Final – Revision 2

Identification of Ecological Risk-Based Remedial Goals Iron Mountain Road and Bains Gap Road Ranges

Fort McClellan
Calhoun County, Alabama

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1.0 Introduction

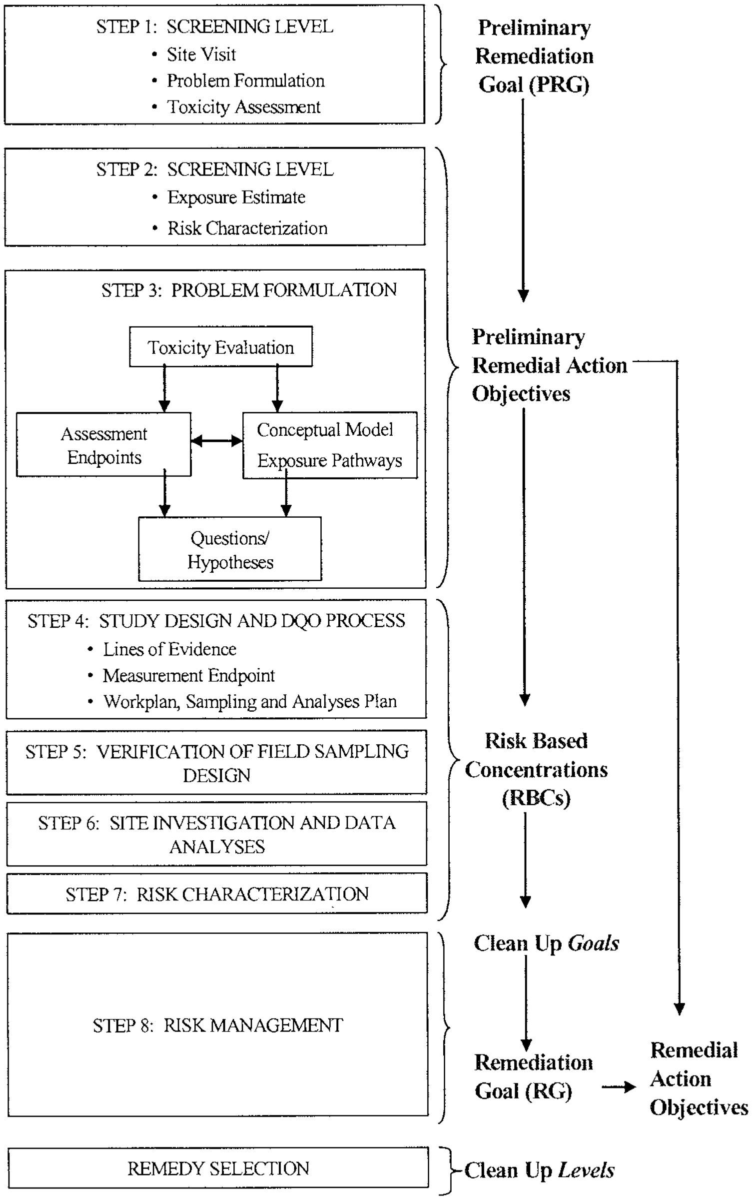
Ecological risk assessments have been conducted at the Iron Mountain Road (IMR) and Bains Gap Road (BGR) Ranges at Fort McClellan (FTMC) starting in January 2002, as documented in the *Screening-Level Ecological Risk Assessment for the Iron Mountain Road Ranges* (IT Corporation [IT], 2002a) and the *Data Evaluation Report and Screening Level Ecological Risk Assessment for the Bains Gap Road Ranges* (IT, 2002b). The *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Iron Mountain Road Ranges* was completed in November 2002 (IT, 2002c), and the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* was completed in April 2003 (Shaw Environmental, Inc. [Shaw], 2003). Based on the results of the screening-level risk assessments (SLERA) and the problem formulation and study designs for the IMR and BGR Ranges, it was determined that a single baseline ecological risk assessment (BERA) would be appropriate to address the assessment endpoints identified in the problem formulations for both of these small arms range complexes. The fieldwork for the combined IMR/BGR BERA was accomplished in May and June 2003. The draft BERA for the IMR and BGR ranges was first reported in the *Draft Remedial Investigation Report, Iron Mountain Road Ranges* (Shaw, 2004). From January 2002 (when the IMR Ranges SLERA was first reported) until the present, numerous rounds of comments have been received by the Army from the various stakeholders at FTMC (i.e., the U.S. Environmental Protection Agency [USEPA], the Alabama Department of Environmental Management [ADEM], and the U.S. Fish and Wildlife Service [USFWS]), and revisions made to the SLERA, problem formulations, study designs, and BERA in response to those comments. The most recent iteration of the BERA conducted for the IMR and BGR Ranges (Shaw, 2008) reflected over eight years of reporting, analysis, negotiation, and consensus between the responsible parties and stakeholders. The IMR/BGR BERA in its current form indicated that one or more constituents in surface soil, surface water, and sediment have the potential to pose adverse effects to sensitive ecological receptors in the terrestrial and riparian ecosystems at the IMR and BGR Ranges.

Based on the results of the BERA, the need for ecological risk-based remedial goals (Eco-RBRG) was identified. In order to identify site-specific concentrations of the constituents of potential ecological concern (COPEC) that are protective of the sensitive receptors potentially present at the IMR and BGR Ranges, the various lines of evidence collected during the BERA were analyzed. Eco-RBRGs were derived from the various lines of evidence. These Eco-RBRGs are concentrations of COPECs in the various environmental media that are protective of the assessment endpoints described in the BERA. Because several lines of evidence were assessed for some of the assessment endpoints and COPECs, several Eco-RBRGs were also derived for these assessment endpoints and COPECs. The following sections describe the identification of the most appropriate Eco-RBRGs for each COPEC in each environmental medium at the IMR and BGR Ranges at FTMC.

2.0 Risk-Based Remedial Goals in the Comprehensive Environmental Response, Compensation, and Liability Act Process

The need for Eco-RBRGs is based on the results of the BERA. If a BERA identifies unacceptable risks, then the responsible party (the U.S. Army) is required under the National Contingency Plan to develop remedial alternatives protective of human health and the environment. The Army, in conjunction with the various stakeholders, establishes remedial action objectives (RAOs) for developing and screening remedial alternatives that may be necessary to address the identified risks. RAOs specify the contaminants, the media of concern, the potential exposure pathways, and the risk-based remedial goals (RBRG).

Figure 2-1. The ERAGS 8-Step Ecological Risk Assessment Process and Position of Key Remediation Terms



DQO = Data Quality Objective

The development of RAOs progresses throughout the ecological risk assessment process (Figure 2-1). Initially, preliminary remediation goals (PRG), or ecological screening values (ESV), are developed based on readily available information, such as screening-level benchmarks published in the literature or chemical-specific applicable or relevant and appropriate requirements. The PRGs are modified as necessary throughout the ecological risk assessment process, as more information becomes available during the remedial investigation (RI)/feasibility study (FS), including baseline risk assessment. Final remediation goals are determined when the remedy is selected in the FS. RBRGs link the ecological risk assessment portions of the RI to the engineering aspects of remedial designs in the FS.

Key definitions in the process of developing cleanup levels are as follows:

Preliminary Remediation Goal (PRG) - Ecological PRGs are screening-level benchmarks or applicable or relevant and appropriate requirements identified early in the initial stages of site investigations, often at the work plan stage prior to commencement of RI/FS activities. They are the ESVs used in the SLERA. PRGs are based on readily available information and are generally not site specific. PRGs are used by managers to begin the screening and identification of remedial alternatives. As the RI/FS progresses, the PRGs may evolve to become final remediation goals (RG) by incorporating site-specific information.

Remedial Action Objective (RAO) - The RAOs describe what the proposed site cleanup is expected to accomplish. The RAOs, as defined in the National Contingency Plan, specify the contaminants, the media of concern, the potential exposure pathways, and the remedial goals (RG). For establishing RAOs protective of the environment, RGs must also specify relevant categories of receptors in the assessment endpoints from the BERA.

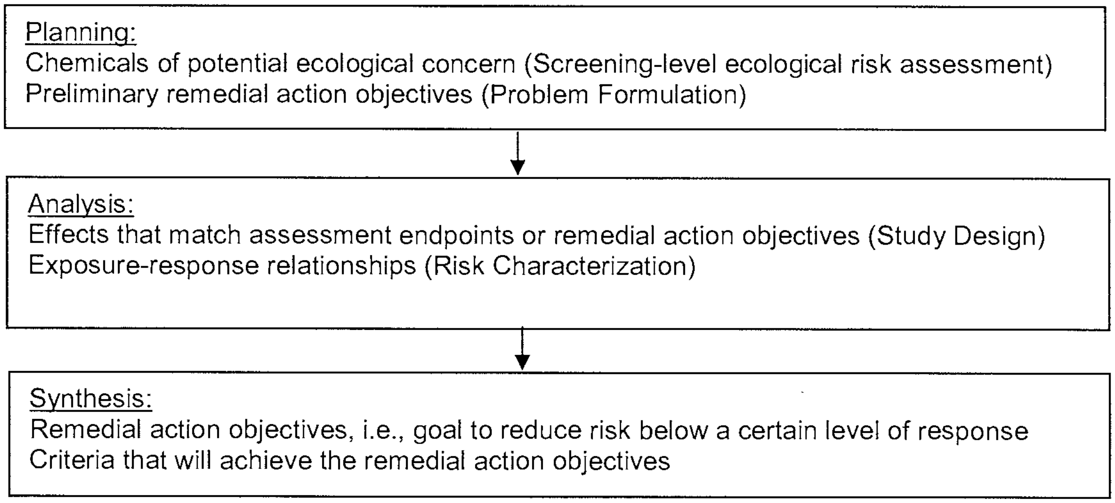
Risk-Based Cleanup Goal (or Risk-Based Remedial Goal [RBRG]) - This term is used to describe the site-specific risk-based media contaminant concentrations associated with an acceptable level of risk. These values are not modified based on remedy selection criteria. They do, however, reflect an element of risk management in that the concentration is deemed to be associated with an acceptable level of risk. RBRGs are selected by risk managers from a range of risk-based media concentrations associated with a specific level of risk. The RBRGs are identified from the results of the BERA and are associated with the assessment endpoints described in problem formulation. Methods for derivation of RBRGs are described in this report.

Cleanup Level - Cleanup level is a term used to describe the medium-specific chemical concentration corresponding to the level of risk identified to be attained by the selected remedy in the record of decision.

3.0 Development of Risk-Based Remedial Goals

The development of cleanup goals is based on the general process outlined in Figure 3-1 (Suter and Cormier, 2008). Numerical goals are typically derived with methods and data developed in the BERA. A cleanup goal expresses the level or concentration of a constituent in an environmental medium that is associated with a level of effect (response) in an ecological receptor that is considered to be acceptable. Cleanup goals are often based on site-specific information and the results of the ecological risk assessment's own unique problem formulation and study design. There is no one method to derive cleanup goals. Cleanup goals are established on the basis of methods used in the BERA and may include predictive risk analysis methods (i.e. food web modeling), toxicity testing of contaminated media, demographic information (i.e. bird population surveys or benthic invertebrate community analyses), and/or other supportive information. Any of the results from these methods may be used in a multiple lines-of-evidence approach. Agreement among site participants and stakeholders on the studies and information that will provide data for development of the cleanup goals is achieved at the scientific and management decision point in the study design.

Figure 3-1. Ecological Risk Assessment Process



Planning:
Chemicals of potential ecological concern (Screening-level ecological risk assessment)
Preliminary remedial action objectives (Problem Formulation)

Analysis:
Effects that match assessment endpoints or remedial action objectives (Study Design)
Exposure-response relationships (Risk Characterization)

Synthesis:
Remedial action objectives, i.e., goal to reduce risk below a certain level of response
Criteria that will achieve the remedial action objectives

The BERA is designed to provide data that relate observed adverse effects in environmental receptors to measured exposure concentrations in environmental samples. The interpretation of these data is the determination of toxicity values that relate chemical concentrations to potential effects. The following terms are used to describe the toxicity values derived in the BERA:

Apparent Effects Threshold (AET) – The concentration at and above which effects are always observed. Since all samples with concentrations of a COPEC at or above the AET have observed effects, there is good evidence that the COPEC, or another co-occurring COPEC or stressor, may be causing the observed effects.

No-Observable-Effect Concentration (NOEC) – The highest concentration at and below which effects are never observed. Since all samples with COPEC concentrations at or below the NOEC have no observable effects, there is strong evidence that the COPEC is not toxic at levels at or below the NOEC under those environmental conditions.

Lowest-Observable-Effect Concentration (LOEC) – The lowest concentration at which an adverse effect is observed. Often, some samples with concentrations between the AET and NOEC are toxic and other samples are not toxic. The LOEC is the lowest concentration of the COPEC in this range that has an observed effect. However, because some samples with COPEC concentrations above the LOEC are not toxic, the evidence that the COPEC is the cause of the observed effect is not as strong. The effects may or may not be related to the COPEC.

Predictive risk methods use calculated or modeled exposures compared to toxicity reference values (TRV) to predict hazard quotients (HQ). Some examples of predictive risk methods include food web modeling and tissue burden bioaccumulation modeling. The equations used to estimate risk can be rearranged and used to calculate a range of risk-based concentrations (RBC) that can be used to derive cleanup goals. Because the TRVs for a particular contaminant are often reported as no-observable-adverse-effect levels (NOAEL) or lowest-observable-adverse-effect levels (LOAEL), the application of these values in rearranged food web models will result in a range of RBCs based on NOAELs and LOAELs. This RBC range reflects the uncertainty in the TRV. Uncertainty can also occur in the estimates of the bioaccumulation factors, which express the degree to which contaminants accumulate in wildlife foods from abiotic media, and also in the exposure factors used to estimate wildlife exposures via food web interactions.

Toxicity tests are often completed in a BERA to quantify the severity and incidence of adverse effects. From these data, relative effects across a range of exposure concentrations can produce stressor-response relationships. Cleanup goals can then be identified as those exposure concentrations that bracket the acceptable ranges of effects. Depending on the type of contaminant, medium, and receptor, the descriptions of pertinent endpoints and terms used to quantify the response will vary appropriately (e.g., LOECs, NOECs, effects concentration for 10 percent of a population, effects concentration for 50 percent of a population, etc.).

Stressor-response relationships between the chemical concentrations in environmental media and the relative response in site receptors can also be obtained from demographic studies, such as benthic invertebrate community studies, fish population or community studies, and mammal or bird census studies. The methods for developing cleanup goals from these studies are similar to those used for toxicity tests in that pertinent endpoints such as LOECs, NOECs, etc., are used.

Multiple Lines of Evidence. The occurrence of converging lines of evidence can serve to strengthen the basis of cleanup goals. Using multiple lines of evidence from the BERA reflective of the assessment endpoints in the RAOs can reduce uncertainty in the development of a cleanup goal. It should be recognized that not all lines of evidence carry equal weight in the decision-making process and not all have equal relevance to real-world conditions at a given site. A test conducted on laboratory organisms or with models that must estimate wildlife exposure has less relevance to actual on-site conditions than a demographic study conducted on site. A demographic study, unless it happens to show a clear gradient of effects across chemical concentrations, provides the researcher with less control and can be affected by confounding variables that hinder its ability to predict a cleanup goal. Toxicity testing is particularly useful in developing a dose-response relationship, because field samples of environmental media can be collected to target levels desired for testing in the laboratory. Evidence from the field (or other tests that may not have exhibited a dose-response relationship) may be used as multiple lines of evidence to support or validate cleanup goals developed by other means. The "Rule of Five" (Greenberg and Charters, 2005) is an example of a lines-of-evidence approach that divides the uncertainty range between the NOEC and LOEC into six segments by inserting five geometrically spaced nodes. The basic concept, however, is the exploration of the overlap between NOEC to LOEC ranges for the various assessment endpoints to select a point within the range of overlap based on the degree of certitude for each.

It is important to note that it is not necessary, nor is it USEPA policy, to systematically select the most sensitive RBRG when multiple RBRGs and multiple lines of evidence are available for a given COPEC in a given environmental medium. Rather, USEPA guidance recommends that Eco-RBRGs be selected from within the range of acceptable risk identified in the BERA. As stated previously, a weight-of-evidence approach has been taken with regard to selecting the most appropriate RBRG for each COPEC in the environmental media at the IMR and BGR Ranges at FTMC. As such, the various lines of evidence that have been developed for each COPEC in each environmental medium are discussed and qualitatively weighted to determine the recommended Eco-RBRGs.

4.0 Risk-Based Remedial Goals for Soil

The ecological endpoints that were investigated in the IMR/BGR BERA with respect to COPECs in soil were earthworm survival and growth, and adverse effects on omnivorous mammals and birds and invertivorous mammals and birds through food web interactions.

Earthworm toxicity tests (survival and growth endpoints) indicated that COPECs in soil at the IMR and BGR ranges may cause adverse effects in terrestrial invertebrates (e.g., reduced survival and/or growth). Additionally, the terrestrial food web model indicated that sensitive terrestrial receptors could experience adverse effects due to exposure to COPECs in soil at the IMR and BGR Ranges through food web interactions.

The results of the earthworm toxicity tests indicated that antimony is most likely not responsible for the observed effects in any of the earthworm tests. Adverse effects in earthworms (e.g., reduced growth) were observed at copper concentrations as low as 62.2 milligrams per kilogram (mg/kg), lead concentrations as low as 779 mg/kg, and zinc concentrations as low as 35.1 mg/kg.

The terrestrial food web model (using NOAEL-based TRVs and site-specific soil-to-invertebrate bioaccumulation factor [$BAF_{soil\text{-}to\text{-}invert}$] values) was used to predict soil concentrations that would be protective of the sensitive terrestrial feeding guilds found at these ranges. The food web model indicated that adverse effects to terrestrial receptors could occur when antimony concentrations in soil exceed 2.95 mg/kg, copper concentrations in soil exceed 267 mg/kg, lead concentrations in soil exceed 55 mg/kg, and zinc concentrations in soil exceed 215 mg/kg.

The calculated Eco-RBRGs for soil COPECs at the IMR and BGR Ranges ranged from 2.95 to more than 1,620 mg/kg for antimony, 61.4 to 16,200 mg/kg for copper, 55 to more than 15,600 mg/kg for lead, and 33.5 to 555,000 mg/kg for zinc. Potential Eco-RBRGs for soil COPECs are presented in the IMR/BGR BERA (Shaw, 2008) and are summarized in Table 4-1. It is important to note that these soil Eco-RBRGs represent only those remedial goals resulting from the specific assessments conducted as part of the IMR/BGR BERA.

Table 4-1. Summary of Potential Ecological Risk-Based Remedial Goals for Soil

Measurement Endpoints	Soil COPECs Antimony (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Terrestrial Invertebrate Survival and Growth				
28-Day Earthworm Survival NOEC	6.7	127	779	47.3
28-Day Earthworm Survival LOEC	17.9	334	2,310	63.9
28-Day Earthworm Survival AET	>1,620	509	15,600	139
28-Day Earthworm Growth NOEC	NA	61.4	760	33.5
28-Day Earthworm Growth LOEC	NA	62.2	779	35.1
28-Day Earthworm Growth AET	NA	334	6,820	72.8
Terrestrial Food Web Exposures				
Site-Specific $BAF_{soil\text{-}to\text{-}invert}$:				
White-Footed Mouse NOAEL	4.85	267	205	1,750
White-Footed Mouse LOAEL	48.5	350	1,680	193,000
American Robin NOAEL	2.95	850	55	39,000
American Robin LOAEL	14.8	1,140	147	555,000
Short-Tailed Shrew NOAEL	6.85	820	100	215
Short-Tailed Shrew LOAEL	68.5	1,185	800	173,000
American Woodcock NOAEL	12.2	11,870	105.5	46,500
American Woodcock LOAEL	61	16,200	280	550,000
Background Screening Values:	1.99	12.7	40.1	40.6
Soil RBRG Range :	2.95 - >1,620	61.4 - 16,200	55 - >15,600	33.5 - 555,000

4.1 Soil Ecological Risk-Based Remedial Goals Based on Terrestrial Invertebrate Endpoints

The terrestrial invertebrate community forms a critical link in many terrestrial food webs and constitutes a food source for many omnivorous and invertivorous birds and mammals. Terrestrial invertebrates also perform an important function in the degradation of organic matter in soil through their bioturbative activities. Terrestrial invertebrates may also accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. For these reasons, the terrestrial invertebrate community was identified as an important ecological resource at FTMC.

Earthworm toxicity tests were conducted as part of the IMR and BRG Ranges BERA in order to determine the bioavailability of the soil COPECs to terrestrial invertebrates, determine the bioaccumulation potential of the soil COPECs in terrestrial invertebrates, and determine the concentrations of COPECs in soil that could induce adverse effects in terrestrial invertebrates. Specifically, the adverse effects (measurement endpoints) that were studied in the earthworm toxicity tests were mortality and growth. The results of the earthworm toxicity tests and the corresponding concentrations of the soil COPECs are summarized in Table 4-2.

Because the earthworm toxicity tests indicated that antimony was most likely not a causative agent in the adverse effects observed, the derivation of an Eco-RBRG for antimony is subjective. However, an Eco-RBRG for antimony, based on earthworm survival, can be identified as 17.9 mg/kg. This antimony concentration in soil is the LOEC for earthworm survival determined in the earthworm toxicity tests. No adverse effects that could be attributed to antimony in soil were observed in the earthworm growth tests.

An Eco-RBRG for copper in soil can be identified as 334 mg/kg, based on earthworm growth and survival. The copper concentration in soil of 334 mg/kg represents the LOEC for earthworm survival and the AET for earthworm growth determined in the earthworm toxicity tests. No effects on earthworm survival were observed below 334 mg/kg. Although adverse effects on earthworms were observed in two soil samples with copper concentrations below 334 mg/kg (e.g. SAR-71-SS05 and SAR-69-SS11, with copper concentrations of 62.2 and 90 mg/kg, respectively), these soil samples exhibited elevated concentrations of lead (779 and 41,300 mg/kg, respectively) and the observed adverse effect on earthworms (reduced growth) was likely attributable to the elevated lead concentrations in these samples and not to the copper. An Eco-RBRG for copper set at the LOEC for earthworm survival and the AET for earthworm growth (334 mg/kg) would be sufficiently protective of the terrestrial invertebrate community at FTMC. However, due to the inherent uncertainties in assigning chemical-specific LOEC and NOEC values based on the results of toxicity tests that assess a mixture of chemicals, it is important to recognize the possibility that an Eco-RBRG for copper of 334 mg/kg could result in growth effects on earthworms from residual copper in soil, and potentially affect the quality of the food resources for invertivores.

An Eco-RBRG for lead in soil can be identified as 760 mg/kg, based on earthworm growth. The lead concentration in soil of 760 mg/kg represents the NOEC for earthworm growth determined in the earthworm toxicity tests. No effects on earthworm survival or growth were observed at lead concentrations less than 760 mg/kg. An Eco-RBRG for lead set at the NOEC for earthworm growth (760 mg/kg) would be sufficiently protective of the terrestrial invertebrate community at FTMC.

Table 4-2

Surface Soil COPEC Concentrations and Earthworm Toxicity
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Sample Name	Sample ID	Antimony Conc. in Surface Soil (mg/kg - dry wt.)	Copper Conc. in Surface Soil (mg/kg - dry wt.)	Lead Conc. in Surface Soil (mg/kg - dry wt.)	Zinc Conc. in Surface Soil (mg/kg - dry wt.)	Toxicity Test Endpoints		
						14-Day Earthworm Survival (percent)	28-Day Earthworm Survival (percent)	Earthworm Growth (% wt. change)
ARTIFICIAL LABORATORY SOIL	ABC CONTROL							
HR-70Q-SS01-SS-RW0001-REG	RW0001	92.2	509	10600	139	100	24 *	-87 *
SAR-85-SS37-SS-RW0002-REG	RW0002	187	711	22600	116	80 *	0 *	-100 *
SAR-85-SS34-SS-RW0004-REG	RW0004	112	508	14900	128	100	96	-49 *
SAR-71-SS05-SS-RW0005-REG	RW0005	ND	62.2	779	35.1	98	82	-55 *
SAR-71-SS09-SS-RW0006-REG	RW0006	ND	34.9	480	39.3	100	100	-23
LMBC-REF1-SS-RW0007-REG	RW0007	ND	5.91	16.5	18.3	98	98	-8
LMBC-REF2-SS-RW0008-REG	RW0008	ND	4.25	38.3	19.2	100	100	-10
LMBC-REF3-SS-RW0009-REG	RW0009	ND	7.66	94.4	22.6	100	100	-23
HR-77Q-SS01-SS-RW0010-REG	RW0010	276	3580	20100	281	0 *	0 *	-100 *
SAR-78-SS34-SS-RW0012-REG	RW0012	72.9	1200	15600	153	62 *	2 *	-99 *
SAR-77-SS33-SS-RW0013-REG	RW0013	35.4	908	6860	72.8	36 *	0 *	-100 *
HR-80Q-MW02-SS-RW0014-REG	RW0014	39.5	127	4660	43.9	98	98	-20
SAR-77-SS50-SS-RW0015-REG	RW0015	ND	14.6	156	19.9	100	100	-22
MMBC-REF-SS-RW0016-REG	RW0016	ND	5.86	39.4	20.3	98	98	-17
SAR-85-SS17-SS-RW0017-REG	RW0017	63.3	334	6820	73.1	96	65 *	-67 *
SAR-78-SS25-SS-RW0018-REG	RW0018	298	2280	23100	229	0 *	0 *	-100 *
SAR-78-SS17-SS-RW0019-REG	RW0019	17.9	393	2310	63.9	73 *	2 *	-99 *
SAR-69-SS11-SS-RW0021-REG	RW0021	1620	90	41300	47.3	94 [a]	96 [a]	-37 *
SAR-85-SS02-SS-RW0022-REG	RW0022	ND	93.1	180	71.5	98	96	-16
HMBC-REF-RW0023-REG	RW0023	ND	15.2	49.9	39.6	100	100	-16
SAR-70-SS12-SS-RW0024-REG	RW0024	ND	22.3	142	33.5	92	98	-19
HR-80Q-GP06-SS-RW0025-REG	RW0025	ND	56.2	486	28.1	100	100	-18
SAR-77-SS16-SS-RW0026-REG	RW0026	6.71	61.4	760	27.1	98	98	-20

▨ * - Significant difference in survival or weight change between reference sites and on-site samples.

[a] - 8 living worms were found on day-14 and 9 living worms were found on day-28 of the toxicity test. One living worm was apparently missed when counting day-14 survival rates.

An Eco-RBRG for zinc in soil can be identified as 72.8 mg/kg, based on earthworm growth. The zinc concentration in soil of 72.8 mg/kg represents the AET for earthworm growth determined in the earthworm toxicity tests. An Eco-RBRG for zinc set at the AET for earthworm growth (72.8 mg/kg) would be sufficiently protective of the terrestrial invertebrate community at FTMC. However, because the earthworm growth LOEC for zinc is 35.1 mg/kg, it is important to recognize the possibility that an Eco-RBRG for zinc of 72.8 mg/kg could result in survival and/or growth effects on earthworms from residual zinc in soil, and potentially affect the quality of the food resources for invertivores.

The following values were identified as the Eco-RBRGs for soil COPECs, based on the results of the terrestrial invertebrate toxicity tests:

- Antimony: 17.9 mg/kg
- Copper: 334 mg/kg
- Lead: 760 mg/kg
- Zinc: 72.8 mg/kg.

4.2 Soil Ecological Risk-Based Remedial Goals Based on Terrestrial Food Web Interactions

The higher trophic level feeding guilds at FTMC were assessed in the IMR/BGR BERA (Shaw, 2008) via a terrestrial food web model. The natural history data for the terrestrial food web model feeding guilds are presented in Table 4-3, and the TRVs for mammalian and avian receptors are presented in Tables 4-4 and 4-5, respectively. An important component in the estimation of the ecological hazards from exposures to the COPECs in soils (antimony, copper, lead, and zinc) is the estimation of the bioaccumulation of COPECs from soil to terrestrial invertebrates. The relationship between the COPEC concentration in soil and the COPEC concentration in terrestrial invertebrate tissues is known as the soil-to-invertebrate bioaccumulation factor ($BAF_{soil\text{-}to\text{-}invert}$).

Table 4-3

Terrestrial Foodweb Model Indicator Species Life History Parameters
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day-dry wt.)	Soil / Sediment Ingestion Rate [d] (kg/kg/day-dry wt.)	Dietary Fraction	Dietary Component
White-Footed Mouse	*Peromyscus leucopus*	Omnivorous Mammal	1 (b)	0.0225 (b)	0.19 (a)	0.1237 (a)	0.00247 (a)	0.254 0.746	Terrestrial Invertebrates Terrestrial Vegetation
American Robin	*Turdus migratorius*	Omnivorous Bird	0.61 (a)	0.081 (a)	0.14 (a)	0.1816 (a)	0.00363 (c)	0.375 0.625	Terrestrial Invertebrates Terrestrial Vegetation
Short-Tailed Shrew	*Blarina brevicauda*	Invertivorous Mammal	0.964 (a)	0.0168 (a)	0.223 (a)	0.0899 (a)	0.00216 (a)	0.887 0.113	Terrestrial Invertebrates Terrestrial Vegetation
American Woodcock	*Scolopax minor*	Invertivorous Bird	61.3 (a)	0.169 (a)	0.1 (a)	0.1517 (a)	0.0158 (a)	0.950 0.050	Terrestrial Invertebrates Terrestrial Vegetation

Notes:

All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.

a USEPA, 1993. *Wildlife Exposure Factors Handbook* . EPA/600/R-93/187a

b Burt, W.H. and R.P. Grossenheider. *Mammals, Peterson Field Guide* .

c Assumed value based on soil ingestion values for other birds presented in USEPA (1993).

d Eco-RBRGs presented in Table 4-9 were calculated based on the assumption that soil/sediment ingestion was equal zero.

Soil ingestion rates (dry weight) were calculated using the following relationship: $IR_{soil} = IR_{food} \times Diet_{soil}$

where:

IR_{soil} = ingestion rate of soil (kg/kg/day, dry weight);
IR_{food} = food ingestion rate (kg/kg/day, dry weight); and
$Diet_{soil}$ = percentage of diet that is soil (percent).

Table 4-4

Mammalian Toxicity Reference Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.	**Dose** (mg/kg/day)	**Uncertainty Factor**	**TRV** (mg/kg/day)	**Ref.**
Inorganic Constituents										
Antimony	Mouse	Longevity	1.25	10	0.125	5	1.25	1	1.25	5
Copper	Mink	Reproduction	12	1	12	1	15.4	1	15.4	1
Lead	Rat	Reproduction	8	1	8	2	80	1	80	2
Zinc	Mouse & Rat	Growth & Reproduction	104	10	10.4	3	320	1	320	4

NOTES :

1) Aulerich, R.J., R.K. Ringer, M.R. Bleavins, and A. Napolitano, 1982. "Effects of Supplemental Dietary Copper on Growth, Reproductive Performance, and Kit Survival of Standard Dark Mink and the Acute Toxicity of Copper to Mink." Journal of Animal Science, Vol. 55, pp. 337-343.

2) Azar, A. H.J. Trochimowicz, and M.E. Maxwell, 1973. "Review of Lead Studies in Animals Carried Out at Haskell Laboratory: Two-Year Feeding Study and Response to Hemorrhage Study." In: Environmental *Health Aspects of Lead: Proceedings, International Symposium*. D. Barth, et al., eds. Commission of Europen Communities, pp. 199-210.

3) Maita, K., M. Hirano, K. Mitsumori, K. Takabashi, and Y. Shirasu, 1981. "Subacute Toxicity Studies with Zinc Sulfate in Mice and Rats. " *Journal of Pesticide Science*, Vol. 6, pp. 327-336.

4) Schlicker, S.A. and D.H. Cox, 1968. "Maternal Dietary Zinc, and Development and Zinc, Iron, and Copper Content of the Rat Fetus." *J. Nutr.*, 95:: 287-294.

5) Schroeder, H.A., M. Mitchener, J.J. Balassa, M. Kanisawa, and A.P. Nason, 1968. "Zirconium, Niobium, Antimony, and Fluorine, in Mice: Effects on Growth, Survival, and Tissue Levels." J. Nutr., 95: 95-101.

Table 4-5

Avian Toxicity Reference Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	**Uncertainty Factor**	**TRV** (mg/kg/day)	**Ref.**	**Dose** (mg/kg/day)	**Uncertainty Factor**	**TRV** (mg/kg/day)	**Ref.**
Inorganic Constituents										
Antimony	Red-winged Blackbird	Mortality	100	900	0.111	3	100	180	0.556	3
Copper	1-Day old chicks	Growth & Mortality	46.97	1	46.97	2	61.72	1	61.72	2
Lead	American Kestrel & Japanese Quail	Reproduction	3.85	1	3.85	5	11.3	1	11.30	1
Zinc	Leghorn hen	Reproduction	130.9	1	130.9	4	130.9	0.1	1310	4

NOTES :

1) Edens, F., W.E. Benton, S.J. Bursian, and G.W. Morgan, 1976. "Effect of Dietary Lead on Reproductive Performance in Japanese Quail, Coturnix coturnix japonica." Toxicol. Appl. Pharmacol., 38: 307-314.

2) Mehring, A.L., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus, 1960. "The Tolerance of Growing Chickens for Dietary Copper." Poultry Science, Vol. 39, pp. 713-719.

3) Schafer, E.W., W.A. Bowles, and J. Hurlbut, 1983. The Acute Oral Toxicity, Repellency, and Hazard Potential of 998 Chemicals to One or More Species of Wild and Domestic Birds. *Arch. Environ Contam. Toxicol*. 12(3): 355-382. As cited in: Hazardous Substances Databank. January 1995.

4) Stahl, J.L., J.L. Greger, and M.E. Cook, 1990. "Breeding-Hen and Progeny Performance When Hens are Fed Excessive Dietary Zinc." Poultry Science, Vol. 69, pp. 259-263.

5) Pattee, O.H., 1984. "Eggshell Thickness and Reproduction in American Kestrels Exposed to Chronic Dietary Lead." *Arch. Environ. Contam. Toxicol*., 13: 213-218.

In order to define the relationship between soil concentrations and earthworm tissue concentrations of COPECs, the soil data and earthworm tissue data collected as part of the IMR/BGR BERA were plotted for each of the soil COPECs (antimony, copper, lead, and zinc) and a number of different regression models were fitted to the data. The results of the analysis of different regression models suggested that the straight line regression of the natural log transformed concentrations of copper, lead, and zinc in soil and earthworm tissues fit the data best. The regressions for the $BAF_{soil\text{-}to\text{-}invert}$ are presented as Figures J-6-9 through J-6-12 in the IMR/BGR BERA. The data for antimony suggest that there are no regression equations that accurately represent the relationship between soil concentrations and earthworm tissue concentrations of antimony. Therefore, in order to estimate a site-specific relationship between soil and earthworm tissue concentrations of antimony, the seven pairs of soil and earthworm tissue samples that had detectable concentrations of antimony were used to estimate a $BAF_{soil\text{-}to\text{-}invert}$ for antimony. The best fit regression models of the natural log transformed data for copper, lead, and zinc represent the site-specific $BAF_{soil\text{-}to\text{-}invert}$ and are summarized in Table 4-6. The $BAF_{soil\text{-}to\text{-}invert}$ for antimony based on paired soil and earthworm tissue samples is also presented in Table 4-6.

Table 4-6. Site-Specific Soil-to-Invertebrate Bioaccumulation Factors

Surface Soil COPEC	Site-Specific Soil-to-Invertebrate BAF
Antimony	0.188[a]
Copper	$y = 0.4673\,x + 1.4266$
Lead	$y = 1.1088\,x - 0.5168$
Zinc	$y = 0.321\,x + 3.1208$

where: y = natural logarithm of terrestrial invertebrate tissue concentration
x = natural logarithm of soil concentration.

[a] Earthworm tissue concentrations of antimony were inversely correlated with associated soil concentrations of antimony. However, a BAF was estimated using the 7 paired soil and earthworm tissue samples.

An important consideration in the calculation of these regression models is the fact that, for lead, only data from soil samples exhibiting lead concentrations less than 2,310 mg/kg were used in the regression analysis. It was assumed that soil exhibiting lead concentrations greater than 2,310 mg/kg would adversely impact the endpoints established for the earthworm toxicity tests and that including these high soil concentrations in the regression only serves to skew the result. Eliminating these data points from the regression analysis provided better resolution in the range of data where the critical endpoints are most likely impacted (i.e. where NOAELs and LOAELs are established). The slope of the linear regression for the edited lead data is greater than the slope of the linear regression for the un-edited lead data; however, the correlation coefficient for the edited data is greater than the correlation coefficient for the un-edited data and the y-intercept for the edited data is less than the y-intercept for the un-edited data. Therefore, within the range of the edited data, the lead $BAF_{soil\text{-}to\text{-}invert}$ values result in somewhat lower calculated earthworm tissue concentrations than the $BAF_{soil\text{-}to\text{-}invert}$ values from the un-edited data. If the entire data set (un-edited) were to be used to define a linear regression for the lead $BAF_{soil\text{-}to\text{-}invert}$, the estimated lead concentrations in soil invertebrates would be greater than those presented in the BERA.

These site-specific $BAF_{soil\text{-}to\text{-}invert}$ values were used in the terrestrial food web model in the IMR/BGR BERA (Shaw, 2008) to estimate the transfer of COPECs from surface soil to terrestrial invertebrates. The terrestrial food web model was subsequently used in conjunction with the site-specific $BAF_{soil\text{-}to\text{-}invert}$ values to estimate soil concentrations of COPECs that would result in hazard quotients (HQs) of one. These estimated soil concentrations (assuming all of the conservatism inherent in the food web model) based on an HQ equal to 1.0 are summarized below in Table 4-7. (Note: The IMR/BGR BERA [Shaw, 2008] utilized a $BAF_{soil\text{-}to\text{-}invert}$ value for antimony of 0.22, which was referenced from the USEPA Combustion Guidance [1999], not accounting for the moisture content of earthworms. This $BAF_{soil\text{-}to\text{-}invert}$ value for antimony is coincidentally very close to the site-specific antimony $BAF_{soil\text{-}to\text{-}invert}$ value estimated using paired soil and earthworm tissue data.)

Table 4-7. Soil Ecological Risk-Based Remedial Goals Based on Site-Specific Soil-to-Invertebrate Bioaccumulation Factors

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{soil\text{-}to\text{-}invert}$) (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{soil\text{-}to\text{-}invert}$) (mg/kg)
White-Footed Mouse :		
- antimony	4.85	48.5
- copper	267	350
- lead	205	1,680
- zinc	1,500	145,000
American Robin :		
- antimony	2.95	14.8
- copper	850	1,140
- lead	55	147
- zinc	31,500	434,000
Short-Tailed Shrew :		
- antimony	6.85	68.5
- copper	820	1,185
- lead	100	800
- zinc	215	173,000

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{soil-to-invert}$) (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{soil-to-invert}$) (mg/kg)
American Woodcock :		
- antimony	12.2	61
- copper	11,870	16,200
- lead	105.5	280
- zinc	46,500	550,000

A site-specific lead $BAF_{soil-to-invert}$ value can also be estimated using the eighteen paired data sets for soil and earthworm tissue that had detectable concentrations of lead. These paired data sets yielded an average $BAF_{soil-to-invert}$ value for lead of 0.839. If this value is used in the terrestrial food web model for the lead $BAF_{soil-to-invert}$ value, then the Eco-RBRGs for lead, based on food web interactions, are the following:

Table 4-8. Soil Ecological Risk-Based Remedial Goals For Lead Based on Paired Soil and Earthworm Tissue Data

Receptor	Soil Lead Conc. Based on NOAEL TRV and HQ = 1.0 (Paired Data $BAF_{soil-to-invert}$) (mg/kg)	Soil Lead Conc. Based on LOAEL TRV and HQ = 1.0 (Paired Data $BAF_{soil-to-invert}$) (mg/kg)
White-footed Mouse	250	2,500
American Robin	59.7	176
Short-tailed Shrew	116	1,170
American Woodcock	123	361

These Eco-RBRGs for lead based on soil and earthworm tissue data pairs are within the range of Eco-RBRGs calculated for food web interactions using the site-specific $BAF_{soil-to-invert}$ values based on regression equations, except for the LOAEL-based Eco-RBRG for the white-footed mouse. These calculated soil lead concentrations based on an HQ of 1.0 and site-specific $BAF_{soil-to-invert}$ values can be considered soil Eco-RBRGs for the protection of the upper trophic level organisms expected to occur at the BGR and IMR Ranges at FTMC.

A number of factors (physical, chemical, and biological) are instrumental in determining the potential for bioaccumulation of soil COPECs into terrestrial invertebrate tissues. Studies have shown that cation exchange capacity, pH, organic carbon content, clay content, manganese oxide levels, and iron oxide levels all contribute to the potential bioavailability and bioaccumulation of metals in soils (Criel, et al., 2008 and Bradham, et al., 2006). There is some debate as to which soil property influences metal bioavailability the greatest, but it is generally agreed that many of the soil properties are inter-correlated and it is difficult to identify a single soil property that influences metal bioavailabilty the greatest. Criel, et al. (2008) have shown that cation exchange capacity influences the bioavailability and bioaccumulation of copper the greatest, while Bradham, et al. (2006) have shown that pH influences the bioavailability and bioaccumulation of lead the greatest. What is clear from the scientific literature is that it is a combination of many of these soil properties acting in combination with one another that controls the bioavailability and bioaccumulation potential of metals in soil.

The implication of the impact of the various soil properties at the IMR and BGR ranges on the $BAF_{soil-to-invert}$ values is that the site-specific $BAF_{soil-to-invert}$ values were derived using soil collected at the IMR and BGR ranges at FTMC; therefore, the site-specific $BAF_{soil-to-invert}$ values take into account the inherent bioavailability of the soils at FTMC.

One potential source of uncertainty with regard to the derivation of the site-specific $BAF_{soil-to-invert}$ values is the fact that earthworms exposed to soils during the bioaccumulation testing conducted as part of the IMR/BGR BERA were not depurated prior to chemical analysis; thus potentially resulting in artificially high COPEC concentrations in the earthworm tissue samples and artificially high $BAF_{soil-to-invert}$ values. Normally, organisms used for bioaccumulation studies are allowed to depurate for a period of time (usually 24 hours) after their exposure period in order to allow for the organisms' gut contents to be cleared (depurated). Depuration of the test organisms prior to chemical analysis ensures that the chemical analysis performed on the test organisms' tissues does not include the contents of the organisms' gut. The fact that the earthworms were not depurated prior to chemical analysis introduces uncertainty into the derivation of site-specific $BAF_{soil-to-invert}$ values.

In order to mitigate some of the uncertainty in the site-specific $BAF_{soil-to-invert}$ values due to the lack of earthworm depuration, the terrestrial food web model can be modified to incorporate an incidental soil ingestion rate of zero. Changing the incidental soil ingestion rate to zero mitigates a portion of the affect of not depurating the earthworms prior to analysis by assuming the soil in the earthworms' guts accounts for the soil that would be incidentally ingested while foraging. The Eco-RBRGs that were derived using the terrestrial food web model, site-specific $BAF_{soil-to-invert}$ values, and zero incidentally ingested soil are summarized in Table 4-9.

Table 4-9. Soil Ecological Risk-Based Remedial Goals Based on Site-Specific Soil-to-Invertebrate Bioaccumulation Factors and Zero Incidental Soil Ingestion

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{soil\text{-}to\text{-}invert}$) (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (Site-Specific $BAF_{soil\text{-}to\text{-}invert}$) (mg/kg)
White-Footed Mouse :		
- antimony	5.15	51.5
- copper	277	363
- lead	212	1733
- zinc	4300	NA
American Robin :		
- antimony	3.14	15.7
- copper	890	1190
- lead	56.5	151
- zinc	NA	NA
Short-Tailed Shrew :		
- antimony	7.37	73.7
- copper	950	1395
- lead	101	808
- zinc	235	NA
American Woodcock :		
- antimony	16.25	81
- copper	37500	53000
- lead	112	295
- zinc	NA	NA

NA – The terrestrial food web model and site-specific $BAF_{soil\text{-}to\text{-}invert}$ values indicate that zinc does not pose a hazard to these receptors.

These values could be considered Eco-RBRGs for soil COPECs based on food web interactions.

4.3 Recommended Soil Ecological Risk-Based Remedial Goals

As presented in the above discussions and summarized in Tables 4-2, 4-7, 4-8, and 4-9, the potential Eco-RBRGs for soil COPECs cover a wide range of values, depending on the measurement endpoint considered. The following sections discuss the soil COPECs and the recommended Eco-RBRGs for each soil COPEC.

4.3.1 Ecological Risk-Based Remedial Goal for Antimony in Soil

As summarized in Table 4-1, the Eco-RBRGs for antimony in soil range from 2.95 to 1,620 mg/kg. The Eco-RBRGs derived using the terrestrial food web model have a significant degree of uncertainty because the bioaccumulation studies conducted as part of the IMR/BGR BERA did not indicate a strong correlation between soil concentrations of antimony and earthworm tissue concentrations of antimony. Therefore, the site-specific $BAF_{soil\text{-}to\text{-}invert}$ values have a significant degree of uncertainty associated with them. However, if the soil-earthworm paired data sets are used to estimate the antimony $BAF_{soil\text{-}to\text{-}invert}$ value, and the incidental soil ingestion rate is set to zero, the Eco-RBRGs for antimony in soil, based on terrestrial food web interactions, range from 3.14 mg/kg to 81 mg/kg. An Eco-RBRG set below the lowest LOAEL-based value of 15.7 mg/kg (Table 4-9) would be protective of all of the terrestrial food web measurement endpoints.

The strongest data set with regard to drawing correlations between antimony in soil and observed adverse impacts in biota is the earthworm survival data. No impacts were observed in the earthworm growth test that could be attributed to antimony. Adverse impacts to earthworm growth were observed at antimony concentrations as low as 17.9 mg/kg, which is the LOEC for earthworm survival. No adverse effects were observed at antimony concentrations less than 17.9 mg/kg. The earthworm survival AET is more than 1,620 mg/kg, which is significantly higher than the LOEC (17.9 mg/kg). It is difficult to resolve the adverse effects due to antimony because the soil samples with elevated antimony concentrations also have elevated copper and lead concentrations. Although reduced earthworm survival was recorded in the soil sample with an antimony concentration of 17.9 mg/kg, this same sample had a copper concentration of 393 mg/kg and a lead concentration of 2,310 mg/kg. It is likely that the observed adverse affect was due to the copper and/or lead in the soil sample and not antimony. Therefore, the recommended Eco-RBRG for antimony in soil is 17.9 mg/kg (which for ease in reporting is rounded to 18 mg/kg). This recommended Eco-RBRG for antimony is also very close to the LOAEL-based Eco-RBRG derived using site-specific $BAF_{soil\text{-}to\text{-}invert}$ value and the terrestrial food web model.

4.3.2 Ecological Risk-Based Remedial Goal for Copper in Soil

The Eco-RBRGs for copper in soil range from 61.4 to 16,200 mg/kg, depending upon the specific endpoint considered (Table 4-1). The terrestrial food web model-derived Eco-RBRGs range from 277 to 53,000 mg/kg (assuming a site-specific $BAF_{soil\text{-}to\text{-}invert}$ value and zero incidental soil ingestion, Table 4-9).

The most sensitive receptor for copper in the terrestrial food web model is the omnivorous mammal (white-footed mouse). The calculated Eco-RBRGs for copper in soil based on terrestrial food web interactions of omnivorous mammals range from 277 to 363 mg/kg (Table 4-9). Because an Eco-RBRG based on the most sensitive endpoint would also be protective of all the less sensitive endpoints, an Eco-RBRG within this concentration range would be protective of the terrestrial food web endpoints. Therefore, an Eco-RBRG for copper in soil within the range of 277 to 363 mg/kg would be protective of the terrestrial food web endpoints.

The Eco-RBRGs for copper in soil based on terrestrial invertebrate toxicity test results range from 61.4 mg/kg (earthworm growth NOEC) to 509 mg/kg (earthworm survival AET). A relatively strong correlation is described by the regression equations for copper concentrations in soil and adverse effects observed in earthworms. These correlations are presented in Figures J-6-2 and J-6-6 in the IMR/BGR BERA (Shaw, 2008). The correlation coefficient for copper in soil and earthworm survival was estimated to be r = 0.83, and the correlation coefficient for copper in soil and earthworm growth was estimated to be r = 0.88. An Eco-RBRG based on the earthworm survival LOEC and earthworm growth AET (334 mg/kg) would be protective of most terrestrial invertebrate endpoints. Based on the earthworm toxicity testing results, copper concentrations in soil less than 334 mg/kg would not induce any adverse affects on earthworm survival. However, copper concentrations as low as 62.2 mg/kg (earthworm growth LOEC) in soil may induce adverse effects on earthworm growth. It is difficult to resolve the adverse effects due to copper because the soil samples with elevated copper concentrations also have elevated antimony and lead concentrations. Although reduced earthworm survival and growth were recorded in the soil sample with a copper concentration of 334 mg/kg, this same sample had an antimony concentration of 63.3 mg/kg and a lead concentration of 6,820 mg/kg. It is possible that the observed adverse affect was due to the antimony and/or lead in the soil sample and not to copper. In fact, if the earthworm growth LOEC for lead is 779 mg/kg, then it is likely that the lead (6,820 mg/kg) in the sample used to characterize the earthworm survival LOEC for copper is a causative agent for a significant portion of the observed toxicity.

Therefore, a reasonable Eco-RBRG for copper in soil is 334 mg/kg. Copper concentrations at or below 334 mg/kg in soil are unlikely to induce adverse effects on earthworm survival and would be protective of all of the endpoints for the receptors assessed via food web interactions. For these reasons, the recommended Eco-RBRG for copper in soil is 334 mg/kg. However, due to the inherent uncertainties in assigning chemical-specific LOEC and NOEC values based on the results of toxicity tests that assess a mixture of chemicals, it is important to recognize the possibility that an Eco-RBRG for copper of 334 mg/kg could result in growth effects on earthworms from residual copper in soil, and potentially affect the quality of the food resources for invertivores.

4.3.3 *Ecological Risk-Based Remedial Goal for Lead in Soil*

The Eco-RBRGs for lead in soil range from 55 to 15,600 mg/kg (Table 4-1), depending upon the specific endpoint considered. The terrestrial food web model-derived Eco-RBRGs for lead in soil range from 56.5 to 1,733 mg/kg (assuming a site-specific $BAF_{soil\text{-}to\text{-}invert}$ value and zero incidental soil ingestion, Table 4-9).

The most sensitive receptor in the terrestrial food web model for lead is the omnivorous bird (American robin). The calculated Eco-RBRGs for lead in soil based on terrestrial food web interactions of omnivorous birds range from 56.5 to 151 mg/kg (Table 4-9). Because an Eco-RBRG based on the most sensitive endpoint would also be protective of the less sensitive endpoints, an Eco-RBRG within this concentration range would be protective of the terrestrial food web endpoints. Therefore, an Eco-RBRG within the range of 56.5 to 151 mg/kg would be protective of the terrestrial food web endpoints.

The Eco-RBRGs for lead in soil, based on terrestrial invertebrate toxicity test results, range from 760 mg/kg (earthworm growth NOEC) to 15,600 mg/kg (earthworm survival AET). A relatively strong correlation is described by the regression equation for lead concentrations in soil and earthworm growth ($r = 0.78$), while a somewhat weaker correlation is described by the regression equation for lead concentrations in soil and earthworm survival ($r = 0.66$). These correlations are presented on Figures J-6-3 and J-6-7 in the IMR/BGR BERA (Shaw, 2008). An Eco-RBRG for lead based on the earthworm growth NOEC (760 mg/kg) would be protective of all of the terrestrial invertebrate endpoints and is very close to the earthworm growth LOEC (779 mg/kg). Based on the earthworm toxicity testing results, lead concentrations in soil less than 760 mg/kg would not induce any adverse effects on earthworm survival or growth. Unlike the other soil COPECs, the adverse effects observed at a lead concentration of 760 mg/kg are likely attributable to lead, because the concentrations of the other soil COPECs are relatively low.

In order to collect empirical data for the purpose of determining potential risk to song birds at lead contaminated firing ranges, Mark Johnson, et al. (2007) conducted a study whereby blood-lead samples were collected from a number of bird species at 2 different small arms range complexes and compared them to a blood-lead TRV to determine if birds inhabiting these ranges were at risk from lead exposures. One of the range complexes studied was the Bains Gap Road (BGR) ranges at FTMC. The other range complex reported in this study was the Known Distance Range (KDR) at Aberdeen Proving Ground, MD. Blood-lead samples were collected from the following bird species at the BGR ranges: eastern bluebird (*Sialia sialis*), yellow-breasted chat (*Icteria virens*), indigo bunting (*Passerina cyanea*), northern cardinal (*Cardinalis cardinalis*), chipping sparrow (*Spizella passerina*), scarlet tanager (*Piranga olivacea*), eastern phoebe (*Sayornis phoebe*), brown thrasher (*Toxostoma rufum*), and downy woodpecker (*Picoides pubescens*). Surface soil samples were also collected from the BGR ranges and mean lead concentrations in surface soil ranged from 13,630 mg/kg in the target berm areas to 57 mg/kg in other areas. The 95% UCL lead concentration in soil for the study area at the BGR ranges was calculated to be 8,727 mg/kg. The blood-lead concentrations for birds sampled at the BGR ranges ranged from 1 to 25 μg/dL. These measured blood-lead concentrations were compared to literature-derived blood-lead TRVs of 29 μg/dL (NOAEL-based TRV) and 58 μg/dL (LOAEL-based TRV) in order to draw conclusions regarding the potential for risk. None of the measured blood-lead concentrations from the BGR ranges exceeded the blood-lead TRVs, indicating negligible risk to song birds at the BGR ranges from exposures to lead, even though the lead concentrations in soil at the BGR ranges were significantly elevated above background levels. These data indicate that a conservative bias is likely built into the terrestrial food web model for the IMR/BGR ranges due to the fact that desirable habitat at these ranges was limited at the time of sampling, and that the Eco-RBRGs that are derived using the terrestrial food web model are conservative, given the habitat restrictions that currently exist at the BGR ranges.

A reasonable Eco-RBRG for lead in soil could be set at 760 mg/kg based on the earthworm toxicity test results. However, if terrestrial food web model interactions are also considered, the Eco-RBRG for lead in soil should be between 56.5 and 151 mg/kg. Empirical data from the BGR ranges suggest that an average concentration of lead in soil of 8,727 mg/kg may not pose risks to songbirds inhabiting the BGR ranges (Johnson, et al., 2007). An Eco-RBRG for lead in soil set at 500 mg/kg is lower than the Eco-RBRG protective of all the terrestrial invertebrate endpoints, and is also less than the soil concentration of lead shown to be protective of songbirds (the most sensitive food web receptor) currently inhabiting the BGR ranges. An Eco-RBRG for lead in soil of 500 mg/kg is likely protective of mammalian omnivores and mammalian invertivores through food web interactions; however, it is greater than the LOAEL-based Eco-RBRGs protective of avian invertivores and avian omnivores in the terrestrial food web model. Given the conservative nature of the terrestrial food web model, an Eco-RBRG for lead in soil of 500 mg/kg may also be protective of avian invertivores and avian omnivores. Therefore, the recommended Eco-RBRG for lead in soil is a "not to exceed value" of 500 mg/kg.

4.3.4 Ecological Risk-Based Remedial Goal for Zinc in Soil

The Eco-RBRGs for zinc in soil range from 33.5 to 555,000 mg/kg, depending upon the specific endpoint considered (Table 4-1). The terrestrial food web model-derived Eco-RBRGs for zinc in soil range from 235 to unlimited (assuming a site-specific $BAF_{soil\text{-}to\text{-}invert}$ value and zero incidental soil ingestion, Table 4-9).

The most sensitive receptor in the terrestrial food web model for zinc is the invertivorous mammal (short-tailed shrew). The calculated Eco-RBRGs for zinc in soil based on terrestrial food web interactions of invertivorous mammals range from 235 mg/kg to unlimited. Due to the nature of the site-specific $BAF_{soil\text{-}to\text{-}invert}$ value for zinc (very low slope), an upper bound on the range of Eco-RBRGs cannot be calculated. Several of the receptors in the terrestrial food web model are not sensitive to zinc exposures. Because an Eco-RBRG based on the most sensitive endpoint would also be protective of the less sensitive endpoints, an Eco-RBRG within this concentration range would be protective of the terrestrial food web endpoints. Therefore, an Eco-RBRG of 235 mg/kg would be expected to be protective of the terrestrial food web endpoints. Using the terrestrial food web model to derive Eco-RBRGs results in an extremely broad range of values, making it difficult to identify a single Eco-RBRG for zinc based on the terrestrial food web model.

The large range in food web-based Eco-RBRG values is due to the fact that the LOAEL-based TRV for zinc (320 mg/kg/day) is more than 30-times greater than the NOAEL-based TRV for zinc (10.4 mg/kg), and also the very flat slope of the site-specific $BAF_{soil\text{-}to\text{-}invert}$ regression equation. The very flat slope of the site-specific $BAF_{soil\text{-}to\text{-}invert}$ regression indicates that even a significant increase in soil concentration of zinc results in only a minimal increase in invertebrate tissue concentrations of zinc. These two factors combined, result in a broad range of food web-based Eco-RBRGs for zinc. Additionally, the Eco-RBRGs based on the terrestrial food web model are different than the Eco-SSLs (USEPA, 2007) for zinc for several reasons; namely, the Eco-SSLs assume different food ingestion rates, the Eco-SSLs assume different soil ingestion rates, the Eco-SSLs assume more simplified feeding strategies (i.e. mammalian invertivore consumes 100% earthworms), and the Eco-SSLs assume a different $BAF_{soil\text{-}to\text{-}invert}$ regression equation.

The zinc Eco-RBRGs based on terrestrial invertebrate toxicity test results range from 33.5 mg/kg (earthworm growth NOEC) to 139 mg/kg (earthworm survival AET). A relatively strong correlation is described by the regression equations for zinc concentrations in soil and adverse effects observed in earthworms. These correlations are presented in Figures J-6-4 and J-6-8 in the IMR/BGR BERA (Shaw, 2008). The correlation coefficient for zinc in soil and earthworm survival was estimated to be r = 0.78, and the correlation coefficient for zinc in soil and earthworm growth was estimated to be r = 0.83. An Eco-RBRG based on the earthworm survival and growth AETs (139 and 72.8 mg/kg, respectively) would be protective of most terrestrial invertebrate endpoints. Using the USEPA's "Rule of 5" (Greenberg and Charters, 2005), the geometric mean of these AET values results in a zinc concentration of 101 mg/kg. Based on the earthworm toxicity testing results and the "Rule of 5," zinc concentrations in soil greater than 100 mg/kg may induce adverse effects on earthworm growth and/or survival.

It is important to note that the adverse affects observed in the soil sample containing zinc at 72.8 mg/kg (earthworm growth AET) also had copper and lead concentrations of 908 and 6,860 mg/kg, respectively, and the soil sample containing zinc at 139 mg/kg (earthworm survival AET) also had copper and lead concentrations of 509 and 10,600 mg/kg, respectively. Therefore, it is likely that the observed adverse effects at 72.8 and 139 mg/kg zinc are at least partially due to the elevated copper and lead in these same soil samples. These elevated copper and lead concentrations make it difficult to resolve the zinc concentrations that may induce adverse affects. Therefore, a reasonable Eco-RBRG for zinc in soil is 100 mg/kg. Zinc concentrations at or below 100 mg/kg in soil would be protective of all of the sensitive endpoints for the receptors assessed via food web interactions. For these reasons, the recommended Eco-RBRG for zinc in soil is 100 mg/kg. However, due to the inherent uncertainties in assigning chemical-specific LOEC and NOEC values based on the results of toxicity tests that assess a mixture of chemicals, it is important to recognize the possibility that an Eco-RBRG for zinc of 100 mg/kg could result in survival and/or growth effects on earthworms from residual zinc in soil, and potentially affect the quality of the food resources for invertivores.

Based on the lines of evidence presented in the previous sections, the recommended Eco-RBRGs for the soil COPECs are as follows:

- Antimony: 18 mg/kg
- Copper: 334 mg/kg
- Lead: 500 mg/kg
- Zinc: 100 mg/kg.

These values are recommended as "not-to-exceed" Eco-RBRGs for soil COPECs at the IMR and BGR Ranges at FTMC. If these recommended Eco-RBRGs are applied as "not-to-exceed" values, the average exposure levels for the soil COPECs would likely be lower, which would mitigate some of the uncertainties inherent in the derivation of the Eco-RBRGs.

5.0 Risk-Based Remedial Goals for Surface Water

Fathead minnow and ceriodaphnid toxicity tests conducted as part of the IMR/BGR BERA (Shaw, 2008) indicated that COPEC concentrations in surface water at the BGR Ranges may cause adverse effects in aquatic vertebrates (reduced fathead minnow survival and growth) and aquatic invertebrates (reduced ceriodaphnid survival and reproduction). The toxicity tests indicated that copper and lead were the most likely causative agents for the observed adverse effects in the surface water toxicity tests. Adverse effects were observed in fathead minnows and ceriodaphnids at copper concentrations as low as 0.0346 milligrams per liter (mg/L) and at lead concentrations as low as 0.00236 mg/L. Background screening values for copper and lead in surface water at FTMC have been established as 0.0127 mg/L for copper and 0.0087 mg/L for lead (IT, 2000).

The Eco-RBRGs for surface water COPECs at the IMR and BGR Ranges, based on fathead minnow survival and growth and ceriodaphnid survival and reproduction, ranged from 0.0129 to 0.0608 mg/L for copper and nondetectable to 0.0462 mg/L for lead. However, there is a significant level of uncertainty associated with a portion of the results of the ceriodaphnid survival test. The results of the ceriodaphnid toxicity testing indicate that seven-day survival rates were reduced in two surface water samples (SAR-77-SW19 and SAR-77-SW20), both of which exhibited nondetectable levels of copper and one of which had a nondetectable level of lead, and the other had a lead concentration of 0.00236 mg/L. Of the three samples that had concentrations of lead in the interval between sample SAR-77-SW20, which had 0.00236 mg/L lead, and sample SAR-78-SW12, which had 0.0306 mg/L lead, none of them induced any toxic effects: SAR-77-SW15, with 0.00357 mg/L lead; SAR-78-SW14, with 0.00762 mg/L lead; and SAR-78-SW13 with 0.0105 mg/L lead. The toxicity observed in SAR-77-SW20, with only 0.00236 mg/L lead, as well as the toxicity in SAR-77-SW19 with no detectable lead, was likely not due to lead, but other unknown factors. Copper similarly had lower levels in the same three samples than any of the other samples with observed toxicity except for SAR-77-12 and SAR-22-SW20, where copper was not detected. The available data are not conclusive as to the cause of the observed toxicity in samples SAR-77-SW19 and SAR-77-SW20. These toxicity test results indicate that a factor other than lead or copper in surface water may be the cause of reduced ceriodaphnid survival in these two samples.

Inclusion of the ceriodaphnid survival test results for samples SAR-77-SW19 and SAR-77-SW20 would indicate that survival is a more sensitive endpoint than reproduction. Because reproduction is almost always a more sensitive endpoint than survival, it is counterintuitive and highly unlikely for the survival endpoints to be lower than the reproductive endpoints. If the ceriodaphnid survival results for these two samples (SAR-77-SW19 and SAR-77-SW20) are not considered further due to their uncertainty, then the results of the fathead minnow growth, ceriodaphnid survival, and ceriodaphnid reproduction tests are identical, as shown in Table 5-1.

Table 5-1. Surface Water Toxicity Test Results

Endpoint	**Surface Water Copper Conc.** (mg/L)	**Surface Water Lead Conc.** (mg/L)
Fathead Minnow Survival LOEC	0.0608	0.0462
Fathead Minnow Survival NOEC	0.0527	0.0422
Fathead Minnow Survival AET	0.0608	0.0462
Fathead Minnow Growth LOEC	0.0346	0.0306
Fathead Minnow Growth NOEC	0.0129	0.0105
Fathead Minnow Growth AET	0.0346	0.0306
Ceriodaphnid Survival LOEC	0.0346	0.00236
Ceriodaphnid Survival NOEC	0.0129	ND
Ceriodaphnid Survival AET	0.0346	0.0306
Ceriodaphnid Reproduction LOEC	0.0346	0.0306
Ceriodaphnid Reproduction NOEC	0.0129	0.0105
Ceriodaphnid Reproduction AET	0.0346	0.0306
Background Screening Values:	0.0127	0.00867
Surface Water Eco-RBRG Range :	0.0129 – 0.0608	ND – 0.0462

The surface water toxicity test results summarized above indicate that fathead minnow survival is the least sensitive endpoint and the other three endpoints (fathead minnow growth, ceriodaphnid survival, and ceriodaphnid reproduction) are identical. Therefore, if the most sensitive endpoint(s) are used to derive an Eco-RBRG, then the Eco-RBRG that is derived will also be protective of the other less sensitive endpoints.

In order to estimate a single Eco-RBRG for each constituent in surface water, the EPA's "Rule of 5" (Greenberg and Charters, 2005) was applied to the range of values calculated for the most sensitive assessment endpoints. By selecting the third progression node for the entire range between the lowest NOAEL and the lowest LOAEL for each assessment endpoint, the Eco-RBRG identified by the "Rule of 5" effectively is the same as calculating the geometric mean of these two values. Using this approach, the following Eco-RBRGs were estimated for surface water COPECs:

- Copper: 0.0211 mg/L
- Lead: 0.0179 mg/L.

These values are recommended for Eco-RBRGs for surface water COPECs at the IMR and BGR Ranges at FTMC. National and Alabama ambient water quality criteria (AWQC) should also be considered by risk managers as possible ecological remedial goals for surface water.

6.0 Risk-Based Remedial Goals for Sediment

Arsenic, barium, copper, lead, manganese, and thallium were identified as sediment COPECs in the SLERA conducted for the IMR and BGR Ranges and were assessed in the IMR/BGR BERA (Shaw, 2008). The sediment-related endpoints that were assessed in the IMR/BGR BERA were chironomid survival and growth, and modeled impacts to invertivorous mammals and birds through food web interactions. The results of the 10-day chironomid survival and growth test showed that growth (the most sensitive endpoint) was statistically reduced in sediment samples with copper concentrations as low as 10.4 mg/kg and lead concentrations as low as 76.7 mg/kg (Table 6-1). Arsenic, barium, and manganese concentrations in sediment were poorly correlated to the sediment toxicity test results, and thallium was not detected in any of the sediment samples collected for toxicity testing; therefore, these constituents were not considered causative agents in the observed adverse effects in the chironomid toxicity tests. Background screening values for copper and lead in sediment at FTMC have been established as 17.1 mg/kg for copper and 37.8 mg/kg for lead (IT, 2000).

The results of the riparian food web model indicated that there is a potential risk to riparian invertivorous mammals and riparian invertivorous birds from food web exposures to copper and lead in sediment. None of the other COPECs in surface water or sediment (arsenic, barium, manganese, and thallium) indicated the potential for adverse affects from food web exposures. The natural history parameters for the riparian food web model receptors are presented in Table 6-2. The riparian food web model was used to predict sediment concentrations that would be protective of the sensitive riparian feeding guilds found at the IMR and BGR Ranges. The riparian food web model indicated that adverse effects to riparian receptors could be expected at copper concentrations as low as 169 mg/kg and lead concentrations as low as 12.4 mg/kg in sediment (Shaw, 2008) (Table 6-1).

Table 6-1. Sediment Toxicity Test and Food Web Model Results

Endpoint	Sediment Copper Conc. (mg/kg)	Sediment Lead Conc. (mg/kg)
Benthic Invertebrate Survival and Growth:		
Chironomid Survival NOEC	126	495
Chironomid Survival LOEC	160	605
Chironomid Survival AET	380	>1,730
Chironomid Growth NOEC	9.06	23.1
Chironomid Growth LOEC	10.4	76.7

Endpoint	**Sediment Copper Conc.** (mg/kg)	**Sediment Lead Conc.** (mg/kg)
Chironomid Growth AET	74.9	432
Riparian Food Web Exposures:		
Invertivorous Mammal NOAEL	175	66
Invertivorous Mammal LOAEL	287	1,290
Invertivorous Bird NOAEL	99	3.1
Invertivorous Bird LOAEL	169	12.4
Background Screening Values:	17.1	37.8
Sediment Eco-RBRG Range :	9.06 – 380	3.1 – 1,730

The calculated Eco-RBRGs for sediment COPECs and all of the assessment endpoints assessed at the IMR and BGR ranges ranged from 9.06 to 380 mg/kg for copper and from 3.1 to 1,730 mg/kg for lead. It is important to note that these sediment Eco-RBRGs represent only those remedial goals resulting from the specific assessments conducted as part of the IMR/BGR BERA (Shaw, 2008).

Utilizing the same methodology as was used to identify Eco-RBRGs for soil and surface water as described above, the sediment Eco-RBRGs are all less than the ESVs and background screening values for sediment at FTMC. Because it is unlikely that the Army would be required to remediate sediment to levels below naturally occurring background levels, an alternative approach to identifying appropriate Eco-RBRGs was sought.

Numerical sediment quality guidelines (SQG) for freshwater ecosystems have previously been developed using a variety of approaches. Each approach has certain advantages and limitations which influence their application in the assessment of sediment quality. In an effort to focus on the agreement among these various published SQGs, consensus-based SQGs were developed by MacDonald, et al., (2000) for 28 chemicals in freshwater sediments. For each chemical, two consensus-based SQGs were developed from the published SQGs: a threshold effect concentration (TEC); and a probable effect concentration (PEC). The TEC is the concentration of a chemical in sediment below which harmful effects are unlikely to be observed, and the PEC is the concentration of a chemical in sediment above which harmful effects are likely to be observed. The range of chemical concentrations between the TEC and the PEC represents chemical concentrations that have an unknown probability of eliciting adverse effects.

The consensus-based TECs and PECs for the COPECs in sediment (copper and lead) at the IMR and BGR Ranges are reported by MacDonald, et al., (2000) and listed in Table 6-3.

Table 6-2

Riparian Foodweb Indicator Species Life History Parameters
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Area Use Factor (unitless)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day-dry wt.)	Soil / Sediment Ingestion Rate (kg/kg/day-dry wt.)	Dietary Fraction	Dietary Component
Little Brown Bat	*Myotis lucifugus*	Invertivorous Mammal	40 (c)	0.5	0.0080 (b)	0.16 (e)	0.0699 (d)	NA	1.0	Aquatic Emergent Invertebrates
Marsh Wren	*Cistothorus palustris*	Invertivorous Bird	0.13 (a)	1.0	0.01038 (a)	0.27 (a)	0.1833 (a)	NA	1.0	Aquatic Emergent Invertebrates

Notes:

All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.

a USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a

b Burt, W.H. and R.P. Grossenheider. *Mammals, Peterson Field Guide*.

c University of Michigan, 2006. *Spatial Foraging Habits of the Little Brown Bat (Myotis lucifugus) and Northern Long-Eared Bat (Myotis septentrionalis)*.

d Anthony and Kunz, 1977. Feeding Strategies of the Little Brown bat, *Myotis lucifugus*, in Southern New Hampshire.

e Sample, et al., 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants.

Table 6-3. Consensus-Based Sediment Quality Guidelines

	Copper	Lead
Consensus-Based TEC	31.6 mg/kg	35.8 mg/kg
Consensus-Based PEC	149 mg/kg	128 mg/kg

In order to identify a single Eco-RBRG for each COPEC in sediment, the geometric mean of the consensus-based TEC and PEC for each COPEC was calculated. The geometric means of the TEC and PEC for copper and lead were calculated to be the following:

- Copper: 69 mg/kg
- Lead: 68 mg/kg.

The recommended Eco-RBRG for copper in sediment (69 mg/kg) is protective of all the chironomid endpoints that are greater than the background screening value and all of the riparian food web endpoints. The recommended Eco-RBRG for lead in sediment (68 mg/kg) is protective of all the chironomid endpoints that are greater than the background screening value and all of the riparian food web endpoints that are greater than the background screening value. If the Eco-RBRGs are set at concentrations greater than the background screening values, then the proposed Eco-RBRGs will be protective of the endpoints assessed in the BERA for the IMR and BGR ranges.

Therefore, the recommended Eco-RBRGs for copper and lead in sediment are as follows:

- Copper: 69 mg/kg
- Lead: 68 mg/kg.

7.0 References

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ATTACHMENT 1

LIST OF ABBREVIATIONS AND ACRONYMS

List of Abbreviations and Acronyms

2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4,5-TP	2,4,5-trichlorophenoxypropionic acid
3D	3D International Environmental Group
AB	ambient blank
AbB3	Anniston gravelly clay loam, 2 to 6 percent slopes, severely eroded
AbC3	Anniston gravelly clay loam, 6 to 10 percent slopes, severely eroded
AbD3	Anniston and Allen gravelly clay loams, 10 to 15 percent slopes, eroded
ABLM	adult blood lead model
Abs	skin absorption
ABS	dermal absorption factor
AC	hydrogen cyanide
ACAD	AutoCadd
AcB2	Anniston and Allen gravelly loams, 2 to 6 percent slopes, eroded
AcC2	Anniston and Allen gravelly loams, 6 to 10 percent slopes, eroded
AcD2	Anniston and Allen gravelly loams, 10 to 15 percent slopes, eroded
AcE2	Anniston and Allen gravelly loams, 15 to 25 percent slopes, eroded
ACGIH	American Conference of Governmental Industrial Hygienists
ACM	asbestos-containing material
AdE	Anniston and Allen stony loam, 10 to 25 percent slope
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
AEC	U.S. Army Environmental Center
AEDA	ammunition, explosives, and other dangerous articles
AEL	airborne exposure limit
AET	adverse effect threshold; apparent effects threshold
AF	soil-to-skin adherence factor
AHA	ammunition holding area
AL	Alabama
ALARNG	Alabama Army National Guard
ALAD	δ-aminolevulinic acid dehydratase
ALDOT	Alabama Department of Transportation
amb.	Amber
AMEC	AMEC Earth & Environmental, Inc.
amsl	above mean sea level
ANAD	Anniston Army Depot
ANOVA	Analysis of Variance
AOC	area of concern
AOI	area of investigation
AP	armor piercing
APEC	areas of potential ecological concern
APT	armor-piercing tracer
AR	analysis request
ARAR	applicable or relevant and appropriate requirement
AREE	area requiring environmental evaluation
AS/SVE	air sparging/soil vapor extraction
ASP	Ammunition Supply Point
ASR	Archives Search Report
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
AT	averaging time
atm-m^3/mol	atmospheres per cubic meter per mole
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
AUF	area use factor
AWARE	Associated Water and Air Resources Engineers, Inc.
AWQC	ambient water quality criteria
AWWSB	Anniston Water Works and Sewer Board
‘B’	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)
BAF	bioaccumulation factor
BAF$_{\text{soil-to-invert}}$	soil-to-invertebrate bioaccumulation factor
BBGR	Baby Bains Gap Road
BCF	blank correction factor; bioconcentration factor
BCT	BRAC Cleanup Team
BERA	baseline ecological risk assessment
BEHP	bis(2-ethylhexyl)phthalate
BFB	bromofluorobenzene
BFE	base flood elevation
BFM	bonded fiber matrix
BG	Bacillus globigii
BGR	Bains Gap Road
bgs	below ground surface
BHC	hexachlorocyclohexane
BHHRA	baseline human health risk assessment
BIRTC	Branch Immaterial Replacement Training Center
bkg	background
bls	below land surface
BOD	biological oxygen demand
Bp	soil-to-plant biotransfer factors
BRAC	Base Realignment and Closure
Braun	Braun Intertec Corporation
BSAF	biota-to-sediment accumulation factors
BSC	background screening criterion
BSV	background screening values
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethyl benzene, and xylenes
BTOC	below top of casing
BTV	background threshold value
BW	biological warfare; body weight
BZ	breathing zone; 3-quinuclidinyl benzilate
C	ceiling limit value
Ca	carcinogen
CaCO$_3$	calcium carbonate
CAA	Clean Air Act
CAB	chemical warfare agent breakdown products
CACM	Chemical Agent Contaminated Media
CAIS	chemical agent identification set
CAMU	corrective action management unit
CBR	chemical, biological, and radiological
CCAL	continuing calibration
CCB	continuing calibration blank
CCV	continuing calibration verification
CD	compact disc
CDTF	Chemical Defense Training Facility
CEHNC	U.S. Army Engineering and Support Center, Huntsville
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CESAS	Corps of Engineers South Atlantic Savannah
CF	chloroform
CF	conversion factor
CFC	chlorofluorocarbon
CFDP	Center for Domestic Preparedness
CFR	Code of Federal Regulations
CG	phosgene (carbonyl chloride)
CGI	combustible gas indicator
ch	inorganic clays of high plasticity
CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
CIH	Certified Industrial Hygienist
CK	cyanogen chloride
cl	inorganic clays of low to medium plasticity
Cl	chlorinated
CLP	Contract Laboratory Program
cm	centimeter
CN	chloroacetophenone
CNB	chloroacetophenone, benzene, and carbon tetrachloride
CNS	chloroacetophenone, chloropicrin, and chloroform
CO	carbon monoxide
CO$_2$	carbon dioxide
Co-60	cobalt-60
CoA	Code of Alabama
COC	chain of custody; chemical of concern
COE	Corps of Engineers
Con	skin or eye contact
COPC	chemical of potential concern
COPEC	constituent of potential ecological concern
CPOM	coarse particulate organic matter
CPSS	chemicals present in site samples
CQCSM	Contract Quality Control System Manager
CRDL	contract-required detection limit
CRL	certified reporting limit
CRQL	contract-required quantitation limit

List of Abbreviations and Acronyms (Continued)

CRZ	contamination reduction zone
Cs-137	cesium-137
CS	ortho-chlorobenzylidene-malononitrile
CSEM	conceptual site exposure model
CSM	conceptual site model
CT	central tendency
CT	carbon tetrachloride
ctr.	container
CWA	chemical warfare agent; Clean Water Act
CWM	chemical warfare materiel; clear, wide mouth
CX	dichloroformoxime
‘D’	duplicate; dilution
D&I	detection and identification
DA	Department of the Army
DAAMS	depot area agent monitoring station
DAF	dilution-attenuation factor
DANC	decontamination agent, non-corrosive
ºC	degrees Celsius
ºF	degrees Fahrenheit
DCA	dichloroethane
DCE	dichloroethene
DD	Defense Department
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DEH	Directorate of Engineering and Housing
DEHP	di(2-ethylhexyl)phthalate
DEP	depositional soil
DFTPP	decafluorotriphenylphosphine
DI	deionized
DID	data item description
DIMP	di-isopropylmethylphosphonate
DM	dry matter; adamsite
DMBA	dimethylbenz(a)anthracene
DMMP	dimethylmethylphosphonate
DNAPL	dense nonaqueous-phase liquid
DNT	dinitrotoluene
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
DP	direct-push
DPDO	Defense Property Disposal Office
DPT	direct-push technology
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
DS	deep (subsurface) soil
DS2	Decontamination Solution Number 2
DSERTS	Defense Site Environmental Restoration Tracking System
DWEL	drinking water equivalent level
E&E	Ecology and Environment, Inc.
EB	equipment blank
EBC	Eastern Bypass Corridor
EBS	environmental baseline survey
EBV	EBV Explosives Environmental Co.
EC_{20}	effects concentration for 20 percent of a test population
EC_{50}	effects concentration for 50 percent of a test population
ECBC	Edgewood Chemical Biological Center
Eco-RGRG	ecological risk-based remedial goal
Eco-SSL	ecological soil screening level
ED	exposure duration
EDD	electronic data deliverable
EF	exposure frequency
EDQL	ecological data quality level
EE/CA	engineering evaluation and cost analysis
Eh	oxidation-reduction potential
Elev.	elevation
EM	electromagnetic
EMI	Environmental Management Inc.
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
EOD	explosive ordnance disposal
EODT	explosive ordnance disposal team
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPIC	Environmental Photographic Interpretation Center
EPRI	Electrical Power Research Institute
EPT	Ephemeroptera, Plecoptera, Trichoptera
ER	equipment rinsate
ERA	ecological risk assessment
ER-L	effects range-low
ER-M	effects range-medium
ESE	Environmental Science and Engineering, Inc.
ESL	ecological screening level
ESMP	Endangered Species Management Plan
ESN	Environmental Services Network, Inc.
ESV	ecological screening value
ET	exposure time
EU	exposure unit
Exp.	Explosives
EXTOXNET	Extension Toxicology Network
E-W	east to west
EZ	exclusion zone
FAR	Federal Acquisition Regulations
FB	field blank
FBI	Family Biotic Index
FD	field duplicate
FDC	Former Decontamination Complex
FDA	U.S. Food and Drug Administration
Fe^{+3}	ferric iron
Fe^{+2}	ferrous iron
FedEx	Federal Express, Inc.
FEMA	Federal Emergency Management Agency
FFCA	Federal Facilities Compliance Act
FFE	field flame expedient
FFS	focused feasibility study
FI	fraction of exposure
Fil	filtered
Flt	filtered
FMDC	Fort McClellan Development Commission
FML	flexible membrane liner
f_{oc}	fraction organic carbon
FOMRA	Former Ordnance Motor Repair Area
FOST	Finding of Suitability to Transfer
Foster Wheeler	Foster Wheeler Environmental Corporation
FR	Federal Register
Frtn	fraction
FS	field split; feasibility study; fuming sulfuric acid
FSP	field sampling plan
ft	feet
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
FTA	Fire Training Area
FTMC	Fort McClellan
FTRRA	FTMC Reuse & Redevelopment Authority
g	gram
g/m^3	gram per cubic meter
G-856	Geometrics, Inc. G-856 magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GAF	gastrointestinal absorption factor
gal	gallon
gal/min	gallons per minute
GB	sarin (isopropyl methylphosphonofluoridate)
gc	clay gravels; gravel-sand-clay mixtures
GC	gas chromatograph
GCL	geosynthetic clay liner
GC/MS	gas chromatograph/mass spectrometer
GCR	geosynthetic clay liner
GFAA	graphite furnace atomic absorption
GFCI	ground fault circuit interruptor
GIS	Geographic Information System
gm	silty gravels; gravel-sand-silt mixtures

gp	poorly graded gravels; gravel-sand mixtures
gpm	gallons per minute
GPR	ground-penetrating radar
GPS	global positioning system
GRA	general response action
GS	ground scar
GSA	General Services Administration; Geologic Survey of Alabama
GSBP	Ground Scar Boiler Plant
GSSI	Geophysical Survey Systems, Inc.
GST	ground stain
GW	groundwater
gw	well-graded gravels; gravel-sand mixtures
H&S	health and safety
HA	hand auger
HC	mixture of hexachloroethane, aluminum powder, and zinc oxide (smoke producer)
HCl	hydrochloric acid
HD	distilled mustard (bis-[dichloroethyl]sulfide)
HDPE	high-density polyethylene
HE	high explosive
HEAST	Health Effects Assessment Summary Tables
Herb.	herbicides
HHRA	human health risk assessment
HI	hazard index
HN	hydrogen mustard
H_2O_2	hydrogen peroxide
HPLC	high-performance liquid chromatography
HNO_3	nitric acid
HQ	hazard quotient
HQ_{screen}	screening-level hazard quotient
hr	hour
HRC	hydrogen releasing compound
HSA	hollow-stem auger
HSDB	Hazardous Substance Data Bank
HTRW	hazardous, toxic, and radioactive waste
‘I’	out of control, data rejected due to low recovery
IASPOW	Impact Area South of POW Training Facility
IATA	International Air Transport Authority
ICAL	initial calibration
ICB	initial calibration blank
ICP	inductively-coupled plasma
ICRP	International Commission on Radiological Protection
ICS	interference check sample
ID	inside diameter
IDL	instrument detection limit
IDLH	immediately dangerous to life or health
IDM	investigative-derived media
IDW	investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic
IF	ingestion factor; inhalation factor
ILCR	incremental lifetime cancer risk
IMPA	isopropylmethyl phosphonic acid
IMR	Iron Mountain Road
in.	inch
Ing	ingestion
Inh	inhalation
IP	ionization potential
IPS	International Pipe Standard
IR	ingestion rate
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information Service
IRP	Installation Restoration Program
IS	internal standard
ISCP	Installation Spill Contingency Plan
IT	IT Corporation
ITEMS	IT Environmental Management System™
ITRC	Interstate Trade and Regulatory Council
IWWP	installation-wide work plan
‘J’	estimated concentration
JeB2	Jefferson gravelly fine sandy loam, 2 to 6 percent slopes, eroded
JeC2	Jefferson gravelly fine sandy loam, 6 to 10 percent slopes, eroded
JfB	Jefferson stony fine sandy loam, 0 to 10 percent slopes have strong slopes
JPA	Anniston-Calhoun County Fort McClellan Development Joint Powers Authority
K	conductivity
K_d	soil-water distribution coefficient
kg	kilogram
KeV	kilo electron volt
K_{oc}	organic carbon partioning coefficient
K_{ow}	octonal-water partition coefficient
$KMnO_4$	potassium permanganate
L	liter; Lewisite (dichloro-[2-chloroethyl]sulfide)
L/kg/day	liters per kilogram per day
l	liter
LAW	light anti-tank weapon
lb	pound
LBP	lead-based paint
LC	liquid chromatography
LCS	laboratory control sample
LC_{50}	lethal concentration for 50 percent population tested
LD_{50}	lethal dose for 50 percent population tested
LEL	lower explosive limit
LOAEL	lowest-observed-adverse-effects-level
LOEC	lowest-observable-effect-concentration
LRA	land redevelopment authority
LT	less than the certified reporting limit
LUC	land-use control
LUCAP	land-use control assurance plan
LUCER	land-use control effectiveness report
LUCIP	land-use control implementation plan
m	meter
m/yr	meters per year
max	maximum
MB	method blank
MBB	Mohr’s Barbara’s buttons
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCPA	4-chloro-2-methylphenoxyacetic acid
MCPP	2-(2-methyl-4-chlorophenoxy)propionic acid
MCS	media cleanup standard
MD	matrix duplicate
MDA	Calhoun County McClellan Development Authority
MDC	maximum detected concentration
MDCC	maximum detected constituent concentration
MDL	method detection limit
MEC	munitions and explosives of concern
MeV	mega electron volt
mg	milligrams
mg/kg	milligrams per kilogram
mg/kg/day	milligram per kilogram per day
mg/kgbw/day	milligrams per kilogram of body weight per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mh	inorganic silts, micaceous or diatomaceous fine, sandy or silt soils
MHz	megahertz
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
min	minimum
MINICAMS	miniature continuous air monitoring system
ml	inorganic silts and very fine sands
mL	milliliter
mm	millimeter
MM	mounded material
MMBtu/hr	million Btu per hour
MNA	monitored natural attenuation
MnO_4-	permanganate ion
MOA	Memorandum of Agreement
MOGAS	motor vehicle gasoline
MOUT	Military Operations in Urban Terrain
MP	Military Police
MPA	methyl phosphonic acid
MPC	maximum permissible concentration
MPM	most probable munition

List of Abbreviations and Acronyms *(Continued)*

MQL	method quantitation limit
MR	molasses residue
MRL	method reporting limit
MS	matrix spike
mS/cm	millisiemens per centimeter
mS/m	millisiemens per meter
MSD	matrix spike duplicate; minimum separation distance
MTBE	methyl tertiary butyl ether
msl	mean sea level
MtD3	Montevallo shaly, silty clay loam, 10 to 40 percent slopes , severely eroded
mV	millivolts
MW	monitoring well
MWI&MP	Monitoring Well Installation and Management Plan
Na	sodium
NA	not applicable; not available
NAD	North American Datum
NAD83	North American Datum of 1983
$NaMnO_4$	sodium permanganate
NAVD88	North American Vertical Datum of 1988
NAS	National Academy of Sciences
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NE	no evidence; northeast
ne	not evaluated
NEW	net explosive weight
NFA	No Further Action
NG	National Guard
NGP	National Guardsperson
ng/L	nanograms per liter
NGVD	National Geodetic Vertical Datum
Ni	nickel
NIC	notice of intended change
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NLM	National Library of Medicine
NO_3^-	nitrate
NOEC	no-observable-effect-concentration
NPDES	National Pollutant Discharge Elimination System
NPW	net present worth
No.	number
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects-level
NR	not requested; not recorded; no risk
NRC	National Research Council
NRCC	National Research Council of Canada
NRHP	National Register of Historic Places
NRT	near real time
ns	nanosecond
N-S	north to south
NS	not surveyed
NSA	New South Associates, Inc.
nT	nanotesla
nT/m	nanoteslas per meter
NTU	nephelometric turbidity unit
nv	not validated
O_2	oxygen
O_3	ozone
O&G	oil and grease
O&M	operation and maintenance
OB/OD	open burning/open detonation
OD	outside diameter
OE	ordnance and explosives
oh	organic clays of medium to high plasticity
OH•	hydroxyl radical
ol	organic silts and organic silty clays of low plasticity
OP	organophosphorus
ORC	Oxygen Releasing Compound
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVM-PID/FID	organic vapor meter-photoionization detector/flame ionization detector
OWS	oil/water separator
oz	ounce
PA	preliminary assessment
PAH	polynuclear aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
Parsons	Parsons Engineering Science, Inc.
Pb	lead
PBMS	performance-based measurement system
PC	permeability coefficient
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PCE	perchloroethene
PCP	pentachlorophenol
PDS	Personnel Decontamination Station
PEC	probable effect concentration
PEF	particulate emission factor
PEL	permissible exposure limit
PEM	palustrine emergent wetland
PERA	preliminary ecological risk assessment
PERC	perchloroethene
PES	potential explosive site
Pest.	pesticides
PETN	pentaerythritoltetranitrate
PFO	palustrine forested wetland
PFT	portable flamethrower
PG	professional geologist
PID	photoionization detector
PkA	Philo and Stendal soils local alluvium, 0 to 2 percent slopes
PM	project manager
POC	point of contact
POL	petroleum, oils, and lubricants
POTW	publicly owned treatment works
POW	prisoner of war
PP	peristaltic pump; Proposed Plan
ppb	parts per billion
ppbv	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
PPMP	Print Plant Motor Pool
ppt	parts per thousand
PR	potential risk
PRA	preliminary risk assessment
PRG	preliminary remediation goal
PS	chloropicrin
PSS	palustrine scrub/shrub wetland
PSSC	potential site-specific chemical
pt	peat or other highly organic silts
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control
QAM	quality assurance manual
QAO	quality assurance officer
QAP	installation-wide quality assurance plan
QC	quality control
QST	QST Environmental, Inc.
qty	quantity
Qual	qualifier
QuickSilver	QuickSilver Analytics, Inc.
R	rejected data; resample; retardation factor
R^2	coefficient of determination
R&A	relevant and appropriate
RA	remedial action
RAO	remedial action objective
RBC	risk-based concentration; red blood cell
RBP	Rapid Bioassessment Protocol
RBRG	risk-based remedial goal
RCRA	Resource Conservation and Recovery Act
RCWM	Recovered Chemical Warfare Material
RD	remedial design

List of Abbreviations and Acronyms *(Continued)*

RDX	cyclotrimethylenetrinitramine
ReB3	Rarden silty clay loams
REG	regular field sample
REL	recommended exposure limit
RFA	request for analysis
RfC	reference concentration
RfD	reference dose
RG	remedial goal
RGO	remedial goal option
RI	remedial investigation
RINRMP	Revised Integrated Natural Resources Management Plan
RL	reporting limit
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
RR	range residue
RRF	relative response factor
RRSE	Relative Risk Site Evaluation
RSD	relative standard deviation
RTC	Recruiting Training Center
RTECS	Registry of Toxic Effects of Chemical Substances
RTK	real-time kinematic
RWIMR	Ranges West of Iron Mountain Road
SA	exposed skin surface area
SAD	South Atlantic Division
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAP	installation-wide sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
sc	clayey sands; sand-clay mixtures
Sch.	schedule
SCM	site conceptual model
SD	sediment
SDG	sample delivery group
SDWA	Safe Drinking Water Act
SDZ	safe distance zone; surface danger zone
SEMS	Southern Environmental Management & Specialties, Inc.
SF	cancer slope factor
SFSP	site-specific field sampling plan
SGF	standard grade fuels
Shaw	Shaw Environmental, Inc.
SHP	installation-wide safety and health plan
SI	site investigation
SINA	Special Interest Natural Area
SL	standing liquid
SLERA	screening-level ecological risk assessment
sm	silty sands; sand-silt mixtures
SM	Serratia marcescens
SMDP	Scientific Management Decision Point
s/n	signal-to-noise ratio
SO_4^{-2}	sulfate
SOD	soil oxidant demand
SOP	standard operating procedure
SOPQAM	U.S. EPA's *Standard Operating Procedure/Quality Assurance Manual*
sp	poorly graded sands; gravelly sands
SP	submersible pump
SPCC	system performance calibration compound
SPCS	State Plane Coordinate System
SPM	sample planning module
SQG	sediment quality guideline
SQRT	screening quick reference tables
Sr-90	strontium-90
SRA	streamlined human health risk assessment
SRI	supplemental remedial investigation
SRM	standard reference material
Ss	stony rough land, sandstone series
SS	surface soil
SSC	site-specific chemical
SSHO	site safety and health officer
SSHP	site-specific safety and health plan
SSL	soil screening level
SSSL	site-specific screening level
SSSSL	site-specific soil screening level
STB	supertropical bleach
STC	source-term concentration
STD	standard deviation
STEL	short-term exposure limit
STL	Severn-Trent Laboratories
STOLS	Surface Towed Ordnance Locator System®
Std. units	standard units
SU	standard unit
SUXOS	senior UXO supervisor
SVOC	semivolatile organic compound
SW	surface water
SW-846	U.S. EPA's *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*
SWMU	solid waste management unit
SWPP	storm water pollution prevention plan
SZ	support zone
TAL	target analyte list
TAT	turn around time
TB	trip blank
TBC	to be considered
TCA	trichloroethane
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofurans
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TDGCL	thiodiglycol
TDGCLA	thiodiglycol chloroacetic acid
TEA	triethylaluminum
TEC	threshold effect concentration
TeCA	1,1,2,2-tetrachloroethane
Tetryl	trinitrophenylmethylnitramine
TERC	Total Environmental Restoration Contract
TEU	Technical Escort Unit
THI	target hazard index
TIC	tentatively identified compound
TLV	threshold limit value
TN	Tennessee
TNB	trinitrobenzene
TNT	trinitrotoluene
TOC	top of casing; total organic carbon
TPH	total petroleum hydrocarbons
TR	target cancer risk
TRADOC	U.S. Army Training and Doctrine Command
TRPH	total recoverable petroleum hydrocarbons
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TSS	total suspended solids
TWA	time-weighted average
TYG	Tennessee yellow-eyed grass
UCL	upper confidence limit
UCR	upper certified range
'U'	not detected above reporting limit
UIC	underground injection control
UF	uncertainty factor
UL	Underwriter's Laboratory
URF	unit risk factor
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEC	U.S. Army Environmental Center
USAEHA	U.S. Army Environmental Hygiene Agency
USACMLS	U.S. Army Chemical School
USAMPS	U.S. Army Military Police School
USATCES	U.S. Army Technical Center for Explosive Safety
USATEU	U.S. Army Technical Escort Unit
USATHAMA	U.S. Army Toxic and Hazardous Material Agency
USC	United States Code
USCG	U.S. Coast Guard
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture

List of Abbreviations and Acronyms *(Continued)*

USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTL	upper tolerance level; upper tolerance limit
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Supervisor
UXOSO	UXO safety officer
V	vanadium
VC	vinyl chloride
VOA	volatile organic analyte
VOC	volatile organic compound
VOH	volatile organic hydrocarbon
VQlfr	validation qualifier
VQual	validation qualifier
VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)
WAC	Women’s Army Corps
Weston	Roy F. Weston, Inc.
WP	white phosphorus
WRS	Wilcoxon rank sum
WS	watershed
WSA	Watershed Screening Assessment
WWI	World War I
WWII	World War II
XRF	x-ray fluorescence
yd^3	cubic yards
ZVI	zero-valent iron

RESPONSE TO COMMENTS

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Response to ADEM Comments on the Final-Revision 1, Identification of Risk-Based Remedial Goals
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Alabama

Comments from Stephen A. Cobb, Chief – Governmental Hazardous Waste Branch, Land Division, received in a letter dated 3/22/10.

Comment 1: **Table 4-1: ADEM accepted these RBRGs during the December 2008 meeting at Fort McClellan, with the understanding that soil RBRGs in Section 4.0 are, or should be, identical to those presented in the BERA in the subject RI reports. Since the antimony values presented in this revised table differ from those presented in Table K-8-1 of the Final RI for Bains Gap Road and Table J-8-1 of the Final RI for Iron Mountain Road, please confirm that these finalized values are presented in all documents. Also, the potential RBRGs for soil are presented in Table J-8-1 of the Final RI for Iron Mountain Road, but, unlike Table K-8-1 of the Final RI for Bains Gap Road, the potential RBRGs for sediments and surface water are not presented. Please address.**

Response 1: As stated in the Eco-RBRG white paper (page 4-10), the terrestrial food web model in the IMR/BGR BERA (Shaw, 2008) utilized the soil-to-invertebrate BAF value for antimony of 0.22 referenced from the USEPA *Combustion Guidance* (1999) without accounting for the moisture content of earthworms. During subsequent revisions of the Eco-RBRG white paper, the RI reports for both the IMR ranges and BGR ranges were finalized. The Eco-RBRGs for antimony in soil have subsequently been re-calculated using the site-specific soil-to-invertebrate BAF (0.188) derived from the paired soil and earthworm data collected during the IMR/BGR BERA. Revising the final RI reports for both the IMR ranges and BGR ranges would entail the revision of more than 30 tables and a number of pages of text in each of the RI reports and BERA appendices. Due to the level of effort, breadth of the revisions, and lack of resources required to revise the RI reports, the Army intends to leave the finalized RI reports un-changed and simply revise the Eco-RBRG white paper accordingly. To allay ADEM's concerns, the Army notes that the Eco-RBRGs presented in the white paper represent the most up-to-date Eco-RBRGs derived for FTMC and will be the values considered in subsequent tasks (e.g., feasibility studies) involving remedial actions at these sites.

Comment 2: **Page 4-5, Paragraph 1: Please revise the last sentence to insert a clause clarifying the reason for the caveat: "However, *because the earthworm growth LOEC for zinc is 35.1 mg/kg*, it is important to recognize that…"**

Response 2: The sentence will be revised as suggested in the comment.

Comment 3: **Table 4-3: At EPA's request (Comment 2 dated October 21, 2009) and as discussed on page 4-12, the incidental soil ingestion rate for the American robin was reset to zero to calculate the RBRGs. However, Table 4-3 still presents an ingestion rate greater than zero. Please revise the table and clarify if the soil ingestion rate also was reset to zero for the American woodcock and either of the mammalian receptors**

Response 3: Eco-RBRGs were initially estimated (Table 4-7) using the exposure parameters presented in Table 4-3. As requested by EPA, incidental soil ingestion was subsequently assumed to equal zero and additional Eco-RBRGs were also estimated for all of the terrestrial receptors assuming an incidental soil ingestion rate of zero and these Eco-RBRGs are summarized in Table 4-9. No changes in the text or tables are necessary.

Comment 4: **Page 4-17, Section 4.3.3, 1st Paragraph: Please revise the first full sentence to indicate that the concentrations quoted from Johnson were mean concentrations of 13,630 mg/kg and 57 mg/kg in the target berm and other areas. Please also revise the fourth full sentence of this paragraph to more explicitly cite the avian blood lead TRV as a NOAEL of 29 µg/dL, not 29.5. Please also mention the blood lead LOAEL of 58 µg/dL cited by Johnson et al.**

Response 4: The soil lead concentrations quoted from Johnson, et al., 2007 will be reported as mean concentrations. The text (p. 2219) of the Johnson et al. (2007) paper reports a NOAEL-based TRV of 29.5 µg/dL while the appendix of the same paper references a NOAEL-based TRV of 29 µg/dL. Given the variability in the derivation of these numbers, 29 µg/dL and 29.5 µg/dL are, in practice, the same number. However, the text will be revised to present a NOAEL-based TRV of 29 µg/dL and a LOAEL-based TRV of 58 µg/dL.

Comment 5: **Page 4-17, Section 4.3.3, 2nd Paragraph: Please add discussions to provide additional context for the results of the Johnson study, including: (a) the observation made in EPA's Comment 9 (dated October 21, 2009), that these birds inhabited peripheral areas of the range outside the bulk of the contamination; (b) it, therefore, cannot be concluded that the blood lead levels of resident birds might not be higher if they were to nest and/or forage more frequently within "hot spot" portions of the range with much higher soil lead concentrations; and (c) a statement explaining that the bluebird with a blood lead level (25 µg/dL) closely approaching the NOAEL was a nestling so that it is conceivable that higher blood lead levels could occur in older birds after more prolonged exposures, especially if they nest/feed mostly in hot spots.**

Response 5: Figure 1 in Johnson, et al. (2007) suggests that the nest boxes that were used to collect samples of food items and blood samples from nestling birds are, in fact, within the areas of greatest lead contamination (target berms) at the Bains Gap Road ranges. Additionally, the mist nets used to capture singing males and nesting females were also set "in the proximity of nests and in areas primarily within the berms, firing points, and target areas." The assertion that the captured birds inhabited peripheral areas of the range outside the bulk of the contamination is not substantiated by the data presented in Johnson, et al. (2007). The Eco-RBRG white paper makes no conclusions regarding the possibility of blood lead levels being higher or lower for birds nesting or foraging in areas other than those sampled by Johnson, et al. (2007). The Eco-RBRG white paper simply reiterates the empirical data presented in Johnson, et al. (2007), as requested by ADEM. The fact that the blood level of a single nestling bluebird was close to the NOAEL cannot be used to substantiate the hypothesis presented in the comment. The data presented in Johnson, et al. (2007) show that "Blood-lead concentrations of nestlings were not different from adults," and to suggest otherwise is pure conjecture and is not supported by the data. No changes to the Eco-RBRG white paper are warranted.

Comment 6: **Page 4-18, Section 4.3.4, 2nd Paragraph: Please revise the next to last sentence in the second paragraph, which incorrectly states that "an Eco-RBRG within the range of 235 to unlimited would be expected to be protective…" ADEM disagrees with this conclusion since zinc very likely could become toxic to wildlife at a higher concentration that would result in a dietary ingestion exceedance of the zinc LOAEL of 320 mg/kgBW/day cited in the next paragraph. Please revise this discussion to indicate that an RBRG set at 235 mg/kg, which is above the soil BTV for zinc, would be protective of wildlife receptors.**

Response 6: The referenced statement presents the results of the site-specific terrestrial food web model and is accurate. However, the last 2 sentences of the 2nd paragraph will be revised as follows: "Therefore, an Eco-RBRG of 235 mg/kg would be expected to be protective of the terrestrial food web endpoints. Using the terrestrial food web model to derive Eco-RBRGs results in an extremely broad range of values, making it difficult to identify a single Eco-RBRG for zinc based on the terrestrial food web model."

Comment 7: **Section 5.0: Although ADEM accepted these RBRGs during the December 2008 meeting at Fort McClellan, it was agreed among ADEM, EPA, and the Army that if these RBRGs prove to be higher than national AWQC or Alabama AWQC, once adjusted using site-specific water hardness data, that the lower AWQC will supersede these RBRGs. Please add a closing statement to this section documenting this discussion and agreement from the meeting.**

Response 7: The following sentence will be added to the last paragraph in Chapter 5: "National and Alabama ambient water quality criteria (AWQC) should also be considered by risk managers as possible ecological remedial goals for surface water."

U.S. ENVIRONMENTAL PROTECTION AGENCY

Response to EPA Comments on
Final-Revision 1, Identification of Risk-Based Remedial Goals
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Alabama

Comments from Sharon Thoms, Life Scientist, Technical Services Section, Superfund Support Branch, Superfund Division, received via e-mail on 4/8/10.

COMMENTS:

Comment 1: **The changes made to the text addressed my previous comments. Text added to Section 4.3.2 Ecological Risk-based Remedial Goal for Lead in Soil on Page 4-17 to address a state comment included a sentence stating that "Empirical data from the BGR ranges suggests that an average concentration of lead in soil of 8,727 mg/kg does not pose risks to songbirds inhabiting the BGR ranges (Johnson *et al.*, 2007)." This comment is written because Johnson *et al.* (2007) do not state that there were no risks to songbirds at the BGR ranges. EPA disagrees that the blood lead levels in songbirds presented by Johnson *et al.* (2007) prove there were no risks to songbirds at the BGR ranges. The paper by Johnson *et al.* (2007) indicated lead exposure to birds at the BGR ranges. Concentrations of lead in blood ranged between 1 to 25 µg/dl (11 birds) at the BGR ranges, relative to the threshold value of 29.5 µg/dl. A similar paper for another firing range documented exposures to lead in birds and small mammals that also were typically below thresholds for adverse effects in captured birds and mammals (Lewis *et al.* 2001). However, Lewis *et al.* (2001) concluded that lead fragments were impacting wildlife at their firing ranges. Lewis *et al.* (2001) described elevated lead levels in liver and kidneys of birds and mammals found dead at the range. The Johnson et al (2007) paper addresses spatially explicit exposure but does not give the full picture on potential impacts of bullet fragments at firing ranges to wildlife. Johnson *et al.* (2007) did not consider impacts to small mammals and did not sample weak or unhealthy birds that could not fly into mist nets or that had died. The white paper appears to imply that an average concentration of lead in soil of 8,727 mg/kg would not pose a risk to songbirds at the site. Because the Johnson *et al.* (2007) study was not conducted by the Base Closure Team as part of the risk assessment, the study can at most inform the risk managers of uncertainties about the conclusions of the BERA. The Johnson *et al.* (2007) study cannot be used to make a statement that there were no risks posed to songbirds by lead in soil at the BRG ranges. A statement that there were no risks at the ranges conflicts with conclusions presented by the Army in the BERA. Change the words "*does not*" to "*may not*" in the sentence.**

Response 1: The wording in the sentence in question will be changed to "may not."

Comment 2: **The response to comments did not include a response for EPA comment 8.**

Response 2: The following response was provided for USEPA's Comment 8 in their previous round of comments.

Response to Comment 8: The recommended Eco-RBRG for lead in soil of 500 mg/kg will be recommended as a "not-to-exceed" value.

REFERENCES:

Johnson, M.S.; Wickwire, W.T.; Quinn, M.J.; Ziolkowski, D.J.; Burmistrov, D.; Menzie, C.A.; Geraghty, C.; Minnich, M.; and P.J. Parsons. 2007. Are songbirds at risk from lead at small arms ranges? An application of the spatially explicit exposure model. *Environ. Tox. Chem.* 26(10):2215-2225.

Lewis, L.A.; Poppenga, R.J.; Davidson, W.R.; Fischer, J.R.; amd K.A. Morgan. 2001. Lead toxicosis and trace element levels in wild birds and mammals at a firearms training facility. *Arch. Environ. Contam. Toxicol.* 41: 208–214