

## **5.0 Screening-Level Risk Estimation**

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A screening-level estimation of potential risk can be accomplished by comparing the exposure point concentration of each detected constituent in each environmental medium to a corresponding screening-level ecological toxicity value. In order to conduct the SLERA, the following steps must be followed:

- Determine appropriate screening assessment endpoints
- Determine the ecological toxicity values that are protective of the selected assessment endpoints
- Determine the exposure point concentrations of constituents detected at the site
- Calculate screening-level hazard quotients.

These steps are summarized below.

### **5.1 Ecological Screening Assessment Endpoints**

Most ecological risk assessments focus on population measures as endpoints, since population responses are more well-defined and predictable than are community or ecosystem responses. For screening-level assessments such as this SLERA, an assessment endpoint is any adverse effect on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments.

Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce the ability of the habitat to support plant and animal populations and communities.

Due to the nature of the SLERA process, most of the screening assessment endpoints are generic in nature (e.g., protection of sediment benthic communities from adverse changes in structure or function).

The assessment endpoints for this SLERA were identified for each environmental medium and are summarized below:

- **Soil**
  - Protection of the terrestrial invertebrate community from adverse changes in structure and function
  - Protection of the terrestrial plant community from adverse changes in structure and function
- **Surface Water**
  - Protection of the aquatic community from adverse changes in structure and function
- **Sediment**
  - Protection of the benthic community from adverse changes in structure and function.

## **5.2 Ecological Screening Values**

The ecological screening values (ESV) used in this assessment represent the most conservative values available from various literature sources and have been selected to be protective of the assessment endpoints described above. These ESVs have been developed specifically for FTMC in conjunction with EPA Region IV and are presented in the *Final Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000). The ESVs used in this assessment are based on NOAEL when available. If a NOAEL-based ESV was not available for a certain COPEC, then the most health-protective value available from the scientific literature was used in this assessment.

For each environmental medium sampled at the small arms ranges (soil, surface water, and sediment), a hierarchy has been developed which presents an orderly method for selection of ESVs. The hierarchy for selecting ESVs for soil is as follows:

- EPA Region IV constituent-specific ecological screening values
- EPA Region IV ecological screening values for general class of constituents
- EPA Region V ecological data quality levels (EDQL)
- EPA Region III Biological Technical Advisory Group (BTAG) values
- Ecological screening values from Talmage, et al., 1999.

The hierarchy for selecting ESVs for surface water is as follows:

- EPA Region IV constituent-specific ecological screening values
- National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQRT), chronic freshwater ambient water quality criteria

- EPA Region V EDQLs
- Office of Solid Waste and Emergency Response (OSWER) ecotox threshold values
- EPA Region III BTAG values
- Lowest chronic value from Suter and Tsao, 1996
- Ecological screening values from Talmage, et al., 1999.

The hierarchy for selecting ESVs for sediment is as follows:

- EPA Region IV constituent-specific ecological screening values
- NOAA SQRs, chronic freshwater ambient water quality criteria
- EPA Region V EDQLs
- OSWER ecotox threshold values
- EPA Region III BTAG values
- Lowest effect levels from Ontario Ministry of the Environment (1992) presented in Jones, et al., (1997)
- Ecological screening values from Talmage, et al., 1999
- Sediment quality adverse effect threshold (AET) values from the Puget Sound Estuary Program.

### ***5.3 Determination of Exposure-Point Concentrations***

Exposure-point concentrations represent the chemical concentrations in environmental media that a receptor may contact. Since the exposure-point concentration is a value that represents the most likely concentration to which receptors could be exposed, a value that reflects the central tendency of the data set is most appropriate to use. However, at the screening-level stage, the data sets are generally not robust enough for statistical analysis, and the level of conservatism in the exposure estimates is high to account for uncertainties. Therefore, in the screening-level stage, the maximum detected constituent concentration (MDCC) in each environmental medium is used as the exposure-point concentration. The use of the MDCC as the exposure-point concentration ensures that the exposures will not be underestimated and, therefore, constituents will not be inadvertently eliminated from further assessment.

The statistical summaries (including the exposure-point concentrations) for surface soil at the IMR ranges and surface water and sediment in Remount Creek in the vicinity of the IMR ranges are presented in Tables 5-1 through 5-6. Table 5-7 presents a summary of the groundwater data from monitoring wells at the IMR ranges. Although these groundwater data do not represent ecological exposure point concentrations, they were used in this screening-level assessment to address the potential for groundwater discharge to surface water at some time in the future.

#### **5.4 Screening-Level Hazard Quotients**

In order to estimate whether constituents detected in environmental media at the site have the potential to pose adverse ecological risks, screening-level hazard quotients ( $HQ_{screen}$ ) were developed. The  $HQ_{screen}$  were developed via a three-step process as follows:

- Comparison to ESVs
- Identification of essential macro-nutrients
- Comparison to naturally-occurring background concentrations.

Constituents that were detected in environmental media at the IMR ranges were evaluated against the ESVs by calculating a  $HQ_{screen}$  for each constituent in each environmental medium. An  $HQ_{screen}$  was calculated by dividing the MDCC in each environmental medium by its corresponding ESV as follows:

$$HQ_{screen} = \frac{MDCC}{ESV}$$

where:

$HQ_{screen}$	=	screening-level hazard quotient;
$MDCC$	=	maximum detected constituent concentration; and
$ESV$	=	ecological screening value.

A calculated  $HQ_{screen}$  value of one indicated that the MDCC was equal to the chemical's conservative ESV and was interpreted in this assessment as a constituent that does not pose the potential for adverse ecological risk. An  $HQ_{screen}$  value less than one indicated that the MDCC was less than the conservative ESV and that the chemical is not likely to pose adverse ecological hazards to most receptors. Conversely, an  $HQ_{screen}$  value greater than one indicated that the MDCC was greater than the ESV and that the chemical might pose adverse ecological hazards to one or more receptors.

Table 5-1

**Constituents of Potential Ecological Concern  
in Surface Soil<sup>a</sup> at the Skeet Range (Parcel 69Q)  
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value <sup>b</sup> (mg/kg)	Ecological Screening Value <sup>c</sup> (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Metals</b>									
Aluminum	1.63E+04	5.00E+01	1.02E+04	1.39E+03	6.76E+03	16 / 16	204.00	135.11	3
Antimony	1.99E+00	3.50E+00	4.97E+00	5.20E-01	3.10E+00	7 / 16	1.42	0.89	YES
Arsenic	1.37E+01	1.00E+01	1.23E+01	2.70E+00	6.32E+00	11 / 11	1.23	0.63	3
Barium	1.24E+02	1.65E+02	1.18E+02	7.61E+00	6.61E+01	16 / 16	0.72	0.40	1,3
Beryllium	8.00E-01	1.10E+00	1.40E+00	5.20E-01	7.72E-01	14 / 14	1.27	0.70	YES
Calcium	1.72E+03	NA	4.84E+03	6.65E+01	5.70E+02	16 / 16	ND	ND	2
Chromium	3.70E+01	4.00E-01	2.14E+01	5.10E+00	1.05E+01	16 / 16	53.50	26.18	3
Cobalt	1.52E+01	2.00E+01	2.49E+01	2.50E+00	6.72E+00	15 / 15	1.25	0.34	YES
Copper	1.27E+01	4.00E+01	1.34E+02	3.70E+00	2.52E+01	16 / 16	3.35	0.63	YES
Iron	3.42E+04	2.00E+02	2.84E+04	7.84E+03	1.33E+04	16 / 16	142.00	66.73	3
Lead	4.01E+01	5.00E+01	1.78E+03	1.00E+01	2.25E+02	37 / 37	35.60	4.50	YES
Magnesium	1.03E+03	4.40E+05	4.20E+02	6.98E+01	2.38E+02	16 / 16	0.00095	0.00054	1,2,3
Manganese	1.58E+03	1.00E+02	1.93E+03	6.31E+01	6.01E+02	16 / 16	19.30	6.01	YES
Mercury	8.00E-02	1.00E-01	7.70E-02	2.90E-02	5.03E-02	14 / 16	0.77	0.50	1,3
Nickel	1.03E+01	3.00E+01	1.59E+01	1.63E+00	6.91E+00	16 / 16	0.53	0.23	1
Potassium	8.00E+02	NA	9.43E+02	6.14E+01	2.20E+02	15 / 15	ND	ND	2
Thallium	3.43E+00	1.00E+00	1.20E+00	7.00E-01	8.35E-01	5 / 11	1.20	0.83	3
Vanadium	5.88E+01	2.00E+00	3.36E+01	9.87E+00	1.67E+01	16 / 16	16.80	8.36	3
Zinc	4.06E+01	5.00E+01	6.24E+01	1.04E+01	2.81E+01	16 / 16	1.25	0.56	YES
<b>Semivolatile Organic Compounds</b>									
Anthracene	NA	1.00E-01	5.00E-02	5.00E-02	1.94E-01	1 / 16	0.50	1.94	1
Benzo(a)anthracene	NA	5.21E+00	8.80E-01	8.40E-02	2.40E-01	2 / 16	0.17	0.05	1
Benzo(a)pyrene	NA	1.00E-01	1.90E+00	1.70E-01	3.09E-01	2 / 16	19.00	3.09	YES
Benzo(b)fluoranthene	NA	5.98E+01	5.70E-01	7.10E-02	2.19E-01	2 / 16	0.0095	0.0037	1
Benzo(ghi)perylene	NA	1.19E+02	9.20E-01	9.20E-02	2.43E-01	2 / 16	0.0077	0.0020	1
Benzo(k)fluoranthene	NA	1.48E+02	2.40E-01	2.40E-01	2.06E-01	1 / 16	0.0016	0.0014	1
Chrysene	NA	4.73E+00	1.20E+00	1.20E-01	2.62E-01	2 / 16	0.25	0.06	1
Dibenz(a,h)anthracene	NA	1.84E+01	4.10E-01	4.10E-01	2.17E-01	1 / 16	0.022	0.012	1
Fluoranthene	NA	1.00E-01	1.60E-01	1.60E-01	2.01E-01	1 / 16	1.60	2.01	YES
Indeno(1,2,3-cd)pyrene	NA	1.09E+02	2.90E-01	2.90E-01	2.09E-01	1 / 16	0.0027	0.0019	1
n-Nitrosodiphenylamine	NA	2.00E+01	2.00E-01	2.00E-01	2.04E-01	1 / 16	0.0100	0.0102	1



Table 5-2

**Constituents of Potential Ecological Concern in Surface Soil at Range 12 (Parcel 70Q)  
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value <sup>b</sup> (mg/kg)	Ecological Screening Value <sup>c</sup> (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Metals</b>									
Aluminum	1.63E+04	5.00E+01	1.20E+04	4.52E+03	7.38E+03	5 / 5	240.00	147.52	3
Antimony	1.99E+00	3.50E+00	2.03E+01	6.00E-01	8.30E+00	4 / 5	5.80	2.37	YES
Arsenic	1.37E+01	1.00E+01	1.98E+01	2.50E+00	7.77E+00	5 / 5	1.98	0.78	YES
Barium	1.24E+02	1.65E+02	8.96E+01	2.22E+01	5.56E+01	5 / 5	0.54	0.34	1,3
Calcium	1.72E+03	NA	1.80E+03	9.29E+01	5.51E+02	5 / 5	ND	ND	2
Chromium	3.70E+01	4.00E-01	1.95E+01	6.90E+00	1.32E+01	5 / 5	48.75	32.95	3
Cobalt	1.52E+01	2.00E+01	1.21E+01	2.20E+00	6.22E+00	5 / 5	0.61	0.31	1,3
Copper	1.27E+01	4.00E+01	3.70E+02	3.00E+00	1.14E+02	5 / 5	9.25	2.86	YES
Iron	3.42E+04	2.00E+02	2.05E+04	7.04E+03	1.29E+04	5 / 5	102.50	64.34	3
Lead	4.01E+01	5.00E+01	8.12E+03	1.15E+01	7.18E+02	18 / 18	162.40	14.36	YES
Magnesium	1.03E+03	4.40E+05	6.53E+02	9.12E+01	3.66E+02	5 / 5	0.0015	0.0008	1,2,3
Manganese	1.58E+03	1.00E+02	9.03E+02	9.60E+01	5.28E+02	5 / 5	9.03	5.28	3
Mercury	8.00E-02	1.00E-01	4.40E-02	2.40E-02	4.15E-02	4 / 5	0.44	0.42	1,3
Nickel	1.03E+01	3.00E+01	8.88E+00	2.20E+00	5.25E+00	5 / 5	0.30	0.18	1,3
Potassium	8.00E+02	NA	4.89E+02	5.18E+01	2.56E+02	5 / 5	ND	ND	2,3
Sodium	6.34E+02	NA	5.18E+01	4.70E+01	1.93E+02	2 / 5	ND	ND	2,3
Thallium	3.43E+00	1.00E+00	9.19E-01	9.19E-01	1.04E+00	1 / 2	0.92	1.04	1,3
Vanadium	5.88E+01	2.00E+00	2.42E+01	8.60E+00	1.51E+01	5 / 5	12.10	7.56	3
Zinc	4.06E+01	5.00E+01	1.64E+02	8.30E+00	6.49E+01	5 / 5	3.28	1.30	YES
<b>Chlorinated Herbicides</b>									
2,4-DB	NA	1.00E-01	3.20E-02	1.80E-02	2.50E-02	2 / 2	0.32	0.25	1
4,4'-DDT	NA	2.50E-03	2.80E-03	2.80E-03	2.55E-03	1 / 2	1.12	1.02	YES
<b>Semivolatile Organic Compounds</b>									
Benzo(a)anthracene	NA	5.21E+00	7.00E-02	7.00E-02	1.68E-01	1 / 5	0.013	0.032	1
Benzo(a)pyrene	NA	1.00E-01	7.30E-02	7.30E-02	1.69E-01	1 / 5	0.73	1.69	1
Benzo(b)fluoranthene	NA	5.98E+01	7.20E-02	7.20E-02	1.68E-01	1 / 5	0.0012	0.0028	1
Benzo(ghi)perylene	NA	1.19E+02	3.90E-02	3.90E-02	1.62E-01	1 / 5	0.00033	0.00136	1
Benzo(k)fluoranthene	NA	1.48E+02	6.10E-02	6.10E-02	1.66E-01	1 / 5	0.0004	0.0011	1
Chrysene	NA	4.73E+00	9.10E-02	9.10E-02	1.72E-01	1 / 5	0.019	0.036	1
Di-n-butyl phthalate	NA	2.00E+02	2.10E-01	1.00E-01	1.67E-01	3 / 5	0.0011	0.0008	1
Fluoranthene	NA	1.00E-01	7.80E-02	7.80E-02	1.70E-01	1 / 5	0.78	1.70	1



Table 5-3

**Constituents of Potential Ecological Concern in Surface Soil at Range 13 (Parcel 71Q)  
Fort McClellan, Calhoun County, Alabama**

(Page 1 of 2)

Constituents	Background Threshold Value <sup>b</sup> (mg/kg)	Ecological Screening Value <sup>c</sup> (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Metals</b>									
Aluminum	1.63E+04	5.00E+01	1.28E+04	6.32E+03	8.77E+03	6 / 6	256.00	175.43	3
Antimony	1.99E+00	3.50E+00	3.91E+01	6.20E-01	8.75E+00	4 / 6	11.17	2.50	YES
Arsenic	1.37E+01	1.00E+01	3.37E+01	2.80E+00	1.06E+01	6 / 6	3.37	1.06	YES
Barium	1.24E+02	1.65E+02	6.80E+01	2.15E+01	4.52E+01	6 / 6	0.41	0.27	1,3
Calcium	1.72E+03	NA	5.87E+02	8.38E+01	3.01E+02	6 / 6	ND	ND	2,3
Chromium	3.70E+01	4.00E-01	2.12E+01	6.60E+00	1.25E+01	6 / 6	53.00	31.17	3
Cobalt	1.52E+01	2.00E+01	6.30E+00	2.50E+00	4.37E+00	6 / 6	0.32	0.22	1,3
Copper	1.27E+01	4.00E+01	4.56E+02	1.09E+01	1.05E+02	6 / 6	11.40	2.63	YES
Iron	3.42E+04	2.00E+02	2.87E+04	7.85E+03	1.61E+04	6 / 6	143.50	80.43	3
Lead	4.01E+01	5.00E+01	4.38E+03	1.30E+01	7.57E+02	22 / 22	87.60	15.14	YES
Magnesium	1.03E+03	4.40E+05	3.19E+02	1.90E+02	2.54E+02	6 / 6	0.00073	0.00058	1,2,3
Manganese	1.58E+03	1.00E+02	1.04E+03	1.60E+02	5.81E+02	6 / 6	10.40	5.81	3
Mercury	8.00E-02	1.00E-01	5.30E-02	2.20E-02	4.28E-02	5 / 6	0.53	0.43	1,3
Nickel	1.03E+01	3.00E+01	7.20E+00	3.30E+00	4.91E+00	6 / 6	0.24	0.16	1,3
Potassium	8.00E+02	NA	3.23E+02	7.91E+01	1.96E+02	6 / 6	ND	ND	2,3
Sodium	6.34E+02	NA	4.41E+01	4.41E+01	2.56E+02	1 / 6	ND	ND	2,3
Vanadium	5.88E+01	2.00E+00	3.86E+01	1.17E+01	2.29E+01	6 / 6	19.30	11.43	3
Zinc	4.06E+01	5.00E+01	1.10E+02	1.39E+01	4.40E+01	6 / 6	2.20	0.88	YES
<b>Semivolatile Organic Compounds</b>									
Di-n-butyl phthalate	NA	2.00E+02	1.00E-01	1.00E-01	1.83E-01	1 / 6	0.00050	0.00091	1
n-Nitrosodiphenylamine	NA	2.00E+01	2.40E-01	2.40E-01	2.06E-01	1 / 6	0.012	0.010	1

Table 5-3

Constituents of Potential Ecological Concern in Surface Soil at Range 13 (Parcel 71Q)  
Fort McClellan, Calhoun County, Alabama

(Page 2 of 2)

Constituents	Background Threshold Value <sup>b</sup> (mg/kg)	Ecological Screening Value <sup>c</sup> (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b><u>Volatile Organic Compounds</u></b>									
2-Butanone	NA	8.96E+01	2.20E-02	2.20E-02	1.38E-02	1 / 5	0.00025	0.00015	1
Acetone	NA	2.50E+00	3.40E-01	2.00E-01	1.41E-01	2 / 4	0.14	0.06	1
p-Cymene	NA	NA	6.50E-03	1.90E-03	3.68E-03	2 / 6	ND	ND	4
Trichlorofluoromethane	NA	1.00E-01	3.00E-03	3.00E-03	5.42E-03	1 / 6	0.030	0.054	1
<b><u>Chlorinated Herbicides</u></b>									
2,4-DB	NA	1.00E-01	9.30E-03	9.30E-03	9.30E-03	1 / 1	0.093	0.093	1

<sup>a</sup> Surface soil at Parcel 71Q is defined as the interval from 0 to 0.5 feet below ground surface.

<sup>b</sup> Background threshold value is 2-times the arithmetic mean background concentration as reported in "Final Background Metals Survey Report, Ft. McClellan, Alabama" (SAIC, 1998).

<sup>c</sup> Ecological screening values are presented in "Human Health and Ecological Screening Values and PAH Background Summary Report" (IT Corp., 2000).

NA - Not Available

ND - Not Determined

Rationale for inclusion / exclusion as COPEC:

- 1 - Maximum detected concentration is less than ecological screening value (ESV).
- 2 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).
- 3 - Maximum detected concentration is less than background threshold value.
- 4 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

mg/kg - milligrams per kilogram.

Table 5-4

Constituents of Potential Ecological Concern in Surface Soil at Range 19 (Parcel 75Q)  
Fort McClellan, Calhoun County, Alabama

(Page 1 of 2)

Constituents	Background Threshold Value <sup>b</sup> (mg/kg)	Ecological Screening Value <sup>c</sup> (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection		Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Metals</b>										
Aluminum	1.63E+04	5.00E+01	7.68E+03	2.15E+03	5.99E+03	8	/ 8	153.60	119.80	3
Antimony	1.99E+00	3.50E+00	1.24E+03	9.20E-01	1.61E+02	4	/ 8	354.29	46.08	YES
Arsenic	1.37E+01	1.00E+01	1.39E+01	3.43E+00	8.39E+00	8	/ 8	1.39	0.84	YES
Barium	1.24E+02	1.65E+02	6.94E+01	2.40E+01	4.44E+01	8	/ 8	0.42	0.27	1,3
Beryllium	8.00E-01	1.10E+00	6.70E-01	5.40E-01	6.17E-01	3	/ 3	0.61	0.56	1,3
Calcium	1.72E+03	NA	8.19E+02	7.50E+01	3.03E+02	7	/ 7	ND	ND	2,3
Chromium	3.70E+01	4.00E-01	3.58E+01	4.59E+00	1.44E+01	8	/ 8	89.50	36.00	3
Cobalt	1.52E+01	2.00E+01	9.30E+00	8.60E-01	5.42E+00	8	/ 8	0.47	0.27	1,3
Copper	1.27E+01	4.00E+01	9.91E+02	1.07E+01	1.83E+02	8	/ 8	24.78	4.57	YES
Iron	3.42E+04	2.00E+02	3.09E+04	7.25E+03	1.67E+04	8	/ 8	154.50	83.62	3
Lead	4.01E+01	5.00E+01	1.16E+05	1.32E+01	5.55E+03	23	/ 23	2320.00	110.93	YES
Magnesium	1.03E+03	4.40E+05	5.96E+02	7.78E+01	2.81E+02	8	/ 8	0.0014	0.0006	1,2,3
Manganese	1.58E+03	1.00E+02	6.58E+02	8.52E+01	2.79E+02	8	/ 8	6.58	2.79	3
Mercury	8.00E-02	1.00E-01	6.80E-02	1.90E-02	4.53E-02	5	/ 8	0.68	0.45	1,3
Nickel	1.03E+01	3.00E+01	1.17E+01	2.00E+00	7.00E+00	8	/ 8	0.39	0.23	1
Potassium	8.00E+02	NA	7.53E+02	3.08E+01	3.29E+02	8	/ 8	ND	ND	2,3
Silver	3.60E-01	2.00E+00	3.69E+00	3.69E+00	9.55E-01	1	/ 8	1.85	0.48	YES
Sodium	6.34E+02	NA	5.83E+01	4.69E+01	2.00E+02	3	/ 8	ND	ND	2,3
Thallium	3.43E+00	1.00E+00	2.76E+00	5.40E-01	1.03E+00	5	/ 8	2.76	1.03	3
Vanadium	5.88E+01	2.00E+00	3.23E+01	1.11E+01	2.01E+01	8	/ 8	16.15	10.04	3
Zinc	4.06E+01	5.00E+01	1.53E+02	1.69E+01	5.38E+01	8	/ 8	3.06	1.08	YES

Table 5-4

Constituents of Potential Ecological Concern in Surface Soil at Range 19 (Parcel 75Q)  
Fort McClellan, Calhoun County, Alabama

(Page 2 of 2)

Constituents	Background Threshold Value <sup>b</sup> (mg/kg)	Ecological Screening Value <sup>c</sup> (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Semivolatile Organic Compounds</b>									
Di-n-butyl phthalate	NA	2.00E+02	2.00E-01	2.00E-01	1.89E-01	1 / 8	0.00100	0.00094	1
n-Nitrosodiphenylamine	NA	2.00E+01	2.60E-01	2.60E-01	1.96E-01	1 / 8	0.013	0.010	1
<b>Volatile Organic Compounds</b>									
Acetone	NA	2.50E+00	2.30E-01	8.00E-03	4.98E-02	4 / 6	0.092	0.020	1
p-Cymene	NA	NA	1.30E-01	1.30E-01	1.90E-02	1 / 8	ND	ND	4

<sup>a</sup> Surface soil at Parcel 75Q is defined as the interval from 0 to 0.5 feet below ground surface.

<sup>b</sup> Background threshold value is 2-times the arithmetic mean background concentration as reported in "Final Background Metals Survey Report, Ft. McClellan, Alabama" (SAIC, 1998).

<sup>c</sup> Ecological screening values are presented in "Human Health and Ecological Screening Values and PAH Background Summary Report" (IT Corp., 2000).

NA - Not Available

ND - Not Determined

Rationale for inclusion / exclusion as COPEC:

1 - Maximum detected concentration is less than ecological screening value (ESV).

2 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

3 - Maximum detected concentration is less than background threshold value.

4 - No ESV available; however, maximum detected concentration is similar to concentrations of other VOAs which are below their respective ESVs.

mg/kg - milligrams per kilogram.

**Table 5-5**

**Constituents of Potential Ecological Concern in Surface Water at the Iron Mountain Road Ranges  
Fort McClellan, Calhoun County, Alabama**

Constituents	Background Threshold Value <sup>a</sup> (mg/L)	Ecological Screening Value <sup>b</sup> (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Metals</b>									
Aluminum	5.26E+00	8.70E-02	5.22E-01	4.42E-01	4.82E-01	2 / 2	6.00	5.54	3
Barium	7.54E-02	3.90E-03	3.25E-02	1.23E-02	2.13E-02	9 / 9	8.33	5.46	3
Calcium	2.52E+01	1.16E+02	1.57E+01	2.88E-01	6.40E+00	9 / 9	0.14	0.06	1,2,3
Copper	1.27E-02	6.54E-03	4.60E-03	4.60E-03	1.15E-02	1 / 8	0.70	1.76	1,3
Iron	1.96E+01	1.00E+00	6.43E-01	6.34E-02	3.08E-01	9 / 9	0.64	0.31	1,3
Lead	8.67E-03	1.32E-03	8.71E-02	1.80E-03	1.50E-02	4 / 9	65.98	11.34	<b>YES</b>
Magnesium	1.10E+01	8.20E+01	2.78E+00	3.25E-01	1.41E+00	9 / 9	0.034	0.017	1,2,3
Manganese	5.65E-01	8.00E-02	8.81E-02	4.60E-03	2.90E-02	9 / 9	1.10	0.36	3
Potassium	2.56E+00	5.30E+01	3.99E-01	2.13E-01	3.21E-01	9 / 9	0.0075	0.0060	1,2,3
Sodium	3.44E+00	6.80E+02	1.05E+00	5.10E-01	7.75E-01	9 / 9	0.0015	0.0011	1,2,3
Zinc	4.04E-02	5.89E-02	1.75E-02	3.20E-03	9.47E-03	5 / 9	0.30	0.16	1,3

<sup>a</sup> Background threshold value is 2-times the arithmetic mean background concentration as reported in

"Final Background Metals Survey Report, Ft. McClellan, Alabama" (SAIC, 1998).

<sup>b</sup> Ecological screening values are presented in "Human Health and Ecological Screening Values and PAH Background Summary Report" (IT Corp., 2000).

NA - Not Available

ND - Not Determined

Rationale for inclusion / exclusion as COPEC:

1 - Maximum detected concentration is less than ecological screening value (ESV).

2 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

3 - Maximum detected concentration is less than background threshold value.

mg/L - milligrams per liter.

Table 5-6

**Constituents of Potential Ecological Concern in Sediment at the Iron Mountain Road Ranges  
Fort McClellan, Calhoun County, Alabama**

Constituents	Background Threshold Value <sup>a</sup> (mg/kg)	Ecological Screening Value <sup>b</sup> (mg/kg)	Maximum Detected Conc. (mg/kg)	Minimum Detected Conc. (mg/kg)	Mean Detected Conc. (mg/kg)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Metals</b>									
Aluminum	8.59E+03	NA	7.16E+03	1.12E+03	4.07E+03	13 / 13	ND	ND	3
Antimony	7.30E-01	1.20E+01	1.04E+01	7.70E-01	4.61E+00	6 / 13	0.87	0.38	1
Arsenic	1.13E+01	7.24E+00	3.80E+01	2.10E+00	1.06E+01	13 / 13	5.25	1.46	YES
Barium	9.89E+01	NA	4.78E+02	9.00E+00	6.30E+01	13 / 13	ND	ND	YES
Beryllium	9.70E-01	NA	1.20E+00	4.10E-01	7.34E-01	9 / 9	ND	ND	YES
Calcium	1.11E+03	NA	1.37E+03	3.23E+01	3.99E+02	13 / 13	ND	ND	2
Chromium	3.12E+01	5.23E+01	5.03E+01	7.50E+00	1.69E+01	13 / 13	0.96	0.32	1
Cobalt	1.10E+01	5.00E+01	1.41E+01	1.60E+00	5.88E+00	13 / 13	0.28	0.12	1
Copper	1.71E+01	1.87E+01	1.53E+02	4.10E+00	2.80E+01	13 / 13	8.18	1.50	YES
Iron	3.53E+04	NA	6.25E+04	1.09E+04	2.32E+04	13 / 13	ND	ND	YES
Lead	3.78E+01	3.02E+01	2.42E+03	6.00E+00	4.16E+02	13 / 13	80.13	13.79	YES
Magnesium	9.06E+02	NA	3.82E+02	5.17E+01	1.70E+02	13 / 13	ND	ND	2,3
Manganese	7.12E+02	NA	2.83E+03	8.77E+01	5.41E+02	13 / 13	ND	ND	YES
Mercury	1.10E-01	1.30E-01	1.20E-01	9.80E-03	2.92E-02	9 / 12	0.92	0.22	1
Nickel	1.30E+01	1.59E+01	3.46E+01	2.30E+00	7.94E+00	13 / 13	2.18	0.50	YES
Potassium	1.01E+03	NA	6.13E+02	9.90E+01	2.78E+02	13 / 13	ND	ND	2,3
Thallium	1.30E-01	NA	2.70E+00	7.10E-01	8.24E-01	4 / 13	ND	ND	YES
Vanadium	4.09E+01	NA	4.30E+01	1.31E+01	2.41E+01	13 / 13	ND	ND	YES
Zinc	5.27E+01	1.24E+02	7.48E+01	1.03E+01	2.98E+01	13 / 13	0.60	0.24	1

<sup>a</sup> Background threshold value is 2-times the arithmetic mean background concentration as reported in "Final Background Metals Survey Report, Ft. McClellan, Alabama" (SAIC, 1998).

<sup>b</sup> Ecological screening values are presented in "Human Health and Ecological Screening Values and PAH Background Summary Report" (IT Corp., 2000).

NA - Not Available

ND - Not Determined

Rationale for inclusion / exclusion as COPEC:

1 - Maximum detected concentration is less than ecological screening value (ESV).

2 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

3 - Maximum detected concentration is less than background threshold value.

mg/kg - milligrams per kilogram.

Table 5-7

**Constituents of Potential Ecological Concern in Groundwater at the Iron Mountain Road Ranges  
Fort McClellan, Calhoun County, Alabama**

Constituents	Background Threshold Value <sup>a</sup> (mg/L)	Ecological Screening Value <sup>b</sup> (mg/L)	Maximum Detected Conc. (mg/L)	Minimum Detected Conc. (mg/L)	Mean Detected Conc. (mg/L)	Frequency of Detection	Maximum Hazard Quotient	Mean Hazard Quotient	Constituent Of Potential Ecological Concern
<b>Metals</b>									
Aluminum	2.34E+00	8.70E-02	1.03E+00	6.44E-02	5.55E-01	5 / 6	11.84	6.38	3
Barium	1.27E-01	3.90E-03	1.29E-01	2.38E-02	6.09E-02	5 / 5	33.08	15.62	YES
Beryllium	1.25E-03	5.30E-04	3.21E-03	3.21E-03	4.70E-03	1 / 6	6.06	8.87	YES
Calcium	5.65E+01	1.16E+02	5.57E+01	1.40E+00	1.35E+01	6 / 6	0.48	0.12	1,2,3
Cobalt	2.34E-02	3.00E-03	3.59E-02	3.59E-02	1.43E-02	1 / 6	11.97	4.77	YES
Iron	7.04E+00	1.00E+00	3.54E+00	5.28E-01	1.66E+00	5 / 5	3.54	1.66	2,3
Lead	8.00E-03	1.32E-03	3.84E-03	2.07E-03	4.32E-03	2 / 6	2.91	3.27	3
Magnesium	2.13E+01	8.20E+01	2.83E+00	6.63E-01	1.36E+00	6 / 6	0.035	0.017	1,2,3
Manganese	5.81E-01	8.00E-02	5.60E+00	1.30E-01	1.42E+00	5 / 6	70.00	17.70	YES
Potassium	7.20E+00	5.30E+01	6.46E+00	1.15E+00	3.15E+00	4 / 6	0.12	0.06	1,2,3
Selenium	NA	5.00E-03	4.40E-03	4.40E-03	4.88E-03	1 / 5	0.88	0.98	1
Sodium	1.48E+01	6.80E+02	9.92E-01	8.47E-01	7.58E-01	3 / 5	0.0015	0.0011	1,2,3
<b>Nitroaromatics</b>									
2-Nitrotoluene	NA	NA	3.90E-03	1.20E-03	1.40E-03	3 / 6	ND	ND	YES
4-Amino-2,6-dinitrotoluene	NA	NA	4.70E-04	4.70E-04	2.45E-04	1 / 6	ND	ND	YES
<b>Volatile Organic Compounds</b>									
1,2,4-Trimethylbenzene	NA	NA	3.60E-04	3.60E-04	4.77E-04	1 / 6	ND	ND	YES
1,2-Dimethylbenzene	NA	NA	4.60E-04	4.60E-04	4.93E-04	1 / 6	ND	ND	YES
Ethylbenzene	NA	4.53E-01	2.60E-04	2.60E-04	4.60E-04	1 / 6	0.00057	0.00102	1
m,p-Xylenes	NA	1.17E-01	5.90E-04	5.90E-04	9.32E-04	1 / 6	0.005	0.008	1

mg/L = Milligrams per liter

<sup>a</sup> Background threshold value is 2-times the arithmetic mean background concentration as reported in

"Final Background Metals Survey Report, Ft. McClellan, Alabama" (SAIC, 1998).

<sup>b</sup> Ecological screening values are presented in "Human Health and Ecological Screening Values and PAH Background Summary Report" (IT Corp., 2000).

NA - Not Available

Rationale for inclusion / exclusion as COPEC:

1 - Maximum detected concentration is less than ecological screening value (ESV).

2 - Essential macronutrient, only toxic at extremely high concentrations (i.e. 10-times naturally-occurring background concentration).

3 - Maximum detected concentration is less than background threshold value.

In order to better understand the potential risks posed by chemical constituents at the ranges, a mean HQ was also calculated by comparing the arithmetic mean constituent concentration in each environmental medium to the corresponding ESV. The calculated  $HQ_{\text{screen}}$  for constituents in surface soil, surface water, sediment, and groundwater at the IMR ranges are presented in Tables 5-1 through 5-7.

The EPA recognizes several constituents in abiotic media that are necessary to maintain normal function in many organisms. These essential macro-nutrients are iron, magnesium, calcium, potassium, and sodium (EPA, 1989). Most organisms have mechanisms designed to regulate nutrient fluxes within their systems; therefore, these nutrients are generally only toxic at very high concentrations. Although iron is an essential nutrient and is regulated within many organisms, it may become increasingly bioavailable at lower soil pH values, thus increasing its potential to elicit adverse affects. Therefore, iron was not evaluated as an essential nutrient in this SLERA. Essential macro-nutrients were considered COPECs only if they were present in site samples at concentrations ten times the naturally-occurring background concentration.

A study of the natural geochemical composition associated with FTMC (Science Applications International Corporation [SAIC], 1998) determined the mean concentrations of 24 metals in surface soil, surface water, and sediment samples collected from presumably unimpacted areas. Per agreement with EPA Region IV, the background threshold value (BTV) for each metal was calculated as two times the mean background concentration for that metal. The BTV for each metal was used to represent the upper boundary of the range of natural background concentrations expected at FTMC and was used as the basis for evaluating metals concentrations measured in site samples.

In order to determine whether metals detected in site samples were the result of site-related activities or were indicative of naturally occurring conditions, the maximum metal concentrations measured in site samples were compared to the corresponding BTVs. Site sample metals concentrations less than or equal to the corresponding BTV represent the natural geochemical composition of media at FTMC, and not contamination associated with site activity. Site sample metals concentrations greater than the corresponding BTV represent contaminants that may be the result of site-related activities and require further assessment.

Thus, the first step in determining  $HQ_{\text{screen}}$  was a comparison of maximum detected constituent concentrations to appropriate ESVs. Constituents with  $HQ_{\text{screen}}$  values less than one were considered to pose insignificant ecological risk and were eliminated from further consideration. Constituents with  $HQ_{\text{screen}}$  values greater than one were eliminated from further consideration if

they were macro-nutrients. Those constituents that had  $HQ_{\text{screen}}$  values greater one and were not considered macro-nutrients were then compared to their corresponding BTVs. If constituent concentrations were determined to be less than their naturally occurring background concentration, then a risk management decision could result in eliminating these constituents from further assessment.

## **6.0 Identification of Constituents of Potential Ecological Concern**

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Constituents were initially identified as COPECs if the following conditions were met:

- The MDCC exceeded the ESV
- The MDCC was 10 times BTV or more if constituent is a macro-nutrient
- The MDCC exceeded the BTV for inorganics.

If a constituent in a given environmental medium did not meet these conditions, then it was not considered a COPEC at the IMR ranges and was not considered for further assessment. If a constituent met these conditions, then it was initially considered a COPEC. Identification of a constituent as a COPEC indicates that further assessment of that particular constituent in a given environmental medium may be appropriate. It does not imply that a particular constituent poses risk to ecological receptors.

The COPECs that have initially been identified for surface soil, surface water, sediment, and groundwater at the IMR ranges are presented in Tables 5-1 through 5-7.

In order to focus future ecological risk assessment efforts on the constituents that are the most prevalent at the IMR ranges and have the greatest potential to pose ecological risk, additional lines of evidence were assessed. These additional lines of evidence were scrutinized to aid in the decision process of whether or not to include a constituent as a COPEC in future ecological assessments at the IMR ranges. These additional lines of evidence are discussed in the following sections.

### **6.1 COPECs in Surface Soil**

Antimony, copper, lead, and zinc were frequently detected at all of the IMR ranges at concentrations that exceeded their respective ESVs. The highest concentrations of these four constituents were found in locations that are associated with small arms use at these ranges (i.e., soil berms that are the impact areas). Thus, it could be concluded that these constituents are site-related and could be considered COPECs in surface soil at all of the IMR ranges.

#### **6.1.1 Surface Soil at the Skeet Range**

In addition to the four constituents discussed above, beryllium, cobalt, manganese, benzo(a)pyrene, fluoranthene, phenanthrene, and pyrene were also detected in surface soil samples at the Skeet Range at concentrations that exceeded their respective ESVs (Table 5-1).

Beryllium was detected in two samples at concentrations that exceeded the ESV. However, the  $HQ_{\text{screen}} = 1.3$ . Cobalt was detected in one sample that exceeded its ESV and the  $HQ_{\text{screen}} = 1.3$ . Manganese was detected in one sample at a concentration that exceeded the background threshold value. Therefore, based on the fact that these inorganic compounds were infrequently detected, their maximum detected concentrations only slightly exceeded their ESVs, and they were not detected in a pattern that would associate their elevated concentrations with Skeet Range activities, these constituents may not be considered COPECs in surface soil at the Skeet Range.

The four PAH compounds that were detected at elevated concentrations in surface soil at the Skeet Range [benzo(a)pyrene, fluoranthene, phenanthrene, and pyrene] were restricted to the clay pigeon area. Benzo(a)pyrene and pyrene were detected in two samples at concentrations that exceeded their ESVs, while fluoranthene and phenanthrene were detected in one sample at concentrations that exceeded their ESVs. It could be concluded that, based on the infrequency of detection and the highly conservative nature of the ESVs, that these PAH compounds may not be considered COPECs in surface soil at the Skeet Range.

### **6.1.2 Surface Soil at Range 12**

In addition to antimony, copper, lead, and zinc, surface soils at Range 12 also exhibited concentrations of arsenic and 4,4'-DDT that exceeded their respective ESVs (Table 5-2). Arsenic and 4,4'-DDT were both detected in one surface soil sample at concentrations greater than their ESVs, and their  $HQ_{\text{screen}}$  values were 1.9 and 1.2, respectively. All of the detected concentrations of arsenic at Range 12 were within the range of arsenic concentrations detected in background samples at FTMC (SAIC, 1998); therefore, arsenic in surface soil at Range 12 may be characteristic of naturally-occurring background concentrations of arsenic. Because these two constituents were only detected sporadically at concentrations that exceeded their ESVs, their  $HQ_{\text{screen}}$  values only slightly exceeded unity, and they are not known to be associated with small arms training activities, it could be concluded that arsenic and 4,4'-DDT are not COPECs in surface soil at Range 12.

### **6.1.3 Surface Soil at Range 13**

The only constituent other than antimony, copper, lead, and zinc detected in surface soil at Range 13 at elevated concentrations was arsenic (Table 5-3). Arsenic was detected in two surface soil samples at concentrations that exceeded the ESV; however, the maximum detected concentrations were not at the locations associated with small arms training (i.e., soil berm impact areas). All of the detected concentrations of arsenic at Range 13 were within the range of arsenic concentrations detected in background samples at FTMC (SAIC, 1998); therefore, arsenic in surface soil at Range 13 may be characteristic of naturally-occurring background

concentrations of arsenic. Based on the fact that the detected arsenic in surface soil does not appear to be associated with small arms training activities, was infrequently detected at concentrations that exceeded the ESV, and all arsenic detections were within the range of background at FTMC, it could be concluded that arsenic is not a COPEC in surface soil at Range 13.

#### **6.1.4 Surface Soil at Range 19**

In addition to antimony, copper, lead, and zinc, surface soils at Range 19 also exhibited concentrations of arsenic and silver that exceeded their respective ESVs (Table 5-4). Arsenic was detected in four samples at concentrations that exceeded the ESV; however, all of the detected concentrations of arsenic at Range 19 were within the range of arsenic detected in background samples at FTMC (SAIC, 1998). It could, therefore, be concluded that arsenic in surface soil at Range 19 may be characteristic of naturally-occurring background concentrations of arsenic. Silver was detected in one surface soil sample and the  $HQ_{screen}$  value was 1.8. Since silver was infrequently detected in surface soil and the maximum concentration only slightly exceeded the ESV, it could be concluded that silver is not a COPEC in surface soil at Range 19.

#### **6.1.5 Surface Soil in Range Safety Fans**

Lead was detected in surface soil samples within the IMR range safety fans at concentrations that were within the range of lead concentration for background soil at FTMC. Additionally, the concentrations of lead in surface soil within the range safety fans are not expected to be toxic to most ecological receptors. Japanese quail fed 5,000 mg/kg lead in their diets showed no effects on survival or food consumption (Hill and Camardese, 1986). Lambs fed 400 mg/kg lead in their diets showed some weight loss but were otherwise normal (Demayo, et al., 1982). American kestrel fed 50 mg/kg lead in their diets showed no effects on survival, egg laying, fertility, or eggshell thickness (Pattee, 1984). Because the mean lead concentration in surface soil in the IMR range safety fans was determined to be 43.7 mg/kg (which is less than the levels discussed above), lead toxicity is not expected from exposure to surface soils in the IMR range safety fans. Therefore, the safety fans at the IMR ranges are not considered areas that have the potential to pose significant ecological risk.

### **6.2 Surface Water**

Lead was the only COPEC detected in surface water from Remount Creek and its tributaries in the vicinity of the IMR ranges (Table 5-5). Only two surface water samples from the Skeet Range exhibited lead concentrations that were greater than the ESV. Surface water samples from the other IMR ranges did not exhibit elevated concentrations of any constituent. Since lead was identified as a COPEC in surface soil and is associated with small arms training activities, it

has been identified as a COPEC in surface water at the IMR ranges, although the extent of lead contamination in surface water appears to be limited to the Skeet Range.

### **6.3 Sediment**

In addition to copper and lead, sediment samples from Remount Creek and its tributaries exhibited elevated concentrations of a number of other constituents (Table 5-6). Barium, beryllium, iron, manganese, thallium, and vanadium were initially identified as COPECs because there are no sediment ESVs associated with these constituents and  $HQ_{screen}$  values could not be calculated. None of these constituents have been identified as constituents that are characteristic of small arms training activities, and they have not been identified as COPECs in other environmental media at the IMR ranges. Therefore, it could be concluded that these constituents are not COPECs in sediment at the IMR ranges. Arsenic and nickel were also detected in sediment samples at the Skeet range at concentrations that exceeded their respective ESVs. Nickel was detected in one sediment sample at an elevated concentration with respect to ESVs and arsenic was detected in three samples at elevated concentrations with respect to background. Based on the relative infrequency of detection, the low magnitude of the  $HQ_{screen}$  values, and the fact that these constituents have not been identified as COPECs in other environmental media at the IMR ranges, it could be concluded that arsenic and nickel are not COPECs in sediment at the IMR ranges.

### **6.4 Groundwater**

The rationale for assessing groundwater at the IMR ranges using surface water ESVs was to determine the potential for impacts to aquatic organisms from groundwater intrusion to Remount Creek and its tributaries. Several inorganic constituents were detected in groundwater at concentrations that exceeded their respective surface water ESVs (Table 5-7). Barium, beryllium, and cobalt were detected in one groundwater sample at concentrations that exceeded their respective background threshold values. Manganese was detected in two groundwater samples at concentrations that exceeded its background threshold value. Based on the infrequency of detection of these inorganic constituents at concentrations that exceed background, and the fact that they have not been identified as being associated with small arms training activities in other environmental media at the IMR ranges, it could be concluded that these inorganic compounds are not COPECs in groundwater at the IMR ranges. 2-Nitrotoluene, 4-amino-2,6-dinitrotoluene, 1,2,4-trimethylbenzene, and 1,2-dimethylbenzene were initially identified as COPECs because there are no surface water ESVs associated with them. 4-Amino-2,6-dinitrotoluene, 1,2,4-trimethylbenzene, and 1,2-dimethylbenzene were detected in one groundwater sample and 2-nitrotoluene was detected in three groundwater samples at the IMR ranges. These constituents have not been detected in any other environmental media at the IMR

ranges. Based on the extremely low concentrations of these constituents detected in groundwater and the infrequency of detection, it could be concluded that these constituents are not COPECs in groundwater at the IMR ranges.

It is important to note that none of the constituents in groundwater that were initially identified as COPECs have been detected in surface water at elevated concentrations. In fact, the only constituent identified in surface water at elevated concentrations (lead) was not found in groundwater at elevated concentrations. The differences in the groundwater and surface water data sets is important because it indicates that, although there may be groundwater/surface water interchange, there does not appear to be a significant exchange of contaminants between the two media.

### **6.5 Summary of COPECs**

In order to focus on the constituents that are most prevalent at the IMR ranges and have the greatest potential to pose adverse ecological effects to local ecological communities and populations, the initial list of COPECs was scrutinized using additional lines of evidence. These additional lines of evidence included frequency of detection, magnitude of the  $HQ_{screen}$  value, association with Army activities, bioaccumulation and toxicity potential. Based on these additional lines of evidence, the following COPECs have been identified at the IMR ranges:

- **Surface Soil:** antimony, copper, lead, and zinc
- **Surface Water:** lead
- **Sediment:** copper and lead.

## **7.0 Uncertainty Analysis**

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Uncertainties are inherent in any risk assessment, and even more so in a SLERA, due to the nature of the assessment process and the assumptions used in the process. A number of the major areas of uncertainty in this assessment are presented below.

A significant level of uncertainty is introduced into this assessment due to the sampling and analysis program conducted at the IMR ranges. The original sampling program was designed to delineate volumes of contaminated soil for potential removal or other remedial action as part of the EE/CA process. The sampling and analysis programs conducted at the small arms ranges at FTMC were designed based on a number of factors, including:

- Known and documented historical operating practices at the ranges (i.e., known dates of construction and operation, knowledge of armaments used, knowledge that no other activities took place at these ranges)
- Physical configuration of the ranges.

The fact that the Army has detailed knowledge of the historical operating practices at these ranges increases the confidence that all of the COPECs have been identified at these small arms ranges. Additionally, the physical configuration of some of the ranges reduces the probability of contamination in certain areas (e.g., range fans that extend beyond a large physical obstacle, such as a mountain, are not likely to exhibit site-related contamination).

The sampling program, however, was not designed to determine the “nature and extent” of contamination at the IMR ranges. As such, many of the original sample locations were near the perimeter of areas of suspected contamination and may not have been collected from the areas of heaviest contamination. Because of the different sampling rationale used in the initial sampling program compared to the rationale often employed in remedial investigations, relatively few samples were collected in the areas suspected of having the heaviest contamination. However, additional sampling and analysis were conducted at the IMR ranges subsequent to the initial sampling event to increase the probability that all contaminants at the site have been detected and that the maximum concentration of each contaminant has been determined. This additional sampling included the analysis of soils in the range fans by XRF technology to determine the potential for contamination in these remote areas.

Another degree of uncertainty was introduced into the estimation of exposure-point concentrations in soil by the removal of bullets and bullet fragments prior to analysis in the laboratory. The presence of bullets and bullet fragments in soil could act as a source of future contamination as these bullet fragments weather and release lead and other contaminants to the soil. The removal of bullets prior to analysis may produce an underestimation of future exposure-point concentrations for bullet-related contaminants in soil. Bullet fragments and/or skeet pellets may also be directly ingested by birds for grit in their crops. Therefore, removal of bullet fragments and skeet pellets from soil samples prior to analysis may act to underestimate the potential exposure of birds and other animals to soil contaminants.

Sampling strategies at the IMR ranges were designed to incorporate areas of the ranges (i.e., impact zones) where the greatest amount of contamination was suspected to occur based on-site history, previous sampling results, and visual observation. Thus, the characterization of environmental media at the IMR ranges included the areas of suspected maximum constituent concentrations at each of the ranges. An area of uncertainty that is inherent in a SLERA is the use of the MDCC as the exposure-point concentration for all receptors in a given medium. Most receptors have a home range large enough that precludes individuals from being exposed to the maximum constituent concentration for their entire lifetimes. Therefore, the actual exposure-point concentration of a given constituent for most receptor species would be less than the maximum detected concentration. The use of the MDCCs as the exposure-point concentrations for all receptors can result in an overestimation of exposure for many receptors.

Additionally, there is no consideration given to the bioavailability of COPECs to different organisms. In this SLERA it is assumed that all constituents are 100 percent bioavailable to all receptor organisms. It is known that many constituents (particularly inorganic compounds) have significantly lower bioavailabilities (e.g., 1 to 10 percent for some inorganics in soil) than the 100 percent that was assumed in this assessment. This assumption has the potential to greatly overestimate exposures to certain COPECs.

Another uncertainty with regard to potential exposures is the identification of Remount Creek in the vicinity of the IMR ranges as poor quality gray bat habitat. Historically, gray bay habitat may have existed along the Remount Creek Corridor in the vicinity of the IMR ranges. Recent changes to the surrounding land use (namely, the clear-cutting of the forest in preparation for construction of the "Eastern Bypass") has decreased the desirability of this stream corridor as gray bat habitat. Because gray bats prefer continuous cover while moving between their roosting caves and their foraging locations, the removal of forest cover along the Remount Creek Corridor significantly reduces its desirability as gray bat habitat.

Several COPECs do not have ESVs. The lack of toxicity data for certain COPECs makes it impossible to determine the potential for ecological risk posed by those constituents. Risks may be underestimated due to this uncertainty.

The ESVs used in this assessment are all the most conservative values from the scientific literature, and many are based on the most sensitive endpoint (NOAEL values) for the most sensitive species tested. A less sensitive endpoint that is still protective of the ecological populations or communities of interest may be the LOAEL or some other endpoint. The use of NOAEL-based ESVs may over-estimate potential for risks from certain COPECs. Additionally, certain ESVs may not be applicable to conditions at the IMR ranges. For instance, a number of the sediment ESVs are referenced from MacDonald (1994) which presents sediment benchmark values for coastal waters (saline) in Florida. The surface water bodies at the IMR ranges are fresh water and exhibit significantly different physical and chemical characteristics compared to those found in the coastal waters of Florida. Therefore, the use of sediment ESVs developed for the coastal waters of Florida to determine risks in the freshwater streams of FTMC introduces a significant level of uncertainty. Similarly, the surface water and soil ESVs do not take into account site-specific conditions at the IMR ranges and, thus, introduce a potentially significant level of uncertainty into the assessment.

Another area of uncertainty is the lack of consideration of synergisms and/or antagonisms between COPECs. Although it is widely accepted that synergisms and antagonisms occur between certain constituents under certain conditions, the SLERA process does not provide methods for assessing these potential synergisms/antagonisms.

## **8.0 Summary and Conclusions**

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The potential for ecological risks at the IMR ranges was determined through a SLERA. This ecological screening process consisted of a characterization of the ecological setting at the IMR ranges, development of an SCM, a description of the fate and transport of constituents detected in various environmental media, a description of the ecotoxicity of the various constituents detected at the ranges, a description of the ecological receptors, a description of the complete exposure pathways, calculation of  $HQ_{screen}$ , and a description of the uncertainties in the process.

### **8.1 SLERA Summary**

The following sections describe the findings of the SLERA process at each of the ranges at IMR and Remount Creek in the vicinity of the IMR ranges.

#### **8.1.1 Skeet Range Surface Soil**

The following constituents in surface soil at the Skeet Range exhibited maximum concentrations that exceeded their respective ESV: antimony, beryllium, cobalt, copper, lead, manganese, zinc, benzo(a)pyrene, fluoranthene, phenanthrene, and pyrene. These eleven constituents exhibited maximum HQ ranging from 1.25 to 35.6. A HQ for p-cymene could not be calculated, as there were no ESVs available for p-cymene. If mean HQ were considered, only lead, manganese, benzo(a)pyrene, fluoranthene, phenanthrene, pyrene exceeded their respective ESVs.

Additional lines of evidence (Section 6.1.1) suggested that only antimony, copper, lead and zinc in surface soil have the potential to pose ecological risk; therefore, these constituents have been identified as COPECs in surface soil at the Skeet Range

#### **8.1.2 Range 12 Surface Soil**

Antimony, arsenic, copper, lead, zinc, and 4,4'-DDT were the only constituents in surface soil at Range 12 whose maximum concentrations exceeded their respective ESVs. The maximum HQs ranged from 1.12 (4,4'-DDT) to 162.3 (lead). Mean HQs for these constituents ranged from 0.78 to 14.36. Additional lines of evidence (Section 6.1.2) suggested that only antimony, copper, lead and zinc in surface soil have the potential to pose ecological risk; therefore, these constituents have been identified as COPECs in surface soil at Range 12.

#### **8.1.3 Range 13 Surface Soil**

Antimony, arsenic, copper, lead, and zinc were detected in surface soils at Range 13 at concentrations that exceeded their respective ESVs. The maximum HQs ranged from 2.2 to

87.6. An  $HQ_{\text{screen}}$  value for p-cymene could not be calculated because there were no ESVs available. If mean HQs were considered, the  $HQ_{\text{screen}}$  for zinc was less than one. Additional lines of evidence (Section 6.1.3) suggested that only antimony, copper, lead and zinc in surface soil have the potential to pose ecological risk; therefore, these constituents have been identified as COPECs in surface soil at Range 13.

#### **8.1.4 Range 19 Surface Soil**

Maximum concentrations of antimony, arsenic, copper, lead, silver, and zinc in surface soil at Range 19 exceeded their respective ESVs. Maximum HQs ranged from 1.39 to 2,320. An  $HQ_{\text{screen}}$  for p-cymene could not be calculated because there were no ESVs available. If mean HQs were considered, the HQs for arsenic and silver were less than one. Additional lines of evidence (Section 6.1.4) suggested that only antimony, copper, lead, and zinc in surface soil have the potential to pose ecological risk; therefore, these constituents have been identified as COPECs in surface soil at Range 19.

#### **8.1.5 Remount Creek Surface Water**

Lead was the only constituent detected in the surface water of Remount Creek with a maximum concentration that exceeded its respective ESV ( $HQ_{\text{screen}} = 65.98$ ). Therefore, the only COPEC for the surface water in Remount Creek in the vicinity of the Iron Mountain Road Ranges was lead. Elevated concentrations of lead in surface water also appeared to be limited to the tributaries within, and adjacent to, the Skeet Range.

#### **8.1.6 Remount Creek Sediment**

Maximum concentrations of the following constituents in sediments of Remount Creek exceeded their respective ESVs: arsenic, copper, lead, and nickel. HQs could not be calculated for barium, beryllium, iron, manganese, thallium, and vanadium because ESVs were not available for these constituents. If mean HQs were considered, the HQ for nickel was less than one. Although definitive statements could not be made regarding a number of constituents in sediment because ESVs were not available (barium, beryllium, manganese, thallium, and vanadium), these constituents were identified as COPECs in sediment of Remount Creek. Additional lines of evidence (Section 6.1.6) suggested that only copper and lead in sediment have the potential to pose ecological risk; therefore, these constituents have been identified as COPECs in sediment at the IMR ranges.

#### **8.1.7 Groundwater**

Maximum concentrations of the following constituents in groundwater at the IMR ranges exceeded surface water ESVs: barium, beryllium, cobalt, manganese, 2-nitrotoluene, 4-amino-

2,6-dinitrotoluene, 1,2,4-trimethylbenzene, and 1,2-dimethylbenzene. It is important to note that none of these constituents in groundwater have been detected in surface water at elevated concentrations. In fact, the only constituent identified in surface water at elevated concentrations (lead) was not found in groundwater at elevated concentrations. Ecological receptors could potentially be exposed to constituents in groundwater only through surface water exposure pathways. Although there may be groundwater/surface water interchange, there does not appear to be a significant exchange of contaminants between the two media. Therefore, none of the constituents in groundwater have been identified as COPECs.

These COPECs (Table 8-1) have been identified through a very conservative screening process that utilizes ESVs based largely on NOAEL values from the scientific literature. If, based on a risk management decision, the potential ecological risks at the IMR ranges are determined to be “unacceptable” at this screening-level stage, then a baseline ecological risk assessment (BERA) is appropriate. The goal of the BERA, if deemed necessary, will be to reduce the levels of uncertainty and conservatism in the assessment process and to determine the potential for ecological risk at the IMR ranges through a number of lines of evidence.

## **8.2 Conclusions of SLERA**

The SLERA at the IMR ranges determined that several inorganic constituents (i.e., antimony, copper, lead, and zinc) were routinely detected in surface soil at the IMR ranges at concentrations that exceeded their respective ESVs. Additionally, lead was detected in surface water and copper and lead were detected in the sediment of Remount Creek and its tributaries at concentrations that exceeded their respective ESVs. Thus, the potential exists that these inorganic constituents may pose adverse ecological risks to the flora and/or fauna at the IMR ranges. Although several other constituents were detected in surface soil, sediment, and groundwater at the IMR ranges, additional lines of evidence have suggested that these constituents do not have the potential to pose significant ecological risk to the local ecological populations and communities at the IMR ranges.

Because several constituents were detected at concentrations exceeding their respective ESVs, and because conservative assessment techniques were used in the SLERA process, a more thorough assessment is warranted to reduce uncertainties inherent in the SLERA process and to determine the potential for ecological risk at the IMR ranges.

**Table 8-1**  
**Summary of COPECs at Iron Mountain Road Ranges**  
**Fort McClellan, Calhoun County, Alabama**

COPECs	Skeet Range Surface Soil	Range 12 Surface Soil	Range 13 Surface Soil	Range 19 Surface Soil	Remount Cr. & Tributaries Surface Water	Remount Cr. & Tributaries Sediment
antimony	X	X	X	X		
arsenic		O	O	O		O
barium						O
beryllium	O					O
cobalt	O					
copper	X	X	X	X		X
iron						O
lead	X	X	X	X	X	X
manganese	O					O
nickel						O
silver				O		
thallium						O
vanadium						O
zinc	X	X	X	X		
benzo(a)pyrene	O					
fluoranthene	O					
phenanthrene	O					
pyrene	O					
4,4'-DDT		O				

O -  $HQ_{screen} > 1.0$ , however additional lines of evidence indicate that this constituent is not a COPEC.

X - Constituent identified as a COPEC.

## 9.0 References

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- 3D/International, Inc. (3D/I), 1998, Biological Assessment, Disposal and Reuse of Fort McClellan, Alabama, 3D/I, Inc., Environmental Group, Cincinnati, OH.
- Adriano, D. C., 1986, *Trace Elements in the Terrestrial Environment*, Springer-Verlag, New York, NY.
- Agency for Toxic Substances and Disease Registry (ATSDR), 1995, *Toxicological Profile for Nickel*, U.S. Public Health Service.
- Agency for Toxic Substances and Disease Registry (ATSDR), 1993, *Toxicological Profile for Beryllium*, U.S. Public Health Service.
- Agency for Toxic Substances and Disease Registry (ATSDR), 1992a, *Toxicological Profile for Barium*, U.S. Public Health Service.
- Agency for Toxic Substances and Disease Registry (ATSDR), 1992b, *Toxicological Profile for Manganese*, U.S. Public Health Service.
- Agency for Toxic Substances and Disease Registry (ATSDR), 1992c, *Toxicological Profile for Vanadium*, U.S. Public Health Service.
- Agency for Toxic Substances and Disease Registry (ATSDR), 1990, *Toxicological Profile for Silver*, U.S. Public Health Service.
- Agency for Toxic Substances and Disease Registry (ATSDR), 1989, *Toxicological Profile for Arsenic*, U.S. Public Health Service.
- Ainsworth, N., 1988, *Distribution and Biological Effects of Antimony in Contaminated Grassland*, Dissertation, as cited in ATSDR, 1990.
- Ambrose, A.M., P.S. Larson, J.F. Borzelleca, and G.R. Hennigar, 1976, *Long-Term Toxicologic Assessment of Nickel in Rats and Dogs*, J. Food Sci. Tech., 13: 181-187.
- Amelung, M., 1981, *Auswirkungen Geloster Eisenverbindungen auf die Ei und Larvalentwicklung von Salmo gairdneri*, Arch. Fisch. Wiss., 32:77-87.
- Anderson, R. L., C. T. Walbridge, and J. T. Fiantt, 1980, *Survival and Growth of Tanytarsus dissimilis (Chironomidae) Exposed to Copper, Cadmium, Zinc, and Lead*, Arch. Environ. Contam. Toxicol., 9:329-335.
- Anderson, D.W., R.W. Risebrough, L.A. Woods, L.R. DeWeese, and W.G. Edgecomb, 1975, *Brown Pelicans: Improved Reproduction Off the Southern California Coast*, Science, 190: 806-808.

Aulerich, R. J., S. J. Bursian, W. J. Breslin, B. A. Olson, and R. K. Ringer, 1985, *Toxicological Manifestations of 2,4,5,2',4'5'-, 2,3,6,2',3',6'-, and 3,4,5,3',4',5'-Hexachlorobiphenyl and Arochlor 1254 in Mink*, J. Toxicol. Environ. Health, 15:63-79.

Aulerich, R.J., R.K. Ringer, M.R. Bleavins, et al., 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*, J. Animal Sci., 55: 337-343.

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 European Communities, pp. 199-210.

Baudouin, M. F. and P. Scoppa, 1974, *Acute Toxicity of Various Metals to Freshwater Zooplankton*, Bull. Environ. Contam. Toxicol., 12:745-751.

Beyer, W. N., O. H. Pattee, L. Sileo, D. J. Hoffman, and B. M. Mulhern, 1985, *Metal Contamination in Wildlife Living Near Two Zinc Smelters*, Environ. Pollut., 38A:63-86.

Biesinger, K. E. and G. M. Christensen, 1972, *Effects of Various Metals on Survival, Growth, Reproduction, and Metabolism of Daphnia magna*, J. Fish. Res. Bd. Canada, 29:1691-1700.

Bogges, W. R. (Ed.), 1977, *Lead in the Environment*, National Science Foundation, Rep. NSF/RA 770214, 272 pp.

Boikat, U., A. Fink, and J. Bleck-Neuhaus, 1985, *Cesium and Cobalt Transfer from Soil to Vegetation on Permanent Pastures*, Radiation and Environmental Biophysics, 24: 287-301.

Bryant, V., D. M. Newbery, D. S. McKlusky, and R. Campbell, 1985, *Effect of Temperature and Salinity on the Toxicity of Arsenic to Three Estuarine Invertebrates (Corophium volutator, Macoma balthica, Tubifex costatus)*, Mar. Ecol. Prog. Ser., 24:129-137.

Burrows, E. P., D. H. Rosenblatt, W. R. Mitchell, and D. L. Parmer, 1989, *Organic Explosives and Related Compounds: Environmental and Health Considerations*, U.S. Army Technical Report 8901.

Cain, B.W. and E. A. Pafford, 1981, *Effects of Dietary Nickel on Survival and Growth of Lallard Ducklings*, Arch. Environ. Contam. Toxicol., 10: 737-745.

Cairns, J. and A. Scheier, 1968, *A Comparison of the Toxicity of Some Common Industrial Waste Components Tested Individually and Combined*, Prog. Fish-Cult., 30:3-8.

Callahan, M. A., M. W. Slimak, and N. Gabel, 1979, *Water-Related Environmental Fate of 129 Priority Pollutants, Volume I*, Office of Water and Waste Management, U.S. Environmental Protection Agency, EPA/440/4-79/092a, Washington, DC.

Carins, M. A., A. V. Nebeker, J. H. Gakstatter, and W. L. Griffis, 1984, *Toxicity of Copper Spiked Sediments to Freshwater Invertebrates*, Environ. Toxicol. Chem., 3(3):435-446.

Carpenter, K. E., 1926, *The Lead Mine as an Active Agent in River Pollution*, Ann. Appl. Biol., 13:395.

Carpenter, K. E., 1925, *On the Biological Factors Involved in the Destruction of River Fisheries by Pollution Due to Lead Mining*, Ann. Appl. Biol., 12:1.

Carpenter, K. E., 1924, *A Study of the Faunal Rivers Polluted by Lead Mining in the Aberystwyth District of Cardiganshire*, Ann. Appl. Biol., 11:1.

Clark, M. L., D. G. Harvey, and D. J. Humphreys, 1981, *Veterinary Toxicology, Second Edition*, Bailliere-Tindall, London, England.

Cox, D. H., S. A. Schlicker, and R. C. Chu, 1969, *Excess Dietary Zinc for the Maternal Rat and Zinc, Iron, Copper, Calcium, and Magnesium Content and Enzyme Activity in Maternal and Fetal Tissues*, J. Nutr., 98:459-466.

Dave, G., 1984, *Effects of Waterborne Iron on Growth, Reproduction, Survival, and Haemoglobin in Daphnia magna*, Comp. Biochem. Physiol., 78C:433-438.

Davies, P. M., J. P. Goettl Jr., J. R. Sinley, and N. F. Smith, 1976, *Acute and Chronic Toxicity of Lead to Rainbow Trout (Salmo Gairdneri) in Hard and Soft Water*, Water Res., 10:199.

Dawson, A. B., 1935, *The Hemopoietic Response in the Catfish, Ameiurus nebulosus, to Chronic Lead Poisoning*, Biol. Bull., 68:335.

Demayo, A., M.C. Taylor, K.W. Taylor, and P.V. Hodson, 1982. *Toxic Effects of Lead and Lead Compounds on Human Health, Aquatic Life, Wildlife Plants, and Livestock*. CRC Crit. Rev. Environ. Control, 12: 257-305.

Domingo, J.L., J.L. Paternain, J.M. Llobet, and J. Corbella, 1986, *Effects of Vanadium on Reproduction, Gestation, and Lactation in Rats Upon Oral Administration*, Life Sci., 39: 819-824.

Efroymson, R. A., M. E. Will, G. W. Suter, and A. C. Wooten, 1997, *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants, 1997 Revision*, Office of Environmental Management, USDOE, Oak Ridge, Tennessee, ES/ER/TM-85/R3.

Eisler, R., 1993, *Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*, U.S. Fish and Wildlife Service, Biological Report, 85(1.26), 123 pp.

Eisler, R., 1988a, *Arsenic Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*, U.S. Fish and Wildlife Service, Biological Report, 85(1.12), 92 pp.

Eisler, R., 1988b, *Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*, U.S. Fish and Wildlife Service, Biological Report, 85(1.14), 134 pp.

Eisler, R., 1987, *Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review*, U.S. Fish and Wildlife Service, Biol. Rep. 85(1.11), 81 pp.

Evans, R. D., D. Andrews, and R. J. Cornett, 1988, *Chemical Fractioning and Bioavailability of Cobalt-60 to Benthic Deposit Feeders*, Journal of Canadian Fisheries and Aquatic Sciences, 45:228-236.

Finger, S. E., E. F. Little, M. G. Henry, J. F. Fairchild, and T. P. Boyle, 1985, *Comparison of Laboratory and Field Assessment of Fluorene, Part I: Effects of Fluorene on the Survival, Growth, Reproduction, and Behavior of Aquatic Organisms in Laboratory Tests. Validation and Predictability of Laboratory Methods for Assessing the Fate and Effects of Contaminants in Aquatic Ecosystems*, T. P. Boyle, ed., American Society for Testing and Materials, ASTM STP 865: 120-133.

Fishbein, L., 1981, *Sources, Transport, and Alterations of Metal Compounds: an Overview. I. Arsenic, Beryllium, Cadmium, Chromium, and Nickel*, Environmental Health Perspectives, 40:43-64.

Fitzhugh, O.G., 1948, *Use of DDT Insecticides on Food Products*, Ind. Eng. Chem., 40: 704-705, pp. 4-15.

Formigli, L., R. Scelsi, P. Poggi, C. Gregotti, A. DiNucci, E. Sabbioni, and L. Manzo, 1986, *Thallium-Induced Testicular Toxicity in the Rat*, Env. Res., 40: 531-539.

Foy, C. D., R. L. Chaney, and M. C. White, 1978, *The Physiology of Metal Toxicity in Plants*. Ann. Review Plant Physiol., 29:511-566.

Francis, C. W., E. C. Davis, and J. C. Goyert, 1980, *Plant Uptake of Trace Elements from Coal Gasification Ashes*, Journal of Environmental Quality, 14:561-569.

Fuller, R. H. and R. C. Averett, 1975, *Evaluation of Copper Accumulation in Part of the California Aqueduct*, Water Res. Bull., 11:946-952.

Garland, B. W., 1996, *Endangered Species Management Plan for Fort McClellan, Alabama*, Directorate of Environment.

Getz, L. L., A. W. Haney, R. W. Larimore, J. W. McNurney, H. W. Leyland, P. W. Price, G. L. Rolfe, R. L. Wortman, J. L. Hudson, R. L. Solomon, and K. A. Reinbold, 1977, *Transport and Distribution in a Watershed Ecosystem: Lead in the Environment*. Boggess (ed.), National Science Foundation, p. 105-134.

Goede, A. A., 1985, *Mercury, Selenium, Arsenic, and Zinc in Waders from the Dutch Wadden Sea*. Environmental Pollution, Vol. 37A, pp. 287-309.

Gregus, Z. and C. D. Klaassen, 1986, ***Disposition of Metals in Rats: A Comparative Study of Fecal, Urinary, and Biliary Excretion and Tissue Distribution of Eighteen Metals***, Toxicology and Applied Pharmacology, Vol. 85, pp. 24-38.

Hall, R. J. and B. M. Mulhern, 1984, ***Are Anuran Amphibians Heavy Metal Accumulators?*** In ***Vertebrate Ecology and Systematics: A Tribute to Henry S. Fitch***, R. A. Seigel, L. E. Hunt, J. L. Knight, L. Malaret, and N. L. Zuschlag (eds.), Museum of Natural History, University of Kansas, Lawrence, Kansas, pp.123-133.

Hara, T., Y. Sonoda, and I. Iwai, 1976, ***Growth Response of Cabbage Plants to Transition Elements Under Water Culture Conditions***, Soil Sci. Plant Nutr., 22(3):307-315.

Hayes, A. W., 1994, ***Principles and Methods of Toxicology***, Third edition, Raven Press, New York, New York.

Health Effects Assessment Summary Tables (HEAST), 1997, Office of Solid Waste and Emergency Response, Washington, DC, EPA-540-R-97-036.

Henny, C. J., L. J. Blus, and C. S. Hulse, 1985, ***Trends and Effects of Organochlorine Residues on Oregon and Nevada Wading Birds, 1979-1983***, Colonial Waterbirds, Vol. 8, pp. 117-128.

Hernandez, L. M., J. Gonzalez, C. Rico, et al., 1985, ***Presence and Biomagnification of Organochlorine Pollutants and Heavy Metals in Mammals in Donana National Park (Spain)***, J. Environ. Sci. Health, 20:633-650.

Hill, E.F. and M.B. Camardese, 1986, ***Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Cortunix***, U.S. Fish and Wildlife Service Technical Report 2, 147 p.

Hoffman, D. J., J. C. Franson, O. H. Pattee, C. M. Bunck, and H. C. Murray, 1985, ***Biochemical and Hematological Effects of Lead Ingestion in Nesting American Kestrels (*Falco sparverinus*)***, Comp. Biochem. Physiol., 80C:431-439.

Hoffman, D. J. and M. L. Gay, 1981, ***Embryotoxic Effects of Benzo(a)pyrene, Chrysene, and 7,12-Dimethylbenz(a)anthracene in Petroleum Hydrocarbon Mixtures in Mallard Ducks***, J. Toxicol. Environ. Health, 7: 775-787.

Holcombe, G. W., D. A. Benoit, E. N. Leonard, and J. M. McKim, 1976, ***Long Term Effects of Lead Exposure on Three Generations of Brook Trout (*Salvelinus fontinalis*)***, J. Fish. Res. Bd. Can., 33:1731.

Hood, R. D., 1985, ***Cacodylic acid: Agricultural Uses, Biological Effects, and Environmental Fate***, VA Monograph, 171 pp., Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Hose, J. E., J. B. Hannah, D. Dijulio, M. L. Landolt, B. S. Miller, W. T. Iwaoka, and S. P. Felton, 1982, *Effects of Benzo(a)pyrene on Early Development of Flatfish*, Arch. Environ. Contam. Toxicol., 11:167-171.

Howard, A.G., M.H. Arbab-Zavar, and S. Apte, 1984, *The Behaviour of Dissolved Arsenic in the Estuary of the River Beaulieu*, Estuarine Coastal Shelf Sci., 19:493-504.

Hudson, R. H., R. K. Tucker, and M. A. Haegele, 1984, *Handbook of Toxicity of Pesticides to Wildlife*, U.S. Fish and Wildlife, Service Resource Publication 153, 90 pp.

Hunter, B. A., and M. S. Johnson, 1982, *Food Chain Relationship of Copper and Cadmium in Contaminated Grassland Ecosystems*, Oikos, Vol. 38, pp. 108-177.

International Commission on Radiological Protection (ICRP), 1979, *Limits for Intakes of Radionuclides by Workers*, Publication 39, Part 1, Commission on Radiological Protection, Washington, DC.

Integrated Risk Information Service (IRIS), 2001, on-line database maintained by EPA.

IT Corporation (IT), 2001a, *Engineering Evaluation and Cost Analysis for the Small Arms Ranges at Iron Mountain Road, Fort McClellan, Calhoun County, Alabama*, April.

IT Corporation (IT), 2001b, *Draft Screening-Level Ecological Risk Assessment for Iron Mountain Road Ranges, Fort McClellan, Calhoun County, Alabama*, July.

IT Corporation (IT), 2000, *Final Human Health and Ecological Screening Values and PAH Background Summary Report, Fort McClellan, Calhoun County, Alabama*, July.

Jenkins, D. W., 1980, *Biological Monitoring of Toxic Trace Metals, Volume 1*, Biological Monitoring and Surveillance, NTIS PB81-103475.

Jones, D. S., G. W. Suter, and K. N. Hull, 1997, *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Efforts on Sediment-Associated Biota: 1997 Revision*, Risk Assessment Program, U.S. Department of Energy, Oak Ridge, Tennessee, ES/ER/TM-95/R4.

Kabata-Pendias, A. and H. Pendias, 1992, *Trace Elements in Soils and Plants*, 2<sup>nd</sup> edition, CRC Press, Boca Raton, FL, 365 pp.

Kendall, R., 1992, *Wildlife Toxicology*, Environ. Sci. Tech., Vol. 16, No. 8:448A-453A.

Khangrot, B. S. and P. K. Ray, 1989, *Investigation of Correlation Between Physiochemical Properties of Metals and their Toxicity to the Water Flea Daphnia magna Straus*, Ecotoxicol. Environ. Saf., 18(2):109-120.

Kinnamon, K. E., 1963, *Some Independent and Combined Effects of Copper, Molybdenum, and Zinc on the Placental Transfer of Zinc-65 in the Rat*, J. Nutr., 81:312-320.

- Klaassen, C. D., M. O. Amdur, and S. Doull, 1991, *Toxicology: The Basic Science of Poisons*, Pergamon Press, Inc., Elmsford, New York.
- Knobloch, K., S. Szendzikowski, and A. Slusarczyk-Zalobna, 1969, *Acute and Subacute Toxicity of Acenaphthene and Acenaphthylene*, Med. Pracy., 20(3):210-222.
- Kosalwat, P., and A. W. Knight, 1987, *Chronic Toxicity of Copper to a Partial Life Cycle of the Midge Chironomus decorus*, Arch. Environ. Contam. Toxicol., 16(3):283-290.
- Laskey, J.W., G.L. Rehnberg, J.F. Hein, and S.D. Carter, 1982. Effects of Chronic Manganese (Mn<sub>3</sub>O<sub>4</sub>) Exposure on Selected Reproductive Parameters in Rats. J. Toxicol. Environ. Health. 9: 677-687.
- Lecyk, M., 1980, *Toxicity of Cupric Sulfate in Mice Embryonic Development*, Zoo. Pollut., 28(2):101-105.
- Lima, A. R., C. Curtis, D. E. Hammermeister, T. P. Markee, C. E. Northcott, and L. T. Brooke, 1984, *Acute and Chronic Toxicities of Arsenic (III) to Fathead Minnows, Flagfish, Daphnids, and an Amphipod*, Arch. Environ. Contam. Toxicol., 13:595-601.
- Long, E. R. and L. G. Morgan, 1990, *The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program*, National Oceanic and Atmospheric Administration Technical Memorandum NOSOMA 52, NOAA, Seattle, Washington.
- MacDonald, D. D., 1994, *Approach to the Assessment of Sediment Quality in Florida Coastal Waters*, Florida Department of Environmental Protection.
- MacKenzie, K. M. and D. M. Angevine, 1981, *Infertility in Mice Exposed in Utero to Benzo(a)pyrene*, Biology of Reproduction, Vol. 24, pp. 183-191.
- Manzo, L., R. Scelsi, A. Moglia, P. Poggi, E. Alfonsi, R. Pietra, F. Mousty, and E. Sabbioni, 1982, *Long-Term Toxicity of Thallium in the Rat*. In *Chemical Toxicology and Clinical Chemistry of Metals*, Academic Press, London, pp. 4-1-405.
- Marceau, N., N. Aspin, and A. Sass-Kortsak, 1970, *Absorption of Copper from Gastrointestinal Tract of the Rat*, American Journal of Physiology, 218:377-383..
- Mehring, A.L., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus, 1960, *The Tolerance of Growing Chickens for Dietary Copper*, Poult. Sci., 39: 713-719.
- Merck Index*, 1983, 10th edition, Rahway, New Jersey, Merck Co., Inc.
- Michnowicz, C. J. and T. E. Weeks, 1984, *Effects of pH on Toxicity of As, Cr, Cu, Ni, and Zn to Selenastrum capricornutum Printz*, Hydrobiologia, 118:299-305.

- Moore, J. W. and S. Ramamoorthy, 1984, *Heavy Metals in Natural Waters: Applied Monitoring and Impact Assessment*, R. S. DeSanto, ed., Springer-Verlag, New York, New York.
- Mount, R.H., 1986, *Vertebrate Animals of Alabama in Need of Special Attention*, Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama, 124 pp.
- Mudge, G. P., 1983, *The Incidence and Significance of Ingested Lead Pellet Poisoning in British Waterfowl*, Biol. Conserv., 27:333-372.
- National Academy of Sciences (NAS), 1979, *Zinc*, Washington, DC, 471 pp.
- National Academy of Sciences (NAS), 1977a, *Arsenic*, Washington, DC, 332 pp.
- National Academy of Sciences (NAS), 1977b, *Drinking Water and Health - Inorganic Solutes*, Washington, DC, pp. 205-488.
- National Academy of Sciences (NAS), 1972, *Lead: Airborne Lead in Perspective*, Washington, DC, 188.
- National Library of Medicine (NLM), 1996, Hazardous Substance Data Bank, Produced by Micromedex, Inc.
- National Research Council (NRC), 1977, *Drinking Water and Health, Volume 1*, Washington, DC, National Academy Press.
- National Research Council of Canada (NRCC), 1980, *Effects of Vanadium in the Canadian Environment*, Publication No. NRCC 18132.
- National Research Council of Canada (NRCC), 1978, *Effects of Arsenic in the Canadian Environment*, Publication No. NRCC 15391, 349 pp.
- National Research Council of Canada (NRCC), 1973, *Lead in the Canadian Environment*, Publication No. BY73-7(ES), 119p.
- Neff, J. M., B. W. Cornaby, R. M. Vaga, T. C. Gulbransen, J. A. Scanlon, and D. J. Bean, 1988, *An Evaluation of the Screening Level Concentration Approach for Validation of Sediment Quality Criteria for Freshwater and Saltwater Ecosystems*. pp. 115-127. In *Aquatic Toxicology and Hazard Assessment*, 10<sup>th</sup> Volume, ASTM STP 971, ed. W. J. Adams, G. A. Chapman, and W. G. Landis, American Society for Testing and Materials, Philadelphia, PA.
- Neff, J. M., 1985, *Polycyclic Aromatic Hydrocarbons*, In *Fundamentals of Aquatic Toxicology*, G. M. Rand and S. R. Petrocelli, eds., Hemisphere Publishing Corp., Washington, DC

Neumann, G., 1976, *Concentration Factors for Stable Metals and Radionuclides in Fish, Mussels, and Crustaceans: A Literature Survey*, National Swedish Environmental Protection Board, Sweden.

Ontario Ministry of the Environment, 1992, *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*.

Pattee, O.H., 1984, *Eggshell Thickness and Reproduction in American Kestrels Exposed to Chronic Dietary Lead*, Arch. Environ. Contam. Toxicol., 13: 29-34.

Persaud, D., R. Jaagumagi, and A. Hayton, 1993, *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*, Ontario Ministry of the Environment and Energy.

Pershagen, G., and M. Vahter, 1979, *Arsenic: A Toxicological and Epidemiological Appraisal*, Naturvardsverket Rapp., SNV PM 1128, Liber Tryck, Stockholm, 265 pp.

Peterson, P. J., and C. A. Girling, 1981, *Other Trace Metals*. In *Effect of Heavy Metal Pollution on Plants, Vol. 1, Effects of Trace Metals on Plant Function*, N. W. Lepp (ed.), Applied Science Publishers, New Jersey, pp. 213-278.

Reeves, A., and A. Vorwald, 1967, *Beryllium Carcinogenesis, Pulmonary Deposition and Clearance of Inhaled Beryllium Sulfate in the Rat*, Cancer Research, 27:446-451.

Rhodes, F. M., S. M. Olsen, and A. Manning, 1989, *Copper Toxicity in Tomato Plants*, Journal of Environmental Quality, Vol. 18, pp. 195-197.

Romney, E. M., and J. D. Childress, 1965, *Effects of Beryllium in Plants and Soil*, Soil Sci. 100(2):210-217.

Sample, B. E., J. J. Beauchamp, R. A. Efroymson, and G. W. Suter, 1998a, *Development and Validation of Bioaccumulation Models for Small Mammals*. Office of Environmental Management, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-219.

Sample, B. E., J. J. Beauchamp, R. A. Efroymson, G. W. Suter, and T. L. Ashwood, 1998b, *Development and Validation of Bioaccumulation Models for Earthworms*, Office of Environmental Management, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN, ES/ER/TM-220.

Sample, B. E., D. M. Opresko, and G. W. Suter, 1996, *Toxicological Benchmarks for Wildlife, 1996 Revision*, Risk Assessment Program, Office of Environmental Management, U. S. Department of Energy, Oak Ridge, Tennessee, ES/ER/TM-86/R3.

Sanders, J. G., 1986, *Direct and Indirect Effects of Arsenic on the Survival and Fecundity of Estuarine Zooplankton*, Can. J. Fish. Aquat. Sci., 43:694-699.

Science Applications International Corporation (SAIC), 1998, *Final Background Metals Survey Report, Fort McClellan, Alabama*, July.

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

Schroeder, H.A. and M. Mitchener, 1975, *Life-Term Studies in Rats: Effects of Aluminum, Barium, Beryllium, and Tungsten*, J. Nutri., 105: 421-427.

Schroeder, H. A. and M. Mitchner, 1971, *Toxic Effects of Trace Elements on Reproduction of Mice and Rats*, Arch. Environ. Health, 23:102-106.

Schroeder, H.A., M. Mitchener, J.J. Baalassa, 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.

Schroeder, H.A., J. J. Balassa, and W. H. Vinton, 1964, *Chromium, Lead, Cadmium, Nickel, and Titanium in Mice: Effects on Mortality, Tumors, and Tissue Levels*, Journal of Nutrition, Vol. 83, pp. 239-250.

Schubauer-Berigan, M. K., J. R. Dierkes, P. D. Monson, and G. T. Ankley, 1993, *pH-Dependent Toxicity of Cd, Cu, Ni, Pb, and Zn to Ceriodaphnia dubia, Pimephales pomelas, yallela azteca, and Lumbriculus variegatus*, Environmental Contamination and Toxicology, Vol. 12, pp. 1261-1266.

Shepard, T. H., 1986, *Catalog of Teratogenic Agents*, 5th edition, Baltimore, Maryland, The Johns Hopkins University Press.

Shugart, L. R., 1991, *Dinitrotoluene in Deer Tissue*, Oak Ridge National Laboratory, Final Report, ORNL/M-1765, September.

Sims, R. C. and M. R. Overcash, 1983, *Fate of Polynuclear Aromatic Compounds (PNAs) in Soil-Plant Systems*, Resource Review, Vol. 88, pp. 1-68.

Smith, I. C. and B. L. Carson, 1981, *Trace Metals in the Environment. Volume 6: Cobalt and Appraisal of Environmental Exposure*, Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc.

Sprague, J. B., 1968, *Avoidance Reactions of Rainbow Trout to Zinc Sulfate Solutions*, Wat. Res., 2:367.

Stahl, J.L., J.L. Greger, and M.E. Cook, 1990, *Breeding-Hen and Progeny Performance When Hens are Fed Excessive Dietary Zinc*, Poult. Sci., 69: 259-263.

Suter, G. W. and C. L. Tsao, 1996, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota, 1996 Revision*, Risk Assessment Program, U. S. Department of Energy, Oak Ridge, Tennessee, ES/ER/TM-96/R2.

Talmage, S. S., D. M. Opresko, C. J. Maxwell, C. Welsh, F. Cretella, P. H. Reno, and F. B. Daniel, 1999, ***Nitroaromatic Munition Compounds: Environmental Effects and Screening Values***, Rev., Environ. Contam. Toxicol., 161:1-156.

Talmage, S. S. and B. T. Walton, 1991, ***Small Mammals as Monitors of Environmental Contaminants***, Reviews in Environmental Contamination and Toxicology, Vol. 119, pp. 47-145.

Talmage, S. S. and B. T. Walton, 1990, Comparative Evaluation of Several Small Mammal Species as Monitors of Heavy Metals, Radionuclides, and Selected Organic Compounds in the Environment, ORNL/TM-11605, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Tikhonova, T. S., 1967, ***Toxicity of Thallium and its Compounds in Workers***, Nov., Dannye Toksikol, Redk. Metal, Ikh Soedin, Chem. Abstr., 71: 53248j.

U.S. Army Environmental Hygiene Agency (USAEHA) 1994, ***Health Risk Assessment for Consumption of Deer Muscle and Liver from Joliet Army Ammunition Plant***, Toxicology Division.

U.S. Environmental Protection Agency (EPA), 1999a. ***Screening-Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities***, Office of Solid Waste and Emergency Response, Washington, DC. EPA/530-D-99-001. (SLERA on pages 4-5 and 4-26)

U.S. Environmental Protection Agency (EPA), 1999b, ***National Recommended Water Quality Criteria for Priority Toxic Pollutants***. Office of Water, Washington, DC, EPA/822-Z-99-001.

U.S. Environmental Protection Agency (EPA), 1993, ***Wildlife Exposure Factors Handbook***, Office of Research and Development, Washington, DC., EPA/600-R-93/187.

U.S. Environmental Protection Agency (EPA), 1989, ***Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual***, Office of Emergency and Remedial Response, Washington, DC, EPA/540/1-89/002.

U.S. Environmental Protection Agency (EPA), 1986, ***Quality Criteria for Water, Office of Water***, Washington, DC, EPA/440/5-86-001.

U.S. Environmental Protection Agency (EPA), 1985a, ***Ambient Water Quality Criteria for Arsenic – 1984***, 440/5-84-033, 66 pp.

U.S. Environmental Protection Agency (EPA), 1985b, ***Proposed Water Quality Guidance for the Great Lakes System*** (p. 4-9).

U.S. Environmental Protection Agency (EPA), 1985c, ***Environmental Profiles and Hazard Indices for Constituents of Municipal Sludge: Beryllium***, Office of Water Regulations and Standards, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1985d, ***Drinking Water Criteria Document on Copper***, Office of Drinking Water, Washington, DC.

U. S. Environmental Protection Agency (EPA), 1984, *Health Effects Assessment for Zinc (and Compounds)*, Cincinnati, Ohio.

U.S. Environmental Protection Agency (EPA), 1980a, *Ambient Water Quality Criteria for Arsenic*, 440/5-80-021, 205 pp.

U. S. Environmental Protection Agency (EPA), 1980b, *Ambient Water Quality Criteria for Thallium*, Office of Water Regulations and Standards, Washington, D.C., EPA 440/5-80-074.

U. S. Environmental Protection Agency (EPA), 1980c, *Ambient Water Quality Criteria for Zinc*, Office of Water Regulations and Standards, Washington, D.C., EPA 440/5-80-079.

U.S. Fish and Wildlife Service (USFWS), 1982, *Gray Bat Recovery Plan*, Washington, DC, 26 pp.

Vanderploeg, H. A., D. C. Parzyck, W. H. Wilcox, J. R. Kercher, and S. V. Kaye, 1975, *Bioaccumulation Factors for Radionuclides in Freshwater Biota*, ORNL-5002, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Venugopal, B., and T. D. Luckey, 1978, *Metal Toxicity in Mammals, Volume 2*, New York, New York, Plenum Press.

Voerman, S., and A. F. H. Besemer, 1975, *Persistence of Dieldrin, Lindane, and DDT in a Light Sandy Soil and Their Uptake by Grass*, Bulletin of Environmental Contamination and Toxicology, Vol. 13, pp. 501-505.

Wallace, A., G. V. Alexander, and F. M. Chaudhry, 1977, *Phytotoxicity and Some Interactions of the Essential Trace Metals Iron, Manganese, Molybdenum, Zinc, Copper, and Boron*, Commun. Soil Sci. Plant Anal., 8(9): 741-750.

Wallihan, E. F., 1966, *Iron In Diagnostic Criteria for Plants and Soils*, H. D. Chapman (ed.) University of California, Div. Agric. Sci., Riverside, pp. 203-212.

Waters, M. D., 1977, *Toxicology of Vanadium*, In *Advances in Modern Toxicology, Vol. 2: Toxicology of Trace Elements*, R. A. Goyer and M. A. Mehlman (eds.), John Wiley & Sons, New York, New York, pp. 147-189.

White, D.H. and M.P. Dieter, 1978, *Effects of Dietary Vanadium in Mallard Ducks*, J. Toxicol. Environ. Health, 4: 43-50.

Woolson, E. A., ed., 1975, *Arsenical Pesticides*, American Chemical Society Symposium, Series 7, 176 pp.

Zander, M., 1983, *Physical and Chemical Properties of Polycyclic Aromatic Hydrocarbons*, Handbook of Polycyclic Aromatic Hydrocarbons, A. Bjorseth, ed., Marcel Dekker, Inc., New York, New York, pp. 1-25.