Streamlined Screening Ecological Risk Assessment for Site 6 (Outside the Fenced Area), Naval Support Facility, Indian Head, Indian Head, MD

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Introduction

The purpose of this technical memorandum is to provide the results of a streamlined Screening Ecological Risk Assessment (SERA) for Site 6 (Outside the Fenced Area) at Naval Support Facility, Indian Head (NSF-IH), Indian Head, Maryland. The streamlined SERA used data from the 2004 sampling effort outside the fenced area, and data collected during the 2005 additional investigation (CH2M HILL, 2006). The SERA compares the results from these investigations to ecological benchmarks to develop a screening-level estimate of ecological risk for the area outside the fence line.

As part of the RI conducted in 2001, samples of surface soil, surface soil from intermittently wet areas, subsurface soil, surface water, and groundwater were collected and analyzed for various parameters. All samples were collected from within the fenced area of Site 6 (herein referred to as "site") (Figure 1). Based on the findings and conclusions of the RI report, a Baseline Ecological Risk Assessment (BERA) Tech Memo (CH2M HILL, 2004) was prepared to address data gaps identified in the RI. However, the only portion of the BERA Tech Memo that was executed was the collection in 2004 of three collocated sediment and surface water samples along the drainage ditch outside the fenced area to evaluate potential offsite migration of silver. The sediment samples were analyzed for silver and the surface water samples for total and dissolved silver. A comparison of the silver results to background levels and ecological screening values indicated that silver had potentially migrated offsite. The results were presented to the Indian Head Installation Restoration Team (IHIRT) at the January 2005 partnering meeting.

Based on the outcome of the IHIRT's decision for the path forward for Site 6, an additional investigation was conducted in October 2005 to (1) identify the lateral extent of silver contamination to support either a removal action or a finding of no further action inside the fenced area, and (2) assess the need for a BERA or remediation outside the fenced area. The

results are presented in the technical memorandum entitled "Site 6 Additional Investigation Results, NSF-IH, Indian Head, Maryland" (CH2M HILL, 2006). Figure 1 shows the sample locations and corresponding silver results from the 2001 RI and 2005 additional investigation sampling events. Figure 2 shows the locations and silver results for the 2004 and 2005 additional investigation sampling events. The results of the additional investigation were presented to the IHIRT at the December 2005 partnering meeting. The IHIRT agreed that a BERA should be performed for the area outside the fence line. However, a streamlined SERA was deemed necessary before performing the BERA to identify potential ecological risks from the silver in surface soil, sediment, and surface water outside of the fenced area at Site 6 to focus the BERA investigation. This technical memorandum presents the evaluation and results of the SERA.

Site Characteristics and History

Site 6 consists of the area around Building 1349 (the former control building, currently used for storage), Building 1718 (the current control building), and Building 1140 (the radiographic accelerator building) (Figure 1). Buildings 1349 and 1140 were built in 1965, and Building 1718 was built in 1985. X-ray photographs of explosives are taken in Building 1140. The x-ray photographs are developed in the control building (Building 1349) using silver-containing fixer and developer solutions.

The area surrounding the Site 6 buildings is maintained and mowed grass. A drainage ditch beginning just south of Building 1718 conveys surface runoff south, then east (Figure 1). The ditch has an approximate maximum width of 2 to 3 feet and depth of 3 to 6 inches. The widest section of the drainage ditch is located near Building 1718 in a low-lying area of the site. Even though this area drains relatively poorly and collects storm water run-off, this section of the ditch is almost entirely covered with grass, indicating infrequent water retention. The eastern portion of the ditch is partially lined with concrete, which ends at the fence line. Outside the fence line, the ditch meanders through a wooded area, eventually forming a small intermittent headwater stream before entering a wooded wetland. At this point, standing water is present and the stream discharges to Mattawoman Creek after passing through the wetland area (Figure 2). The historical use of Site 6 has been documented in "Site #6: Radiographic Facility Accelerator Summary of Use Paper" (Dolph, 2001). According to this paper, the first building at the site, a Radiographic Accelerator Facility, was constructed in 1965. During that same year, a Control Building and Equipment Building were constructed at Site 6. Within the Control Building was a darkroom for processing the x-ray photographs taken at the Radiographic Accelerator Facility. In 1969, a trailer, which is no longer present, was moved to the site. The trailer contained a darkroom and a silver recovery unit. In 1985, three additional structures were constructed at Site 6: a Control and Silver Recovery Building, a Transformer Pad, and a Tool Shelter. As documented in Dolph (2001), the only industrial process that has been performed at Site 6 is the development of x-ray photographs.

In the early 1980s, approximately 2,000 x-ray sheets were being developed per month (NEESA, 1983). In this development process, some of the silver from the solution is "fixed" to the x-ray film and the remainder of the silver is washed off. Before 1977, it is possible that some of the photographic process liquid wastes, including spent fixer and developer, were directly discharged into a nearby open ditch. According to one interviewee during the

Initial Assessment Study (NEESA, 1983), before 1977 all photographic process liquid wastes, including spent fixer, were discharged to the open ditch.

Ten gallons of fixer were reportedly spilled onto the ground adjacent to and south of Building 1349 in 1973 when the contents of an old tank were transferred to a new storage facility. Subsequent spills may also have occurred south of Building 1349 (NEESA, 1983). Anecdotal information suggests that liquid wastes have not been discharged to the ditch since 1977.

Ecological Conceptual Site Model

Information on silver sources, potential receptors, and the fate and transport of silver was used to develop an ecological conceptual site model for the area outside the fence line (Figure 3). Releases and/or disposal activities at the site have caused the release of silver into areas around the buildings. Through surface runoff, silver has been transported from the vicinity of Building 1349 into the drainage ditch and ultimately to the wetland system outside the fenced area.

Groundwater is not expected to be a source of water to the ditch because the water table was encountered at depths ranging from approximately 8 feet to 11 feet below ground surface (bgs) (HGL, 2004). Based on water level measurements taken in monitoring wells at the site during the RI, it was determined that the water table slopes gently to the east under the site.

The wetland and stream system outside the fenced area is surrounded by mixed hardwood and pine forest and provides potential habitat for limited aquatic biota, such as small fish, aquatic insects, amphibians, and reptiles. The forested area may provide refuge and foraging habitats for some mammals and avian species using the areas inside and outside the fence line. The drainage ditch between the site and the wetland does not provide viable habitat for aquatic receptors because the water that accumulates in it is shallow and transitory.

Ecological receptors may be exposed to silver through the following routes:

- Direct contact with soil
- Direct contact with sediment
- Direct contact with surface water
- Ingestion of soil
- Ingestion of sediment
- Ingestion of surface water
- Root uptake (plants)
- Ingestion of biota that have accumulated silver from the soil, sediment, or surface water

Potential ecological receptors in the area outside the fence line include plants, invertebrates, amphibians, fish, reptiles, birds, and mammals. Soil invertebrates may be exposed to silver in soil through dermal contact and ingestion. Benthic invertebrates may be exposed to silver in sediment through dermal contact and ingestion. Because these organisms are the prey base for other animals, they also represent an exposure source.

Assessment and Measurement Endpoints

Endpoints in the SERA define ecological attributes that are to be protected (assessment endpoints) and measurable characteristics of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has or could occur. Assessment endpoints most often relate to attributes of biological populations or communities, and are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by exposure to contaminants from the site (EPA, 1997). Assessment endpoints contain an entity (e.g., piscivorous birds) and an attribute of that entity, such as survival rate.

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, receptor species (e.g., green heron) or species groups are often selected as surrogates to evaluate potential risks to larger components of the ecological community (feeding guilds, e.g., piscivorous birds) represented in the assessment endpoints (e.g., survival and reproduction of piscivorous birds). Selection criteria typically include species that:

- Are known to occur, or are likely to occur, at the site
- Have a particular ecological, economic, or aesthetic value
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present at the site for which complete exposure pathways are likely to exist
- Can be expected to represent potentially sensitive populations at the site because of their toxicological sensitivity or potential exposure magnitude
- Can be evaluated because of the availability of sufficient ecotoxicological information

Based on the habitats and types of contaminants present, the assessment endpoints chosen to evaluate the risk to ecological receptor populations from silver outside the fenced area at Site 6 were impacts to growth, survival, and/or reproduction. The assessment endpoints and measurement endpoints for terrestrial habitats, and for wetland and aquatic habitats, are presented in Table 1.

Although potentially complete exposure pathways exist for reptiles and amphibians, they were not specifically selected as receptors because use of ambient water quality criteria is protective of the larval stages of amphibians. Furthermore, information about the toxicological effects of chemicals on adult amphibians and reptiles via ingestion is limited. Finally, reptiles and amphibians are unlikely to be more sensitive to chemical exposures than other receptor groups that are evaluated in a risk assessment (A.T. Kearney, 1997).

TABLE 1
Measurement Endpoints for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Assessment Endpoints		Measurement Endpoints
Terrestrial Habitats		
Impact on growth and survival of the soil invertebrate community.	⇨	Comparison of hazard quotients (HQs) for soil invertebrates to a target HQ of 1. Medium-specific HQs are calculated by dividing the soil concentration by a soil benchmark that is intended to be protective of soil invertebrates.
Impact on growth and survival of the plant community.	⇨	Comparison of HQs for terrestrial plants to a target HQ of 1. Medium-specific HQs are calculated by dividing the soil concentration by a soil benchmark that is intended to be protective of terrestrial plants.
Impact on growth, survival, and reproduction of avian terrestrial insectivores.	⇨	Comparison of HQs for American woodcock to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of avian terrestrial carnivores.	⇨	Comparison of HQs for Eastern screech owl to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of mammalian terrestrial insectivores.	⇨	Comparison of HQs for short-tailed shrew to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of mammalian terrestrial carnivores.	⇨	Comparison of HQs for red fox to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated level of exposure (dose) by a screening toxicity value that is associated with no adverse effects.
Wetland and Aquatic Habitats		
Impact on the growth and survival of the benthic invertebrate community.	⇨	Comparison of HQs for benthic invertebrates to a target HQ of 1. Media-specific HQs are calculated by dividing the sediment concentration by a sediment screening value that is intended to be protective of benthic invertebrates.
Impact on the growth and survival of the aquatic and wetland plant community.	⇨	Comparison of HQs for aquatic plants to a target HQ of 1. Media-specific HQs are calculated by dividing the sediment concentration by a sediment screening value that is intended to be protective of aquatic/wetland plants.
Impact on the growth and survival of water column receptors.	⇨	Comparison of HQs for water column receptors to a target HQ of 1. Media-specific HQs are calculated by dividing the surface water concentration by a surface water screening value that is intended to be protective of water column organisms.
Impact on growth, survival, and reproduction of avian aquatic/wetland omnivores.	⇨	Comparison of HQs for wood duck to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of avian wetland/open water piscivores.	⇨	Comparison of HQs for green heron to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, and reproduction of mammalian omnivores.	⇨	Comparison of HQs for raccoon to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.
Impact on growth, survival, or reproduction of mammalian aquatic/ wetland herbivores.	⇨	Comparison of HQs for muskrat to a target HQ of 1. Receptor-specific HQs are calculated by dividing an estimated maximum level of exposure by a screening toxicity value that is associated with no adverse effects.

Direct Exposure Screening

Direct exposure screening refers to an evaluation of potential risk to ecological receptors that are in constant or prolonged contact with site media (e.g., soil invertebrates). Concentrations of silver in the various media (soil, sediment, and surface water) sampled outside the fenced area during 2004 investigation and the 2005 additional investigation were compared to EPA Region III screening criteria for surface soil (2 mg/kg) and sediment (1 mg/kg), and the National Ambient Water Quality Criteria for silver in surface water (6.46 mg/L). The analytical results for silver for the various media are presented on Figure 2. The screening criteria for silver in surface water is hardness dependent; therefore, the screening criterion of 6.46 µg/L for silver was calculated using the hardness data (150 µg/L) for the one surface water sample analyzed during the 2005 additional investigation. For each medium, hazard quotients (HQs) were calculated by dividing the maximum and mean concentrations of silver by the media-specific screening values to arrive at potential ecological risk. One-half of the detection limits was used as a surrogate value for non-detected samples when calculating mean concentrations. Tables 2, 3, and 4 present the statistics.

For surface soil, the HQs for the maximum and mean concentrations are 228 and 60, respectively. This means that silver is considered a chemical of potential concern (COPC) for soil invertebrates and terrestrial plants. For sediment, the HQs for the maximum and mean concentrations are 234 and 42, respectively. This means that silver is considered a COPC for benthic invertebrates and aquatic plants. For total metals in surface water, the HQs for the maximum and mean concentrations are 9.4 and 2.5, respectively. For dissolved silver in surface water, the HQs for the maximum and mean concentrations are 6.0 and 1.3, respectively. This means that silver is considered a COPC for water column receptors.

As shown on Table 4, silver was detected in three out of the seven surface water samples. These three samples were collected in 2004 from the drainage ditch between the fence line and the wetland. The other four samples were collected in 2005 in the wetland. The ditch only conveys water during runoff events; therefore, these data represent temporary exposure during storm events. Because the samples were collected at different times, there could be a potential effect of storm events on silver concentrations in the surface water of the wetland.

Upper Trophic Level Screening

Potential risk to upper trophic level receptors was estimated by calculating exposures via the food web. Exposure doses were compared to the ingestion-based screening criteria to derive risk estimates using the HQ method. HQs were calculated by dividing the exposure dose by the corresponding chemical- and receptor-specific screening criteria. HQs equaling or exceeding 1 indicate the potential for unacceptable risk because the dose (exposure) equals or exceeds the toxicity reference value (effect level). HQs less than 1 indicate that unacceptable risks are unlikely. The intake equations, exposure assumptions, and toxicity factors used in this screening are provided in Attachment A.

Terrestrial

The short-tailed shrew (*Blarina brevicauda*), red fox (*Vulpes vulpes*), American woodcock (*Scolopax minor*), and Eastern screech owl (*Megascops asio*), were selected as surrogate

receptors to represent the terrestrial upper trophic level receptors in the wooded upland area.

Maximum detected concentrations were used for the exposure dose in the initial screening to conservatively estimate potential exposures (Table 5). Based upon a comparison to No Observed Adverse Effect Levels (NOAELs), or dosage levels that produce no adverse effects in test organisms, silver had an HQ that equaled or exceeded 1 for the short-tailed shrew (90.97), the red fox (1.98), the American woodcock (182), and the Eastern screech-owl (45.54).

Mean exposure doses were used in the refined screen to give a more realistic estimate of potential exposures across the site (Table 6). Based upon a comparison to NOAELs, silver had an HQ that equaled or exceeded 1 for the short-tailed shrew (2.13), the American woodcock (3.88), and the Eastern screech-owl (1.16). Based upon a comparison to Lowest Observed Adverse Effect Levels (LOAELs), or the lowest test dosage that produces an adverse effect in test organism, no receptors had an HQ that equaled or exceeded 1.

Aquatic

The raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), green heron (*Butorides virescens*), and the wood duck (*Aix sponsa*) were selected as surrogate receptors to represent the aquatic upper trophic level receptors in the wetland area.

Maximum detected concentrations were used for the exposure dose in the initial screen to conservatively estimate potential exposures (Table 5). Based on a comparison to NOAELs, only one receptor, green heron, had an HQ (1.45) that equaled or exceeded 1.

Mean exposure doses were used in the refined screen to give a more realistic estimate of potential exposures across the site (Table 6). Based on a comparison to NOAELs and LOAELs, no receptors had an HQ that equaled or exceeded 1.

Results of Risk Evaluation

Silver exceeded the ecological screening values for surface soil, sediment, and surface water indicating that potential risk exists to direct contact receptors (plants and invertebrates) in both the terrestrial and aquatic environments. However, silver was not detected in any of the surface water samples collected in the wetland, indicating that potential risk to water column receptors is likely transitory in nature (related to stormwater runoff) and limited to the drainage ditch and intermittent stream between the site and the wetland.

Based upon the ingestion-based screening for terrestrial upper trophic level receptors, exposure to the maximum concentrations of silver pose potential risk to all the surrogate terrestrial receptors. Although the NOAEL HQs for shrew, woodcock, and owl all exceed 1, the LOAEL HQs for these receptors are below 1, and the Maximum Acceptable Toxicant Concentration (MATC) HQ, which is based on the average of the NOAEL and LOAEL toxicity values, is below 1 for all receptors, except woodcock (1.7). This indicates that while there may be potential risk at certain locations, sitewide risk to terrestrial receptors is unlikely.

Based on the maximum concentration ingestion-based screening for aquatic upper trophic level receptors, only the green heron had an HQ greater than 1 (1.45). However, based on mean concentrations, none of the receptors had an NOAEL-based HQ greater than 1.

Therefore, potential risk to aquatic upper trophic level receptors from silver in the wetland sediments is unlikely.

References

A. T. Kearney. 1997. Risk Assessment for the Waste Technologies Industries (WTI) Hazardous Waste Incinerator Facility (East Liverpool, Ohio). Volume 6. Screening Ecological Risk Assessment. *EPA/905/R-97/002F*.

CH2M HILL. 2004. Final Technical Memorandum: Sampling Design and Rationale for Baseline Ecological Risk Assessment at Site 6, Naval District Washington, Indian Head.

CH2M HILL. 2006. Site 6 Additional Investigation Results, NSF-IH, Indian Head, Maryland.

Dolph, J.E. 2001. Site #6 Radiographic Facility Accelerator Summary of Use Paper, Naval Surface Warfare Center, Indian Head, Maryland.

EPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. *EPA/540/R-97/006*.

HydroGeologic, Inc. (HGL). 2004. Final Remedial Investigation Report for Sites 6, 39, and 45, Naval District Washington, Indian Head, Indian Head, Maryland.

Naval Energy and Environmental Support Activity (NEESA). 1983. Initial Assessment Study of Naval Ordnance Station, Indian Head, Maryland.

TABLE 2
Screening Statistics for Surface Soil
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Analyte Name	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	Screening Value	Frequency of Exceedance	Maximum Hazard Quotient	COPC?	Mean Hazard Quotient	COPC?
Silver (mg/kg)	19 / 19	456	IS06SS68-1005	120	124	2.00	19 / 19	228	YES	60.0	YES

TABLE 3
Screening Statistics for Sediment
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Analyte Name	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	Screening Value	Frequency of Exceedance	Maximum Hazard Quotient	COPC?	Mean Hazard Quotient	COPC?
Silver (mg/kg)	18 / 18	234	IS06SD77-1005	42.2	55.5	1.00	18 / 18	234	YES	42.2	YES

TABLE 4
Screening Statistics for Surface Water
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Analyte Name	Frequency of Detection	Maximum Concentration Detected	Sample ID of Maximum Detected Concentration	Arithmetic Mean	Standard Deviation of Mean	Screening Value	Frequency of Exceedance	Maximum Hazard Quotient	COPC?	Mean Hazard Quotient	COPC?
Total Silver (µg/L)	3 / 7	60.6	IS06SW13P	15.8	21.8	6.46	2 / 7	9.4	YES	2.4	YES
Dissolved Silver (µg/L)	3 / 7	38.9	IS06SW13P	8.43	13.5	6.46	1 / 7	6.0	YES	1.3	YES

TABLE 5
Summary of Maximum Hazard Quotients for Food Web Exposures
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Chemical	Short-tailed shrew			Red fox			American woodcock			Eastern screech-owl		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Silver	91.0	18.2	40.7	2.0	0.4	0.9	181.7	36.3	81.2	45.5	9.1	20.4

Chemical	Raccoon			Muskrat			Green heron			Wood duck		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Silver	0.2	<0.1	0.1	0.3	0.1	0.2	1.5	0.3	0.6	0.4	0.1	0.2

TABLE 6
Summary of Average Hazard Quotients for Food Web Exposures
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Chemical	Short-tailed shrew			Red fox			American woodcock			Eastern screech-owl		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Silver	2.1	0.4	1.0	0.1	<0.1	<0.1	3.9	0.8	1.7	1.2	0.2	0.5

Chemical	Raccoon			Muskrat			Green heron			Wood duck		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Silver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	0.1	<0.1	<0.1	<0.1

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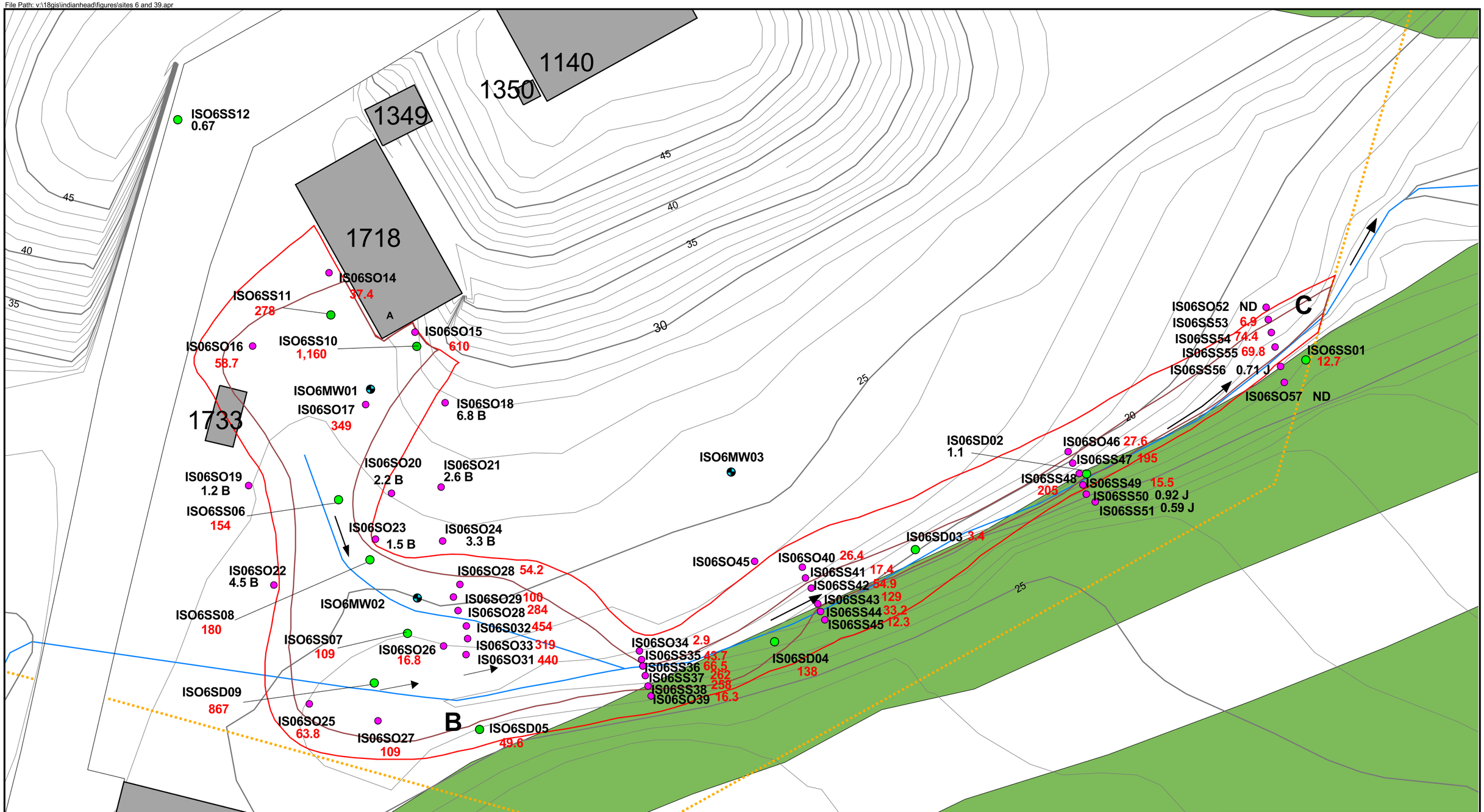

LEGEND

- Sample Location
- 2.2 Silver Concentration in mg/kg
- Previously Sampled Location (HGL, 2004)
- Monitoring Well Location
- Surface Water Drainage
- Fence
- Flow of Water in Ditch
- Isoconcentration Line - 2 mg/kg
- Isoconcentration Line - 50 mg/kg
- ND - Not Detected
- J - Estimated
- B - Possible Blank Contamination

Notes:
1. Concentrations in red indicate detection above the minimum ecologically based screening criteria of 2 mg/kg.
2. Isoconcentration lines are drawn using the October 2005 analytical data.
3. HGL, 2004 - Final Remedial Investigation for Sites 6,39, and 45.

N

0 20 40 Feet

1 inch = 20 feet

Figure 1
Silver Detection Within the Fenced Area
Site 6 Additional Investigation
NSF-IH, Indian Head, Maryland

CH2MHILL

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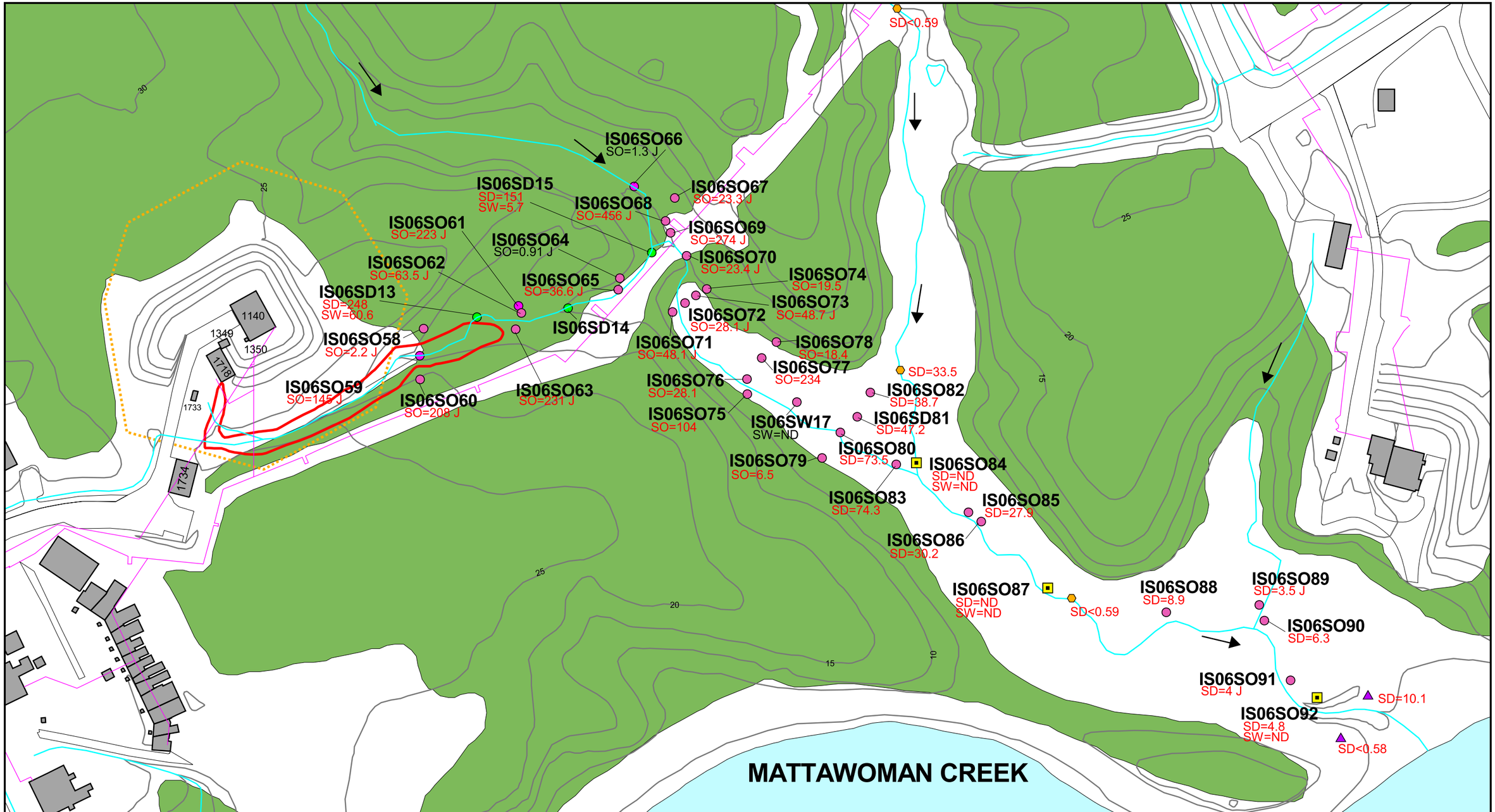

LEGEND

- Sample Location
- 2.2 Silver Concentration (unit for soil and sediment is mg/kg; unit for surface water is µg/L)
- Surface Water and Sediment Sample Location
- Previously Sampled Location (by SAIC in 2001)
- Previously Sampled Location (by TTNUS in 2003)
- Previously Sampled Location (by CH2M HILL in 2004)
- Surface Water Drainage
- Fence

SD - Sediment Analytical Result
SO - Surface Soil Analytical Result
SW - Surface Water Analytical Result
J - Estimated

N

0 60 120 180 Feet

1 inch = 120 feet

Note:
1. Concentrations in red indicate detection above the minimum ecologically based screening criteria of 2 mg/kg.
2. SAIC, 2001, Site Report for Sediment Toxicity Identification Evaluation Demonstration.

Figure 2
Silver Detection Outside the Fenced Area
Site 6 Additional Investigation
NSF-IH, Indian Head, Maryland

CH2MHILL

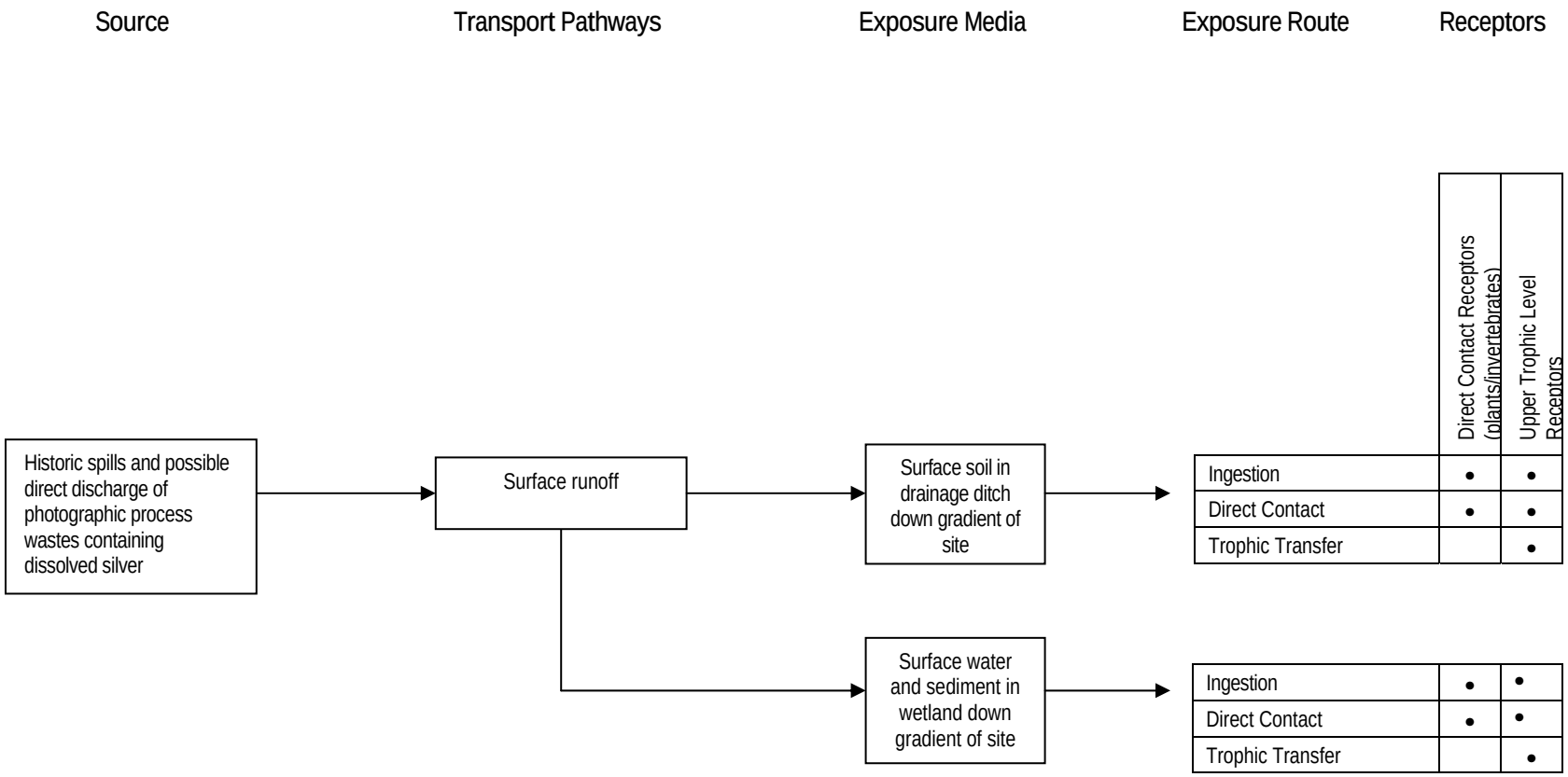

Figure 3
Conceptual Site Model
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Attachment A

Food Web Exposure Model and Ingestion Screening Values

Food Web Exposure Model for Wildlife

Short-tailed shrew, red fox, American woodcock, Eastern screech owl, raccoon, muskrat, green heron, and wood duck exposures (via the food web) to silver were estimated using measured silver concentrations in site media and food web models. Incidental ingestion of soil and sediment was not included when calculating the total level of exposure for heron because these receptors feed directly on prey and are unlikely to have a significant exposure to soil or sediment via incidental ingestion. Incidental ingestion of soil or sediment was included for exposure calculations for the other surrogate receptors.

Dietary intakes for each receptor species were calculated using the following formula (modified from EPA [1993]):

$$DI_x = \frac{[\sum_i (FIR)(FC_{xi})(PDF_i)]}{BW}$$

where:	DI_x	=	Dietary intake for chemical x (mg chemical/kg body weight/day)
	FIR	=	Food ingestion rate (kg/day, dry weight)
	FC_{xi}	=	Concentration of chemical x in food item i (mg/kg, dry weight)
	PDF_i	=	Proportion of diet composed of food item i (dry weight basis)
	BW	=	Body weight (kg, wet weight)

The exposure assumptions used in the food web model were:

- All of the dietary items consumed by the receptor were assumed to be obtained from the site (i.e., an Area Use Factor of 1 was assumed).
- Silver in site media was assumed to be 100 percent bioavailable.
- Maximum ingestion rates were used for Step 2 calculations and average ingestion rates were used for Step 3 calculations.
- Maximum body weights were used for Step 2 calculations and average body weights were used for Step 3 calculations.

The exposure parameters used in the food web model are shown in Tables A-1 and A-2 for maximum exposure scenario (Step 2), and Tables A-3 and A-4 for mean exposure scenario (Step 3).

Tissue concentrations in plants were estimated by multiplying the measured surface soil and sediment concentrations by soil-to-plant bioconcentration factors (BCFs), and tissue concentrations in small mammals were estimated using soil-to-mammal bioaccumulation factors (BAFs). The BCFs and BAFs used for Step 2 and Step 3 are presented in Tables A-5 and A-6, respectively. The BCF and BAF values used were based on the ratio between dry-weight soil or sediment and dry-weight tissue.

Ingestion Screening Values

Ingestion screening values for dietary exposures of silver were obtained for each receptor. Toxicological information from the literature for wildlife species most closely related to the receptor species was used, where available, but was also supplemented by laboratory studies of non-wildlife species (e.g., rats) where necessary. The ingestion screening values are expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day).

Sublethal endpoints were emphasized as assessment endpoints where available because they are the most relevant, ecologically, to maintaining viable populations and because they are generally the most studied chronic toxicological endpoints for ecological receptors. Sublethal endpoints are assumed to influence the probability of survival and/or the success of reproduction. If several chronic toxicity studies were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint, and test species. No Observed Adverse Effect Levels (NOAELs) and Lowest Observed Adverse Effect Levels (LOAELs) based on survival, growth, or reproduction were used, where available, as the screening values. Ingestion screening values for birds and mammals are shown in Table A-7.

Risk Calculation

Chemicals of potential concern were selected using the hazard quotient method. Hazard quotients were calculated by dividing the exposure dose by the corresponding reference toxicity value.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. *Toxicological Profile for Silver*. December.

Bechtel Jacobs. 1998. *Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants.* Prepared for U.S. Department of Energy. BJC/OR-133. September 1998.

Bellrose, F.C. 1980. *Ducks, Geese, and Swans of North America.* Third edition. Stackpole Books, Harrisburg, PA. 540 pp.

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *Journal of Wildlife Management*. 58:375-382.

Conover, M. R. 1989. Potential compounds for establishing conditioned food aversions in raccoons. Wildlife Society Bulletin. 17:430-435.

Demarest, D.W., R.M. Kaminski, L.A. Brennan, and C.R. Boyle. 1997. Body-mass, survival, and pairing consequences of winter-diet restriction in wood ducks. Journal of Wildlife Management 61:822-832.

Dunning, J.B., Jr. (editor). 1993. *CRC Handbook of Avian Body Masses.* CRC Press. Boca Raton, FL. 371 pp.

Eisler, R. 1996. *Silver Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review.* National Biological Service, Biological Report 32, Contaminant Hazard Reviews Report 32. 44 pp.

U.S. Environmental Protection Agency (EPA). 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.* EPA/530/D-99/001A. Peer Review Draft. August.

EPA. 1993. *Wildlife Exposure Factors Handbook*. Volume I of II. EPA/600/R-93/187a.

Hirsch, M.P. 1998. Bioaccumulation of silver from laboratory-spiked sediments in the oligochaete (*Lumbriculus variegatus*). *Environmental Toxicology and Chemistry.* 17:605-609.

Johnsgard, P.A. 1988. *North American Owls: Biology and Natural History*. Smithsonian Institution Press, Washington DC.

Martin, Alexander C, H.S. Zim, and A.L. Nelson. 1951. *American Wildlife and Plants, a Guide to Wildlife Food Habits*. Dover Publications, New York, New York.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter II, and T.L. Ashwood. 1998a. *Development and Validation of Bioaccumulation Models for Earthworms.* Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-220.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter II. 1998b. *Development and Validation of Bioaccumulation Models for Small Mammals.* Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-219.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter II, and C.J.E. Welsh. 1997. *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants.* Environmental Sciences Division, Oak Ridge National Laboratory. ORNL/TM-13391.

Sample, B.E. and G.W. Suter II. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants.* Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-125.

Silva, M. and J.A. Downing. 1995. *CRC Handbook of Mammalian Body Masses*. CRC Press, Boca Raton, FL. 359 pp.

TABLE A-1
Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 2
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Receptor	Body Weight (kg)		Water Ingestion Rate (L/day)		Food Ingestion Rate (kg/day - dry)	
	Value	Reference	Value	Reference	Value	Reference
Birds						
American woodcock	0.145	Dunning 1993	0.0233	allometric equation	0.0292	USEPA 1993
Green heron	0.158	Sample et al. 1997	0.0227	allometric equation	0.0458	allometric equation
Eastern screech-owl	0.145	Dunning 1993	0.0216	allometric equation	0.0219	allometric equation
Wood duck	0.522	Bellrose 1980	0.0534	allometric equation	0.2055	Demarest et al. 1997
Mammals						
Muskrat	0.750	USEPA 1993	0.1426	allometric equation	0.0765	USEPA 1993
Raccoon	4.23	Silva and Downing 1995	0.6092	allometric equation	0.1307	Conover 1989
Red fox	3.17	Silva and Downing 1995	0.4115	allometric equation	0.1476	Sample and Suter 1994
Short-tailed shrew	0.013	USEPA 1993	0.0048	USEPA 1993a	0.0019	USEPA 1993

TABLE A-2
Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 2
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Receptor	Dietary Composition (percent)							Soil/ Sediment Ingestion (percent)	
	Terr. Plants	Soil Invert.	Small Mammals	Fish/ Frogs	Aquatic Plants	Benthic Invert.	Reference	Value	Reference
Birds									
American woodcock	0	89.6	0	0	0	0	USEPA 1993	10.4	Beyer et al. 1994
Green heron	0	0	0	71.0	0	29.0	Sample et al. 1997	0	Sample et al. 1997
Eastern screech-owl	0	28.0	70.0	0	0	0	Johnsgard 1988	2.0	Assumed based on diet
Wood duck	0	0	0	0	77.0	12.0	Martin et al. 1951	11.0	Beyer et al. 1994
Mammals									
Muskrat	0	0	0	0	90.6	0	USEPA 1993	9.4	Beyer et al. 1994 (raccoon)
Raccoon	0	0	0	7.0	40.0	43.6	USEPA 1993	9.4	Beyer et al. 1994
Red fox	7.0	2.8	87.4	0	0	0	USEPA 1993	2.8	Beyer et al. 1994
Short-tailed shrew	4.7	82.3	0	0	0	0	USEPA 1993; Sample and Suter 1994	13.0	Sample and Suter 1994

TABLE A-3
Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 3
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Receptor	Body Weight (kg)		Water Ingestion Rate (L/day)		Food Ingestion Rate (kg/day - dry)	
	Value	Reference	Value	Reference	Value	Reference
Birds						
American woodcock	0.198	Dunning 1993	0.0199	allometric equation	0.0231	USEPA 1993
Green heron	0.212	Dunning 1993	0.0209	allometric equation	0.0405	allometric equation
Eastern screech-owl	0.181	Dunning 1993	0.0188	allometric equation	0.0191	allometric equation
Wood duck	0.676	Bellrose 1980	0.0454	allometric equation	0.1660	Demarest et al. 1997
Mammals						
Muskrat	1.17	Silva and Downing 1995	0.1139	allometric equation	0.0596	USEPA 1993
Raccoon	5.94	Silva and Downing 1995	0.4921	allometric equation	0.1031	Conover 1989
Red fox	4.06	Silva and Downing 1995	0.3494	allometric equation	0.1231	Sample and Suter 1994
Short-tailed shrew	0.017	USEPA 1993	0.0038	USEPA 1993	0.0015	USEPA 1993

TABLE A-4
Exposure Parameters for Upper Trophic Level Ecological Receptors - Step 3
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Receptor	Dietary Composition (percent)							Soil/ Sediment Ingestion (percent)	
	Terr. Plants	Soil Invert.	Small Mammals	Fish/ Frogs	Aquatic Plants	Benthic Invert.	Reference	Value	Reference
Birds									
American woodcock	0	89.6	0	0	0	0	USEPA 1993	10.4	Beyer et al. 1994
Green heron	0	0	0	71.0	0	29.0	Sample et al. 1997	0	Sample et al. 1997
Eastern screech-owl	0	28.0	70.0	0	0	0	Johnsgard 1988	2.0	Assumed based on diet
Wood duck	0	0	0	0	77.0	12.0	Martin et al. 1951	11.0	Beyer et al. 1994
Mammals									
Muskrat	0	0	0	0	90.6	0	USEPA 1993	9.4	Beyer et al. 1994 (raccoon)
Raccoon	0	0	0	7.0	40.0	43.6	USEPA 1993	9.4	Beyer et al. 1994
Red fox	7.0	2.8	87.4	0	0	0	USEPA 1993	2.8	Beyer et al. 1994
Short-tailed shrew	4.7	82.3	0	0	0	0	USEPA 1993; Sample and Suter 1994	13.0	Sample and Suter 1994

TABLE A-5

Silver Bioconcentration and Bioaccumulation Factors - Step 2

Streamlined SERA for Site 6 (Outside the Fenced Area)

NSF-IH, Indian Head, Maryland

Soil-Plant BCF		Soil-Invertebrate BAF		Soil-Mouse BAF		Soil-Vole BAF		Soil-Shrew BAF	
Value	Reference	Value	Reference	Value	Reference	Value	Reference	Value	Reference
0.037	Bechtel Jacobs 1998	15.34	Sample et al. 1998a	0.810	Sample et al. 1998b	0.007	Sample et al. 1998b	0.501	Sample et al. 1998b

Sediment-Invertebrate BAF		Sediment-Fish BAF		Sediment-Plant BCF		Sediment-Frog BAF		
Value	Reference	Value	Reference	Value	Reference	Value	Reference	
0.180	Hirsch 1998	1.000	--	0.037	Bechtel Jacobs 1998	1.000	--	Factors are based on dry weight

Notes

BCF - Bioconcentration Factor

BAF - Bioaccumulation Factor

TABLE A-6

Silver Bioconcentration and Bioaccumulation Factors - Step 3

Streamlined SERA for Site 6 (Outside the Fenced Area)

NSF-IH, Indian Head, Maryland

Soil-Plant BCF		Soil-Invertebrate BAF		Soil-Mouse BAF		Soil-Vole BAF		Soil-Shrew BAF	
Value	Reference	Value	Reference	Value	Reference	Value	Reference	Value	Reference
0.013	Bechtel Jacobs 1998	2.05	Sample et al. 1998a	0.151	Sample et al. 1998b	0.006	Sample et al. 1998b	0.036	Sample et al. 1998b

Sediment-Invertebrate BAF		Sediment-Fish BAF		Sediment-Plant BCF		Sediment-Frog BAF		
Value	Reference	Value	Reference	Value	Reference	Value	Reference	
0.180	Hirsch 1998	1.000	--	0.013	Bechtel Jacobs 1998	1.000	--	Factors are based on dry weight

Notes

BCF - Bioconcentration Factor

BAF - Bioaccumulation Factor

TABLE A-7
Ingestion Screening Values for Birds and Mammals
Streamlined SERA for Site 6 (Outside the Fenced Area)
NSF-IH, Indian Head, Maryland

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	LOAEL (mg/kg/d)	NOAEL (mg/kg/d)	Reference
Birds								
Silver (aquatic birds)	mallard	1.10	14 days	oral in diet	survival	178	35.6	USEPA 1999
Silver (terrestrial birds)	chicken	0.80	not specified	oral in diet	growth	35.0	7.00	Eisler 1996
Mammals								
Silver	rat	0.35	2 weeks	oral in water	survival	45.3	9.06	ATSDR 1990