulates (mg/m^3) generated during soil remediation of other FUSRAP sites. Dust limits (shown as red, green, or black lines) are explained in the text.

CONCLUSIONS

A fairly comprehensive characterization of Luckey site soil, sediment, surface water, and groundwater indicates that beryllium is present in high enough concentrations in some areas of the site to pose potential inhalation risks even when the site soils are not disturbed. However, excavation of site soils to achieve the remedial goals established in the Luckey ROD will generate airborne dust concentrations that could result in unacceptable levels of airborne beryllium. While typical dust suppression techniques will ameliorate these risks, the USACE must be even more diligent at the Luckey site to eliminate significant dust generation during remediation.

USACE Buffalo District has created a CBDPP with medical monitoring and clearance requirements that should prevent progression of CBD by removing workers that have become sensitized to beryllium from further beryllium exposure.

Using extensive site characterization data, a comprehensive new CBDPP geared towards protection of USACE workers at FUSRAP sites, and recently gathered airborne dust data generated during soil remediation of other USACE FURAP sites, USACE Buffalo District will undertake to remediate beryllium-contaminated soils in a safe manner at the Luckey site.

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