BASELINE ECOLOGICAL RISK ASSESSMENT

IOWA ARMY AMMUNITION PLANT (IAAAP)
Iowa

Volume I
MAIN REPORT
APPENDICES A-B

DRAFT FINAL

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October 2004

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AO	American Ordnance
AOC	Area of Concern
BCS	Biological Condition Score
BEHP	bis(2-ethylhexyl)phthalate
BERA	Baseline Ecological Risk Assessment
CAMU	Corrective Action Management Unit
CC	Critical Concentration
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHPPM	Center for Health Promotion and Preventative Medicine
COPEC	Chemicals of Potential Ecological Concern
CPOM	Coarse Particulate Organic Matter
CSM	Conceptual Site Model
CV	Chronic Value
DELT	Deformities, Eroded Fins, Lesions, or Tumors
EPC	Exposure Point Concentration
EPT	Ephemeroptera, Plecoptera and Trichoptera taxa
ERA	Ecological Risk Assessment
ERAA	Ecological Risk Assessment Addendum
ERAGS	Ecological Risk Assessment Guidance for Superfund
FFA	Federal Facility Agreement
FSP	Field Sampling Plan
HQ	Hazard Quotient
HRS	Hazard Ranking Score
HSWA	Hazardous and Solid Waste Amendments
IAAAP	Iowa Army Ammunition Plant
IAG	Inter Agency Agreement
IDA	The Inert Disposal Area
IRIS	Integrated Risk Information System
LOAEL	Lowest Observed Adverse Effects Level
MWH	MWH Americas, Inc.
NAWQC	National Ambient Water Quality Criteria
NOAEL	No Observed Adverse Effects Level
NOEC	No Observed Effects Concentration
NPDES	National Pollutant Discharge Elimination System

NPL	National Priorities List
OU	Operable Units
PAH	Polyaromatic Hydrocarbons
PRG	Preliminary Remedial Goals
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RAIS	Risk Assessment Information System
RBP	Rapid Bioassessment Protocols
RCRA	Resource Conservation and Recovery Act
RG	Remediation Goals
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RTC	Response to Comments
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SHSP	Site Health and Safety Plan
SI	Site Investigation
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific/Management Decision Points
SUF	Site Utilization Factors
SV	Screening Values
SVOC	Semi-Volatile Organic Compound
TM	Technical Memorandum
TRV	Toxicity Reference Values
TRV MEMO	TRV Memorandum
TSC	Tissue Screening Concentration
UCL	Upper Bound Confidence Limit
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Services
VOC	Volatile Organic Compound
WP	Work Plan

IAAAP SITE DESIGNATION

AREA OF CONCERN	SITE DESIGNATION (OLD)	SITE DESIGNATION (CURRENT)
Line 1 Ammo LAP (Missile/Former AEC)	R01	IAAP-001
Line 2 Ammo LAP (Artillery/Shaped)	R02	IAAP-002
Line 2 Ammo LAP (Artillery/Shaped)-GW	NA	IAAP-002G
Line 3 Ammo LAP (Artillery)	R03	IAAP-003
Line 3 Ammo LAP (Artillery)-GW	NA	IAAP-003G
Line 3A Ammo LAP (Artillery)	R04	IAAP-004
Line 3A Ammo LAP (Artillery)-GW	NA	IAAP-004G
Line 4A & 4B Ammo Assembly	R05	IAAP-005
Line 5A & 5B Ammo Assembly	R06	IAAP-006
Line 6 Ammo Production (Detonator)	R07	IAAP-007
Line 7 Ammo LAP (Fuze/Blank)	R08	IAAP-008
Line 8 Ammo LAP (Fuze/Rocket)	R09	IAAP-009
Line 9 Ammo LAP (Mine)	R10	IAAP-010
Line 9 Ammo LAP (Mine)-GW	NA	IAAP-010G
Line 800 Ammo Renov	R11	IAAP-011
Explosive Disposal Area (East Burn Pads)	R12	IAAP-012
Explosive Disposal Area (East Burn Pads)-GW	NA	IAAP-012G
Incendiary Disposal Area (East Yard D)	NA	IAAP-013
Boxcar Unloading Area	NA	IAAP-014
Old Fly Ash Waste Pile	NA	IAAP-015
Line 1 Former Wastewater Impoundment	NA	IAAP-016
Pesticide Pit	R13	IAAP-017
Possible Demolition Site (South Yard G)	NA	IAAP-018
Contaminated Clothing Laundry	NA	IAAP-019
Inert Disposal Area	R14	IAAP-020
Inert Disposal Area-GW	NA	IAAP-020G
Demolition Area/Deactivation Furnace	R15	IAAP-021
Unidentified Substance (Oil) Waste Site	NA	IAAP-022
Contaminated Waste Processor	R16	IAAP-024
Explosive Waste Incinerator	R17	IAAP-025
Sewage Treatment Plant/Drying Beds	R18	IAAP-026
Fly Ash Landfill (new Bldg 400-139)	R19	IAAP-027
Construction Debris Landfill (NW Yard O)	R20	IAAP-028
Line 3A Sewage Treatment Plant/Drying Beds	R21	IAAP-029
Firing Site Area	R22	IAAP-030
Yard B Ammo Box Chipper Disposal Pit	R23	IAAP-031

AREA OF CONCERN	SITE DESIGNATION (OLD)	SITE DESIGNATION (CURRENT)
Burn Cages, BCLF, West Burn Pads, WBPLF	R24	IAAP-032
Burn Cages, BCLF, West Burn Pads, WBPLF-GW	NA	IAAP-032G
North Burn Pads(2) (Near IAAP-024)	R25	IAAP-036
North Burn Pads Landfill	NA	IAAP-037
Building 600-86 Septic System	R26	IAAP-038
Fire Training Pit	R27	IAAP-039
Fire Training Pit-GW	NA	IAAP-039G
Roundhouse Transformer Storage Area	R28	IAAP-040
Line 3A Pond	R29	IAAP-041
Abandoned Coal Storage Yard	NA	IAAP-042
Fly Ash Disposal Area	R30	IAAP-043
Line 800 Pinkwater Lagoon	NA	IAAP-044
Line 800 Pinkwater Lagoon-GW	NA	IAAP-044G
Former Fuel Station USTs	NA	IAAP-045
Off-Post Contamination Areas of Potential Concern	NA	IAAP-046
Central Test Area	NA	IAAP-047

Note: NA = Not Applicable

EXECUTIVE SUMMARY

The objective of this Baseline Ecological Risk Assessment (BERA) is to evaluate potential risks to ecological receptors due to operations at the Iowa Army Ammunition Plant (IAAAP). The BERA was developed following the United States Environmental Protection Agency's (USEPA) eight-step approach for conducting ecological risk assessments (ERA) (USEPA 1997). This BERA builds on several tasks that were conducted at different times, including the Screening Level Ecological Risk Assessment (SLERA), and therefore, could not follow a linear eight-step process. However, USEPA (1997) recognizes that such non-linear approaches are logical and appropriate at some sites. In addition, this Draft Final BERA incorporates USEPA and U.S. Fish and Wildlife Services (USFWS) service comments on the Draft BERA.

In response to a Federal Facility Agreement (FFA) between the U.S. Department of Defense and USEPA Region 7, IAAAP completed a facility-wide Preliminary Assessment/Site Inspection (PA/SI) of 44 Areas of Concern (AOCs), and subsequently, a facility-wide Remedial Investigation (RI) for 35 AOCs. Previous ecological evaluations have been performed as part of the RI/FS process and other ancillary assessments that evaluated the unique ecological habitat at IAAAP.

Several AOCs have already been slated for remediation. For these AOCs, remediation is driven by human health, rather than by ecological health concerns. AOCs for which remedial decisions have not yet been made are evaluated in greater depth in this BERA.

SLERA

The Draft Final SLERA includes screening level problem formulation and identification of chemicals of potential ecological concern (COPECs). The Draft Final SLERA for IAAAP confirmed that complete exposure pathways exist for some media and consequently, COPECs were identified for several media to be evaluated further in the BERA. The selected COPECs represent the constituents most likely to be of concern to the environment. COPECs were selected for soils at each AOC by comparing the maximum concentration of each constituent against soil screening values (SV) for that constituent. Similarly, surface water and sediment COPECs were identified for each stream by comparing the maximum concentration in each stream to the corresponding surface water or sediment SVs. The SVs are constituent concentrations above which exposure by a receptor could lead to adverse effects. Media-specific SVs were selected by reviewing available literature.

Problem Formulation

Problem formulation for the BERA includes description of the ecological and physical characteristics of the IAAAP and results in a Conceptual Site Model (CSM) identifying exposure pathways and receptors. IAAAP is drained by four principal watersheds, Long Creek, the Skunk River, Brush Creek, and Spring Creek. Soil AOCs, which are the potential source areas for contamination, are located within these watersheds, with some draining into more than one. Principal constituents were explosives and metals, prevalent at multiple AOCs, with Aroclor1260, polyaromatic hydrocarbons (PAHs), and pesticides detected locally. Soil contaminants are localized within the physical boundary of most AOCs. Others, particularly some where high concentrations of explosives were found, have acted as source areas for surface water and sediment contamination in the streams. Based on these data, the CSM for the BERA at IAAAP identified the following complete and significant exposure pathways:

- Exposure of aquatic plants, aquatic insects, fish, birds, bats, terrestrial mammals to surface water COPECs via ingestion or direct contact
- Exposure of bats to COPECs via ingestion of terrestrial insects, aquatic insects, and water
- Exposure of benthic invertebrates, aquatic plants, fish, and aquatic mammals via ingestion of sediment
- Exposure of birds to COPECs via ingestion of fish, water, and sediment
- Exposure of soil macroinvertebrate, insectivores, herbivorous mammals and carnivorous mammals to COPECs via ingestion of soil and water

The assessment endpoints, or specific ecological values to be protected, were established as follows:

- Survival, growth and reproduction of orangethroat darters.
- Maintenance of the benthic community structure.
- Survival, growth and reproduction of aquatic algae.
- Survival, growth and reproduction of aquatic piscivores, using the belted kingfisher as the representative of this feeding guild.
- Survival, growth and reproduction of sensitive species using the Indiana bat as the representative of this feeding guild.
- Survival, growth and reproduction of terrestrial herbivores using the white-footed mouse as the representative of this guild.
- Survival, growth and reproduction of terrestrial vermivores/carnivores using the shorted-tailed shrew as the representative of this guild.
- Survival, growth and reproduction of terrestrial insectivores using the Indiana bat as the representative of this guild.

Measurement endpoints, selected as measures of effects, were water quality standards, Rapid Bioassessment Protocols (RBP) results, fish DELTs (deformities, eroded fins, lesions, or tumors) observations, vegetation surveys, and laboratory-derived chronic effect levels.

Exposure Analysis

Soil, sediment, and surface water data were collected to characterize the concentrations of constituents to which receptors may be exposed. Fish tissues were collected to evaluate the potential exposure to contaminants by fish, and piscivorous receptors. Exposure dose models for estimating doses to all the receptors were developed. Exposure parameter values were selected for each of the receptors. All data collected, including soil, sediment, and surface water data, and tissue data were used to evaluate exposures to each of the selected receptors, including the magnitude of exposure to COPECs in soil, surface water, and sediment.

Effects Analysis

A vegetation survey, benthic macroinvertebrate studies using RBP, and a fish survey in conjunction with fish collection for tissue analysis were conducted to provide direct lines of evidence regarding any apparent effects of contamination on communities of organisms (e.g., plants, invertebrates, and fish). Water quality parameters were monitored during fish and benthic sampling. Benthic macroinvertebrate samples were collected utilizing RBP II methods in which community indices obtained for the sample sites are compared to the indices found at reference (or control) stations. Samples were evaluated using eight common community metrics. Results of the benthic survey showed that benthic community structure is not exhibiting ecological stress in Long Creek and Brush Creek. One of the two tributaries to the Skunk River was rated as unimpaired and the other was rated as slightly impaired. The slight impairment at the Skunk River tributary is likely due to poor habitat quality and intermittent flow, as opposed to chemical contamination. The slight impairment exhibited at stations on Spring Creek is considered to be more the result of agricultural practices at the site than IAAAP industrial operations. Individual fish species examined did not show signs of stress, as indicated by DELTs. An earlier inventory and assessment of habitats and biota at IAAAP, conducted by Horton and others (1996), indicate that IAAAP facility development, through restriction of forest lot size, may be limiting forest quality to the same or a greater degree than contamination.

The direct lines of evidence, such as the RBP II methods or DELT, have inherent limitations associated with them. The information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but unlikely would detect effects on individual benthic species. Similarly, DELT evaluations are visual observations used to qualitatively assess the apparent health of an individual fish. Such evaluations can not account for health effects, such as reduced reproductive success or adverse effects during more sensitive life stages. Numerous uncertainties and limitations are associated with the hazard quotient (HQ) lines of evidence. Therefore, the effects-based lines of evidence are used in combination with the HQ lines of evidence that are performed on a species specific basis using toxicity reference values (TRV) to assess toxicity and potential risk. These two lines of evidence (effects-based evaluations and HQs) together provide a weight of evidence as to whether the aquatic or terrestrial environment is at risk.

Toxicity Assessment

The toxicity assessment summarizes methods applied for developing TRVs, in contrast to the direct observations of effects described above. The TRVs are used to quantitatively estimate the magnitude of toxicity of each analyte selected for risk characterization.

TRVs for wildlife receptors represent doses that are protective based on specific toxicity endpoints (e.g., survival, growth, reproduction, etc.). Toxicity reference values for each COPEC and the four wildlife species (the white-footed mouse, short-tailed shrew, belted kingfisher, and Indiana bat) were derived from literature. Literature that provided information on study design, such as duration, handling of test species, physical information on test species, and dose route, was selected over literature with more limited information. Chronic toxicity studies were considered preferentially because, at most sites, receptors were exposed over a long period. Toxicity endpoints that correlated with significant ecological impacts, such as reproduction, development, and survival, were preferred over systemic and acute effects. Doses administered through an oral route (diet, water, gavage) were preferred over other routes (e.g. direct injection). The literature search focused on laboratory studies to obtain information on the Lowest Observed Adverse Effects Level (LOAEL) and No Observed Adverse Effects Level (NOAEL). The exception to this was for TNT for the Indiana bat, where a LED10 value was used to represent the NOAEL-based TRV. Toxicity reference values for water exposure to fish used the lowest chronic value (CV) for fish. TRVs for fish tissue residues were developed based on Tissue screening concentrations (TSCs) for fish tissue residues. Screening level ecological benchmarks that are concentration-based were used as TRVs for aquatic plants.

Risk Characterization

Risks to receptors were evaluated for exposure to soil contaminants at the AOCs and surface water and sediment contaminants in the three streams, Long Creek, Brush Creek, and Spring Creek and in tributaries to these three streams and the Skunk River. The AOCs are located within the four watersheds associated with the streams and their tributaries.

The AOCs where human health-based remediation is slated to occur are:

Line 1 (IAAP-001/R01)	Line 6 (IAAP-007/R07)
Line 2 (IAAP-002/R02)	Line 8 (IAAP-009/R09)
Line 3 (IAAP-003/R03)	Line 9 (IAAP-010/R10)
Line 3A (IAAP-004/R04)	Line 800 (IAAP-011/R11)
Lines 4A/4B (IAAP-005/R05)	Firing Site (IAAP-030/R22)
Roundhouse Transformer Storage Area (IAAP-040/R28)	

The ecological risks associated with these AOCs have not been described in detail within this BERA or summarized in this section, because the remediation slated for protection of human health risks at these AOCs should mitigate potential ecological risks. Whether the remedial actions to protect human health will mitigate ecological risks can not be confirmed until after the remedial actions occur, and thus there will need to be a check of this logic after remediation is complete. However, during the remediation process, soils will likely be excavated to over 2 ft in depth, similar to previous remedial actions already completed at IAAAP, and will thus eliminate contamination and, for a time, any ecological habitat that currently exist at these AOCs for wildlife. During past remedial actions at IAAAP, the depth of excavation of material have been much greater than two feet, and then fill material has been placed to bring the excavation to grade, thus eliminating exposure of ecological receptors to the residual level of COPECs remaining. Post-remediation TNT data from IAAP-006/R06 was compared to the NOAEL-based critical concentrations (CCs) as an example to validate that this is a reasonable assumption. Although the ecological risks associated with those AOCs that are slated for human health remediation are not discussed in detail, ecological risks for each of these AOCs were provided in summary form within Section 6, and detailed risk calculations are provided in Appendix J.

The AOCs for which human health based remediation are not slated to occur, and which are evaluated in greater depth in this BERA include:

- Line 7 (IAAP-008/R08)
- Contaminated Waste Processor (IAAP-024/R16)
- Sewage Treatment Plant (IAAP-026/R18)
- Fly Ash Landfill (IAAP-027/R19)
- Construction Debris Landfill (IAAP-028/R20)
- Line 3A Sewage Treatment Plant (IAAP-029/R21)
- Building 600-86 Septic System (IAAP-038/R26)
- Line 3A Pond (IAAP-041/R29)
- Fly Ash Disposal Area (IAAP-043/R30)

To evaluate the risks to ecological receptors, specific lines of evidence (i.e., measurement endpoints) were selected to estimate whether a particular assessment endpoint was being satisfied. For the terrestrial environment, only one line of evidence (i.e., NOAEL- and LOAEL-based HQs) was used to estimate risk, while for the aquatic environment, multiple lines of evidence were collected. Information on exposure and effects, or toxicity, was combined to estimate whether particular COPEC concentrations pose ecological concerns at each AOC or the streams.

This characterization started with assessment of effects on the selected endpoints. If the selected receptors are estimated to be at no risk, then the ecosystem as a whole is considered to be protected. On the other hand, if individual receptors or communities are estimated to be at risk, there is still the question of whether the receptor population or community is at risk. The risk characterization on the particular receptor species or communities is used to make qualitative judgments concerning any estimated potential effects to cause actual ecological harm. For the special status Indiana bat, risk characterization included effects on individual bats, and not community level effects, because of its special status. The goal is to not harm an individual for special status species like the bat. The question of effects for the selected receptors is quantitatively documented. The probability of individual, community and population effects is handled qualitatively.

The potential for risk was characterized by evaluating four primary forms of exposure and effects data, referred to as lines of evidence. These were:

Evaluation of media-specific data - Surface water data were used to evaluate risks to fish and algae. Media-specific data were used to estimate tissue concentrations in aquatic and terrestrial receptors. Fish tissue analytical results were used for comparison to estimated doses and also to model exposure doses for piscivores.

Evaluation of field survey results - Field observations of fish (DELT) and benthic community (RBP results) were interpreted to identify any apparent effects.

Development of HQs - Hazard quotients were developed for surface water, sediment, and soil, at each AOC and for each ecological receptor. In the screening process, HQ values were determined as the ratio of the maximum concentration of a constituent in a media to its corresponding SV. In the BERA, HQ values are calculated by comparing modeled COPEC doses to TRVs. Two separate HQs are calculated for each COPEC using the NOAEL- and LOAEL-based TRVs, and are referred to as the NOAEL- and LOAEL– based HQs. According to USEPA (1997), the lower bound, or threshold, below which risk is assumed to be insignificant is based on conservative assumptions and NOAEL-based toxicity values. A NOAEL corresponds to a dose that is *not associated with adverse effects*. Therefore, NOAEL-based HQs greater than one represent the lower end of the potential ecological risk range. Hazard quotients developed in ecological risk assessments are generally represented to one significant digit, because the certainty of exposure factors is only known to one significant digit. Therefore, HQs were rounded to the nearest whole integer using normal arithmetic methods (i.e. 1.4 was rounded to 1.0, 1.5 to 2, etc.). For some COPECs, NOAEL-based HQs could not be estimated because NOAELs were not available. It should be noted that a NOAEL-based HQ greater than one does not necessarily represent an environmental concentration that would pose a concern to the ecological receptor. For this reason, a NOAEL-based HQ is a fairly weak line of evidence to use to estimate if a COPEC poses a potential ecological concern.

A LOAEL is used as a lower bound to estimate an exposure dose that could *potentially cause an adverse effect* to an ecological receptor. A LOAEL represents the lowest dose in a toxicological study that was observed to cause an adverse effect on the test organism. Therefore, LOAEL-based HQs of one or greater, generally, are associated with some level of adverse effect in the test species. However, while the observed LOAEL-based dose may have caused an effect in the test organism, it may or may not show direct effects on species found in the IAAAP. Therefore, LOAEL-based HQ values equal to or greater than one may or may not indicate adverse effects on the assessment endpoints selected in this BERA. Lowest observed adverse effects level-based HQs are developed using the same conservative exposure dose that is used for the NOAEL-based HQs. However, the TRV used is different because it is based on a LOAEL. The LOAEL-based HQ is considered to be a more realistic prediction of potential risk for an ecological receptor than the NOAEL-based HQ. Therefore, when a LOAEL-based HQ is equal to or greater than one for a COPEC, it is evaluated further for each terrestrial AOC. In these cases, LOAEL-based and NOAEL-based CCs are calculated which are concentrations of a COPEC that correspond to a LOAEL-based or a NOAEL-based HQ of one, respectively. This is discussed further below.

Development of CCs - Critical concentrations are calculated analyte concentrations in soil, surface water and sediment that equate to a HQ of 1. The CCs are developed considering cumulative chemical exposure from all applicable sources (e.g., soil invertebrates and soil). Critical concentrations are COPEC concentrations, calculated for a specific COPEC-receptor combination that may pose a risk to that receptor. The CCs are calculated analyte concentrations in soil, surface water and sediment that equate to a HQ of one. Lowest observed adverse effect level based CCs in soils calculated for the three terrestrial receptors at IAAAP are provided in Table 6-1a. Lowest observed adverse effect level based CCs in surface water and sediment calculated for the two aquatic receptors at IAAAP are provided in Table 6-2a. Exposure to soil, surface water or sediment containing COPECs at or below the LOAEL based CCs should not result in unacceptable levels of risk to receptor population. Therefore, the CC values corresponding to LOAEL-based HQs of one were used to estimate COPEC concentrations in soil, surface water or sediment that might pose an ecological concern. The CCs are not meant to be used as clean-up goals, but are rather one line of evidence to be used to evaluate if a site poses a potential risk to ecological receptors. For metals, site-specific background soil criteria are also provided in Table 6-1a, because sometimes the CCs are less than background concentrations. The background concentrations are considered representative of natural conditions in areas unaffected by the IAAAP.

These four main lines of evidence were used in a weight of evidence approach to evaluate ecological risks to the terrestrial and aquatic ecosystems at the IAAAP. In aggregate, the line-of-evidence approach provided a means of evaluating which receptors or communities are most sensitive to the site COPECs, and which COPECs are of greatest ecological concern. Where key COPECs within an ecosystem at the IAAAP appeared to pose a potential ecological risk to many ecological receptors, the spatial distribution of the contamination in relation to HQ/CC exceedances was assessed to identify potential problem areas within the ecosystem.

General Risk Characterization Approach – Terrestrial Environment - To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for three specific ecological receptors including the white-footed mouse, the short-tailed shrew and the Indiana bat by AOC. In addition, soil concentrations that are equivalent to a LOAEL-based or NOAEL-based HQ of one, called CCs were calculated for each receptor. The HQ and related CC line of evidence is the only line of evidence available to evaluate the potential ecological risks for the terrestrial environment. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

For two of the main COPECs found at most of the AOCs, RDX and lead, the human health remediation goals (RGs) are lower than the corresponding ecological CCs. For these COPECs, protection of human health is likely to drive remediation rather than the ecological risk. In the case of TNT, which is a main COPEC at a number of the AOCs where remediation has already occurred to human health standards, it still needs to be verified that the ecological risks are protected too. This is because the ecological based CCs for TNT for the Indiana bat are lower than the human health RG for TNT. As noted previously, an example evaluation has been performed using line 5A/5B (IAAP-006/R06) TNT data, and so this assumption seems likely to be valid. However, this evaluation will have to be performed for the other AOCs where TNT is a COPEC and where remediation has already been performed to a human health-based TNT RG. In the case of inorganic analytes, if the concentration of the inorganic COPEC (i.e., a metal) did not exceed its background concentration, even though it was associated with a LOAEL-based CC exceedance, it was not considered to pose an ecological concern. For such inorganic constituents, the background concentration is the default LOAEL-based CC. The appropriate CCs for each constituent are presented (shaded) in Table 6-1a.

General Risk Characterization Approach – Aquatic Environment - Several lines of evidence were available for evaluation of the aquatic environment. For certain receptors, only HQs were evaluated (e.g., bat species), because other lines of evidence are not practical to collect (e.g., tissue data). For the other lines of evidence collected for receptors, the detailed discussions on the effects assessment provided in Section 4 of this BERA are used to make an evaluation of the risk to each receptor. The effects-based lines of evidence and the HQ lines of evidence both have associated limitations. Where both lines of evidence are available for a receptor, they are used in combination as a weight of evidence to determine if there is a potential ecological risk to a receptor.

Hazard quotient values were estimated for many COPECs in this BERA. Solely to help focus the discussion, the BERA generally discusses HQ values from the perspective of overall magnitude. Designation of risks as low, medium, or high cannot be made based on HQ values alone. Such designation, if attempted, should be a result of a risk management decision that considers all lines of evidence. It is more helpful, in the case of the soil AOCs, to be aware of the spatial distribution of those locations where the CCs are exceeded. This gives a more definitive indication of whether remedial efforts might be needed and if so, where these efforts should be focused, rather than an impression of a particular level of risk to a population over the entire AOC. For the aquatic environment, the direct lines of evidence should be considered in combination with the HQ values.

A summary of the risk descriptions for the terrestrial environment and the aquatic environments are provided separately below. Results of the weight of evidence evaluation are summarized in the following paragraphs for aquatic and terrestrial receptors.

<u>Terrestrial Line of Evidence</u>

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for three ecological receptors, including the white-footed mouse, the short-tailed shrew, and Indiana bat by AOC. In addition, soil concentrations that are equivalent to a NOAEL-based or LOAEL-based HQ of one, called NOAEL-based or LOAEL-based CCs, were calculated for each receptor. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

These LOAEL-based CCs were compared to human health preliminary remedial goals (PRGs) available for IAAAP, which are to be utilized in soil removal activities at several AOCs. The major risk-driving chemicals for human health (i.e., those with high concentrations throughout the facility) include TNT, RDX, and lead, for which the human-health-based PRGs or RGs are lower than the ecological LOAEL-based CCs, with the exception of TNT. In the case of TNT, the ecological-based CC is lower than the human health RG for TNT, but this is based on the assumptions used to model uptake of TNT for the Indiana bat. It is likely that RDX and lead will drive remediation at these remaining sites. For RDX and lead, the human health based PRG or RG would be more restrictive than the ecological based CC, and therefore, remediation to human health based goals should be protective of ecological risks. Therefore, the PRGs or RGs are likely appropriate values on which to base vertical and horizontal removal boundaries for most areas (i.e. ecological issues are not indicated to be driving the remediation efforts). For many of the metal COPECs where LOAEL-based HQs exceed one, background concentrations also are higher than the LOAEL-based CCs; therefore, cleanup would not be necessary below background levels.

For the AOCs not slated for cleanup based on protection of human health, concentrations of 11 COPECs exceeded LOAEL-based CCs primarily based on the short-tailed shrew and sometimes the white-footed mouse. Altogether, only a total of 28 individual sample locations exceeded LOAEL-based CCs among the nine AOCs where human-health based remediation is not currently planned. Very few COPECs exceed their LOAEL-based CCs in the terrestrial environment, and there is no one COPEC that stands out as an ecological risk driver across the AOCs. Most AOCs have exceedances for only one or two COPECs at a few (three or less) locations, which would indicate the extent of COPEC concentrations above the LOAEL-based CC is very limited. The greatest exceedances are at R08 and R18, with eight locations. Figures 6-1 through 6-9 illustrate that these exceedances are isolated and many are in very close proximity to buildings and other structures, indicating the contamination is localized. At most of these AOCs, sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding LOAEL-based CCs. Fate and transport evaluations for most of the AOCs (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs.

The toxicity endpoint that was used to estimate the risk associated with most of the COPECs (but not TNT for Indiana bat) was reduction in offspring numbers or growth. For these reproductive effects to have an ecological impact on the mouse and the shrew, the COPEC concentrations would have to be above a level of concern (i.e., LOAEL-based CC) in a large area of the site. However, this does not occur at any of the AOCs, and so effects on the population of small mammals (e.g., mouse or shrew) would not be expected at any of the individual AOCs. In addition, primary habitat for the receptors exists in the area surrounding most AOCs. Based on the observations that spatial distribution of the COPECs is limited, that there is no evidence of contaminant migration from these AOCs, and that primary habitat for the receptors exists outside the AOCs, it is conceivable that individual terrestrial receptors exposed to COPECs at these 28 locations above the LOAEL-based CCs could be adversely impacted. But, it is not expected that the white-footed mouse or the short-tailed shrew community will be impacted due to these isolated exceedances of the CCs.

In the case of the Indiana bat, the goal is to protect the individual bat because of its special status. No observed adverse effects level-based HQs exceeded one at three of the nine AOCs evaluated that have not been previously remediated, within the four watersheds. For this reason, potential risks to the Indiana bat are very localized in nature in the terrestrial environment. Considering that the LOAEL-based HQ for the Indiana bat equals or exceeds one, it is possible that individual bats may be harmed at some AOCs. However, as noted previously, the risks may be overestimated by the assumption used to predict uptake of COPECs into the insects that the Indiana bat feeds upon.

In summary, it is anticipated that remediation to address human health at several AOCs would cover areas where ecological risks could exist. In the terrestrial environment, there are only isolated areas where potential ecological risks might occur, and these are not expected to pose a concern to the populations of small mammals. It is likely that these isolated locations would be remediated as the site is remediated to address human health risks. The exact dimensions of the areas to be remediated at these AOCs are not known. Typically, post-excavation confirmatory samples are collected to verify that remediation goals have been achieved. Once human–health based remediation has been completed, the AOCs should be evaluated to determine if all areas where ecological-based risks exist have also been cleaned up. For the AOCs slated for remediation, ecological risk-based LOAEL-based CCs exceed measured concentrations for several COPECs. The locations for such exceedances are listed by COPEC in Tables J-37 through J-55 in Appendix J. This information may aid in determining whether further remediation is required at the AOCs slated for human-health based remediation or where human-health based remediation has already taken place.

Aquatic Lines of Evidence

The results of the aquatic environment evaluations are provided below by receptor. For the aquatic environment, a number of lines of evidence were collected for each creek or stream. The lines of evidence included dose modeling to develop HQs and CCs for aquatic wildlife receptors (belted kingfisher and Indiana bat) similar to the assessment performed for the terrestrial environment. In addition, for fish and algae, HQ calculations were made based on comparisons to either modeled fish body burdens or simply comparing to screening benchmarks. In addition, field assessments were conducted to evaluate fish health (i.e., DELT) and the health of the benthic invertebrate community (i.e., RBP). Where both effects-based lines of evidence and the HQ lines of evidence (DELT and RBP) are available for a receptor, the two lines of evidence are used in combinations, as a weight of evidence, to determine if there is a potential ecological risk to a receptor.

The orangethroat darter is a special status species, and thus was selected for evaluation in this BERA. However because of its special status, specimens of this species could not be collected for purposes of tissue analysis. To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated for a number streams including direct observations of the fish in the creek (i.e., DELT analysis), tissue analysis of a similar darter species for specific COPECs, and estimation of HQs using two different methods. These lines of evidence are used in combination to evaluate the potential risk to the orangethroat darter.

Based on the lines of evidence evaluated in most streams, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals. However, no apparent effects were observed based on the results of the field observations (DELT). However, the DELT is not designed to detect toxic effects to fish that are not readily apparent, and so there are limitations with this line of evidence. It is possible that the levels of some metals may have toxic effects on the orangethroat darters in the streams, but this can not be verified based on the lines of evidence that were evaluated. The presence of the orangethroat darter or similar species of darter in most of the streams is a promising sign that the stream habitat can support darter populations.

The RBP was performed to provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected within the aquatic habitat. It is important to consider the habitat characteristics at each sample station when performing the RBP, as there are many environmental factors (e.g., riparian vegetation and stream characteristics), other than contaminant concentrations, that can effect the benthic community composition at a given location. When performing the RBP at IAAAP, the sample locations were selected to evaluate potential source areas of contamination to the creek, and also, sample stations were selected so that they would be similar in characteristics to one another. There are certain limitations that can not be overcome, such as the presence of some stations at locations that are not ideally matched to the reference station. In these cases, a qualitative determination has to be made to determine if there are environmental factors other than chemical concentrations that would likely effect the benthic community composition. Keeping this in mind, the information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but is unlikely to detect toxic effects on individual benthic species. Results of the RBP indicated that some sample locations were considered unimpaired or slightly impaired. Where the sample location was rated as slightly impaired, it was generally because of low grade habitat rather than any apparent effects related to chemical concentrations of COPECs. Based on the results of the RBP, the benthic invertebrate community within streams at IAAAP did not appear to be effected by IAAAP facility operations. However, the RBP is not a definitive analysis, and thus has its own inherent limitations that have previously been discussed.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. Hazard quotients exceeded one for some phthalate esters, and specific metals in some of the streams (e.g., Long Creek). Such HQ exceedances are not necessarily an indication that adverse effects are actually taking place. The algae HQs are likely a weak line of evidence given the conservatism of the screening values.

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs, that have the potential to bioaccumulate in fish tissue, might pose an ecological risk to this feeding guild. Some metals were the only COPECs with LOAEL-based CC exceedances and HQ exceeding one. However, these results might be an over estimation of the actual risk, based on the conservative nature of the exposure model and TRV used to develop the HQs. These LOAEL-based HQs have a low level of confidence associated with them and the belted kingfisher or other piscivores are not likely to be affected by contamination in the streams. However, much of the uncertainty surrounding these risk estimates is related to the lack of fish tissue concentrations of COPECs, and as a result the concentration in fish were modeled.

The risk to the Indiana bat was evaluated as an aquatic receptor, because it is known to be present at the IAAAP and utilize the riparian corridor along streams as habitat. Therefore, it was considered important to protect even individuals within the population. The LOAEL-based HQs exceeded one for a number of metals within most of the watersheds. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the aquatic environment. However, for purposes of the BERA, some of the HQ estimates have been evaluated as a means of informing the risk manager about the limitations of these risk estimates, and when considering these limitations, indicate that the bat might not be at risk.

In summary, based on the multiple lines of evidence, the fish populations (including orangethroat darters), and the benthic invertebrate populations in the streams evaluated do not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations). However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so, there is possibly adverse effects that are occurring due to IAAAP operations that could not be detected. In the case of the Indiana bat, exceedances of LOAEL-based CCs (i.e., HQs >1) were detected in a number of the streams within the aquatic environment. These risk estimates might be conservative in nature due to the assumptions used to evaluate exposure and toxicity to this species.

In addition, to the bat, the evaluation of algae in some creeks (e.g., Long Creek) indicated the potential for effects on this community by specific metals. However, the line of evidence used was more of a screening level assessment and has a large degree of uncertainty associated with it.

Overall Conclusions

Within the BERA, both evaluations of the terrestrial environment and the aquatic environment were performed. Outside of the limited circumstances where ecological risks were estimated to potentially occur within the terrestrial and aquatic environment, ecological risks were not predicted. The results of this BERA can be used to evaluate the need for remediation at a given AOC or stream, and also be useful in evaluating past remediation efforts at IAAAP. Within the terrestrial environment, potential ecological risks rather than human health risks might drive the need for remediation at only nine AOCs within the four watersheds. For those AOCs where human health risk will likely drive remediation, remediation goals are set, and if achieved should mitigate ecological risks. This latter assumption will have to be verified after the human health remediation is complete to validate that ecological health is protected too.

At the nine AOCs that were evaluated in more detail within the BERA, very few COPECs were detected in any one AOC above concentrations that would pose a potential ecological concern (i.e., CCs) to the three terrestrial receptors evaluated (mice, shrew, and Indiana bat). Based on the observations that spatial distribution of the COPECs is limited, it is not expected that the white-footed mouse or the short-tailed shrew community will be impacted due to these isolated exceedances of the CCs. It is conceivable that individual terrestrial receptors exposed to COPECs above the LOAEL-based CCs could be adversely impacted. However, the goal for these two wildlife species is to protect the community rather than individuals within the population.

In the case of the Indiana bat, the goal is to protect the individual bat because of its special status. No observed adverse effects level-based HQs exceeded one at three of the nine AOCs evaluated that have not been previously remediated, within the four watersheds. Considering that the NOAEL-based HQ for the Indiana bat equals or exceeds one, it is possible that individual bats may be harmed due to the level of mercury found at some AOCs. However, based on a sensitivity analysis that was conducted, these risks might be overestimated by the assumptions used to predict uptake of COPECs into the insects that the Indiana bat feeds upon.

The AOCs within a particular watershed are the source areas for COPECs in surface water and sediment. However, based on an evaluation of the COPECs in the terrestrial environment of the AOCs that were not slated for remediation, there was no clear relationship between the COPECs in the aquatic and terrestrial environments. In many cases, the COPECs identified in the aquatic environment were different than the COPECs identified in an AOC. Based upon the multiple lines of evidence collected for the aquatic environment, the fish populations (including orangethroat darters), and the benthic invertebrate populations in the streams evaluated do not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations). However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so, there is possibly adverse effects that are occurring due to IAAAP operations that could not be detected.

In the case of the Indiana bat, exceedances of LOAEL-based CCs (i.e., HQs >1) were detected in a number of the streams within the aquatic environment. However, these risk estimates might be conservative in nature due to the assumptions used to evaluate exposure and toxicity to this species.

Special Considerations

The LOAEL and NOAEL-based HQ exceedances noted for specific receptors within this BERA may be the result of the conservative approach followed throughout this evaluation. More definitive direct lines of evidence could be collected to validate the estimated HQs that are predicted to be greater than one. Some of the limitations of the HQ estimates have been evaluated as a means of informing the risk manager about the limitations of these risk estimates. To more clearly identify whether conditions at the IAAAP pose a health concern to the receptors, some of these limitations could be further evaluated. The site-specific risks could be evaluated in light of the likely remedial solution that will be used to mitigate potential risks, before a decision is made concerning whether additional study is needed.

For example, because of the special status of the Indiana bat, there may be a need for verification of some of the exposure assumptions to address whether individual Indiana bats are truly at risk. These additional levels of assessment could be performed, if deemed necessary, by the risk assessment team (i.e., risk assessor and risk managers). Some of the additional evaluations that could potentially be conducted to put into perspective the HQ exceedances or refine the HQs include:

- Comparison of post-remediation data to CCs---It is anticipated that remediation to address human health at several AOCs would cover areas where ecological risks could exist. Typically, post-excavation confirmatory samples are collected to verify that remediation goals have been achieved and are protective of human health. Post-remediation TNT data from IAAP-006/R06 have been used as a case example in this BERA to validate that residual soil concentrations would also be protective of ecological health. However, this type of evaluation may be conducted for the other AOCs to verify that this assumption holds for other AOCs where remediation has already been conducted based on human health RGs. In the future, once human–health based remediation has been completed, the AOCs could be evaluated to determine if all areas where ecological-based risks existed have also been cleaned up.
- Additional sampling---One of the major sources of uncertainty in the BERA is the use of literature-derived bioaccumulation factors. Since the data used was not site-specific, it may be required that these bioaccumulation estimates be verified. The need for verification sampling would be made by the risk assessment team (risk assessors and risk managers). Such verification sampling may include collection of terrestrial and aquatic flying insects, terrestrial invertebrate, terrestrial plants, and other food sources for the selected receptors, as deemed necessary by the risk assessment team.
- Additional fish tissue analysis---Much of the uncertainty surrounding risk estimates for the orangethroat darter and the belted kingfisher is related to the lack of fish tissue concentrations for several COPECs. As a result, concentrations of these COPECs in

fish tissue were estimated using models. To decrease the uncertainty associated with these risk estimates, fish tissue data could be collected for the select COPECs that were estimated to pose a potential concern.

- Algal assay---Risk to algae was estimated based on a single line of evidence, which is essentially a screening level evaluation. It can not be determined with any certainty that algae are not being harmed. A more definitive evaluation, such as algal assay, could be conducted, if deemed necessary by the risk assessment team.

1.0 INTRODUCTION

Ecological risk assessments (ERAs) are conducted to evaluate the actual or potential effects of contaminants on plants and animals. Results of an ERA are used by decision-makers to aid in formulating remedial objectives, analyzing remedial alternatives, and selecting an appropriate remedy, if necessary. The purpose of this report is to document the results of a Baseline Ecological Risk Assessment (BERA) at the Iowa Army Ammunition Plant (IAAAP), near Middletown, Iowa. The BERA was conducted by MWH Americas, Inc. (MWH) for the U.S. Army Corps of Engineers (USACE), Omaha District under terms of Delivery Order No. 0007, Contract No. DACW25-00-D-0004.

The BERA was conducted using data collected during facility-wide Site Investigations (SIs) and the Remedial Investigation (RI), and supplemental investigations conducted specifically to collect data for the BERA. The BERA discusses the potential risks to ecological receptors at the site associated with exposure to chemicals of potential ecological concern (COPECs) that may have resulted from past IAAAP activities. Chemicals of potential ecological concern were selected based on results of the Screening Level Ecological Risk Assessment (SLERA) completed for the site and provided in Appendix A1.

The BERA utilized current published resources, referenced within this document where appropriate. The primary U.S. Environmental Protection Agency (USEPA) guidance documents used to perform the BERA include:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, (USEPA 1997).
- Guidelines for Ecological Risk Assessment, (USEPA 1998a).
- The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments, ECO Update Bulletin Series, (USEPA 2001).

This BERA builds upon a previous basewide ERA that was conducted for IAAAP during the Remedial Investigation/Feasibility Study (RI/FS) process. This BERA conforms to the newer guidance, listed previously, which was not available at the time that the basewide ERA was conducted. Background information explaining the need for this BERA, after the original basewide ERA was completed, is included in the Project Background, Section 1.2. Section 1.1 includes an overview of the current ERA process.

1.1. OVERVIEW OF CURRENT ERA PROCESS

ERAs performed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund) and Superfund Amendments and Reauthorization Act of 1986 (SARA) includes an eight-step process. This process is detailed in Ecological Risk Assessment Guidance for Superfund (ERAGS) published by USEPA in 1997. The generic model for this process is presented in Figure 1-1.

Steps 1 and 2 of the ERA process form the SLERA. The SLERA, or Tier 1 assessment, is strictly a paper study that contains all of the elements of a more detailed ERA, but can be conducted using limited data. This type of ERA accepts a higher level of uncertainty than a BERA and uses protective assumptions to manage data gaps. Assumed values used to calculate ecological health risks are consistently biased in the direction of over estimating risk to reduce the likelihood of falsely screening out a site from further assessment (i.e., failing to identify ecological risks that are actually present). The goal of the SLERA is to quickly and cost effectively determine if a more detailed BERA is warranted. If the result of the SLERA is that site conditions do not pose an ecological health concern, then the assessment ends at this point. The SLERA for the IAAAP is contained in Appendix A1 of this BERA.

If the SLERA (i.e., Steps 1 and 2 of the ERA process) indicates that there is the potential for ecological effects associated with the site, a more detailed BERA is conducted (i.e., Steps 3 through 7 of the ERA process) and the SLERA is documented as part of the BERA.

Steps 3 through 7 constitute a more detailed approach to the ERA process described in the Framework for ERA (USEPA, 1992a). These steps can be composed of what are known as a refined Tier 1, Tier 2 and/or Tier 3 BERA depending upon the type of investigation performed. A refined Tier 1 assessment is a paper study, like the SLERA, but less conservative assumptions are used to estimate the potential for ecological risk. Tier 2 assessments rely mainly on ex-situ testing of media in a controlled laboratory to determine the potential for toxicity. Tier 3 assessments rely on in-situ (i.e., field) investigations to determine the potential for ecological effects. These more detailed BERAs are generally more data intensive and accept a lower level of uncertainty.

Common to both the SLERA (Steps 1 and 2) and the BERA (Steps 3 through 7), is an iterative process of problem formulation, data collection, and data analysis with the ultimate goal being to estimate whether the site conditions pose an ecological concern (i.e., risk characterization). Problem formulation is composed of reviewing the analytical data obtained to date for the site, visiting the site to make observations concerning site ecology and potential chemical fate and transport processes, and reviewing information concerning the toxicology of the contaminants present. The result is a conceptual site model (CSM), which is updated appropriately as more information is collected and analyzed. The CSM includes a summary of those exposure pathways that are potentially complete, meaning those exposure pathways that cause ecological receptors to become exposed to a contaminated medium or multiple contaminated media. Once the complete exposure pathways are determined, appropriate assessment endpoints and measurement endpoints are selected and incorporated into the CSM. Assessment endpoints are "explicit expressions of environmental values to be protected" at the site (USEPA, 1992a). The purpose of identifying assessment endpoints is to focus the ERA and define the scope of the assessment. Because assessment endpoints are environmental values, they are often location sensitive. An example of an assessment endpoint for the IAAAP would be protection of the health of benthic invertebrates living in the streams that flow through IAAAP.

Assessment endpoints cannot usually be measured directly. Therefore, measurement endpoints are selected which are indirect measures of whether the assessment endpoint is being achieved. For the example assessment endpoint at IAAAP, provided above, an example measurement endpoint for protecting the health of benthic invertebrates would be a statistical comparison of the number of invertebrates per unit area in a surface water body at IAAAP compared to a reference site located upstream of IAAAP. If the number of organisms per unit area is not statistically different, this provides one line of evidence to support a conclusion that the assessment endpoint is being achieved. Many times, for a given assessment endpoint, a number of lines of evidence (both qualitative and quantitative) are used to determine if an assessment endpoint is being achieved. The selection of assessment endpoints and measurement endpoints is dependent upon the nature of the contamination, the ecology of a specific site, and the risk managers and stakeholders desired end use for the site. Thus, it is important that all parties be involved when selecting the assessment and measurement endpoints for a site. A CSM for IAAAP is presented in Section 2 of this BERA.

The ERA process is an iterative process of defining the problem in the form of a CSM and collecting data to assess preselected measurement endpoints, to ultimately determine if selected assessment endpoints are being achieved. Data that are collected to support the ERA usually have the purpose of describing the level of exposure an organism has to a particular medium, or defining the toxicity of the medium to the organism. These data (exposure and toxicity information) are collected and analyzed to estimate whether the level of exposure is anticipated to be toxic (i.e., cause an effect). A toxic effect has the potential to occur when the chemical dose an organism receives is higher than a threshold level (i.e., a level below which adverse effects should not occur). If the threshold concentration is exceeded, a toxic effect may occur; in other words, an assessment endpoint is not being achieved. This process of comparing the level of contaminant exposure and contaminant toxicity is called risk characterization. Risk characterization is used to inform the risk managers.

The ERA process contains a technical oversight and consensus-building feature called scientific/management decision points (SMDPs). At SMDPs (i.e., at completion of many of the eight ERA steps), the risk assessors and risk managers meet to review the progress of the ERA. The ERA is evaluated and the progress is approved at the SMDP meeting, or the group may decide to redirect the ERA.

Early on in the process, before ERAGS was published, an informal ERA Team was formed to oversee the development of ecological evaluations at IAAAP. The ERA team continues in this role. The ERA Team members primarily involved in the ERA process at IAAAP represent IAAAP, USACE, US Army Center for Health Promotion and Preventive Medicine (USACHPPM), USEPA, and US Fish and Wildlife Services (USFWS). At SMDPs, this group came together to discuss the approach, progress, and direction of the ERA. Throughout this document, this group is referred to as the ERA

Team. The CSM presented in the BERA was developed utilizing the input of all parties from the ERA Team meetings.

1.2. PROJECT BACKGROUND

1.2.1. Iowa Army Ammunition Plant History And Regulatory Framework

The IAAAP is a government-owned, contractor-operated facility under the command of the U.S. Army Joint Munitions Command, Rock Island, Illinois. The current operating contractor is American Ordnance (AO). Production of ammunition items began in 1941 and the facility remains in operation. Production activities at IAAAP currently include the loading, assembling, and packaging of ammunition items, including projectiles, mortar rounds, warheads, demolition charges, anti-tank mines, and anti-personnel mines. The loading, assembling, and packaging operations use explosive materials and lead-based initiating compounds.

The IAAAP occupies approximately 19,000 acres in the town of Middletown in Des Moines County, Iowa, and lies approximately 10 miles west of the Mississippi River. U.S. Highway 34 borders IAAAP to the north, upland agricultural farms to the east and west, and the Skunk River Valley to the south. Surface topography is characterized by flat to gently rolling uplands dissected by entrenched streams and rivers. Approximately one-third of the IAAAP property is occupied by active or formerly active production or storage facilities. The remaining land is either woodlands or leased for agricultural usage.

Wastewater generated at various plant facilities and effluent from wastewater treatment plants are discharged to surface streams under the provisions of a National Pollutant Discharge Elimination System (NPDES) permit. Past munitions production at IAAAP has resulted in contamination of soil and groundwater, and discharge of wastewater-containing explosives and explosive by-products to surface water. The primary source of contamination resulted from placing explosives and waste containing heavy metals directly on soil and into surface water. Explosive contaminants and heavy metals migrated through the soil into the groundwater and also over land into surface water. The facility also has identified minor amounts of volatile organic compound (VOC) contamination in soil and groundwater.

Sites include surface impoundments, production areas, landfills, and a fire training pit. The facility map (Figure 1-2) shows the site locations, creeks, and other features of interest at IAAAP.

Pursuant to the Resource Conservation and Recovery Act (RCRA) Hazardous and Solid Waste Amendments (HSWA) of 1984, USEPA completed an assessment of the facility in 1987 (USEPA, 1987) and reported that releases had occurred. IAAAP was subsequently proposed for the National Priorities List (NPL) and, in August 1990, the facility was placed on the NPL with a Hazard Ranking Score (HRS) of 29.73.

A Federal Facility Agreement (FFA) between the U.S. Department of Defense and USEPA Region 7 was signed on September 20, 1990. Under the agreement, IAAAP investigations and remedial activities will be completed under CERCLA. The agreement allows RCRA and CERCLA activities at the site to be coordinated. In response to the FFA, JAYCOR (1992) completed a facility-wide Preliminary Assessment/Site Inspection (PA/SI) of 44 sites with potential contamination listed in the IAG (Interagency Agreement). Subsequently, JAYCOR (1996) completed a facility-wide Remedial Investigation (RI) and Risk Assessment (RA) for approximately 35 of the sites. Additional sites were added over the year as a result of added studies and best management practices and a total of 43 physical sites exist today.

The IAAAP facility has been divided into three operable units (OUs) to facilitate project management. These include:

- Soils OU #1 - to address contamination in the soils
- Groundwater OU #3 - to address contamination of groundwater within the IAAAP boundaries and potentially off-site
- Facility-wide OU #4 - to address closure of the Corrective Action Management Unit (CAMU), institutional controls, previously un-addressed areas of soil contamination, VOC contaminated media, ecological risks, groundwater monitoring requirements, and any other unacceptable risks which may be identified and not addressed in either OU #1 or OU #3

Operable unit #2 was originally established for the soil removal actions, but was subsequently merged into OU #1. This BERA is being performed to satisfy some of the ecological requirements for facility-wide OU#4.

1.2.2. Project Background Pre-Dating The BERA

Previous ecological evaluations have been performed as part of the RI/FS process and other ancillary assessments that evaluated the unique ecological habitat at IAAAP. The following are the primary ecological evaluations that have been performed prior to this BERA. The results of many (highlighted with asterisks) are relied upon in this BERA.

- Basewide ERA performed by JAYCOR (1996) as part of the RI/FS.
- Inventory and assessment of habitats and biota of the IAAAP performed by Horton and others (1996)*.
- A study entitled Uptake of Explosives from Contaminated Soil by Existing Vegetation at the Iowa Army Ammunition Plant, conducted by USAEC (1995).
- Ecological Risk Assessment Addendum (ERAA), performed by Harza Engineering Company (now MWH, 1998)*.

- Technical Memorandum No. 1 (TM 1) - Assessment and Measurement Endpoints, prepared by MWH (1999)*.
- Technical Memorandum No. 2 - Collection of Water and Sediment Quality Data for Ecological Risk Assessment, prepared by MWH (2000)*.
- Technical Memorandum No. 3 - Development of Hazard Models and Ecological Preliminary Remedial Goals (PRGs) for Ecological Risk Assessment, prepared by MWH (2000)*.
- Technical Memorandum No. 4 - Contaminant Screening Process for ERA, prepared by MWH (2000)*.
- TRV Memorandum (TRV Memo) - Development of Dose Estimation Models and Toxicity Reference Values, prepared by MWH (2001)*.

The following summary provides a general picture of how these previous evaluations relate to the BERA and helps explain, in part, the need for this BERA.

As part of JAYCOR's basewide RI (JAYCOR, 1996), ICAIR Life Systems, Inc. of Cleveland, Ohio, conducted a basewide ERA, documented in JAYCOR (1996, Volume 11 of 11). During their review of the basewide ERA, USEPA determined that additional data should be collected to evaluate potential risks to the IAAAP ecosystem, with emphasis on sensitive receptors and habitat.

In the same year that the JAYCOR RI was published, an inventory and assessment of habitats and biota of IAAAP was published (Horton and others, 1996). While their objective was to assess the entire facility, they focused on natural areas along creeks and drainage ways, where temperate deciduous forest predominates. To assess the health of the vascular plant communities potentially affected by chemical contamination or land use practices, the forest community structure quality index, as determined by Horton and others (1996) was evaluated.

After the basewide ERA and the Horton study were published, an addendum to the original basewide ERA was conducted to address the data gaps identified by USEPA. Harza (currently MWH) conducted the field investigation and subcontracted the laboratory based toxicity tests required for the ERAA. This investigation took place in 1997 and 1998, but was never finalized. At that time, the new USEPA guidance (USEPA, 1997) became available, as previously described, and provided the eight-step approach for conducting ERA. It was decided that a new risk assessment (i.e., the BERA) should be conducted at IAAAP, using the revised approach. For this reason, the ERA Team decided the information from the ERAA would be incorporated as appropriate in the SLERA/or BERA.

The following is a summary of the findings of the basewide ERA and the ERAA that predate the BERA. These summaries help to explain the need for a BERA.

Basewide ERA - The basewide ERA (JAYCOR 1996) concluded that significant risks might exist to several ecological receptors at IAAAP, but that uncertainty was high for most aspects of their assessment. The literature screening approach utilized by JAYCOR suggested that phytotoxicity due to metals exposure might pose a threat basewide. However, they expected the degree of toxicity to be subtle in nature, given the general lack of signs of chemical stress observed during the vegetation survey. They also indicated that most soils posed a potential for toxicity to soil invertebrates due to chemical exposure. A simplistic model suggested that herbivorous mammals could be at risk due to exposure to metals, nitrite, and explosives.

JAYCOR also examined aquatic ecosystems on IAAAP in a screening analysis. Maximum contaminant concentrations in sediment samples were compared to sediment quality criteria established for five, non-ionic organic chemicals, or to apparent effect thresholds for metallic and other organic chemicals. The order of expected adverse impacts due to chemical exposure for each of the streams at IAAAP was presented as:

Brush Creek > Long Creek > Skunk River > Spring Creek

JAYCOR indicated that food chain transfer for explosives was not expected to be significant due to relatively low bioconcentration factors and a high degree of expected metabolism. However, it was noted that certain metals have been shown to bioaccumulate and may pose a threat to terrestrial and aquatic organisms.

JAYCOR recommended the following additional ERA studies, based on their screening evaluations.

- Sediment toxicity testing in some areas
- Plant toxicity tests
- Earthworm toxicity tests
- Tissue sampling of terrestrial vegetation, earthworms, small mammals, benthic invertebrates, and fish

Samples were recommended from background locations and locations where toxicity had been indicated, to determine if contaminants were bioavailable to potentially exposed organisms and to evaluate bioaccumulation potential and toxicity threats to organisms at higher trophic levels.

Ecological Risk Assessment Addendum (ERAA) - During their review of the ERA (JAYCOR 1996), USEPA and the Army determined that additional data collection and analysis were needed. Following issuance of the JAYCOR RI, a study produced by the USAEC entitled Uptake of Explosives from Contaminated Soil by Existing Vegetation at the Iowa Army Ammunition Plant (USAEC, 1995) was issued. This study provided site-specific information on the potential for TNT and RDX uptake by plants. However, the study provided only limited information that is relevant for ecological assessment because the focus of the study was to evaluate the impact on human health. Based on the findings of the USEPA and the USAEC, a Scope of Services for additional data collection was issued to determine the potential impacts of chemical contamination on the IAAAP ecosystem, with emphasis on sensitive receptors and habitat. These services were to be performed as an addendum to the original ERA (i.e the ERAA).

Harza conducted the ERAA by assessing risks posed by past and ongoing plant operations in each of the main watersheds. Small burrowing mammals inhabiting flood plain forests at IAAAP were identified as key receptors for the study. Because of federal listing as a threatened species at the time of the study, the viability of bald eagle (*Haliaeetus leucocephalus*) population was also assessed. Selection of key aquatic receptors in the ERAA focused on two levels of biological organization: an individual fish species and the benthic community. Fish and benthic invertebrate samples were collected as part of the ERAA.

The ERAA indicated that small mammal populations did not appear to be at significant risk in any watershed and that bald eagle populations did not appear to be at risk at IAAAP. In general, aquatic systems were found to be exposed to concentrations of some metals that may potentially be affecting some of the orangethroat darters in Spring and Brush Creeks. The benthic community was appraised as being impaired to slightly impaired.

The ERA Team, composed of representatives from USACE, IAAAP, USEPA, USACHPPM, USFWS, Harza (now MWH), and Techlaw (USEPA's Contractor), met in Chicago on April 8, 1999, to discuss the results of the ERAA. It was determined that a new ERA process should be conducted at IAAAP that would be consistent with current guidance (USEPA 1997). The principal changes that were agreed to at the meeting for the approach of the BERA included:

- use of a site-specific approach to address terrestrial issues;
- use of a feeding guild approach for assessment and measurement endpoints;
- inclusion of the Indiana bat as a receptor; and,
- collection of additional sediment and surface water data to address data gaps associated with the RI data set.

Because a new BERA was required, the ERAA was not finalized. Instead, the ERA Team agreed that information collected and work conducted for the ERAA would be incorporated in the BERA.

1.3. ECOLOGICAL RISK ASSESSMENT APPROACH FOR IAAAP

The ERA Team decided that a series of TMs would be prepared by MWH to address key portions of the evaluation. Because the project was so far along at the time, it was decided that the original basewide ERA would be revised to conform to the new ERA guidance. The TMs would document the planning steps to be used instead of a formal BERA work plan. As part of this process, the screening values to be used in the SLERA were also developed. In accordance with current guidance, the screening values for the SLERA, and the SLERA itself, would have been performed before many of the TMs for the BERA were developed. However, the original project started well before the current USEPA ERA guidance was published, and so, to be in conformance with that guidance, the SLERA had to be performed in a retroactive manner, after the planning for the BERA had begun. The following is a summary of the planning documents that were prepared for development of the BERA and the SLERA.

1.3.1. Technical Memoranda

Four TMs were prepared to define procedures, models, and data collection. An additional memorandum was developed describing the dose models and proposing toxicity reference values (TRV). These memoranda were developed to facilitate review and concurrence on the general approach for the SLERA and the BERA. They are described below:

TM No. 1 (TM 1) - Assessment and Measurement Endpoints. Technical Memorandum 1 was developed to document the assessment and measurement endpoints that would be evaluated in the BERA. The ERA Team discussed and decided upon specific assessment endpoints and measures of effect to be used in the BERA during a meeting on April 8, 1999, in Chicago. Subsequent to that meeting, USEPA and USACHPPM contributed to the development of a table that listed the assessment endpoints and corresponding measures of effect agreed to at the meeting. Exposures to soil, sediment, and surface water were considered significant, and so assessment endpoints and measures of effect were developed for these media. The information was documented in TM 1, dated November 19, 1999, which is provided in Appendix B1 to this BERA.

TM No. 2 (TM 2) - Collection of Water and Sediment Quality Data for Ecological Risk Assessment. Technical Memorandum 2 was developed as a comprehensive facility-wide plan for collecting sufficient surface water and sediment data to complete the SLERA and the BERA. Surface water and sediment samples had been collected from the water bodies at IAAAP during several previous investigations. These include samples collected during the RI (JAYCOR 1996), the supplemental groundwater investigations (Harza, 1997), and the supplemental RI for Line 800 (Harza, 2001). These data were evaluated and used to design a comprehensive sediment and surface water investigation. The objectives of the surface water and sediment sampling were:

- to delineate the nature and extent of contamination for ecological receptors;

- to estimate the exposure of aquatic organisms to contaminants in streams at IAAAP and preying on aquatic insects or fish; and,
- to estimate contaminant doses to terrestrial organisms due to drinking water at the site.

Some of the ERA Team members met on March 9, 2000, in Kansas City to select the sample locations that would be documented in TM 2. The ERA Team members present represented USACE, Harza, USEPA, and Techlaw. Locations were selected by the ERA Team based upon known or suspected sources of aquatic pollution, identified locations of fine sediment deposition, and threatened or endangered species records. Locations immediately downgradient of NPDES discharges, tributaries, sediment depositional areas, and groundwater discharge areas were specifically identified. Site-specific scenarios that include groundwater discharge to surface water were considered. The surface water and sediment sampling conducted included consideration of COPECs in groundwater contributing to surface water. Groundwater discharge areas were specifically considered to identify surface water and sediment sampling locations. The selected locations provided coverage of all major streams across the plant property and included streams entering IAAAP on the west and east boundaries.

Based on this meeting, TM 2, dated April 7, 2000, was prepared by MWH to delineate the rationale and procedure for collection of water and sediment data. TM2 is contained in Appendix B2. Surface water samples were collected in May 2000. A second phase of sampling, in accordance with TM 2, was conducted in September 2000 to collect sediment and further surface water samples The results of this investigation are documented in the SLERA (Appendix A1). The work was conducted in accordance with an existing approved Work Plan/Sampling and Analysis Plan (WP)/(SAP) for the installation, containing a Quality Assurance Project Plan (QAPP), Field Sampling Plan (FSP), and Site Health and Safety Plan (SHSP) (Harza, 1999). All portions of the installation SAP were applicable to the collection of the additional water and sediment samples, except as amended specifically for this additional sampling (Harza, 2000).

TM No. 3 (TM 3) - Development of Hazard Models and Ecological Preliminary Remedial Goals (PRGs) for Ecological Risk Assessment. Technical Memorandum 3 was developed to document the ecological risk models that would be used in the SLERA and the BERA, and the screening levels (i.e., ecological PRGs) that would be used in the SLERA. Exposure to contaminants by a receptor may derive from multiple sources, including food (plant or animal), water, soil, and sediment. Therefore, the models were needed to incorporate chemical exposure from these multiple sources for each of the selected receptors. Screening values (SVs) were selected for each constituent detected at the IAAAP for each medium. The SVs are media-specific concentrations, above which there is sufficient concern to warrant further evaluation regarding the potential for adverse ecological effects. For each media, a focused literature search was conducted to identify screening levels developed to protect a broad range of organisms, rather than specific species. TM3, dated September 15, 2000, was developed by MWH and submitted for ERA Team review and input. The draft version of TM 3 is provided in Appendix B3. At a working meeting on February 22, 2001, the ERA Team members revised the dose models to address comments. Changes to the dose models based on these comments were incorporated in the TRV Memorandum, discussed later in this document.

TM No. 4 (TM 4) - Contaminant Screening Process for ERA. Technical Memorandum 4, dated August 31, 2000, was developed to provide the procedures to be used to select ecological SVs for the SLERA. TM4 is provided in Appendix B4. The procedures have since been revised in response to comments from ERA Team members provided at a working meeting. These revisions were incorporated into the Draft Final SLERA presented in Appendix A1.

TRV Memorandum (TRV Memo) - Development of Dose Estimation Models and Toxicity Reference Values. The last in the series of TM is known as the "TRV Memorandum". Toxicity reference values (TRVs) for wildlife receptors represent doses that are protective based on specific toxicity endpoints (e.g., survival, growth, reproduction, etc.). TRVs for wildlife are species-specific and are used to estimate the toxic potency of a chemical. The TRVs were presented in the Development of Dose Estimation Models and Toxicity Reference Values (August 31, 2001) and contained in Appendix B5. This document was in essence an update of the exposure models provided in TM 3, except that it also included the TRVs for the BERA. The TRVs used in the BERA include revisions made to address comments from stakeholders that were received after the TRV Memorandum was developed.

1.3.2. Screening Level Ecological Risk Assessment

The USACE, IAAAP, USACHPPM, USEPA, Harza, and Techlaw personnel met in Burlington, Iowa, on February 22, 2001. The purpose of the meeting was to formulate responses to comments from stakeholders on TM 3, TM 4, and the TRV Memorandum. It was considered important to first perform the SLERA to conform to the new USEPA ERA guidance and help develop a focused problem formulation for the BERA.

A Draft SLERA was conducted for IAAAP in conformance with pertinent TMs and was submitted to the ERA Team for review in July 2001. Comments were received from USEPA on the Draft SLERA by e-mails dated November 7, 2001, stating that the screening process should be modified. As part of the BERA development, a Draft Final SLERA was developed and is provided in Appendix A1 of this document. The Draft Final SLERA incorporates changes that were made to address USEPA comments. The responses to comments (RTC) on the Draft SLERA are also provided as Appendix A2. Response to a number of USEPA comments on the Draft SLERA appeared to be more relevant to the BERA. The RTC provides a road map for where each SLERA comment was addressed (i.e., the Draft Final SLERA or BERA).

The Draft Final SLERA includes screening level problem formulation and identification of COPECs. The SLERA for IAAAP confirmed what was suspected; that complete exposure pathways exist for some media and consequently, COPECs were identified for several media that would be further evaluated in the BERA. This is further discussed in Problem Formulation, Section 2 of the BERA.

1.3.3. Draft Baseline Ecological Risk Assessment

Prior to development of the Draft BERA, USACE, USACHPPM, IAAAP, and MWH personnel met in Chicago, Illinois between April 29 and May 1, 2003, to discuss the scope and content of the BERA. An annotated outline of the Table of Content was developed during and following the meeting, and then submitted to all Stakeholders for review and approval. The Draft BERA was submitted to the Stakeholders in October 2003.

USEPA and USFWS provided comments on the Draft BERA. The Stakeholders participated in numerous telephone conferences to discuss the comments and reach resolution on how the comments would be addressed in concept. Responses to USEPA and USFWS comments on the Draft BERA are presented in Appendix K-1 and K-2, respectively. This Draft Final BERA incorporates revisions made to address these comments.

1.3.4. Technical Memorandum No. 5

A fifth TM was developed in response to comments on the Draft BERA. It addresses three separate topics recommended by the USFWS for inclusion in the Draft Final BERA. The USFWS recommendations were as follows:

- The explosives TRVs published by the USACHPPM be used for the risk calculations for Indiana bat.
- Critical concentrations (CCs) for sediment and surface water be derived for the mammalian and avian receptors in the aquatic conceptual model.
- The Indiana bat be considered as an ecological receptor in the terrestrial conceptual model.

The procedures developed to address the three issues are contained in TM 5, which is attached as Appendix B6.

1.4. OBJECTIVES AND SCOPE OF THE BERA

The objectives of the BERA are to evaluate potential risks to terrestrial receptors from exposure to soil contaminants within each AOC, and to evaluate potential risks to aquatic receptors within IAAAP.

Surface water, sediment, fish tissue, and benthic invertebrate samples were collected primarily from water bodies within the plant boundary. A few samples were also collected from locations immediately downstream of the plant during the surface water and sediment investigations in this BERA. Three locations in Brush Creek and one location in Spring Creek, sampled in 2000, were located outside the plant boundary. Furthermore, eight surface water samples were collected during the Off-site Groundwater

Remedial Investigations (URS 2003). Contaminant concentrations in surface water at off-post locations are compared to corresponding CCs in Section 6. Information regarding Off-site physical habitat was presented in URS (2003). This information is summarized in Section 2.

This BERA was conducted using soil data collected during the SI and RI process, and surface water, sediment, fish tissue, and benthic invertebrate data collected specifically for the BERA and the SLERA. Soil analytical data used in this BERA is presented in Appendix C1, and soil-sampling locations are presented in Appendix C2. Soil data from background locations are presented in Appendix C3. Surface water and sediment data are presented in Appendix D, and fish tissue and benthic invertebrate data are presented in Appendix E.

The IAAAP covers approximately 30 square miles. Investigations for such large facilities are generally biased to focus on areas with known activities that have the potential to contaminate surrounding media. The SI, and the subsequent RI (JAYCOR, 1996), focused on determining the nature and extent of contamination within the AOCs. Soil data was specifically collected from the AOCs based on information that indicated potential soil contamination might have occurred in these areas. This BERA and the SLERA do not include evaluation of soil in areas outside the AOCs because soil contamination is not expected in these areas. Therefore, risks due to exposure to soil outside the plant are not addressed in this BERA. However, the BERA was designed to evaluate the potential for migration of chemical contamination outside the boundaries of the soil AOCs to the watersheds that are located on IAAAP. These include the watersheds of Spring Creek, Brush Creek, and Long Creek, as well as some of the tributaries of the Skunk River.

To support this evaluation, a comprehensive surface water and sediment investigation was completed in watersheds that could be potentially affected by the AOCs. Depending upon its location, an AOC has the potential to effect one or more of these watersheds. This approach was adopted to address the potential impact to these surface water bodies. A watershed approach made sense, because multiple AOCs could potentially effect a given water course; the overall objective of the BERA remained determining whether the ecological function of these surface water courses was detrimentally effected by the combination of multiple IAAAP-related operations.

The northern area of IAAAP is drained by a fifth watershed, Little Flint Creek. The drainage area is primarily upstream of activities at the IAAAP and not impacted by any release of contaminants. Therefore, the Little Flint Creek watershed is not included for evaluation in the BERA.

Investigations were conducted during the RI/SI at the following AOCs.

- Line 1 (IAAP-001/R01)
- Line 2 (IAAP-002/R02)
- Line 3 (IAAP-003/R03)

- Line 3A(IAAP-004/R04)
- Line 4A and 4B (IAAP-005/R05)
- Line 5A and 5B (IAAP-006/R06)
- Line 6 (IAAP-007/R07)
- Line 7 (IAAP-008/R08)
- Line 8 (IAAP-009/R09)
- Line 9 (IAAP-010/R10)
- Line 800 (IAAP-011/R11)
- EDA East Burn Pads ((IAAP-012/R12)
- Pesticides Pit (IAAP-017/R13)
- Inert Disposal Area (IAAP-020/R14)
- Demolition Area and Deactivation Furnace (IAAP-023/R15)
- Contaminated Waste Processor (IAAP-024/R16)
- Explosive Waste Incinerator (IAAP-025/R17)
- Sewage Treatment Plant/Sludge Drying Beds (IAAP-026/R18)
- Fly Ash Landfill (IAAP-027/R19)
- Construction Debris Landfill (IAAP-028/R20)
- Line 3A Sewage Treatment Plant (IAAP-029/R21)
- Firing Site Area (IAAP-030/R22)
- Ammunition Box Chipper Disposal Pit (IAAP-031/R23)
- Burn Cages, Burn Cage Ash Disposal Landfill, West Burn Pads, and West Burn Pad Landfill (IAAP-032/IAAP-033/IAAP-034/IAAP-035/R24)
- North Burn Pads (IAAP-0036/R25)
- Building 600-86 Septic System (IAAP-038/R26)
- Fire Training Pit (IAAP-039/R27)
- Roundhouse Transformer Storage Area (IAAP-040/R28)
- Line 3A Pond (IAAP-041/R29)
- Fly Ash Disposal Area (IAAP-0043/R30)
- North Burn Pads Landfill (IAAP-037)

Investigations were conducted, during the SI phase, at an additional seven AOCs, but these were not included in the RI phase because results indicated that further investigations were not warranted or, as in the case of the coal storage area, the coal pile was removed. These AOCs include:

- Incendiary Disposal Area (IAAP-013)
- Boxcar Unloading Area (IAAP-014)
- Old Flyash Waste Pile (IAAP-015)
- Possible Demolition Site (South Yard G) (IAAP-018)
- Contaminated Clothing Laundry (IAAP-019)
- Unidentified Substance (Oil) Waste Site (IAAP-022)
- Abandoned Coal Storage Yard (IAAP-042)

Removal actions have been completed at several AOCs, where contaminated soil has been removed and replaced with uncontaminated fill. These actions included removal of soil to depths greater than two feet. Therefore, for the purposes of evaluations to be conducted under an ERA, these AOCs have been remediated and RI/SI data reflecting contamination do not represent current conditions. These AOCs are:

- Line 5A/5B (IAAP-006/R06)
- East Burn Pads (IAAP-012/R12)
- Pesticide Pit (IAAP-017/R13)
- Burn Cages, Burn Cage Ash Disposal Landfill, West Burn Pads, and West Burn Pad Landfill (IAAP-032/IAAP-033/IAAP-034/IAAP-035/R24)
- North Burn Pads (IAAP-036/R25)
- Fire Training Pit (IAAP-039/R27)
- North Burn Pad Landfill (IAAP-037)

An evaluation to determine whether the human health-based remediation, that was been performed at these AOCs, is protective of ecological receptors is discussed in Section 6. For these AOCs, the ecological risks presented in this BERA are based on the RI data. However, for purposes of validating that the human health-based remediation is also likely protective of ecological health, an example evaluation of the residual concentrations of contaminants in soil has been performed for an AOC (Line 5A/5B, IAAP–006/R06). Evaluations of the residual concentrations of contaminants at the remaining AOCs could be performed as a separate task outside the scope of this BERA.

The AOCs where human health-based remediation is slated to occur in the future are:

Line 1 (IAAP-001/R01)	Line 6 (IAAP-007/R07)
Line 2 (IAAP-002/R02)	Line 8 (IAAP-009/R09)
Line 3 (IAAP-003/R03)	Line 9 (IAAP-010/R10)
Line 3A (IAAP-004/R04)	Line 800 (IAAP-011/R11)
Lines 4A/4B (IAAP-005/R05)	Firing Site (IAAP-030/R22)
Roundhouse Transformer Storage Area (IAAP-040/R28)	

At these sites, a human health-based remediation may be protective of ecological risks. However, before remediation is completed, it will need to be determined if this is a reasonable assumption. These evaluations could be conducted separately from the BERA. However, as part of the ERA, ecological-based media concentrations (referred to as critical concentrations or CCs) were developed, which will be useful in evaluating whether the human health-based remediation will be protective of ecological health. These CCs are not remediation goals.

Several other AOCs are not included in this BERA, for various reasons. The Inert Disposal Area (IDA) (IAAP-020/R14) is not included because it is currently being used as a treatment area for contaminated soils from other parts of IAAAP. The Explosive Waste Incinerator (IAAP-025/R17) and the Demolition Area and the Deactivation Furnace (IAAP-021, IAAP-023/R15) were closed under RCRA and, therefore, are not addressed by this BERA. Past investigations did not verify the existence or location of possible past disposal activities at the Ammunition Box Chipper Disposal Area (R23), and therefore, it is not included.

Several additional AOCs have been designated at the IAAAP since the SI/RI. These include

- Line 2-GW (IAAP-002G)
- Line 3-GW (IAAP-003G)
- Line 4-GW (IAAP-004G)
- Line 9-GW (IAAP-010G)
- Explosives Disposal Area-GW (IAAP-012G)
- Inert Disposal Area-GW (IAAP-020G)
- Burn Cages, West Burn Pad-GW (IAAP-032G)
- Fire Training Pit-GW (IAAP-039G)
- Line 800 Pinkwater Lagoon-GW (IAAP-044G)
- Line 800 Pinkwater Lagoon (IAAP-044)
- Former Fuel Station USTs (IAAP-045)
- Off-Post Contamination Areas of Potential Concern (IAAP-046)
- Central Test Area (IAAP-047)

The groundwater AOCs are expected to discharge water into the surface water bodies. The comprehensive surface water and sediment investigation conducted in 2000 was completed in watersheds that could potentially be affected by the groundwater AOCs. The AOCs identified and investigated since the SI/RI are not addressed in this BERA.

Several radionuclides were analyzed for and detected at Line 1 (IAAP-001/R01) and the Firing Site (IAAP-030/R22). Background soil samples were also analyzed for gross alpha and gross beta. Evaluation of the impact of radionuclides on biota at IAAAP is not addressed in this BERA. The radionuclides were detected only at the Firing Site Area and at Line 1. These areas have been accepted into the Formerly Utilized Sites Remedial Action Program (FUSRAP) for assessment and cleanup as applicable. The assessment of these two areas to determine the presence of radionuclides above actionable levels has not yet begun. If actionable levels are present, the determination of cleanup levels would include both ecological and human health risk assessments. However, this is not part of the scope of this ERA.

Partial clean-up operations have been conducted at some other sites, including Line 1, Line 6, and Line 800. However, sources of backfill material at some of these locations are not known and follow-up soil sampling detected explosives in some samples (ECC, 2001). Therefore, these AOCs have been retained for further assessment in this BERA.

The AOCs retained for further assessment in this BERA are listed below. The list includes AOCs that are slated for remediation based on protection of human health.

- Line 1 (IAAP-001/R01)
- Line 2 (IAAP-002/R02)

- Line 3 (IAAP-003/R03)
- Line 3A (IAAP-004/R04)
- Line 4A/4B (IAAP-005/R05)
- Line 6 (IAAP-007/R07)
- Line 7 (IAAP-008/R08)
- Line 8 (IAAP-009/R09)
- Line 9 (IAAP-010/R10)
- Line 800 (IAAP-011/R11)
- Contaminated Waste Processor (IAAP-024/R16)
- Sewage Treatment Plant/Sludge Drying Beds (IAAP-026/R18)
- Fly Ash Landfill (IAAP-027/R19)
- Construction Debris Landfill (IAAP-028/R20)
- Line 3A Sewage Treatment Plant (IAAP-029/R21)
- Firing Site Area (IAAP-030/R22)
- Building 600-86 Septic System (IAAP-038/R26)
- Roundhouse Transformer Storage Area (IAAP-040/R28)
- Line 3A Pond (IAAP-041/R29)
- Fly Ash Disposal Area (IAAP-043/R30)

1.5. BERA ORGANIZATION

This BERA incorporates documentation of the tasks performed under the ERAA and the Draft Final SLERA, as well as the remaining tasks required in USEPA's eight-step approach.

The BERA is divided into sections as follows:

- Executive Summary - provides a concise summary of the methods, results, and conclusions of the BERA.

- Section 1.0, Introduction - provides a description of the project and site background, BERA scope and objectives, and organization of the BERA.

- Section 2.0, Problem Formulation - describes the results of the SLERA, environmental setting, and contaminants; establishes the assessment endpoints and measures of effect; and describes the CSM. This section in essence provides the overview of the environmental problems that the BERA will try to evaluate, along with the general approach that will be taken to complete the evaluation.

- Section 3.0, Exposure Analysis - develops exposure dose models, exposure factors, uptake factors, and exposure point concentration, which are used to estimate levels of chemical exposure for the ecological receptors that were selected during the problem formulation.

- Section 4.0, Effects Analysis - describes the effect data that was collected to evaluate whether a medium posed apparent toxic effects to a receptor or community of receptors. This includes a discussion of the rapid bioassessment protocol results, a summary of fish tissue analysis results, and other field observations.

- Section 5.0, Toxicity Assessment - presents the process used to develop TRVs. The TRVs are used as measures of the toxic potential of each chemical to specific receptors, and are based on literature studies rather than direct measures of effects in the field at IAAAP.

- Section 6.0, Risk Characterization - describes procedures used to characterize potential ecological risks by ecological receptor or community of receptors. Within this section, the results of the ecological risk for each AOC and watershed are presented.

- Section 7.0, Uncertainty - discusses uncertainties inherent in the ERA process, so that the potential risks can be put into perspective.

- Section 8.0, Conclusions and Recommendations - summarizes the results of the BERA and provides recommendations based on the results.

- Section 9, References - provides the references for the sources of information and guidance used to complete the BERA.

Appendices provide the data and evaluations, which support the BERA. Appendices are:

- Appendix A, SLERA - contains the results of the Draft Final SLERA and RTCs for USEPA comments on the Draft SLERA. The SLERA provides the screening evaluation leading to selection of COPECs for the BERA, and to focus the scope of the BERA.

- Appendix B, TM - contains the six TMs that were produced by the ERA Planning Team, which contain many of the methods used and the approach to the SLERA and the BERA.

- Appendix C, Soil Analytical Data - includes soil sampling locations and soil background data.

- Appendix D, Surface Water and Sediment Data

- Appendix E, Fish Tissue and Benthic Invertebrate Data

- Appendix F, Fate and Transport Data by AOC - contains detailed information about the fate and transport of chemical effected media within each AOC and how this might potentially effect the watersheds within IAAAP. This information is used within Section 2, Problem Formulation, of the BERA to develop an appropriate CSM.

- Appendix G, TRVs and Uptake Factors - includes TRVs and uptake factors for the COPECs required for risk calculations.

- Appendix H, Ecotoxicity Profiles - contains discussions of the toxic effects of each of the COPECs.

- Appendix J, Risk Calculations - includes exposure point concentrations, exposure parameters, and risk calculations at each AOCs and watersheds.

- Appendix K, Response to Comments on Draft BERA- includes response to USEPA and USFWS comments.

- Appendix L, IAAP-006/R06 Residual TNT Concentrations.

2.0 PROBLEM FORMULATION

Step 3 of the Superfund ERA process is BERA problem formulation. Problem formulation, as stated in ERAGS (USEPA, 1997), establishes the goals, breadth, and focus of the BERA. It also establishes assessment endpoints, or the specific ecological values to be protected. Within this step, questions and issues that need to be addressed in the BERA are defined based on potentially complete exposure pathways and ecological effects. This is embodied in a CSM for the site. The CSM relates the relevant site data on contamination, chemical fate and transport, and ecology of the site and surrounding area into one cohesive diagram that ties the contamination at the site to selected assessment and measurement endpoints. The assessment and measurement endpoints are selected to determine whether the contamination present at the site has the potential to affect valued ecological resources. This is discussed in more detail later in this section.

Problem formulation is an iterative process. Two iterations of problem formulation occurred prior to the final problem formulation for the BERA. First, an informal problem formulation step was completed as part of the ERAA. This predated the work conducted in conformance with ERAGS, which was ultimately used to develop the BERA. The second problem formulation iteration was completed for development of the SLERA. Problem Formulation for the SLERA is provided in Section 2.0 of Appendix A1. This contains supporting information used for problem formulation in the BERA, specifically:

- Physical Description – provides a summary of the geology and hydrogeology of the site, and the watersheds located within IAAAP.

- General Ecological Site Description –provides an overview of the terrestrial and aquatic habitats within IAAAP.

These are not repeated in this BERA.

As part of the ERA process, if the decision is made at the first SMDP to continue the assessment beyond the SLERA (i.e. to complete the BERA), then the preliminary problem formulation from the SLERA is updated to form the problem formulation for the BERA. The BERA problem formulation is developed in light of the SLERA results. At IAAAP, the SLERA was completed retroactively to address new USEPA guidelines. New information has not been collected since the time the SLERA was performed. For this reason, the primary difference between this BERA problem formulation and the SLERA problem formulation is that the CSM has been further detailed and evaluates specific ecological receptors. The SLERA problem formulation is more general, given its more limited objectives.

Based on the results of the SLERA, the ERA team decided to move forward with the facility-wide BERA for IAAAP. The ERA Team reviewed a draft version of the SLERA and provided comments, which are incorporated into the version contained in Appendix A1.

The BERA problem formulation focuses on specific goals and establishes the scope of the assessment. The specific assessment endpoints and measurement endpoints were documented in TM 1 (Appendix B1) and were developed in 1999 before additional surface water and sediment data were collected. The BERA problem formulation is provided in this section, updated from the SLERA and based on the planning conducted for the BERA (i.e. TM 1, 2, 3, 4, and TRV Memo), findings of the 2000 surface water and sediment investigation, and results of the SLERA. It provides an integration of available information, including an overview of the ecological problem evaluated in the BERA, a discussion of the assessment and measurement endpoints selected for the BERA, and an update to the CSM.

2.1 INTEGRATION OF AVAILABLE INFORMATION

Much information has been collected and evaluated related to the ecology of IAAAP prior to performing the facility-wide BERA. This section provides an integration of available information that has been collected to date, leading to an overview of the ecological problem at IAAAP. A summary of the SLERA is provided first, followed by a discussion of the general ecology of IAAAP, along with the fate and transport of the COPECs within the ecological habitats. This information sets the stage for selecting the assessment and measurement endpoints for the BERA.

2.1.1 Summary of the SLERA

The SLERA was a screening level assessment that evaluated potential ecological risks to both the terrestrial and the aquatic environments at IAAAP. The Revised SLERA is contained in Appendix A1.

For terrestrial environments associated with specific soil AOCs, a screening level assessment was conducted which compared maximum analyte concentrations to conservative, ecologically based SVs for soils. The SVs were initially documented in TM 3, and later updated in the SLERA. For each AOC, a toxicity-based screening was performed and summarized. For each analyte, the ratio of the maximum analyte soil concentration to the soil SV was calculated, and is referred to as a hazard quotient (HQ). If a HQ is greater than 1, the constituent has failed the toxicity screen. A comparison to background analyte concentrations also was performed to determine if certain metals were present at background concentrations. If the maximum concentration of an inorganic analyte in an AOC was above its SV (i.e., HQ>1) and its background criterion, and it is not an essential nutrient, then it was considered a COPEC. Common laboratory contaminants, such as bis(2-ethylhexyl)phthalate (BEHP), were retained as COPECs if not specifically identified by the laboratory as being present as an artifact of laboratory contamination. The COPECs represent the constituents that were carried forward into the BERA for further evaluation. If a constituent is selected as a COPEC, it only means that it needs to be evaluated further within the BERA to determine whether it poses an ecological risk. The SVs used for the SLERA were selected to conservatively represent constituent concentrations that could potentially be a concern to even sensitive terrestrial receptors. However, within the BERA, more specific evaluations are performed for specific receptors applicable to IAAAP and considered valued as an ecological resource.

An analogous approach was used for the aquatic environments at IAAAP. A watershed approach was used for this evaluation because a number of AOCs could potentially affect one or more of the watersheds at IAAAP. The concept adopted for this assessment was that as long as the watershed as a whole was protected, the aquatic environment would be protected. The four watersheds evaluated were:

- Long Creek
- Skunk River
- Brush Creek
- Spring Creek

The Little Flint Creek is not included for evaluation in the BERA because the drainage area is primarily upstream of activities at the IAAAP and not impacted by release of contaminants. For each watershed, the maximum surface water and sediment concentration was compared to the ecologically based surface water or sediment SV. Unlike the terrestrial environment, background metals data was not available because there are no appropriate background locations on-site. Similar to the selection of soil COPECs, essential nutrients were not selected as COPECs. Common laboratory contaminants, such as BEHP, were retained as COPECs if not specifically identified by the laboratory as being present as an artifact of laboratory contamination. Constituents detected at a low frequency (5 percent or less) in surface water and sediment were reviewed further to determine if they were also detected in any of the source areas (e.g. soil AOCs). Constituents detected at a low frequency in surface water or sediment, but not identified as soil COPEC, were eliminated from further consideration as COPECs. There were several constituents detected at a low frequency in sediment, however, these constituents were retained as COPECs because they were also detected in the source area.

Three chemicals were detected at a frequency of less than 5 percent in surface water, and not at all in other media. These include 2,4-D (one in 27 samples), 2,4-DB (one in 27), and pentachlorophenol (one in 27). The 2,4-D detection was at LC1, upgradient of Long Creek. None of these constituents were detected in any of the source areas. One of the concerns generally raised, with regard to eliminating COPECs based on frequency of detection, is that there may be a cluster of samples in one part of the site (or stream) where the specific constituent was detected that would indicate the presence of a hot spot area. This particular concern is not applicable for these three constituents because there was only one detection of each constituent. Therefore, these three analytes were eliminated as COPECs in surface water. There were several other constituents detected at low frequency (less than 5 percent) in surface water, however, these constituents were retained as COPECs because they were also detected in the source area.

The results of the SLERA indicate that a number of chemicals are present at IAAAP at levels above their respective SVs, indicating that further ecological evaluation of these COPECs is required within the BERA. The selected COPECs for soil, surface water, and sediment are listed in Tables 2-1 and 2-2. Metals and explosives are the primary COPECs, while pesticides and VOCs are COPECs at selected AOCs and watersheds.

Table 2-1

Summary of COPECs – IAAAP Surface Water and Sediment

Brush Creek Sediment	**Brush Creek Surface Water**	**Long Creek Sediment**	**Long Creek Surface Water**
1,3,5-Trinitrobenzene	2-Amino-4,6-Dinitrotoluene	Aluminum	2-Amino-4,6-Dinitrotoluene
2,4,6-Trinitrotoluene	4-Amino-2,6-Dinitrotoluene	Arsenic	4-Amino-2,6-Dinitrotoluene
2,4-Dinitrotoluene	Arsenic	Barium	Arsenic
2-Amino-4,6-Dinitrotoluene	Barium	Beryllium	Barium
4-Amino-2,6-Dinitrotoluene	Beryllium	Cadmium	Beryllium
HMX	Bis(2-Ethylhexyl) Phthalate	Copper	Bis(2-Ethylhexyl) Phthalate
RDX	Cadmium	Lead	Cobalt
Aluminum	Cobalt	Manganese	Copper
Barium	Copper	Nickel	Lead
Beryllium	Lead	Selenium	Manganese
Manganese	Mercury	Thallium	Selenium
Selenium	Selenium	Vanadium	Silver
Silver	Silver		Thallium
Vanadium	Thallium		Zinc
Toxaphene	Zinc		

Table 2-1 (Continued)

Summary of COPECs – IAAAP Surface Water and Sediment

Spring Creek Sediment	Spring Creek Surface Water	Skunk River Sediment	Skunk River Surface Water
Bis(2-Ethylhexyl) Phthalate	Arsenic	Aluminum	Barium
Aluminum	Barium	Barium	Beryllium
Arsenic	Beryllium	Beryllium	Lead
Barium	Cobalt	Manganese	Selenium
Beryllium	Copper	Silver	Zinc
Cadmium	Lead	Vanadium	
Chromium	Manganese		
Copper	Selenium		
Lead	Silver		
Manganese	Zinc		
Mercury	4,4'-DDT		
Nickel			
Selenium			
Silver			
Vanadium			
Zinc			
4-methylphenol			

Table 2-2

Summary of COPECs – IAAAP Surface Soil

IAAP-001/R01	IAAP-002/R02	IAAP-003/R03	IAAP-004/R04	IAAP-005/R05	IAAP-007/R07
1,2,4-Trimethylbenzene	1,3,5-Trinitrobenzene	1,3,5-Trinitrobenzene	1,3,5-Trinitrobenzene	2,4,6-Trinitrotoluene	2,4,6-Trinitrotoluene
1,3,5-Trinitrobenzene	1,3-Dinitrobenzene	1,3-Dinitrobenzene	1,3-Dinitrobenzene	Barium	Antimony
1,3-Dinitrobenzene	2,4,6-Trinitrotoluene	2,4,6-Trinitrotoluene	2,4,6-Trinitrotoluene	Cadmium	Arsenic
2,4,6-Trinitrotoluene	2,4-Dinitrotoluene	2,4-Dinitrotoluene	2,4-Dinitrotoluene	Chromium	Barium
2,4-Dinitrotoluene	Anthracene	2,6-Dinitrotoluene	Bis(2-Ethylhexyl) Phthalate	Cobalt	Cadmium
2-Amino-4,6-Dinitrotoluene	Arsenic	4,4'-DDT	Cadmium	Manganese	Chromium
4-Amino-2,6-Dinitrotoluene	Barium	Aldrin	Chromium	Mercury	HMX
Anthracene	Benzo(a)anthracene	Anthracene	HMX	Thallium	Lead
Antimony	Benzo(a)pyrene	Antimony	Lead		Mercury
Aroclor 1260	Bis(2-Ethylhexyl) Phthalate	Arsenic	Manganese		Nickel
Arsenic	Cadmium	Barium	Mercury		RDX
Barium	Carbazole	Benzo(a)anthracene	Niobium		Silver
Benzo(a)anthracene	Chromium	Benzo(a)pyrene	RDX		Thallium
Benzo(a)pyrene	Chrysene	Bis(2-Ethylhexyl) Phthalate	Selenium		
Benzo(b)fluoranthene	Cobalt	Cadmium	Silver		
Benzyl Butyl Phthalate	Dibenzofuran	Carbazole	Thallium		
Bis(2-Ethylhexyl) Phthalate	Fluoranthene	Chromium			
Cadmium	HMX	Chrysene			
Carbazole	Lead	Cobalt			
Chromium	Manganese	Copper			
Chrysene	Mercury	Dibenzofuran			
Cobalt	Naphthalene	Dieldrin			
Copper	Niobium	Endrin			
Dibenzofuran	Phenanthrene	Fluoranthene			
Fluoranthene	Pyrene	Gamma-BHC			
HMX	RDX	HMX			
Lead	Selenium	Lead			
Manganese	Silver	Manganese			
Mercury	Tetryl	Mercury			
Naphthalene	Thallium	Naphthalene			
Nickel	Toluene	Nickel			
Phenanthrene	Vanadium	Niobium			
Pyrene	Zinc	Phenanthrene			
RDX		Pyrene			
Selenium		RDX			
Silver		Selenium			
Thallium		Silver			
Toluene		Thallium			
Vanadium		Vanadium			
Zinc		Zinc			

Table 2-2 (Continued)

Summary of COPECs – IAAAP Surface Soil

IAAP-008/R08	IAAP-009/R09	IAAP-010/R10	IAAP-011/R11	IAAP-024/R16	IAAP-026/R18	IAAP-027/R19
2,4,6-Trinitrotoluene 4,4'-DDD 4,4'-DDT Aldrin Aroclor 1260 Cadmium Chromium Copper Dieldrin Fluoranthene Mercury Phenanthrene Pyrene RDX Thallium Toluene Zinc	Aroclor 1254 Cadmium Chromium Lead Mercury Pyrene Thallium	Arsenic Beryllium Cadmium Chromium Mercury Thallium Vanadium	1,1,1-Trichloroethane 1,3,5-Trinitrobenzene 1,3-Dinitrobenzene 2,4,6-Trinitrotoluene 2,4-Dinitrotoluene 2,6-Dinitrotoluene 2-Amino-4,6-Dinitrotoluene 4,4'-DDE 4,4'-DDT Antimony Arsenic Barium Bis(2-Ethylhexyl) Phthalate Cadmium Chromium Cobalt Fluoranthene HMX Lead Manganese Mercury Pyrene RDX Thallium Zinc	2,4,6-Trinitrotoluene HMX RDX	4,4'-DDT Aldrin Aroclor 1260 Cadmium Chromium Dieldrin Endrin Mercury Silver	Arsenic Selenium

Table 2-2 (Continued)

Summary of COPECs – IAAAP Surface Soil

IAAP-028/R20	IAAP-029/R21	IAAP-030/R22	IAAP-038	IAAP-040/R28	IAAP-041/R29	IAAP-043/R30
1,3-Dinitrobenzene	4,4'-DDT	Arsenic	Cadmium	4,4'-DDD	Cobalt	Cadmium
4,4'-DDD	Endrin	Barium	Chromium	4,4'-DDE	Manganese	Mercury
4,4'-DDE	Silver	Cadmium	Fluoranthene	4,4'-DDT		
4,4'-DDT		Chromium	Mercury	Aroclor 1260		
Aroclor 1254		Copper	Phenanthrene	Dieldrin		
Dieldrin		HMX		Endrin		
HMX		Lead		Fluoranthene		
		Mercury		Pyrene		
		Nickel				
		RDX				
		Silver				
		Thallium				
		Zinc				

Dieldrin and heptachlor epoxide were not selected as COPECs in surface water and sediment in the SLERA. However, both of these compounds were detected in fish tissue samples. As a conservative approach, dieldrin and heptachlor epoxide were included for dose modeling to estimate uptake as a food source for the belted kingfisher. In addition, potential impact on the orangethroat darter from exposure to dieldrin and heptachlor epoxide is also evaluated.

2.1.2 General Description of Ecological Habitats and Fate and Transport of COPECs

The revised SLERA provides detailed description of the ecological habitats within IAAAP, and Appendix F contains a detailed description of the nature and extent of contamination by AOC and watershed, along with information on the fate and transport of COPECs. A summary of the information presented in Appendix F is provided below.

Soil AOCs are the potential source areas for contamination. Soil AOCs are located within the watersheds, with some draining into more than one watershed. The habitats around the AOCs are variable. Forests, agricultural land, ruderal areas, and other habitats suitable for terrestrial and aquatic receptors exist throughout IAAAP. Appendix F discusses specific migration pathways and migration potential of contaminants to the streams and identification of habitats within AOCs and along migration pathways. Numerous constituents were detected in soils at the AOCs during the SI and the RI. Explosives and metals were most common. Others included Aroclor1260, polyaromatic hydrocarbons (PAHs), pesticides, and BEHP. At most of the AOCs, soil contaminants appear to be localized within the physical boundary of the AOCs. However, some AOCs, particularly those containing high concentrations of explosives, appear to have acted as source areas for surface water and sediment contamination to the streams.

The surface water and sediment sampling locations selected for this BERA provided coverage of all major streams across the plant property. Sampling locations on the watersheds were selected downstream of all of the AOCs identified in the SI/RI. For example, Tables F-1 and F-18 lists sample locations in the Long Creek and Brush Creek watersheds, which are downgradient of Line 800 (including the Pink Water Lagoon).

The following is an overview of the ecological habitats pertinent to the BERA for both the terrestrial and aquatic environments.

2.1.2.1 Terrestrial Habitats

Based on the nature of the operations at IAAAP, there are groups of buildings associated with present or past operations (e.g., load lines) that are separated by large areas of terrestrial habitat. The terrestrial habitats between the load lines are composed of forests, prairies, industrial and ruderal areas, and agricultural croplands. Forest types can be separated into floodplain and upland forests, with the former predominating. Agricultural uses include row crops, corn and soybeans, and pasture for beef production.

Most of the AOC-specific ecological evaluations at IAAAP focus on the terrestrial environment directly adjacent to the operational facilities, which is where soil contamination is primarily located. This is because the primary COPECs at the site are metals and explosives, which in soil, generally do not migrate a great distance from where they are discharged. The discharge of the metals and explosives to the terrestrial environment has generally occurred in the immediate area of the buildings producing or handling explosives. The terrestrial environments around these operational facilities are managed, to a certain degree, to control vegetation growth, and thus, are distinctively different than the terrestrial habitat at distances. Thus, the majority of the high quality terrestrial habitat at IAAAP is removed from the facility operations and from areas where known or suspected soil contamination occurs. Therefore, the focus of the evaluation of the terrestrial habitats in the BERA is on somewhat managed terrestrial habitats that occur near the facility operations, rather than in the more forested areas of IAAAP. The terrestrial habitats located adjacent to facility operations are vegetated where buildings and pavement do not occur, and are utilized by small- and medium-sized mammals, such as rodents and raccoons. Avian species also use the areas to forage for food and to nest.

URS (2003) identified general habitats during the remedial investigation at off-site locations, which is summarized in this paragraph. The study area of the off-site investigation is located southeast of the IAAAP property near the intersection of Brush Creek and Highway 61. Cropland dominates the off-site area landscape, which is planted with corn, soybeans, winter wheat, and alfalfa and pasture grasses. Areas along U.S. Highway 61, and north of the Skunk River adjacent to cropland, are restored grassland with vegetation consistent with reseeded grassland areas. The Skunk River, several oxbow lakes, ponds, gravel pits and creeks scattered throughout the off-site areas are open water wetlands. An area north of the Skunk River is identified as a palustrine emergent wetland with vegetation consistent with a non-forested wetland. There are industrial areas along U.S. Highway 61 (along with farmstead and residential areas) throughout the off-site area having vegetation consistent with heavily disturbed areas. Lowland forest was identified in the north and south of the Skunk River, which is woodland vegetation consistent with riparian/lowland areas. North of the Skunk River floodplain is upland forest with woodland vegetation consistent with upland areas.

The terrestrial habitats within the BERA have been evaluated and some are already slated for remediation on the basis of the protection of human health. Therefore, although plants and animals live in the areas adjacent to the AOCs, remediation may occur that would destroy much of the present habitat for a period of time. Typically, at AOCs where remediation has already been completed to protect human health, contaminated soils were excavated and removed, and the excavations were backfilled with clean fill. In many cases, the factor that dictated the extent of remediation has been the transport of the most mobile analyte present at the AOC (generally RDX) both vertically and laterally in the soil environment. This has required excavation of the soils well below the 2-foot depth usually evaluated for ecological risk, and laterally a distance that, for all practical purposes, has removed other contaminants. Thus, when the more mobile COPEC is removed, the other less mobile COPECs are removed as well. This parallels the likely outcome of future remediation at other AOCs where RDX and lead will likely drive the extent of remediation. The remediation goals for RDX, and lead in the ROD, based on human health, will likely be less than concentrations required to protect the ecology of the area. As discussed in Section 6, the TNT soil concentration that would be protective of ecological health, might be less than the human health RG for TNT. However, the residual concentrations of TNT may not pose an ecological concern, if RDX concentrations control the limits of contamination at a site. Under this scenario, remediation of a site to the RDX human health RG, might also remediate TNT concentrations that could potentially pose an ecological concern. This assumption will need to be verified for those sites where remediation has occurred or is planned. However this evaluation is outside the scope of this BERA.

Based on this larger picture of the terrestrial AOCs, the main questions that need to be evaluated are as follows:

- Do the COPECs identified in the SLERA for a particular AOC actually pose a potential risk to ecological receptors in the terrestrial environment?

- If there is potential ecological risk within an AOC, will it be mitigated by remediation designed to protect human health?

The second question is important because, even if there is a potential ecological concern at an AOC, further evaluation may not be warranted. The concerns may be mitigated as part of the remediation to protect human health. Functionally, this becomes a powerful approach to handle ecological risks at AOCs, because there is already a ROD in place, which mandates soil remediation goals to protect human health.

2.1.2.2 Aquatic Habitats

The aquatic habitats evaluated in the BERA include the sections of Long Creek, Brush Creek, and Spring Creek that flow within IAAAP, along with any related tributaries and tributaries to the Skunk River. Because of IAAAP's large size, some of the headwaters of these streams and tributaries originate within the boundaries of IAAAP. These streams primarily flow through deciduous forests and deciduous wetland swamps, and are removed some distance from the soil AOCs. These streams provide habitat for a wide variety of aquatic receptors, including fish, benthic invertebrates, and amphibians. Wildlife and avian species use the streams as a source of water and food. Noteworthy is the presence of the State-endangered orangethroat darter.

The primary COPECs identified within the streams were metals and explosives. In collecting surface water and sediment data for purposes of the BERA, the focus of the evaluation was to determine if COPECs identified at the AOCs had migrated to the streams. For this reason, the surface water and sediment samples were biased toward areas where surface water runoff from AOCs would most likely occur within the streams. These samples were supplemented with additional sample locations along the other reaches of the stream to provide a broad view of the nature and extent of chemical constituents that might have been transported from the AOCs. Soil and sediment data collected along drainageways leading to the streams were also used as evidence to evaluate whether chemical transport was occurring between the AOCs and the streams. A detailed evaluation of the likelihood for chemical transport, along with a discussion of the nature of the soil and related sediment and surface water results, is provided in Appendix F. However, this evaluation was not used alone to eliminate any constituent detected in surface water or sediment from further consideration as a COPEC

Unlike the terrestrial habitats evaluated adjacent to AOCs where facility operations occur, the stream habitats have relatively minimal human impact and provide high quality aquatic habitat. There is no current plan for remediation to address chemical contamination in these sensitive aquatic habitats where remediation might cause more harm than the contamination. Instead, emphasis has been placed on evaluating the potential for these aquatic habitats to be harmed by facility operations. These stream habitats would not be remediated based on the potential to cause destruction of the habitat, unless there was compelling evidence to suggest that remediation could correct some ecological problem caused by IAAAP operations.

Based on protecting the ecology of the aquatic habitats, the main ecological questions that need to be evaluated for the BERA are:

- Do the COPECs that were identified in the SLERA for a particular stream actually pose a potential risk to ecological receptors in the aquatic environment?

- If there is potential ecological risk within a stream, is the risk isolated to a particular reach of the stream that might be associated with migration of COPECs from a particular AOC?

The second point is important because, if a particular external source of COPECs can be identified as the source of the potential ecological risk, remediation of the sources at the AOCs may with time correct the potential effects that have occurred. While it is beyond the scope of this BERA to evaluate the effectiveness of remediation and its potential to reduce future risks in the stream at a particular AOC, it is possible to point out potential problem AOCs.

2.2 ASSESSMENT ENDPOINTS

Assessment endpoints are “explicit expressions of environmental values to be protected” (USEPA, 1992a). The purpose of identifying assessment endpoints is to focus the BERA and define the scope of the assessment. Because assessment endpoints are environmental values, they are often location sensitive. Thus, stakeholder input is a vital step in establishing assessment endpoints that are responsive to local societal values, as well as broader environmental goals. The assessment endpoints selected by the ERA Team (including stakeholders) are presented in TM 1 (Appendix B1), a working memorandum developed to facilitate review and concurrence on the general approach in the BERA. As part of the selection process, five specific management goals were outlined. These five management goals were used as a guide to establish the assessment endpoints for the BERA, and are:

- Protect the biological, physical, and chemical integrity of aquatic habitats;
- Protect the biological integrity of piscivorous waterfowl populations;
- Protect sensitive species;
- Protect the biological integrity of terrestrial herbivore populations; and
- Protect the native wildlife species.

Exposures to COPECs in soil, sediment, and surface water were considered potentially significant based on the SLERA. Assessment endpoints were developed for both the terrestrial and aquatic environments to address the potential ecological problems discussed in Section 2.1, and to meet the management goals presented above. The assessment endpoints are discussed below.

2.2.1 Terrestrial Habitats

As note previously, evaluation of terrestrial habitats focused on areas adjacent to AOCs, where the most significant contamination occurs. Two assessment endpoints for addressing the IAAAP's natural resource management goal of sustaining native wildlife species include:

- Survival, growth, and reproduction of terrestrial herbivores - the white-footed mouse is used as the representative of this guild; and,

- Survival, growth, and reproduction of terrestrial vermivores/carnivores - the short-tailed shrew is used as the representative of this guild.

Another assessment endpoint included to protect sensitive species was:

- Survival, growth, and reproduction of terrestrial insectivores - the Indiana bat is used as the representative of this guild because of its special status.

2.2.2 Aquatic Stream Habitats

To protect the ecological integrity of IAAAP streams, the selected assessment endpoints are:

- Survival, growth, and reproduction of orangethroat darters;
- Maintenance of the benthic community structure; and
- Survival, growth, and reproduction of aquatic algae.

To protect biological integrity of wildlife species using the stream environments for food and water, the selected assessment endpoint is:

- Survival, growth, and reproduction of aquatic piscivores - the belted kingfisher is used as the representative of this feeding guild.

To protect sensitive species, the selected assessment endpoint is:

- Survival, growth, and reproduction of aquatic insectivores - the Indiana bat is used as the representative of this feeding guild because of its special status.

2.3 MEASUREMENT ENDPOINTS

Measurement endpoints are measurable characteristics that can be used to infer impacts to assessment endpoints. Measurable characteristics are often in the form of in situ or ex situ toxicity tests, or field community evaluations in comparison with a reference site. Measurement endpoints can be categorized as measures of exposure (e.g., tissue body burdens) and measures of effects (e.g., toxicity tests).

Measurement endpoints were selected to relate to the assessment endpoints established during the BERA problem formulation previously presented. The measurement endpoints were selected based on:

- Representativeness of receptors included in the assessment endpoint;
- Sufficient sensitivity (e.g., life history, habitat, and behavioral considerations);
- Relationship to the contaminant(s) of concern; and
- Mechanisms of ecotoxicity.

The measurement endpoints for each of the assessment endpoints were discussed among the ERA Team members and documented in TM 1. A summary of the measurement endpoints for each assessment endpoint is included in Table 2-3.

Table 2-3
Summary of Assessment and Measurment Endpoints
BERA - IAAAP

Assessment Endpoint	Measurement Endpoints	
	Measures of Exposure	Measures of Effect
1. Survival, growth and reproduction of terrestrial carnivores foraging in the terrestrial habitat adjacent to AOCs at IAAAP, using the short-tailed shrew as the representative of this feeding guild.	Soil analytes concentrations, modeled invertbrate analyte concentrations, and modeled shrew dose	NOAEL and LOAEL based HQs
2. Survival, growth and reproduction of terrestrial herbivores foraging in the terrestrial habitat adjacent to AOCs at IAAAP, using the white-footed mouse as the representative species of this guild.	Soil analytes concentrations, modeled vegetation analyte concentrations, modeled mouse dose	NOAEL and LOAEL based HQs
3. Survival, growth and reproduction of sensitive terrestrial insectivores foraging in the terrestrial habitat adjacent to AOCs at IAAAP, using the Indiana Bat as the representative species of this guild.	Soil analytes concentrations, modeled insects analyte concentrations, modeled Indiana Bat dose	NOAEL and LOAEL based HQs
4. Maintain the benthic community structure within the streams of IAAAP.	Total and dissolved surface water concentrations, and sediment analyte concentrations	NAWQC, RBP II metrics
5. Survival, growth and reproduction of orangethroat darters within the streams of IAAAP.	Total and dissolved surface water concentrations, sediment analyte concentrations, and fish tissue analyte concentrations	NAWQC, RBP II metrics, Laboratory-derived chronic effects levels, Fish DELTs
6. Survival, growth and reproduction of aquatic algae within the streams of IAAAP.	Total and dissolved surface water concentrations, and sediment analyte concentrations	Laboratory-derived chronic effects levels
7. Survival, growth and reproduction of aquatic piscivores foraging in the streams habitats within IAAAP, using the belted kingfisher as the representative species of this feeding guild.	Water and sediment analyte concentrations, fish tissue analyte concentrations, modeled avian dose	NOAEL and LOAEL based HQs
8. Survival, growth and reproduction of aquatic insectivores foraging within the stream habitat of IAAAP, using the Indiana bat as the representative species of this feeding guild.	Water and sediment analyte concentrations, modeled flying insect analyte concentrations, modeled bat dose	NOAEL and LOAEL based HQs

2.4 CONCEPTUAL SITE MODEL

2.4.1 Overview of CSM

The CSM for the facility-wide BERA was considered the most efficient way of tying together the threads of logic used for selecting specific assessment and measurement endpoints for the IAAAP BERA. The CSM incorporates both past and new information into the assessment.

The CSM includes a summary of those exposure pathways that are potentially complete (i.e. where ecological receptors are exposed to the COPECs within a medium or multiple media). The CSM includes the specific assessment and measurement endpoints discussed in Sections 2.2 and 2.3. The selection of assessment and measurement endpoints was based on the nature of the COPECs and ecology of IAAAP, the five specific management goals for IAAAP, and the input provided by the ERA Team (including stakeholders).

Figure 2-1 provides an overview of the CSM showing the sources of COPECs, exposure pathways, and ecological receptors. Primary sources of COPECs at IAAAP are the ordnance production lines, waste management sites, and burning/detonation sites.

COPECs leave these areas via atmospheric releases; infiltration to groundwater; surface runoff from spillage, rain runoff, and soil erosion; and NPDES discharges. These release mechanisms result in surface and subsurface soil contamination that can act as secondary sources. Runoff and leaching of COPECs from soils result in migration of COPECs to surface water/sediment, surface soil, and groundwater. Groundwater at the site eventually drains into one of the five watersheds.

Primary receptors exposed to soil COPECs include soil macroinvertebrates, vegetation, and burrowing animals. Terrestrial receptors include both plants and animals. Plant uptake of COPECs directly from the soil, as well as direct incidental ingestion of soil containing COPECs, provide entry to the terrestrial food chain. Some COPECs are slow to degrade and may pose a risk for years or decades following their release into the environment. If the COPEC is also hydrophobic (having an affinity for dissolution in oil or fatty tissue), it will tend to biomagnify with trophic level and pose the greatest threat to secondary receptors. Secondary receptors are those animals that are exposed to the COPECs through ingestion of prey containing COPECs, rather than directly from the media (e.g., soil or surface water).

Primary receptors exposed to surface water/sediment include benthic macroinvertebrates, vegetation, and fish. Aquatic receptors are exposed in streams by direct contact with COPECs in the water and sediment. Ingestion by these exposed receptors can lead to transport of the chemicals up the food chain, depending upon the COPECs characteristics.

Numerous secondary receptors can accumulate chemicals from media and plants and animals in their diet. However, Figure 2-1 shows only the secondary receptors selected for quantitative risk estimation to satisfy specific assessment/measurement endpoints combinations are shown in Figure 2-1.

A CSM was developed for both the terrestrial and the aquatic environments at IAAAP. This information is further developed in specific sections within the CSM that detail the relationship between the assessment and measurements endpoints and the rationale for selecting the receptor used to evaluate these endpoints.

Figure 2-1 shows the complete and significant exposure pathways. These exposure pathways are more specifically discussed later within this CSM. Exposures to some receptors are not expected to be significant for several of the complete pathways. Also, some exposure pathways may not be significant for any of the receptors. Ingestion is the primary pathway through which secondary receptors are exposed to COPECs. Dermal contact and inhalation of COPECs are potentially complete exposure pathways for primary receptors, but the accumulated doses are expected to be insignificant compared to those via the ingestion pathway. In addition, dermal contact and inhalation pathways cannot be evaluated because toxicity data are not available. The uncertainties associated with only evaluating the ingestion route of exposure will be further discussed in Section 7.0.

The CSM for the facility-wide BERA for IAAAP is split between the terrestrial ecosystem and the aquatic ecosystem because of the differences in the receptors in each of these environments, their potential for exposure to contamination, and their differences in sensitivity to the contaminants present. In addition, there is a ROD that mandates the remediation of soils at AOCs to specific remedial goals (RGs) for COPECs, but not within the aquatic environments. Therefore, a different level of ERA was considered appropriate for terrestrial and aquatic habitats. For the terrestrial habitat, less emphasis was put on field observations and studies of effects within the BERA. The rationale for this was that human health based remediation is already slated to occur at the soil AOCs, which will likely be protective of ecological receptors (see Section 6). In the aquatic environment, more detailed ecological evaluation was performed, including specific effects assessments. With further ecological evaluation, it might be possible to determine with more certainty whether the aquatic environments are at risk due to facility operations.

For each complete exposure pathway, only those analytes that were selected as COPECs within the SLERA were carried forward for further analysis within the BERA. Some analytes could not be evaluated due to lack of TRVs. These include beryllium, cobalt, and thallium for the belted kingfisher and carbazole for the white-footed mouse and short-tailed shrew. This is discussed in Section 7.0 of the BERA. Ecotoxicological effects of these four analytes, along with all other COPECs, are discussed in Appendix H.

The terrestrial and aquatic ecosystem CSMs are discussed in the following sections.

2.4.2 Terrestrial Ecosystem CSM

The terrestrial ecosystem CSM for IAAAP was developed to answer the following question:

- Do the COPECs that were identified in the SLERA for a particular AOC actually pose a potential risk to ecological receptors in the terrestrial environment?

To answer this question, assessment and measurement endpoints were selected for the primary exposure pathways. It was determined that the primary sources of the metals and explosives contamination in IAAAP soils were derived from the facility operations that occurred at each AOC. The primary exposure pathways considered potentially complete for the terrestrial ecosystem include:

- Vermivore/carnivore exposure to soils, water, and invertebrates;
- Invertebrate species exposure to soil; and,
- Herbivore exposure to plants, invertebrate, soil, and water.
- Insectivore exposure to flying insects

Other exposure pathways could be included, but these were considered to adequately address the potential for terrestrial receptors to be exposed. For open burning sites, the aerial deposition from the open burning operation would have likely been a minor source of contamination compared to the disposal of the materials that remained after the burn was complete. In addition, this was an exposure pathway that is historical in nature and does not occur any longer. For this reason, the air pathway was eliminated as one of concern, since most of these areas are now vegetated, preventing wind erosion of contaminated soils.

The assessment and measurement endpoints selected for each complete exposure pathway are discussed in the following sections, which provide how each of the exposure pathways have been assessed in the BERA.

2.4.2.1 Vermivore/Carnivore Exposure to Contaminated Soils, Water, and Invertebrates

Numerous species rely on invertebrates to provide a large portion of their food. North American mammals (e.g., shrews), reptiles, amphibians, and birds (e.g., robins) are known to consume significant quantities of invertebrates. Based on the chemical characteristics of the COPECs, i~~I~~nvertebrates may accumulate COPECs due to exposure to soil. Therefore, the vermivore/carnoivorous species may be exposed to contamination by ingestion of the contaminated soil and the contaminated invertebrates that live in the soil. Dermal contact and inhalation exposure would be less likely routes of exposure, because most contaminants at the site are not readily absorbed through the skin, and are nonvolatile.

The assessment endpoint selected for this exposure pathway is: *the survival, growth and reproduction of terrestrial vermivores/carnivores foraging in the terrestrial habitat adjacent to AOCs at IAAAP using the short-tailed shrew as the representative of this feeding guild.*

Being a voracious vermivore/insectivore, the short-tailed shrew should bioaccumulate contaminants from lower order accumulators (i.e., worms, insects, snails). Additionally, shrews are common prey for raptors and higher order carnivores. The shrew inhabits a wide range of habitats, but prefers cool, moist habitats because of their high metabolic and water loss rates, and (if habitat conditions are suitable) should be readily found in the floodplain areas of IAAAP (USEPA, 1993). Home ranges for shrews are, at most, one hectare, so body residues would reflect local exposures from contaminants. Nests are usually under rocks, logs, or other objects and connected to surface runways or tunnels that may be as deep as 20 inches (Jackson, 1961). Short-tailed shrews are primarily carnivorous; they feed mostly on earthworms that consume soil and invertebrates that consume plants and plant material.

The measurement endpoint selected to estimate whether this assessment endpoint is being achieved for vermivores was the calculation of HQs by analyte for the short-tailed shrew. Hazard quotients were calculated based on the average (95 percent UCL) concentration detected at an AOC. The HQs were calculated considering consumption of earthworms and incidental ingestion of soil. These HQs are used as the primary line of evidence for these receptors.

For the short-tailed shrew, the exposure estimates were used with toxicity data to predict HQs. The toxicity endpoints used to estimate the HQs were chronic NOAEL- and LOAEL- based TRVs for purposes of the risk calculations. The TRVs are based on growth, development, and/or reproductive effects for rodent species. The background associated with the selection of TRVs is described in Section 5.0.

2.4.2.2 Herbivore Exposure to Contaminated Soils, Invertebrate, Water, and Plants

Small mammals such as rodents and rabbits rely on plant material as their main source of food. These animals provide the primary food supply for carnivorous mammalian and avian species. Small herbivorous mammals may be exposed to contamination in the soil by direct ingestion of the soil and ingestion of plant material.

Dermal contact and inhalation exposure would be less likely routes of exposure for herbivores. The areas around the AOCs are either paved or thickly vegetated, such that dust would not be expected and dermal contact with the soils would be minimal.

The assessment endpoint selected for this exposure pathway is: *the survival, growth, and reproduction of terrestrial herbivores foraging in the terrestrial habitat adjacent to AOCs at IAAAP using the white-footed mouse as the representative species of this guild.*

The white-footed mouse (*Peromyscus leucopus*) has numerous similarities with the short-tailed shrew, and would serve as an equally suitable receptor for study. The white-footed mouse is similar in size and mass to the short-tailed shrew, and both are active in the day and night. However, the white-footed mouse is primarily a herbivore and its diet consists of seeds, other vegetation, and arthropods. It is abundant in areas with a canopy such as brushy fields and deciduous woodlots, and its home range is from 0.5 to 1.5 acres. The white-footed mouse usually nests in trees and shrubs, but may nest in rock crevices, underlogs, or in burrows dug by other species. Hawks, owls, snakes, and carnivorous mammals, including the short-tailed shrew, prey upon the white-footed mouse.

The measurement endpoint selected to estimate whether this assessment endpoint is being achieved is the calculation of HQs by analyte for the white-footed mouse. The toxicity endpoints for this assessment endpoint, and the approach used to apply toxicity data, are analogous to the vermivores/carnivores.

2.4.2.3 Insectivore Exposure to Contaminated Soil, Water, and Invertebrates

Numerous species rely on invertebrates to provide a large portion of their food. North American mammals (e.g., bats), reptiles, amphibians, and birds (e.g., robins) are known to consume significant quantities of invertebrates. These inveterate species may be exposed to COPECs in the terrestrial environment by ingestion, and pass the contamination onto insectivorous wildlife when they feed on these organisms. Dermal contact and inhalation exposure would be less likely routes of exposure, because primary COPECs, such as metals and explosives, are not readily absorbed through the skin and are nonvolatile.

The assessment endpoint selected for this exposure pathway is: *the survival, growth, and reproduction of sensitive species within the terrestrial habitat of IAAAP using the Indiana bat as the representative species of this feeding guild.*

The Indiana bat was selected as a receptor because it is an insectivore and a special-status species found on IAAAP. The Indiana bat was listed as endangered in 1967 because of declines observed in its major hibernacula believed to be due to human disturbance, potentially low birth rate, loss and degradation of summer habitat, and pesticides (USFWS, 2002). IAAAP (2003) discusses foraging and roosting behavior of Indiana Bat at the IAAAP. The Indiana bats were found primarily foraging along edges of agricultural fields, along and in the floodplain of the water bodies, and in forested areas around headwaters of the surface water bodies. The bats were found to spend some time around a stone quarry, although it is not clear if they are foraging or roosting in that area. Some of the bats were found to fly across an open field, but not forage there. The bats were not specifically found to forage near the production lines. The nature and extent of contamination around the production lines are limited to areas close to the lines that are not forested. Based on the foraging and roosting characteristics described in IAAAP (2003), the bats are not expected to forage around the AOCs. However, at the request of the USFWS, it is assumed in this BERA, that the bats are foraging in the AOCs. The Indiana bat eats flying insects. The Indiana bat also is expected to drink water from water bodies within the watershed in which specific soil AOCs are located.

The measurement endpoints selected to estimate, whether this assessment endpoint is being achieved, is the calculation of HQs for the Indiana bat. For this insectivorous species, the concentrations of COPECs in insects were modeled and used as input to develop exposure estimates. The toxicity endpoints for this assessment endpoint, and the approach used to apply toxicity data are analogous to the vermivores/carnivores.

2.4.3 Aquatic Ecosystem CSM

The aquatic ecosystem CSM for four of the watersheds at IAAAP was developed to answer the following two questions:

- Do the COPECs that were identified in the SLERA for a particular stream actually poses a potential risk to ecological receptors in the aquatic environment?

- If there is potential ecological risk within a stream, is the risk isolated to a particular reach of the stream that might be associated with migration of COPECs from a particular AOC?

The second question is addressed in Section 6 of the BERA, based on a spatial analysis of the distribution of the COPECs that are predicted to pose a health concern, along with observations on whether specific AOCs are associated with HQ exceedances of one.

To answer the first question, assessment and measurement endpoints were selected for the primary exposure pathways. The primary source of contamination in sediments and surface water was considered to be past erosion of contaminated soils from AOCs during storm events, and NPDES discharges to the streams. The primary exposure pathways that were considered potentially complete for the aquatic ecosystem include:

- Exposure of aquatic plants, aquatic insects, fish, birds, bats, and terrestrial mammals to surface water COPECs via ingestion or direct contact;
- Exposure of bats to COPECs via ingestion of aquatic insects and water;
- Exposure of benthic invertebrates, aquatic plants, fish, and aquatic mammals via ingestion of sediment; and,
- Exposure of birds to COPECs via ingestion of fish, water, and sediment.

Additional exposure pathways could be included, but these were considered to adequately address the potential for aquatic receptors (including threatened and endangered species) to be exposed to the contamination in the aquatic environments of IAAAP. Similar to the terrestrial ecosystem, the aerial deposition of dust from former operations would have likely been only a minor source of contamination to the aquatic ecosystem, because of the distance of these operations from the streams.

The following is a discussion of the assessment endpoint(s) and measurement endpoints that were selected for each complete exposure pathway and explain how these exposure pathways were evaluated in the BERA.

2.4.3.1 Benthic Invertebrate Exposure to Contaminated Sediment

The benthic community was selected as a key receptor because of its place in the food chain for fish, waterfowl, wading birds, and aquatic mammals. Because certain components of the benthos are sensitive to pollution, it is also frequently used to measure the health of the aquatic biological community. A healthy population of these aquatic organisms is essential for a balanced aquatic ecosystem. These organisms spend most of their life-cycle in contact with sediments. For this reason, sediments with elevated concentrations of constituents present a source of exposure to these organisms that could cause a health concern.

The assessment endpoint selected for this exposure pathway is: *to maintain the benthic community structure within the streams of IAAAP*.

For the benthic macroinvertebrate population, the measurement endpoints selected were a comparison of surface water concentrations (total and dissolved) to National Ambient Water Quality Criteria (NAWQC), and field evaluation of the streams using the Rapid

Bioassessment Protocol II published by USEPA (Plafkin, et al., 1989). Results of the bioassessment protocol with samples from each of the streams were compared to results from a reference location within the same stream.

2.4.3.2 Fish Exposure to Contaminated Surface Water

Fish constitute an important link in the aquatic food chain of many stream environments. A number of species of birds and animals rely on fish as a main portion of their diet. Therefore, it was considered important to maintain the health of the fish population in the aquatic environment. In addition, one of the management objectives was to maintain sensitive species at IAAAP. The orangethroat darter is known to live in a number of the streams at IAAAP, and this fish species is on the Iowa list of endangered species.

The assessment endpoint selected for this exposure pathway is: *the survival, growth, and reproduction of orangethroat darters within the streams of IAAAP*.

Typically, all fish species co-habitating in a water body are chosen as the generic receptor of interest. However, in this assessment an individual species, the orangethroat darter (*Etheostoma spectabile*), was selected as a key receptor in the aquatic environment because of its listing as a threatened species by the State of Iowa. Darters can bioaccumulate chemicals primarily from water, plankton, larvae, and other small fish. To assess the potential risk to the reproduction of orangethroat darter population, the levels of COPECs bioaccumulated in fish tissue and collected from IAAAP, were to be examined. However, because these fish are listed as a threatened species, tissue samples could not be collected. Instead, individuals of fantail and Johnny darters were collected as surrogates to measure mercury, explosives, and pesticide concentrations in tissue. Both have similar food habits as the orangethroat and are found at IAAAP.

For this fish population, multiple measurement endpoints were selected to evaluate if the assessment endpoint was being satisfied. Similar to the benthic invertebrates, a comparison of surface water concentrations (total and dissolved) to NAWQC was performed. In addition, fantail and Johnny darter species were collected and used to perform tissue analysis to measure the concentration of specific COPECs. Both the measured tissue concentrations and modeled fish tissue concentrations were compared against literature-derived body burden effect concentrations to determine if fish were bioaccumulating concentrations of COPECs that would pose a health concern. During the fish collection, fish were inspected to look for obvious deformities and lesions in the fish population (DELT). Based on these multiple lines of evidence, a determination was made whether orangethroat darter populations in the IAAAP streams would be maintained.

2.4.3.3 Plant Exposure to Contaminated Surface Water

Plants provide the base of the food chain, and all other animals rely directly or indirectly on plants for their energy. Therefore, it is important to maintain a healthy population of plants within an aquatic ecosystem.

The fifth assessment endpoint selected is: *the survival, growth, and reproduction of aquatic algae within the streams of IAAAP*.

Aquatic algae were selected as a key receptor because of its sensitivity to contaminants in the water column. Algae are routinely used as a primary indicator of aquatic pollution. Being at the bottom of the food chain, algae are used as a food source by aquatic insects, benthic invertebrates, and fish.

The measurement endpoints selected for this assessment endpoint were the comparison of surface water COPEC concentrations to laboratory derived chronic effect levels.

2.4.3.4 Piscivorous Species Exposure To Fish, Water and Sediment

Piscivorous avian species (e.g., great egret, great blue heron, belted kingfisher, and bald eagle) are present in the area of IAAAP. These species occupy the top end of the aquatic food chain and require large amounts of smaller prey (predominantly fish) to provide their energy. These top-level predators would be exposed to contaminated sediment and water primarily through ingestion of contaminated fish.

The assessment endpoint selected for this exposure pathway is: *the survival, growth, and reproduction of aquatic piscivores foraging in the stream habitats within IAAAP using the belted kingfisher as the representative species of this feeding guild.*

The belted kingfisher is a fish-eating bird (piscivore) expected to bioaccumulate chemicals in its prey. This species was selected as a representative receptor because it exists on the site, occupies the top end of the aquatic food chain, and requires large amounts of smaller prey (predominantly fish) to provide its energy. It nests in burrows and excavates in exposed stream banks (USEPA, 1993). The belted kingfisher was considered to be a sensitive avian receptor, because it has a smaller home range than the larger piscivorous avian species, and so would potentially ingest all of its fish from an on-site contaminated area. The primary exposure pathway for kingfishers would be ingestion of contaminated fish.

The measurement endpoint selected to estimate whether the assessment endpoint is being achieved is the calculation of HQs. Fish, water, and sediment ingestion were considered in the development of the HQs. Utilizing the body burdens of COPECs in fish (i.e., the darter data discussed previously and modeled tissue concentrations), the likely body burdens for contaminants in kingfisher were projected. The HQ is the sole line of evidence for this receptor.

The toxicity endpoints for this assessment endpoint, and the approach used to apply toxicity data is analogous to the approach used for vermivores.

2.4.3.5 Insectivore Exposure to Contaminated Sediment, Water, and Invertebrates

Numerous species rely on invertebrates to provide a large portion of their food. North American mammals (e.g., bats), reptiles, amphibians, and birds (e.g., robins) are known to consume significant quantities of invertebrates. These invertebrate species may be exposed to COPECs in the aquatic environment by ingestion, and pass the contamination onto insectivorous wildlife when they feed on these organisms. Dermal contact and inhalation exposure would be less likely routes of exposure, because primary COPECs, such as metals and explosives, are not readily absorbed through the skin and are nonvolatile. In addition for many insectivores, such as bat species, they have no direct contact with soil.

The assessment endpoint selected for this exposure pathway is: *the survival, growth, and reproduction of sensitive species within the stream habitat of IAAAP using the Indiana bat as the representative species of this feeding guild.*

The Indiana bat was selected as a receptor because it is an insectivore and a special-status species found on IAAAP. The Indiana bat eats aquatic insects (*e.g.* dipterans, lepadoptera, tricopterans, and plecopterans) that would, during their larval stages, be exposed to contaminants in water and sediment. The Indiana bat may be indirectly exposed to water and sediment contaminants via the consumption of emerged aquatic insects.

The measurement endpoints selected to estimate whether this assessment endpoint is being achieved is the calculation of HQs for the Indiana bat. Procedure for calculating HQs is same as that discusses in Section 2.4.2.3.

3.0 EXPOSURE ANALYSIS

The exposure analysis was performed to estimate the magnitude of COPEC exposure to the ecological receptors selected for evaluation in the problem formulation. It addresses the development of exposure point concentrations (EPCs) for each COPEC in the abiotic media of concern, discusses COPECs in fish tissue, presents the equations used to model chemical exposure data, and develops receptor-specific exposure factors and media-specific uptake factors. The estimated exposure doses for COPECs are used in conjunction with TRVs (discussed in Section 5.0) to develop HQs, which are used as one line of evidence to characterize ecological risk.

3.1. EXPOSURE POINT CONCENTRATION

The EPC is an estimate of COPEC concentration that an ecological receptor may come in contact with in an abiotic medium such as soil, or a biotic medium such as fish. EPCs were calculated using procedures described in Supplemental Guidance to RAGS: Calculating the Concentration Term (USEPA, 1992b). EPCs are estimates of the arithmetic average concentration of a COPEC in a specific medium. Due to uncertainties associated with estimating the true average concentration, the 95 percent upper-bound confidence limit (UCL) of the arithmetic mean concentration is used as a measure of the arithmetic average concentration. USEPA (1992b) recommends the use of the maximum COPEC concentration, if the 95% UCL is greater than the maximum concentration.

To calculate the 95% UCL of the arithmetic mean concentration in each medium, the type of distribution of the data sets was first determined. This is required because equations used to calculate EPCs vary for normal and lognormal distributions. The Shapiro and Wilk's W-Test (Gilbert, 1987) was used to determine the distribution of the data sets. The results are summarized as part of the SLERA in Tables 3-5 through 3-32 in Appendix A1. In accordance with USEPA (1992b), lognormal distribution was assumed as the default if the data sets were distributed neither normally nor lognormally. Proxy values were assigned to non-detect results. Although a chemical may be reported as a non-detect, it may be present at a concentration below the quantitation limit. As a conservative measure, one half the value of the sample quantitation limit was used as a proxy value for non-detect results. EPCs for soil, surface water, and sediment are discussed in the following sections. Only a limited number of fish tissue samples were analyzed for some COPECs in each watershed. In these cases, the sample size is too small for statistical analysis. Therefore, maximum fish tissue concentrations of each COPEC in each watershed were selected as the EPC.

3.1.1 Soil

Analytical results collected in the RI for surface soil at AOCs IAAP-001 to IAAP-005 (R01-R05), IAAP-007 to IAAP-011 (R07-R11), IAAP-024 (R16), IAAP-026 (R18), IAAP027 (R19), IAAP-028 (R20), IAAP-030 (R22), IAAP-038 (R26), IAAP-040 (R28), and IAAP-043 (R30) are presented in Appendix C. Sediment samples were collected from drainage pathways at some AOCs, including IAAP-001 to IAAP-005 (R01-R05), IAAP-010 (R10), IAAP-028 (R20), IAAP-040 (R28), and IAAP-041 (R29). However, the drainage pathways are shallow and dry for most of the year. Terrestrial receptors may be exposed to sediment within these drainage pathways in a manner similar to their exposure to soil. Therefore, data for these sediment samples were included with surface soil data for the purpose of calculating EPCs for soil (Appendix C). Based on the toxicity screen presented in the SLERA, explosives, metals, SVOCs, and pesticides/PCBs are identified as COPECs at various AOCs. Appendix J presents EPCs for the soil COPECs at each AOC.

3.1.2 Surface Water and Sediment

Five watersheds drain IAAAP. The Little Flint Creek Watershed is not included for evaluation because the drainage area is primarily upstream of activities at the IAAAP. The plant is drained west to east, by Long Creek, Skunk River, Brush Creek, and Spring Creek. Long Creek is a tributary to the Skunk River and includes the George M. Mathes Dam and Reservoir within IAAAP. Other minor tributaries to the Skunk River drain the extreme southwest part of the installation. Brush Creek traverses the central and eastern portions of the installation and is a tributary to the Skunk River. Spring Creek traverses the central and eastern portions of the installation and is a tributary to the Mississippi River, located about ten miles east of the creek. The Long, Brush, and Spring Creek valleys are relatively shallow in the north part of IAAAP, deepening to the south before exiting the installation at a steep bluff bounding the Skunk River valley.

Long Creek originates about two miles north of IAAAP's northwest corner and drains most of the western portion of IAAAP. The stream exits the plant at the southwestern boundary, and drains approximately 7,700 acres of the IAAAP property. Long Creek joins the Skunk River just south of the IAAAP, and the latter flows into the Mississippi River about 9 miles east of the confluence of these two streams. Long Creek was dammed near the center of the installation to create George H. Mathes Lake, with a surface area of approximately 83 acres. There is also a smaller lake, Stump Lake, located north of Mathes Lake. Stump Lake is a manmade sediment control structure that is presently being expanded and restructured for safety.

The Skunk River is located just south of IAAAP and flows from north-northwest to south-southeast to the Mississippi River. The Skunk River is fed by Long Creek and several unnamed tributaries that originate on the IAAAP. The Skunk River Watershed has a drainage area of about 2,500 acres within the southwestern part of IAAAP, characterized by steep, wooded terrain.

Brush Creek has a drainage area of approximately 5,000 acres within IAAAP and flows into the Skunk River south of the plant. Brush Creek drains the central portion of the IAAAP, including the majority of industrial operations. Of the five watersheds within IAAAP, Brush Creek is located closest to many of the facility operations. The watershed contains Lines 1, 2, 3, 6, 7, 9, the former Line 800 Pink Water Lagoon, the former Line 1 Impoundment, and parts of Lines 4A, 5A and 800.

Spring Creek originates off-site, drains the easternmost portion of IAAAP, and exits IAAAP at the southeastern corner. Its drainage area within the boundaries of IAAAP covers approximately 3,900 acres. The creek flows intermittently, and thus, is seasonally dry within the IAAAP limits. Spring Creek flows off-site at the southeastern corner and continues in a south-southeasterly direction approximately 10 miles, where it flows directly into the Mississippi River.

The surface water and sediment data collected during the RI were limited and not sufficient to fully characterize the potential for ecological risks within the BERA. In order to meet the ERA objectives, additional sediment and surface water samples were collected during 2000. The objectives of the surface water and sediment sampling for the BERA were:

- To further delineate the nature and extent of contamination for ecological receptors;
- To estimate the exposure of aquatic organisms to COPECs in streams at IAAAP; and,
- To estimate COPEC doses to aquatic organisms exposed to COPECs in surface water, sediment, and prey items (e.g., aquatic insects or fish).

Surface water samples were collected in two phases: May 2000 and September 2000. Sediment samples were collected in September 2000. Surface water and sediment samples were analyzed for explosives, metals, VOCs, SVOCs, pesticides, PCBs, and herbicides. The sediment samples were also analyzed for total organic carbon. Sampling locations were selected based on known or suspected sources of aquatic pollution, identified locations of fine sediment deposition, and records of threatened or endangered species. In addition, the sediment sampling locations were identified following site reconnaissance. USEPA, USACE, and MWH determined during preparation of the sediment sampling plan (i.e. Technical Memorandum No. 2), that at most sediment sampling locations, COPECs would likely to be associated with top two inches of the sediment.

Analytical results for the surface water and sediment data collected in 2000 are presented in Appendix D. Based on the toxicity screen performed as part of the SLERA, metals are the primary COPECs in surface water and sediment. Bis(2-ethylhexyl) phthalate and some explosives, were identified as additional COPECs in Long Creek surface water. Bis(2-ethylhexyl) phthalate was identified as an additional COPEC in Spring Creek sediment (See Appendix A1). Appendix H presents toxicological profiles for the COPECs. The EPCs for COPECs in surface water and sediment are presented in Appendix J.

Stream flow within IAAAP comprises three principal elements: surface runoff, groundwater inflow, and wastewater discharge under NPDES permits. Groundwater within the facility recharges surface water within the five watersheds. However, groundwater (as a source of surface water due to inflow) was not identified as a media providing a complete and significant exposure pathway to ecological receptors. Concerns arose within the ERA Team as to whether variations in groundwater flow are adequately reflected by the surface water sampling. Surface water flow at IAAAP reflects a base flow regime for most of the year. Flow increases immediately following rainfall, but returns to the base flow regime within 24 hours. Base flow conditions existed at the streams during sampling conducted in May and September 2000, while surface water and sediment investigations conducted over the years appear to have accounted for variations in flow conditions at IAAAP. Contaminant concentrations monitored in surface water during various investigations are comparable. For example, highest RDX concentrations detected in Brush Creek during the supplemental groundwater investigation (Harza, 1997), and the supplemental RI (Harza, 2001a) are 9.3 and 14 μg/L, respectively. These concentrations are comparable to the maximum RDX concentration of 15 µg/L observed during sampling for the SLERA and the BERA in 2000.

3.2. FISH SAMPLING

The objectives of the fish tissue sampling were to determine if contaminants are bioavailable to potentially exposed aquatic organisms, to evaluate if COPECs are bioaccumulating in fish tissue, and use this data to evaluate exposure/toxicity at higher trophic levels. Fish sampling was performed in Brush Creek, Long Creek, and Spring Creek in July 1997. Fish (and benthos) sampling locations are shown in Figure 3-1. HQs for fish were developed for both water exposure and measured or modeled tissue residues. For this investigation, TRVs for water exposure to fish were derived from the literature (See Appendix G, Table G-5). The modeled or measured tissue concentration (or detection limit, if the constituent was not detected) was divided by the Tissue TRVs (presented in Appendix G, Table G-6) to obtain the HQ. The exposure model to calculate fish tissue concentrations for organic COPECs utilized COPEC-specific bioaccumulation factors discussed in Section 3.5.1.

Riffle areas were seined or electrofished for collection of darters. In general, seining was found to be the more effective method. Orangethroat darter, if found, were noted in the field logs and returned immediately to the stream. Darter species were identified using the key of Smith (1979). Darters collected at each site were identified, enumerated, and weighed. A single species, either Johnny darter or fantail darter was used for each fish sample. A composite sample of whole fish weighing at least 38 grams was used for analysis. At SC5 in Spring Creek, the mass of a single species sufficient for analysis could not be collected. Therefore, two species were combined to obtain a sample.

Whole fish were analyzed for explosives and biomagnifying COPECs such as mercury, pesticides, and PCBs. Several metals, other than mercury, were identified as COPECs in surface water and sediment. At the time of the fish sampling, it was envisioned that mercury was the only metal with significant bioaccumulation potential at IAAAP. While these metals may not have significant biomagnification potential as mercury, some other metals have the potential to be bioaccumulated or bioconcentrated. For this reason, these other metals also represent a potential source of exposure to aquatic receptors. The impact of metal concentrations in surface water and sediment to higher trophic level organisms was evaluated through dose modeling within this ERA.

The detection limits for these COPECs were lower than the corresponding available fish tissue-based LOAELs or NOAELs for the COPECs identified in the SLERA, with the exception of some explosives. Fish tissue samples were analyzed for explosives, but none were detected. During the planning stage for this BERA, it was discussed as to whether the detection limits for the explosives are protective of the birds that consume fish. It was decided that half the detection limits for the explosives would be used in the dose modeling to evaluate impact on the belted kingfisher, although explosives were not detected in these samples. Fish tissue analytical results are presented in Appendix E. Fish collected are shown in Table 3-1.

Table 3-1
Darter Species Collected at IAAAP, 16 July through 25 July 1997

Watershed	Site	Species Present	Species Analyzed for COPECs
Long Creek	LC1	None Present	None
Long Creek	LC2	Johnny and Fantail Darters	Fantail Darter
Brush Creek	BC5	Orangethroat, Johnny, Fantail Darters	Fantail Darter
Brush Creek	BC6	Orangethroat, Johnny, Fantail Darters	Fantail Darter
Brush Creek	BC8	Orangethroat, Johnny, Fantail Darters	Fantail Darter
Spring Creek	SC1	Orangethroat, Johnny Darters	Johnny Darter
Spring Creek	SC2	Orangethroat, Johnny, Fantail Darters	Fantail Darter
Spring Creek	SC4	Orangethroat, Johnny, Fantail Darters	Johnny Darter
Spring Creek	SC5	Orangethroat, Johnny, Fantail Darters	Johnny and Fantail Darter
Spring Creek	SC6	Orangethroat, Johnny, Fantail Darters	Fantail Darter

Fantail darters were caught in each of the three sampling locations in Brush Creek. The fish tissue analyses indicated no evidence that aquatic biota are accumulating explosives (i.e., no explosives were detected in fish tissue). Mercury concentrations in darter tissue from Brush Creek ranged from 0.12 to 0.25 mg/kg, which were much lower than the mercury TRV in fish of 1.06 mg/kg. No pesticides were detected in fish tissue, except for dieldrin in sample BC8, which is off-site and downstream from the southern boundary of IAAAP.

Fish sampling at two stations on Long Creek revealed that fantail darter were present at one station, LC2, but did not inhabit the agriculturally impacted silty areas surrounding LC1. Therefore, fish samples could not be collected from LC1. Explosives and metals were not detected in fish tissue collected at LC2. Dieldrin was the only pesticide detected in Long Creek fish.

Fantail darters were caught at sampling Stations SC2 and SC6 in Spring Creek. Johnny darters were caught at Stations SC1, SC4, and SC6. Explosives were not detected in fish tissue collected in Spring Creek. Analysis of mercury in darters from Spring Creek indicated mercury levels up to 0.13 mg/kg. Pesticides, dieldrin, and heptachlor epoxide were detected in fish tissue.

3.3. DEVELOPMENT OF EXPOSURE DOSE MODELS

Exposure doses were estimated for four wildlife receptors evaluated in the BERA to address specific assessment/measurement endpoint combinations. The receptors include:

- A piscivore represented by the belted kingfisher;
- An aquatic insectivore represented by the Indiana bat;
- A terrestrial herbivore represented by the white-footed mouse; and,
- A terrestrial carnivore represented by the short-tailed shrew,
- A terrestrial insectivore represented by the Indiana bat.

Exposure to COPECs by a receptor may derive from multiple sources, including food (plant or animal), water, soil, and sediment. Figures 3-2 through 3-6 represent the ecorisk pathways for the four ecological receptors examined in the BERA. These figures provide a conceptual model of how the exposure dose for each of these four receptors was estimated. The exposure dose models were presented in TM 3 and further refined in the Development of Dose Estimation Models and Toxicity Reference Values TM (TRV Memorandum) and TM 5.

The generalized equation (ORNL, 1996) for estimating the daily COPEC dose a receptor may receive from a particular COPEC in a particular medium is presented below. The equation normalizes the dose to the receptors body weight.

$$E_j = \sum_{i=1}^{m} P_i\left(IR_i \times C_{ij}\right)/(\mathrm{BW}) \qquad (1)$$

Where:

- E_j = Total exposure dose from COPEC (j), mg/kg/d
- m = Total number of ingested media
- P_i = Proportion of medium (i) consumed
- IR_i = Consumption rate for medium (i), kg/d or L/d
- C_{ij} = Concentration of COPEC (j) in medium (i), mg/kg or mg/L
- BW = Body weight of wildlife receptor, kg

Specific models for estimating exposure doses to the four wildlife receptors are provided in the Subsections 3.3.1 through 3.3.5. The EPC is used as the representative COPEC concentration in each media.

3.3.1 Piscivore - Belted Kingfisher

Belted kingfishers are exposed to COPECs through ingestion of water, sediment, and food. Information provided in the Wlidlife Exposure Assessment Handbook (USEPA, 1993) indicates that the belted kingfisher's diet consists primarily of fish. The exposure dose model for this aquatic piscivore may be expressed as:

$$\mathrm{E_j = (IR_w \times C_{w\text{-}j})/(BW) + (IR_f \times P_f \times C_{f\text{-}j})/(BW) + (IR_f \times P_{se} \times C_{se\text{-}j} \times CF_{se})/(BW)} \qquad (2)$$

Where:

- E_j = Exposure dose from COPEC (j), mg/kg/d
- IR_w = Ingestion rate of water, L/d
- $C_{w\text{-}j}$ = COPEC concentration (j) in water, mg/L
- IR_f = Ingestion rate of food, kg/d
- P_f = Fraction of fish ingested as a proportion of total food intake, unitless
- $C_{f\text{-}j}$ = COPEC concentration (j) in fish, mg/kg
- P_{se} = Fraction of sediment ingested as a proportion of total food intake, unitless (as proportion of food ingested)
- $C_{se\text{-}j}$ = COPEC concentration (j) in sediment, mg/kg
- CF_{se} = Conversion factor (sediment dry weight to wet weight), (mg/kg wet sediment)/(mg/kg dry sediment)
- BW = Body weight, kg

The sediment dry weight to wet weight conversion factor (CFse) was selected to be 34.8%, representing the average value of moisture content for all sediment samples collected in the four watersheds. Mercury, dieldrin, and heptachlor epoxide were the only COPECs detected in fish tissue. Actual fish tissue concentrations in each watershed for these compounds were used in the BERA as the primary line of evidence. As a second line of evidence, fish tissue concentrations were modeled for COPECs not analyzed in fish samples, or not detected in fish tissue. For comparative purposes, concentrations of mercury in fish tissue were also modeled and compared against measured mercury concentrations from the fish collected from the streams. The results of this comparative analysis are discussed in Section 6.0 of the BERA. The following equations were used for estimating fish tissue concentrations three different ways:

$$C_{fish-j} = C_{w-j} \times BAF_{fish} \quad (3)$$

or

$$C_{fish-j} = C_{w-j} \times BCF_{fish} \quad (4)$$

Where:

C_{fish-j} = COPEC concentration (j) in fish, mg/kg
C_{w-j} = COPEC concentration (j) in water, mg/L
BCF_{fish} = Bioconcentration factor (water-to-fish), (mg/kg wet tissue)/ (mg/L water)
BAF_{fish} = Bioaccumulation factor (water-to-fish), (mg/kg wet tissue)/ (mg/L water)
BAF_{fish} = BCF_{fish} X FCM (Food-chain Multiplication Factor)

The exposure factors used to calculate the COPEC exposure doses are discussed in detail in Section 3.4. The $BAF_{fish,}$ and BCF_{fish} values are further discussed in Section 3.5.

3.3.2 Aquatic Insectivore - Indiana Bat

The Indiana bat eats primarily aquatic insects (*e.g.* dipterans, tricopterans, and plecopterans). The Indiana bat may be indirectly exposed to water COPECs via consumption of emergent aquatic insects. Therefore, an exposure dose model was developed assuming the bat's diet to consist primarily of aquatic invertebrates. Incidental ingestion of water was also evaluated as an exposure pathway. The COPEC concentration in aquatic insect tissue was calculated utilizing COPEC-specific bioaccumulation factors for aquatic insects. The exposure dose model for the aquatic insectivore may be expressed as:

$$E_j = (IR_w \times C_{w-j})/(BW) + (IR_f \times P_{aqu\text{-}insect} \times C_{aqu\text{-}insect\text{-}j})/(BW) \quad (5)$$

Where:

E_j = Exposure dose from COPEC (j), mg/kg/d
IR_w = Ingestion rate of water, L/d
C_{w-j} = COPEC concentration (j) in water, mg/L

IR_f	=	Ingestion rate of food, kg/d
$P_{aqu\text{-}insect}$	=	Fraction of insect ingested as a proportion of total diet, unitless
$C_{aqu\text{-}insect\text{-}j}$	=	COPEC concentration (j) in aquatic insect, mg/kg
BW	=	Body weight, kg

It was assumed that the Indiana bat's diet consists primarily of aquatic insects. The COPEC concentrations in aquatic insects ($C_{insect\text{-}j}$) were estimated using the following equation:

$$C_{insect-j} = C_{w-j} \times BAF_{aq-inv} + C_{se-j} \times BSAF_{aq-inv} \qquad (6)$$

Where:

$C_{insect\text{-}j}$ =	COPEC concentration (j) in aquatic insect, mg/kg
$C_{w\text{-}j}$ =	COPEC concentration (j) in water, mg/L
$BAF_{aq\text{-}inv}$ =	Bioaccumulation factor (water-to-aquatic invertebrate), (mg/kg wet tissue)/(mg/L water)
$C_{se\text{-}j}$ =	COPEC concentration (j) in sediment, mg/kg
$BSAF_{aq\text{-}inv}$ =	Bioaccumulation factor (sediment-to-aquatic invertebrate), (mg/kg wet tissue)/(mg/kg dry sediment)

The exposure factors used to calculate the COPEC exposure dose are discussed in detail in Section 3.4. The $BAF_{aq\text{-}inv}$ and $BSAF_{aq\text{-}inv}$ values are further discussed in Section 3.5.

3.3.3 Terrestrial Herbivore - White-Footed Mouse

The diet of the white-footed mouse includes arthropods, seeds, and other vegetation. Therefore, an exposure dose model was developed considering that the mouse's food intake consisted primarily of soil invertebrates and vegetation. Incidental ingestion of soil and water were also considered in the model. The COPEC concentrations in plant material were calculated using a chemical-specific soil-to-vegetation bioaccumulation factor, and the invertebrate COPEC concentrations were calculated using a chemical-specific soil-to-terrestrial invertebrate bioaccumulation factor. The exposure model contains terms for each of these dietary components. The equation for the exposure dose model is as follows:

$$\begin{aligned} E_j &= (P_s \times IR_f \times C_{s\text{-}j} \times CF_s)/(BW) + (P_v \times IR_f \times C_{v\text{-}j} \times CF_v)/(BW) \\ &+ (P_{terr\text{-}inv} \times IR_f \times C_{terr\text{-}inv\text{-}j} \times CF_{terr\text{-}inv})/(BW) + (IR_w \times C_{w\text{-}j})/(BW) \end{aligned} \qquad (7)$$

Where:

E_j =	Exposure dose from COPEC (j), mg/kg/d
P_s =	Fraction soil ingested as a proportion of the total diet, unitless (as a proportion of food ingested)
$C_{s\text{-}j}$ =	COPEC concentration (j) in soil, mg/kg

IR_f = Ingestion rate of food, kg/d
CF_s = Conversion factor (soil dry weight to soil wet weight)
P_v = Fraction of vegetation ingested as a proportion of the total diet, unitless
$C_{v\text{-}j}$ = COPEC concentration (j) in vegetation, mg/kg
CF_v = Conversion factor (vegetation dry weight to wet weight), (mg/kg wet vegetation)/(mg/kg dry vegetation)
$P_{terr\text{-}inv}$ = Fraction of terrestrial invertebrate ingested as a proportion of the total diet, unitless
$C_{terr\text{-}inv\text{-}j}$ = COPEC concentration (j) in terrestrial invertebrate, mg/kg
$CF_{terr\text{-}inv}$ = Conversion factor (terrestrial invertebrate dry weight to wet weight), (mg/kg wet terrestrial invertebrate tissue)/(mg/kg dry terrestrial invertebrate tissue)
$C_{w\text{-}j}$ = COPEC concentration (j) in water, mg/L
IR_w = Ingestion rate of water, L/d
BW = Body weight, kg

The dry to wet weight conversion factor for soil was conservatively assumed to be 80%, because typical moisture content of soil is greater than 20%. Assuming that terrestrial herbivores ingest vegetation composed of 50% fruit and 50% seeds, 57% was selected as the dry weight to wet weight conversion factor for vegetation (Sample and others, 1997). For terrestrial invertebrates, Sample and others (1997) have provided a value of 16% as the dry to wet weight conversion factor.

The COPEC concentrations in vegetation were estimated using the following equation:

$$C_{v-j} = C_{s-j} \times U_{s-v} \qquad (8)$$

Where:

$C_{v\text{-}j}$ = COPEC concentration (j) in vegetation, mg/kg
$C_{s\text{-}j}$ = COPEC concentration (j) in soil, mg/kg
$U_{s\text{-}v}$ = Bioaccumulation Factor (soil-to-vegetation), (mg/kg dry tissue)/(mg/kg dry soil)

The COPEC concentrations in terrestrial invertebrates were estimated using the following equation:

$$C_{terr-inv-j} = C_{s-j} \times BAF_{terr-inv} \qquad (9)$$

Where:

$C_{terr\text{-}inv\text{-}j}$ = COPEC concentration (j) in terrestrial invertebrate, mg/kg
$C_{s\text{-}j}$ = COPEC concentration (j) in soil, mg/kg
$BAF_{terr\text{-}inv}$ = Bioaccumulation factor (soil-to-terrestrial invertebrate), (mg/kg dry tissue)/(mg/kg dry soil)

The exposure factors used to calculate the COPEC exposure dose are discussed in detail in Section 3.4. The $U_{s\text{-}v}$ and $BAF_{terr\text{-}inv}$ are discussed in Section 3.5.

3.3.4 Terrestrial Vermivore/Carnivore - Short-Tailed Shrew

Short-tailed shrews are exposed to COPECs via ingestion of soil, terrestrial invertebrates, and water. Short-tailed shrews are primarily carnivorous and feed mostly on earthworms (i.e., a vermivore) which, in turn, consume soil and other invertebrates that consume plants and plant material. Therefore, a dose model was developed where the shrew's dietary intake was assumed to consist primarily of soil invertebrates and incidental ingestion of soil and water. The COPEC concentration in the invertebrates was calculated using a chemical-specific soil-to-terrestrial invertebrate bioaccumulation factor. The exposure model contains terms for each of these dietary components:

$$E_j = (P_s \times IR_f \times C_{s\text{-}j} \times CF_s)/(BW) + (P_{terr\text{-}inv} \times IR_f \times C_{terr\text{-}inv\text{-}j} \times CF_{terr\text{-}inv})/(BW) + (IR_w \times C_{w\text{-}j})/(BW) \quad (10)$$

Where:

E_j =	Exposure dose from COPEC (j), mg/kg/d
P_s =	Fraction of soil ingested as a proportion of the total diet, unitless (as a proportion of food ingested)
IR_f =	Ingestion rate of food, kg/d
$C_{s\text{-}j}$ =	COPEC concentration (j) in soil, mg/kg
CF_s =	Conversion factor (soil dry weight to wet weight), (mg/kg wet soil)/(mg/kg dry soil)
$P_{terr\text{-}inv}$ =	Fraction of terrestrial invertebrate ingested as a proportion of the total diet, unitless
$C_{terr\text{-}inv\text{-}j}$ =	COPEC concentration (j) in terrestrial invertebrate, mg/kg
$CF_{terr\text{-}inv}$ =	Conversion factor (terrestrial invertebrate dry weight to wet weight), (mg/kg wet terrestrial invertebrate tissue)/(mg/kg dry terrestrial invertebrate tissue)
IR_w =	Ingestion rate of water, L/d
$C_{w\text{-}j}$ =	COPEC concentration (j) in water, mg/L
BW =	Body weight, kg

The exposure factors used to calculate the COPEC exposure dose are discussed in detail in Section 3.4. The $U_{s\text{-}v}$ and $BAF_{terr\text{-}inv}$ are discussed in Section 3.5.

3.3.5 Terrestrial insectivore – Indiana Bat

Remedial management decisions at IAAAP are expected to be made for individual areas of concern (AOCs). Risk estimates developed for each AOCs may be used as a management tool for making such decisions. The dose model for the Indiana bat is focused towards developing risk estimates for exposure to COPECs in soil at each AOC.

The Indiana bat's diet consists of 100% flying insects. USACE (2001) notes that the Indiana bat eats both aquatic and terrestrial insects. The exposure dose model for the Indiana bat via the aquatic pathway was developed based on the assumption that it exclusively consumes aquatic insects. Similarly, for development of exposure dose model via the terrestrial pathway, it is assumed that the Indiana bat only consumes terrestrial insects.

The exposure dose model for Indiana bat as a terrestrial insectivore may be expressed as:

$$E_j = (IR_w \times C_{w\text{-}j})/(BW) + [(IR_f \times P_{terr\text{-}insect} \times C_{terr\text{-}insect\text{-}j})/(BW)] \times AUF \qquad (11)$$

Where,

E_j	=	Exposure dose from COPEC (j), mg/kg/d
IR_w	=	Ingestion rate of water, L/d
$C_{w\text{-}j}$	=	COPEC concentration (j) in water, mg/L
IR_f	=	Ingestion rate of food, kg/d
$P_{terr\text{-}insect}$	=	Fraction of insect ingested as a proportion of total diet, unitless
$C_{terr\text{-}insect\text{-}j}$	=	COPEC concentration (j) in aquatic insect, mg/kg
BW	=	Body weight, kg
AUF	=	Area use factor

The COPEC concentrations in terrestrial insects are estimated using the following equation:

$$C_{terr\text{-}inv\text{-}j} = C_{s\text{-}j} \times BAF_{terr\text{-}inv} \qquad (12)$$

Where,

$C_{terr\text{-}inv\text{-}j}$	=	COPEC concentration (j) in terrestrial invertebrate, mg/kg
$C_{s\text{-}j}$	=	COPEC concentration (j) in soil, mg/kg
$BAF_{terr\text{-}inv}$	=	Bioaccumulation factor (soil-to-terrestrial invertebrate), (mg/kg dry tissue)/(mg/kg dry soil)

The exposure factors used to calculate the COPEC exposure dose are discussed in detail in Section 3.4. The AUF and $BAF_{terr\text{-}inv}$ is discussed in Section 3.5.

3.4. DEVELOPMENT OF EXPOSURE FACTORS

Development of exposure factors for the terrestrial and aquatic receptors was first presented in TM 3, and later revised in the TRV Memorandum based on input received from the ERA Team on TM 3. These exposure factors include ingestion rates (food, water, and soil), dietary composition, and body weights. The exposure factors are presented in Table 3-2 by receptor, along with the source of the factor. Area Use Factors (AUF) were not incorporated into the exposure models presented previously, because the size of the AOCs or watersheds was always larger than the home range of the white-footed mouse or the short-tailed shrew. Therefore, by convention, this exposure factor would be equivalent to 1 for those receptors, and provides no added value for the BERA. For the Indiana Bat, some of the AOCs were smaller than the home range of a juvenile Indiana bat. The AUFs used for the Indiana bat are discussed in Section 3.5.6.

Table 3-2
Exposure Parameter Values

Parameter		Short-Tailed Shrew		White-Footed Mouse		Belted Kingfisher		Indiana Bat	
BW	Body Weight (kg)	0.015	A	0.022	b	0.136	a	0.0072	c
IR_f	Food Intake (kg/day)	0.008	A	0.0034	b	0.068	d	0.0025	e
IR_w	Water Intake (L/day)	0.0033	B	0.0066	b	0.015	d	0.0012	e
P_s	Soil Intake In Diet (%)	13%	F	2%	g	NA		NA	
P_{se}	Sediment intake in diet (%)	NA		NA		2%	i	NA	
$P_{terr\text{-}inv}$	Terrestrial Invertebrate In Diet (%)	87%	H	49%	i	NA		100%	i
P_{fish}	Fish In Diet (%)	NA		NA		98%	i	NA	
$P_{aq\text{-}inv}$	Aquatic Invertebrate In Diet (%)	NA		NA		NA		100%	i
P_v	Vegetation In Diet (%)	NA		49%	i	NA		NA	

Notes:
A EPA (1993)
b Sample and others (1996)
c USAMC (1998)
d Calculated value based on body weight and normalized ingestion rate (EPA, 1993)
E Use values for Brown Bat as surrogate values (Sample and others, 1996)
F Talmage and Walton (1993)
g Beyer and others (1994)
h Calculated value based on intake of soil in diet
i Assumed value

3.4.1 Short-Tailed Shrew

Exposure factors for the shrew were obtained from the Wildlife Exposure Factors Handbook Volume I of II (USEPA, 1993). The food ingestion rate is listed as 0.008 kg/day, the water ingestion rate as 0.0033 L/day, and the body weight as 15g. Thirteen percent of the shrew's diet consists of soil (Talmage and Walton, 1993). Shrews may eat insects, worms, snails, mice, voles, frogs, and other invertebrates and vertebrates. However, the fraction of diet as invertebrates was assumed to be 87%, because invertebrates comprise most of a shrew's diet.

3.4.2 White-Footed Mouse

Exposure factors for the white-footed mouse were obtained from Sample and others (1996), where the food ingestion rate was reported as 0.0034 kg/day, the water ingestion rate as 0.0066 L/day, and body weight as 22 g. A conservative soil ingestion rate of 2% was selected based on a value presented in USEPA (1993) of <2% soil in the diet of the white-footed mouse. The rest of the diet was assumed to comprise 49% plants and 49% terrestrial invertebrates.

3.4.3 Indiana Bat

Exposure factor data available for the Brown bat was used to represent exposure factors for the Indiana bat because they are similar species. Data from Sample and others (1996) for the Brown bat were used as surrogate data for the Indiana bat. The food and water ingestion rates selected were 0.0025 kg/day and 0.0012 L/day, respectively. Because the Indiana bat preys upon airborne insects, it is unlikely that the bats incidentally ingest sediment. Therefore, the sediment ingestion rate was set to zero. The weight of the Indiana bat (i.e., 0.0072 kg) was obtained from USAMC (1998). It was assumed that aquatic insects comprise 100% of the Indiana bat's diet when evaluation is conducted for the aquatic exposure pathway. Similarly, it was assumed that terrestrial insects comprise 100% of the Indiana bat's diet when evaluating the terrestrial exposure pathway.

3.4.4 Belted Kingfisher

The food ingestion rate for the kingfisher (0.068 kg/day) was based on the value listed in the Wildlife Exposure Factors Handbook (USEPA, 1993). The belted kingfisher body weight of 0.136 kg is an average of available adult data (USEPA, 1993). The sediment ingestion rate for the belted kingfisher was not given, so an estimated value of 2% based on food habits of the belted kingfisher and data for other bird species in USEPA (1993) was used. This is conservative, considering that the bird eats mostly fish caught in the upper 15 cm of the water column. The fraction of diet as fish is set to equal 98% because fish comprise most of the belted kingfisher's diet. The water ingestion rate is listed as 0.0015 L/day in USEPA (1993).

3.5. DEVELOPMENT OF UPTAKE FACTORS

The BCF, BSAF, and BAF are collectively termed uptake factors. Uptake factors are required in the dose models presented in Section 3.3. Uptake factors are rarely available directly from the literature. In the absence of measured values, models are used to estimate uptake factors. Values for the uptake factors were presented in the Development of Dose Estimation Models and Toxicity Reference Values (i.e., TRV Memorandum), a working memorandum developed to facilitate review of general approach in the BERA. The uptake factors presented below include revisions made to address comments from stakeholders.

3.5.1 Bioconcentration/Bioaccumulation Factors for Fish

The concentrations of COPECs in fish were calculated either as a BCF or BAF, according to equations 3 and 4 in Section 3.3.1. The BCF is used for non-bioaccumulating COPECs, such as most inorganic and organic compounds with low affinities to partition into fats in an organism's body (i.e. with low log octanol-water partitioning coefficients [log Kow]). BCF_{fish} is the ratio of the COPEC concentration in fish to the COPEC concentration in the water column where the fish is exposed. It accounts for the uptake of COPECs by fish due to exposure to COPECs in water. For all organic compounds with a log Kow less than 4.0, and for all inorganic compounds except mercury and lead, BCF_{fish} is used to estimate COPEC concentrations in fish tissue (USEPA, 1998b). BCF_{fish} values presented in this report were obtained from USEPA (1999).

BCF_{fish} values are not available for several organic compounds. When BCF values were not available from USEPA (1999), the following equation developed by Meylan and others (1999) was used:

$$\log BCF_{fish} = 0.76 \times \log Kow - 0.39 \qquad (13)$$

The BCF values for cobalt, manganese, and vanadium were not available from USEPA (1999). Values for these compounds were obtained from Oak Ridge National Laboratory (ORNL, 1999).

Organic compounds with a log Kow value greater than 4.0, and inorganics such as mercury, tend to bioaccumulate. The BAF is the ratio of a COPEC in tissue to its concentration in the water column where both the organism and its prey are exposed. In accordance with USEPA (1998b) for organic compounds with a log Kow greater than 4.0, and for mercury, BAF_{fish} were used to estimate fish tissue concentration. Bis(2-ethylhexyl) phthalate, toxaphene, and 4,4'-DDT were identified as COPECs with a log Kow greater than 4.0. As presented in Section 3.3.1,

> $BAF_{fish} = BCF_{fish}$ X FCM
> BAF_{fish} values for BEHP, toxaphene, and 4,4'-DDT were calculated by multiplying a FCM by the BCF_{fish} values.

The FCM for organic compounds depends on the consumer trophic level. Trophic level 4 is applied to top predators and piscivorous fish. For small fish (e.g., darters), a consumer trophic level of 3 was applied (Sample and others, 1996), which accounts for the COPEC that has accumulated in the fish's food source (e.g., zooplankton). Sample and others (1996) list a FCM of 13.474, 6.27, 13.662 for BEHP, toxaphene, and 4,4'-DDT at trophic level 3, respectively. Sample and others (1996) have provided a FCM of 1 for all inorganic chemicals except mercury. A trophic level 3 BAF_{fish} of 27,900 (Sample and others, 1996) was used to estimate mercury concentration in fish tissue.

The log Kow, BCF_{fish} and BAF_{fish} values of COPECs are listed in Appendix G, Table G-8.

3.5.2 Water-To-Aquatic Invertebrate Bioconcentration Factors

$BCF_{aq\text{-}inv}$ is the ratio of the COPEC concentration in aquatic invertebrate to the COPEC concentration in the water body where the aquatic invertebrate is exposed. $BAF_{aq\text{-}inv}$ values are needed to calculate COPEC concentrations in insects, as presented in Equation 6, and were estimated by applying a FCM to the $BCF_{aq\text{-}inv}$ values. The FCM for organic compounds depends on the consumer trophic level and the compound's Kow. The primary food source for the bat is aquatic insects with a trophic level of 2. Therefore, the consumer trophic level for the Indiana bat was selected to be 3.

$BCF_{aq\text{-}inv}$ values presented in this report were obtained from Screening Level Ecological Risk Assessment Protocol, Appendix C: Media-To-Receptor BCF Values (USEPA, 1999). When $BCF_{aq\text{-}inv}$ values were not available from USEPA (1999), the following equation developed by Lyman and others (1990) was used:

$$\log BCF_{aq\text{-}inv} = 0.76 \times \log Kow - 0.23 \qquad (14)$$

The BCF values for cobalt, manganese, and vanadium are not available from USEPA (1999). Values for these compounds were obtained from ORNL (1999).

The log Kow, FCM, $BCF_{aq\text{-}inv}$, and $BAF_{aq\text{-}inv}$ values of COPECs are listed in Appendix G, Table G-9.

3.5.3 Sediment-To-Aquatic Invertebrate Bioaccumulation Factors

$BSAF_{aq-inv}$ is needed to calculate COPEC concentrations in insects, as presented in Equation 6. The ratio of the COPEC concentration in aquatic invertebrates to the COPEC concentration in the sediment is where the aquatic invertebrates are exposed. A $BSAF_{aq-inv}$ value of 1.7 was used for all organic COPECs (Konemann and van Leeuwen, 1980; Karickhoff, 1981; cited in McFarland and Clarke, 1987). For inorganic COPECs, the $BSAF_{aq-inv}$ values were obtained from USEPA (1999). The $BSAF_{aq-inv}$ values for COPECs are listed in Appendix G, Table G-9.

3.5.4 Soil-To-Vegetation Uptake Factors

Soil-to-vegetation U_{s-v} values are needed to calculate COPEC concentrations in vegetation, as presented in Equation 8, and account for vegetation uptake of COPECs from soil. For inorganics, U_{s-v} values presented in this report were obtained from USEPA (1999). For organics, U_{s-v} values were estimated using the following equation developed by Travis and Arms (1988):

$$\log U_{s-v} = 1.588 - 0.578 (\log Kow) \qquad (15)$$

The log Kow and U_{s-v} values of COPECs are listed in Appendix G, Table G-10.

3.5.5 Soil-To-Terrestrial Invertebrate Bioaccumulation Factors

Soil-to-terrestrial invertebrate BAF values account for uptake of COPECs from soil by terrestrial invertebrates and are needed to calculate COPEC concentrations in invertebrates, as presented in Equation 9. Soil-to-terrestrial invertebrate BAF values were developed mainly from data for earthworms. For inorganics, $BAF_{terr-inv}$ values presented in this report were obtained from USEPA (1999). For organics, values were estimated using the following equation developed by Connell and Markwell (1990):

$$BAF_{terr-inv} = \frac{Y_1 \times \log K_{ow}{}^{b-a}}{x \times f_{oc}} \qquad (16)$$

Where:

Y_1 =	Terrestrial invertebrate lipid content = 0.02 (Stafford and Tacon, 1988), unitless
log Kow =	Octanol-water partition coefficient, unitless
b-a =	Nonlinearity constant = 0.05
x =	Proportionality constant = 0.66
foc =	Organic carbon in soil = 0.006, unitless (USEPA 1996a)

The log Kow and $BAF_{terr-inv}$ values of COPECs are listed in Appendix G, Table G-11.

Soil-to-terrestrial invertebrate BAF values account for uptake of COPECs from soil by terrestrial invertebrates. Significant uncertainties are associated with empirical models that could describe the soil to plant to insect uptake of food that an insect obtains partly from soil and partly from plants. Literature that specifically provides values (or an approach for estimation of values) for uptake of chemicals by flying terrestrial insects is not available. As a conservative approach, the soil-to-terrestrial invertebrate BAF values are used in this BERA to represent contaminant concentration in insects. $BAF_{terr-inv}$ values are primarily developed based on uptake by worms, which is expected to overestimate uptake by flying insects because worms are in contact with the soil during 100 % of their life cycle and flying insects are not.

Concentrations of selected constituents in soil and flying insects were monitored at the Savanna Army Depot (SVDA) in Illinois in the backwaters of the Mississippi River. Therefore, these flying insect data represent insects that may have originated from the terrestrial environment or the aquatic environment. Available data from SVDA was used to determine BAF values for the insects. Risk estimates are developed based on these measured values, when available, to represent HQ estimates based on measured values as compared to those based on BAF values developed using soil to worm model. Comparisons of literature and measured BAFs are shown in Table 3-3. In general, the measured BAFs are higher than the literature derived $BAF_{terr-inv}$ values. However, for several constituents, such as copper, selenium, 1,3-DNB, 2,4-DNT, HMX, and RDX, the literature derived $BAF_{terr-inv}$ values are higher.

Table 3-3 Comparisons of Measured and Literature BAF Values

Compound	BAF_{terr} Measured	$BAF_{terr-inv}$ Literature
Metals		
Aluminum	0.001	0.22
Barium	0.049	0.22
Beryllium	0.043	0.22
Cadmium	0.562	0.96
Calcium	0.133	NA
Chromium	0.018	0.01
Cobalt	0.019	0.065
Copper	0.083	0.04
Iron	0.005	NA
Lead	0.001	0.03
Magnesium	0.145	NA
Manganese	0.047	0.16
Mercury	0.097	8.5
Nickel	0.025	0.02
Potassium	9.222	NA
Selenium	2.215	0.22
Sodium	1.175	NA
Vanadium	0.004	0.03
Zinc	0.287	0.56
Explosives		
1,3,5-Trinitrobenzene	0.632	0.821
1,3-Dinitrobenzene	3.846	0.828
2,4,6-Trinitrotoluene	0.001	0.837
2,4-Dinitrotoluene	2.222	0.837
2-amino-4,6-Dinitrotoluene	0.014	0.835

Table 3-3 Comparisons of Measured and Literature BAF Values

Compound	BAF_{terr} Measured	$BAF_{terr-inv}$ Literature
4-amino-2,6-Dinitrotoluene	0.332	0.835
HMX	0.942	0.735
Nitrobenzene	7.728	NA
RDX	2.090	0.802
Tetryl	2.500	0.829

Note: BAFterr measured equals average concentration in insects divided by average concentration in site soils.

3.5.6 Area Use Factor (AUF) [Used for Indiana Bat only]

The IAAAP is a 19,000-acre facility. The AOCs, and therefore, soil contamination by COPECs, cover only a small portion of the site. Garner and Gardner (1992, as cited in Evans and others, 1998) monitored foraging activities of Indiana bat. They found that foraging territory ranged from 70 acres for juveniles to 526 acres for females. An Indiana bat is primarily expected to catch insects from areas outside the AOCs, with only a fraction from near the AOCs. Area of most AOCs is lower than the average home range of a juvenile Indiana bat. Therefore, an AUF is used for the bat, which is equivalent to the ratio of the area of an AOC to the average foraging area of a juvenile bat. When the size of the AOC is greater than foraging area of the bat, then the AUF is set to 1 (or 100 percent). The areal extent of sampling, measured from Figures in Appendix C-2 for each AOC, constitutes the exposure area for each AOC.

The USFWS, as a conservative approach, postulated that the nightly foraging ranges of a given bat could be much smaller compared to the species territory range of 70 to 526 acres (Coffey 2004). If the foraging area is found to be smaller than 70 acres, then the AUFs for each AOC would be higher than those calculated based on 70-acre foraging area. IAAAP (2003) noted that the core foraging area of an individual Indiana bat (Sodalis 824) was found to be in a field south of K-Road. This is the only terrestrial area identified in the report, which could provide a significant part of a bat's diet. USFWS postulated that this area has the potential to be smaller than 70 acres, and if so, could be used to develop an alternate estimate of AUF and characterize the sensitivity associated with AUF estimates. At the request of the USFWS, the field south of K-Road was measured and was found to be more than 200 acres. Because this area was larger than 70 acres, alternate estimate of AUF was not developed and a sensitivity analysis with different AUFs was not conducted. The AUF for each AOC, listed in Table 3-4, is only calculated based on an average foraging area of 70 acres. The AUF was set to one for AOCs larger than 70 acres.

Table 3-4 AUF for Each AOC

Soil AOC	Area (acre)	AUF
IAAP-001/R01	190	1
IAAP-002/R02	140	1
IAAP-003/R03	149	1
IAAP-004/R04	119	1
IAAP-005/R05	37	0.53
IAAP-007/R07	30	0.43
IAAP-008/R08	9	0.13
IAAP-009/R09	69	0.99
IAAP-010/R10	9	0.13
IAAP-011/R11	18	0.26
IAAP-024/R16	0.1	0.001
IAAP-026/R18	1	0.01
IAAP-027/R19	9.5	0.14
IAAP-028/R20	3	0.04
IAAP-029/R21	0.5	0.007
IAAP-030/R22	460	1.00
IAAP-038/R26	13	0.19
IAAP-040/R28	1.4	0.02
IAAP-041/R29	0.04	0.001
IAAP-043/R30	5	0.07

4.0 EFFECTS ANALYSIS

Section 4.0 summarizes the results of field observations conducted in the investigation. Surveys performed during the investigation included a vegetation survey, benthic macroinvertebrate studies using Rapid Bioassessment Protocols (RBP), and a fish survey in conjunction with fish collection for tissue analysis. The field surveys provide direct observational information on apparent (or lack of apparent) effects of contamination on communities of organisms (e.g., plants, invertebrates, and fish). Water quality parameters were monitored during fish and benthic sampling. The data are presented in Appendix E-1. Water temperature ranged from 17 ^{o}C to 25^{o}C and dissolved oxygen (DO) concentration ranged from 6.4 to 10.6 mg/l. The water columns at the sampling stations are sufficiently oxic to support healthy aquatic habitat.

4.1 AQUATIC HABITAT METHODOLOGIES

4.1.1 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate sampling was conducted in 1997 as part of the ERAA. Benthic invertebrates collected from the four watersheds are tabulated in Appendix E, Tables E-1 and E-2. Sampling was done to assess the health of the benthic community. Samples were collected utilizing RBP III methods (Plafkin, J.L., and others, 1989) in which community indices obtained for the sample sites are compared to the indices found at a reference (or control) station. The Sampling locations for fish and benthos are shown on Figure 3-1.

Two types of substrates were sampled, with the data processed separately: coarse particulate organic matter (CPOM) and riffle/run material. Sampling of CPOM was performed separately to characterize functional feeding groups in the benthos. Coarse particulate organic matter includes plant parts such as leaves, twigs, and bark. The field samplers examined a variety of these forms. Neither newly deposited, nor fully decomposed CPOM was collected. Organisms were classified strictly as either shredders or non-shredders using Cummins and Wilzbach's (1985) method. The number of shredder individuals and the number of total individuals in the CPOM sample were recorded.

Riffle/run habitat was sampled in areas with a relatively fast current over cobble or gravel substrate. These were located and sampled three times or more with a Surber sampler to obtain approximately 100 individuals at each site. The Surber samples were combined for processing. If submerged fixed structures, such as logs, pier pilings, or bridge abutments were present, these were also sampled by hand picking and the organisms added to the sample. The sample was inspected in the field to obtain a preliminary assessment of the presence or absence of major groups, and to determine if sampling efforts were adequate to obtain 100 individuals. If a site was found to be too severely impaired to support organism abundance (i.e., not allowing collection of 100 individuals), then the field samplers noted the effort in the field log. However, this situation did not occur.

Samples were evaluated using eight common community metrics:

- Species Richness (the number of taxa identified)

- Modified Hilsenhoff Biotic Index (HBI)
- Ratio of Scraper and Filtering Collector Functional Feeding Groups
- Ratio of EPT (Ephemeroptera, Plecoptera, Tricoptera) and Chironomidae Abundances
- Percent Contribution of Dominant Taxon
- EPT Index (number of Ephemeroptera, Plecoptera and Trichoptera taxa)
- Community Loss Index ([reference species richness minus species in common]/species richness)
- Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected in Coarse Particulate Organic Matter

The RBP results can be used in an ecological risk assessment to determine impairment at a sample site compared to a reference site. In the RBP, the ratio of most metrics for a sample and the corresponding metrics for its reference station were used to assign a Biological Condition Score (BCS) that has a value of 0, 2, 4, or 6. Biological Condition Score's derived from the Percent Contribution of the Dominant Taxon Index and the Community Loss Index, were compared to standard ranges rather than the reference station values. The sum of scores for a station was expressed as a percentage of the sum for the reference station, which relates to Biological Condition Categories according to the following definitions:

>83%	Nonimpaired	Comparable to the best situation to be expected within an ecoregion; Balanced trophic structure; Optimum community structure (composition and dominance) for stream size and habitat quality
54-79%	Slightly impaired	Community structure less than expected; Composition (species richness) lower than expected due to loss of some intolerant forms
21-50%	Moderately impaired	Fewer species due to loss of most intolerant forms; Reduction in EPT index
<17%	Severely impaired	Few species present; if high densities of organisms, then dominated by one or two taxa

Percentages intermediate to the above ranges requires subjective judgment. An unimpaired site is considered to reflect optimum condition. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. It may be that other land-use impacts such as forest clearing or farming have altered the habitat enough to change the community composition, or that the habitat is naturally of a quality that is not optimal for supporting full diversity of benthic species.

The information provided by the RBP is a semiquantitative analysis, that is designed to evaluate apparent changes in benthic community structure, but unlikely would detect toxic effects on individual benthic species. The RBP is not a definitive analysis, but rather provides a relative comparison of the results of observations at a reference location compared to observations at downstream sampling stations. Many environmental factors (e.g., riparian vegetation and stream characteristics), other than contaminant concentrations, can effect the benthic community composition at a given location. For example, difference in physical conditions, such as water flow regimes, between the selected reference station and the test stations, may significantly bias the results. There are certain limitations that can not be overcome, such as the presence of some stations at locations that are not ideally matched to the reference station. If an impaired reference station is used for comparison to other test stations, it is conceivable that a "slightly impaired" sampling station would in actuality be moderately impaired. In these cases, a qualitative evaluation has to be made, to determine if there are environmental factors other than chemical concentrations that would likely effect the benthic community composition. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. It may be that other land-use impacts such as forest clearing or farming have altered the habitat enough to change the community composition, or that the habitat is naturally of a quality that is not optimal for supporting a full diversity of benthic species.

Results for the different watersheds at IAAAP are discussed in the following sections.

4.1.1.1 Long Creek

Benthic sampling stations in the Long Creek watershed yielded 154 to 261 individuals and 8 to 16 macroinvertebrate taxa at each site. The number collected by station and the HBI tolerance values for all taxa are presented in Appendix E, Table E-1. Pollution tolerance values, as used in the RBP, are provided by Hilsenhoff (1988). The greatest number of taxa was collected at Stations LC2 (16 taxa) and LCT1 (14 taxa). Location LC1 on Long Creek is upstream of all the AOCs within IAAAP. Contamination originating in the source areas is not expected to impact water quality at LC1. Therefore, LC1 was considered a reference station for Long Creek. Only 11 taxa were collected at reference station LC1. Taxa that accounted for most of the collected total were:

asellid isopods	54%
chironomid midge larvae	12%
hydropsychid caddis fly nymphs	11%
physid snails	8%

These taxa are fairly tolerant of pollution. Tolerance values vary from 0 (intolerant, sensitive) to 10 (highly tolerant). Hydropsychids have a tolerance value of 4; chironomids 6; and physids and asellids 8.

There were three sampling locations on tributaries to Long Creek, referred to as LCT1, LCT2, and LCT3. Physical habitat at sampling sites throughout the Long Creek watershed, including the reference station, was generally similar. Watershed erosion appeared to be moderate at all locations. While riparian habitat between the reference site and evaluation sites was similar, upstream land use at LC1 is intensively agricultural. Due to agricultural activities off-site, the upstream reference station, LC1, had greater amounts of silt in substrate areas. Predominant land use in the areas surrounding the other sampling stations is forest. Dissolved oxygen concentrations at the four stations are comparable, ranging from 7.28 to 8.32 mg/L. Water depth at the riffle and the run areas are 0.02 to 0.03 meters deep. In the pool areas, water depth is between 0.05 to 0.1 meter, except at LC2, where it is 0.8 meters deep. Similarly, stream width at all locations is 0.5 meters, while it is at 4 meters at LC2. Therefore, water volume in the pool area at LC2 is much higher than that at other locations within Long Creek, and consequently more suitable for supporting a diverse habitat.

Results of the RBP assessment are presented in Table E-3. Compared to the reference station, LC2 and LCT1 are considered unimpaired and benthic community structure is not exhibiting ecological stress, as measured using the RBP. Stations LCT2 and LCT3 were rated as slightly impaired, generally because the tributaries had few EPT taxa. This may reflect increasing diversity from headwaters to downstream rather than anthropogenic effects.

4.1.1.2 Skunk River

Two small tributaries of the Skunk River in the southwest part of IAAAP were compared to the Long Creek reference station. Number and species of macroinvertebrates collected at the two stations in the watershed (SRT1 and SRT2) and the HBI tolerance values for all taxa are presented in Table E-1. There were qualitative differences between the macroinvertebrate communities in the tributaries, used as the basis for the community assessment. Taxa that accounted for most of the benthos were:

	SRT1	SRT2
chironomid midge larvae	12%	6%
hydropsychid caddis fly nymphs	18%	2%
asellid isopods	23%	66%

These taxa are fairly tolerant of pollution. Tolerance values vary from 0 (intolerant, sensitive) to 10 (highly tolerant). Hydropsychids have a tolerance value of 4; chironomids 6; and asellids 8.

The results of the RBP in the Skunk River tributaries are provided in Table E-4. The small streams in this watershed originate on the IAAAP property and have contaminated areas in their headwaters. Therefore, no reference site is available within the watershed. Because LC1 is upstream of all locations on tributaries to the Skunk River at IAAAP, LC1 was selected for use as the reference site for the Skunk River Watershed.

The reference station, LC1 is located at the western boundary of IAAAP. While riparian habitat between the reference site and evaluation sites was similar, upstream land use at LC1 is intensively agricultural, while land use in the small watersheds of the Skunk River tributaries is principally forest. Dissolved oxygen concentrations at the three stations are comparable, ranging from 7.27 to 9.02 mg/L. Water depth at the riffle and the run areas are less than ankle deep. In the pool areas, water depth is 0.05 meter at LC1 and SRT2, while it is 0.6 meter deep at SRT1. Similarly, stream width is between 0.3 and 0.5 meter at LC1 versus SRT1. Sampling was conducted in the riffle areas of the stations. Flow volume at the three stations is generally comparable.

In comparison to LC1, SRT1 was rated as unimpaired and SRT2 was rated as slightly impaired. The principal difference affecting the ratings was the abundance of EPT taxa. Data in Table E-1 shows that 12 baetids, 28 hydropsychids, and 11 hydroptilids were collected from SRT1. Respective totals for SRT2 were 0, 2, and 1, lowering the score for this site. The results of the RBP in Table E-4 show that greater numbers of certain community metrics, such as ratio of scrapers and filtering collectors, community loss index, and shredder/total number of individuals, were present at SRT 2 compared to the reference station. The BCS system does not allow for higher scores at the sample stations compared to the reference station. However, because of the low variability in the metrics utilizing EPT abundance, and the high sensitivity of these taxa to contamination, the benthic community at SRT2 is designated as slightly impaired.

4.1.1.3 Brush Creek

Benthic sampling stations along Brush Creek yielded 137 to 294 individuals and 8 to 17 macroinvertebrate taxa at each site. The number collected by station and the HBI tolerance values for all taxa are presented in Table E-2. Pollution tolerance values used in the RBP technique were provided in Hilsenhoff (1988). There were 10 sampling stations in Brush Creek. The greatest number of taxa were collected at reference Station BC9 (13 taxa) and off-site station BC8 (17 taxa) downstream of IAAAP. Taxa that accounted for most of the collected total include:

hydropsychid caddis fly nymphs	37%
asellid isopods	20%
chironomid midge larvae	15%
black fly larvae	12%
baetid mayfly nymphs	5%

These taxa are moderately tolerant of pollution. HBI tolerance values vary from 0 (intolerant, sensitive) to 10 (highly tolerant). Asellid isopods have a tolerance value of 8; all of the other taxa listed above have tolerance values of 4 to 6.

Physical habitat at sampling sites throughout the Brush Creek watershed, including the reference station, was generally similar. However, watershed erosion appeared to be moderate at all evaluation locations; while no erosion was apparent at the reference station. The riparian habitat at stations BC1 through BC8 is predominantly composed of forest. Land use upgradient of BC9 is agricultural; while land use at BC 10 is industrial. Dissolved oxygen concentrations at the ten sampling stations are comparable, ranging from 7.04 to 10.6 mg/L. Water depth at the riffle and the run areas are all equal to or less than 0.1 meter. Stream width is variable at the stations, ranging from 0.5 at BC 9 and BC 10 to 4.2 meters at BC4.

The RBP results for Brush Creek are presented in Table E-5. Sampling station BC 9 is located upstream of the AOCs in the Brush Creek watershed and was considered a reference station for the benthic community at the time of the benthic community study. However, it cannot be conclusively established whether this station is impacted by contaminants originating within IAAAP. Stations BC1, BC3, BC4, and BC7 were rated as slightly impaired, differing from other stations largely on the basis of the ratio of scrapers to filter feeders, low EPT indices, and low proportions of shredders. These differences indicated communities that were based more on fine particulate organic matter in the water column, a condition generally indicative of organic pollution, than on leaves and other coarse particulate organic matter. However, most stations, including the stations that were rated as slightly impaired, scored better than the reference station for several metrics. Biological condition scores allow no credit for exceeding the metric scores for the reference station.

Because most of the watershed is intensively cultivated, the reference station itself may represent a slightly impaired condition. The impairment exhibited at stations where BCSs suggested a slightly degraded condition is considered to be more the result of agricultural practices at the site than by IAAAP industrial operations. It is conceivable that a “slightly impaired” sampling station could in actuality be moderately impaired, because an impaired reference station is used for comparison.

4.1.1.4 Spring Creek

There were six sampling stations in Spring Creek. Benthic sampling stations along Spring Creek yielded 137 to 294 individuals and 8 to 17 macroinvertebrate taxa at each site. The number collected by station and the HBI tolerance values for all taxa are presented in Table E-1. Pollution tolerance values used in the RBP are provided in Hilsenhoff (1988). The greatest number of taxa was collected at the off-site location, SC6 (16 taxa). Taxa that accounted for most of the benthos includes:

chironomid midge larvae	26%
blood-red chironomid midge larvae	15%
hydropsychid caddis fly nymphs	18%
freshwater clams	10%
asellid isopods	9%

These taxa are fairly tolerant of pollution. HBI tolerance values vary from 0 (intolerant, sensitive) to 10 (highly tolerant). Hydrophychids have a tolerance value of 4; chironomids 6; and blood-red chironomids and asellids 8. There are no pollution tolerance values for clams.

Physical habitat at sampling sites throughout the Spring Creek watershed, including the reference station, was generally similar. Watershed erosion appeared to be moderate at all locations, except none was apparent at SC5. Riparian habitat around most stations is forest; stations SC5 and SC6 also have pasture and agricultural land use, respectively. Dissolved oxygen concentrations at the six stations are comparable, ranging from 6.4 to 8.61 mg/L. Water depth at the riffle and the run areas are less than ankle deep. Stream width ranges from 1.1 to 3 meters.

Site SC1 is upstream of all IAAAP activities, and was considered the watershed reference site at the time of the benthic study. Sites SC2 and SC3, within IAAAP, are rated as unimpaired in comparison to the reference (Table E-6). Further downstream, stations SC4, SC5 and SC6, were rated as slightly impaired. Macroinvertebrate communities at these three lower stations differed from other stations largely on the basis of an abundance of chironomids. This, in turn, lowered the scraper/filterer, EPT/chironomid, and shredders/total ratios. These differences indicated communities that were based more on fine particulate organic matter in the water column, a condition that is generally indicative of organic pollution, than on leaves and other coarse particulate organic matter. Even the stations that were rated as slightly impaired scored better than the reference station on some metrics. However, BCSs allow no credit for exceeding the metric scores for the reference station.

Because most of the watershed is intensively cultivated, the reference station itself may represent a slightly impaired condition. The impairment exhibited at stations where BCSs suggested a slightly degraded condition is considered to be more the result of agricultural practices at the site than by IAAAP industrial operations.

Aquatic ecosystem health in the Spring Creek watershed, as measured by the RBP appraisal of benthic community structure, is unaffected by IAAAP operations. Agricultural activities in areas downstream of IAAAP open the stream to sunlight and cause a shift in the community from one feeding on leaves and other coarse particulate organic matter to one feeding on fine particulate organic matter in the water column. Generally, this is considered indicative of organic pollution (e.g., agricultural waste).

4.1.2 Fish Sampling and Analysis

Fish samples were collected in 1997. The methods used and results of these samples are described in Section 3.2. The risks posed by past and ongoing operations at IAAAP were assessed separately for each of the four watersheds. Because of its listing as a threatened species by the State of Iowa, the orangethroat darter (*Etheostoma spectabile*) was selected as a key receptor. Good numbers of this threatened species were found in Long, Brush, and Spring Creeks during field investigations, and individuals examined did not show signs of stress, as indicated by DELTs (deformities, eroded fins, lesions, or tumors). Fish were not sampled in the Skunk River, but were observed at some areas. Orangethroat darters were observed at some locations, but these were not sampled because of their special status. Data regarding the exact number of fish collected and their size are not available. However, information is available indicating whether fish are rare (1 to 2), common (3 to 5), abundant (6 to 10), or dominant (greater than 10) at the sampling locations. This information is presented in Appendix E.

DELT evaluations are visual observations used to qualitatively assess the apparent health of an individual fish, and extrapolate this information to the overall fish community. There are limitations associated with interpretation of effects-based lines of evidence, such as DELT. While these provide direct measures and observations of the health of the creek environment, they can not account for health effects, such as reduced reproductive success or adverse effects during more sensitive life stages.

4.2 TERRESTRIAL HABITAT METHODOLOGY

In 1996, an inventory and assessment of habitats and biota of IAAAP was published by Horton and others. Although not performed for this BERA, the work is summarized here. Horton and others (1996) focused on natural areas along creeks and drainageways, where temperate deciduous forest predominates, to assess the health of the vascular plant communities potentially affected by chemical contamination or land use practices. They used a forest community structure quality index composed of six metrics, based on the richness and dominance of indigenous vascular plants and presence of rare vascular plants and bryophytes. Horton and others (1996) inventoried 30 forest community sites in, or near, IAAAP and developed a site quality index (SQI) for each locality. The SQI represents the sum of the class scores across all six metrics. Horton and others (1996) classified sites as being of "exceptional", "significant", or "marginal value".

Although the SQI was developed and used by Horton *et al.* to define the value of a site as a natural area, it is assumed for the BERA, that sites having "exceptional" or "significant" SQIs are not degraded by chemical contamination. However, it is also recognized that sites identified as "marginal natural areas" may have been altered from a "natural state" by factors other than chemical contamination. Foremost among such factors would be land clearing and agricultural activities on the IAAAP property.

Fifteen of the Horton and others (1996) study sites were in the Long Creek Watershed. The sites adjacent to and north of Plant Road K, represent some of the highest quality forest in the Long, Brush, and Spring Creek Watersheds and the entire IAAAP (Horton and others, 1996). Contamination in these drainages is heaviest in the northern, upland areas and affects the site north of Plant Road K more than sites south of that road. Therefore, it appears that IAAAP facility development, through restriction of forest lot size, may be limiting forest quality to the same or a greater degree than contamination.

The forest communities in the small drainages to the Skunk River are some of the highest quality forests at IAAAP. SQI values indicate "exceptional" forest communities at three sites and "significant" communities at the other sites surveyed. Several State-protected plants are recorded in the watershed, and are not being threatened by ongoing IAAAP operations.

5.0 TOXICITY ASSESSMENT

Section 5.0 of the BERA summarizes methods applied to developing TRVs. The TRVs are used to quantitatively estimate the magnitude of toxicity of each analyte selected for risk characterization. The TRVs are used with modeled wildlife exposure doses to calculate HQs by analyte for each receptor.

5.1 DEVELOPMENT OF TOXICITY REFERENCE VALUES

TRVs for wildlife receptors represent doses that are protective based on specific toxicity endpoints (e.g., survival, growth, reproduction, etc.). TRVs for wildlife are species-specific and are used, with the modeled wildlife exposure doses, to calculate HQs for each COPEC and for each receptor. The TRVs used in risk assessments are extrapolated from information obtained in the laboratory. The laboratory experiments are conducted under controlled environment. Site characteristics that influence exposure by receptors such as seasonal variations and temperature extremes are not generally considered in a BERA. The TRVs were presented in the Development of Dose Estimation Models and Toxicity Reference Values (i.e. TRV Memorandum), a working memorandum developed to facilitate review of the general approach in the BERA. Methods for developing the TRVs are discussed in the following subsections and include revisions addressing comments from stakeholders.

5.1.1 Mammalian and Avian Wildlife Species

Toxicity reference values for each COPEC and the four wildlife species (the white-footed mouse, short-tailed shrew, belted kingfisher, and Indiana bat) were derived from literature. Research for TRVs on each COPEC began with searches of published toxicity studies on mammals and birds in several databases, including Agency of Toxic Substance and Disease Registry (ATSDR) toxicological profiles, National Library of Medicine's Hazardous Substance Database (Toxline), Oak Ridge National Laboratory's Risk Assessment Information System (RAIS), USEPA's Integrated Risk Information System (IRIS), and USEPA's ECOTOX. Several comprehensive reports, such as USEPA Region 6 Draft Screening Level Ecological Risk Assessment Protocol (USEPA, 1999), Toxicological Benchmarks for Wildlife (Sample and others, 1996), and CH_2M Hill and USACE's review of TRVs (2000), were also reviewed. Literature that provided information on study design, such as duration, handling of test species, physical information on test species, and dose route, was selected over literature with more limited information. Chronic toxicity studies were considered preferentially because, at most sites, receptors were exposed over a long period. For a study on laboratory rodents, at least one year was considered to be chronic exposure (Sample and others, 1996). For avian studies, exposure duration greater than ten weeks was considered to be chronic exposure (Sample and others 1996). Toxicity endpoints that correlated with significant ecological impacts, such as reproduction, development, and survival, were preferred over systemic and acute effects. Doses administered through an oral route (diet, water, gavage) were preferred over other routes (e.g. direct injection).

The literature search focused on laboratory studies to obtain information on the Lowest observed adverse effects level (LOAEL) and No observed adverse effects level (NOAEL). Values available only from subchronic studies were adjusted by dividing the indicated value by an uncertainty factor of 10 to estimate a chronic LOAEL or NOAEL. Hazard quotients were evaluated using both the LOAEL and NOAEL to present a range for the risk characterization. The LOAEL or NOAEL for a mammalian or avian wildlife species used the same value as the LOAEL or NOAEL for a mammalian or avian test species, if available.

LOAEL or NOAEL based TRVs were selected primarily from studies that used reproduction or growth as endpoints. The LOAEL-based TRVs were used to assess the lower limit of where adverse toxic effects might occur to individual ecological receptors. The NOAEL-based TRVs were used to assess an upper limit of exposure that would not be toxic to an individual receptor. Within the dose range between the NOAEL and LOAEL, effects on a given species may or may not occur.

In the case of TNT, a NOAEL- and LOAEL-based TRV had been used in the draft version of the BERA, which was based on survival. Based on comment on the draft BERA, the USFWS desired that a more sensitive toxicity endpoint than survival be selected to evaluate the toxicity of TNT for the Indiana bat, because of the special status of this bat species. In addition, TNT was considered a key COPEC at a number of sites at IAAAP. Therefore, it was considered important to reevaluate the TRV for this analytes. For these reasons, an alternate TRV for TNT was used in this draft final BERA for the Indiana bat. The selected TRV for TNT was a Lower Effective Dose (10 percent) [LED10] value that was developed by USACHPPM (2000) and not a NOAEL. The LED 10 (95% lower confidence limit for not exceeding a benchmark response) value for TNT is 0.2 mg/kg-d and was used for calculating NOAEL- based HQs. The study data used to calculate the values were based on changes in body weight, hemoglobin, and hematocrit in dogs. These were determined to be the most sensitive endpoints and may be ecologically significant to sensitive species. It should be noted that the LED 10 (0.2 mg/kg-d) is ten times lower than the NOAEL that is predicted by the study used to develop the LED10. Therefore, the use of the LED 10 as the NOAEL -based TRV for TNT for the bat would be expected to conservatively estimate the risk to this species. Further details regarding TRVs for TNT for Indiana bat are presented in Technical Memorandum No. 5.

In discussions with the USFWS concerning the TNT TRV for the bat, the RDX TRV used for the bat was also reviewed. It was decide that the TRVs for RDX would remain the same as that used in the draft BERA, because it was considered that the original TRVs were adequately protective. This is also discussed in TM5. For example, the effect dose (10 percent) [ED10] value for RDX in the USACHPPM study was found to be 1.19 mg/kg-d, while the NOAEL value found in the literature, that was used in the draft BERA, is 1.38 mg/kg-d. Because the two values are comparable, the NOAEL and LOAEL based TRVs for RDX were used in the dose estimation process.

The LOAEL and NOAEL for the four upper trophic level receptors are presented in Appendix G, Tables G-1 through G-4.

5.1.2 Fish

Toxicity reference values for water exposure to fish used the lowest Chronic Value (CV) for fish from Suter and Tsao (1996), where possible. The CV is the geometric mean of the lowest observed effect concentration (LOEC) and the no observed effect concentration (NOEC). For constituents with no CV in Suter and Tsao (1996), the highest NOEC from the literature was used, except for TNT and its metabolites, barium, and dieldrin. For TNT, a LOEC of 40 μg/L was multiplied by a safety factor of 0.1. The LOEC for 2-amino-4,6-DNT and 4-amino-2,6-DNT are not available. Therefore, the LOEC for TNT was used as a surrogate for these two compounds. For barium, the secondary CV was used (USEPA, 1996b). For dieldrin, the final CV was used, as calculated by USEPA for use in derivation of sediment quality criteria (Suter and Tsao, 1996).

Toxicity reference values for fish tissue residues were developed based on Tissue Screening Concentrations (TSCs) for fish tissue residues derived from the literature compiled in a database by Jarvinen and Ankley (1999). Values were available for most of the metals and dieldrin. There were no data for barium, beryllium, cobalt, manganese, thallium, phthalates, or explosives. In searching the database, priority was given to chronic studies using early life stages; whole body, muscle, vital organ, or reproductive organ analyses; and growth or reproductive endpoints. The TSC was calculated as the arithmetic mean between the lowest effect level and the highest no effect level within a study, for the same tissue type. If there was no single appropriate study with both an effect level and a no-effect level, the lowest effect level found (or the highest no-effect level, if lower than the effect level) was used as the TSC. The modeled or measured tissue concentration (or detection limit, if the constituent was not detected) was divided by the tissue residue TSC to obtain the HQ for fish tissue residue. For COPECs for which data was unavailable from Jarvinen and Ankley, the Environmental Residue Effects Database at http://ered1.wes.army.mil/ered/index.cfm was checked. However, this source provided no further data.

Toxicity reference values for water exposure to fish are presented in Appendix G, Table G-5. Toxicity reference values for fish tissue residue are presented in Appendix G, Table G-6. These two methods have different advantages and disadvantages, but are similar in the levels of associated uncertainty. The tissue residue method more adequately accounts for bioavailability and assimilation when used with measured tissue concentrations. The water exposure method is a more direct comparison with TRVs based on media concentration. They provide a check on each other as lines of evidence for the same receptor.

5.1.3 Algae

Toxicity reference values for aquatic plants were derived from the literature and, where available, used in place of the AWQC. Where possible, the lowest CV for aquatic plants from Suter and Tsao (1996) was used. The CV is the geometric mean of the LOEC and the NOEC. For constituents with no CV in Suter and Tsao (1996), the highest NOEC from the literature was used, except for TNT, 1,3,5-TNB, RDX, BEHP, cobalt, manganese, and vanadium. For TNT, 1,3,5-TNB, and RDX, LOECs were multiplied by a safety factor of 0.1. For the other constituents, the AWQC or secondary CV (Suter and Tsao, 1996) was used for comparison. TRVs for algae are presented in Appendix G, Table G-7.

6.0 RISK CHARACTERIZATION

Risk characterization combines information on exposure and effects (or toxicity) to estimate whether particular levels of contamination pose a potential ecological concern. Risk characterization starts with the assessment of effects on particular receptors that were selected during planning for the assessment (see Section 2.0). The receptors that were selected represent the most sensitive or highly valued species at the site considering their habitat needs and the nature of the contamination. If these selected receptors are estimated to be at no risk, then the ecosystem, as a whole, is considered protected. On the other hand, if individual receptors or communities are estimated to be at risk, there is still the question of whether the receptor population or community, as a whole, is at risk. The risk characterization is used to make qualitative judgements concerning the potential to cause actual ecological harm on a receptor species or community. At IAAAP, if a particular AOC is estimated to pose a health concern to an ecological receptor, the further issue is raised as to what that may mean for the species or related species on the population (i.e. facility wide).

The question of effects for the selected receptors is quantitatively documented in this section. The probability of community and population effects is addressed qualitatively. Many factors contribute to uncertainties associated with the BERA including the selection of indicator species, estimation of exposure, characterization of potential ecological effects, and final evaluation of risk. For this assessment, conservatism was incorporated at many points in the process to guard against underestimation of the actual risk to ecological receptors at the site. The dose estimation models used in this BERA to estimate HQs are based on conservative assumptions. When several conservative assumptions are multiplied together to estimate a given HQ, the resultant HQ is conservative in nature. Some of the high HQ values (i.e., much greater than one) are evaluated further in terms of a sensitivity analysis that looks at a range of values for some of the key exposure assumptions. In this way, the uncertainty associated with some of these elevated HQs are discussed in more detail in applicable areas within this section to help risk managers better understand the range of potential ecological risks. In cases where the HQs are high, the results of the BERA may be considered sufficient by the risk managers to make decisions concerning the required remedy for the AOCs not slated for human health-based remediation, and thus further assessment beyond the BERA would not be needed.

For wildlife species where exposure modeling was required and field measures of effects were not practical, explanation is provided on how risks were quantitatively evaluated (i.e., development of HQs and critical concentrations, CCs). Risks to the terrestrial environment are addressed at each AOC within a particular watershed. For each group of AOCs within a watershed, a summary is provided to indicate which COPECs were estimated to pose potential ecological concern. This information is provided first by watershed because the COPECs that are a potential concern in the terrestrial environment are also the COPECs that have the potential to migrate and cause concerns to the aquatic environment.

Following the summary of risks to wildlife species in the terrestrial environment is evaluation of the aquatic environment for each watershed. Multiple lines of evidence were collected (i.e., wildlife exposure modeling, DELT, RBP II) to evaluate if releases from the AOCs are effecting the aquatic environment. The ‘line-of-evidence’ approach is used because it provides a better means of evaluating if receptors or communities appear to be effected by the COPECs present, by looking at the results from the multiple line of evidence as a whole. When only one line of evidence is available, like with the terrestrial environment risk assessment, there is less confidence in the results of the assessment.

Finally, the results of the BERA for each watershed are summarized to identify the key COPECs (if any) that appear to pose a potential ecological risk. For these key COPECs, the spatial distribution of the contamination in relation to LOAEL-based CCs are provided for the most sensitive receptor for the applicable AOCs within the watershed. In addition, whether there is any apparent relationship between the key COPECs in the AOCs, which are considered the sources area, and the COPECs in the surface water bodies is also discussed. This information is used to identify potential problem areas within the watershed.

6.1 GENERAL RISK CHARACTERIZATION PROCESS AND METHODOLOGY

This subsection provides the general methods used for risk characterization for the receptors selected at the planning stages of the BERA and is based on consideration of the results of the ecological risk analysis (i.e., field survey, HQ calculations and comparison to CCs).

6.1.1 Evaluation of Field Survey Results

Field surveys conducted within the aquatic environment at IAAAP included the RBP II and fish survey for DELT. If species abundance or diversity differs obviously between the upstream and investigative areas, the class of receptors of concern may have been negatively impacted by contamination originating within IAAAP. This information is used as one line of evidence for the aquatic environment, and is combined with HQ information (described in the next subsection) to provide a weight of evidence concerning potential risks for the aquatic environment. The results of the field survey are described in Section 4.0 of this BERA and are incorporated into a description of the lines of evidence at the end of each subsection describing the results of the aquatic environment ecological risks for a watershed.

6.1.2 Development of HQs

HQs are a means of relating the estimated level of exposure to the stressor-response relationship, for each COPEC and receptor. In the screening process (see Appendix A), HQ values were determined as the ratio of the maximum concentration of a constituent in a media to its corresponding SV. In the BERA, HQ values are calculated by comparing modeled COPEC doses to TRVs. The food and soil/sediment/water COPEC doses together make up the total exposure dose and were developed as detailed in Section 3.0. The TRVs were derived using NOAEL and LOAEL values from the literature, as discussed in Section 5.0. The HQs are evaluated separately for each COPEC. Two separate HQs are calculated for each COPEC using the NOAEL- and LOAEL-based TRVs, and are referred to as the NOAEL- and LOAEL– based HQs. It should be noted that the TRVs used in the HQ calculations were extrapolated from laboratory studies conducted with test organisms, and were not based on species found on the IAAAP. HQ values for all COPECs are not summed in a BERA to develop a cumulative HQ.

The equation used to calculate the NOAEL- and LOAEL-based HQs is as follows:

$$HQ = ED_{total}/TRV$$

Where:

HQ	=	Hazard Quotient (unitless)
ED_{total}	=	Total Exposure Dose (mg/kg/day)
TRV	=	NOAEL- or LOAEL-based Toxicity Reference Value (mg/kg/day)

According to USEPA (1997), the lower bound, or threshold, below which risk is assumed to be insignificant is based on conservative assumptions and NOAEL-based toxicity values. A NOAEL corresponds to a dose that is *not associated with adverse effects*. Therefore, NOAEL-based HQs greater than one represent the lower end of the potential risk range. HQs developed in ecological risk estimates are generally represented to one significant digit, because the certainty of exposure factors is only known to one significant digit. Therefore, HQs were rounded to the nearest whole integer using normal arithmetic methods (i.e. 1.4 was rounded to 1.0, 1.5 to 2, etc.). For some COPECs, NOAEL-based HQs could not be estimated because NOAELs were not available. This will be discussed further under uncertainties in Section 7.0. NOAEL-based HQs found to be greater than one are discussed further for each AOC. However, it should be noted that a NOAEL-based HQ greater than one does not necessarily represent an environmental concentration that would pose a concern to the ecological receptor. For this reason, a NOAEL-based HQ is a fairly weak line of evidence to use to determine if a COPEC poses a potential ecological concern.

A LOAEL is used as a lower bound to estimate an exposure dose that could potentially *cause an adverse effect* to an ecological receptor. A LOAEL represents the lowest dose in a toxicological study that was observed to cause an adverse effect on the test organism. Therefore, LOAEL-based HQs of one or greater, generally, are associated with some level of adverse effect in the test species. However, while the observed LOAEL-based dose may have caused an effect in the test organism, it may or may not show direct effects on species found in the IAAAP. Therefore, LOAEL-based HQ values equal to or greater than one may or may not indicate adverse effects on the assessment endpoints selected in this BERA. LOAEL-based HQs are developed using the same exposure dose that is used for the NOAEL-based HQs. However, the TRV used is different because it is based on a LOAEL. The LOAEL-based HQ is considered to be a more realistic prediction of potential risk for an ecological receptor than the NOAEL-based HQ. Therefore, when a LOAEL-based HQ is equal to or greater than one, it is evaluated further for each terrestrial AOC. In these cases, LOAEL-based CCs are calculated which are concentrations of a COPEC that correspond to a LOAEL-based HQ of one. This is discussed further in Section 6.1.3 below.

The NOAEL and LOAEL-based HQs are presented for each watershed first by AOC within the terrestrial environment, then for the aquatic environment in terms of the potential for risk to receptor groups. More lines of evidence (other than just HQs) are presented for the aquatic habitats than terrestrial. There have been no other evaluations or plans made for remedial decisions in the aquatic habitat. Conversely, remedial planning has occurred for many of the terrestrial AOCs based on human health risk or other factors. Of the AOCs evaluated in the BERA, the following have already been slated for remediation based on human health concerns:

Line 1 (IAAP-001/R01)
Line 2 (IAAP-002/R02)
Line 3 (IAAP-003/R03)
Line 3A (IAAP-004/R04)
Lines 4A/4B (IAAP-005/R05)
Line 6 (IAAP-007/R07)
Line 8 (IAAP-009/R09)
Line 9 (IAAP-010/R10)
Line 800 (IAAP-011/R11)
Firing Site (IAAP-030/R22)
Roundhouse Transformer (IAAP-040/R28)

For these AOCs, remediation is driven by human health rather than ecological health concerns. The ecological risks associated with these AOCs have not been described in detail within this section, because the remediation slated for protection of human health risks at these AOCs should mitigate potential ecological risks. Also it should be noted that the COPECs associated with these AOCs are located next to buildings and other facility structures that do not provide prime wildlife habitat. During the remediation process, soils will be (or were) excavated to over 2 ft in depth. This will eliminate contamination and, for a time, any ecological habitat that may currently exist at these AOCs for wildlife. For this reason, this section emphasizes an evaluation of ecological risk for those AOCs that are not currently slated for remediation. However, for completeness, ecological risks were estimated for the AOCs listed above, and the results are included in this BERA. In addition, an evaluation has been completed for Line 5A/5B, where human health based remediation has already occurred, to determine if residual contamination is protective of ecological health.

The AOCs for which human health based remediation are not currently slated to occur, and are evaluated in greater depth in this BERA, include:

Line 7 (IAAP-008/R08)
Contaminated Waste Processor (IAAP-024/R16)
Sewage Treatment Plant (IAAP-026/R18)
Fly Ash Landfill (IAAP-027/R19)
Construction Debris Landfill (IAAP-028/R20)
Line 3A Sewage Treatment Plant (IAAP-029/R21)
Building 600-86 Septic System (IAAP-038/R26)
Line 3A Pond (IAAP-041/R29)
Fly Ash Disposal Area (IAAP-043/R30)

For these AOCs where remediation is not currently planned, LOAEL-based HQ exceedances were evaluated on a spatial basis to assess whether ecological risks are associated with site-wide contamination or just scattered hot-spots. As mentioned above, LOAEL-based HQs were considered a stronger line of evidence than the NOAEL-based HQs, and for this reason, were used to identify those COPECs that should be further evaluated on a spatial basis. This level of assessment helps to put into perspective whether the LOAEL-based HQ exceedances would be associated with potential ecological health concerns. The spatial distribution of LOAEL-based HQ exceedances was accomplished by calculating LOAEL-based CCs for COPECs that had LOAEL-based HQs of one or greater. The process used to estimate the CCs is described below.

In essence a LOAEL-based CC is a soil concentration of a COPEC that equates to a LOAEL-based HQ equal to one. In this way, a search of the analytical database could be performed to identify soil sample locations that would have a concentration that would equate to a LOAEL-based HQ of one or higher.

6.1.3 Development of Critical Concentrations

Critical Concentrations are COPEC concentrations, calculated for a specific COPEC-receptor combination that may pose a risk to that receptor. The CCs are calculated analyte concentrations in soil, surface water, and sediment that equate to a LOAEL-based HQ of one or a NOAEL-based HQ greater than one. The NOAEL-based CC provides a lower bound HQ estimate below which no ecological risk would be considered likely, while the LOAEL-based CC represents a concentration above which ecological risks are more likely. Between the NOAEL-based and LOAEL-based CC is a gray area where ecological risks are possible, but unlikely.

6.1.3.1 Soil Critical Concentrations

For each analyte, exposure doses (Ej) presented in equations 7, 10, and 11 for terrestrial receptors in Section 3.3, are set equal to the LOAEL or NOAEL based TRV and solved for Cs-j, which represents the COPEC concentration in soil. The resulting CC values are the COPEC concentration in soil that corresponds to the LOAEL or NOAEL based HQ of one for white-footed mouse, short-tailed shrew, and the Indiana bat. The LOAEL- and NOAEL- based CCs calculated for the three terrestrial receptors at IAAAP are provided in Table 6-1a and 6-1b, respectively. Exposure to soil containing COPECs below the LOAEL based CCs should not result in unacceptable levels of risk to ecological receptors. Therefore, the CC values corresponding to LOAEL-based HQs of one were used to estimate COPEC concentrations in soil that might pose an ecological concern. The CCs are not meant to be used as clean-up goals, but are rather as one line of evidence to be used to evaluate if a site poses a potential risk to ecological receptors. To provide additional information to the risk managers, NOAEL- based CCs for terrestrial receptors were calculated for constituents with LOAEL based HQs equal to or exceeding one (1). It should be noted that a NOAEL -based TRV was not used to calculate CCs for exposure of the Indiana bat to TNT. At the request of the USFWS and the risk managers, the USACHPPM (2000) Wildlife Toxicity Assessment value of 0.2 mg/kg-d was used to calculate CCs for TNT for Indiana bat. The USACHPPM value was derived using USEPA's benchmark dose approach and eliminates some of the limitations of the LOAEL/NOAEL approach. Further details regarding the TRV development for TNT are provided in Technical Memorandum No. 5.

For metals, site-specific background soil criteria are provided in Table 6-1a and 6-1b, because sometimes the LOAEL-based or the NOAEL-based CCs are less than background concentrations. The background concentrations are considered representative of natural conditions in areas unaffected by the IAAAP. That some CCs are less than background is likely a function of the conservative nature of the models used to estimate the HQs (and CCs). In these situations, the CCs would not be expected to represent concentrations that would truly be associated with ecological effects. For this reason, for situations where LOAEL-based CC exceedances were identified, these exceedances were put into perspective in comparison to the magnitude of their background concentrations. If the concentration of the COPEC did not exceed its background concentration, even though it was associated with a LOAEL-based CC exceedance, it was not considered to pose an ecological concern. This is why it was considered important to include the background concentration for each COPEC on Tables 6-1a and 6-1b. For such constituents, the background concentration is the default CC. The appropriate CCs for each constituent are presented with asterisks in Tables 6-1a and 6-1b. The values with asterisks, which include the background concentrations if higher than the CCs, are noted as the CCs during further discussion presented in this document. It should be noted that for RDX and lead, no specific ecological-based CC was selected, because remediation will be driven by a lower human health remediation goal (shown in bold). This is discussed further in the next paragraph.

Remediation goals (RGs) or preliminary remediation goals (PRGs) are available at IAAAP that are based on protection of human health. If such RGs or PRGs are exceeded for a constituent, then remediation involving removal of at least the top two feet of soil are planned at the AOCs discussed previously (see Section 6.1.2). It is clear that the human health PRGs are lower than the corresponding CCs for the two (i.e., RDX and lead) of the three main COPECs (i.e., TNT, RDX, and lead) at most of these AOCs. These two RGs/PRGs are bolded to emphasize that for these COPECs, at the AOCs where these two COPECs are the primary concern, protection of human health will drive remediation rather than ecological risk. It should be noted that for the third primary COPEC (i.e., TNT), the human health RG of 47.6 is much higher than the ecological LOAEL-based CC of 27.5. For this reason, at AOCs where TNT is present as the sole COPEC of concern, the assumption that remediation to human health RGs would be protective of ecological risk is not self-evident. However, in most cases, where TNT is present as a primary COPEC, RDX is also co-located. In practice, to meet the human health RG for RDX, the TNT concentrations are also removed. Whether the residual TNT contamination is protective of ecological health needs to be evaluated following the BERA. An example of such evaluation, using residual concentration data from Line 5A/5B, is presented later in this section. Therefore, as discussed previously, for those AOCs where human health considerations will drive the remediation of these three COPECs, detailed evaluation of the ecological risk is not provided. The ecological risks associated with these AOCs have not been described in detail within this section (although they have been summarized in the tables and included in appendices to the BERA) because the remediation slated for protection of human health risks at these AOCs should mitigate potential ecological risks. Also it should be noted that the COPECs associated with these AOCs are located next to buildings and other facility structures that do not provide prime wildlife habitat. During the planned remediation process to handle human health risks, soils will be excavated to over 2 ft in depth. For this reason, this section emphasizes an evaluation of ecological risk for those AOCs that are not currently slated for remediation.

TABLE 6-1a
LOAEL-based Critical Concentrations for Terrestrial Receptors

COPEC	CC (mg/kg)			Human Health RG or PRG	Background (Metals)
	White-footed Mouse	Short-tailed Shrew	Indiana Bat		
	(LOAEL)	(LOAEL)	(LOAEL)	mg/kg	mg/kg
1,3-Dinitrobenzene	0.67	0.39*	0.60		
2,4,6-Trinitrotoluene	407[a]	163[a]	27.5*	47.60	
Aroclor 1254	9.72	1.46*	2.21	10.00[b]	
Aroclor 1260	9.71	1.45*	2.20	10.00[b]	
Dieldrin	0.28	0.04*	0.07		
HMX	5.25*	18.91	29.4	51,000.00	

TABLE 6-1a
LOAEL-based Critical Concentrations for Terrestrial Receptors

COPEC	CC (mg/kg)			Human Health RG or PRG	Background (Metals)
	White-footed Mouse	Short-tailed Shrew	Indiana Bat		
	(LOAEL)	(LOAEL)	(LOAEL)	mg/kg	mg/kg
RDX	22.90	32.28	49.6	**1.30**	
Antimony	44.94	7.92	16.4	816.00	31.39*
Arsenic	127.79	14.83	41.4	30.00	15.37*
Barium	771.76	125.50	259		368.37*
Cadmium	110.03	19.96*	30.0	1,000.00	0.97
Cobalt	124.42	14.01	53.2		26.40*
Copper	428.63	131.83	703		2,444.73*
Lead	18,842.54	1,815.90	12,100	**1,000.00**	1,210.09
Manganese	10,463.17	2,187.45	5,110		1,932.75*
Mercury	0.25	0.04	0.05	4	0.14*
Nickel[a]	1,350.19	111.96*	1,040	20,000.00	78.99
Selenium	16.55	2.09*	4.32		0.72
Silver	10.28	2.38*	4.91		0.83
Thallium	3.76	0.46	0.97	143.00	19.05*
Vanadium	281.21	30.25	202		53.84*

Note:
a NOAEL-based value because LOAEL-based TRVs are not available
b Total PCBs
* Selected CCs

TABLE 6-1b
NOAEL-based Critical Concentrations for Terrestrial Receptors

COPEC	CC (mg/kg)			Human Health RG or PRG	Background (Metals)
	White-footed Mouse	Short-tailed Shrew	Indiana Bat		
	(NOAEL)	(NOAEL)	(NOAEL)	mg/kg	mg/kg
1,3-Dinitrobenzene	0.20	0.12*	0.18		
2,4,6-Trinitrotoluene	407	163	0.69[a*]	47.60	
Aroclor 1260	1.41	0.21*	0.32	10[b]	
HMX	3.05*	11.0	17.0	51,000	
RDX	3.32*	4.68	7.19	**1.30**	
Antimony	6.53	1.15	2.37	816	31.39*
Arsenic	46.5	5.39	15.0	30	15.37*
Barium	289	46.9	96.8		368.37*
Cobalt	16.0	2.03	7.71		26.40*
Copper	404	124	662		2,444.73*
Lead	9,107	878	5,846	**1,000**	1,210.09*
Manganese	4707	984	2,297		1,932.75*
Mercury	0.07	0.01	0.02	4	0.14*
Selenium	14.6	1.82*	3.80		0.72
Silver	1.49	0.34*	0.71		0.83
Thallium	0.56	0.07	0.14	143	19.05*
Vanadium	40.8	4.39	29.2		53.84*

Note:

a For Indiana bat, toxicity assessment value of 0.2 mg/kg/day (USACHPPM 2000) was used as the TRV to calculate the CC.
b Total PCBs
* Selected CCs

For those nine AOCs where human health based remediation is not planned, and where ecological risk might be the remediation driver, applicable spatial distributions of LOAEL-based CCs are discussed, in conjunction with the watershed's ecological risks. These spatial evaluations identify the location of the LOAEL-based CC exceedances in relation to ecological habitat, and thus help evaluate the significance of these exceedances.

Table 6-1c lists COPECs exceeding LOAEL-based CCs for the nine AOCs not currently slated for remediation based on protection of human health. Figures 6-1 through 6-9 show the spatial distribution of locations within these AOCs where COPEC concentrations exceed LOAEL-based CCs.

TABLE 6-1c
COPECs Exceeding LOAEL-Based CCs, by Watershed and AOC

Watershed	AOCs	Constituents
Long Creek	IAAP-027/R19	Arsenic (1), Selenium (1)
	IAAP-028/R20	1,3-Dinitrobenzene (1)
	IAAP-038/R26	Mercury (3)
	IAAP-041/R29	Cobalt (1)
	IAAP-043/R30	Mercury (1)
Skunk River	IAAP-029/R21	Silver (3)
Brush Creek	IAAP-008/R08	Copper (1), Dieldrin (1), Mercury (4), PCBs (1), Thallium (1)
	IAAP-026/R18	Mercury (4), Silver (4)
Spring Creek	IAAP-024/R16	HMX (1)

Note: Number in parenthesis refers to the number of sample locations within the AOC exceeding LOAEL-based CCs. IAAP-041/R29 also drains to the Skunk River watershed.

The AOCs listed above are evaluated in greater detail in this BERA.

There are numerous COPECs, for which NOAEL- and LOAEL- based HQ values were estimated and presented in the BERA for each AOC or surface water body. The BERA generally discusses HQ values from the perspective of overall magnitude to help focus the discussion. Designation of ecological risks as high, medium, or low cannot be made based on HQ values alone. Other lines of evidence, that are effect-based, would be required beyond HQ values, to define the degree of potential ecological risk, if any. It is more helpful, in the case of the soil AOCs, to be aware of the spatial distribution of those locations where the LOAEL-based CCs are exceeded. This gives a more definitive indication of whether remedial actions might be needed, and if so, where the actions should be focused, rather than an impression of a particular level of risk to a population over the entire AOC.

6.1.3.2 Surface Water and Sediment Critical Concentrations

The surface water and sediment CCs are calculated analyte concentrations in surface water and sediment that equate to a LOAEL- or NOAEL- based HQ of one. The CCs are back calculated based on the dose models presented as Equations 2 and 5 in Section 3.3 of the BERA. For each analyte, exposure doses are set equal to the LOAEL- or NOAEL- based TRV and solved for Cw-j or Cse-j, which represents the COPEC concentrations in surface water and sediment, respectively. The resulting LOAEL- and NOAEL- based CC values are the COPEC concentrations that correspond to LOAEL- or NOAEL- based HQ of one for Indiana bat and Belted kingfisher.

Exposure to surface water or sediment, containing COPECs at or above the LOAEL based CCs, has the potential for unacceptable levels of risk to ecological receptors. Further evaluation is conducted for constituents with LOAEL based HQs exceeding or equal to one. Similar to the soil CCs, NOAEL based CCs are calculated for such constituents to provide risk managers with additional information regarding sensitivity of the HQ estimates. The NOAEL-based CC provides a lower bound below which no ecological risk would be considered likely, while the LOAEL-based CC represents a concentration above which ecological risks are more likely. Between the NOAEL-based and LOAEL-based CC is a gray area where ecological risks are possible, but unlikely. It should be noted that instead of using a NOAEL -based TRV for TNT for the Indiana bat to calculate the NOAEL-based CC, an LED10 value of 0.2 mg/kg-d, developed by USACHPPM (2000), was used to calculate the NOAEL based CC. The LED10 dose is an order of magnitude below the NOAEL (i.e., 2 mg/kg-day) reported in the study used to derive the LED10. Further details regarding the TRV development for TNT and the calculation of surface water and sediment CCs are provided in Technical Memorandum No. 5.

Table 6-2a shows the LOAEL-based CCs of surface water and sediment for aquatic receptors.

TABLE 6-2a

LOAEL-based Critical Concentrations for Aquatic Receptors

COPEC	Surface Water CC (mg/L)		Sediment CC (mg/kg)	
	Belted Kingfisher (LOAEL)	Indiana Bat (LOAEL)	Belted Kingfisher (LOAEL)	Indiana Bat (LOAEL)
2,4,6-Trinitrotoluene	2.51	1.10*	5110	13.6*
RDX	13.9	12.9*	3970	23.4*
Bis(2-Ethylhexyl)phthalate[a]	0.0035*[a]	0.123	463[a]	310*
4,4'-DDT	0.000000454*	0.0000633	8.05	6.78*
Aluminum	111[a]	0.0137*	45800[a]	61.8*
Arsenic	0.72	0.049*	11600	4.03*
Barium	0.013*	0.28	1200	63.4*
Cadmium	0.045	0.008*	5750	8.47*
Copper	0.00096*	0.0076	95.8[a]	93.7*
Mercury	0.000027	0.0000084*	106	0.96*
Nickel	2.02*	16.2	22200	511*
Selenium	0.013	0.00075*	230	1.06*
Silver	1.11	0.0036*	13800	1.20*
Thallium	NA	0.000014*	NA	0.237*
Zinc	0.13*	0.20	37600	1620*

Note:
a NOAEL-based value because LOAEL-based TRVs are not available
* Selected CCs

No observed adverse effects level (NOAEL) based CCs for aquatic receptors were calculated for constituents with LOAEL based HQs exceeding one (1), as shown in Table 6-2b.

TABLE 6-2b
NOAEL-based Critical Concentrations for Aquatic Receptors

COPEC	Surface Water CC (mg/L)		Sediment CC (mg/kg)	
	Belted Kingfisher (NOAEL)	Indiana Bat (NOAEL)	Belted Kingfisher (NOAEL)	Indiana Bat (NOAEL)
2,4,6-Trinitrotoluene	0.143	0.040*[a]	292	0.49*[a]
4,4'-DDT	0.0000000658*	0.0000183	1.17*	1.97
Aluminum	111	0.00198*	45800	8.96*
Arsenic	0.24	0.00716*	3880	0.59*
Barium	NA	0.11*	NA	23.7*
Copper	0.00096*	0.0071	95.8	88.3*
Mercury	0.0000072	0.0000024*	28.3	0.28*
Selenium	0.0092	0.00066*	167	0.93*
Silver	NA	0.00053*	NA	0.17*
Thallium	NA	0.0000021*	NA	0.034*

Note:
a For Indiana Bat, LED10 (0.2 mg/kg/day) was used as the TRV to calculate the CC.
* Selected CCs.
NA NOAEL-based TRV not available.

Sampling locations within the four watersheds where COPEC concentrations exceed their corresponding LOAEL-based CCs are presented in Table 6-2c. Most of the COPECs for which concentrations in surface water and sediment exceed LOAEL-based CCs are metals. In general, COPECs exceeding CCs in surface water are similar to those exceeding CCs in sediment for each of the watershed.

TABLE 6-2c
COPECs Exceeding LOAEL-Based CCs for Surface Water and Sediment

Watershed	Surface Water	Sediment
Long Creek	Aluminum (5)	Aluminum (13)
	Barium (9)	Arsenic ((11)
	Copper (10)	Barium (12)
	Selenium (6)	Selenium (2)
	Thallium (1)	Thallium (1)
Skunk River	Aluminum (2)	Aluminum (2)
	Barium (1)	Arsenic (2)
	Selenium (1)	Barium (1)
		Silver (1)
Brush Creek	Aluminum (12)	Aluminum (22)
	Barium (21)	Arsenic (9)
	Copper (20)	Barium (22)
	Mercury (2)	Silver (6)
	Selenium (5)	
	Silver (7)	
	Thallium (16)	
Spring Creek	Barium (14)	Aluminum (15)
	Copper (13)	Arsenic (9)
	Selenium (5)	Barium (13)
		Copper (2)
		Selenium (1)

TABLE 6-2c COPECs Exceeding LOAEL-Based CCs for Surface Water and Sediment		
Watershed	**Surface Water**	**Sediment**
		Silver (4)
Note: Number in parenthesis refers to the number of sample locations within the watershed exceeding LOAEL-based CCs.		

6.2 LONG CREEK WATERSHED RISK CHARACTERIZATION

The following is an overall summary of the results of the risk characterization for the Long Creek watershed. Additional detailed evaluations by AOC and the Creek habitat are provided after this summary.

Soil AOCs within the Long Creek Watershed are Line 3A (IAAP-004/R04), Line 4A/4B (IAAP-005/R05), Line 8 (IAAP-009/R09), Line 800 (IAAP-011/R11), Fly Ash Landfill (IAAP-027/R19), Construction Debris landfill (IAAP-028/R20), Firing Site (IAAP-030/R22), Building 600-86 Septic System (IAAP-038/R26), Line 3A Pond (IAAP-041/R29), and Fly Ash Disposal Area (IAAP-043/R30). Of the 10 AOCs located in the watershed, five are AOCs where remediation to protect human health is not slated to occur. These are listed in the table below, which provides an overview of the COPECs that had exceedances of their LOAEL-based CCs at individual AOCs.

COPECs Exceeding LOAEL-Based CCs, by AOC within Long Creek Watershed	
AOCs	**Constituents**
IAAP-027/R19	Arsenic (1), Selenium (1)
IAAP-028/R20	1,3-Dinitrobenzene (1)
IAAP-038/R26	Mercury (3)
IAAP-041/R29	Cobalt (1)
IAAP-043/R30	Mercury (1)
Note: Number in parenthesis refers to the number of sample locations within the AOC exceeding LOAEL-based CCs. R29 also drains to the Skunk River watershed and is evaluated for that watershed too.	

6.2.1 Summary of Terrestrial Risks by AOC

Chemicals of potential ecological concern and estimated HQs (greater than 1) for AOCs in the Long Creek watershed are summarized in Table 6-3a, 6-3b, and 6-3c for terrestrial receptors. Risks for specific COPECs are listed if they exceed a NOAEL-based HQ of one or equal or exceed a LOAEL-based HQ of one.

TABLE 6-3a COPECs and Estimated HQs>1 for Terrestrial Receptors Long Creek Watershed										
AOCs	**White-footed Mouse LOAEL and NOAEL HQs**									
	IAAP-004/R04		**IAAP-005/R05**		**IAAP-009/R09**		**IAAP-011/R11**		**IAAP-027/R19***	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
1,3-Dinitrobenzene	2	<1	NA	NA	NA	NA	3	<1	NA	NA
2,4,6-Trinitrotoluene	67	NA	<1	NA	NA	NA	<1	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	2	<1	NA	NA

TABLE 6-3a
COPECs and Estimated HQs>1 for Terrestrial Receptors
Long Creek Watershed

Arsenic	NA	NA	NA	NA	NA	NA	≤1	<1	3	<1
HMX	809	323	NA	NA	NA	NA	21	8	NA	NA
Mercury	5	1	≤1	<1	16	3	3	<1	NA	NA
RDX	4802	480	NA	NA	NA	NA	4	<1	NA	NA
Silver	132	13	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	43	4	58	6	56	6	108	10.8	NA	NA
Long Creek AOC	**IAAP-028/R20***		**IAAP-030/R22**		**IAAP-038/R26***		**IAAP-041/R29***		**IAAP-043/R30***	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
1,3-Dinitrobenzene	7	1	NA	NA	NA	NA	NA	NA	NA	NA
Barium	NA	NA	4	<1	NA	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	4	<1	NA	NA
Copper	NA	NA	29	19	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	≤1	<1	98	20	NA	NA	4	<1
Thallium	NA	NA	47	5	NA	NA	NA	NA	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

TABLE 6-3b
COPECs and Estimated HQs>1 for Terrestrial Receptors
Long Creek Watershed

Long Creek AOCs	**Short-tailed Shrew LOAEL and NOAEL HQs**									
	IAAP-004/R04		**IAAP-005/R05**		**IAAP-009/R09**		**IAAP-011/R11**		**IAAP-027/R19***	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
1,3-Dinitrobenzene	4	<1	NA	NA	NA	NA	5	<1	NA	NA
2,4,6-Trinitrotoluene	169	NA	<1	NA	NA	NA	<1	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	8	<1	NA	NA
Aroclor 1254	NA	NA	NA	NA	2	<1	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	2	<1	27	7
Barium	NA	NA	8	2	NA	NA	8	2	NA	NA
Cobalt	NA	NA	8	<1	NA	NA	7	<1	NA	NA
HMX	225	90	NA	NA	NA	NA	6	2	NA	NA
Lead	≤1	<1	NA	NA	3	<1	≤1	<1	NA	NA
Manganese	2	<1	≤1	<1	NA	NA	≤1	<1	NA	NA
Mercury	32	6	7	1	97	19	19	4	NA	NA
RDX	3407	341	NA	NA	NA	NA	3	<1	NA	NA
Selenium	≤1	<1	NA	NA	NA	NA	NA	NA	11	6
Silver	570	57	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	347	35	475	48	456	46	884	88	NA	NA
	IAAP-028/R20*		**IAAP-030/R22***		**IAAP-038/R26***		**IAAP-041/R29***		**IAAP-043/R30***	
	NOAEL	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
1,3-Dinitrobenzene	12	2	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor 1254	3	<1	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NA	NA	3	<1	NA	NA	NA	NA	NA	NA

TABLE 6-3b COPECs and Estimated HQs>1 for Terrestrial Receptors Long Creek Watershed										
Long Creek AOCs	**Short-tailed Shrew LOAEL and NOAEL HQs**									
Barium	NA	NA	22	6	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	≤1	<1	3	<1	NA	NA	≤1	<1
Cobalt	NA	NA	NA	NA	NA	NA	33	3	NA	NA
Copper	NA	NA	96	62	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	8	2	600	120	NA	NA	27	5
Nickel	NA	NA	10	<1	NA	NA	NA	NA	NA	NA
Silver	NA	NA	4	<1	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	380	38	NA	NA	NA	NA	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

TABLE 6-3c COPECs and Estimated HQs>1 for Terrestrial Receptors Long Creek Watershed										
Long Creek AOCs	**Indiana Bat LOAEL and NOAEL HQs**									
	IAAP-004/R04		**IAAP-005/R05**		**IAAP-009/R09**		**IAAP-011/R11**		**IAAP-027/R19***	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
1,3-Dinitrobenzene	2	<1	NA	NA	NA	NA	≤1	<1	NA	NA
2,4,6-Trinitrotoluene	27,600	690	<1	<1	NA	NA	2	<1	NA	NA
Barium	NA	NA	2	<1	NA	NA	≤1	<1	NA	NA
HMX	145	58	NA	NA	NA	NA	≤1	<1	NA	NA
Mercury	24	5	3	<1	71	14	4	<1	NA	NA
RDX	2220	222	NA	NA	NA	NA	≤1	<1	NA	NA
Silver	276	28	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	168	17	122	12	219	22	111	11	NA	NA
	IAAP-028/R20*		**IAAP-030/R22***		**IAAP-038/R26***		**IAAP-041/R29***		**IAAP-043/R30***	
	NOAEL	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Barium	NA	NA	11	3	NA	NA	NA	NA	NA	NA
Copper	NA	NA	18	12	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	6	1	84	17	NA	NA	≤1	<1
Silver	NA	NA	2	<1	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	184	18	NA	NA	NA	NA	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

Hazard quotients were calculated for three receptors, the white-footed mouse, the short-tailed shrew, and Indiana bat for each AOC. Figures 6-10, 6-11, and 6-12 present spatial views of LOAEL-based HQ exceedances for the white-footed mouse, short-tailed shrew, and Indiana bat, respectively, in all the AOCs. As discussed above, there are existing plans for removal of contaminated soils at five of the AOCs in this watershed. Hazard quotient calculations for these AOCs that are to be remediated based on human health concerns are provided in Appendix J, as follows: Line 3A (IAAP-004/R04, Tables J-1a and J-1b); Lines 4A/4B (IAAP-005/R05, Tables

J-2a and 2b); Line 8 (IAAP-009/R09, Tables J-3a and 3b); Line 800 (IAAP-011/R11, Tables J-4a and 4b); and Firing Site (IAAP-030/R22, Tables J-5a and 5b). The results for these AOCs are not further discussed within this Section.

Hazard quotient results for the remaining AOCs where remediation is not planned are summarized in the following AOC specific subsections. For these AOCs, not slated for remediation, a comparison to LOAEL-based CCs was performed as described in Section 6.1.3. Locations within these AOCs, where the LOAEL-based CCs are exceeded, are shown on Figures 6-1 through 6-5 to demonstrate their spatial distribution. As discussed previously, the LOAEL-based CC is a soil concentration limit above which, health effects to receptor population might be expected. A soil concentration equivalent to a LOAEL-based CC is equivalent to a LOAEL-based HQ of one.

6.2.1.1 Fly Ash Landfill (IAAP-027/R19)

Arsenic and selenium are the COPECs at the Fly Ash Landfill. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - NOAEL-based HQ for arsenic was greater than at one at 3. No LOAEL-based HQs equaled or exceeded one (Table J-6a).

- **Short-tailed Shrew** – Arsenic and selenium had NOAEL-based HQs that exceeded one at 27 and 10, respectively. Both arsenic and selenium had LOAEL-based HQs equal to or exceeding one at 7 and 6, respectively (Table J-6b).

- **Indiana Bat**– No NOAEL-based HQs exceeded one. No LOAEL-based HQs equaled or exceeded one (Table J-6c).

There are no NOAEL-based HQs exceeding one for the Indiana bat, therefore, exposure to this AOC should not pose a health concern to this special status species.

To put the LOAEL-based HQ exceedances of one into perspective for the other two receptor species, a comparison to the LOAEL-based CC was performed for these analytes. Critical concentrations for these COPECs are included in Table 6-1a, discussed previously. Arsenic and selenium at one location within the Fly Ash landfill, out of the three samples collected, exceeded corresponding LOAEL-based CCs, as illustrated on Figure 6-1. The location of the LOAEL-based CC exceedance is in the middle of the landfill with other locations at the periphery of the landfill reporting COPEC concentrations less than their LOAEL-based CCs. This location is accessible by terrestrial receptors. Habitat within close proximity of the AOC is similar to that within the AOC. Text in Section 2.3.5 in Appendix F indicates that some constituents may have migrated from this site to Long Creek. However, there is no evidence of arsenic or selenium migration. In addition, there is no evidence based on the samples that were taken along the periphery of the landfill that there would be migration of COPECs to Long Creek from this AOC. Although it is possible that individuals within the species may be impacted due to the isolated presence of arsenic and selenium, this limited spatial distribution and the lack of evidence regarding COPEC migration suggest exposure to COPECs at the Fly Ash Landfill should not impact the white-footed mouse or short-tailed shrew community.

6.2.1.2 Construction Debris Landfill (IAAP-028/R20)

Chemicals of potential ecological concern for the Construction Debris Landfill are 1,3-DNB, HMX, dieldrin, Aroclor 1254, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse -** Only 1,3-DNB had NOAEL- or LOAEL-based HQs that exceeded or equaled one, at 7 and 1, respectively (Table J-7a).

- **Short-tailed Shrew** - NOAEL-based HQs for the short-tailed shrew exceeded one for 1,3-DNB, at 12, and Aroclor 1254, at 3. The LOAEL-based HQ exceeded one for 1,3-DNB, at 2 (Table J-7b).

- **Indiana Bat** - No NOAEL-based HQs exceeded one. No LOAEL-based HQs equaled or exceeded one (Table J-7c).

There are no NOAEL-based HQs exceeding one for the Indiana bat, therefore, exposure to this AOC should not pose a health concern to this special status species.

To put the LOAEL-based HQ exceedances of one into perspective for the other two receptor species, a comparison to the LOAEL-based CC was performed for these analytes. Only 1,3-DNB at one location, out of 13 samples collected from this AOC, exceeded its LOAEL-based CC, as illustrated on Figure 6-2. The location of the LOAEL-based CC exceedance is in a vegetated area within the boundary of the construction debris landfill, where there is suitable habitat for both the white-footed mouse and the short-tailed shrew. However, the primary habitat for these receptors is outside the landfill area. Surrounding the landfill and along the drainageway leading from the landfill, the area is heavily forested, and no LOAEL-based CC exceedances were estimated. Text in Section 2.3.6 in Appendix F indicates that there is limited potential for contaminant migration from the Construction Debris landfill to Long Creek. There is no evidence of migration of COPECs from the AOC to Long Creek. It is possible that individuals within the terrestrial community may be impacted due to an isolated presence of 1,3-DNB at the landfill. However, based on the limited spatial distribution of 1,3-DNB, on-site and surrounding habitat quality, and evidence that contaminant transport is not occurring, the white-footed mouse or short-tailed shrew at the Construction Debris Landfill should not be impacted.

6.2.1.3 Building 600-86 Septic System (IAAP-038/R26)

Cadmium, chromium, mercury, fluoranthene, and phenanthrene were COPECs at Building 600-86 Septic System. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - For mercury, both the NOAEL-based and LOAEL-based HQs were greater than one. The NOAEL- and LOAEL-based HQs for mercury were 98 and 20, respectively (Table J-8a).

- **Short-tailed Shrew -** NOAEL-based HQs for cadmium and mercury exceeded one at 3 and 600, respectively for the short-tailed shrew. LOAEL-based HQs equaled or exceeded one for mercury at 120 (Table J-8b).

- **Indiana Bat -** NOAEL-based HQ for mercury exceeded one at 84. LOAEL-based HQ exceeded one for mercury at 17 (Table J-8c).

It should be noted that the analytical results for mercury reported in this BERA are based on total mercury concentrations in soil or sediment and dissolved mercury concentrations in water. However, the TRVs are based on studies conducted with methyl mercury, which is more toxic than total mercury. Therefore, the HQ values presented for mercury are likely to have been overestimated.

To put the LOAEL-based HQ exceedances of one into perspective, a comparison to the LOAEL-based CC was performed for these analytes. Only mercury, at three locations, out of a total of four sampling locations, exceeded the LOAEL-based CCs for terrestrial receptors, as illustrated on Figure 6-3. The locations with LOAEL-based CC exceedances are within a forested area in close proximity to a road, which likely represents suitable habitat for all three receptors. The RI concluded that this AOC did not appear to be contributing metals to the surface water pathway. Text in Section 2.3.8 in Appendix F indicates that contaminants do not appear to have migrated from this site to surface water. Based on the evidence that contaminant migration is not occurring, the area represented by the three exceedances is not large enough to impact the short-tailed shrew or the white-footed mouse community, although it is possible that individuals may be impacted. Considering that the LOAEL-based HQ for the Indiana bat exceeds one, it is possible that individual bats may be harmed due to the level of mercury found at the site. The Indiana bat is a special status species that is known to be present at IAAAP, and the ecological goal for this species is to protect individual bats, rather than just the population as a whole.

Risks associated with mercury may have been overestimated by the assumption used to predict uptake of mercury into the insects that the Indiana bat feeds upon. For purposes of the BERA, bioaccumulation estimates for mercury from soils to earthworms were used to estimate the amount of mercury that flying insects would accumulate in their tissue, which is a conservative assumption. Based on data from another similar site in the Midwest (The Savanna Army Depot Activity (SVDA), MWH 2002), where actual tissue concentrations of mercury were measured in flying insects to evaluate exposures for the Indiana bat, a BAF was estimated so that a sensitivity analysis could be performed for this assessment. Using the BAF estimates for flying insects, the HQs for the bat would be less than one (see Section 6.6). Also, as discussed previously, the analytical results for mercury reported in this BERA are based on total mercury concentrations in soil or sediment and dissolved mercury concentrations in water. However, the TRVs are based on studies conducted with methyl mercury, which is more toxic than total mercury. Therefore, the HQ values presented for mercury are likely to have been overestimated.

Based on this additional level of analysis, the mercury at this site would unlikely pose a health concern to the Indiana bat.

6.2.1.4 Line 3A Pond (IAAP-041/R29)

Cobalt and manganese were identified as COPECs in soil at the Line 3A Pond. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - NOAEL-based HQs exceeded one for cobalt, at 4. None of the LOAEL-based HQs exceeded one (Table J-9a).

- **Short-tailed Shrew** - NOAEL-based HQs exceeded one for cobalt and manganese at 33 and 4, respectively. The LOAEL-based HQs exceeded or equaled one for cobalt and manganese at 3 and 1, respectively (Table J-9b).

- **Indiana Bat -** No NOAEL-based HQs exceeded one. No LOAEL-based HQs equaled or exceeded one (Table J-9c)

There are no NOAEL-based HQs exceeding one for the Indiana bat, therefore, exposure to this AOC should not pose a health concern to this special status species.

To put the LOAEL-based HQ exceedances of one into perspective for the other two receptor species, a comparison to the LOAEL-based CC was performed for these analytes. Only cobalt at one location, out of three samples, exceeded its LOAEL-based CC, as shown on Figure 6-4. The exceedance occurs in a forested area where there is suitable habitat for each of the receptors. The location of LOAEL-based CC exceedance is very close to two other locations where COPEC concentrations did not exceed LOAEL-based CCs. Text in Section 2.3.9 in Appendix F indicates that surface water and sediment concentrations at locations on the Long Creek and the Skunk River watersheds immediately downgradient from the Line 3A Pond were comparable to other locations within the watershed. Therefore, there is no direct evidence of COPEC migration from this AOC. Based on the spatial distribution of the CC exceedance and the lack of evidence indicating COPEC migration, the isolated exposure to cobalt is not expected to impact the white-footed mouse or short-tailed shrew community, although it is possible that individuals may be impacted.

6.2.1.5 Fly Ash Disposal Area (IAAP-043/R30)

Cadmium and mercury were selected as COPECs for R30. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - The NOAEL-based HQ for mercury, at 4, was the only value that exceeded one for the white-footed mouse (Table J-10a).

- **Short-tailed Shrew** - The NOAEL-based HQs exceeded one for mercury at 27. The only LOAEL-based HQ that equaled or exceeded one was for mercury, at 5 (Table J-10b).

- **Indiana Bat-** No NOAEL-based HQs exceeded one. No LOAEL-based HQs equaled or exceeded one (Table J-10c).

There are no NOAEL-based HQs exceeding one for the Indiana bat, therefore, exposure to this AOC should not pose a health concern to this special status species.

Again, the TRVs used for mercury are based on studies conducted with methyl mercury, which is more toxic than total mercury, the constituent analyzed in this BERA. Therefore, the HQ values presented for mercury are likely to have been overestimated.

To put the LOAEL-based HQ exceedances of one into perspective for the other two receptor species, a comparison to the LOAEL-based CC was performed for these analytes. Only mercury at one location, out of three sampling locations, exceeded its LOAEL-based CC, as shown on Figure 6-5. The location of LOAEL-based CC exceedance is along the edge of a forested area, which would provide suitable habitat for either of the terrestrial receptors. However, the primary habitat for these receptors is in the surrounding forested area. Section 2.3.10 in Appendix F indicated that a sampling location on a tributary leading to Long Creek, immediately downstream of the Fly Ash Disposal Area had elevated COPEC concentrations compared to other locations on the watershed. However, the RI concluded that off-site migration of contaminants had not occurred from the Fly Ash Disposal Area. Therefore, there is a lack of definitive evidence linking contaminant migration from this AOC. Based on the limited spatial distribution of the CC exceedance and the surrounding habitat quality, the isolated exposure to mercury is not expected to impact the white-footed mouse or short-tailed shrew community, although it is possible that individuals may be impacted.

6.2.2 Aquatic Environment Risk Evaluation for Long Creek Watershed

The results of the ecological evaluation for Long Creek are provided below by receptor. For certain receptors, only HQs were evaluated (e.g., bat species), because other lines of evidence are not practical to collect (e.g., tissue data). For the other lines of evidence collected for receptors, the detailed discussions on the effects assessment provided in Section 4 of this BERA are used to make an evaluation of the risk to each receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, all the lines of evidence are used together in a weight-of- evidence approach to evaluate whether a particular analyte might pose a risk to a particular receptor. While the effects-based lines of evidence (i.e., RBP II and DELT) provide direct measures and observations of the health of the creek environment, they can not account for health effects that are not openly visible. For example, while DELT evaluations are useful for estimating the apparent health of a captured adult fish, these types of visual evidence may not necessarily be appropriate or representative of other toxic effects, such as reduced reproductive success, or adverse effects to more sensitive life stages. The HQ line of evidence evaluates in many cases toxic effects (e.g., reproductive endpoints) that would not be identifiable by the RBP II or DELT. However, these HQ estimates are theoretical predictions from laboratory based toxicity data, and their applicability to the natural environment is not well known. Therefore, there are limitations and advantages to each line of evidence, and they are used together to evaluate whether an ecological risk is possible to a given receptor.

The HQs, along with media concentrations, estimated tissue concentrations, and TRVs for each receptor, are listed in Appendix J. Hazard quotients for each receptor, where they are applicable, are also summarized in Table 6-3d, which is presented below.

TABLE 6-3d
COPECs and Estimated HQs>1 for Aquatic Receptors
Long Creek Watershed

Long Creek Combined Aquatic List	Fish Tissue HQs	Indiana Bat NOAEL HQs	Indiana Bat LOAEL HQs	Kingfisher NOAEL HQs	Kingfisher LOAEL HQs
Aluminum*	<1	**1633**	**163**	≤1	NA
Arsenic*	<1	**21**	**2**	≤1	<1
Barium*	NA	**13**	**3**	NA	**9**
Bis(2-Ethylhexyl) Phthalate	NA	1	<1	**5**	NA
Cadmium*	**1**	1	<1	≤1	<1
Copper*	**5**	1	1	**4**	NA
Mercury	NA	NA	NA	**<1**	<1
Nickel*	<1	**1**	<1	≤1	<1
Selenium*	**2**	**8**	**5**	≤1	<1
Silver	<1	**6**	**1**	NA	<1
Thallium*	NA	**1988**	**199**	NA	NA
Surface Water COPECs				**Algae HQs**	**Fish HQs**
4-Amino-2,6-Dinitrotoluene				<1	**1**
Barium				<1	**31**
Bis(2-Ethylhexyl) Phthalate				**4**	<1
Copper				**2**	1
Manganese				**10**	**1**
Silver				<1	**11**

Bold =COPECs in both the terrestrial and aquatic (sediment and/or surface water) environments. *COPECs in sediment.
NA = Not Available.

Based on the AOC by AOC evaluations provided for the Long Creek watershed, there was no clear migration of COPECs from the AOCs to the creek that could be identified. Therefore, it does not appear that there is a clear connection between any AOCs within the watershed and the COPECs that were identified in the creek.

The following is a discussion of the ecological risks by receptor for Long Creek.

6.2.2.1 Orangethroat Darter

The orangethroat darter is a special status species, and thus was selected for evaluation in this BERA. However because of its special status, specimens of this species could not be collected for purposes of tissue analysis. To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated including direct observations of the fish in the creek (i.e., DELT analysis), tissue analysis of a similar darter species for specific COPECs, and estimation of HQs using two different methods. These lines of evidence are used in combination to evaluate the potential risk to the orangethroat darter.

Fish HQs were developed following two methods to evaluate potential risk to the orangethroat Darter. In the modeled tissue method, tissue concentrations were modeled using water-fish bioaccumulation factors, which were compared to fish tissue TRVs listed in Appendix G. In the water exposure method, HQs were calculated by dividing the COPEC concentration in water by the water-based TRV, which were, primarily, conservative screening values for protection of fish. For most COPECs, these water-based TRVs were the lowest chronic values from Suter and Tsao (1996). If a lowest chronic value was not available, then the NOEC was used. Of the modeled tissue concentrations, cadmium, copper, and selenium in the Long Creek watershed resulted in HQs equal to or exceeding one, at 1, 5, and 2, respectively (Appendix J, Table J-11). Using the water exposure method, HQs for barium and silver exceeded one, at 31 and 12, respectively.

For most COPECs, HQs based on modeled tissue concentrations are higher than the water HQs; for arsenic, three orders of magnitude higher. The only exceptions were nickel, silver, and vanadium, for which water concentration-based HQs were higher than modeled tissue concentration-based HQs.

Explosives and mercury were not detected in fish samples collected from Long Creek, nor was mercury identified as a COPEC in surface water or sediment. The explosives 2-amino-4,6-DNT and 4-amino-2,6-DNT were identified as COPECs in Long Creek surface water. These explosive COPECs were not detected in fish, possibly because of elevated tissue detection limits. When the potential for bioaccumulation of the explosives in fish tissue was modeled based on surface water concentration of the explosives, the resultant HQs for these explosives were less than one. Therefore, explosives were not estimated to pose a health concern to darters.

The DELT analysis was performed to evaluate if there was any visible signs of stress for darter species within Long creek, which was used to provide an indication of possible stress to the orangethroat darter. Based on the results of the DELT, individual johnny and fantail darters examined did not show signs of stress.

Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values could be artifacts of the conservative nature of the models used to estimate the ecological risks. It may be that the body burden of these metals of concern is much lower than what the models predicted. Also, the procedures associated with development of TRVs are more likely to overestimate risk. The test methods, endpoints, and type of tissue analyzed to derive fish tissue TRVs vary widely between tests. The test results were reviewed but, in most cases, conservative approach was used to select TRVs. Explosives or mercury, which were actually analyzed for in fish tissue, were not detected in fantail darter samples collected from Long Creek, and thus would not be expected to pose an ecological concern.

Based on the weight-of-evidence for the two lines of evidence evaluated, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals (barium and silver), but this was not apparent based on the results of the field observations (DELT).

6.2.2.2 Benthic Community

The RBP was performed to evaluate the health of the benthic community of the creek and provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected within the aquatic habitat. Detailed results for the RBP analysis are found in Section 4.0 and Appendix E. The RBP is not a definitive analysis, but rather provides a relative comparison of the results of observations at a reference location compared to observations at downstream sampling stations. It is important to consider the habitat characteristics at each sample station when performing the RBP, as there are many environmental factors (e.g., riparian vegetation and stream characteristics) other than contaminant concentrations that can effect the benthic community composition at a given location. When performing the RBP at IAAAP, the sample locations were selected to evaluate potential source areas of contamination to the creek, and similarity in characteristics. There are certain limitations that can not be overcome, such as the presence of some stations at locations that are not ideally matched to the reference station. In these cases, a qualitative determination has to be made to determine if there are environmental factors other than chemical concentrations that would likely affect the benthic community composition. Keeping this in mind, the information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but is unlikely to detect toxic effects on individual benthic species that are not readily apparent. However, the limitations of the RBP are outweighed by the information that the assay provides, and its limitations were known at the time that it was included as part of the BERA. USEPA (2003) notes that measuring taxa richness and abundance of macroinvertebrate communities is practical and well established assessment endpoints

Benthic sampling stations for the RPB in the Long Creek watershed yielded 154 to 261 individuals and eight to 16 macroinvertebrate taxa at each site. Table E-1 of Appendix E presents the number collected, by station, and the HBI tolerance values for all taxa. The detailed results are discussed in Section 4.0. Results of the RBP assessment are presented in Table E-3. Compared to the reference station, LC2 and LCT1 are considered unimpaired and benthic community structure is not exhibiting ecological stress, as measured using the RBP. Stations LCT2 and LCT3 were rated as slightly impaired, generally because the tributaries had few EPT taxa. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. It may be that other land-use impacts such as farming, noted to have impacted the reference station in Section 4, have altered the habitat enough to change the community composition. The tributaries to the Long Creek generally are very small streams, which could be dry during part of the year, and provide habitat of less quality than the upstream reference site. Such ephemeral stream habitat will not accommodate as wide a range of taxa as a perennial stream habitat. Based on the results of the RBP, the benthic invertebrate community within Long Creek did not appear to be effected by IAAAP facility operations.

6.2.2.3 Aquatic Algae

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. For surface water exposure, HQs were calculated by dividing the COPEC concentration in water by the surface water- based TRV. The results are presented in Table J-12 of Appendix J. HQs exceeded one for BEHP, copper, and manganese. The HQ for manganese was the highest at 10. The surface water-based TRVs for algae were generally screening values available in the literature. Such screening values are inherently conservative. When a surface water concentration exceeds a screening value, it is not an indication that adverse effects are actually taking place. Therefore, the aquatic algae HQs present some uncertainty as to whether or not there is a problem, but are likely a weak line of evidence given the conservatism of the screening values.

6.2.2.4 Belted Kingfisher

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs that have the potential to bioaccumulate in fish tissue might pose an ecological risk to this feeding guild. No observed adverse effects level based HQs for the belted kingfisher exceeded one for BEHP, copper, and mercury (Table J-13), but the LOAEL-based HQs for these COPECs were less than one. As mentioned previously, a LOAEL-based HQ of one is considered a better indication of a level of exposure that may be associated with toxic effects in a receptor. Being that the LOAEL-based HQs were less than one, it is unlikely there would be toxic effects in the belted kingfisher or other similar piscivore population based on exposure to these COPECs. Mercury was not an aquatic COPEC for this watershed and was not detected in fish tissue. However, the detection limit was used to calculate exposure, resulting in a HQ less than one.

Surface water and sediment concentrations for several metals exceed LOAEL-based CCs, as shown in Table 6-2c. However, barium was the only LOAEL-based HQ exceeding one, at nine. A chronic NOAEL is not available for barium. Based on this result, there is the potential for the belted kingfisher to be harmed by barium exposure to fish consumed from the Creek. However, this result may be an over estimation of the actual risk based on the conservative nature of the exposure model and/or TRV used to develop the HQ. Fish tissue samples were not analyzed for barium. So, the fish tissue based HQs were developed only based on modeled barium concentration, which has inherent uncertainties associated with the estimation process. Barium should not cause a concern to a piscivore, as barium is not known to classically bioaccumulate in fish tissue. Also barium is generally a nontoxic metal unless it is present in a water-soluble form which makes it more bioavailable. In many toxicity studies used to develop barium TRVs, more water-soluble forms of barium are used than what would be found in the normal environment. However, the barium that is contained in fish tissue is not water soluble, but rather bound in the tissues as an organo-metallic complex of soft tissues, or incorporated into the mineral structure of the bone. Also, empirical data for fish BCF value for barium is not available. EPA (1999) lists a value of 633 based on the arithmetic mean of the values for 14 inorganics with available empirical data, which was used in this BERA. Therefore, there is considerable uncertainty associated with the fish BCF value used in the dose modeling. For these reasons, the barium LOAEL-based HQ has a low level of confidence associated with it and the belted kingfisher or other piscivores may not be affected by contaminants in the Long Creek watershed even considering this exceedance.

6.2.2.5 Indiana Bat

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. HQs were the only line of evidence that were collected to evaluate risk to the Indiana bat, as other means of evaluation were not feasible.

No observed adverse effects level based HQs for the Indiana bat exceeded one for aluminum, arsenic, barium, selenium, silver, and thallium (Table J-14). The LOAEL-based HQs exceeded one for aluminum, arsenic, barium, selenium, and thallium at 163, 2, 3, 5, and 199, respectively.

The LOAEL-based HQ values might be, to some degree, artifacts of the conservative nature of the models used to estimate the ecological risks for aluminum, arsenic, barium, selenium, and thallium. Indiana bats have been spotted on the IAAAP. In the evaluation of effect of the Long Creek watershed, the Indiana bat was assumed to ingest all of the insects it feeds upon from Long Creek and its tributaries, which is not realistic. Rather the bat could also consume insects from areas outside the plant. This has been verified by recent studies of Indian bat habits at the IAAAP where it has been documented that some Indiana bats forage in agricultural fields (IAAAP 2003). Furthermore, the literature supports the fact that the diet of Indiana bat also consists of insects from terrestrial habitats. Evans and others (1998) stated that Indiana bats feed on terrestrial insects in the forest canopy. Laval and others (1977) noted foraging by Indiana bats among trees in dense forest and suggested that competitive exclusion by other bats may force Indiana bats to forage away from streams.

The modeled insect COPEC concentrations for aluminum and barium appear to be much higher than what would be expected if insects had been collected and analyzed. This was generally the case for many of the metals evaluated for the bat, and is discussed in more detail in Section 3.0. This is based on a comparison of field collected insect metal concentrations detected at another similar facility (SVDA). At SVDA, concentrations of several metals including aluminum and barium were measured in flying insects, sediment, and soil at multiple locations. Average insect to sediment accumulation factors, based on actual measured values, were about 0.001 and 0.05, for aluminum, and barium, respectively (see Table 3-3). Average insect to soil accumulation factors was similar to those for insect to sediment. The insect to sediment accumulation factors for aluminum and barium used in the dose modeling in this BERA is 0.9. It is likely that values such as those measured at SVDA are closer to the actual ratio at IAAAP than the literature-derived value. If insect to sediment accumulation factors measured at SVDA were used in the BERA, then the LOAEL-based HQs for bat due to exposure to aluminum and barium in the Long Creek watershed would decrease to 3.3 and 0.6, respectively, from the estimated values of 163 and 3.

In addition, aluminum was not selected as a COPEC at any AOCs within the watershed, because soil pH was found to be above 5.5, indicating that aluminum is not bioavailable. Although sediment pH data is not available, it is unlikely that sediment pH at the streams and their tributaries are below 5.5 because of the generally aerobic nature of the aquatic environment and sandy characteristics of the sediment.

Thallium, although detected consistently in sediment, was detected in only one of 21 surface water samples. Also, analytical results for thallium are known to have associated uncertainties. Revanasiddappa and Kumar (2002) notes that Atomic Adsorption Spectroscopy (method used in the current study) often lacks sensitivity and displays matrix effects for thallium measurements.

The matrix effects can lead to false positive detections of thallium, meaning it is detected even though it is really not present in the sample. For this reason, there is uncertainty associated with the thallium results.

Considering the elevated LOAEL-based HQ values for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Long Creek aquatic environment. However, for purposes of the BERA, some of the limitations of the HQ estimates have been evaluated, as a means of informing the risk manager about these limitations.

6.2.3 Summary of Risk Descriptions, Long Creek Watershed

6.2.3.1 Terrestrial Environment

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for three ecological receptors including the white-footed mouse, the short-tailed shrew, and Indiana bat by AOC. In addition, soil concentrations that are equivalent to a LOAEL-based HQ of one, called LOAEL-based CCs were calculated for each receptor. The HQ and related LOAEL-based CC line of evidence is the only line of evidence available to evaluate the potential ecological risks for the terrestrial environment. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

Of the 10 AOCs located in the watershed, remediation to protect human health is not slated to occur at five AOCs. The remediation planned at the other AOCs should be protective of ecological risks, because it involves excavation of the top two feet of soil at the AOCs where terrestrial receptors are expected to be exposed. An evaluation of the residual concentrations of COPECs are evaluated for Line 5A/5B (see Section 6.7) where remediation has occurred to verify that this assumption is valid.

Very few COPECs exceed their LOAEL-based CCs in the terrestrial environment, and there is no one COPEC that stands out as an ecological risk driver at most of the AOCs. The number of exceedances of the LOAEL-based CC for a given COPECs is usually no more than one, which would indicate the extent of COPEC concentrations above the LOAEL-based CC is very limited. At most of these AOCs, the CC exceedances are isolated and localized. Sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding CCs. Fate and transport evaluations for most of the AOCs (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs. In addition, primary habitat for the receptors exists in the area surrounding most AOCs.

For all COPECs with the exception of 1,3 –DNB and TNT (for the bat only), the toxicity endpoint that was used to estimate the risk associated with each of the COPECs exceeding LOAEL-based CCs was reduction in offspring numbers or growth. For these reproductive effects to have an ecological impact on the mouse and the shrew, the COPEC concentrations would have to be above a level of concern (i.e., LOAEL-based CC) in a large area of the site. However, this does not occur at any of the AOCs, and so effects on the population of these receptors would not be expected at any of the individual AOCs. For the Indiana bat, the goal is to protect individual Indiana bats because of their special status. Therefore the concept of protecting the populations rather than individuals does not apply. For the specific case of TNT exposure, the endpoints selected in the toxicity study were anemia, and decreased body weight. Whether these sublethal effects would have an adverse effect on individual bats is not known. However, the method used to estimate the dose at which these sublethal type effects might occur, is conservative in nature, in that it gives the 95% lower confidence limit on the benchmark dose. The difference in the benchmark dose derived TRV compared to the NOAEL derived TRV is that the TNT benchmark doses derived TRV is ten times lower than the NOAEL for anemia and decreased body weight. The NOAEL has been used as the basis of the TRV for the other analytes, but an exception was made for the bat because of its special status and the additional level of analysis that has been performed of the toxicology data by USACHPPM.

Although LOAEL-based HQ values exceed one for some COPECs for the mouse and the shrew, these might be in part due to the conservative nature of the models used to estimate the ecological risks, and the limitations associated with specific analytes has been discussed for each AOC. Based on the observations that spatial distribution of the COPECs is limited, that there is no evidence of contaminant migration from these AOCs, and that primary habitat for the receptors exists outside the AOCs, it is not expected that the white-footed mouse or the short-tailed shrew community will be impacted.

In the case of the Indiana bat, the goal is to protect the individual bat because of its special status. No NOAEL-based HQs exceeded at the AOCs evaluated within the Long Creek watershed that have not been previously remediated with the exception of Building 600-86 Septic System (IAAP-038/R26). At this AOC, the NOAEL-based HQ for mercury exceeded one at 84, and the LOAEL-based HQ exceeded one for mercury at 17. Considering that the LOAEL-based HQ for the Indiana bat exceeds 1, it is possible that individual bats may be harmed due to the level of mercury found at the site. However, as noted previously in Section 6.2.1.3, the risk associated with mercury may be overestimated by the assumption used to predict uptake of mercury into the insects that the Indiana bat feeds upon and also due to the use of methyl mercury toxicity data to derive TRV for total mercury. Based on this additional level of analysis, the mercury at this site would unlikely pose a health concern to the Indiana bat. Although, the data used for the BAF sensitivity evaluation was not site specific, both SVDA and IAAAP are located in similar climatic and geographical region, are located very close to the Mississippi River, and therefore, the background soil characteristics are expected to be similar.

6.2.3.2 Aquatic Environment

The results of the ecological evaluation for Long Creek are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, the two lines of evidence are used in combination as a weight of evidence to determine if there is a potential ecological risk to a receptor.

To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated including direct observations of the fish (i.e., DELT analysis), tissue analysis of a similar darter species for specific COPECs, and estimation of HQs using two different methods. Using the water exposure method, HQs for barium and silver exceeded one, at 31 and 12, respectively. Of the modeled tissue concentrations, cadmium, copper, and selenium in the Long Creek watershed resulted in HQs equal to or exceeding one, at 1, 5, and 2, respectively. Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values might be artifacts of the conservative nature of the models used to estimate the ecological risks. For explosives and mercury, where fish tissue was collected for analysis, these analytes were not detected in fish samples collected from Long Creek. Mercury was not identified as a COPEC in Long Creek, therefore modeling was not conducted to estimate mercury concentration in fish tissue. Among the explosives, 2-amino-4,6-DNT and 4-amino-2,6-DNT were the only constituents identified as COPECs in Long Creek, and modeled fish tissue concentrations were estimated. However, the modeled fish tissue concentrations were less than the detection limits for these analytes for fish tissue analyses. In addition, individual johnny and fantail darters examined did not show signs of stress. Based on these observations, adverse effects might not occur to orangethroat darters in the Long Creek watershed. However, based on the weight-of-evidence for the two lines of evidence evaluated, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals (barium and silver), but this was not apparent based on the results of the field observations (DELT). The DELT is not designed to detect toxic effects to fish that are not readily apparent, and so there are limitations with this line of evidence.

The RBP was performed to provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected with the aquatic habitat. When performing the RBP at IAAAP, the sample locations were selected to evaluate potential source areas of contamination to the creek, and similarity in characteristics to one another. The RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but it is unlikely to detect toxic effects on individual benthic species. Results of the RBP assessment show that compared to the reference station, LC2 and LCT1 are considered unimpaired and benthic community structure is not exhibiting ecological stress, as measured using the RBP. Stations LCT2 and LCT3 were rated as slightly impaired, generally because the tributaries had few EPT taxa. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. It may be that other land-use impacts such as farming, noted to have impacted the reference station in Section 4, have altered the habitat enough to change the community composition. Also, the tributaries to the Long Creek generally are very small streams, which could be dry during part of the year, and provide habitat of less quality than the upstream reference site. Such ephemeral stream habitat will not accommodate as wide a range of taxa as a perennial stream habitat. Based on the results of the RBP, the benthic invertebrate community within Long Creek did not appear to be effected by IAAAP facility operations. However, the RBP is not a definitive analysis, and thus has its own inherent limitations discussed above.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. HQs exceeded one for BEHP, copper, and manganese. Such HQ exceedances are not necessarily an indication that adverse effects are actually taking place. The algae HQs are likely a weak line of evidence given the conservatism of the screening values.

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs that have the potential to bioaccumulate in fish tissue might pose an ecological risk to this feeding guild. Barium was the only LOAEL-based HQ exceeding one, at nine. However, this result might be an over estimation of the actual risk based on the conservative nature of the exposure model and TRV used to develop the HQ. The uncertainty surrounding the barium risk estimates has previously been discussed. The barium LOAEL-based HQ has a low level of confidence associated with it and the belted kingfisher or other piscivores are not likely to be affected by contamination in the Long Creek watershed.

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and it is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. The LOAEL-based HQs exceeded one for aluminum, arsenic, barium, selenium, and thallium at 163, 2, 3, 5, and 199, respectively. The estimated HQ values are likely artifacts of the conservative nature of the models used to estimate ecological risks. In the evaluation of effect of the Long Creek watershed, the Indiana bat was assumed to ingest all of the insects it feeds upon from Long Creek and its tributaries, which is not realistic. Rather the bat could also consume insects from areas outside the plant. Furthermore, diet of the Indiana bat also consists of insects from terrestrial habitats. The modeled insect COPEC concentrations appear to be much higher than what would be expected if insects had been collected and analyzed. In addition, aluminum may not be bioavailable. Thallium, although detected consistently in sediment, was detected in only one of 21 surface water samples. Also, analytical results for thallium are known to have associated uncertainties. Taking into consideration the various uncertainties and conservative approach associated with the dose-modeling conducted for Indiana bat in this BERA, the LOAEL-based HQ values for aluminum, arsenic, barium, selenium, and thallium are unlikely to translate to adverse health effects in Indiana bats in the Long Creek watershed. This conclusion would also apply to other bat species that may be present at the IAAAP that feed primarily on insects (e.g., little brown bat).

Based on the multiple lines of evidence, the fish populations (including oragnethroat darters), and the benthic invertebrate populations in Long Creek does not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations on the Long Creek watershed). The benthic community structure endpoint showed that Long Creek is essentially unimpaired or slightly impaired and does not show adverse effects. Also, individual darter samples examined did not show any signs of stress, and their presence indicates that darter species are reproducing in the stream. However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so there are possibly adverse effects that are occurring due to IAAAP operations that could not be detected.

In the case of the Indiana bat, LOAEL-based HQs exceeded or equaled one in the Long Creek aquatic environment. Although these risk estimates might be conservative in nature due to the assumptions used to evaluate exposure and toxicity to this species, it is beyond the scope of this BERA to verify these results. In addition to the bat, the evaluation of algea in Long Creek indicated the potential for effects on this community by specific metals. The line of evidence used was more of a screening level assessment and has a large degree of uncertainty associated with it.

6.3 SKUNK RIVER WATERSHED RISK CHARACTERIZATION

The following is an overall summary of the results of the risk characterization for Skunk River watershed. Additional detailed evaluations by AOC and the River habitat are provided after this summary.

Soil AOCs in the Skunk River watershed at IAAAP are Line 3A (IAAP-004/R04), Line 3A Sewage Treatment Plant (IAAP-029/R21), and Line 3A Pond (IAAP-041/R29). Of the 3 AOCs located in the watershed, remediation is not slated to occur at Line 3A Sewage Treatment Plant and Line 3A Pond. Therefore, risks at these two AOCs are discussed within this Section. The table below provides an overview of the COPECs that had exceedances of their LOAEL-based CCs for terrestrial receptors at individual AOCs, where remediation has not occurred or is not currently planned.

COPECs Exceeding LOAEL-BASED CCs, by AOC within The Shunk River Watershed	
AOCs	**Constituents**
IAAP-029/R21	Silver (3)
IAAP-041/R29	Cobalt (1)
Note: Number in parenthesis refers to the number of sample locations within the AOC exceeding CCs. R29 also drains to the Long Creek watershed and is evaluated for that watershed too.	

6.3.1 Summary of Terrestrial Risks by AOC

Chemicals of potential ecological concern and estimated HQs for the Skunk River watershed are summarized in Table 6-4a and 6-4b for terrestrial receptors. Risk estimates for all AOCs within the Skunk River watershed are presented in these two tables. As for the Long Creek watershed, risks for specific receptors in the Skunk Creek watershed are listed if they exceed a NOAEL-based HQ of one or equal or exceed a LOAEL-based HQ of one.

TABLE 6-4a
COPECs and Estimated HQs>1 for Terrestrial Receptors
Skunk River Watershed

Skunk River AOCS	White-footed Mouse HQs						Short-tailed Shrew HQs					
	IAAP-004/R04		IAAP-029/R21*		IAAP-041/R29*		IAAP-004/R04		IAAP-029/R21*		IAAP-041/R29*	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
1,3-Dinitrobenzene	2	<1	NA	NA	NA	NA	4	<1	NA	NA	NA	NA
2,4,6-Trinitrotoluene	67	NA	NA	NA	NA	NA	169	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	4	<1	NA	NA	NA	NA	33	3
HMX	809	323	NA	NA	NA	NA	225	90	NA	NA	NA	NA
Mercury	5	1	NA	NA	NA	NA	32	6	NA	NA	NA	NA
RDX	4802	480	NA	NA	NA	NA	3407	341	NA	NA	NA	NA
Selenium	≤1	<1	NA	NA	NA	NA	≤1	<1	NA	NA	NA	NA
Silver	132	13	15	2	NA	NA	570	57	65	7	NA	NA
Thallium	43	4	NA	NA	NA	NA	347	35	NA	NA	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

TABLE 6-4b
COPECs and Estimated HQs>1 for Terrestrial Receptors
Skunk River Watershed

Skunk River AOCS	Indiana Bat HQs					
	IAAP-004/R04		IAAP-029/R21*		IAAP-041/R29*	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
1,3-Dinitrobenzene	2	<1	NA	NA	NA	NA
2,4,6-Trinitrotoluene	27,600	690	NA	NA	NA	NA
HMX	145	58	NA	NA	NA	NA
Mercury	24	5	NA	NA	NA	NA
RDX	2,220	222	NA	NA	NA	NA
Silver	276	28	≤1	<1	NA	NA
Thallium	168	17	NA	NA	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

Hazard quotients were calculated for three terrestrial receptors, the white-footed mouse, the short-tailed shrew, and Indiana bat for each AOC. Figures 6-13, 6-14, and 6-15 presents a spatial view of LOAEL-based HQ exceedances for the white-footed mouse, short-tailed shrew, and Indiana bat, respectively, in all the AOCs. There are existing plans for removal of contaminated soil at one of the AOCs, Line 3A (IAAP-004/R04), in the Skunk Creek watershed. Hazard quotient calculations for this AOC are provided in Appendix J (IAAP-004/R04, Tables J-1a and J-1b). The results for this AOC are not further discussed within this Section. The other two AOCs, IAAP-029/R21 and IAAP-041/R29, not slated for remediation, are discussed in the following sections.

6.3.1.1 Line 3A Sewage Treatment Plant (IAAP-029/R21)

Silver and two pesticides are the COPECs at Line 3A Sewage Treatment Plant. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - Silver had NOAEL-based HQs above one, at 15. The LOAEL-based HQ for silver was the only HQ exceeding one, at 2 (Table J-15a).
- **Short-tailed Shrew** - Silver had NOAEL-based HQ that exceeded one for the short-tailed shrew at 65. Silver had LOAEL-based HQ exceeding one, at 7 (Table J-15b).
- **Indiana Bat** - No NOAEL-based HQs exceeded one. No LOAEL-based HQs equaled or exceeded one (Table J-15c).

There are no NOAEL-based HQs exceeding one for the Indiana bat, therefore, exposure to this AOC should not pose a health concern to this special status species.

To put the LOAEL-based HQ exceedances of one into perspective for the other two receptor species, a comparison to the LOAEL-based CC was performed for these analytes. Only silver at three locations, out of five samples analyzed for silver, exceeded the LOAEL-based CCs, as illustrated on Figure 6-6. The area represented by the three silver exceedances is small. This area near the sewage treatment plant is suitable habitat for terrestrial receptors. However, the primary habitat for these receptors is outside the treatment plant in the surrounding area, which is heavily forested, and no LOAEL-based CC exceedances were estimated. Text in Section 3.3.2 in Appendix F indicates low potential for contaminant migration from the plant to the tributaries of the Skunk River. Based on the limited spatial distribution of the CC exceedance, the lack of evidence suggesting contaminant migration, and availability of primary habitat close to the AOC, exposure at this AOC is not expected to result in a community-wide impact for the small mammals (e.g., white-footed mouse or short-tailed shrew), although it is possible that individuals may be impacted.

6.3.1.2 Line 3A Pond (IAAP-041/R29)

The Line 3A Pond is drained by both the Long Creek and the Skunk River watersheds. Risks to the white-footed mouse, short-tailed shrew, and Indiana bat at this AOC are discussed in Section 6.1.1.4, under the Long Creek watershed.

6.3.2 Aquatic Environment Risk Characterization for the Skunk River Watershed

The results of the ecological evaluation for the Skunk River are provided below by receptor. For certain receptors, only HQs were evaluated (e.g., bat species), because other lines of evidence are not practical to collect (e.g., tissue data). The HQs, along with media concentrations, estimated tissue concentrations, and TRVs for each receptor, are listed in Appendix J. HQs for each receptor where they are applicable are also summarized in Table 6-4c, which is presented below. For the other lines of evidence collected for receptors, the detailed discussions on the effects assessment provided in Section 4 of this BERA are used to make an evaluation of the risk to each receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, all the lines of evidence are used together in a weight-of- evidence approach to evaluate whether a particular analyte might pose a risk to a particular receptor. While the effects-based lines of evidence (i.e., RBP II and DELT) provide direct measures and observations of the health of the creek environment, they can not account for health effects that might be present but are not readily apparent. For example, while DELT evaluations are useful for estimating the apparent health of a captured adult fish, these types of visual evidence may not necessarily be appropriate or representative of other toxic effects, such as reduced reproductive success, or adverse effects to more sensitive life stages. The HQ line of evidence evaluates in many cases toxic effects (e.g., reproductive endpoints) that would not be identifiable by the RBP II or DELT. However, these HQ estimates are theoretical predictions from laboratory based toxicity data, and their applicability to the natural environment is not well known. Therefore, there are limitations and advantages to each line of evidence, and they are used together to evaluate whether an ecological risk is possible to a given receptor.

TABLE 6-4c
COPECs and Estimated HQs>1 for Aquatic Receptors
Skunk River Watershed

Skunk River Combined Aquatic List	Fish Tissue HQs	Indiana Bat NOAEL HQs	Indiana Bat LOAEL HQs	Kingfisher NOAEL HQs	Kingfisher LOAEL HQs
Aluminum*	<1	**548**	**55**	≤1	NA
Barium*	NA	**7**	**2**	NA	**6**

TABLE 6-4c
COPECs and Estimated HQs>1 for Aquatic Receptors
Skunk River Watershed

Selenium	**4**	14	8	≤1	<1
Silver*	NA	48	5	NA	<1
Zinc	**1**	≤1	<1	1	<1
Surface Water COPECs				**Algae HQs**	**Fish HQs**
Barium				<1	**19**

Bold – COPECs in both the terrestrial and aquatic (sediment and/or surface water) environments. *COPECs in sediments. NA = Not Available

6.3.2.1 Orangethroat Darter

The orangethroat darter is a special status species, and thus was selected for evaluation in this BERA. However because of its special status, specimens of this species could not be collected for purposes of tissue analysis. To evaluate ecological risks to the orangethroat darter in Skunk Creek a single line of evidence was used (i.e., HQs using two different methods), because darter species were not collected from tributaries to the Skunk River.

Hazard quotients were developed for the water exposure method by dividing the COPEC concentration in surface water by the water-based TRV. Only the HQ for barium exceeded one, at 19 (Table J-16). The water-based TRVs were conservative screening values for protection of fish. For most COPECs, these were the lowest chronic values from Suter and Tsao (1996). If the lowest chronic value was not found, then the NOEC was used. In the modeled tissue method, tissue concentrations were modeled using water-fish bioaccumulation factors, which were compared to fish tissue TRVs. Selenium is the only COPEC for which a HQ based on modeled fish tissue concentration exceeded one, at 4. The estimated HQs might be artifacts of the conservative nature of the models used to estimate the ecological risks. It may be in fact that the body burden of these metals of concern is much lower than what the models predicted. However, darter samples were not collected from tributaries to the Skunk River to be able to confirm actual body burdens of COPECs. Therefore, there is still uncertainty associated with whether darter populations are at risk within the Skunk River watershed.

6.3.2.2 Benthic Community

The RBP was performed to evaluate the health of the benthic community of the creek and provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected within the aquatic habitat. Detailed results for the RBP analysis are found in Section 4.0 and Appendix E, along with any noted limitations of the analysis based on varying characteristics among sample stations.

The benthic community in two small tributaries of the Skunk River in the southwest part of IAAAP was compared to the Long Creek reference station. The number and species of macroinvertebrates collected at the two stations (SRT1 and SRT2) and the HBI tolerance values for all taxa are presented in Appendix E, Table E-1 and are discussed in detail in Section 4.0.

The results of the RBP in the two Skunk River tributaries are provided in Appendix E, Table E-4. The two tributaries subjected to the aquatic risk assessment using RBP were SRT1, rated as unimpaired, and SRT2, rated as slightly impaired.

6.3.2.3 Aquatic Algae

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. The HQ values are presented in Appendix J, Table J-17. None of the HQs exceeded one; thus, there is no risk predicted to aquatic algae due to COPECs in the Skunk River.

6.3.2.4 Belted Kingfisher

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs that have the potential to bioaccumulate in fish tissue might pose an ecological risk to this feeding guild. Nine metals are COPECs in the aquatic environment. No avian toxicity data were available for four of these COPECs. However, there was either a NOAEL or LOAEL-based TRV for each of the remaining five COPECs. None of the NOAEL-based HQs exceeded one.

Surface water and sediment concentrations of several metals exceeded their corresponding LOAEL-based CCs. However, barium is the only COPEC that had a LOAEL-based HQ greater than one, at six (Table J-18). Note that barium had no NOAEL-based TRV. Based on this result, there is the potential for the belted kingfisher to be harmed by barium exposure to fish consumed from the tributaries. The barium result might be an over estimation of the actual risk based on the conservative nature of the exposure model and TRV used to develop the HQ. The kingfisher was assumed to consume all fish from within the watershed; while home ranges for belted kingfisher may include areas outside the plant boundary. Barium should not cause a concern to piscivores, as barium is not known to classically bioaccumulate in fish tissue. Also barium is a nontoxic metal unless it is present in a water-soluble form which makes it more bioavailable. In many toxicity studies used to develop barium TRVs, more water-soluble forms of barium are used than what would be found in the normal environment. However, the barium that is contained in fish tissue is not water soluble, but rather bound in the tissues as an organo-metallic complex of soft tissues, or incorporated into the mineral structure of the bone. Also, empirical data for fish BCF value for barium is not available. EPA (1999) lists a value of 633 based on the arithmetic mean of the values for 14 inorganics with available empirical data, which was used in this BERA. Therefore, there is considerable uncertainty associated with the fish BCF value used in the barium dose modeling. For these reasons, the barium LOAEL-based HQ has a low level of confidence associated with it and the belted kingfisher or other piscivores might not be affected by contamination in the Skunk River watershed.

6.3.2.5 Indiana Bat

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and it is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. HQs were the only line of evidence that were collected to evaluate risk to the Indiana bat, as other means of evaluation were not feasible.

Aluminum, barium, selenium, and silver had both NOAEL- and LOAEL-based HQs greater than one. LOAEL-based HQs equaled or exceeded one for aluminum, at 55, barium, at two, selenium, at eight, and silver, at five (Table J-19). Considering the elevated LOAEL-based HQ values for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Skunk River aquatic environment. However, for purposes of the BERA, some of the limitations of the HQ estimates have been evaluated, as a means of informing the risk manager about these limitations.

Although there are LOAEL-based HQ exceedances for some COPECs, these are artifacts of the conservative nature of the models used to estimate the ecological risks for these analytes. Indiana bats have been spotted on the IAAAP. In the evaluation of effect of the Skunk River watershed, the Indiana bat was assumed to ingest all of the insects it feeds upon from the tributaries to the Skunk River, which is not realistic. Rather the bat could also consume insects from areas outside the plant.

The modeled insect COPEC concentrations appear to be much higher than what would be expected if insects had been collected and analyzed. This was generally the case for many of the metals evaluated for the bat, and is discussed in more detail in Section 3.0. This is based on a comparison of field collected insect metal concentrations detected at SVDA. As discussed previously, BAF values, such as those measured at SVDA, are closer to the actual ratio at IAAAP than the literature-derived value. If insect to sediment accumulation factors measured at SVDA were used in the BERA, then the LOAEL-based HQs for bat due to exposure to aluminum and barium in the Skunk River watershed would decrease to 2 and 0.3, respectively, from the estimated values of 55 and 2.

In addition, aluminum was not selected as a COPEC at any AOCs within the watershed, because soil pH was found to be above 5.5, indicating that aluminum is not bioavailable. Although sediment pH data is not available, it is unlikely that sediment pH in the streams and their tributaries are below 5.5 because of the generally aerobic nature of the aquatic environment and sandy characteristics of the sediment.

6.3.3 Summary of Risk Descriptions, Skunk River Watershed

6.3.3.1 Terrestrial Environment

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for three ecological receptors including the white-footed mouse, the short-tailed shrew, and Indiana bat by AOC. In addition, soil concentrations that are equivalent to a LOAEL-based HQ of one, called LOAEL-based CCs were calculated for each receptor. The HQ and related CC line of evidence is the only line of evidence available to evaluate the potential ecological risks for the terrestrial environment. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

Of the three AOCs located in the watershed, remediation to protect human health is not slated to occur at the Line 3A Sewage Treatment Plant and the Line 3A Pond. The remediation planned at Line 3A should be protective of ecological risks, because it involves excavation of the top two feet of soil where terrestrial receptors are expected to be exposed. An evaluation of the residual concentrations of COPECs was conducted with data from Line 5A/5B (see Section 6.7) where remediation has occurred to verify that this assumption is valid.

Neither NOAEL nor LOAEL-based HQs equaled or exceeded one for any COPECs for the Indiana bat. Therefore risks to the Indiana bat would not be expected in the upland areas of the terrestrial AOCs.

Only one COPEC (i.e., either silver or cobalt), at each of the two AOCs, not slated for remediation based on human health, exceeded its LOAEL-based CCs in the terrestrial environment based on small mammal risk estimates. The spatial distribution of LOAEL-based CC exceedances were very limited at both AOCs for the mouse or the shrew, which would indicate that the extent of COPEC concentrations above the LOAEL-based CC is very limited and would not be expected to pose an ecological risk to these receptors. Cobalt causes reproductive effects, while silver affects activity patterns in receptors. For reproductive effects or broad effects, such as impact on activity, to have an ecological impact on the mouse and the shrew, the COPEC concentrations would have to be above a level of concern (i.e., LOAEL-based CC) in a large area of the site. However, this does not occur at either AOC, where the CC exceedances are isolated and localized. Sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding CCs. Fate and transport evaluations (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs. In addition, the exceedances are sometimes located next to building structures (refer to Figure 6-6), where the selected receptors (mouse and shrew) would normally be managed for extermination rather than protection. Primary habitat for the receptors exists in the area surrounding most AOCs.

Although LOAEL-based HQ values exceed one for some COPECs for the two small mammal receptors (i.e., mouse and shrew), it is not expected that the white-footed mouse or the short-tailed shrew community will be impacted. This is primarily based on the observations that the spatial distribution of the COPECs is limited, that there is no evidence of contaminant migration from these AOCs, and that the primary habitat for the receptors exists outside the AOCs.

6.3.3.2 Aquatic Environment

The results of the ecological evaluation for the tributaries to the Skunk River are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, they are used in combinations as a weight of evidence to determine if there is a potential ecological risk to a receptor.

Orangethroat darters were evaluated by developing HQs following two methods. Hazard quotients for the water exposure method were calculated and only barium had an HQ greater than one, at 19. Selenium is the only COPEC for which a HQ based on modeled fish tissue concentration exceeded one, at 4. The estimated HQs might be artifacts of the conservative nature of the models used to estimate the ecological risks. It may be in fact that the body burden of these metals of concern is much lower than what the models predicted. However, darter samples were not collected from tributaries to the Skunk River to be able to confirm actual body burdens of COPECs. Therefore, there is still uncertainty associated with whether darter populations are at risk with the Skunk River that may need to be verified in the future.

The RBP was performed to provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected with the aquatic habitat. Limitations associated with RBP results have been discussed previously. The benthic communities in two small tributaries of the Skunk River in the southwest part of IAAAP were compared to the Long Creek reference station. The two tributaries subjected to the aquatic risk assessment using RBP were SRT1, rated as unimpaired, and SRT2, rated as slightly impaired. However, the RBP is not a definitive analysis, and thus has its own inherent limitations discussed above that need to be considered.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. None of the HQs exceeded one; thus, there is no risk predicted to aquatic algae due to COPECs in the Skunk River.

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs that have the potential to bioaccumulate in fish tissue might pose an ecological risk to this feeding guild. For belted kingfisher, only barium had a LOAEL-based CC exceedance and a LOAEL-based HQ greater than one, at six. However, this result might be an over estimation of the actual risk based on the conservative nature of the exposure model and TRV used to develop the HQ and the CC. The uncertainty surrounding the barium risk estimates has previously been discussed. The barium LOAEL-based HQ has a low level of confidence associated with it and the belted kingfisher or other piscivores are not likely to be affected by contamination in the Skunk River watershed.

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and it is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. Aluminum, barium, selenium, and silver had both NOAEL- and LOAEL-based HQs greater than one for the Indiana bat. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Skunk River aquatic environment. However, for purposes of the BERA, some of the limitations of the HQ estimates have been evaluated (refer to Section 6.3.2.5), as a means of informing the risk manager about the limitations of these risk estimates.

The conservative screening assessment for algae indicated no health concern to the algae community. In addition, the RBP showed that Skunk River watershed is essentially unimpaired or slightly impaired and does not show adverse effects. However, there are limitations with the RBP, and so there is possibly adverse effects that are occurring on the benthic community due to IAAAP operations that could not be readily detected.

6.4 BRUSH CREEK WATERSHED RISK CHARACTERIZATION

The following is an overall summary of the results of the risk characterization for the Brush Creek watershed. Additional detailed evaluations by AOC and the Creek habitat are provided after this summary.

Soil AOCs within the Brush Creek Watershed are Line 1 (IAAP-001/R01), Line 2 (IAAP-002/R02), Line 3 (IAAP-003/R03), Line 4A/4B (IAAP-005/R05), Line 6 (IAAP-007/R07), Line 7 (IAAP-008/R08), Line 9 (IAAP-010/R10), Line 800 (IAAP-011/R11), and Sewage Treatment Plant/Sludge Drying Beds (IAAP-026/R18). Of the nine AOCs located in the watershed, Only Line 7 and the Sewage Treatment Plant/Sludge Drying Beds are not slated for remediation. The table below provides an overview of the COPECs that had exceedances of their LOAEL-based CCs at individual AOCs.

COPECs Exceeding LOAEL-Based CCs, by AOC within Brush Creek Watershed	
AOCs	**Constituents**
IAAP-008/R08	Copper (1), Dieldrin (1), Mercury (4), PCBs (1), Thallium (1)
IAAP-026/R18	Mercury (4), Silver (4)
Note: Number in parenthesis refers to the number of sample locations within the AOC exceeding LOAEL-based CCs.	

6.4.1 Summary of Terrestrial Risks by AOC

Chemicals of potential ecological concern and estimated HQs in the Brush Creek watershed are summarized in Table 6-5a, 6-5b, and 6-5c for terrestrial receptors. As previously, risks for specific receptors in the Brush Creek watershed are listed if they exceed a NOAEL-based HQ of one or equal or exceed a LOAEL-based HQ of one.

TABLE 6-5a
COPECs and Estimated HQs>1for Terrestrial Receptors
Brush Creek Watershed

Brush Creek AOCs	White-footed Mouse HQs									
	IAAP-001/R01		IAAP-002/R02		IAAP-003/R03		IAAP-005/R05		IAAP-007/R07	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
1,3-Dinitrobenzene	2	<1	2	<1	3	<1	NA	NA	NA	NA
2,4,6-Trinitrotoluene	≤1	NA	<1	NA	233	NA	<1	NA	≤1	NA
Antimony	≤1	<1	NA	NA	2	<1	NA	NA	5	<1
Aroclor 1260	103	10	NA	NA	NA	NA	NA	NA	NA	NA
Barium	3	<1	≤1	<1	≤1	<1	≤1	<1	2	<1
HMX	11	4	46	19	6	2	NA	NA	≤1	<1
Mercury	8	2	6	1	3	<1	≤1	<1	2,649	530
RDX	3	<1	19	2	15	2	NA	NA	≤1	<1
Silver	≤1	<1	≤1	<1	≤1	<1	NA	NA	3	<1
Thallium	38	4	63	6	54	5	58	6	51	5

Brush Creek AOC	IAAP-008/R08*		IAAP-010/R10		IAAP-011/R11		IAAP-026/R18*	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
1,3-Dinitrobenzene	NA	NA	NA	NA	3	<1	NA	NA
Antimony	NA	NA	NA	NA	2	<1	NA	NA
Copper	2	1	NA	NA	NA	NA	NA	NA
HMX	NA	NA	NA	NA	21	8	NA	NA
Mercury	4	<1	204	41	3	<1	114	23
RDX	≤1	<1	NA	NA	4	<1	NA	NA
Silver	NA	NA	NA	NA	NA	NA	135	13
Thallium	47	5	39	4	108	11	NA	NA

Note:

* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

TABLE 6-5b
COPECs and Estimated HQs>1 for Terrestrial Receptors
Brush Creek Watershed

Brush Creek AOCs	Short-tailed Shrew HQs									
	IAAP-001/R01		IAAP-002/R02		IAAP-003/R03		IAAP-005/R05		IAAP-007/R07	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
1,3-Dinitrobenzene	3	<1	3	<1	5	1	NA	NA	NA	NA
2,4,6-Trinitrotoluene	≤1	NA	<1	NA	581	NA	<1	NA	≤1	NA
Antimony	7	<1	NA	NA	10	<1	NA	NA	30	3
Aroclor 1260	689	69	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	2	<1	2	<1	2	<1	NA	NA	2	<1
Barium	16	4	7	2	8	2	8	2	10	3
Cobalt	9	<1	7	<1	9	<1	8	<1	NA	NA
Dieldrin	NA	NA	NA	NA	3	<1	NA	NA	NA	NA
HMX	3	1	13	5	2	<1	NA	NA	≤1	<1
Lead	≤1	<1	≤1	<1	≤1	<1	NA	NA	9	3
Manganese	≤1	<1	≤1	<1	2	<1	≤1	<1	NA	NA
Mercury	48	10	38	8	16	3	7	1	16,248	3,250
RDX	2	<1	13	1	11	1	NA	NA	≤1	<1
Silver	2	<1	2	<1	2	<1	NA	NA	12	1
Thallium	309	31	514	51	438	44	475	47	413	41
Vanadium	11	1	10	<1	11	1	NA	NA	NA	NA

Brush Creek AOCs	IAAP-008/R08*		IAAP-010/R10		IAAP-011/R11		IAAP-026/R18*	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
1,3-Dinitrobenzene	NA	NA	NA	NA	5	<1	NA	NA
2,4,6-Trinitrotoluene	≤1	<1	NA	NA	<1	NA	NA	NA
Antimony	NA	NA	NA	NA	8	<1	NA	NA
Aroclor 1260	7	<1	NA	NA	NA	NA	2	<1
Arsenic	NA	NA	3	<1	2	<1	NA	NA
Barium	NA	NA	NA	NA	8	2	NA	NA
Cobalt	NA	NA	NA	NA	7	<1	NA	NA
Copper	6	4	NA	NA	NA	NA	NA	NA
Dieldrin	9	<1	NA	NA	NA	NA	≤1	<1
HMX	NA	NA	NA	NA	6	2	NA	NA
Mercury	26	5	1,250	250	19	4	700	140
RDX	≤1	<1	NA	NA	3	<1	NA	NA
Silver	NA	NA	NA	NA	NA	NA	584	58
Thallium	382	38	319	32	884	88	NA	NA
Vanadium	NA	NA	14	1	NA	NA	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

TABLE 6-5c
COPECs and Estimated HQs>1 for Terrestrial Receptors
Brush Creek Watershed

Brush Creek AOCs	Indiana Bat HQs									
	IAAP-001/R01		IAAP-002/R02		IAAP-003/R03		IAAP-005/R05		IAAP-007/R07	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
1,3-Dinitrobenzene	2	<1	2	<1	4	<1	NA	NA	NA	NA
2,4,6-Trinitrotoluene	2	<1	57	1	95,000	2,380	≤1	<1	≤1	<1
Antimony	3	<1	NA	NA	5	<1	NA	NA	6	<1
Aroclor 1260	454	45	NA	NA	NA	NA	NA	NA	NA	NA
Barium	8	2	3	<1	4	<1	2	<1	2	<1
Cobalt	3	<1	2	<1	2	<1	≤1	<1	NA	NA
Dieldrin	NA	NA	NA	NA	2	<1	NA	NA	NA	NA
HMX	2	<1	8	3	≤1	<1	NA	NA	≤1	<1
Mercury	36	7	28	6	12	2	3	<1	5,156	1,031
RDX	≤1	<1	9	<1	7	<1	NA	NA	≤1	<1
Silver	≤1	<1	≤1	<1	≤1	<1	NA	NA	3	<1
Thallium	150	15	249	25	212	21	122	12	86	9
Vanadium	2	<1	2	<1	2	<1	NA	NA	NA	NA

Brush Creek AOCs	IAAP-008/R08*		IAAP-010/R10		IAAP-011/R11		IAAP-026/R18*	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
2,4,6-Trinitrotoluene	≤1	<1	NA	NA	2	<1	NA	NA
Mercury	2	<1	120	24	4	<1	5	1
Silver	NA	NA	NA	NA	NA	NA	3	<1
Thallium	24	2	20	2	111	11	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC, or the TRV is not available

Hazard quotients were calculated for the three terrestrial receptors, the white-footed mouse, the short-tailed shrew, and Indiana bat. Figures 6-16, 6-17, and 6-18 present spatial view of LOAEL-based HQ exceedances for the white-footed mouse, the short-tailed shrew, and Indiana bat, respectively, in all the AOCs. There are existing plans for removal of contaminated soils at seven of the AOCs in this watershed. HQs for these AOCs slated for remediation are provided in Appendix J, as follows: Line 1 (IAAP-001/R01, Tables J-20a and J-20b), Line 2 (IAAP-002/R02, Tables J-21a and J-21b), Line 3 (IAAP-003/R03, Tables J-22a and J-22b), Line 4A/4B (IAAP-005/R05, Tables J-23a and J-23b), Line 6 (IAAP-007/R07, Tables J-24a and J-24b), Line 9 (IAAP-010/R10, Tables J-25a and J-25b), and Line 800 (IAAP-011/R11, Tables J-4a and J-4b). Results for the remaining AOCs, Line 7 and the Sewage Treatment Plant/Sludge Drying Beds are summarized in the following subsections. For these AOCs, LOAEL-based CCs were developed as previously described and locations where LOAEL-based CCs are exceeded are illustrated on Figures 6-7 and 6-8.

6.4.1.1 Line 7 (IAAP-008/R08)

Two explosives, six metals, three SVOCs, five pesticides/PCBs, and toluene were selected as COPECs soil at Line 7. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - NOAEL-based HQs for copper and mercury were greater than one at 2 and 4, respectively, while the NOAEL-based HQ for thallium was 47 (Table J-25a). The only constituents with LOAEL-based HQs equal to or greater than one were copper, at 1, and thallium, at 5.

- **Short-tailed Shrew** - NOAEL-based HQs for copper, mercury and thallium were 6, 25 and 382, respectively (Table J-25b). NOAEL-based HQs for Aroclor-1260 and dieldrin were 7 and 9, respectively. Copper, mercury, and thallium had LOAEL-based HQs of 4, 5, and 38, respectively.

- **Indiana Bat** - NOAEL-based HQs for mercury and thallium were 3 and 24, respectively (Table J-25c). Thallium had LOAEL-based HQ of 2.

To put the LOAEL-based HQ exceedances of one into perspective for the white-footed mouse and the short-tailed shrew, a comparison to the LOAEL-based CC was performed for these analytes. Sample locations where COPEC concentrations exceeded LOAEL-based CCs are shown on Figure 6-7. Mercury concentrations at four locations, and copper, dieldrin, PCBs, and thallium at one location each, exceeded LOAEL-based CCs. At Line 7, samples were collected from 26 locations. As seen on Figure 6-7, most of these locations are isolated with many in very close proximity to buildings and other structures, indicating the contamination is localized. The habitat close to the buildings and in the surrounding area is devoid of vegetation. Text in Section 4.3.6 in Appendix F indicates that there is no evidence of pesticides or metal migration from this AOC to Brush Creek. It is conceivable that individual terrestrial receptors exposed to COPECs at these locations could be adversely impacted. However, based on the localized nature of the CC exceedances and lack of evidence indicating contaminant migration, it is not expected that the white-footed mouse or the short-tailed shrew community will be impacted.

Considering that the LOAEL-based HQ for the Indiana bat exceeds one, it is possible that individual bats may be harmed due to the level of thallium found at the site. The Indiana bat is a special status species that is known to be present at IAAAP, and the ecological goal for this species is to protect individual bats, rather than just the population as a whole. However, the risk associated with thallium and mercury may have been overestimated. Uncertainty associated with matrix effects on thallium analytical results has been discussed previously. Also, the risk associated with mercury may be overestimated by the assumption used to predict uptake of mercury into the insects that the Indiana bat feeds upon and also due to the use of methyl mercury toxicity data to derive TRV for total mercury.

6.4.1.2 Sewage Treatment Plant/Sludge Drying Beds (IAAP-026/R18)

Four metals and five pesticides/PCBs were selected as COPECs in soil at IAAP-026/R18. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a

NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - Mercury and silver had NOAEL-based HQs of 114 and 135, respectively, and LOAEL-based HQs of 23 and 13, respectively (Table J-26a).

- **Short-tailed Shrew** – Mercury and silver had NOAEL-based HQs for the shrew above one, at 700 and 584, respectively. Aroclor 1260 had a NOAEL-based HQ of 2. Mercury and silver had LOAEL-based HQs of 140 and 58, respectively (Table J-26b).

- **Indiana Bat** - NOAEL-based HQs for mercury and silver were 5 and 3, respectively (Table J-26c). Mercury had LOAEL-based HQ of 1.

To put the LOAEL-based HQ exceedances of one into perspective, a comparison to the LOAEL-based CC was performed for these analytes. Sample locations where COPEC concentrations exceeded LOAEL-based CCs are shown on Figure 6-8. Mercury and silver concentrations at four locations each, out of five sampling locations, exceeded the LOAEL-based CCs. Figure 6-8 illustrates that these exceedances are in very close proximity to buildings and other structures, indicating contamination is localized. Also, structural barriers around the sludge drying beds may prevent exposure by terrestrial receptors, such as the white-footed mouse and the short-tailed shrew, at these locations. Text in Section 4.3.9 in Appendix F indicates that there is no evidence of metal migration from this AOC to Brush Creek. It appears that receptors may not be exposed to the localized contamination within the sludge drying beds.

Considering that the LOAEL-based HQ for the Indiana bat equals 1, it is possible that individual bats may be harmed due to the level of mercury found at the site. However, the risk associated with mercury may have been overestimated by the assumption used to predict uptake of mercury into the insects that the Indiana bat feeds upon and also due to the use of methyl mercury toxicity data to derive TRV for total mercury. Therefore, the HQ values are likely to have been overestimated.

6.4.2 Aquatic Environment Risk Evaluation for Brush Creek Watershed

Risk estimates for each aquatic receptor are discussed below. The HQs, along with media concentrations, estimated tissue concentrations, and TRVs for each receptor, are listed in Appendix J. Hazard quotients for all receptors are also summarized in Table 6-5d.

TABLE 6-5d
COPECs and Estimated HQs>1 for Aquatic Receptors
Brush Creek Watershed

Brush Creek Combined Aquatic List	Fish Tissue HQs	Indiana Bat NOAEL HQs	Indiana Bat LOAEL HQs	Kingfisher NOAEL HQs	Kingfisher LOAEL HQs
2,4,6-Trinitrotoluene	<1	**4**	<1	<1	<1
RDX*	NA	**3**	<1	NA	<1
Aluminum*	<1	**1050**	**105**	1	NA
Arsenic	<1	**12**	**1**	<1	<1
Barium*	NA	**11**	**3**	NA	**8**
Bis(2-Ethylhexyl) Phthalate	NA	1	<1	**6**	NA
Copper	**10**	1	1	**6**	NA

TABLE 6-5d
COPECs and Estimated HQs>1 for Aquatic Receptors
Brush Creek Watershed

Mercury	**2**	**35**	**7**	**2**	<1
Selenium*	**1**	**6**	**3**	<1	<1
Silver	<1	**29**	**3**	NA	<1
Thallium	NA	**3433**	**343**	NA	NA
Surface Water COPECs				**Algae HQs**	**Fish HQs**
Barium				<1	**26**
Bis(2-Ethylhexyl) Phthalate				**4**	<1
Copper				**4**	**1**
Silver				<1	**26**

Bold – COPECs in both the terrestrial and aquatic (sediment and/or surface water) environments. *COPECs in sediments. NA = Not Available

6.4.2.1 Orangethroat Darter

Mercury and dieldrin were the only biomagnifying COPECs detected in fantail darter tissue. Dieldrin was only detected at BC8, an off-site sample location downstream of the southern boundary of the IAAAP property.

Weiner and Spry (1996) summarized the toxicological significance of mercury in freshwater fish. They cited numerous studies showing mercury in piscivorous fish (whole body) tissue (walleye, northern pike, largemouth bass) from unpolluted waters to range from the levels found in the Brush Creek orangethroat darter to an order of magnitude higher. Neurotoxicity is considered to be the most probable chronic response of wild adult fish exposed to mercury. Symptoms include lack of coordination, inability to feed, and diminished responsiveness. Weiner and Spry cited studies of one-year old walleye (taxonomically related to the orangethroat darter) in which no adverse effects were observed in fish having tissue levels of 2.5 mg/kg wet weight. That level is ten times the highest level found in the Brush Creek fantail darter. In another cited study of brook trout, Weiner and Spry (1998) described mercury muscle tissue residues for a NOAEL to be 5 mg/kg, twenty times greater than the highest level found in Brush Creek fantail darters. However, numerous fish studies were cited in Jarvinen and Ankley (1999), including 62 for inorganic and 88 for organic mercury. Of these, a 60-day life-cycle study on fathead minnows showed reduced growth at 1.31 mg/kg, with a no-effect level of 0.80 mg/kg (Snarsky and Olson, 1982). Mercury concentrations in tissues where effects were observed were higher overall in studies where fish were exposed to methylated mercury compounds. Therefore, a conservative TRV for mercury was set at 1.06 mg/kg, still approximately four times the highest concentration in the Brush Creek fantail darter.

To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated including direct observations of the fish in the creek (i.e., DELT analysis), tissue analysis of fantail darters for specific COPECs, and estimation of HQs using two different methods. These lines of evidence are used in combination to evaluate the potential risk to the orangethroat darter.

Of the modeled tissue concentrations, HQs for cadmium, copper, mercury, and selenium exceeded one (Table J-27). Cadmium, mercury, and selenium were less than two, while the copper HQ was 10. The HQ for mercury, detected in fish tissue from collection stations in Brush Creek, was less than one.

For the water exposure method, HQs were calculated by dividing the COPEC concentration in water by the water-based TRV. Barium and silver HQs exceeded one, both at 26. For most COPECs, HQs based on modeled tissue concentrations are higher than the water HQs. The only exception was silver, for which water concentration-based HQs were higher than modeled tissue concentration-based HQs.

No tissue residue screening levels were available for explosives for comparison in the literature or the Environmental Residue Effects Database (USACE, 2003). Because fish are present in Brush Creek, there is a potential for adverse effects due to barium, cadmium, copper, mercury, selenium, and silver contamination. Within Brush Creek, orangethroat darters were captured during the field investigation, which was an important finding as it indicates this species is present, and likely reproducing in the creek aquatic environment. Individual orangethroat darters that were examined did not show signs of stress, as indicated by DELTs. However, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals. The DELT is not designed to detect toxic effects to fish that are not readily apparent, and so there are limitations with this line of evidence.

Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values are likely to be artifacts of the conservative nature of the models used to estimate the ecological risks. Mercury concentrations in fantail darter samples were much lower than its TRV. Individual orangethroat darters examined did not show signs of stress. Based on these observations, adverse effects are not expected to orangethroat darters in the Brush Creek watershed.

6.4.2.2 Benthic Community

Detailed results for the RBP analysis are found in Section 4.0 and Appendix E, along with any noted limitations of the analysis based on varying characteristics among sample stations. It should be noted that the RBP is not a definitive analysis, but rather provides a relative comparison of the results of observations at a reference location compared to observations at downstream sampling stations.

Benthic sampling stations along Brush Creek yielded 137 to 294 individuals and eight to 17 macroinvertebrate taxa at each site. Table E-2 in Appendix E presents the number collected by station, and the HBI tolerance values for all taxa. Results are discussed in detail in Section 4.0.

The RBP results for Brush Creek are presented in Table E-5. Sampling station BC 9, located upstream of the AOCs in the Brush Creek watershed, was considered a reference station. However, it cannot be conclusively established whether this station is impacted by contaminants originating within IAAAP. Stations BC1, BC3, BC4, and BC7 were rated as slightly impaired. However, most stations, including the stations that were rated as slightly impaired, scored better than the reference station for several metrics. Biological condition scores suggest the slightly degraded condition is more the result of agricultural practices than IAAAP operations.

6.4.2.3 Aquatic Algae

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. As described previously, for surface water exposure, HQs were calculated by dividing the COPEC concentration by the water-based TRV. Hazard quotients exceeding one were calculated for BEHP and copper, at 4 and 4, respectively (Table J-28). The surface water-based TRVs for algae were generally screening values available in the literature. Such screening values are inherently conservative. When a surface water concentration exceeds a screening value, it is not an indication that adverse effects are actually taking place. Therefore, the aquatic algae HQs present some uncertainty as to whether or not there is a problem, and is likely a weak line of evidence given the conservatism of the screening values.

6.4.2.4 Belted Kingfisher

There were seven explosives, BEHP, and 15 metals selected as COPECs for the Brush Creek aquatic environment. Bis(2-ethylhexyl)phthalate, copper, and mercury had NOAEL-based HQs greater than one but less than 10 (Table J-29). The mercury HQ was modeled based on the measured maximum concentration of mercury in the fantail darter sampled from Brush Creek, with a resulting HQ less than two. Barium was the only constituent with a LOAEL-based HQ above one, at eight. However, this LOAEL exceedance in itself does not likely translate to a concern for the belted kingfisher or similar piscivore population, as these are likely artifacts of the conservative nature of the models used to estimate the ecological risks for these analytes. The kingfisher was assumed to consume all fish from within the watershed; while home ranges for belted kingfisher may include areas outside the plant boundary. However, risk estimates were developed by assuming that the belted kingfisher acquires all food items from on-post area within the Brush Creek watershed. Also, uncertainties associated with barium risk estimates have previously been discussed.

Eisler (1987) states that reproductive effects on some birds were noted at dietary dose ranging from 50 to 100 µg/kg. The author postulated that for sensitive species of birds that regularly consume fish and other aquatic organisms, total mercury concentration in prey items (i.e., fish) should probably not exceed 100 µg/kg. Mercury concentrations in fish tissue exceeded 100 µg/kg in all three samples collected from Brush Creek. The modeled NOAEL and LOAEL based HQs to belted kingfisher, which was assumed to consume 100 percent of its prey from Brush Creek were 2 and less than 1, respectively. Therefore, although measured tissue concentrations exceed the level that Eisler (1987) postulated as causing reproductive effects, the dose modeling, with LOAEL based HQs less than 1, does not indicate such potential effects.

6.4.2.5 Indiana Bat

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and it is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. HQs were the only line of evidence that were collected to evaluate risk to the Indiana bat, as other means of evaluation were not feasible.

For the Indiana bat, RDX is the only organic compound with a NOAEL-based HQ exceeding one, at three (Table J-30). Among the metals; aluminum, arsenic, barium, mercury, selenium, silver, and thallium had NOAEL-based HQs exceeding one, ranging from six for selenium to 3,430 for thallium. All these metals had LOAEL-based HQs greater than one, but below ten, except aluminum at 105 and thallium at 343. The LOAEL-based HQ values are likely artifacts of the conservative nature of the models used to estimate the ecological risks for these analytes.

The modeled insect COPEC concentrations appear to be much higher than what would be expected if insects had been collected and analyzed. This is based on a comparison of field collected insect metal concentrations detected at SVDA, as discussed previously. If insect to sediment accumulation factors measured at SVDA were used in the BERA, then the LOAEL-based HQs for bat due to exposure to aluminum and barium in the Brush Creek watershed would decrease to 3.2 and 0.5, respectively from the estimated values of 105 and 3.

In addition, aluminum was not selected as a COPEC at any AOCs within the watershed, because soil pH was found to be above 5.5, indicating that aluminum is not bioavailable. Although sediment pH data is not available, it is unlikely that sediment pH at the streams and their tributaries are below 5.5 because of generally aerobic nature of the aquatic environment and sandy characteristics of the sediment. Uncertainty associated with matrix effects on thallium analytical results has been discussed previously.

6.4.3 Summary of Risk Descriptions, Brush Creek Watershed

6.4.3.1 Terrestrial Environment

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for white-footed mouse, short-tailed shrew, and Indiana bat by AOC. In addition, soil concentrations that are equivalent to a LOAEL-based HQ of one, called LOAEL-based CCs were calculated for each receptor. The HQ and related LOAEL-based CC line of evidence is the only line of evidence available to evaluate the potential ecological risks for the terrestrial environment. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was considered to be a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

Of the nine AOCs located in the watershed, remediation to protect human health is not slated to occur at two AOCs, Line 7 and the Sewage Treatment Plant/Sludge Drying Beds. The remediation that is planned at the other AOCs should be protective of ecological risks because it involves excavation of the top two feet of soil at the AOCs where terrestrial receptors are expected to be exposed. An evaluation of the residual concentrations of COPECs are evaluated for Line 5A/5B (see Section 6.7) where remediation has occurred to verify that this assumption is valid.

COPEC (copper, dieldrin, mercury, PCBs, silver, and thallium) concentrations exceed their corresponding LOAEL-based CCs at multiple locations. These exceedances are localized (see Figures 6-7 and 6-8), next to buildings and structures, and are not present throughout these AOCs. At most of these AOCs, the CC exceedances are isolated and localized. Sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding CCs. Fate and transport evaluations (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs. At the sludge drying Beds, structural features may preclude receptor exposure to contamination and further contaminant migration away from the AOC.

Mercury, copper, PCBs, and thallium produce effects on reproductive systems of wildlife receptors. Dieldrin causes behavioral effects such as decreased avoidance of predators. For these effects to have a community-wide impact on the white-footed mouse and the short-tailed shrew, the COPEC concentrations would need to be greater than their corresponding LOAEL-based CCs in a large area. However, the exceedances are localized, and therefore, impact on the white-footed mouse or the short-tailed shrew community is not expected.

No Observed Adverse Effects Level (NOAEL) based HQs exceeded one for mercury and thallium at Line 7 and for mercury and silver at the Sewage Treatment Plant/Sludge Drying Beds. Considering that the LOAEL-based HQ for the Indiana bat exceeds 1, it is possible that individual bats may be harmed due to the level of thallium at Line 7. Also, LOAEL-based HQ for mercury was one (1) at R018. However, the risk associated with thallium and mercury may be overestimated. Uncertainty associated with the thallium results and mercury HQs have been discussed previously. Based on this additional level of analysis, mercury and thallium at this site would unlikely pose a health concern to the Indiana bat.

6.4.3.2 Aquatic Environment

The results of the ecological evaluation for Brush Creek are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, the two lines of evidence are used in a combination as a weight of evidence to determine if there is a potential ecological risk to a receptor.

Mercury and dieldrin were the only biomagnifying COPECs detected in darter tissue. A conservative TRV for mercury was set at 1.06 mg/kg, still approximately four times the highest concentration in the Brush Creek fantail darter. Of the modeled tissue concentrations, HQs for cadmium, copper, mercury, and selenium exceeded one (Table J-27). For the water exposure method, barium and silver HQs exceeded one, both at 26. Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values are likely to be artifacts of the conservative nature of the models used to estimate the ecological risks. Within Brush Creek, orangethroat darters were captured during the field investigation, which was an important finding as it indicates this species is present, and likely reproducing in the creek aquatic environment. Individual orangethroat darters that were examined did not show signs of stress, as indicated by DELTs. Based on these observations, adverse effects are not expected to orangethroat darters in the Brush Creek watershed. However, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals, but this was not apparent based on the results of the field observations (DELT).

Benthic sampling stations along Brush Creek were rated as slightly impaired. However, most stations, including the stations that were rated as slightly impaired, scored better than the reference station for several metrics. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. Biological condition scores suggest the slightly degraded condition is more the result of agricultural practices than IAAAP operations. The conditions at IAAAP are considered to pose little risk to the aquatic biological community in the Brush Creek watershed. However, the RBP is not a definitive analysis, and thus has its own inherent limitations.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. HQs exceeded one for copper and BEHP. The aquatic algae HQs present some uncertainty as to whether or not there is a problem, and are likely a weak line of evidence given the conservatism of the screening values.

Barium was the only constituent with a LOAEL-based HQ above one, at eight, for belted kingfisher. However, this LOAEL exceedance in itself does not likely translate to a concern for the belted kingfisher or similar piscivore population as the result might be an over estimation of the actual risk based on the conservative nature of the models used to estimate the ecological risks. The uncertainty surrounding the barium risk estimates has been discussed in previous sections.

Aluminum, arsenic, barium, mercury, selenium, silver, and thallium had LOAEL-based HQs exceeding one for the Indiana bat. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Brush Creek aquatic environment. However, there is considerable conservatism built into the dose modeling estimation process that may lead to over estimation of actual risks. The Indiana bat was assumed to ingest all of the insects it feeds upon from Brush Creek and its tributaries, which is not realistic. Rather the bat could also consume insects from areas outside the IAAAP. Furthermore, diet of Indiana bat also consists of insects from terrestrial habitats. The modeled insect COPEC concentrations appear to be much higher than what would be expected if insects had been collected and analyzed. In addition, aluminum may not be bioavailable. Also, there is uncertainty associated with the thallium results.

Based on the multiple lines of evidence, the fish and benthic population in the Brush Creek watershed do not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations on the Brush Creek watershed). The benthic community structure endpoint showed that Brush Creek watershed is essentially slightly impaired and does not show adverse effects. Although the HQ line of evidence indicated certain COPECs may pose an ecological concern, individual darter samples examined did not show any signs of stress, and their presence indicates that darter species are reproducing in the stream.

6.5 SPRING CREEK WATERSHED RISK CHARACTERIZATION

Soil AOCs in the Spring Creek watershed are the Contaminated Waste Processor (IAAP-024/R16) and Roundhouse Transformer Storage Area (IAAP-040/R28). Only the Contaminated Waste Processor is not slated for remediation.

The Contaminated waste processor is evaluated in more detail within the Spring Creek watershed. Only HMX at one location, had exceedances of their LOAEL-based CCs at this AOC.

6.5.1 Summary of Terrestrial Risks By AOC

Chemicals of potential ecological concern and estimated HQs are summarized in Table 6-6a and 6-6b for terrestrial receptors. As previously, risks for specific COPECs are listed if they exceed a NOAEL-based HQ of one or equal or exceed a LOAEL-based HQ of one.

TABLE 6-6a
COPECs and Estimated HQs>1 for Terrestrial Receptors
Spring Creek Watershed

Spring Creek AOCs	White-footed Mouse HQs				Short-tailed Shrew HQs			
	IAAP-024/R16*		IAAP-040/R28*		IAAP-024/R16*		IAAP-040/R28*	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Aroclor 1260	NA	NA	62	6	NA	NA	413	41
HMX	6	2	NA	NA	2	<1	NA	NA

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

Table 6-6b
COPECs and Estimated HQs>1 for Terrestrial Receptors
Spring Creek Watershed

Spring Creek AOCs	Indiana Bat HQs			
	IAAP-024/R16*		IAAP-040/R28*	
Soil COPECs	NOAEL	LOAEL	NOAEL	LOAEL
Aroclor 1260	NA	NA	6	<1

Note:
* Indicates AOCs not slated for human health-based remediation
NA Indicates the constituent is not a COPEC in this AOC

As previously, HQs were calculated for the selected terrestrial receptors. Figures 6-19, 6-20, and 6-21 present spatial view of LOAEL-based HQ exceedances for the white-footed mouse, the short-tailed shrew, and the Indiana bat, respectively, in all the AOCs. Of the two AOCs in the Spring Creek watershed, plans currently exist for removal of contaminated soils from the Roundhouse Transformer (IAAP-040/R28). The HQ calculation results for IAAP-040/R28 are provided in Appendix J, Tables J-31a, J-31b, and J-31c. The results for the Contaminated Waste Processor (IAAP-024/R16) are summarized in the following subsection.

6.5.1.1 Contaminated Waste Processor (IAAP-024/R16)

Three explosives were identified as soil COPECs at the Contaminated Waste Processor. HQs for the terrestrial receptors are described as follows for these COPECs (only COPECs that had a NOAEL-based HQ greater than one or LOAEL-based HQ equal to or greater than one are discussed further):

- **White-footed Mouse** - NOAEL-based HQ for HMX was above one at 6. HMX also had a LOAEL-based HQ above one, at 2 (Table J-32a).
- **Short-tailed Shrew** – HMX had NOAEL-based HQ greater than one at 2 for the short-tailed shrew (Table J-32b).
- **Indiana Bat** – No NOAEL or LOAEL based HQs equal or exceed 1. (Table J-32c).

There are no NOAEL-based HQs exceeding one for the Indiana bat, therefore, exposure to this AOC should not pose a health concern to this special status species.

To put the LOAEL-based HQ exceedance of one into perspective, a comparison to the LOAEL-based CC was performed for these analytes. Sample locations where COPEC concentrations exceeded LOAEL-based CCs are shown in Figure 6-9. HMX concentration at one location out of nine sampling locations, exceeded the LOAEL-based CC. The habitat at this AOC is devoid of vegetation. However, densely forested area indicating primary habitat for terrestrial receptors exist in the close proximity of this AOC. Text in Section 5.3.1 in Appendix F indicates that potential exists for contaminant migration from this AOC to Spring Creek. However, figure 6-9 illustrates that the CC exceedance is isolated and other locations showed COPEC concentrations less than their corresponding CCs. Based on the poor habitat quality on this AOC and the isolated exceedance of LOAEL-based HQ, only individuals within the receptor community may be impacted. It is not expected that the white-footed mouse or the short-tailed shrew community will be impacted from exposure to COPECs at the Contaminated Waste Processor.

6.5.2 Aquatic Environment Risk Evaluation for Spring Creek Watershed

Risk estimates for each aquatic receptor are discussed below. The HQs, along with media concentrations, estimated tissue concentrations, and TRVs for each receptor, are listed in Appendix J. HQs for all receptors are also summarized in Table 6-6c.

TABLE 6-6c
COPECs and Estimated HQs>1 for Aquatic Receptors
Spring Creek Watershed

Spring Creek Combined Aquatic List	Fish Tissue HQs	Indiana Bat NOAEL HQs	Indiana Bat LOAEL HQs	Kingfisher NOAEL HQs	Kingfisher LOAEL HQs
Aluminum*	NA	**950**	**95**	≤1	NA
Arsenic*	<1	**36**	**4**	≤1	<1
Barium*	NA	**22**	**6**	NA	**9**
Copper*	**10**	**4**	3	**10**	NA
4-4'-DDT	**20**	**5**	**<1**	1301	130
Selenium	**2**	**8**	**5**	≤1	<1
Silver*	<1	**553**	**55**	NA	<1
Surface Water COPECs				**Algae HQs**	**Fish HQs**
Barium				<1	**30**
Copper				**4**	1
Manganese				**2**	<1
Silver				<1	**18**

Bold – COPECs in both the terrestrial and aquatic (sediment and/or surface water) environments. *COPECs in sediments.
NA = Not Available.

6.5.2.1 Orangethroat Darter

The orangethroat darter is a special status species, and thus was selected for evaluation in this BERA. However because of its special status, specimens of this species could not be collected for purposes of tissue analysis. To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated including direct observations of the fish in the creek (i.e., DELT analysis), tissue analysis of a similar darter species for specific COPECs, and estimation of HQs using two different methods. These lines of evidence are used in combination to evaluate the potential risk to the orangethroat darter.

COPECs detected in surface water were modeled to estimate fish tissue concentrations. Of the modeled tissue concentrations, copper and selenium had HQs exceeding one, at 10 and 2, respectively (Table J-33).

For the water exposure of fish, HQs were calculated by dividing the COPEC concentration in water by the water-based TRV. Barium, copper, and silver HQs exceeded one, with barium the highest, at 30 (Table J-33). The tissue-based modeled HQs were higher than the water-based HQs with the exception of silver.

Because fish are present in Spring Creek, there is a potential for adverse effects due to barium, copper, selenium, and silver. However, the barium TRV is considered highly conservative, and silver had a water exposure HQ exceeding one, but the tissue residue HQ was less than one.

Within Spring Creek, orangethroat darters were captured during the field investigation, which was an important finding as it indicates this species is present, and likely reproducing in the creek aquatic environment. Individual orangethroat darters that were examined did not show signs of stress, as indicated by DELTs.

Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values are likely to be artifacts of the conservative nature of the models used to estimate the ecological risks. Mercury, dieldrin, and heptachlor epoxide were detected in johnny and fantail darter collected from Spring Creek. However, the tissue concentrations were much lower than corresponding TRVs. Individual orangethroat darters examined did not show signs of stress. Based on the weight-of-evidence for the direct and the dose-modeling lines of evidence, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals (barium, copper, selenium, and silver), but this was not apparent based on the results of the field observations (DELT).

6.5.2.2 Benthic Community

The RBP was performed to evaluate the health of the benthic community of the creek and provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected within the aquatic habitat. Detailed results for the RBP analysis are found in Section 4.0 and Appendix E. The limitations associated with RBP analysis have been discussed previously.

Benthic sampling stations in the Spring Creek watershed yielded 137 to 294 individuals and eight to 17 macroinvertebrate taxa at each site. Table E-1 presents the number collected, by station, and the HBI tolerance values for all taxa. Results are discussed in detail in Section 4.0.

Site SC1 is upstream of IAAAP activities, and was considered the watershed reference site at the time of the benthic study. Sites SC2 and SC3, within IAAAP, are rated as unimpaired in comparison to the reference site (Table E-6). Further downstream, stations SC4, SC5 and SC6 were rated as slightly impaired. However, the stations that were rated as slightly impaired scored better than the reference station on some metrics. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. Because most of the watershed is intensively cultivated, the reference station itself may represent a slightly impaired condition. The impairment exhibited at stations where the BCS suggested a slightly degraded condition is considered to be more the result of agricultural practices at the site than IAAAP operations.

6.5.2.3 Aquatic Algae

Aquatic algae were selected as plants exposed to surface water COPECs in the water column. Hazard quotients exceeding one were calculated for copper and manganese at 4 and 2, respectively (Table J-34). The surface water- based TRVs for algae were generally screening values available in the literature. Such screening values are inherently conservative. When a surface water concentration exceeds a screening value, it is not an indication that adverse effects are actually taking place. Therefore, the aquatic algae HQs present some uncertainty as to whether or not there is a problem, but are likely a weak line of evidence given the conservatism of the screening values.

6.5.2.4 Belted Kingfisher

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs that have the potential to bioaccumulate in fish tissue might pose an ecological risk to this feeding guild. Bis(2-ethylhexyl)phthalate, 4,4'-DDT, 4-methylphenol, and 16 metals were selected as COPECs for the Spring Creek aquatic environment. Copper and 4,4'-DDT had NOAEL-based HQs greater than one, at 16 and 1,301, respectively (Table J-35).

The mercury HQ was modeled based on the measured maximum concentration of mercury in the johnny and fantail darter with a resulting HQ less than one. Eisler (1987) states that reproductive effects on some birds were noted at dietary dose ranging from 50 to 100 μg/kg. The author postulated that for sensitive species of birds that regularly consume fish and other aquatic organisms, total mercury concentration in prey items (i.e., fish) should probably not exceed 100 μg/kg. Mercury concentrations in fish tissue exceeded 100 μg/kg in two of six samples collected from Spring Creek. The modeled NOAEL and LOAEL based HQs to belted kingfisher, which was assumed to consume 100 percent of its prey from Spring Creek, were both less than 1. Therefore, although measured tissue concentrations exceed the level that Eisler (1987) postulated as causing reproductive effects, the dose modeling does not indicate such potential effects.

Barium and 4,4'-DDT were the only constituent with LOAEL-based HQs above one, at 8 and 130, respectively. Uncertainties associated with estimation of Barium HQs have previously been discussed.

4,4'-DDT can bioaccumulate from water, but it was detected in only one of 11 samples at a concentration of 0.0059 μg/L, slightly exceeding the detection limit. Such isolated detection of pesticides, which may have been used for activities other than those related to the operation at the IAAAP, may have little effect on the fish and piscivore communities.

6.5.2.5 Indiana Bat

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and it is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. HQs were the only line of evidence that were collected to evaluate risk to the Indiana bat, as other means of evaluation were not feasible.

Of the metals, aluminum, arsenic, barium, copper, selenium, and silver had NOAEL- and LOAEL-based HQs greater than one (Table J-36). The highest values were for aluminum at 950 and 95, for NOAEL and LOAEL, respectively. Also, arsenic, barium, copper, selenium, and silver had LOAEL-based HQs at 4, 6, 3, 5, and 6, respectively. Of the organics, 4,4'-DDT had NOAEL-based HQ greater than one. Considering the elevated LOAEL-based HQ values for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Spring Creek aquatic environment. Some of the limitations of the HQ estimates have been evaluated, as a means of informing the risk manager about these limitations.

The LOAEL-based HQ values for metals might be artifacts of the conservative nature of the models used to estimate the ecological risks for these analytes. Indiana bats have been spotted on the IAAAP property. In the evaluation of effect of the Spring Creek watershed, the Indiana bat was assumed to ingest all of the insects it feeds upon from Spring Creek and its tributaries, which is not realistic. Rather the bat could also consume insects from areas outside the plant.

The modeled insect COPEC concentrations appear to be much higher than what would be expected if insects had been collected and analyzed. If insect to sediment accumulation factors measured at SVDA were used in the BERA, then the LOAEL-based HQs for bat due to exposure to aluminum and barium in the Spring Creek watershed would decrease to 0.11 and 0.71, respectively from the estimated values of 95 and 6.

In addition, aluminum was not selected as a COPEC at any AOCs within the watershed, because soil pH was found to be above 5.5, indicating that aluminum is not bioavailable. Although sediment pH data is not available, it is unlikely that sediment pH at the streams and their tributaries are below 5.5 because of generally aerobic nature of the aquatic environment and sandy characteristics of the sediment.

6.5.3 Summary of Risk Descriptions, Spring Creek Watershed

6.5.3.1 Terrestrial Environment

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for white-footed mouse, short-tailed shrew, and Indiana bat, by AOC. In addition, soil concentrations that are equivalent to a LOAEL-based HQ of one, called LOAEL-based CCs were calculated for each receptor. The HQs and related LOAEL-based CC line of evidence is the only line of evidence available to evaluate the potential ecological risks for the terrestrial environment. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was considered to be a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

Of the two AOCs located in the watershed, remediation to protect human health is slated to occur at the Roundhouse Transformer Storage Area. The remediation planned at the Roundhouse Transformer Storage Area should be protective of ecological risks because it involves excavation of the top two feet of soil at the AOCs where terrestrial receptors are expected to be exposed. An evaluation of the residual concentrations of COPECs are evaluated for Line 5A/5B (see Section 6.7) where remediation has occurred to verify that this assumption is valid.

COPEC concentrations exceed their corresponding LOAEL-based CCs at only one location. This exceedance is localized and is not present throughout the AOC. Sampling locations around the CC exceedance also showed COPEC concentrations that did not exceed their corresponding CCs. LOAEL or NOAEL-based HQs do not exceed or equal 1 for any COPECs for Indiana bat. Although LOAEL-based HQ values exceed one for HMX for white-footed mouse and short-tailed shrew, this is likely due to the conservative nature of the models used to estimate the ecological risks. Based on the observations that spatial distribution of HMX is limited, that there is no evidence of contaminant migration from these AOCs, that potential exposure to receptors are limited, it is not expected that the terrestrial receptor community will be impacted.

6.5.3.2 Aquatic Environment

The results of the ecological evaluation for Spring Creek are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, the two lines of evidence are used in combination to determine if there is a potential ecological risk to a receptor or a receptor community.

Several lines of evidence were available to evaluate risks to orangethroat darters. Of the modeled tissue concentrations, copper and selenium had HQs exceeding one, at 10 and 2, respectively. For the water exposure of fish, barium, copper, and silver HQs exceeded one. Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values may have been the result of overestimation of risks due to the conservative nature of the models. Mercury, dieldrin, and heptachlor epoxide were detected in johnny and fantail darter collected from Spring Creek. However, the tissue concentrations were much lower than corresponding TRVs. Within Spring Creek, orangethroat darters were captured during the field investigation, which was an important finding as it indicates this species is present, and likely reproducing in the creek aquatic environment. Individual orangethroat darters that were examined did not show signs of stress, as indicated by DELTs. Based on these observations, adverse effects are not expected to orangethroat darters in the Spring Creek watershed.

Some of the benthic sampling stations in the Spring Creek watershed are rated as unimpaired in comparison to the reference site. Further downstream, stations SC4, SC5 and SC6 were rated as slightly impaired. However, the stations that were rated as slightly impaired scored better than the reference station on some metrics. Because most of the watershed is intensively cultivated, the reference station itself may represent a slightly impaired condition. The impairment exhibited at stations where the BCS suggested a slightly degraded condition is considered to be more the result of agricultural practices at the site than IAAAP operations.

Aquatic algae HQs exceeding one were calculated for copper and manganese at 4 and 2, respectively. These HQs present some uncertainty as to whether or not there is a problem, and is likely a weak line of evidence given the conservatism of the screening values.

Barium and 4,4'-DDT were the only constituents with LOAEL-based HQs above one, at 8 and 130, respectively, for belted kingfisher. Such high LOAEL-based HQs might be an overestimation of risks due to the conservative nature of the models. The kingfisher was assumed to consume all fish from within the watershed; while home ranges for belted kingfisher may include areas outside the plant boundary. Uncertainties related to barium toxicity have been discussed. 4,4'-DDT can bioaccumulate from water, but it was detected in only one of 11 samples at a concentration of 0.0059 μg/L, slightly exceeding the detection limit. Eisler (1987) states that reproductive effects on some birds were noted at dietary dose from mercury ranging from 50 to 100 μg/kg. Mercury concentrations in fish tissue exceeded 100 μg/kg in two of six samples collected from Spring Creek. However, the modeled NOAEL and LOAEL based HQs to belted kingfisher, which was assumed to consume 100 percent of its prey from Spring Creek, were both less than 1.

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and it is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. Aluminum, arsenic, barium, copper, selenium, and silver had LOAEL-based HQs greater than one for the Indiana bat. The highest value was for aluminum at 950. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Spring Creek aquatic environment. Some of the limitations of the HQ estimates have been evaluated as a means of informing the risk manager about the limitations of these risk estimates.

Based on the multiple lines of evidence, the fish populations (including oragnethroat darters), and the benthic invertebrate populations in Spring Creek does not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations on the Spring Creek watershed). Also, individual darter samples examined did not show any signs of stress, and their presence indicates that darter species are reproducing in the stream. However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so there is possibly adverse effects that are occurring due to IAAAP operations that could not be readily detected. Evaluation of algea in Spring Creek indicated the potential for effects on this community by specific metals. However, the line of evidence used was more of a screening level assessment and has a large degree of uncertainty associated with it.

6.6 SENSITIVITY ANALYSIS

Some of the high HQ values (i.e., much greater than one) are evaluated further in terms of a sensitivity analysis that looks at a range of values for some of the key exposure assumptions. In this way, the uncertainty associated with some of these elevated HQs are discussed in more detail in applicable areas within this section, to help risk managers better understand the potential range of ecological risks. Sensitivity analyses with two key parameters are presented below.

6.6.1 Toxicity Reference Value

One of the key parameter evaluated in this BERA is the TRV. Two sets of TRVs, one LOAEL-based and the other NOAEL-based, were obtained from the literature, when available. Two separate HQs are calculated for each COPEC using the NOAEL- and LOAEL-based TRVs, and are referred to as the NOAEL- and LOAEL– based HQs. The NOAEL-based HQ provides a lower bound estimate of risk and ecological risk would be considered unlikely if HQ does not exceed one. The LOAEL-based HQ, if equal to or greater than one, represents possible adverse effects. Between the NOAEL-based and LOAEL-based HQs, is a gray area where ecological risks are possible. The LOAEL-based HQ is considered to be a more realistic prediction of potential risk for an ecological receptor than the NOAEL-based HQ. Therefore, when a LOAEL-based HQ is equal to or greater than one, it was evaluated further to provide a range of risk estimates.

Risk estimates presented for each of the COPECs at the AOCs and the aquatic environment (tables 6-3 through 6-6) show the difference between NOAEL-based and LOAEL-based HQs. In most cases, the LOAEL-based HQ is about an order of magnitude lower than the NOAEL-based HQ. For TNT for Indiana bat, LOAEL-based HQ estimates are even lower than LED10 based estimates. For example, LED10 based HQ for Indiana bat in the Brush Creek is about 3.66; compared to LOAEL-based HQ of 0.09.

6.6.2 Bioaccumulation Factor

The bioaccumulation factors for estimating uptake into various upper trophic level organisms have significant uncertainty associated with the values used in this BERA. For example, the HQ calculations for Indiana bat in this BERA were conducted with BAF values for terrestrial invertebrate available in the literature. These $BAF_{terr\text{-}inv}$ values were used to model uptake of contaminants from soil to invertebrate that a short-tailed shrew may ingest. The same $BAF_{terr\text{-}inv}$ values were also used to model uptake of COPECs by flying insects that a bat may ingest. Significant uncertainties are associated with empirical models that could describe the soil to plant to insect uptake of food that an Indiana bat obtains partly from soil and partly from plants. $BAF_{terr\text{-}inv}$ values are primarily developed based on uptake by worms, which is expected to overestimate uptake compared to those by flying insects because worms are in contact with the soil during 100 % of their life cycle. As discussed in Section 3.3, available data from SVDA was used to determine BAF values for the insects. Risk estimates are developed based on these measured values, when available, to represent HQ estimates based on measured values as compared to those based on BAF values developed using soil to worm model.

Comparisons of HQs to Indiana bat at the nine AOCs not slated for remediation, based on literature and measured BAF, are shown in Table 6-7. The data in this table shows to what extent, risks due to mercury may have been overestimated. No Observed Adverse Health Effects and LOAEL based HQs for mercury at R26 was estimated at 84 and 17, respectively, based on literature $BAF_{terr\text{-}inv}$ values. However, both NOAEL and LOAEL-based HQs were less than one when BAF value measured at SVDA was used. In general, the measured BAFs are higher than the literature derived $BAF_{terr\text{-}inv}$ values. However, for several constituents, such as copper, selenium, 1,3-DNB, 2,4-DNT, HMX, and RDX, the literature derived $BAF_{terr\text{-}inv}$ values are higher. For some COPEC, such as silver, the HQ estimates are comparable using the literature or the measured BAF values. It is interesting to note that measured BAF values are not always lower than the literature derived values.

TABLE 6-7
COPECs Exceeding LOAEL-based HQs of 1 for Terrestrial Receptors
Measured and Literature BAFs

AOCs	**Indiana Bat**							
	IAAP-027/R19 Long Creek				**IAAP-028/R20 Long Creek**			
	Literature BAF		**Measured BAF**		**Literature BAF**		**Measured BAF**	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
1,3-Dinitrobenzene	NA	NA	NA	NA	<1	<1	1	<1
Selenium	<1	<1	7	4	NA	NA	NA	NA
AOCs	**IAAP-038/R26 Long Creek**				**IAAP-041/R29 Long Creek**			
	Literature BAF		**Measured BAF**		**Literature BAF**		**Measured BAF**	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Mercury	84	17	<1	<1	NA	NA	NA	NA
AOCs	**IAAP-043/R30 Long Creek**				**IAAP-029/R21 Skunk River**			
	Literature BAF		**Measured BAF**		**Literature BAF**		**Measured BAF**	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Mercury	1	<1	<1	<1	NA	NA	NA	NA
AOCs	**IAAP-008/R08 Brush Creek**				**IAAP-026/R18 Brush Creek**			
	Literature BAF		**Measured BAF**		**Literature BAF**		**Measured BAF**	
Soil COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Mercury	2	<1	<1	<1	5	1	<1	<1
Silver	NA	NA	NA	NA	3	<1	3	<1
AOCs	**IAAP-024/R16 Spring Creek**							
	Literature BAF				**Measured BAF**			
Soil COPECs	NOAEL		**LOAEL**		**NOAEL**		**LOAEL**	
No COPECs in IAAP-024/R16 exceeding LOAEL-based HQ of 1.								

Note: NA indicates the constituent is not a COPEC in this AOC

At the nine AOCs evaluated in detail in this BERA, LOAEL-based HQs to Indiana bat due to exposure to TNT did not exceed one. In order to provide additional information to the risk managers, NOAEL and LOAEL-based HQs at R03 were calculated with BAF values measured at SVDA, in addition to the HQ estimates conducted based on literature $BAF_{terr\text{-}inv}$ value. The NOAEL and LOAEL-based HQs with literature-derived $BAF_{terr\text{-}inv}$ value are 95,000 and 2,380, respectively. The NOAEL and LOAEL-based HQs with BAF value measured at Savanna are 114 and 3, respectively, indicating values that are about three orders of magnitude lower.

As discussed within the specific watersheds, risks to Indiana bat may be lower for some of the COPECs, if BAF values measured at SVDA are used instead of the literature-derived BSAF values. Average insect to sediment accumulation factors, based on measured values, were about 0.001 and 0.05 for aluminum and barium, respectively. The insect to sediment accumulation factors used in the dose modeling in this BERA is 0.9 for aluminum and barium. If insect to sediment accumulation factors measured at SVDA were used in the BERA, then the LOAEL-based HQs for bat due to exposure to aluminum and barium in the Brush Creek watershed would decrease to 3.2 and 0.5, respectively from the estimated values of 105 and 3. It should be noted that the flying insects collected at SVDA were those generally associated with the terrestrial environment, such as moth. Therefore, there is additional uncertainty associated with applying the measured BAF values for terrestrial insects in an aquatic setting.

6.7 COMPARISON TO RESIDUAL TNT CONCENTRATIONS IN IAAP-006/R06

Removal actions have been completed at several AOCs, where contaminated soil was removed and replaced with uncontaminated fill. These actions included removal of soil to depths greater than two feet. As shown in Tables 6-1a and 6-1b, TNT is one of the COPECs for which CC based on protection of ecological risks is lower than human health based remediation goal. Therefore, human health-based remediation at some of the AOCs may not mitigate potential ecological risks associated with TNT. An example evaluation of the residual TNT concentrations of contaminants in soil has been performed for IAAP-006 (R06) consisting of Lines 5A and 5B to evaluate if human health-based remediation is also likely to be protective of ecological health.

Soil sampling was conducted in 1999 at Lines 5A/5B in association with the non-time critical Remedial Actions (RA) (IAAAP 2001). The sampling was conducted to obtain a better definition of areas that require soil excavation based on exceedance of human health based remediation objectives. During the characterization phase, over 1,400 samples were collected from Lines 5A and 5B. Excavation plans were developed, implemented, and confirmation samples were collected from each site. The data are presented in Appendix L. Concentrations of TNT in soil from 0 to 2 feet below ground surface (bgs) prior to excavation are presented in Table L-1. In Table L-2, only the detected TNT concentrations prior to excavation are listed. Tables L-1 and L-2 show that TNT was detected in only 86 out of the 974 samples (less than 10 percent) prior to excavation. Excavation was conducted in several areas to address soil contamination. The areas of excavation and associated sample numbers are shown on Figures in IAAAP (2001). In Table L-3, TNT concentrations in 911 soil samples left after excavation are listed. TNT concentrations exceeded the ecological risk based CC of 0.69 mg/kg in only 35 of the 911 samples.

Ecological risk based CC for TNT is based on protection of Indiana bat. Area of IAAP-006 (R06) is about 74 acres, which is about same as the home range of an Indiana bat. An Indiana bat, is therefore, expected to be exposed to the representative TNT concentration at IAAP-006 (R06) after excavation has been conducted to protect human health. The representative TNT concentration, the 95% UCL concentration, is 0.36 mg/kg, a value much lower than the CC of 0.69 mg/kg. Ecological risks to Indiana Bats exposed to residual TNT concentration of 0.36 mg/kg will be estimated to have NOAEL- and LOAEL based HQs less than one. Therefore, it appears that remediation to address human health risk at IAAP-006 (R06) is protective of ecological risks. Similar evaluations could be conducted at other AOCs to determine if human health based remediation is protective of ecological health at these AOCs.

6.8 SUMMARY OF BASEWIDE RISKS

Within the four watersheds that were evaluated at IAAAP, separate ecological evaluations were performed for the terrestrial and the aquatic environment. The terrestrial evaluations looked not only at the potential for ecological risks to be present at specific AOCs, but also evaluated whether there was any apparent transport of contamination from a particular AOC to the creek or river within the watershed. The AOCs were evaluated by watershed to be able to identify any contaminant inputs to a given a creek or river within a watershed. In general, the contamination in the terrestrial environment of each watershed was mainly found around buildings and did not appear to be migrating away from the specific AOCs to the creeks or rivers at IAAAP. It should be noted that a number of AOCs have already been remediated, and although ecological risks have been assessed for each of these AOCs based on the data available prior to remediation, the assumption has been made that these AOCs, that have been remediated, do not present an ecological risk any longer. For this reason, the AOCs that have been remediated were not evaluated in detail within this BERA, but a representative AOC (IAAP-006/R06) was further evaluated using residual concentrations data to verify that this assumption was appropriate. This is further explained in the terrestrial environment summary. The following is an overall summary of the results of the four individual watershed assessments, beginning first with the terrestrial environment followed by the aquatic environment.

6.8.1 Terrestrial Environment

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for three ecological receptors including the white-footed mouse, the short-tailed shrew, and Indiana bat by AOC. In addition, soil concentrations that are equivalent to a NOAEL-based or LOAEL-based HQ of one, called NOAEL-based or LOAEL-based CCs, were calculated for each receptor (refer to Section 6.1.3). If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

These LOAEL-based CCs were compared to human health PRGs available for IAAAP and which are to be utilized in soil removal activities at several AOCs (Table 6-1a). The major risk-driving chemicals for human health (i.e., those with high concentrations throughout the facility) include TNT, RDX, and lead, for which the human-health-based PRGs or RGs are lower than the ecological LOAEL-based CCs, with the exception of TNT. In the case of TNT, the ecological-based CC is lower than the human health RG for TNT, but this is based on the assumptions used to model uptake of TNT for the Indiana bat. These assumptions are likely very conservative, but to verify this, additional study may have to occur at IAAAP. Whether additional study would be required will depend upon further evaluation of the residual soil contaminant concentrations at AOCs that have been remediated. In addition, there were no AOCs that have not been remediated yet, where TNT concentrations posed a risk to the Indiana bat. Therefore it is likely that RDX and lead, will drive remediation at these remaining sites. For RDX and lead, the human health based PRG or RG would be more restrictive than the ecological based CC, and therefore remediation to human health based goals should be protective of ecological risks. Therefore, the PRGs or RGs are likely appropriate values on which to base vertical and horizontal removal boundaries for most areas (i.e. ecological issues are not indicated to be driving the remediation efforts). For many of the metal COPECs where LOAEL-based HQs exceed one, background concentrations also are higher than the LOAEL-based CCs; therefore cleanup would not be necessary below background levels.

For the AOCs not slated for cleanup based on protection of human health, concentrations of 11 COPECs exceeded LOAEL-based CCs primarily based on the short-tailed shrew and sometimes the white-footed mouse. Altogether, only a total of 28 individual sample locations exceeded LOAEL-based CCs among the nine AOCs where human-health based remediation is not currently planned. Very few COPECs exceed their LOAEL-based CCs in the terrestrial environment, and there is no one COPEC that stands out as an ecological risk driver across the AOCs. Most AOCs have exceedances for only one or two COPECs at a few (three or less) locations, which would indicate the extent of COPEC concentrations above the LOAEL-based CC is very limited. The greatest exceedances are at R08 and R18, with eight locations. Figures 6-1 through 6-9 illustrate that these exceedances are isolated and many in very close proximity to buildings and other structures, indicating the contamination is localized. At most of these AOCs, sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding LOAEL-based CCs. Fate and transport evaluations for most of the AOCs (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs.

The toxicity endpoint that was used to estimate the risk associated with most of the COPECs (but not TNT for Indiana bat) was reduction in offspring numbers or growth. For these reproductive effects to have an ecological impact on the mouse and the shrew, the COPEC concentrations would have to be above a level of concern (i.e., LOAEL-based CC) in a large area of the site. However, this does not occur at any of the AOCs, and so effects on the population of small mammals (e.g., mouse or shrew) would not be expected at any of the individual AOCs. In addition, primary habitat for the receptors exists in the area surrounding most AOCs. Based on the observations that spatial distribution of the COPECs is limited, that there is no evidence of contaminant migration from these AOCs, and that primary habitat for the receptors exists outside the AOCs, it is conceivable that individual terrestrial receptors exposed to COPECs at these 28 locations above the LOAEL-based CCs could be adversely impacted. But, it is not expected that the white-footed mouse or the short-tailed shrew community will be impacted due to these isolated exceedances of the CCs.

In the case of the Indiana bat, the goal is to protect the individual bat because of its special status. NOAEL-based HQs exceeded one at three of the nine AOCs evaluated that have not been previously remediated, within the four watersheds. For this reason, potential risks to the Indiana bat are very localized in nature in the terrestrial environment. Considering that the LOAEL-based HQ for the Indiana bat exceeds one, it is possible that individual bats may be harmed due to the level of mercury found at some AOCs. However, as noted previously, the risks may be overestimated by the assumption used to predict uptake of COPECs into the insects that the Indiana bat feeds upon.

In summary, it is anticipated that remediation to address human health at several AOCs would cover areas where ecological risks could exist. In the terrestrial environment, there are only isolated areas where potential ecological risks might occur, and these are not expected to pose a concern to the populations of small mammals. It is likely that these isolated locations would be remediated as the site is remediated to address human health risks. For the AOCs slated for remediation, ecological risk-based LOAEL-based CCs exceed measured concentrations for several COPECs. The locations for such exceedances are listed by COPEC in Tables J-37 through J-55 in Appendix J. This information may aid in determining whether further remediation is required at the AOCs slated for human-health based remediation or where human-health based remediation has already taken place.

6.8.2 Aquatic Environment

The results of the aquatic environment evaluations are provided below by receptor. For the aquatic environment, a number of lines of evidence were collected for each creek or stream. The lines of evidence included dose modeling to develop HQs and CCs for aquatic wildlife receptors (Belted kingfisher and Indiana bat) similar to the assessment performed for the terrestrial environment. In addition, for fish and algae, HQ calculations were made based on comparisons to either modeled fish body burdens or simply comparing to screening benchmarks. In addition, field assessments were conducted to evaluate fish health (i.e., DELT) and the health of the benthic invertebrate community (i.e., RBP). Where both effects-based lines of evidence and the HQ lines of evidence (DELT and RBP) are available for a receptor, the two lines of evidence are used in combinations, as a weight of evidence, to determine if there is a potential ecological risk to a receptor.

The orangethroat darter is a special status species, and thus was selected for evaluation in this BERA. However because of its special status, specimens of this species could not be collected for purposes of tissue analysis. To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated for a number streams including direct observations of the fish in the creek (i.e., DELT analysis), tissue analysis of a similar darter species for specific COPECs, and estimation of HQs using two different methods. These lines of evidence are used in combination to evaluate the potential risk to the orangethroat darter.

Based on the lines of evidence evaluated in most streams (but not Skunk River), it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals. However, no apparent effects were observed based on the results of the field observations (DELT). However, the DELT is not designed to detect toxic effects to fish that are not readily apparent, and so there are limitations with this line of evidence. It is possible that the levels of some metals may have toxic effects on the orangethroat darters in the streams, but this can not be verified based on the lines of evidence that were evaluated. The presence of the orangethroat darter or similar species of darter in most of the streams is a promising sign that the stream habitat can support darter populations.

The RBP was performed to provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected within the aquatic habitat. It is important to consider the habitat characteristics at each sample station when performing the RBP, as there are many environmental factors (e.g., riparian vegetation and stream characteristics) other than contaminant concentrations that can effect the benthic community composition at a given location. When performing the RBP at IAAAP, the sample locations were selected to evaluate potential source areas of contamination to the creek, and also, sample stations were selected so that they would be similar in characteristics to one another. There are certain limitations that can not be overcome, such as the presence of some stations at locations that are not ideally matched to the reference station. In these cases, a qualitative determination has to be made to determine if there are environmental factors other than chemical concentrations that would likely effect the benthic community composition. Keeping this in mind, the information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but is unlikely to detect toxic effects on individual benthic species. Results of the RBP indicated that some sample locations were considered unimpaired or slightly impaired. Where the sample location was rated as slightly impaired, it was generally because of low grade habitat rather than any apparent effects related to chemical concentrations of COPECs. Based on the results of the RBP, the benthic invertebrate community within streams at IAAAP did not appear to be effected by IAAAP facility operations. However, the RBP is not a definitive analysis, and thus has its own inherent limitations that have previously been discussed.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. HQs exceeded one for some phthalate esters, and specific metals in some of the streams (e.g., Long Creek). Such HQ exceedances are not necessarily an indication that adverse effects are actually taking place. The algae HQs are likely a weak line of evidence given the conservatism of the screening values.

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs that have the potential to bioaccumulate in fish tissue might pose an ecological risk to this feeding guild. Ecological risk-based LOAEL-based CCs for surface water and sediment exceed measured concentrations for several COPECs. The locations for such exceedances are listed by COPEC in Tables J-56 through J-69 in Appendix J. Some metals were the only COPECs with LOAEL-based CC exceedances and HQ exceeding one. However, these result might be an over estimation of the actual risk, based on the conservative nature of the exposure model and TRV used to develop the HQs. The uncertainty surrounding these risk estimates has previously been discussed. These LOAEL-based HQs have a low level of confidence associated with them and the belted kingfisher or other piscivores are not likely to be affected by contamination in the streams. However, much of the uncertainty surrounding these risk estimates is related to the lack of fish tissue concentrations of COPECs, and as a result the concentration in fish were modeled.

The risk to the Indiana bat was evaluated as an aquatic receptor, because it is known to be present at the IAAAP and utilize the riparian corridor along streams as habitat. Therefore, it was considered important to protect even individuals within the population. The LOAEL-based HQs exceeded one for a number of metals within most of the watersheds. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the aquatic environment. However, for purposes of the BERA, some of the HQ estimates have been evaluated as a means of informing the risk manager about the limitations of these risk estimates, and when considering these limitations, indicate that the bat might not be at risk.

In summary, based on the multiple lines of evidence, the fish populations (including oragnethroat darters), and the benthic invertebrate populations in the streams evaluated do not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations). However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so, there is possibly adverse effects that are occurring due to IAAAP operations that could not be readily detected. In the case of the Indiana bat, exceedances of LOAEL-based CCs (i.e., HQs >1) were detected in a number of the streams within the aquatic environment. Although these risk estimates might be conservative in nature due to the assumptions used to evaluate exposure and toxicity to this species, it is beyond the scope of this BERA to verify these results.

In addition, to the bat, the evaluation of algae in some creeks (e.g., Long Creek) indicated the potential for effects on this community by specific metals. However, the line of evidence used was more of a screening level assessment and has a large degree of uncertainty associated with it.

6.9 OFF-SITE IAAAP SURFACE WATER SAMPLING

Soil samples have not been collected from locations outside the plant boundary because there are no known or anticipated release of contaminants via the soil pathway from the plant to outside locations. Therefore, evaluation of risks due to exposure to contaminants in the terrestrial media to receptors outside the boundary of the IAAAP is not included in this BERA. However, contaminants in surface water and sediments inside the plant may migrate outside of the plant boundary. Elevated concentration of contaminants in aquatic environment outside of the plant boundary may pose threats to aquatic receptors, such as belted kingfisher and Indiana bat. Several surface water samples, two in Brush Creek and one in Spring Creek, were collected from locations downstream and outside of the plant boundary during sampling for this BERA. Results from these locations are included in the evaluation of risks. Additional surface water data has since become available (URS 2003). Results of this data are discussed qualitatively in this section in relation to on-site surface water concentrations and surface water CCs. Information regarding sediment contamination at off-site locations are not available.

Eight surface water samples were collected during the off-site groundwater remedial investigation. Five of the samples were collected from Brush Creek and three from privately owned water bodies within the Brush Creek watershed. Samples were analyzed for explosives only. The primary compounds detected in surface water samples included RDX and HMX. Mono-nitroso RDX (MNX) was also detected in one sample location. Maximum concentration of HMX, RDX and MNX were 5.5 μg/L, 22 μg/L and 0.44 μg/L, respectively. Summary of explosives detected in surface water is presented in Table 6-8.

In the baseline risk assessments, HMX and RDX were identified as COPECs in surface water. Maximum concentration of HMX and RDX detected in Brush Creek on-site was 7.5 μg/L and 15 μg/L, respectively. The maximum concentration of HMX detected in the off-site surface water was 5.5 μg/L, which is lower than the maximum concentration detected in on-site samples from

Brush Creek. However, maximum off-site RDX concentration of 22 μg/L was higher than RDX concentrations detected on-site.

The LOAEL and NOAEL based HQs of HMX, using sample results primarily from on-site locations, are less than one for Belted kingfisher and Indiana bat. Since the LOAEL and NOAEL based HQs of HMX are less than one in Brush Creek on-site, HMX in the off-site surface water of IAAP would not pose significant risks to aquatic receptors.

The NOAEL based HQ of RDX is three for Indiana bat. Critical concentrations were developed for COPECs with HQ greater than one. The LOAEL-based CC for RDX in surface water is 12.9 μg/L (see Table 6-2c). RDX concentrations detected in the off-site samples were compared to the LOAEL-based CC for RDX, as shown in Table 6-8. Four of the eight surface water samples have RDX concentration greater than the LOAEL-based CC. While, this may indicate that RDX in the off-site surface water of IAAAP may pose threats to aquatic receptors, such as Indiana bat, one should refer back to the uncertainty associated with the CC and exposure models to determine how real the potential threats are.

Table 6-8. Off-Site Surface Water Sample Results (in μg/L)

Chemical	CC	BC-OFF1	BC-OFF2	BC-OFF3	BC-OFF4	BC-OFF5	SW1	SW2	SW3
HMX	NA	5.1	4.9	5.5	5.3	4.2	<0.47	<0.71	<0.84
MNX	NA	<1	0.44	<1.3	<8.7	<0.96	<0.58	<0.89	<1.1
RDX	12.9	22	22	21	19	16	<0.47	<0.71	<0.84

Note: NA- Not available.

7.0 UNCERTAINTIES

Many factors contribute to uncertainties associated with this BERA. Uncertainty is inherent in all aspects of the risk process, including the selection of indicator species, estimation of exposure, characterization of potential ecological effects, and final evaluation of risk.

Some uncertainties exist where it is not known whether the assumptions used are conservative in nature, or may actually underestimate risk. For example, it is assumed that additive and cumulative risks from exposures to multiple stressors are negligible. The potential for additive risks from exposures to multiple stressors is considered in this assessment for some receptors via RBP. However, if additive and cumulative risks from multiple exposures are possible, the individual, COPEC-specific HQs presented in Section 6.0 may underestimate the actual risk.

Specific areas of uncertainty inherent in the BERA are described below:

- Many factors contribute to uncertainties associated with the BERA including the selection of indicator species, estimation of exposure, characterization of potential ecological effects, and risk characterization. The dose estimation models used in this BERA to estimate HQs are based on conservative assumptions. When several conservative assumptions are multiplied together to estimate a given HQ, the resultant HQ is likely conservative in nature. Some of the high HQ values (i.e., much greater than one) are evaluated further in terms of a sensitivity analysis that looks at a range of values for some of the key exposure assumptions (refer to Section 6). The uncertainty associated with elevated HQs are discussed in more detail in applicable areas within this section to help risk managers understand the limitations of these values in terms of evaluating potential ecological risks.

- Metals occur naturally in the environment. It is probable that levels of metals found in at least some soils at the AOCs reflect background conditions. Risks estimated for exposure to some of the metals detected in site soils may therefore unreasonably raise concerns while being comparable to risks from exposure to natural background levels.

- Thallium, although detected consistently in sediment, was detected in only one of 21 surface water samples. Also, analytical results for thallium are known to have associated uncertainties. Revanasiddappa and Kumar (2002) notes that Atomic Adsorption Spectroscopy (method used in the current study) often lacks sensitivity and displays matrix effects for thallium measurements. The matrix effects can lead to false positive detections of thallium, meaning it is detected even though it is really not present in the sample. For this reason, there is uncertainty associated with the thallium results.

- The sampling conducted during the SI/RI was designed to overestimate actual risks when there is an uncertainty. The directed (biased) nature of the sampling plan, which focuses on the most contaminated parts of the site, inherently overestimates 95% UCL of COPEC concentrations.

- The sediment sampling locations were identified following site reconnaissance. USEPA, USACE, and MWH determined, during preparation of the sediment sampling plan (i.e., Technical Memorandum No. 2), that at most locations, the highest concentration of COPECs are likely to be associated with the top two inches of surficial sediment. However, it is probable that at some locations, COPECs associated with deeper sediment may be available to receptors that can dig into deeper sediment or following disturbance of the sediment. Minimal exposure is expected to be associated with sediments deeper than two inches. Exclusion of sediment deeper than two inches may over- or under-estimate risks, depending upon the concentrations of COPECs in deep sediment compared to surficial sediment.

- The use of steady state assumptions for estimating source concentrations (i.e. COPEC concentrations) assumes that concentrations do not decrease due to attenuation and/or degradation for the duration of the exposure period. This overestimates constituent concentrations in the media.

- Due to uncertainties associated with estimating the true average concentration, the 95% UCL of the arithmetic mean concentration is used as a measure of the arithmetic average concentration. However, for most COPECs, maximum concentrations were used as the EPC. Maximum concentrations were also used for fish tissue as the representative concentration. Using the 95% UCL, or the maximum measured COPEC concentrations, as the EPC, provide a conservative estimate of potential risk to wildlife receptors. COPECs with HQs determined to be less than one, based on exposure at the 95% UCL or maximum concentrations, can be predicted with a high degree of confidence to present no risk to that receptor. While short-term exposures at the maximum levels may occur, it is highly unlikely that the wildlife receptors will feed exclusively from maximally contaminated locations. Therefore, the actual risks to wildlife receptors from exposures to COPECs may be lower than indicated by the HQ values that are based on the maximum concentration of a COPEC.

- Physical, chemical, biological, and seasonal variables interact to influence the availability of metals to receptors. Certain metals are accumulated and retained to a much greater degree, while, for others, only a fraction of the ingested amount is absorbed. For example, USEPA (1997) discusses literature values that indicate mammals absorb approximately 10% of ingested lead. For most metals, with the exception of aluminum, information regarding bioavailability is not available in the literature. Therefore, it was assumed that 100% of the ingested metal is bioavailable. Such assumptions may result in an overestimation of risks.

- Exposures to the wildlife receptors were based on modeled concentrations in their food items and results in uncertainty associated with developing exposure factors. Uncertainties in the development of exposure factors include the selection of BAFs and BCFs, which are not site-specific values. Some were empirically derived under laboratory circumstances or based on related species, and others were calculated based on chemical properties. Feeding rates, body weights, and ingestion rate of soils or other media are estimates that vary among literature sources. However, generally the value resulting in the most conservative result (highest exposure dose) is used.

- Soil-to-terrestrial invertebrate BAF values account for uptake of COPECs from soil by terrestrial invertebrates. As a conservative approach, the soil-to-terrestrial invertebrate BAF values were used in this BERA to predict the contaminant concentrations in insects. The $BAF_{terr\text{-}inv}$ values were primarily developed based on uptake by worms, which is expected to overestimate uptake compared to those by flying insects, because worms are in contact with the soil during 100 % of their life cycle and flying insects are not.

- Barium should not cause a concern to a piscivore, as barium is not known to classically bioaccumulate in fish tissue. Also, barium is a nontoxic metal, unless it is present in a water-soluble form, which makes it more bioavailable. In many toxicity studies used to develop barium TRVs, more water-soluble forms of barium are used than what would be found in the normal environment. Therefore, HQ values for barium is believed to be over-estimated.

- Toxicity reference values are also a source of uncertainty. In some cases, information gaps, such as the lack of toxicity information for avian receptors, precluded estimation of risk for particular COPEC/receptor combinations. For example, no avian wildlife data could be found for beryllium, cobalt, or thallium. While, limited information regarding general ecotoxicological characteristics of these COPECs is available, threshold values related to ecotoxicological effects are not available. Thus, quantitative assessments of potential adverse effects of these COPECs on the specific receptors were not conducted. It is still possible that beryllium, cobalt, or thallium could trigger ecotoxicological responses in belted kingfishers. Such responses may include localized effects in lungs or digestive tracks due to exposure to beryllium and reproductive effects due to exposure to cobalt and thallium. Also, there were no NOAEL data available for RDX, barium, or silver. For mammalian receptors, no data were available for carbazole and no LOAEL data were available for TNT. Information regarding ecotoxicological characteristics of carbazole is not available. Due to the lack of toxicity values, there is some uncertainty associated with the risk characterization of these receptors. Some TRVs were extrapolated from data for surrogate chemicals. A TRV based on a NOAEL is conservative due to the fact that a NOAEL dose is not associated with adverse effects and an adverse effect may not occur until the dose is much higher than the NOAEL (i.e., possibly an order of magnitude higher depending upon the chemical). Although a LOAEL is a more reasonable indicator of a dose at which adverse effects might begin, it may underestimate risk because there may be some level below the LOAEL where the effect was observed. This is due to the fact that the determination of the NOAEL and LOAEL are based on the doses chosen by the investigator, that conducts the toxicology study, on which the TRV was based. For this reason, the NOAEL and LOAEL are not bright line points on the dose response curve where no adverse effect occurs, or where an adverse effect starts to occur. There is also variability in the way toxicity studies are conducted, which may result in a NOAEL in one study at a dose level, above which an effect was observed in another study. In these cases, the circumstances of the studies were reviewed to determine what appears to be a more reliable result. This was often true of the fish tissue residue TRVs, where there was wide variability in the test methods, endpoints, and types of tissue analyzed. Finally, the analytical results for mercury reported in this BERA are based on total mercury concentrations in soil or sediment and dissolved mercury concentrations in water. However, the TRVs are based on studies conducted with methyl mercury, which is more toxic than total mercury. Therefore, the HQ values presented for mercury are likely to have been overestimated. The procedures associated with development of TRVs are more likely to overestimate risks than to underestimate risks, because the approach used to derive the TRV, or select the study, are conservative in nature.

- A number of studies have evaluated the ability of single-chemical laboratory toxicity test results to predict adverse effects of that chemical on organisms under field conditions. Preliminary studies suggest that laboratory toxicity tests represent more conservative exposure scenarios than those that occur in nature (USEPA, 1991). Uncertainties underlying the assessment of toxicity arise because information from laboratory toxicity studies is extrapolated to the exposure scenarios evaluated in the risk assessment. Furthermore, concentrations of chemicals causing no effect in laboratory tests also do not appear to affect communities in the field. Thus, the use of chronic NOAEL-equivalent TRVs is likely to provide a conservative level of protection to plant and wildlife communities and populations observed in the field.

- The selected wildlife receptors represent avian and mammalian receptors that may use the IAAAP site. Indiana bat was selected as a sensitive species that may eat flying insects from the AOCs. However, available information does not indicate that the bats are susceptible to exposure at the AOCs. IAAAP (2003) discusses foraging and roosting behavior of Indiana Bat at the IAAAP. The Indiana bats were found primarily foraging along edges of agricultural fields, along and in the floodplain of the water bodies, and in forested areas around headwaters of the surface water bodies. The bats were found to spend some time around a stone quarry, although it is not clear if they are foraging or roosting in that area. Some of the bats were found to fly across an open field, but not forage there. The bats were not specifically found to forage near the production lines. The nature and extent of contamination around the production lines are limited to areas close to the lines that are not forested. Based on the foraging and roosting characteristics described in IAAAP (2003), the bats are not expected to forage around the AOCs. However, as a conservative approach, it is assumed that the bats are foraging in the AOCs.

- The relative sizes of the species selected as representative receptors may impact their relative sensitivities and will have varying rates of metabolism, and of food, water, and sediment ingestion per unit of body weight. However, based on recent literature (Sample and Arenal, 1999), allometric relationships between wildlife and test animals are closer to one than previously assumed. Therefore, no body weight scaling factors were used in this study. This allows for some uncertainty, since Sample and Arenal's (1999) calculations resulted in their recommendation of the use of mean mammalian and avian scaling factors of 0.94 and 1.2, respectively. Additionally, these factors were based on observations from acute studies. The applicability of these scaling factors to chronic toxicity data, used to develop the IAAAP TRVs, is unknown.

- There are also uncertainties associated with empirically derived results, such as the fish tissue analysis. Laboratory analyses of tissue, as well as other environmental media, are subject to variability. This uncertainty is somewhat reduced by the use of quality control procedures, including duplicate analyses of environmental media samples. However, duplicate analyses of single organism samples are often not possible due to a limited amount of material.

- There are limitations associated with interpretation of effects-based lines of evidence, such as RBP II and DELT. The information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but unlikely would detect subtle effects on individual benthic species. The RBP is not a definitive analysis, but rather provides a relative comparison of the results of observations at a reference location compared to observations at downstream sampling stations. Many environmental factors (e.g., riparian vegetation and stream characteristics), other than contaminant concentrations, can effect the benthic community composition at a given location. For example, difference in physical conditions, such as water flow regimes, between the selected reference station and the test stations, may significantly bias the results. There are certain limitations that can not be overcome, such as the presence of some stations at locations that are not ideally matched to the reference station. If an impaired reference station is used for comparison to other test stations, it is conceivable that a "slightly impaired" sampling station would in actuality be moderately impaired. In these cases, a qualitative evaluation has to be made to determine if there are environmental factors other than chemical concentrations that would likely effect the benthic community composition. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. It may be that other land-use impacts such as forest clearing or farming have altered the habitat enough to change the community composition, or that the habitat is naturally of a quality that is not optimal for supporting a full diversity of benthic species.

- DELT evaluations are visual observations used to qualitatively assess the apparent health of an individual fish, and extrapolate this information to the overall fish community. While these provide direct measures and observations of the health of the creek environment, they can not account for more subtle health effects, such as reduced reproductive success or adverse effects during more sensitive life stages.

- Fish tissue samples were not analyzed for metals, other than mercury. While these COPECs may not have the significant biomagnification potential associated with mercury, some have the potential to bioaccumulate or bioconcentrate. The impact of metal concentrations in surface water and sediment to higher trophic level organisms was evaluated through dose modeling. Exposures to the wildlife receptors were based on modeled concentrations in their food items, which results in some level of uncertainty with these estimates, because of the assumptions needed to predict prey concentrations.

The lack of metals data in fish tissue samples adds to the uncertainty associated with evaluation of potential adverse biological or ecological effects.

- The surface water-based TRVs for algae were generally screening values available in the literature that are not based specifically on adverse effects to algae, but to a wide range of aquatic receptors. Such screening values are inherently conservative, because they are derived to protect even the most sensitive ecological receptor. When a surface water concentration exceeds a screening value, it is not an indication that adverse effects are actually taking place to algae, but rather that there is the potential for some concern. The aquatic algae HQs present a great degree of uncertainty as to whether or not an effect to algae is actually taking place, but this is likely a weak line of evidence, given the conservatism of the screening values.

For this assessment, conservatism was incorporated at many points in the process to guard against underestimation of the actual risk to ecological receptors at the site. As mentioned at the beginning of this section, conservatism is more likely to lead to overestimation of actual risk, especially when multiple conservative estimates are used in combination to estimate risk. The risk results obtained in the BERA were interpreted in light of these potential uncertainties.

8.0 SUMMARY AND CONCLUSIONS

The objective of this BERA is to evaluate potential risks to ecological receptors due to operations at the IAAAP. The BERA was developed following USEPA's eight-step approach for conducting ecological risk assessments (ERA) (USEPA 1997). This BERA builds on several tasks that were conducted at different times, including the SLERA, and therefore, could not follow a linear eight-step process. However, USEPA (1997) recognizes that such non-linear approaches are logical and appropriate at some sites.

In response to a FFA between the U.S. Department of Defense and USEPA Region 7, IAAAP completed a facility-wide PA/SI of 44 AOCs, and subsequently, a facility-wide RI for 35 AOCs. Previous ecological evaluations have been performed as part of the RI/FS process and other ancillary assessments that evaluated the unique ecological habitat at IAAAP.

Several AOCs have already been slated for remediation. For these AOCs, remediation is driven by human health, rather than by ecological health concerns. AOCs for which remedial decisions have not yet been made are evaluated in greater depth in this BERA.

SLERA

The revised draft SLERA includes screening level problem formulation and identification of COPECs. The revised draft SLERA for IAAAP confirmed that complete exposure pathways exist for some media and consequently, COPECs were identified for several media to be evaluated further in the BERA. The selected COPECs represent the constituents most likely to be of concern to the environment. COPECs were selected for soils at each AOC by comparing the maximum concentration of each constituent against soil SV for that constituent. Similarly, surface water and sediment COPECs were identified for each stream by comparing the maximum concentration in each stream to the corresponding surface water or sediment SVs. The SVs are constituent concentrations above which exposure by a receptor could lead to adverse effects. Media-specific SVs were selected by reviewing available literature.

Problem Formulation

Problem formulation for the BERA includes description of the ecological and physical characteristics of the IAAAP and results in a CSM identifying exposure pathways and receptors. IAAAP is drained by four principal watersheds, Long Creek, the Skunk River, Brush Creek, and Spring Creek. Soil AOCs, which are the potential source areas for contamination, are located within these watersheds, with some draining into more than one. Principal constituents were explosives and metals, prevalent at multiple AOCs, with Aroclor1260, PAHs, and pesticides detected locally. Soil contaminants are localized within the physical boundary of most AOCs. Others, particularly some where high concentrations of explosives were found, have acted as source areas for surface water and sediment contamination in the streams. Based on these data, the CSM for the BERA at IAAAP identified the following complete and significant exposure pathways:

- Exposure of aquatic plants, aquatic insects, fish, birds, bats, terrestrial mammals to surface water COPECs via ingestion or direct contact

- Exposure of bats to COPECs via ingestion of terrestrial insects, aquatic insects, and water
- Exposure of benthic invertebrates, aquatic plants, fish, and aquatic mammals via ingestion of sediment
- Exposure of birds to COPECs via ingestion of fish, water, and sediment
- Exposure of soil macroinvertebrate, herbivorous mammals and carnivorous mammals to COPECs via ingestion of soil and water

The assessment endpoints, or specific ecological values to be protected, were established as follows for the terrestrial and aquatic environments:

Terrestrial Environment

- Survival, growth and reproduction of terrestrial herbivores using the white-footed mouse as the representative of this guild.
- Survival, growth and reproduction of terrestrial vermivores/carnivores using the short-tailed shrew as the representative of this guild.
- Survival, growth and reproduction of terrestrial insectivores using the Indiana bat as the representative of this guild.

Aquatic Environment

- Survival, growth and reproduction of orangethroat darters
- To maintain the benthic community structure
- Survival, growth and reproduction of aquatic algae
- Survival, growth and reproduction of aquatic piscivores using the belted kingfisher as the representative of this feeding guild.
- Survival, growth and reproduction of sensitive species using the Indiana bat as the representative of this feeding guild.

Measurement endpoints are measurable characteristics that can be used to infer impacts to assessment endpoints. The measurement endpoints for each of the assessment endpoints were discussed among the ERA Team members and documented in TM 1. A summary of the measurement endpoints for each assessment endpoint is included in Table 2-3.

Exposure Analysis

Soil, sediment, and surface water data were collected to characterize the concentrations of constituents to which receptors may be exposed. Fish tissues were collected to evaluate the potential exposure to contaminants by fish, and piscivorous receptors. Exposure dose models for estimating doses to all the receptors were developed. Exposure parameter values were selected for each of the receptors. All data collected, including soil, sediment, and surface water data, and tissue data were used to evaluate exposures to each of the selected receptors, including the magnitude of exposure to COPECs in soil, surface water, and sediment.

Effects Analysis

A vegetation survey, benthic macroinvertebrate studies using RBP, and a fish survey in conjunction with fish collection for tissue analysis were conducted to provide direct lines of evidence regarding any apparent effects of contamination on communities of organisms (e.g., plants, invertebrates, and fish). Benthic macroinvertebrate samples were collected utilizing RBP II methods in which community indices obtained for the sample sites are compared to the indices found at reference (or control) stations. Samples were evaluated using eight common community metrics. Results of the benthic survey showed that benthic community structure is not exhibiting ecological stress in Long Creek and Brush Creek. One of the two tributaries to the Skunk River was rated as unimpaired and the other was rated as slightly impaired. The slight impairment at the Skunk River tributary is likely due to poor habitat quality and intermittent flow, as opposed to chemical contamination. The slight impairment exhibited at stations on Spring Creek is considered to be more the result of agricultural practices at the site than IAAAP industrial operations. Individual fish species examined did not show signs of stress, as indicated by DELTs (deformities, eroded fins, lesions, or tumors). An earlier inventory and assessment of habitats and biota at IAAAP, conducted by Horton and others (1996), indicate that IAAAP facility development, through restriction of forest lot size, may be limiting forest quality to the same or a greater degree than contamination.

The direct lines of evidence, such as the RBP II methods or DELT, have inherent limitations associated with them. The information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but unlikely would detect toxic effects on individual benthic species. Similarly, DELT evaluations are visual observations used to qualitatively assess the apparent health of an individual fish. Such evaluations can not account for health effects, such as reduced reproductive success or adverse effects during more sensitive life stages. The uncertainty and limitations associated with the estimation of HQs have been discussed in Sections 6 and 7. Therefore, these effects-based lines of evidence are used in combination with the HQ lines of evidence. These two lines of evidence (effects-based evaluations and HQs) together provide a weight of evidence as to whether the aquatic or terrestrial environment is at risk.

Toxicity Assessment

The toxicity assessment summarizes methods applied for developing TRVs, in contrast to the direct observations of effects described above. The TRVs are used to quantitatively estimate the magnitude of toxicity of each analyte selected for risk characterization. TRVs for wildlife receptors represent doses that are protective based on specific toxicity endpoints (e.g., survival, growth, reproduction, etc.). TRVs for each COPEC for the four wildlife species (the white-footed mouse, short-tailed shrew, belted kingfisher, and Indiana bat) were derived from literature. Literature that provided information on study design, such as duration, handling of test species, physical information on test species, and dose route, was selected over literature with more limited information. Chronic toxicity studies were considered preferentially because, at most sites, receptors were exposed over a long period. Toxicity endpoints that correlated with significant ecological impacts, such as reproduction, development, and survival, were preferred over systemic and acute effects. Doses administered through an oral route (diet, water, gavage) were preferred over other routes (e.g. direct injection). The literature search focused on laboratory studies to obtain information on the LOAEL and NOAEL. The exception to this was for TNT for the Indiana bat, where a LED10 value was used to represent the NOAEL-based TRV. TRVs for water exposure to fish used the lowest CV for fish. TRVs for fish tissue residues were developed based on TSCs for fish tissue residues. Screening level ecological benchmarks, that are concentration-based, were used as TRVs for aquatic plants.

Risk Characterization

Risks to receptors were evaluated for exposure to soil contaminants at the AOCs and surface water and sediment contaminants in the three streams, Long Creek, Brush Creek, and Spring Creek and in tributaries to these three streams and the Skunk River. The AOCs are located within the four watersheds associated with the streams and their tributaries.

The AOCs where human health-based remediation is slated to occur are:

- Line 1 (IAAP-001/R01)
- Line 2 (IAAP-002/R02)
- Line 3 (IAAP-003/R03)
- Line 3A (IAAP-004/R04)
- Lines 4A/4B (IAAP-005/R05)
- Line 6 (IAAP-007/R07)
- Line 8 (IAAP-009/R09)
- Line 9 (IAAP-010R10)
- Line 800 (IAAP-011/R11)
- Firing Site (IAAP-030/R22)
- Roundhouse Transformer (IAAP-040/R28)

The ecological risks associated with these AOCs have not been described in detail within this BERA or summarized in this section, because the remediation slated for protection of human health risks at these AOCs should mitigate potential ecological risks. Whether the remedial actions to protect human health will mitigate ecological risks can not be confirmed until after the remedial actions occur, and thus there will need to be a check of this logic after remediation is complete. However, during the remediation process, soils will likely be excavated to over 2 ft in depth, similar to previous remedial actions already completed at IAAAP, and will thus eliminate contamination and, for a time, any ecological habitat that currently exist at these AOCs for wildlife. During past remedial actions at IAAAP, the depth of excavation of material have been much greater than two feet, and then fill material has been placed to bring the excavation to grade, thus eliminating exposure of ecological receptors to the residual level of COPECs remaining. Post-remediation data from Line 5A/5B are compared to the LOAEL-based CCs as an example to validate that this is a reasonable assumption. The risk assessment team may decide to conduct similar comparisons with post-remediation data for the other AOCs where remediation has already occurred based on human health RGs. This summary and conclusions section emphasizes an evaluation of ecological risk for those AOCs that are not currently slated for remediation based on human health. Although the ecological risks associated with those AOCs that are slated for human health remediation are not discussed in detail, ecological risks for each of these AOCs were provided in summary form within Section 6, and detailed risk calculations are provided in Appendix J.

The AOCs for which human health based remediation has not yet been planned, and which are evaluated in greater depth in this BERA, include:

- Line 7 (IAAP-008/R08)
- Contaminated Waste Processor (IAAP-024/R16)
- Sewage Treatment Plant (IAAP-026/R18)
- Fly Ash Landfill (IAAP-027/R19)
- Construction Debris Landfill (IAAP-028/R20)
- Line 3A Sewage Treatment Plant (IAAP-029/R21)
- Building 600-86 Septic System (IAAP-038/R26)
- Line 3A Pond (IAAP-041/R29)
- Fly Ash Disposal Area (IAAP-043/R30)

To evaluate the risks to ecological receptors, specific lines of evidence (i.e., measurement endpoints) were selected to estimate whether a particular assessment endpoint was being satisfied. For the terrestrial environment, only one line of evidence (i.e., NOAEL- and LOAEL-based HQs) was used to estimate risk, while for the aquatic environment, multiple lines of evidence were collected. Information on exposure and effects, or toxicity, was combined to estimate whether particular COPEC concentrations pose ecological concerns at each AOC or the streams.

This characterization started with assessment of effects on the selected endpoints. If the selected receptors are estimated to be at no risk, then the ecosystem as a whole is considered to be protected. On the other hand, if individual receptors or communities are estimated to be at risk, there is still the question of whether the receptor population or community is at risk. The risk characterization on the particular receptor species or communities is used to make qualitative judgments concerning any estimated potential effects to cause actual ecological harm. For the special status Indiana bat, risk characterization included effects on individual bats, and not community level effects, because of its special status. The goal is to not harm an individual for special status species like the bat. The question of effects for the selected receptors is quantitatively documented. The probability of individual, community and population effects is handled qualitatively.

The potential for risk was characterized by evaluating four primary forms of exposure and effects data, referred to as lines of evidence. These were:

Evaluation of media-specific data - Surface water data were used to evaluate risks to fish and algae. Media-specific data were used to estimate tissue concentrations in aquatic and terrestrial receptors. Fish tissue analytical results were used for comparison to estimated doses and also to model exposure doses for piscivores.

Evaluation of field survey results - Field observations of fish (DELT) and benthic community (RBP results) were interpreted to identify any apparent effects.

Development of HQs - HQs were developed for surface water, sediment, and soil, at each AOC and for each ecological receptor. In the screening process, HQ values were determined as the ratio of the maximum concentration of a constituent in a media to its corresponding SV. In the BERA, HQ values are calculated by comparing modeled COPEC doses to TRVs. Two separate HQs are calculated for each COPEC using the NOAEL- and LOAEL-based TRVs, and are referred to as the NOAEL- and LOAEL- based HQs. According to USEPA (1997), the lower bound, or threshold, below which risk is assumed to be insignificant is based on conservative assumptions and NOAEL-based toxicity values. A NOAEL corresponds to a dose that is *not associated with adverse effects*. Therefore, NOAEL-based HQs greater than one represent the lower end of the potential ecological risk range. HQs developed in ecological risk assessments are generally represented to one significant digit, because the certainty of exposure factors is only known to one significant digit. Therefore, HQs were rounded to the nearest whole integer using normal arithmetic methods (i.e. 1.4 was rounded to 1.0, 1.5 to 2, etc.). For some COPECs, NOAEL-based HQs could not be estimated because NOAELs were not available. It should be noted that a NOAEL-based HQ greater than one does not necessarily represent an environmental concentration that would pose a concern to the ecological receptor. For this reason, a NOAEL-based HQ is a fairly weak line of evidence to use to estimate if a COPEC poses a potential ecological concern.

A LOAEL is used as a lower bound to estimate an exposure dose that could *potentially cause an adverse effect* to an ecological receptor. A LOAEL represents the lowest dose in a toxicological study that was observed to cause an adverse effect on the test organism. Therefore, LOAEL-based HQs of one or greater, generally, are associated with some level of adverse effect in the test species. However, while the observed LOAEL-based dose may have caused an effect in the test organism, it may or may not show direct effects on species found in the IAAAP. Therefore, LOAEL-based HQ values equal to or greater than one may or may not indicate adverse effects on the assessment endpoints selected in this BERA. LOAEL-based HQs are developed using the same conservative exposure dose that is used for the NOAEL-based HQs. However, the TRV used is different because it is based on a LOAEL. The LOAEL-based HQ is considered to be a more realistic prediction of potential risk for an ecological receptor than the NOAEL-based HQ. Therefore, when a LOAEL-based HQ is equal to or greater than one for a COPEC, it is evaluated further for each terrestrial AOC. In these cases, LOAEL-based and NOAEL-based CCs are calculated which are concentrations of a COPEC that correspond to a LOAEL-based HQ or a NOAEL-based HQ of one. This is discussed further below.

Development of CCs - Critical concentrations (CCs) are calculated analyte concentrations in soil that equate to a HQ of 1. The CCs are developed considering cumulative chemical exposure from all applicable sources (e.g., soil invertebrates and soil). Critical Concentrations are COPEC concentrations, calculated for a specific COPEC-receptor combination that may pose a risk to that receptor. The CCs are calculated analyte concentrations in soil, surface water and sediment that equate to a LOAEL-based HQ of one. LOAEL-based CCs calculated for the three terrestrial receptors at IAAAP are provided in Table 6-1a. NOAEL- based CCs for terrestrial receptors are also calculated in Table 6-1b for constituents with LOAEL based HQs exceeding one, to provide additional information to the risk managers. LOAEL-based CCs in surface water and sediment calculated for the two aquatic receptors at IAAAP are provided in Table 6-2a. NOAEL- based CCs for aquatic receptors are provided in Table 6-2b for constituents with LOAEL based HQs exceeding one. Exposure to soil, surface water or sediment containing COPECs at or below the LOAEL based CCs should not result in unacceptable levels of risk to receptor population. Therefore, the CC values corresponding to LOAEL-based HQs of one were used to estimate COPEC concentrations in soil, surface water and sediment that might pose an ecological concern. The CCs are not meant to be used as clean-up goals, but are rather one line of evidence to be used to evaluate if a site poses a potential risk to ecological receptors. For metals, site-specific background soil criteria are also provided in Table 6-1a, because sometimes the CCs are less than background concentrations. The background concentrations are considered representative of natural conditions in areas unaffected by the IAAAP.

These four main lines of evidence were used in a weight of evidence approach to evaluate ecological risks to the terrestrial and aquatic ecosystems at the IAAAP. In aggregate, the line-of-evidence approach provided a means of evaluating which receptors or communities are most sensitive to the site COPECs, and which COPECs are of greatest ecological concern. Where key COPECs within an ecosystem at the IAAAP appeared to pose a potential ecological risk to many ecological receptors, the spatial distribution of the contamination in relation to HQ/CC exceedances was assessed to identify potential problem areas within the ecosystem.

General Risk Characterization Approach – Terrestrial Environment

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for three specific ecological receptors including the white-footed mouse, the short-tailed shrew and the Indiana Bat by AOC. In addition, soil concentrations that are equivalent to a LOAEL-based or NOAEL-based HQ of one, called CCs were calculated for each receptor. The HQ and related CC line of evidence is the only line of evidence available to evaluate the potential ecological risks for the terrestrial environment. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

For two of the main COPECs found at most of the AOCs, RDX and lead, the human health RGs are lower than the corresponding ecological CCs. For these COPECs, protection of human health is likely to drive remediation rather than the ecological risk. In the case of TNT, which is a main COPEC at a number of the AOCs where remediation has already occurred to human health standards, it still needs to be verified that the ecological risks are protected too. This is because the ecological based CCs for TNT for the Indiana bat are lower than the human health RG for TNT. As noted previously, an example evaluation has been performed using line 5A/5B data. In the case of inorganic analytes, if the concentration of the inorganic COPEC (i.e., a metal) did not exceed its background concentration, even though it was associated with a LOAEL-based CC exceedance, it was not considered to pose an ecological concern. For such inorganic constituents, the background concentration is the default LOAEL-based CC. The appropriate CCs for each constituent are presented (shaded) in Table 6-1a.

General Risk Characterization Approach – Aquatic Environment

Several lines of evidence were available for evaluation of the aquatic environment. For certain receptors, only HQs were evaluated (e.g., bat species), because other lines of evidence are not practical to collect (e.g., tissue data). For the other lines of evidence collected for receptors, the detailed discussions on the effects assessment provided in Section 4 of this BERA are used to make an evaluation of the risk to each receptor. The effects-based lines of evidence and the HQ lines of evidence both have associated limitations. Where both lines of evidence are available for a receptor, they are used in combination as a weight of evidence to determine if there is a potential ecological risk to a receptor.

HQ values were estimated for many COPECs in this BERA. Solely to help focus the discussion, the BERA generally discusses HQ values from the perspective of overall magnitude. Designation of risks as low, medium, or high cannot be made based on HQ values alone. Such designation, if attempted, should be a result of a risk management decision that considers all lines of evidence. It is more helpful, in the case of the soil AOCs, to be aware of the spatial distribution of those locations where the CCs are exceeded. This gives a more definitive indication of whether remedial efforts might be needed and if so, where these efforts should be focused, rather than an impression of a particular level of risk to a population over the entire AOC. For the aquatic environment, the direct lines of evidence should be considered in combination with the HQ values. Results of the risk characterization are summarized below, by watershed. A summary of the risk descriptions for the terrestrial environment and the aquatic environments are provided separately

8.1 LONG CREEK

Risk Descriptions for the Terrestrial Environment

Soil AOCs within the Long Creek Watershed not slated for remediation based on human health are Fly Ash Landfill (IAAP-027/R19), Construction Debris landfill (IAAP-028/R20), Building 600-86 Septic System (IAAP-038/R26), Line 3A Pond (IAAP-041/R29), and Fly Ash Disposal Area (IAAP-043/R30). The table below provides an overview of the COPECs that had exceedances of their LOAEL-based CCs at individual AOCs.

COPECs Exceeding LOAEL-Based CCs, by AOC within Long Creek Watershed

AOCs	Constituents
IAAP-027/R19	Arsenic (1), Selenium (1)
IAAP-028/R20	1,3-Dinitrobenzene (1)
IAAP-038/R26	Mercury (3)
IAAP-041/R29	Cobalt (1)
IAAP/043R30	Mercury (1)

Note: Number in parenthesis refers to the number of sample locations within the AOC exceeding LOAEL-based CCs. IAAP-041/R29 also drains to the Skunk River watershed and is evaluated for that watershed too.

Very few COPECs exceed their LOAEL-based CCs in the terrestrial environment, and there is no one COPEC that stands out as an ecological risk driver at most of the AOCs. The number of exceedances of the LOAEL-based CC for a given COPECs is usually no more than one, which would indicate the extent of COPEC concentrations above the LOAEL-based CC is very limited. At most of these AOCs, the CC exceedances are isolated and localized. Sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding CCs. Fate and transport evaluations for most of the AOCs (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs. Also, primary habitat for terrestrial receptors exists outside most of the AOCs.

For all COPECs with the exception of 1,3-DNB and TNT (for Indiana bat), the toxicity endpoint that was used to estimate the risk associated with each of the COPECs listed above was reduction in offspring numbers or growth. For these reproductive effects to have an ecological impact on the mouse and the shrew, the COPEC concentrations would have to be above a level of concern (i.e., LOAEL-based CC) in a large area of the site. However, this does not occur at any of the AOCs. For the Indiana bat, the goal is to protect individual Indiana bats because of their special status. Therefore the concept of protecting the populations rather than individuals does not apply. For the specific case of TNT exposure, the toxicity endpoint selected was hematological changes in the blood (i.e., anemia, and lowered hemoglobin levels). Whether these sublethal effects would have a toxic effect on individual bats is not known. However, the method used to estimate when these sublethal type effects might occur, is very conservative in nature, based on the statistical methods used to derive the TRV. The TRV value for TNT is many orders of magnitude below a dose that is estimated to cause reproductive effect, or cause lethal effects to the Indiana bat. In addition, the Indiana bat TNT TRV is ten times lower than the NOAEL for hematological changes. The NOAEL has been used as the basis of the TRV for the other analytes, but an exception was made for the bat, because of its special status, and the additional level of analysis that has been performed of the toxicology data by USACHPPM.

Although LOAEL-based HQ values exceed one for some COPECs, these might be due to the conservative nature of the models used to estimate the ecological risks. Based on the observations that spatial distribution of the COPECs is limited, that there is no evidence of contaminant migration from these AOCs, and that the primary habitat for the receptors exists outside the AOCs, it is not expected that the white-footed mouse or the short-tailed shrew community will be impacted.

In the case of the Indiana bat, no NOAEL-based HQs exceeded at the AOCs evaluated that have not been previously remediated, with the exception of Building 600-86 Septic System (IAAP-038/R26). At this AOC, the NOAEL-based HQ for mercury exceeded one at 84, and the LOAEL-based HQ exceeded one for mercury at 17. Considering that the LOAEL-based HQ for the Indiana bat exceeds one, it is possible that individual bats may be harmed due to the level of mercury found at the site. However, risk associated with mercury may be overestimated by the assumption used to predict uptake of mercury into the insects that the Indiana bat feeds upon. Based on data from SVDA where tissue concentrations of mercury were measured in insects, a BAF was estimated so that a sensitivity analysis could be performed. Using this alternate BAF estimate for flying insects, the HQs for the bat would be less than one. Based on this additional level of analysis, the mercury at this site would unlikely pose a health concern to the Indiana bat.

Risk Descriptions for the Aquatic Environment

The results of the ecological evaluation for Long Creek are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, the two lines of evidence are used in combination as a weight of evidence to determine if there is a potential ecological risk to a receptor.

To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated including direct observations of the fish (i.e., DELT analysis), tissue analysis of a similar darter species for specific COPECs, and estimation of HQs using two different methods. Using the water exposure method, HQs for barium and silver exceeded one, at 31 and 12, respectively. Of the modeled tissue concentrations, cadmium, copper, and selenium in the Long Creek watershed resulted in HQs equal to or exceeding one, at 1, 5, and 2, respectively. Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values might be artifacts of the conservative nature of the models used to estimate the ecological risks. For explosives and mercury, where fish tissue were collected for analysis, these analytes were not detected in fish samples collected from Long Creek. In addition, individual johnny and fantail darters examined did not show signs of stress. Based on these observations, adverse effects might not occur to orangethroat darters in the Long Creek watershed. Based on the weight-of-evidence for the two lines of evidence evaluated, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals (barium and silver), but this was not apparent based on the results of the field observations (DELT). The DELT is not designed to detect very toxic effects to fish that are not readily apparent, and so there are limitations with this line of evidence.

The RBP was performed to provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected within the aquatic habitat. The RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but it is unlikely to detect toxic effects on individual benthic species. Results indicated that locations LC2 and LCT1 are considered unimpaired and benthic community structure is not exhibiting ecological stress, while stations LCT2 and LCT3 were rated as slightly impaired, generally because the tributaries had few EPT taxa. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. It may be that other land-use impacts such as farming, noted to have impacted the reference station (refer to Section 4), have altered the habitat enough to change the community composition. Also, the tributaries to the Long Creek generally are very small streams, which could be dry during part of the year. Such ephemeral stream habitat will not accommodate as wide a range of taxa as a perennial stream habitat. Based on the results of the RBP, the benthic invertebrate community within Long Creek did not appear to be effected by IAAAP facility operations. However, the RBP is not a definitive analysis, and thus has its own inherent limitations that were discussed above.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. HQs exceeded one for BEHP, copper, and manganese. Such HQ exceedances are not necessarily an indication that adverse effects are actually taking place. The algae HQs are likely a weak line of evidence given the conservatism of the screening values used to perform this assessment.

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs that have the potential to bioaccumulate in fish tissue might pose an ecological risk to this feeding guild. Barium was the only LOAEL-based HQ exceeding one, at nine. However, this result might be an over estimation of the actual risk based on the conservative nature of the exposure model and TRV used to develop the HQ. Barium should not cause a concern to a piscivore, as barium is not known to classically bioaccumulate in fish tissue. Also barium is generally a nontoxic metal unless it is present in a water-soluble form which makes it more bioavailable. In many toxicity studies used to develop barium TRVs, more water-soluble forms of barium are used than what would be found in the normal environment. However, the barium that is contained in fish tissue is not water soluble, but rather bound in the tissues as an organo-metallic complex of soft tissues, or incorporated into the mineral structure of the bone. Also, empirical data for fish BCF value for barium is not available. EPA (1999) lists a value of 633 based on the arithmetic mean of the values for 14 inorganics with available empirical data, which was used in this BERA. Therefore, there is considerable uncertainty associated with the fish BCF value used in the dose modeling. For these reasons, the barium LOAEL-based HQ has a low level of confidence associated with it and the belted kingfisher or other piscivores may not be affected by contamination in the Long Creek watershed even considering this exceedance.

The risk to the Indiana bat was evaluated because it is known to be present at the IAAAP, and it is listed as a special status species. Therefore, it was considered important to protect even individuals within the population. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Long Creek aquatic environment.

Based on the multiple lines of evidence, the fish populations (including orangethroat darters), and the benthic invertebrate populations in Long Creek do not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations on the Long Creek watershed). The benthic community structure endpoint showed that Long Creek is essentially unimpaired or slightly impaired and does not show adverse effects. Also, individual darter samples examined did not show any signs of stress, and their presence indicates that darter species are reproducing in the stream. However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so, there is possibly adverse effects that are occurring due to IAAAP operations that could not be detected.

In the case of the Indiana bat, exceedances of LOAEL-based CC (i.e., HQs >1) were detected in the Long Creek aquatic environment. In addition to the bat, the evaluation of algea in Long Creek indicated the potential for effects on this community by specific metals. However, the line of evidence used was more of a screening level assessment and has a large degree of uncertainty associated with it.

8.2 SKUNK RIVER

Risk Descriptions for the Terrestrial Environment

Only two AOCs are not currently slated for remediation in the Skunk River watershed to achieve human health-based RGs. These are, Line 3A Sewage Treatment Plant (IAAP-029/R21) and Line 3A Pond (IAAP-041/R29). Line 3A Pond has been discussed as part of the Ling Creek watershed.

Neither NOAEL nor LOAEL-based HQs equaled or exceeded one for any COPECs for the Indiana bat. Therefore risks to the Indiana bat would not be expected in the upland areas of the terrestrial AOCs.

Only one COPEC (i.e., either silver or cobalt), at each of the two AOCs, not slated for remediation based on human health, exceeded its LOAEL-based CCs in the terrestrial environment based on small mammal risk estimates. The spatial distribution of LOAEL-based CC exeedances were very limited at both AOCs for the mouse or the shrew, which would indicate that the extent of COPEC concentrations above the LOAEL-based CC is very limited and would not be expected to pose an ecological risk to these receptors. Cobalt causes reproductive effects, while silver affects activity patterns in receptors. For reproductive effects or broad effects, such as impact on activity, to have an ecological impact on the mouse and the shrew, the COPEC concentrations would have to be above a level of concern (i.e., LOAEL-based CC) in a large area of the site. However, this does not occur at either AOC, where the CC exceedances are isolated and localized. Sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding CCs. Fate and transport evaluations (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs. In addition, the exceedances are sometimes located next to building structures (refer to Figure 6-6), where the selected receptors (mouse and shrew) would normally be managed for extermination rather than protection. Primary habitat for the receptors exists in the area surrounding most AOCs.

The remediation planned at Line 3A should be protective of ecological risks, because it involves excavation of the top two feet of soil where terrestrial receptors are expected to be exposed. An evaluation of the residual concentrations of COPECs was conducted with data from Line 5A/5B where remediation has occurred to verify that this assumption is valid.

Risk Descriptions for the Aquatic Environment

The results of the ecological evaluation for the tributaries to the Skunk River are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, they are used in combinations as a weight of evidence to determine if there is a potential ecological risk to a receptor.

Orangethroat darters were evaluated by developing HQs following two methods. Hazard quotients for the water exposure method had only the HQ for barium exceeding, at 19. Selenium is the only COPEC for which a HQ based on modeled fish tissue concentration exceeded one, at 4. The estimated HQs might be artifacts of the conservative nature of the models used to estimate the ecological risks, because darter samples were not collected from tributaries to the Skunk River. Therefore, there is still uncertainty associated with whether darter populations are at risk in the Skunk River watershed that may need to be verified in the future.

The RBP was performed to provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected with the aquatic habitat. It is important to consider the habitat characteristics at each sample station when performing the RBP, as there are many environmental factors (e.g., riparian vegetation and stream characteristics), other than contaminant concentrations, that can effect the benthic community composition at a given location. When performing the RBP at IAAAP, the sample locations were selected to first evaluate potential source areas of contamination to the creek, and secondly, sample stations were selected so that they would be similar in characteristics to one another. There are certain limitations that cannot be overcome, such as the presence of some stations at locations that are not ideally matched to the reference station. In these cases, a qualitative determination has to be made concerning if there are environmental factors other than chemical concentrations that would likely effect the benthic community composition. Keeping this in mind, the information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but unlikely would detect toxic effects on individual benthic species.

The benthic community in two small tributaries of the Skunk River in the southwest part of IAAAP was compared to the Long Creek reference station. The two tributaries subjected to the aquatic risk assessment using RBP were SRT1, rated as unimpaired, and SRT2, rated as slightly impaired. Based on the results of the RBP, the benthic invertebrate community within the Skunk River did not appear to be effected by IAAAP facility operations. However, the RBP is not a definitive analysis, and thus has its own inherent limitations discussed above that need to be considered.

Aquatic algae were selected as the representative group of plant species. None of the HQs exceeded one; thus, there is no risk predicted to aquatic algae due to COPECs in the Skunk River.

For belted kingfisher, only barium had a LOAEL-based HQ greater than one, at six. However, this result is likely an over estimation of the actual risk based on the conservative nature of the exposure model and TRV used to develop the HQ. The uncertainty surrounding the barium risk estimates has previously been discussed. The barium LOAEL-based HQ has a low level of confidence associated with it and the belted kingfisher or other piscivores are not likely to be affected by contamination in the Skunk River watershed.

Aluminum, barium, selenium, and silver had both NOAEL- and LOAEL-based HQs greater than one for the Indiana bat. Although there are LOAEL-based HQ exceedances for some COPECs, these might be due to the conservative nature of the models used to estimate the ecological risks for these analytes. The Indiana bat was assumed to ingest all of the insects it feeds upon from the tributaries to the Skunk River, which is not realistic. Rather the bat could also consume insects from areas outside the IAAAP. Furthermore, the diet of Indiana bat also consists of insects from terrestrial habitats. The modeled insect COPEC concentrations appear to be much higher than what would be expected if insects had been collected and analyzed. In addition, aluminum may not be bioavailable. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Skunk River aquatic environment. However, for purposes of the BERA, some of the limitations of the HQ estimates have been evaluated (refer to Section 6.3.2.5), as a means of informing the risk manager about the limitations of these risk estimates.

8.3 BRUSH CREEK

Risk Descriptions for the Terrestrial Environment

The AOCs evaluated for terrestrial receptors in the Brush Creek watershed are Line 7 (IAAP-008/R08) and Sewage Treatment Plant/Sludge Drying Beds (IAAP-026/R18). The table below provides an overview of the COPECs that had exceedances of their LOAEL-based CCs at individual AOCs.

COPECs Exceeding LOAEL-Based CCs, by AOC within Brush Creek Watershed

AOCs	Constituents
IAAP-008/R08	Copper (1), Dieldrin (1), Mercury (4), PCBs (1), Thallium (1)
IAAP-026/R18	Mercury (4), Silver (4)

Note: Number in parenthesis refers to the number of sample locations within the AOC exceeding LOAEL-based CCs.

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for white-footed mouse, short-tailed shrew, and Indiana bat by AOC. In addition, soil concentrations that are equivalent to a LOAEL-based HQ of one, called LOAEL-based CCs were calculated for each receptor. The HQ and related LOAEL-based CC line of evidence is the only line of evidence available to evaluate the potential ecological risks for the terrestrial environment. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was considered to be a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

Of the nine AOCs located in the watershed, remediation to protect human health is not slated to occur at two AOCs, Line 7 and the Sewage Treatment Plant/Sludge Drying Beds. The remediation that is planned at the other AOCs should be protective of ecological risks because it involves excavation of the top two feet of soil at the AOCs where terrestrial receptors are expected to be exposed.

COPEC (copper, dieldrin, mercury, PCBs, silver, and thallium) concentrations exceed their corresponding LOAEL-based CCs at multiple locations. These exceedances are localized (see Figures 6-7 and 6-8), next to buildings and structures, and are not present throughout these AOCs. Sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding CCs. Fate and transport evaluations (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs. At the sludge drying Beds, structural features may preclude receptor exposure to contamination and further contaminant migration away from the AOC.

Mercury, copper, PCBs, and thallium produces effects on reproductive systems of wildlife receptors. Dieldrin causes behavioral effects such as decreased avoidance of predators. For these effects to have a community-wide impact on the white-footed mouse and the short-tailed shrew, the COPEC concentrations would need to be greater than their corresponding LOAEL-based CCs in a large area. However, the exceedances are localized, and therefore, impact on the white-footed mouse or the short-tailed shrew community is not expected.

For the Indiana Bat, NOAEL based HQs exceeded one for mercury and thallium at Line 7 and for mercury and silver at the Sewage Treatment Plant/Sludge Drying Beds. Also, LOAEL-based HQ for mercury was one at R018. Considering that the LOAEL-based HQ for the Indiana bat equals one, it is possible that individual bats may be harmed due to the level of thallium at Line 7. However, the risk associated with thallium and mercury may be overestimated. Revanasiddappa and Kumar (2002) notes that Atomic Adsorption Spectroscopy (method used in the current study) often lacks sensitivity and displays matrix effects for thallium measurements. The matrix effects can lead to false positive detection of thallium, meaning it is detected even though it is really not present in the sample. For this reason, there is uncertainty associated with the thallium results. Based on data from another similar site (i.e., SVDA), where actual tissue concentrations of mercury were measured in insects, a BAF was estimated so that a sensitivity analysis could be performed. Using this alternate BAF estimates for flying insects, the HQs for the bat would be less than one. Also, the uncertainty associated with the use of toxicity values that were developed based on methyl mercury for use to develop HQs for total mercury has been discussed previously. Based on this additional level of analysis, the mercury at this site would unlikely pose a health concern to the Indiana bat.

Risk Descriptions for the Aquatic Environment

The results of the ecological evaluation for Brush Creek are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, the two lines of evidence are used in a combination as a weight of evidence to determine if there is a potential ecological risk to a receptor.

Mercury and dieldrin were the only biomagnifying COPECs detected in darter tissue. A conservative TRV for mercury was set at 1.06 mg/kg, still approximately four times the highest concentration in the Brush Creek fantail darter. Of the modeled tissue concentrations, HQs for cadmium, copper, mercury, and selenium exceeded one (Table J-27). For the water exposure method, barium and silver HQs exceeded one, both at 26. Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values are likely to be artifacts of the conservative nature of the models used to estimate the ecological risks. Within Brush Creek, orangethroat darters were captured during the field investigation, which was an important finding as it indicates this species is present, and likely reproducing in the creek aquatic environment. Individual orangethroat darters that were examined did not show signs of stress, as indicated by DELTs. Based on these observations, adverse effects are not expected to orangethroat darters in the Brush Creek watershed. However, it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals (cadmium, copper, mercury, selenium, and silver), but this was not apparent based on the results of the field observations (DELT).

Benthic sampling stations along Brush Creek were rated as slightly impaired. However, most stations, including the stations that were rated as slightly impaired, scored better than the reference station for several metrics. Although community structure at a slightly impaired station is less than expected, this does not necessarily indicate that the station has been impacted by contaminants. Biological condition scores suggest the slightly degraded condition is more the result of agricultural practices than IAAAP operations. The conditions at IAAAP are considered to pose little risk to the aquatic biological community in the Brush Creek watershed. However, the RBP is not a definitive analysis, and thus has its own inherent limitations.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. The aquatic algae HQs present some uncertainty as to whether or not there is a problem, and are likely a weak line of evidence given the conservatism of the screening values.

Barium was the only constituent with a LOAEL-based HQ above one, at eight, for belted kingfisher. However, this LOAEL exceedance in itself does not likely translate to a concern for the belted kingfisher or similar piscivore population as the result might be an over estimation of the actual risk based on the conservative nature of the models used to estimate the ecological risks. The uncertainty surrounding the barium risk estimates has been discussed in previous sections.

Aluminum, arsenic, barium, mercury, selenium, silver, and thallium had LOAEL-based HQs exceeding one for the Indiana bat. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Brush Creek aquatic environment. However, the LOAEL-based HQ values are likely artifacts of the conservative nature of the models used to estimate the ecological risks for these analytes. The Indiana bat was assumed to ingest all of the insects it feeds upon from Brush Creek and its tributaries, which is not realistic. Rather the bat could also consume insects from areas outside the IAAAP. Furthermore, diet of Indiana bat also consists of insects from terrestrial habitats. The modeled insect COPEC concentrations appear to be much higher than what would be expected if insects had been collected and analyzed. In addition, aluminum may not be bioavailable. Also, there is uncertainty associated with the thallium results.

Based on the multiple lines of evidence, the fish and benthic population in the Brush Creek watershed do not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations on the Brush Creek watershed). The benthic community structure endpoint showed that Brush Creek watershed is essentially slightly impaired and does not show adverse effects. Although the HQ line of evidence indicated certain COPECs may pose an ecological concern, individual darter samples examined did not show any signs of stress, and their presence indicates that darter species are reproducing in the stream. However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so there is possibly toxic effects that are occurring due to IAAAP operations that could not be detected.

8.4 SPRING CREEK

Risk Descriptions for the Terrestrial Environment

Of the two AOCs located in the watershed, remediation to protect human health is slated to occur at the Roundhouse Transformer Storage Area. The AOC evaluated for terrestrial receptors in the Spring Creek watershed is the Contaminated Waste Processor (IAAP-024/R16). The remediation planned at the Roundhouse Transformer Storage Area should be protective of ecological risks because it involves excavation of the top two feet of soil at the AOCs where terrestrial receptors are expected to be exposed. An evaluation of the residual TNT concentrations of COPECs has been conducted for Line 5A/5B, where remediation has occurred, to verify that this assumption is valid.

COPEC concentrations exceed their corresponding LOAEL-based CCs at only one location. This exceedance is localized and is not present throughout the AOC. Sampling locations around the CC exceedance also showed COPEC concentrations that did not exceed their corresponding CCs. LOAEL or NOAEL-based HQs do not exceed or equal one for any COPECs for Indiana bat. Although LOAEL-based HQ values exceed one for HMX for white-footed mouse and short-tailed shrew, this is likely due to the conservative nature of the models used to estimate the ecological risks. Based on the observations that spatial distribution of HMX is limited, that there is no evidence of contaminant migration from these AOCs, that potential exposure to receptors are limited, it is not expected that the terrestrial receptor community will be impacted.

Risk Descriptions for the Aquatic Environment

The results of the ecological evaluation for Spring Creek are provided below by receptor. Where both effects-based lines of evidence and the HQ lines of evidence are available for a receptor, the two lines of evidence are used in combination to determine if there is a potential ecological risk to a receptor or a receptor community.

Several lines of evidence were available to evaluate risks to orangethroat darters. Of the modeled tissue concentrations, copper and selenium had HQs exceeding one, at 10 and 2, respectively. For the water exposure of fish, barium, copper, and silver HQs exceeded one. Although HQ values estimated from water-based and tissue-based TRVs exceed one for several COPECs, these values may have been the result of overestimation of risks due to the conservative nature of the models. Mercury, dieldrin, and heptachlor epoxide were detected in johnny and fantail darter collected from Spring Creek. However, the tissue concentrations were much lower than corresponding TRVs. Within Spring Creek, orangethroat darters were captured during the field investigation, which was an important finding as it indicates this species is present, and likely reproducing in the creek aquatic environment. Individual orangethroat darters that were examined did not show signs of stress, as indicated by DELTs. Based on these observations, adverse effects are not expected to orangethroat darters in the Spring Creek watershed.

Some of the benthic sampling stations in the Spring Creek watershed are rated as unimpaired in comparison to the reference site. Further downstream, stations SC4, SC5 and SC6 were rated as slightly impaired. However, the stations that were rated as slightly impaired scored better than the reference station on some metrics. Because most of the watershed is intensively cultivated, the reference station itself may represent a slightly impaired condition. The impairment exhibited at stations where the BCS suggested a slightly degraded condition is considered to be more the result of agricultural practices at the site than IAAAP operations.

Aquatic algae HQs exceeding one were calculated for copper and manganese at 4 and 2, respectively. These HQs present some uncertainty as to whether or not there is a problem, and is likely a weak line of evidence given the conservatism of the screening values.

Barium and 4,4'-DDT were the only constituents with LOAEL-based HQs above one, at 8 and 130, respectively, for belted kingfisher. Such high LOAEL-based HQs might be an overestimation of risks due to the conservative nature of the models. The kingfisher was assumed to consume all fish from within the watershed; while home ranges for belted kingfisher may include areas outside the plant boundary. Uncertainties related to barium toxicity have been discussed. 4,4'-DDT can bioaccumulate from water, but it was detected in only one of 11 samples at a concentration of 0.0059 μg/L, slightly exceeding the detection limit. Eisler (1987) states that reproductive effects on some birds were noted at dietary dose from mercury ranging from 50 to 100 ug/kg. Mercury concentrations in fish tissue exceeded 100 ug/kg in two of six samples collected from Spring Creek. However, the modeled NOAEL and LOAEL based HQs to belted kingfisher, which was assumed to consume 100 percent of its prey from Spring Creek, were both less than one.

Aluminum, arsenic, barium, copper, selenium, and silver had LOAEL-based HQs greater than one for the Indiana bat. The highest value was for aluminum at 950. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the Spring Creek aquatic environment. Some of the limitations of the HQ estimates have been evaluated as a means of informing the risk manager about the limitations of these risk estimates. To more clearly identify whether conditions at the IAAP pose a health concern to the bat, some of these limitations may need to be further evaluated.

Based on the multiple lines of evidence, the fish populations (including orangethroat darters), and the benthic invertebrate populations in the Spring Creek watershed does not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations on the Spring Creek watershed). The benthic community structure endpoint showed that Spring Creek watershed is essentially unimpaired or slightly impaired and does not show adverse effects. Also, individual darter samples examined did not show any signs of stress, and their presence indicates that darter species are reproducing in the stream. However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so there is possibly adverse effects that are occurring due to IAAAP operations that could not be detected. Evaluation of algae indicated the potential for effects by specific metals. Although the HQ line of evidence indicated certain COPECs may pose a ecological concern, this is likely more due to the conservatism of the modeling, and is considered a weaker line of evidence than the effects based analyses.

8.5 OVERALL CONCLUSIONS

Within the four watersheds that were evaluated at IAAAP, separate ecological evaluations were performed for the terrestrial and the aquatic environment. The terrestrial evaluations looked not only at the potential for ecological risks to be present at specific AOCs, but also evaluated whether there was any apparent transport of contamination from a particular AOC to the creek or river within the watershed. The AOCs were evaluated by watershed to be able to identify any contaminant inputs to a given a creek or river within a watershed. In general, the contamination in the terrestrial environment of each watershed was mainly found around buildings and did not appear to be migrating away from the specific AOCs to the creeks or rivers at IAAAP. It should be noted that a number of AOCs have already been remediated, and although ecological risks have been assessed for each of these AOCs based on the data available prior to remediation, the assumption has been made that these AOCs, that have been remediated, do not present an ecological risk any longer. For this reason, the AOCs that have been remediated were not evaluated in detail within this BERA, but a representative AOC (IAAP-006/R06) was further evaluated using the post-remediation data to verify that this assumption was appropriate.

To evaluate the risks to terrestrial receptors, NOAEL- and LOAEL-based HQs were calculated for three ecological receptors including the white-footed mouse, the short-tailed shrew, and Indiana bat by AOC. In addition, soil concentrations that are equivalent to a NOAEL-based or LOAEL-based HQ of one, called NOAEL-based or LOAEL-based CCs, were calculated for each receptor. If soil concentrations of a COPEC equaled or exceeded a LOAEL-based CC of one, then there was a potential ecological concern associated with that COPEC. However, to better evaluate the significance of these LOAEL-based CC exceedances, the spatial distribution of the exceedances was evaluated in relation to the available habitat and population dynamics of the receptor.

These LOAEL-based CCs were compared to human health PRGs available for IAAAP and which are to be utilized in soil removal activities at several AOCs (Table 6-1a). The major risk-driving chemicals for human health (i.e., those with high concentrations throughout the facility) include TNT, RDX, and lead, for which the human-health-based PRGs or RGs are lower than the ecological LOAEL-based CCs, with the exception of TNT. In the case of TNT, the ecological-based CC is lower than the human health RG for TNT, but this is based on the assumptions used to model uptake of TNT for the Indiana bat. These assumptions are likely very conservative. In addition, there were no AOCs that have not been remediated yet, where TNT concentrations posed a risk to the Indiana bat. Therefore it is likely that RDX and lead, will drive remediation at these remaining sites. For RDX and lead, the human health based PRG or RG would be more restrictive than the ecological based CC, and therefore remediation to human health based goals should be protective of ecological risks. Therefore, the PRGs or RGs are likely appropriate values on which to base vertical and horizontal removal boundaries for most areas (i.e. ecological issues are not indicated to be driving the remediation efforts). For many of the metal COPECs where LOAEL-based HQs exceed one, background concentrations also are higher than the LOAEL-based CCs; therefore cleanup would not be necessary below background levels.

For the AOCs not slated for cleanup based on protection of human health, concentrations of 11 COPECs exceeded LOAEL-based CCs primarily based on the short-tailed shrew and sometimes the white-footed mouse. Altogether, only a total of 28 individual sample locations exceeded LOAEL-based CCs among the nine AOCs where human-health based remediation is not currently planned. Very few COPECs exceed their LOAEL-based CCs in the terrestrial environment, and there is no one COPEC that stands out as an ecological risk driver across the AOCs. Most AOCs have exceedances for only one or two COPECs at a few (three or less) locations, which would indicate the extent of COPEC concentrations above the LOAEL-based CC is very limited. The greatest exceedances are at R08 and R18, with eight locations. Figures 6-1 through 6-9 illustrate that these exceedances are isolated and many in very close proximity to buildings and other structures, indicating the contamination is localized. At most of these AOCs, sampling locations around the CC exceedances also showed COPEC concentrations that did not exceed their corresponding LOAEL-based CCs. Fate and transport evaluations for most of the AOCs (detailed in Appendix F) indicated little or no evidence of contaminant migration from these AOCs.

The toxicity endpoint that was used to estimate the risk associated with most of the COPECs (but not TNT for Indiana bat) was reduction in offspring numbers or growth. For these reproductive effects to have an ecological impact on the mouse and the shrew, the COPEC concentrations would have to be above a level of concern (i.e., LOAEL-based CC) in a large area of the site. However, this does not occur at any of the AOCs, and so effects on the population of small mammals (e.g., mouse or shrew) would not be expected at any of the individual AOCs. In addition, primary habitat for the receptors exists in the area surrounding most AOCs. Based on the observations that spatial distribution of the COPECs is limited, that there is no evidence of contaminant migration from these AOCs, and that primary habitat for the receptors exists outside the AOCs, it is conceivable that individual terrestrial receptors exposed to COPECs at these 28 locations above the LOAEL-based CCs could be adversely impacted.

In the case of the Indiana bat, the goal is to protect the individual bat because of its special status. NOAEL-based HQs exceeded one at three of the nine AOCs evaluated that have not been previously remediated, within the four watersheds. For this reason, potential risks to the Indiana bat are very localized in nature in the terrestrial environment. Considering that the LOAEL-based HQ for the Indiana bat equals or exceeds one, it is possible that individual bats may be harmed at some AOCs. However, as noted previously, the risks may be overestimated by the assumption used to predict uptake of COPECs into the insects that the Indiana bat feeds upon.

It is anticipated that remediation to address human health at several AOCs would cover areas where ecological risks could exist. In the terrestrial environment, there are only isolated areas where potential ecological risks might occur, and these are not expected to pose a concern to the populations of small mammals. It is likely that these isolated locations would be remediated as the site is remediated to address human health risks. The exact dimensions of the areas to be remediated at these AOCs are not known. Typically, post-excavation confirmatory samples are collected to verify that remediation goals have been achieved. Once human–health based remediation has been completed, the AOCs should be evaluated to determine if all areas where ecological-based risks exist have also been cleaned up. For the AOCs slated for remediation, ecological risk-based LOAEL-based CCs exceed measured concentrations for several COPECs. The locations for such exceedances are listed by COPEC in Tables J-37 through J-55 in Appendix J. This information may aid in determining whether further remediation is required at the AOCs slated for human-health based remediation or where human-health based remediation has already taken place.

The results of the aquatic environment evaluations are provided below by receptor. For the aquatic environment, a number of lines of evidence were collected for each creek or stream. The lines of evidence included dose modeling to develop HQs and CCs for aquatic wildlife receptors (belted kingfisher and Indiana bat) similar to the assessment performed for the terrestrial environment. In addition, for fish and algae, HQ calculations were made based on comparisons to either modeled fish body burdens or simply comparing to screening benchmarks. In addition, field assessments were conducted to evaluate fish health (i.e., DELT) and the health of the benthic invertebrate community (i.e., RBP). Where both effects-based lines of evidence and the HQ lines of evidence (DELT and RBP) are available for a receptor, the two lines of evidence are used in combinations, as a weight of evidence, to determine if there is a potential ecological risk to a receptor.

The orangethroat darter is a special status species, and thus was selected for evaluation in this BERA. However because of its special status, specimens of this species could not be collected for purposes of tissue analysis. To evaluate ecological risks to the orangethroat darter, three lines of evidence were evaluated for a number streams including direct observations of the fish in the creek (i.e., DELT analysis), tissue analysis of a similar darter species for specific COPECs, and estimation of HQs using two different methods. These lines of evidence are used in combination to evaluate the potential risk to the orangethroat darter.

Based on the lines of evidence evaluated in most streams (but not Skunk River), it is possible that toxic effects may occur to the darter based on the HQ values presented for certain metals. However, no apparent effects were observed based on the results of the field observations (DELT). However, the DELT is not designed to detect toxic effects to fish that are not readily apparent, and so there are limitations with this line of evidence. It is possible that the levels of some metals may have toxic effects on the orangethroat darters in the streams, but this can not be verified based on the lines of evidence that were evaluated. The presence of the orangethroat darter or similar species of darter in most of the streams is a promising sign that the stream habitat can support darter populations.

The RBP was performed to provide an effects-based measurement endpoint on which to base a decision of whether the benthic community was protected within the aquatic habitat. It is important to consider the habitat characteristics at each sample station when performing the RBP, as there are many environmental factors (e.g., riparian vegetation and stream characteristics) other than contaminant concentrations that can effect the benthic community composition at a given location. When performing the RBP at IAAAP, the sample locations were selected to evaluate potential source areas of contamination to the creek, and also, sample stations were selected so that they would be similar in characteristics to one another. There are certain limitations that can not be overcome, such as the presence of some stations at locations that are not ideally matched to the reference station. In these cases, a qualitative determination has to be made to determine if there are environmental factors other than chemical concentrations that would likely effect the benthic community composition. Keeping this in mind, the information provided by the RBP is a semiquantitative analysis that is designed to evaluate apparent changes in benthic community structure, but is unlikely to detect toxic effects on individual benthic species. Results of the RBP indicated that some sample locations were considered unimpaired or slightly impaired. Where the sample location was rated as slightly impaired, it was generally because of low grade habitat rather than any apparent effects related to chemical concentrations of COPECs. Based on the results of the RBP, the benthic invertebrate community within streams at IAAAP did not appear to be effected by IAAAP facility operations. However, the RBP is not a definitive analysis, and thus has its own inherent limitations that have previously been discussed.

Aquatic algae were selected as the representative group of plant species to be evaluated to determine if exposure to surface water COPECs in the water column might be posing a risk to aquatic plants. HQs exceeded one for some phthalate esters, and specific metals in some of the streams (e.g., Long Creek). Such HQ exceedances are not necessarily an indication that adverse effects are actually taking place. The algae HQs are likely a weak line of evidence given the conservatism of the screening values. However, based on this single line of evidence, it can not be determined with any certainty that algae are not being harmed.

The belted kingfisher was selected as the representative piscivore to evaluate if ingestion of COPECs, that have the potential to bioaccumulate in fish tissue, might pose an ecological risk to this feeding guild. Surface water and sediment concentrations at several locations exceeded their corresponding LOAEL-based CCs. These locations are listed in Tables J-56 through J-69 in Appendix J. Some metals were the only COPECs with LOAEL-based CC exceedances and HQ exceeding one. However, these results might be an over estimation of the actual risk, based on the conservative nature of the exposure model and TRV used to develop the HQs. The uncertainty surrounding these risk estimates has previously been discussed. These LOAEL-based HQs have a low level of confidence associated with them and the belted kingfisher or other piscivores are not likely to be affected by contamination in the streams. However, much of the uncertainty surrounding these risk estimates is related to the lack of fish tissue concentrations of COPECs, and as a result the concentration in fish were modeled.

The risk to the Indiana bat was evaluated as an aquatic receptor, because it is known to be present at the IAAAP and utilize the riparian corridor along streams as habitat. Therefore, it was considered important to protect even individuals within the population. The LOAEL-based HQs exceeded one for a number of metals within most of the watersheds. Considering the elevated LOAEL-based HQ values and CC exceedances for a number of the metals, there is the potential that individual Indiana bats may be harmed from exposure to the aquatic environment. However, for purposes of the BERA, some of the HQ estimates have been evaluated as a means of informing the risk manager about the limitations of these risk estimates, and when considering these limitations, indicate that the bat might not be at risk.

In summary, based on the multiple lines of evidence, the fish populations (including orangethroat darters), and the benthic invertebrate populations in the streams evaluated do not appear to be impacted (i.e., direct evidence does not indicate aquatic risks from IAAAP operations).

However, there are limitations with the lines of evidence used to evaluate these aquatic communities, and so, there is possibly adverse effects that are occurring due to IAAAP operations that could not be detected. In the case of the Indiana bat, exceedances of LOAEL-based CCs (i.e., HQs >1) were detected in a number of the streams within the aquatic environment.

In addition, to the bat, the evaluation of algae in some creeks (e.g., Long Creek) indicated the potential for effects on this community by specific metals. However, the line of evidence used was more of a screening level assessment and has a large degree of uncertainty associated with it.

8.6 SPECIAL CONSIDERATIONS

The LOAEL and NOAEL-based HQ exceedances noted for specific receptors within this BERA may be the result of the conservative approach followed throughout this evaluation. More definitive direct lines of evidence could be collected to validate the estimated HQs that are predicted to be greater than one. Some of the limitations of the HQ estimates have been evaluated as a means of informing the risk manager about the limitations of these risk estimates. To more clearly identify whether conditions at the IAAAP pose a health concern to the receptors, some of these limitations could be further evaluated. The site-specific risks could be evaluated in light of the likely remedial solution that will be used to mitigate potential risks, before a decision is made concerning whether additional study is needed.

For example, because of the special status of the Indiana bat, there may be a need for verification of some of the exposure assumptions to address whether individual Indiana bats are truly at risk. These additional levels of assessment could be performed, if deemed necessary, by the risk assessment team (i.e., risk assessor and risk managers). Some of the additional evaluations that could potentially be conducted to put into perspective the HQ exceedances or refine the HQs include:

- Comparison of post-remediation data to CCs---It is anticipated that remediation to address human health at several AOCs would cover areas where ecological risks could exist. Typically, post-excavation confirmatory samples are collected to verify that remediation goals have been achieved and are protective of human health. Post-remediation TNT data from Line 5A/5B have been used as a case example in this BERA to evaluate where residual soil concentrations would also be protective of ecological health. However, this type of evaluation may be conducted for the other AOCs and the other COPECs to verify that this assumption holds for other AOCs where remediation has already been conducted based on human health RGs. In the future, once human–health based remediation has been completed, the AOCs could be evaluated to determine if all areas where ecological-based risks existed have also been cleaned up.
- Additional sampling---One of the major sources of uncertainty in the BERA is the use of literature-derived bioaccumulation factors. Since the data used was not site-specific, it may be required that these bioaccumulation estimates be verified. The need for verification sampling would be made by the risk assessment team (risk assessors and risk managers). Such verification sampling may include collection of terrestrial and aquatic flying insects,

terrestrial invertebrate, terrestrial plants, and other food sources for the selected receptors, as deemed necessary by the risk assessment team.

- Additional fish tissue analysis---Much of the uncertainty surrounding risk estimates for the orangethroat darter and the belted kingfisher is related to the lack of fish tissue concentrations for several COPECs. As a result, concentrations of these COPECs in fish tissue were estimated using models. To decrease the uncertainty associated with these risk estimates, fish tissue data could be collected for the select COPECs that were estimated to pose a potential concern.
- Algal assay---Risk to algae was estimated based on a single line of evidence, which is essentially a screening level evaluation. It can not be determined with any certainty that algae are not being harmed. A more definitive evaluation, such as algal assay, could be conducted, if deemed necessary, by the risk assessment team.

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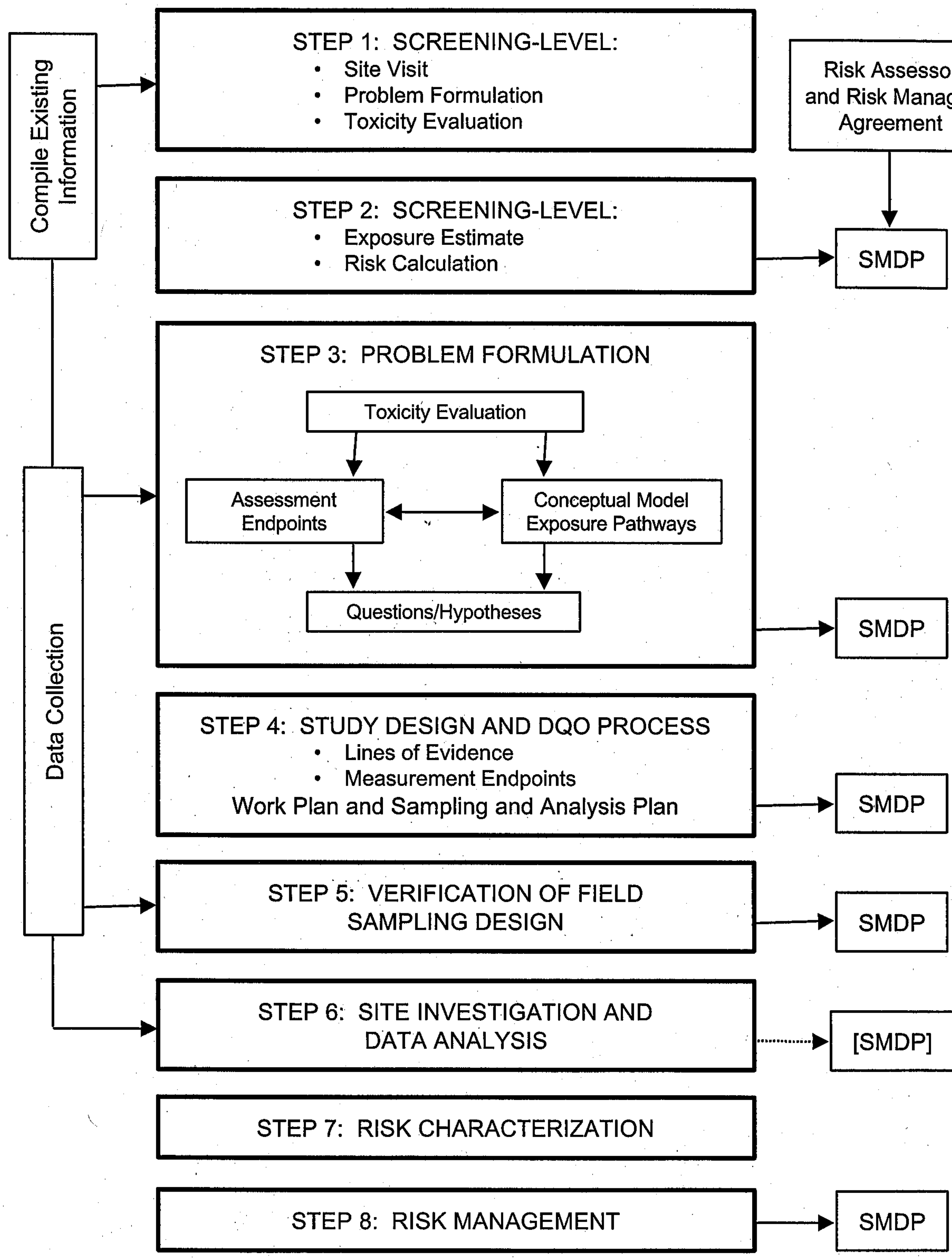
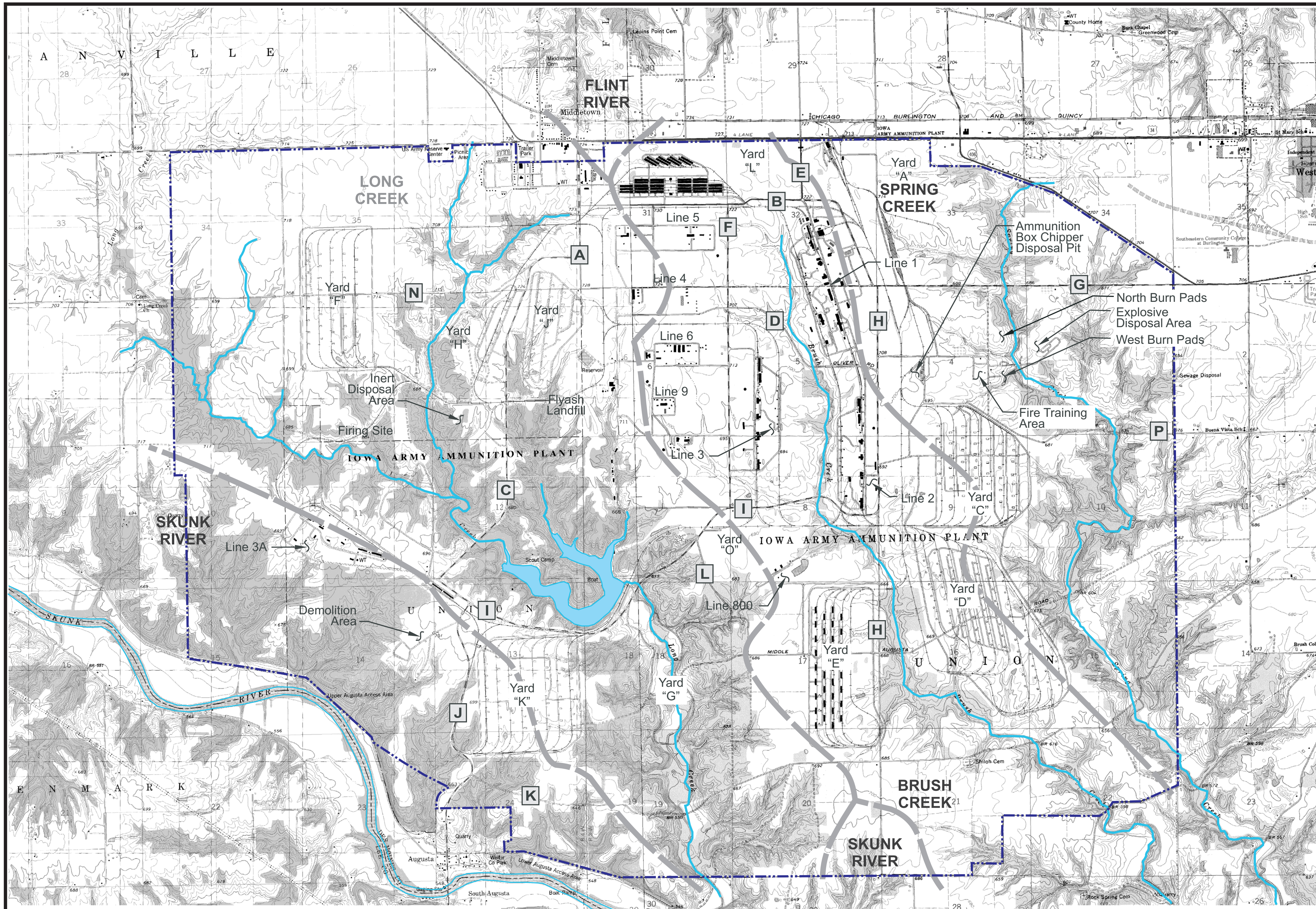
Figure 1-1
Eight-step Ecological Risk Assessment Process for Superfund



SMDP: Scientific/Management Decision Point

Source: USEPA, 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. June 5.



LEGEND:

- A — ROAD NAME
- PLANT PROPERTY BOUNDARY
- DRAINAGE BASIN BOUNDARY
- RIVER / STREAM

Scale 0 2000 4000 6000 8000 Feet

MWH

Figure 1-2

DRAINAGE BASINS AND SITE FEATURES MAP

SUPPLEMENTAL GROUNDWATER RI

IOWA ARMY AMMUNITION PLANT

Middletown, Iowa

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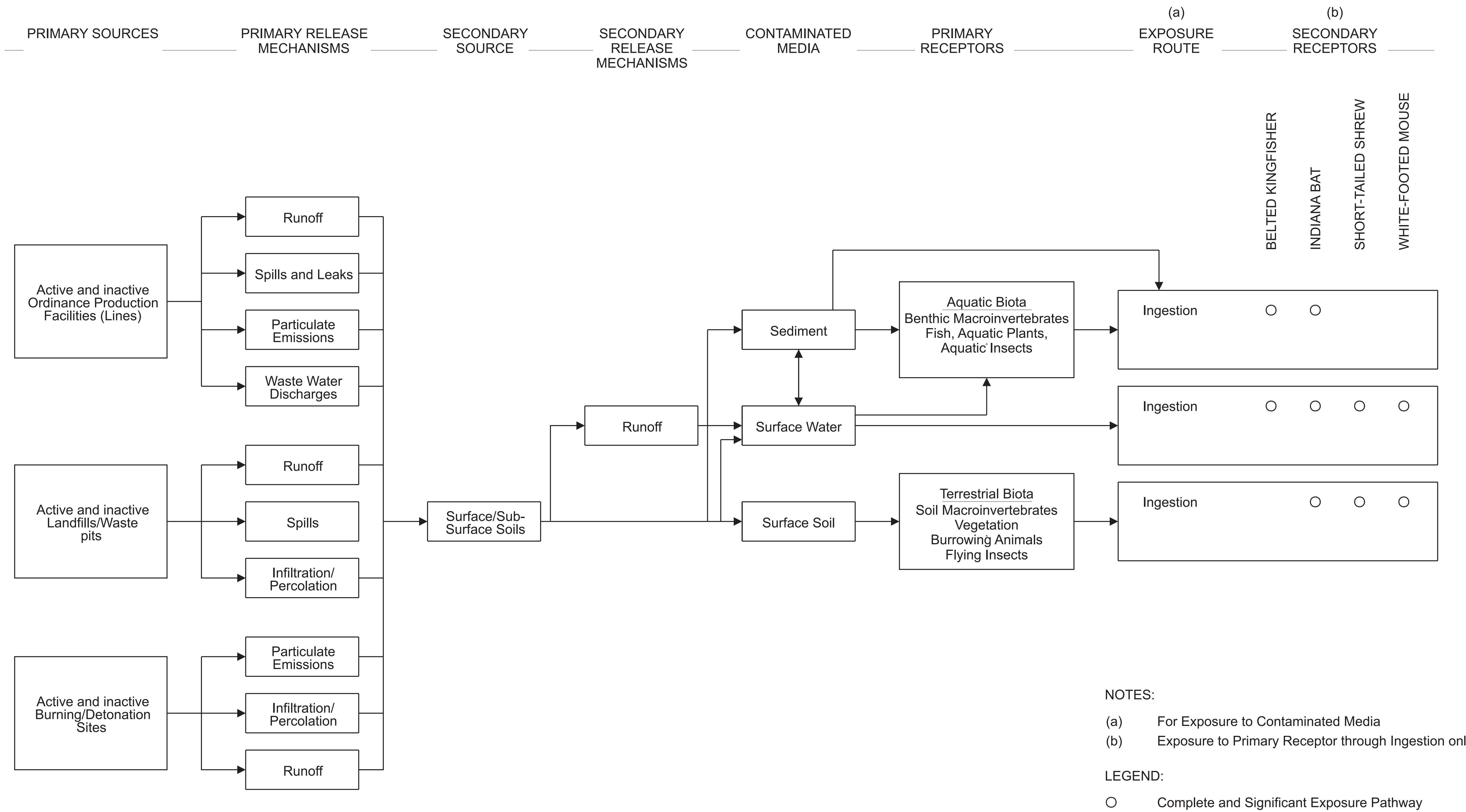

Figure 2-1
CONCEPTUAL SITE MODEL
BASELINE ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

MWH

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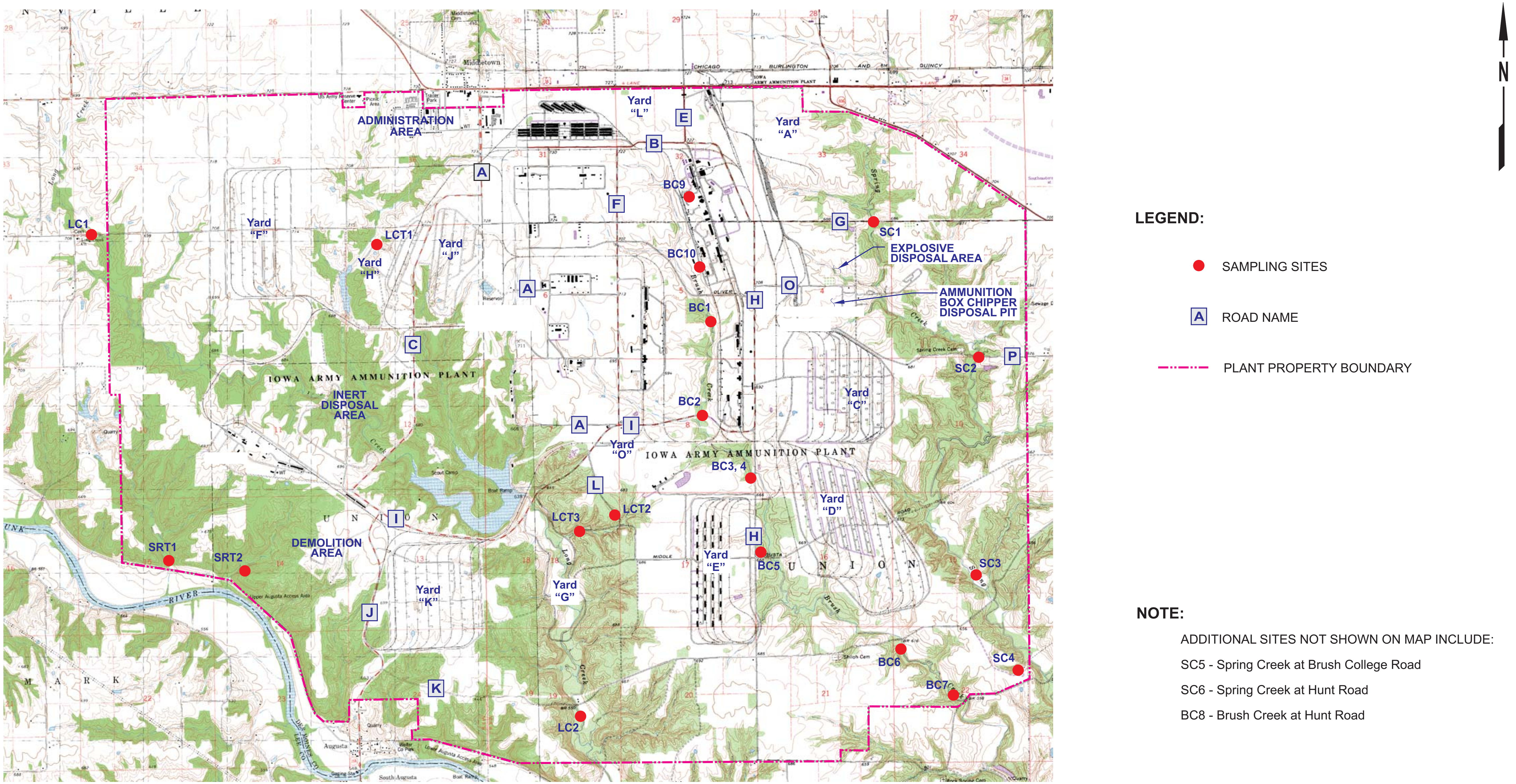

LEGEND:

● SAMPLING SITES

[A] ROAD NAME

-·-·- PLANT PROPERTY BOUNDARY

NOTE:

ADDITIONAL SITES NOT SHOWN ON MAP INCLUDE:

SC5 - Spring Creek at Brush College Road

SC6 - Spring Creek at Hunt Road

BC8 - Brush Creek at Hunt Road

	SRT1	SRT2	LC1	LC2	LCT1	LCT2	LCT3	BC1	BC2	BC3	BC4	BC5	BC6	BC7	BC8	BC9	BC10	SC1	SC2	SC3	SC4	SC5	SC6
BENTHOS	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
FISH				•								•	•		•			•	•		•	•	•

Scale 0 2000 4000 6000 8000 Feet

MWH

Figure 3-1

SAMPLING LOCATION MAP
BENTHOS AND FISH

ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

c:\iowa\risk-assessment\figure 3-1.cdr

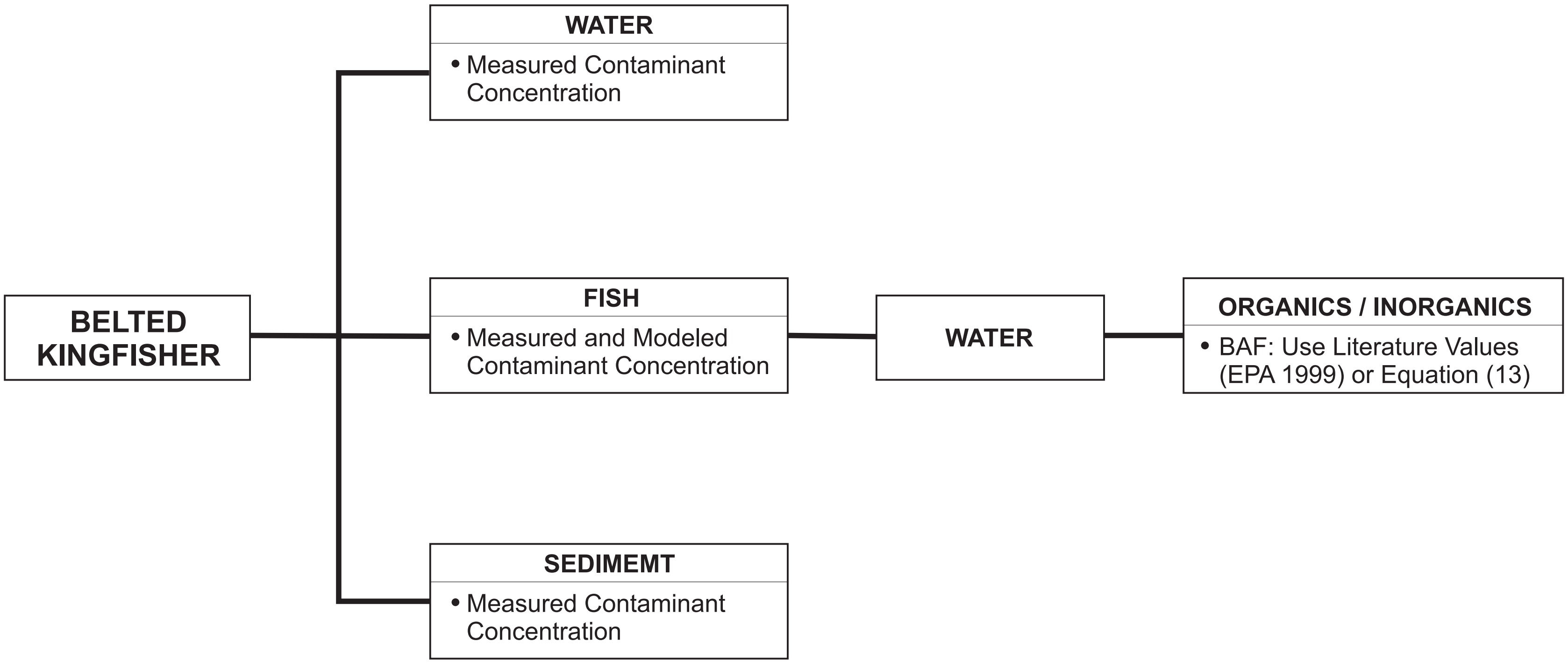

Figure 3-2
ECORISK PATHWAY FOR BELTED KINGFISHER
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

MWH

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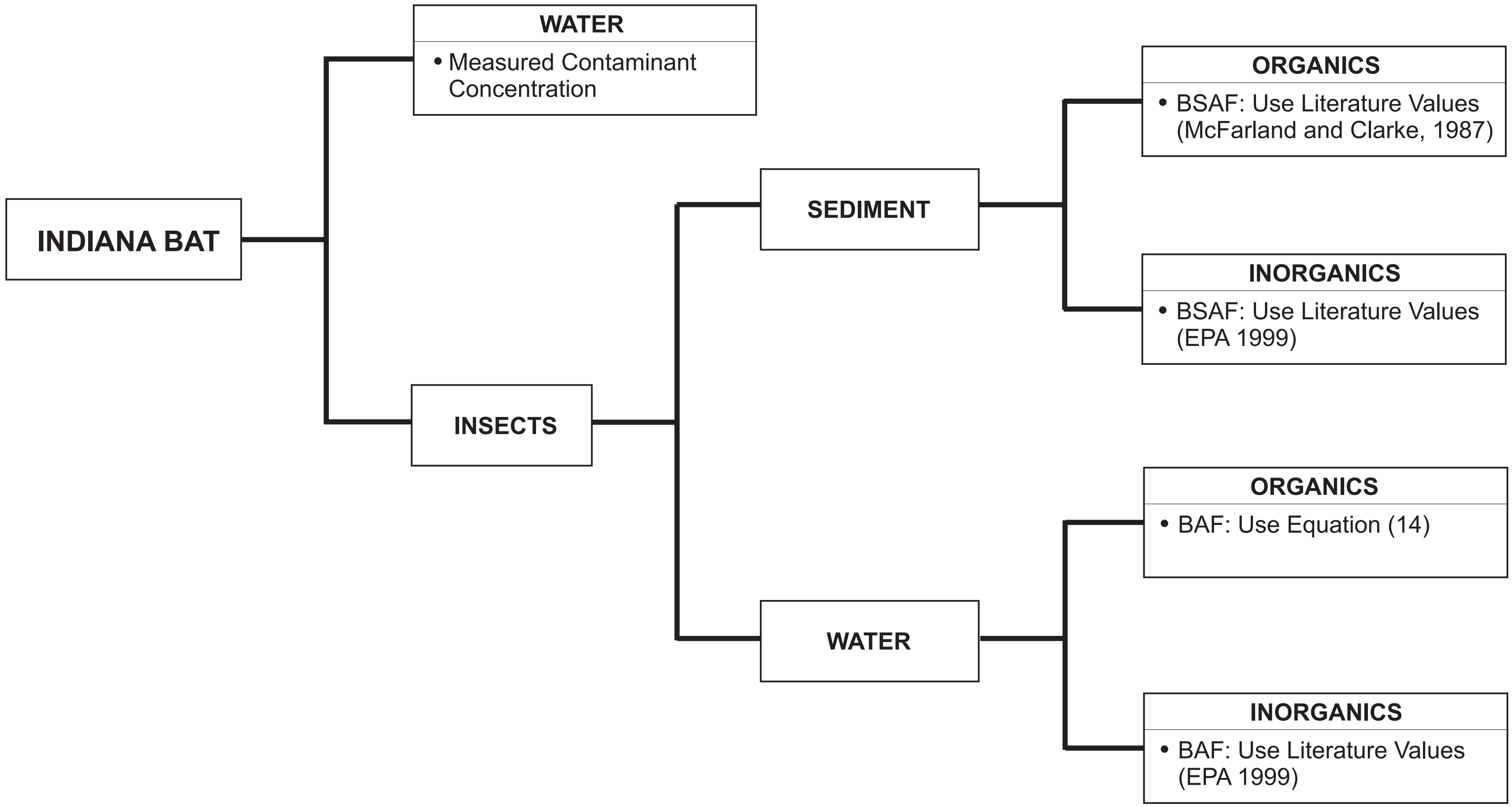

MWH

Figure 3-3
ECORISK PATHWAY FOR INDIANA BAT VIA THE AQUATIC PATHWAY
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

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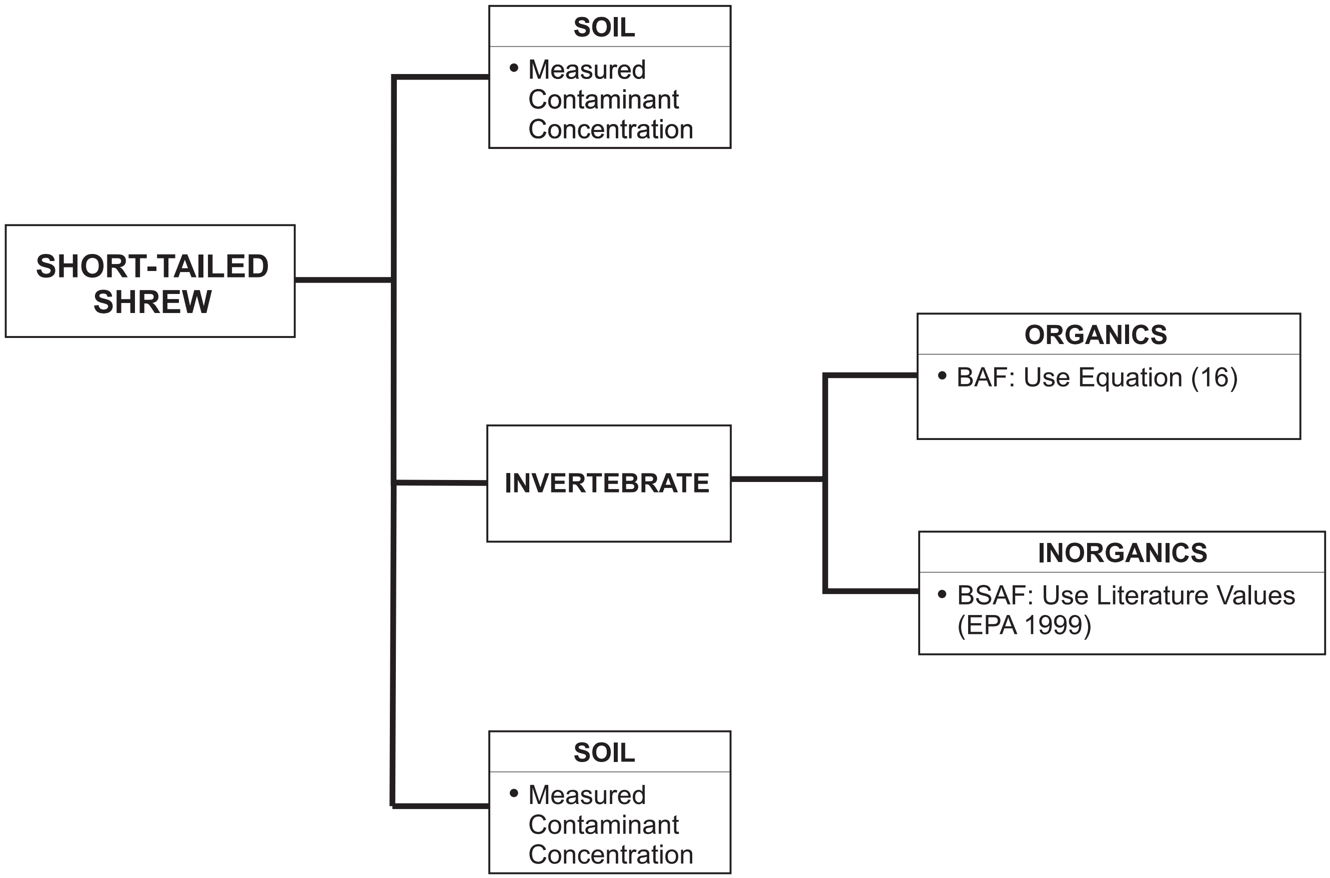


Figure 3-4

ECORISK PATHWAY FOR SHORT-TAILED SHREW

ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

MWH

o:/iowa/risk assessment/revised eco-risk.cdr

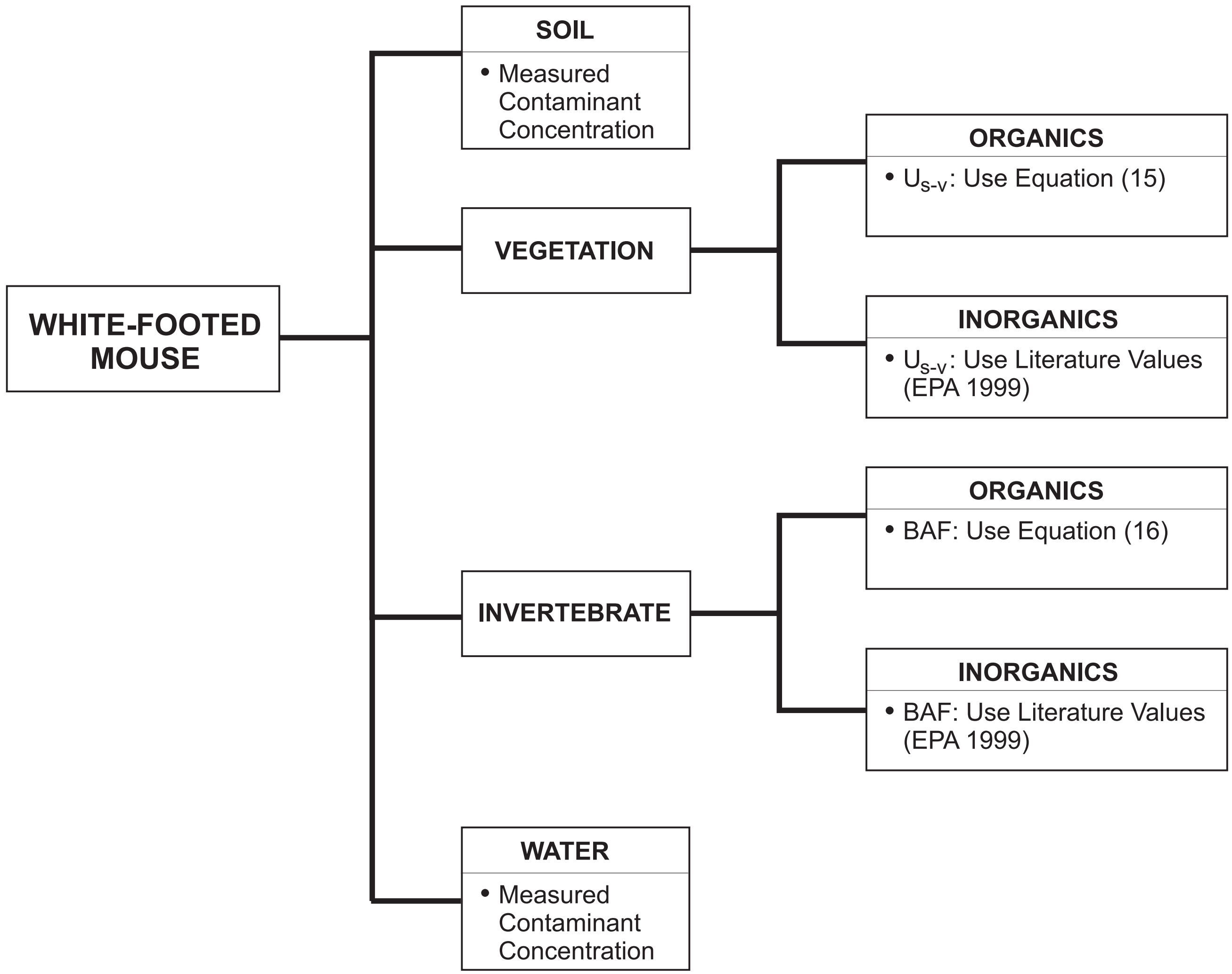


Figure 3-5

ECORISK PATHWAY FOR WHITE-FOOTED MOUSE

ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

MWH

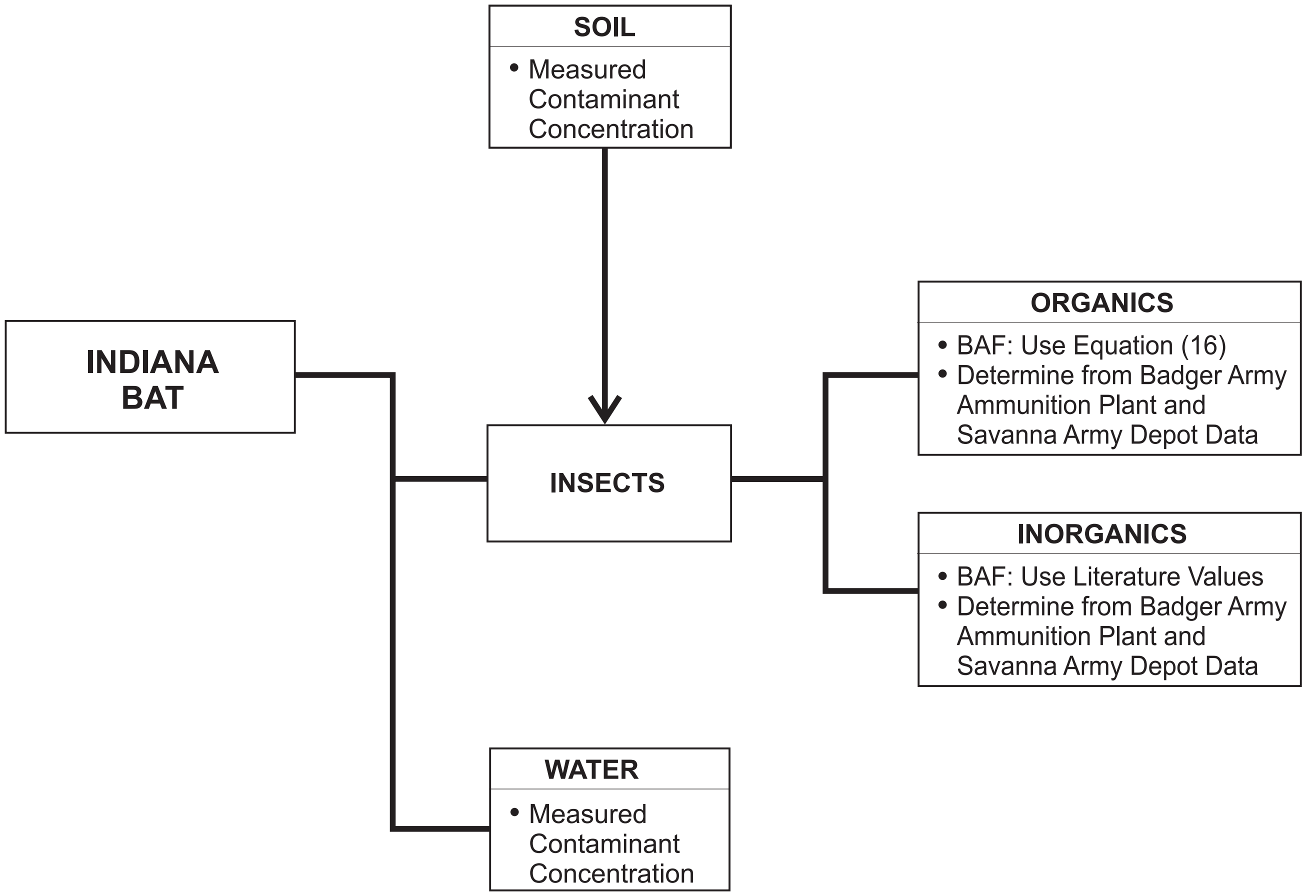


Figure 3-6

ECORISK PATHWAY FOR INDIANA BAT VIA THE TERRESTRIAL PATHWAY

ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

MWH

70 0 70 140 Feet

MWH

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

Figure 6-1
COPEC DISTRIBUTION: IAAP-027/R19
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

MWH

Figure 6-2
COPEC DISTRIBUTION: IAAP-028/R20
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

MWH

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

Figure 6-3
COPEC DISTRIBUTION: IAAP-038/R26
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

MWH

Figure 6-4
COPEC DISTRIBUTION: IAAP-041/R29
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

MWH

Figure 6-5

COPEC DISTRIBUTION: IAAP-043/R30

ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

MWH

Figure 6-6
COPEC DISTRIBUTION: IAAP-029/R21
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

MWH

Figure 6-7
COPEC DISTRIBUTION: IAAP-008/R08
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

MWH

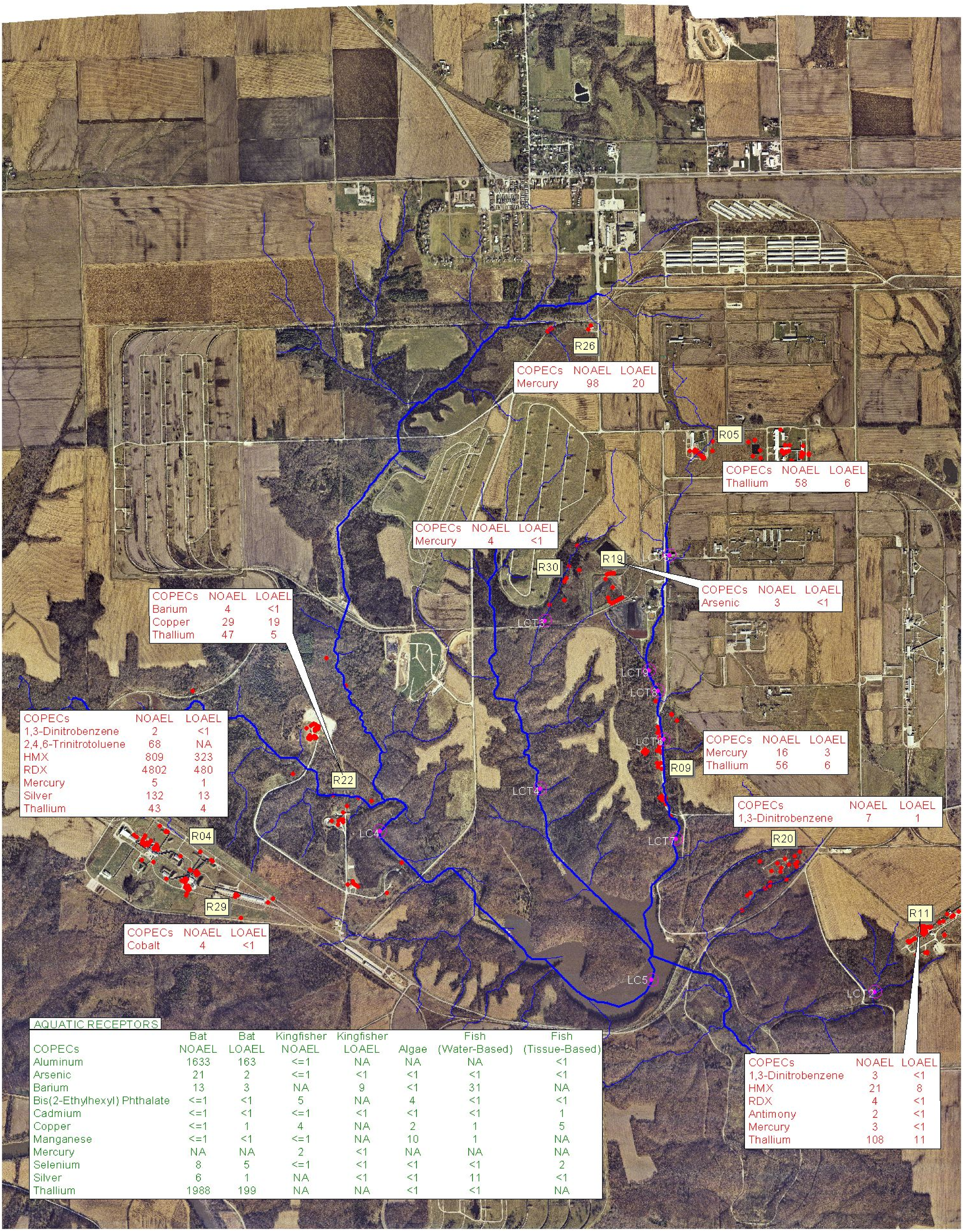
LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

Figure 6-8
COPEC DISTRIBUTION: IAAP-026/R18
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

LEGEND:
Red Dot - Constituent Concentration > Critical Concentration
White Dot - Constituent Concentration < Critical Concentration

MWH

Figure 6-9
COPEC DISTRIBUTION: IAAP-024/R16
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa



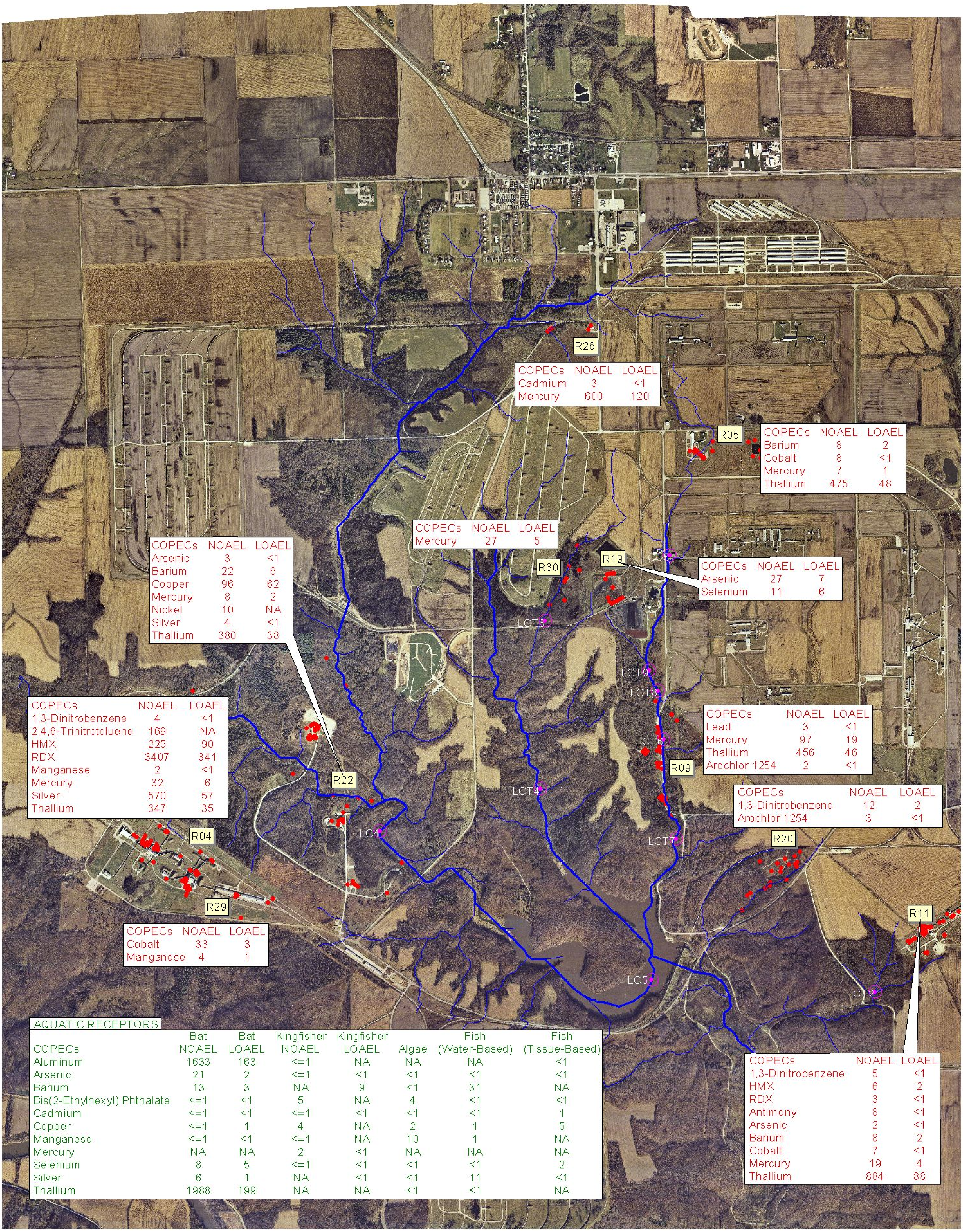
COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	1633	163	<=1	NA	NA	NA	<1
Arsenic	21	2	<=1	<1	<1	<1	<1
Barium	13	3	NA	9	<1	31	NA
Bis(2-Ethylhexyl) Phthalate	<=1	<1	5	NA	4	<1	<1
Cadmium	<=1	<1	<=1	<1	<1	<1	1
Copper	<=1	1	4	NA	2	1	5
Manganese	<=1	<1	<=1	NA	10	1	NA
Mercury	NA	NA	2	<1	NA	NA	NA
Selenium	8	5	<=1	<1	<1	<1	2
Silver	6	1	NA	<1	<1	11	<1
Thallium	1988	199	NA	NA	<1	<1	NA

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

1000 0 1000 Feet

MWH

Figure 6-10
LONG CREEK AOC
WHITE-FOOTED MOUSE: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa



AQUATIC RECEPTORS

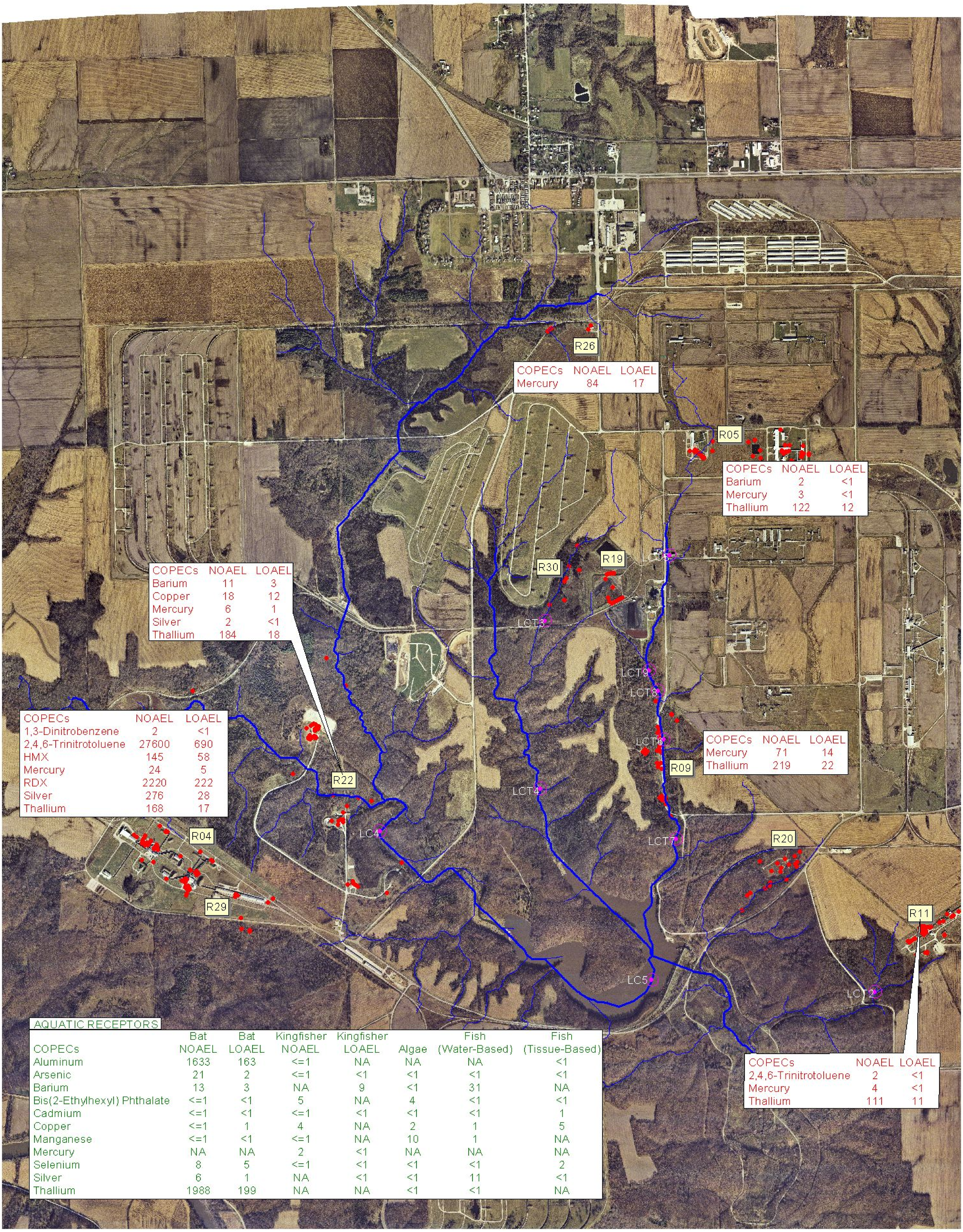
COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	1633	163	<=1	NA	NA	NA	<1
Arsenic	21	2	<=1	<1	<1	<1	<1
Barium	13	3	NA	9	<1	31	NA
Bis(2-Ethylhexyl) Phthalate	<=1	<1	5	NA	4	<1	<1
Cadmium	<=1	<1	<=1	<1	<1	<1	1
Copper	<=1	1	4	NA	2	1	5
Manganese	<=1	<1	<=1	NA	10	1	NA
Mercury	NA	NA	2	<1	NA	NA	NA
Selenium	8	5	<=1	<1	<1	<1	2
Silver	6	1	NA	<1	<1	11	<1
Thallium	1988	199	NA	<1	<1	<1	NA

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

1000 0 1000 Feet

MWH

Figure 6-11
LONG CREEK AOC
SHORT-TAILED SHREW: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa



AQUATIC RECEPTORS

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	1633	163	<=1	NA	NA	NA	<1
Arsenic	21	2	<=1	<1	<1	<1	<1
Barium	13	3	NA	9	<1	31	NA
Bis(2-Ethylhexyl) Phthalate	<=1	<1	5	NA	4	<1	<1
Cadmium	<=1	<1	<=1	<1	<1	<1	1
Copper	<=1	1	4	NA	2	1	5
Manganese	<=1	<1	<=1	NA	10	1	NA
Mercury	NA	NA	2	<1	NA	NA	NA
Selenium	8	5	<=1	<1	<1	<1	2
Silver	6	1	NA	<1	<1	11	<1
Thallium	1988	199	NA	NA	<1	<1	NA

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

1000 0 1000 Feet

MWH

Figure 6-12
LONG CREEK AOC
INDIANA BAT: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

800 0 800 1600 Feet

MWH

Figure 6-13
SKUNK RIVER AOC
WHITE-FOOTED MOUSE: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

COPECs	NOAEL	LOAEL
Silver	65	7

COPECs	NOAEL	LOAEL
1,3-Dinitrobenzene	4	<1
2,4,6-Trinitrotoluene	169	NA
HMX	225	90
RDX	3407	341
Manganese	2	<1
Mercury	32	6
Silver	570	57
Thallium	347	35

COPECs	NOAEL	LOAEL
Cobalt	33	3
Manganese	4	1

AQUATIC RECEPTORS

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	548	55	<=1	NA	NA	NA	<1
Barium	7	2	NA	6	<1	19	NA
Selenium	14	8	<=1	<1	<1	<1	4
Silver	48	5	NA	<1	NA	NA	NA

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

800 0 800 1600 Feet

MWH

Figure 6-14
SKUNK RIVER AOC
SHORT-TAILED SHREW: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

COPECs	NOAEL	LOAEL
1,3-Dinitrobenzene	2	<1
2,4,6-Trinitrotoluene	27600	690
HMX	145	58
Mercury	24	5
RDX	2220	222
Silver	276	28
Thallium	168	17

AQUATIC RECEPTORS

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	548	55	<=1	NA	NA	NA	<1
Barium	7	2	NA	6	<1	19	NA
Selenium	14	8	<=1	<1	<1	<1	4
Silver	48	5	NA	<1	NA	NA	NA

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

800 0 800 1600 Feet

MWH

Figure 6-15
SKUNK RIVER AOC
INDIANA BAT: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

AQUATIC RECEPTORS

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
2,4,6-Trinitrotoluene	4	<1	<1	<1	NA	NA	<1
RDX	3	<1	NA	<1	NA	NA	<1
Aluminum	1050	105	<=1	NA	NA	NA	<1
Arsenic	12	1	<=1	<1	<1	<1	<1
Barium	11	3	NA	8	<1	26	NA
Bis(2-Ethylhexyl) Phthalate	<=1	<1	6	NA	4	<1	<1
Cadmium	<=1	<1	<=1	<1	<1	<1	2
Copper	<=1	1	6	NA	4	1	10
Mercury	35	7	2	<1	<1	<1	2
Selenium	6	3	<=1	<1	<1	<1	1
Silver	29	3	NA	<1	<1	26	<1
Thallium	3433	343	NA	NA	<1	<1	NA

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

MWH

Figure 6-16
BRUSH CREEK AOC
WHITE-FOOTED MOUSE: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

Figure 6-17
BRUSH CREEK AOC
SHORT-TAILED SHREW: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

COPECs	NOAEL	LOAEL
1,3-Dinitrobenzene	2	<1
2,4,6-Trinitrotoluene	2	<1
Antimony	3	<1
Aroclor 1254	454	45
Barium	8	2
Cobalt	3	<1
HMX	2	<1
Mercury	36	7
Thallium	150	15
Vanadium	2	<1

COPECs	NOAEL	LOAEL
Barium	2	<1
Mercury	3	<1
Thallium	122	12

COPECs	NOAEL	LOAEL
1,3-Dinitrobenzene	4	<1
2,4,6-Trinitrotoluene	95000	2380
Antimony	5	<1
Barium	4	<1
Cobalt	2	<1
Dieldrin	2	<1
Mercury	12	2
RDX	7	<1
Thallium	212	21
Vanadium	2	<1

COPECs	NOAEL	LOAEL
Antimony	6	<1
Barium	2	<1
Mercury	5156	1031
Silver	3	<1
Thallium	86	9

COPECs	NOAEL	LOAEL
1,3-Dinitrobenzene	2	<1
2,4,6-Trinitrotoluene	57	1
Barium	3	<1
Cobalt	2	<1
HMX	8	3
Mercury	28	6
RDX	9	<1
Thallium	249	25
Vanadium	2	<1

COPECs	NOAEL	LOAEL
Mercury	120	24
Thallium	20	2

COPECs	NOAEL	LOAEL
Mercury	2	<1
Thallium	24	2

COPECs	NOAEL	LOAEL
Mercury	5	1
Silver	3	<1

COPECs	NOAEL	LOAEL
2,4,6-Trinitrotoluene	2	<1
Mercury	4	<1
Thallium	111	11

AQUATIC RECEPTORS

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
2,4,6-Trinitrotoluene	4	<1	<1	<1	NA	NA	<1
RDX	3	<1	NA	<1	NA	NA	<1
Aluminum	1050	105	<=1	NA	NA	NA	<1
Arsenic	12	1	<=1	<1	<1	<1	<1
Barium	11	3	NA	8	<1	26	NA
Bis(2-Ethylhexyl) Phthalate	<=1	<1	6	NA	4	<1	<1
Cadmium	<=1	<1	<=1	<1	<1	<1	2
Copper	<=1	1	6	NA	4	1	10
Mercury	35	7	2	<1	<1	<1	2
Selenium	6	3	<=1	<1	<1	<1	1
Silver	29	3	NA	<1	<1	26	<1
Thallium	3433	343	NA	NA	<1	<1	NA

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

500 0 500 1000 Feet

MWH

Figure 6-18
BRUSH CREEK AOC
INDIANA BAT: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	950	95	<=1	NA	NA	NA	NA
Arsenic	36	4	<=1	<1	NA	NA	<1
Barium	22	6	NA	9	<1	30	NA
Copper	4	3	10	NA	4	1	10
Manganese	<=1	<1	<=1	NA	2	<1	NA
Selenium	8	5	<=1	<1	<1	<1	2
Silver	553	55	NA	<1	<1	18	<1
4,4'-DDT	5	<1	1301	130	<1	<1	20

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

500 0 500 1000 Feet

MWH

Figure 6-19
SPRING CREEK AOC
WHITE-FOOTED MOUSE: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

AQUATIC RECEPTORS

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	950	95	<=1	NA	NA	NA	NA
Arsenic	36	4	<=1	<1	NA	NA	<1
Barium	22	6	NA	9	<1	30	NA
Copper	4	3	10	NA	4	1	10
Manganese	<=1	<1	<=1	NA	2	<1	NA
Selenium	8	5	<=1	<1	<1	<1	2
Silver	553	55	NA	<1	<1	18	<1
4,4'-DDT	5	<1	1301	130	<1	<1	20

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

MWH

Figure 6-20
SPRING CREEK AOC
SHORT-TAILED SHREW: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

AQUATIC RECEPTORS

COPECs	Bat NOAEL	Bat LOAEL	Kingfisher NOAEL	Kingfisher LOAEL	Algae	Fish (Water-Based)	Fish (Tissue-Based)
Aluminum	950	95	<=1	NA	NA	NA	NA
Arsenic	36	4	<=1	<1	NA	NA	<1
Barium	22	6	NA	9	<1	30	NA
Copper	4	3	10	NA	4	1	10
Manganese	<=1	<1	<=1	NA	2	<1	NA
Selenium	8	5	<=1	<1	<1	<1	2
Silver	553	55	NA	<1	<1	18	<1
4,4'-DDT	5	<1	1301	130	<1	<1	20

Surface Water and Sediment Sampling Locations
Soil Sampling Locations
Multiple Soil Sampling Locations
Surface Water Migration Pathways

500 0 500 1000 Feet

MWH

Figure 6-21
SPRING CREEK AOC
INDIANA BAT: HQ > 1
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

Appendix A
Screening Level Ecological Risk Assessment

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SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

Appendix A-2
RESPONSE TO COMMENTS ON: SCREENING LEVEL RISK ASSESSMENT, ECOLOGICAL RISK ASSESSMENT, IOWA ARMY AMMUNITION PLANT

Appendix A-1
SLERA

DRAFT FINAL SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT (SLERA)

IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

Prepared for

U.S. Army Corps of Engineers
Omaha District
By

MWH
MONTGOMERY WATSON HARZA

October, 2003

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Refer to the Baseline Ecological Risk Assessment

AO	American Ordnance
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
BERA	Baseline Ecological Risk Assessment
BTAG	Biological Technical Assistance Group
CAMU	Corrective Action Management Unit
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHPPM	Center for Health Promotion and Preventative Medicine
COPEC	Chemicals of Potential Ecological Concern
CSM	Conceptual Site Model
DBH	Diameter at Breath Height
EDQL	Ecological Data Quality Levels
ERA	Ecological Risk Assessment
ERAA	Ecological Risk Assessment Addendum
ERAGS	Ecological Risk Assessment Guidance for Superfund
FFA	Federal Facility Agreement
FSP	Field Sampling Plan
HRS	Hazard Ranking Score
HSWA	Hazardous and Solid Waste Amendments
IAAAP	Iowa Army Ammunition Plant
IAG	Interagency Agreement
IDA	The Inert Disposal Area
IDNR	Iowa Department of Natural Resources
KOC	Organic Carbon Partition Coefficient
LOAEL	Lowest Observed Adverse Effects Level
MWH	MWH Americas, Inc.
NAWQC	National Ambient Water Quality Criteria
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List

ORNL	Oak Ridge National Laboratory
OU	Operable Units
PA/SI	Preliminary Assessment/Site Inspection
ppb	parts per billion
ppm	parts per million
PRG	Preliminary Remedial Goals
QAPP	Quality Assurance Project Plan
RA	Risk Assessment
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SHSP	Site Health and Safety Plan
SI	Site Investigation
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific/Management Decision Points
SV	Screening Values
SVOC	Semi-Volatile Organic Compound
TM	Technical Memorandum
TOC	Total Organic Carbon
TRV MEMO	TRV Memorandum
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Services
VOC	Volatile Organic Compound
WP	Work Plan

1.0 INTRODUCTION

Ecological risk assessments (ERAs) are conducted to evaluate the actual or potential effects of contaminants on plants and animals. Results of an ERA are used by decision-makers to aid in formulating remedial objectives, analyzing remedial alternatives, and selecting an appropriate remedy, if necessary. The purpose of this report is to document the results of a Screening Level Ecological Risk Assessment (SLERA) at the Iowa Army Ammunition Plant (IAAAP), near Middletown, Iowa. The SLERA was conducted by MWH Americas, Inc. (MWH) for the U.S. Army Corps of Engineers (USACE), Omaha District under terms of Delivery Order No. 0007, Contract No. DACW25-00-D-0004.

The SLERA was conducted using data collected during facility-wide Site Investigations (SIs) and the Remedial Investigation (RI), and supplemental investigations conducted specifically to collect data for the SLERA. The SLERA identifies chemicals of potential ecological concern (COPECs) that may have resulted from past IAAAP activities. A Baseline Ecological Risk Assessment (BERA) that discusses the potential risks to ecological receptors at the IAAAP associated with exposure to COPECs may be conducted based on results of the SLERA.

The SLERA utilized available published resources, referenced within this document where appropriate. The primary U. S. Environmental Protection Agency (USEPA) guidance documents used to perform the SLERA include:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997).
- Guidelines for Ecological Risk Assessment (USEPA ,1998).
- The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments, ECO Update Bulletin Series (USEPA, 2001).

This SLERA builds upon a previous Basewide ERA that was conducted for IAAAP during the Remedial Investigation/Feasibility Study (RI/FS) process. This SLERA conforms to the newer guidance, listed previously, which was not available at the time that the previous Basewide ERA was conducted. Background information explaining the reason for performing this SLERA, after the original Basewide ERA was completed, is included in the Project Background, Section 1.2. Section 1.1 includes an overview of the current ERA process.

1.1. OVERVIEW OF CURRENT ERA PROCESS

Ecological Risk Assessments performed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund) and Superfund Amendments and Reauthorization Act of 1986 (SARA) include an eight-step process. This process is detailed in Ecological Risk Assessment Guidance for Superfund (ERAGS) published by USEPA in 1997. The generic model for this process is presented in Figure 1-1.

Steps 1 and 2 of the ERA process form the SLERA. The SLERA, or Tier 1 assessment, is strictly a paper study that contains all of the elements of a more detailed ERA, but can be conducted using limited data. This type of ERA accepts a higher level of uncertainty than a BERA and uses protective assumptions to manage data gaps. Assumed values used to calculate ecological health risks are consistently biased in the direction of over estimating risk to reduce the likelihood of falsely screening out a site from further assessment (i.e., failing to identify ecological risks that are actually present). The goal of the SLERA is to quickly and cost effectively determine if a more detailed BERA is warranted. If the result of the SLERA is that site conditions do not pose an ecological health concern, then the assessment ends at this point.

If the SLERA (i.e., Steps 1 and 2 of the ERA process) indicates that there is the potential for ecological effects associated with the site, a more detailed BERA is conducted (i.e., Steps 3 through 7 of the ERA process) and the SLERA is documented as part of the BERA.

Common to both the SLERA (Steps 1 and 2) and the BERA (Steps 3 through 7), is an iterative process of problem formulation, data collection, and data analysis with the ultimate goal being to estimate whether the site conditions pose an ecological concern (i.e., risk characterization). Problem formulation is composed of reviewing the analytical data obtained to date for the site, visiting the site to make observations concerning site ecology and potential chemical fate and transport processes, and reviewing information concerning the toxicology of the contaminants present. The result is a conceptual site model (CSM) which is updated appropriately as more information is collected and analyzed. The CSM includes a summary of those exposure pathways that are potentially complete, meaning those exposure pathways that cause ecological receptors to become exposed to a contaminated medium or multiple contaminated media. A CSM for IAAAP is presented in Section 2 of this SLERA.

The ERA process contains a technical oversight and consensus-building feature called scientific/management decision points (SMDPs). At SMDPs (i.e., at completion of many of the eight ERA steps), the risk assessors and risk managers meet to review the progress of the ERA. The ERA is evaluated and the progress is approved at the SMDP meeting, or the group may decide to redirect the ERA.

Early on in the process, before ERAGS was published, an informal ERA Team was formed to oversee the development of ecological evaluations at IAAAP. The ERA Team continues in this role. The ERA Team members primarily involved in the ERA process at IAAAP represent IAAAP, USACE, U. S. Army Center for Health Promotion and Preventive Medicine (CHPPM), USEPA, and U. S. Fish and Wildlife Services (USFWS). At SMDPs, this group came together to discuss the approach, progress, and direction of the ERA. Throughout this document, this group is referred to as the ERA Team.

1.2. PROJECT BACKGROUND

1.2.1. Iowa Army Ammunition Plan History and Regulatory Framework

Iowa Army Ammunition Plant is a government-owned, contractor-operated facility under the command of the U.S. Army Joint Munitions Command, Rock Island, Illinois. The current operating contractor is American Ordnance (AO). Production of ammunition items began in 1941 and the facility remains in operation. Production activities at IAAAP currently include the loading, assembling, and packaging of ammunition items, including projectiles, mortar rounds, warheads, demolition charges, anti-tank mines, and anti-personnel mines. The loading, assembling, and packaging operations use explosive materials and lead-based initiating compounds.

Wastewater generated at various plant facilities and effluent from wastewater treatment plants are discharged to surface streams under the provisions of a National Pollutant Discharge Elimination System (NPDES) permit. The munitions production at IAAAP has resulted in contamination of soil and groundwater, and discharge of wastewater-containing explosives and explosive by-products to surface water. The primary source of contamination resulted from placing explosives and waste containing heavy metals directly on soil and into surface water. Explosive contaminants and heavy metals migrated through the soil into the groundwater and also over land into surface water. The facility also has identified minor amounts of volatile organic compound (VOC) contamination in soil and groundwater.

Sites at IAAAP include surface impoundments, production areas, landfills, and a fire training pit. The facility map (Figure 1-2) shows the site locations, creeks, and other features of interest at IAAAP.

Pursuant to the Resource Conservation and Recovery Act (RCRA) Hazardous and Solid Waste Amendments (HSWA) of 1984, USEPA completed an assessment of the facility in 1987 (USEPA, 1987) and reported that releases had occurred. Iowa Army Ammunition Plant was subsequently proposed for the National Priorities List (NPL) and, in August 1990, the facility was placed on the NPL with a Hazard Ranking Score (HRS) of 29.73.

A Federal Facility Agreement (FFA) between the U.S. Department of Defense and USEPA Region 7 was signed on September 20, 1990. Under the agreement, IAAAP investigations and remedial activities will be completed under CERCLA. The agreement allows RCRA and CERCLA activities at the IAAAP to be coordinated. In response to the

FFA, JAYCOR (1992) completed a facility-wide Preliminary Assessment/Site Inspection (PA/SI) of 44 sites with potential contamination listed in the Interagency agreement (IAG). Subsequently, JAYCOR (1996) completed a facility-wide RI and Risk Assessment (RA) for approximately 35 of the sites. Additional sites were added over the year as a result of added studies and best management practices and a total of 43 physical sites exist today.

The IAAAP facility has been divided into three operable units (OUs) to facilitate project management. These include:

- Soils OU #1 - to address contamination in the soils
- Groundwater OU #3 - to address contamination of groundwater within the IAAAP boundaries and potentially off-site
- Facility-wide OU #4 - to address closure of the Corrective Action Management Unit (CAMU), institutional controls, previously un-addressed areas of soil contamination, VOC contaminated media, ecological risks, groundwater monitoring requirements, and any other unacceptable risks which may be identified and not addressed in either OU #1 or OU #3

Operable unit #2 was originally established for the soil removal actions, but was subsequently merged into OU #1. This SLERA is being performed to satisfy some of the ecological requirements for facility-wide OU#4.

1.2.2. Project Background Pre-dating the SLERA

Previous ecological evaluations have been performed as part of the RI/FS process and other ancillary assessments that evaluated the unique ecological habitat at IAAAP. These previous evaluations are listed below and the results of many (highlighted with asterisks) are relied upon in this SLERA.

- Basewide ERA performed by JAYCOR (1996) as part of the RI/FS
- Inventory and assessment of habitats and biota of the IAAAP performed by Horton (1996)
- A study entitled Uptake of Explosives from Contaminated Soil by Existing Vegetation at the Iowa Army Ammunition Plant, conducted by USAEC (1995)
- Ecological Risk Assessment Addendum (ERAA), performed by Harza Engineering Company (now MWH, 1998)*
- Technical Memorandum No. 1 (TM 1) - Assessment and Measurement Endpoints, prepared by MWH (1999)

- TM 2 - Collection of Water and Sediment Quality Data for Ecological Risk Assessment, prepared by MWH (2000)*

- TM 3 - Development of Hazard Models and Ecological Preliminary Remedial Goals (PRGs) for Ecological Risk Assessment, prepared by MWH (2000)*

- TM 4 - Contaminant Screening Process for ERA, prepared by MWH (2000)*

- TRV Memorandum (TRV Memo) - Development of Dose Estimation Models and Toxicity Reference Values, prepared by MWH (2001)

The following summary provides a general picture of how these previous evaluations relate to the SLERA and helps explain, in part, the need for this SLERA.

During their review of the JAYCOR ERA (1996), USEPA determined that additional data collection and analysis were needed. A Scope of Services for additional data collection was issued to determine the potential impacts of chemical contamination on the IAAAP ecosystem, with emphasis on sensitive receptors and habitat. These services were to be performed as an addendum to the original ERA (i.e the ERAA).

The addendum to the original basewide ERA was conducted to address data gaps identified by USEPA and included field sampling and laboratory analysis. Harza (currently MWH) conducted the field investigation and subcontracted laboratory-based toxicity tests (Rapid Bioassessment Protocol) for the ERAA. This investigation took place in 1997 and 1998, but was never finalized. At that time, the new USEPA guidance (USEPA, 1997), became available as previously described, and provided the eight-step approach for conducting ERAs. It was decided that a new risk assessment should be conducted at IAAAP, using the revised approach. For this reason, the ERA Team decided the information from the ERAA would be incorporated as appropriate in the SLERA and/or the BERA.

Harza conducted the ERAA by assessing risks posed by past and ongoing operations at each of the major watersheds. Small burrowing mammals inhabiting flood plain forests at IAAAP were identified as key receptors for the study. Because of federal listing as a threatened species at the time of the study, the viability of bald eagle (Haliaeetus leucocephalus) population was also assessed. Selection of key aquatic receptors in the ERAA focused on two levels of biological organization: an individual fish species and the benthic community. Fish and benthic invertebrate samples were collected as part of the ERAA.

The ERAA indicated that small mammal populations did not appear to be at significant risk in any watershed. Bald eagle populations did not appear to be at risk at IAAAP. In general, aquatic systems were found to be exposed to concentrations of some metals that may potentially be affecting orangethroat darters in some of the major streams. The benthic community was appraised as being impaired to slightly impaired.

The ERA Team, composed of representatives of USACE, IAAAP, USEPA, CHPPM, USFWS, Harza, and Techlaw (USEPA's Contractor), met in Chicago on April 8, 1999, to discuss the results of the ERAA. It was determined that a new risk assessment should be conducted at IAAAP that would be consistent with the new USEPA guidance (1997). The principal changes in approach to the risk assessment that were agreed to at that meeting included the following:

- use a site-specific approach to address terrestrial issues;
- use a feeding guild approach for assessment and measurement endpoints;
- inclusion of the Indiana bat as a receptor; and,
- collection of additional sediment and surface water data to address data gaps associated with the RI data set.

Because a new ERA was required, the ERAA was not finalized. Instead, the ERA Team agreed that information collected and work conducted for the ERAA would be incorporated in the new ERA.

1.3. ECOLOGICAL RISK ASSESSMENT APPROACH FOR IAAAP

The ERA Team decided that a series of Technical Memoranda (TM) would be prepared by MWH to address key portions of the evaluation. These TMs would document the planning steps to be used instead of a formal work plan. As part of this process, the screening values to be used in the SLERA were also developed. In accordance with current guidance, the screening values for the SLERA, and the SLERA itself, would have been performed before many of the TMs for the BERA were developed. However, the original project started well before the current USEPA ERA guidance was published, and so, to be in conformance with that guidance, the SLERA had to be performed in a retroactive manner, after the planning for the BERA had begun.

Five TMs were prepared to define procedures, models, and data collection. Three of these memoranda, TM2, TM3, and TM4, were developed to facilitate review and concurrence on the general approach for the SLERA. These are described below.

Technical Memorandum No. 2 (TM 2) - Collection of Water and Sediment Quality Data for Ecological Risk Assessment. TM 2 was developed as a comprehensive facility-wide plan for collecting surface water and sediment data to complete the ERA. Surface water and sediment samples had been collected from the water bodies at IAAAP during several previous investigations. These included samples collected during the RI (JAYCOR 1996), the supplemental groundwater investigations (Harza, 1997), and the supplemental RI for Line 800 (Harza, 2001a). These data were evaluated and used to design a comprehensive sediment and surface water investigation. The objectives of the surface water and sediment sampling were:

- to delineate the nature and extent of contamination for ecological receptors;
- to estimate the exposure of aquatic organisms to contaminants in streams at IAAAP and preying on aquatic insects or fish; and,
- to estimate contaminant doses to terrestrial organisms due to drinking water at the IAAAP.

Some of the ERA Team members met on March 9, 2000, in Kansas City to select the sample locations that would be documented in TM 2. Ecological Risk Assessment Team members present represented USACE, Harza, USEPA, and Techlaw. Locations were selected by the ERA Team based upon known or suspected sources of aquatic pollution, identified locations of fine sediment deposition, and threatened or endangered species records. Locations immediately downgradient of NPDES discharges, tributaries, sediment depositional areas, and groundwater discharge areas were specifically identified. The selected locations provided coverage of all major streams across the plant property and included streams entering IAAAP on the west and east boundaries.

Based on this meeting, TM2, dated April 7, 2000 was prepared by MWH to delineate the rationale and procedure for collection of water and sediment data. Technical Memorandum 2 is contained in Appendix B2 of the BERA. Surface water samples were collected in May 2000. A second phase of sampling, in accordance with TM2, was conducted in September 2000 to collect sediment and further surface water samples. The work was conducted in accordance with an existing approved Work Plan/Sampling and Analysis Plan (WP)/(SAP) for the installation, containing a Quality Assurance Project Plan (QAPP), Field Sampling Plan (FSP), and Site Health and Safety Plan (SHSP) (Harza, 1999). All portions of the installation SAP were applicable to the collection of the additional water and sediment samples, except as amended specifically for this additional sampling (Harza, 2000). The results of this investigation are documented in this SLERA.

Technical Memorandum No. 3 (TM 3) - Development of Hazard Models and Ecological PRGs for Ecological Risk Assessment. Technical Memorandum 3 was developed to document the ecological risk models and the screening levels (i.e., ecological PRGs) that would be used in the SLERA. Exposure to contaminants by a receptor may derive from multiple sources, including food (plant or animal), water, soil, and sediment. Therefore, the models were needed to incorporate chemical exposure from these multiple sources for each of the selected receptors. Screening Values (SVs) were selected for each constituent detected at the IAAAP for each medium. The SVs are media-specific concentrations, above which there is sufficient concern to warrant further evaluation regarding the potential for adverse ecological effects. For each media, a focused literature search was conducted to identify screening levels developed to protect a broad range of organisms, rather than specific species. Technical Memorandum 3, dated September 15, 2000, was developed by MWH and submitted for ERA Team review and input. The draft version of TM 3 is provided in Appendix B3 of the BERA.

Technical Memorandum No. 4 (TM 4) - Contaminant Screening Process for ERA. TM 4, dated August 31, 2000, was developed to provide the procedures to be used to select ecological SVs that would be used in the SLERA. Technical Memorandum 4 is provided in Appendix B4 of the BERA. The procedures in TM4 have since been revised in response to comments from ERA Team members at a working meeting. The revised procedures have been incorporated in this Draft Final SLERA.

1.4. OBJECTIVES AND SCOPE OF THE SLERA

The objectives of the SLERA are to evaluate site contaminant data with respect to benchmark data available in the literature for protection of a broad range of organisms and to identify COPECs for each media, if any.

Samples used in the SLERA were collected primarily from water bodies within the plant boundary. A few surface water and sediment samples were also collected from locations immediately downstream of the plant. However, evaluation of risks at locations outside IAAAP is outside the scope of this SLERA. Surface water and sediment data are presented in Appendix D of the BERA. Soil analytical data used in this SLERA is presented in Appendix C1 of the BERA, and soil-sampling locations are presented in Appendix C2 of the BERA. Soil data from background locations are presented in Appendix C3 of the BERA.

The Iowa Army Ammunition Plant covers approximately 30 square miles. Investigations for such large facilities are generally biased to focus on areas with known activities that have the potential to contaminate surrounding media. The SI, and the subsequent RI (JAYCOR, 1996), focused on determining the nature and extent of contamination within the areas of concern (AOCs). Soil data was specifically collected from the AOCs based on information that indicated potential soil contamination might have occurred in these areas. This SLERA does not include an evaluation of soil in the areas outside the AOCs because soil contamination is not expected in these areas. However, the SLERA was designed to evaluate the potential for migration of chemical contamination outside the boundaries of the soil AOCs to the watersheds that are located on IAAAP. These include the watersheds of Spring Creek, Brush Creek, and Long Creek, as well as some of the tributaries to these three streams and the Skunk River. To support this evaluation, a comprehensive surface water and sediment investigation was completed in watersheds that could be potentially affected by the AOCs.

The northern area of IAAAP is drained by a fifth watershed, Little Flint Creek. The drainage area is primarily upstream of activities at the IAAAP and not impacted by any release of contaminants. Therefore, the Little Flint Creek watershed is not included for evaluation in the SLERA.

Removal actions have been completed at several AOCs where contaminated soil has been removed and replaced with uncontaminated fill material. These actions included removal of soil to depths greater than two feet. Therefore, for the purpose of evaluations to be conducted under an ERA, these AOCs have been remediated and RI data reflecting contamination do not represent current conditions. These AOCs are:

- Line 5A/5B (R06)
- East Burn Pads (R12)
- Pesticide Pit (R13)
- West Burn Pads (R24)
- North Burn Pads (R25)
- Fire Training Pit (R27)
- North Burn Pad Landfill (IAAAP 37)

Several other AOCs are not included in this SLERA, for various reasons. The Inert Disposal Area (IDA) (R14) is not included because it is currently being used as a treatment area for contaminated soils from other parts of IAAAP. The Demolition Area and Deactivation Furnace (R15) and the Explosive Waste Incinerator (R17) were closed under RCRA, and therefore, is not addressed in this SLERA. Past investigations did not verify the existence or location of possible past disposal activities at the Ammunition Box Chipper Disposal Area (R23), and therefore, it is not included.

Partial clean-up operations have been conducted at some other AOCs, including Line 1, Line 6, and Line 800. However, sources of backfill material at some of these locations are not known and follow-up soil sampling detected explosives in some samples (ECC, 2001). Therefore, these AOCs have been retained for further assessment in this SLERA.

Several radionuclides were analyzed for and detected at Line 1 (R01) and the Firing Site (R22). Background soil samples were also analyzed for gross alpha and gross beta. Evaluation of the impact of radionuclides on biota at IAAAP is not addressed in this SLERA, however, will be conducted in a separate effort.

1.5. SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT ORGANIZATION

This SLERA incorporates documentation of the tasks performed under the ERAA and the draft SLERA.

The SLERA is divided into sections as follows:

- Section 1.0, Introduction - provides a description of the project and IAAAP background, SLERA scope and objectives, and organization of the SLERA.

- Section 2.0, Problem Formulation - describes the environmental setting, and contaminants and describes the CSM.

- Section 3.0, Selection of Contaminants of Potential Concern - develops criteria for selection of COPECs, develops screening values for each media, conducts screening, and identifies COPECs.

- Section 4.0, Conclusions and Recommendations - summarizes the results of the SLERA and provides recommendations based on the results.

2.0 PROBLEM FORMULATION

2.1. ENVIRONMENTAL SETTING

2.1.1. Soil Sampling

As outlined in Section 1.2.1, forty-four sites with known or suspected contamination were identified for preliminary assessment at IAAAP and, subsequently, in 1991, 42 sites were selected for SI. The results of the SI were used to further focus the RI on 31 AOCs designated R01 through R30 and IAAAP-37 (Figure 2-1). These AOCs were specifically investigated during the RI based on past activities that had resulted in soil contamination. The data used in the SLERA and the BERA include analytical results of soil samples collected during the SI and the RI. Samples also were taken from drainageways and were termed sediment in the RI, but are representative of soil. The analytical results are presented in Appendix C1 of the BERA. Sample locations for each of the AOCs are presented in Appendix C2 of the BERA, reproduced from JAYCOR (1996). Most burrowing animals, such as the white-footed mouse and short-tailed shrew, do not usually burrow below about 24 inches. Therefore, the SLERA does not consider terrestrial receptors to be exposed to soils deeper than 24 inches and samples from greater depths did not need to be considered. Site investigations at each of the AOCs were designed to address the potential contamination associated with each AOC. Therefore, contaminants analyzed were tailored to each specific AOC and are variable. For example, soils from some of the AOCs were not analyzed for pesticides/PCBs because available information did not indicate that these AOCs were probable source areas for pesticide/PCB contamination.

2.1.2. Surface Water and Sediment Sampling

Surface water and sediment samples were collected at IAAAP during several investigations. These include samples collected during the RI (JAYCOR, 1996) and during supplemental basewide groundwater investigations (Harza, 1997), and supplemental RI for Line 800 (Harza, 2001a). These data were evaluated and used to design a comprehensive sediment and surface water investigation. The objectives of the surface water and sediment sampling for the SLERA/BERA were: 1) to further delineate the nature and extent of contamination in these media for ecological receptors; 2) to estimate the exposure of aquatic organisms to contaminants in streams at the IAAAP and preying on aquatic insects or fish; and, 3) to estimate contaminant doses to terrestrial organisms due to drinking water at the IAAAP. USACE, Harza, USEPA, and Techlaw personnel met on March 9, 2000 in Kansas City to select sample locations. Locations were selected based on known or suspected sources of aquatic pollution, identified locations of fine sediment deposition, and threatened or endangered species records. As noted previously, locations immediately downgradient of NPDES discharges, tributaries, sediment depositional areas, and groundwater discharge areas were specifically identified. The selected locations provided coverage of all major streams across the plant property and included streams entering IAAAP on the west and east boundaries.

The procedure for collection of water and sediment data was presented in TM2 (Appendix B2 of the BERA), a working memorandum developed for the sampling. The work was completed in accordance with an existing approved Work Plan/SAP, containing a QAPP, FSP, and SHSP (Harza, 1999). All portions of the approved SAP were applicable to the water and sediment sampling, except as amended specifically for this additional sampling (Harza, 2000).

Surface water samples were collected from Long Creek, Spring Creek, Brush Creek, several small tributaries to the Skunk River and to the three major streams, in spring and fall 2000. Sediment samples were collected in Fall 2000. The first and second phase sampling locations are shown on Figure 2-3 and Figure 2-4, respectively. It was not feasible to collect samples from location SCT02 because water flow was not visible and the exact flow path of the Spring Creek tributary could not be clearly identified. Five additional sampling locations, SCT04, SCT05, LCT08, LCT09, and SC13 were added during the second phase of sampling to further address data gaps. Water samples were analyzed for explosives and total and dissolved TAL metals. Sediment samples were analyzed for explosives, TAL metals, and organic carbon. PCBs, pesticides, herbicides and semi-volatile organic compounds (SVOCs) were also analyzed in 25% of the sediment and water samples. The analytical results are presented in Appendix D of the BERA.

Water samples were collected prior to disturbance of the sediment. Bottles were filled manually, with minimal entrainment of surface films or bottom sediment. Water for analysis of dissolved metals was filtered at the laboratory, more closely approximating the bioavailable fraction of the metals in the water column. In the SLERA and the BERA, only data for dissolved metals in surface water were used. Sediment grab samples were collected using a stainless steel scoop or trowel. Care was taken to collect sediment no deeper than two inches.

Groundwater does not present a significant exposure pathway to ecological receptors at IAAAP. Groundwater is known to enter streams at the IAAAP and then can become an exposure point. Monitored surface water and sediment data generated during comprehensive sampling conducted in spring and fall 2000 provide adequate characterization of this contribution of groundwater to the surface water bodies.

2.1.3. Physical Description

Iowa Army Ammunition Plant occupies approximately 19,000 acres in the town of Middletown in Des Moines County, Iowa, and lies approximately 10 miles west of the Mississippi River. U.S. Highway 34 borders IAAAP to the north, upland agricultural farms to the east and west, and the Skunk River Valley to the south. Surface topography is characterized by flat to gently rolling uplands dissected by entrenched streams and rivers. Approximately one-third of the IAAAP property is occupied by active or formerly active production or storage facilities. The remaining land is either woodlands or leased for agricultural usage.

2.1.3.1. Geology and Hydrogeology

Geology at IAAAP is characterized by a sequence of unconsolidated Pleistocene Age loess and glacial tills, underlain by sedimentary bedrock. The loess deposits at IAAAP are fine-grained materials deposited by wind action in the Wisconsin period. They are reported to overlie the glacial drift intermittently to thickness up to 26 feet, averaging 6 to 8 feet. In borings, they are similar in properties and difficult to distinguish from the underlying tills. The glacial tills are predominantly dense, fine-grained, silty clay and clayey silt with local sand seams and interbeds. They extend to the top of bedrock at depths in excess of 100 feet locally in the northern half of the IAAAP. The bedrock is exposed along the edges of the Skunk River Valley in the southwest and near the Mathes Lake Dam, and is very shallow in portions of the northeast portion of the IAAAP. The bedrock consists predominantly of limestone interbedded with varying thicknesses of shale and sandstone. The limestone varies between closely fractured and massive, with the uppermost part typically more highly fractured than at greater depths, and somewhat weathered, providing a more permeable zone relative to the overlying clay tills or the deeper bedrock zones. However, transmissivity of the upper bedrock is highly variable locally. Hydrogeologic units of interest in the risk assessment are the water-bearing portion of the combined loess and till deposits and, locally, the uppermost bedrock, where it is exposed or very close to the surface.

The glacial deposits contain little free groundwater, primarily in silt and sand seams, and act as an aquitard, slowing precipitation recharge of the underlying bedrock. Most identifiable groundwater recharge to site wells and borings derives from thin, generally one to two feet thick or less, discontinuous silt and sand seams within the clayey till. Despite a paucity of significant water-bearing strata, the drift is saturated below shallow depths and the groundwater is in hydraulic communication with the bedrock. The groundwater table in the drift generally occurs within ten feet of the ground surface and shallow groundwater flow closely parallels the ground surface. Thus, shallow groundwater flow within IAAAP is from topographic highs, including most of the Line and Yard areas, toward surface drainage, particularly the larger streams such as Spring, Brush, and Long Creeks. This is the flow regime of most interest to the ERA since it provides a potential migration path from contaminant sources to surface water. Piezometric data from well pairs and clusters show that a significant downward vertical gradient also exists within the drift, and between the drift and the bedrock. Therefore, the glacial drift is recharged directly by infiltration of precipitation and discharges downward to the bedrock aquifer. However, this component of recharge is expected to be minor compared to lateral flow toward surface streams. The glacial drift soils are fine-grained and available data indicate they have moderate to very low permeabilities. Results of field tests indicate permeability values ranging from 1×10^{-4} to 1×10^{-7} cm/sec (Harza, 1997). Data reported in the Draft Final RI Report (JAYCOR, 1996) indicate laboratory permeabilities for till samples ranging from 2.4×10^{-7} to 9.6×10^{-9} cm/sec and results of field permeability tests in monitoring wells ranging from 6.7×10^{-5} to 6.9×10^{-4} cm/sec. Based on these moderate to low permeability values, groundwater flow rate and velocity in the drift will be slow, dependent on local gradient.

Available data suggest that the drift and upper bedrock aquifer are in hydraulic communication, comprising a single hydraulic system. Where the bedrock is exposed at the surface or shallow, it provides a contaminant migration pathway to surface streams similar to the drift. The groundwater occurs primarily in open bedding planes and/or joints, the frequency of which is widely variable across the IAAAP. Therefore, groundwater flow in the bedrock varies widely. Hydraulic conductivity data available for bedrock wells indicate a wide range of values, from very permeable to very tight. This variability is expected to persist throughout the IAAAP and can affect local, although generally not regional, flow.

2.1.3.2. Watersheds

Five watersheds, displayed on Figure 2-2, drain IAAAP. As stated in Section 1.3, the Little Flint Creek Watershed is not included for evaluation in the SLERA. The plant is drained by, west to east, the Long Creek, Skunk River, Brush Creek, and Spring Creek. Long Creek is a tributary to the Skunk River and includes the George M. Mathes Dam and Reservoir within IAAAP. Other minor tributaries to the Skunk River drain the extreme southwest part of the installation. Brush Creek traverses the central and eastern portions of the installation and is a tributary to the Skunk River. Spring Creek traverses the central and eastern portions of the installation and is a tributary to the Mississippi River, located about ten miles east. The Long, Brush, and Spring Creek Valleys are relatively shallow in the north part of IAAAP, deepening to the south before exiting the installation at a steep bluff bounding the Skunk River Valley.

Long Creek originates about two miles north of IAAAP's northwest corner and drains most of the western portion of IAAAP. The stream exits the plant at the southwestern boundary, after draining approximately 7,700 acres of the IAAAP property. Long Creek joins the Skunk River just south of the IAAAP, and the latter flows into the Mississippi River about 9 miles east. Long Creek has been dammed near the center of the installation to create George H. Mathes Lake, with a surface area of approximately 83 acres. There is also a smaller lake, Stump Lake, located north of Mathes Lake. Stump Lake is a manmade sediment control structure that is presently being expanded and restructured for safety.

The Skunk River is located just south of IAAAP and flows from north-northwest to south-southeast to the Mississippi River. The Skunk River is fed by Long Creek and several unnamed tributaries that originate on the IAAAP. The Skunk River Watershed has a drainage area of about 2,500 acres within the southwestern part of IAAAP, characterized by steep, wooded terrain.

Brush Creek has a drainage area of approximately 5,000 acres within IAAAP and flows into the Skunk River south of the plant. Brush Creek drains the central portion of the IAAAP, including the majority of industrial operations. Of the five watersheds within IAAAP, Brush Creek has the most activity associated with facility operations. The watershed contains Lines 1, 2, 3, 6, 7, 9, the former Line 800 Pink Water Lagoon, the former Line 1 Impoundment, and parts of Lines 4A, 5A and 800.

Spring Creek originates off-site, just north of the Burlington Northern Railroad easement, drains the easternmost portion of IAAAP, and exits IAAAP at the southeastern corner. Its drainage area within the boundaries of IAAAP covers approximately 3,900 acres. The creek is intermittent and is seasonally dry within the IAAAP limits. Spring Creek flows off-site at the southeastern corner and continues in a south-southeasterly direction approximately 10 miles, where it flows directly into the Mississippi River.

Stream flow within IAAAP comprises three principal elements: surface runoff, groundwater inflow, and discharges under NPDES, although groundwater was not identified as a media providing a complete and significant exposure pathway for the SLERA. Groundwater within the facility recharges surface water within the five watersheds. Concerns arose within the ERA Team as to whether variations in groundwater flow are adequately reflected in surface water sampling conducted to date. Surface water flow at IAAAP reflects a base flow regime for most of the year. Flow increases immediately following rainfall, but returns to the base flow regime within 24 hours. Base flow conditions existed at the streams during sampling conducted in May and September 2000, while surface water and sediment investigations conducted over the years appear to have accounted for variations in flow conditions at IAAAP. Contaminant concentrations monitored in surface water during various investigations are comparable. For example, highest RDX concentrations detected in Brush Creek during the supplemental groundwater investigation (Harza, 1997), and the supplemental RI (Harza, 2001a) are 9.3 and 14 µg/L, respectively. These concentrations are comparable to the maximum RDX concentration of 15 µg/L observed during sampling for the SLERA and the BERA in 2000.

Explosives are the primary contaminants of concern at IAAAP. Harza (2001b) evaluated the relative loading of explosives and other organic compounds to surface water and sediment in Brush Creek and Spring Creek by modeling two potential migration pathways: groundwater migration and the wastewater discharge pathway. Loading into Long Creek and Skunk River was not estimated because explosives were detected at trace levels in these streams. Explosive concentrations estimated in the modeling study were in agreement with concentrations observed in Spring and Brush Creeks during sampling in 2000, validating the modeling effort. The principle modeling conclusions are as follows:

For Brush Creek Watershed:

- Line 800/Pink Water Lagoon was the most significant potential contributor of explosives to groundwater contamination.
- Explosives from Line 2 and VOCs (Freon) from Line 9 were other potential contaminant sources from groundwater.
- Other areas of known groundwater contamination examined did not appear to contribute significantly to surface water contamination or have significant potential to do so.

For Spring Creek Watershed:

- The West Burn Pads and the East Burn Pads were the major sources of contamination. Remedial actions have been taken at these AOCs.

2.1.4. General Ecological Site Description

Approximately a third of the IAAAP property is occupied by active or formerly active production and storage facilities. The remaining land is evenly divided between leased agricultural acreage and woodlands. Potentially exposed habitats include terrestrial and aquatic habitats where monitoring data show contamination, or those that could become contaminated due to contaminant migration. There is abundant and diverse fauna at IAAAP due not only to the diverse habitat mosaic provided by the upland and lowland forests, streams, wetlands, prairies, and agricultural areas; but also to the relative protection from human disturbance outside of plant facilities. The RI Report (JAYCOR, 1996) contains a comprehensive list of species observed on IAAAP. Discussions on the potential receptors are focused on species observed within the facility boundaries or those that could inhabit the facility, with particular attention to state and federally listed threatened and endangered species.

2.1.4.1. Terrestrial Habitat

Land use at each of the soil AOCs is presented in Figure 2-5. Land use/land cover types at IAAAP include forests, water, bottomland forests and other wetlands, prairies, industrial and ruderal areas, residential areas, and agriculture. Forest types can be separated into floodplain and upland forests, with the former predominating. Black willow, honey locust, American and slippery elms, cottonwood, and sycamore dominate the floodplain forests, with an understory consisting largely of poison ivy, grape, Virginia creeper, gooseberry, blackberry, multiflora rose, nettle, carrot, sedge, and mint. Upland forests at IAAAP are xeric, oak-dominated successional communities that represent transitional stages between oak and sugar maple dominance. Red and white oak, shagbark, and bitternut hickory dominate the overstory. The understory is characterized by young sugar maple, hophornbeam, and other tree and shrub species.

The other major land use/land cover types include those developed for agriculture and industrial plant operations. Agricultural uses include row crops (corn and soybeans) and pasture for beef production. Most pasturing takes place in munitions storage yards.

Land use/land cover on Figure 2-5 were prepared from 1994 aerial black and white photographs, soil survey maps, and National Wetland Inventory maps. The preliminary map was later field checked. Land was categorized according to the following system:

Forest:	Saplings and mature trees over 6" in diameter at breast height (DBH) forming an overhead canopy providing more than 50 percent groundcover on uplands (other than bottomland, floodplain, topography).

Bottomland Forest: Saplings and mature trees over 6" DBH, hydrophytic species, forming an overhead canopy providing more than 50 percent groundcover on bottomland (floodplain) topography.

Old Field: Areas cleared of woody vegetation in the past and allowed to revegetate with primarily herbaceous grasses, herbs, woody shrubs, and may have a tree canopy providing less than 50 percent groundcover. Such areas may be used as pasture for cattle, but not for crop production, and are not maintained as landscaped lawn.

Wetland: Areas exhibiting hydrophytic conditions of emergent wetland vegetation and bottomland (floodplain) and/or depression-like topography.

Agriculture: Areas exhibiting recent or active evidence of crop production, either by the existence of recently plowed crops or fallow.

Base Facilities: Includes areas occupied by structures, railways, and paved and unpaved roads and parking lots.

Residential: Single or multi-family residential homes and apartments and surrounding landscaped lawn areas.

Disturbed (Barren): Lands recently cleared of all vegetation with no indication of agricultural or other use.

Using this system, land use/land cover in the four watersheds (without considering Little Flint Creek) are characterized in Table 2-1.

Because of the diversity of habitats, numerous species of mammals are expected to live at the IAAAP. More common species include:

- Whitetail deer
- Red fox
- Gray squirrels
- White-footed mouse
- Short-tailed shrew
- Field mouse
- Moles
- Pocket gophers
- Beaver
- Muskrat
- Badgers
- Opossum
- Mink

Upland birds that are most common at the IAAAP based on observations include:

- American robin
- Northern cardinal
- Blue jay
- Red-headed woodpecker
- Common crow
- Common grackle
- Mourning dove
- Red-winged blackbird
- Chipping sparrow
- Eastern eadowlark
- American goldfinch
- Turkey
- Red-tailed hawk

The worm snake (*Carphophis amoenus*) is a State Special Concern species that may be present on IAAAP. It feeds on earthworms and soft-bodied insects, and may be present in lower ends of stream valleys on IAAAP.

2.1.4.2. Aquatic Habitat

Surface water features on IAAAP include the three major streams Brush Creek, Spring Creek, and Long Creek and their tributaries; tributaries to the Skunk River; Little Flint Creek; Mathes and Stump Lakes; drainage ditches; lagoons; and ponds.

A variety of forage, pan, and game fish live in the lakes and streams that drain the IAAAP. Orangethroat darter (*Etheostoma spectabile*) is considered by the Iowa Department of Natural Resources (IDNR) as threatened in that state. Fish species observed on IAAAP include:

- Largemouth bass
- Channel catfish
- Black crappie
- White crappie
- Walleye
- Flathead catfish
- Gizzard shad
- Bluegill
- Carp
- Black bullhead
- Green sunfish
- Darter
- Yellow bullhead

Several wading and diving birds have been observed or could potentially inhabit the aquatic habitats at the plant. These include:

- White heron
- Black-crowned night heron
- Belted kingfisher
- Osprey
- Red-shouldered hawk
- Cormorant

The bald eagle (*Haliaeetus leucocephalus*) has been spotted on IAAAP. This species is currently federally listed as threatened, but has been proposed for delisting (M. Coffey, 2002). Indiana bats (*Myotis sodalis*), considered a special status species, have been spotted on the property. The lower reaches of the streams present habitat suitable for the Indiana bat.

Common waterfowl in the vicinity of IAAAP include:

- Mallard
- Blue-winged teal
- Goldeneye
- Bufflehead
- Wood duck
- Hooded merganser
- Green-winged teal
- Northern shoveler
- Canada goose

Iowa Department of Natural Resources provided a complete list of state-listed threatened or endangered species that range into Des Moines County (IDNR, 2002). Crawfish frog (*Rana areolata*), yellow mud turtle (*Kinosternon flavescens*), red-shouldered hawk (*Buteo lineatus*), water willow (*Justicia americana*), dwarf dandelion (*Krigia virginica*), and green arrow arum (*Peltandra virginica*) are considered by the state to be endangered, but have not been found at IAAAP. Western sand darter (*Ammocrypta clara*), grass pickerel (*Esox americanus*), Western worm snake (*Carphophis amoenus*) and yellow monkey flower (*Mimulus glabratus*) are considered by the state to be threatened, but are not known to occur at IAAAP.

2.2. CONCEPTUAL SITE MODEL

The information assembled during Problem Formulation is summarized in a conceptual model that illustrates how ecological receptors at IAAAP can be exposed to COPECs, and how exposure to COPECs can adversely impact the assessment endpoints. The CSM is used to formulate hypotheses regarding ecological risk.

Figure 3-6 is the CSM showing contaminant sources, exposure pathways, and ecological receptors. Primary sources of contamination at IAAAP are the ordnance production lines, waste management sites, and burning/detonation sites. Contamination leaves these areas via atmospheric releases, infiltration to groundwater, surface runoff from spillage, rain runoff and soil erosion, and NPDES discharges. These release mechanisms result in surface and subsurface soil contamination that now act as secondary sources. Runoff and leaching of contaminants from soils result in contamination of surface water/sediment, surface soil, and groundwater. Groundwater at the IAAAP eventually drains into one of the five watersheds.

Primary receptors exposed to surface water/sediment include benthic macroinvertebrates, vegetation, insects, and fish. Aquatic receptors are exposed in streams by direct contact with COPECs in water and sediment. Ingestion by these exposed receptors begins to transport the contaminant up the food chain.

Primary receptors exposed to soil include soil macroinvertebrates, vegetation, and burrowing animals. Terrestrial receptors include both plants and animals. Plant uptake of contaminants directly from the soil, as well as direct incidental ingestion of contaminated soil, provides entry to the terrestrial food chain for the COPECs. Some COPECs are slow to degrade and may pose a risk for years or decades following their release to the environment. If the COPEC is also hydrophobic (having an affinity for dissolution in oil or fatty tissue), it will tend to biomagnify with trophic level, and pose the greatest threat to secondary receptors.

Numerous secondary receptors could accumulate contaminants from contaminated media and plants and animals in their diet. Ingestion is the primary pathway through which secondary receptors are exposed to contaminants. Dermal contact and inhalation of contaminants are complete exposure pathways for secondary receptors, but the accumulated doses are expected to be insignificant compared to those via the ingestion pathway.

The complete exposure pathways are described below.

- Exposure to surface water via ingestion, inhalation, and dermal contact.
- Exposure to sediment via ingestion, inhalation, and dermal contact.
- Exposure via ingestion, inhalation, and dermal contact to soil.
- Exposure to groundwater via dermal contact by terrestrial plants with long roots.

The groundwater exposure pathway listed above is complete, but not significant because the exposure doses are expected to be much lower than those due to exposure to surface water.

3.0 CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

This section discusses the identification and selection of COPECs for detailed evaluation. The purpose of selecting COPECs is to identify those chemicals associated with the AOC or the watershed, which are most likely to be of concern to the environment. Selection of a chemical as a COPEC does not necessarily indicate it poses an ecological risk, but rather, that it should be evaluated to determine if it represents a potential ecological risk.

The following methodology was used in selecting COPECs:

- Media of concern are soil, surface water, and sediment. For each constituent in soil, maximum concentrations detected in each AOC were compared to soil SVs. For surface water and sediment, maximum constituent concentrations in each watershed were compared to the corresponding SVs. Constituents whose maximum concentrations in soil, surface water, or sediment exceeded their SVs were retained for further consideration as COPECs.

- Calcium, magnesium, potassium, iron, and sodium were detected in all media. These inorganics are essential nutrients for all receptors and generally do not present a hazard to ecological receptors. Limited toxicological information is available on these inorganics. These essential nutrients were eliminated from consideration as COPECs.

- Inorganic constituents occur naturally in soils. Concentrations of inorganics in IAAAP soils were compared to background levels. Constituents detected at concentrations determined to be elevated in comparison to background levels were retained for further evaluation as COPECs.

- Surface water and sediment on IAAAP may be receiving contaminants migrating from areas upstream of IAAAP. However, data from sampling locations upstream of IAAAP are not available for Brush Creek and Spring Creek. Long Creek is the only stream with a surface water and sediment location upstream of IAAAP. Constituents in surface water and sediment were not eliminated from consideration as COPECs based on comparison to upstream concentrations in any of the watersheds because of limited data availability.

- Constituents detected at low frequency (5 percent or less) in surface water and sediment were reviewed further to determine if they were also detected in source areas (e.g., soil AOCs). Constituents detected at low frequency, but not detected in source areas, were eliminated from further consideration as COPECs.

- SVs are not available for some chemicals in some media. In the absence of further information, chemicals with SVs not available for a particular media were retained as COPECs. However, constituents were not identified as COPECs if available information indicated minimal toxic effects at concentrations measured in site samples.

Soil data used to determine maximum concentrations was collected during the RI and the SI. The data are presented in Appendix C1 of the BERA.

As noted earlier, most burrowing animals, such as the white-footed mouse and short-tailed shrew, do not usually burrow below about 24 inches. Therefore, in identifying constituent concentrations in soil, the SLERA does not consider terrestrial receptors to be exposed to soils deeper than 24 inches.

Samples collected from drainage ditches within the AOCs were designated as sediment samples in the RI. However, these drainage ditches are dry for most of the year and terrestrial receptors could be exposed to sediment in the same manner as they are exposed to soil. Therefore, the sediment samples were considered soil samples for the ERA. Surface water and sediment data collected in May and September of 2000 are presented in Appendix D of the BERA.

Groundwater does not present a significant exposure pathway to ecological receptors at IAAAP. Groundwater within the facility recharges surface water within the five watersheds. Monitored surface water and sediment data was generated during comprehensive sampling conducted in spring and fall of 2000 and provides adequate characterization of contribution of groundwater to surface water.

3.1. SCREENING LEVELS

The procedure for selection of the SVs was initially presented in TM4, noted previously as a working memorandum developed to facilitate review and concurrence on the general approach for the SLERA and the BERA. The procedure has since been revised in response to comments from stakeholders. Screening Values were selected for each constituent detected at the IAAAP for each medium. The SVs are media-specific concentrations, where there is sufficient concern to warrant further investigation regarding the potential for adverse ecological effects. The SVs are not specific to a particular species or particular adverse effect on a species. The SVs are meant to be protective of most organisms. For each media, a literature search was conducted to obtain screening levels to protect a broad range of organisms. Selection of SVs for each media is discussed below.

3.1.1. Surface Water Screening Values

Surface water SVs are available from multiple sources:

- U.S. Environmental Protection Agency National Ambient Water Quality Criteria (NAWQC) (USEPA, 1999a) - NAWQC are available for 157 pollutants. Criterion continuous concentration (CCC) for fresh water is one of the criteria. A CCC is an estimate of the highest concentration of a material in surface water to which an aquatic community, such as algae and fish, can be exposed indefinitely without resulting in an unacceptable effect.

- Oak Ridge National Laboratory (ORNL) PRGs for Ecological Endpoints (Efroymson and others, 1997a) - These PRGs, developed by ORNL, are upper concentration limits for contaminants in surface water that are anticipated to protect aquatic life, and should correspond with an acceptable level of effect on aquatic ecological assessment endpoints. The PRGs were developed using two types of toxicological benchmarks: quantities derived from toxicity test endpoints and Applicable or Relevant and Appropriate Requirements (ARARs) for remedial action. Although the PRGs were developed for ORNL, they have been widely used at other facilities for screening purposes.

- U.S. Environmental Protection Agency Ecotox Database (USEPA, 1996a) - Media-specific No Observed Adverse Effects Level (NOAEL) and Lowest Observed Adverse Effects Level (LOAEL) values are available from the Ecotox database. The database for surface water (Aquire) lists NOAELs and/or LOAELs for different organisms.

- U.S. Environmental Protection Agency Region 4 Surface Water Chronic Screening Values for Hazardous Waste Sites (USEPA, 1999b) - These represent the chronic ambient water quality criteria for the protection of aquatic life. The lowest reported effect level divided by a safety factor of 10 was used if there was insufficient information available to derive a criterion. A safety factor of ten was also used to derive a chronic value if only acute information was available.

- National Oceanic and Atmospheric Administration (NOAA) Freshwater Chronic Ambient Water Quality Criteria (NOAA, 1999) - These values were developed by the Coastal Protection and Restoration Division of NOAA and are intended for preliminary screening purposes. They and primarily include USEPA (1999a) values.

- U.S. Environmental Protection Agency Ecotox Thresholds Update (USEPA, 1996b) - The surface water Ecotox benchmark values were derived primarily from chronic Ambient Water Quality Criteria (AWQC). If the AWQC was not available for a constituent, Great Lakes Water Quality Initiative Tier I and Tier II methods were used to calculate benchmark values.

- Oak Ridge National Laboratory Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota (Suter and Tsao, 1996) - Screening benchmarks for chemicals that have been detected in Oak Ridge were developed.

- U.S. Environmental Protection Agency Region 3 Biological Technical Assistance Group (BTAG) Ecological Screening Values (USEPA, 1995).

- Nitroaromatic Munition Compounds Screening Values (Talmage and others, 1999).

- U.S. Environmental Protection Agency Region 5 Ecological Data Quality Levels (EDQL) (USEPA, 1999c) - USEPA (1999c) did not present a discussion on how these values were developed. However, EDQL values appear to have been developed based on conservative assumptions.

The lowest available SV from all listed sources was selected as the surface water SV, except USEPA Region 5 EDQLs (USEPA, 1999c), which were used as SVs in the absence of other benchmarks. The SVs for surface water are presented in Table 3-1.

3.1.2. Sediment Screening Values

Sediment SVs selected from multiple sources are listed below:

- U.S. Environmental Protection Agency Ecological Benchmarks (USEPA, 1999d) - The sediment benchmarks are primarily based on measured sediment concentrations that resulted in minimal effects to biota.

- U.S. Environmental Protection Agency Region 4 Chronic Screening Values for Hazardous Waste Sites (USEPA, 1999b) - These values, based on studies in marine environment, were derived from statistical interpretation of observations of direct toxicity.

- Oak Ridge National Laboratory PRGs for Ecological Endpoints (Efroymson and others, 1997a) - The PRGs were developed from several sources, such as the NOAA Effects Range-Low (ER-L), Florida Department of Environmental Protection sediment document, and USEPA ARCS Program Probable Effects Concentration. The lowest of these available values was selected as the PRG.

- U.S. Environmental Protection Agency Region 3 BTAG Ecological Screening Values (USEPA, 1995).

- Nitroaromatic Munition Compounds Screening Values (Talmage and others, 1999).

- For organics only, values calculated using the USEPA Equilibrium Partitioning Method (USEPA, 1993) - Sediment screening concentrations can be estimated based on equilibrium partitioning as the product of the surface water SV, the fraction of organic carbon in sediment, and the organic carbon partition coefficient (Koc). The total organic carbon (TOC) content was measured for each sediment sample collected at the IAAAP in September 2000. The analytical results are presented in Table 3-2. Koc values are available in the literature (USEPA, 1996c; USEPA, 1990). Sediment screening values were calculated for each constituent based on the measured TOC and literature-based Koc values.

- U.S. Environmental Protection Agency Region 5 EDQLs (USEPA, 1999c).

Sediment ecological benchmarks listed in USEPA (1999d) were used preferentially as SVs. In the absence of data from USEPA (1999d), SVs developed by USEPA Region 4 were used. Preliminary remedial goals listed in Efroymson and others (1997) were used as SVs in the absence of data from USEPA (1999b), USEPA Region 4, and so on. The SVs for sediment are presented in Table 3-3.

3.1.3. Soil Screening Values

Soil SVs were selected from sources presented below.

- U.S. Environmental Protection Agency Ecological Benchmarks (USEPA, 1999d) - USEPA derived soil ecological benchmarks for the terrestrial plant and soil communities. For the terrestrial plant community, benchmarks were developed from Efroymson and others (1997b) based primarily on phytotoxic effects. For the soil community, benchmarks were developed based on No Observed Effects Concentration to reproductive and developmental endpoints. A second set of benchmarks for the soil community was developed based on Low Observed Effects Concentration for earthworms and microbial endpoints using the ER-L. The lowest of the benchmarks were selected as ecological benchmarks by USEPA (1999d).

- U.S. Environmental Protection Agency Region 4 Chronic Screening Values for Hazardous Waste Sites (USEPA, 1999b).

- Oak Ridge National Laboratory PRGs for Ecological Endpoints (Efroymson and others, 1997a).

- U.S. Environmental Protection Agency Region 3 BTAG Ecological Screening Values (USEPA, 1995).

- Nitroaromatic Munition Compounds Screening values (Talmage and others, 1999).

- U.S. Environmental Protection Agency Region 5 EDQLs (USEPA, 1999c).

- U.S. Environmental Protection Agency Ecotox Database (USEPA, 1996a) - Media-specific NOAELs and LOAELs for single chemicals are available from the Ecotox database. The database for soil (Terratox) lists NOAEL and/or LOAELs for different organisms. The Terratox database was queried to identify the lowest NOAEL or 10% of the LOAEL values for each chemical.

U.S. Environmental Protection Agency ecological benchmarks (USEPA, 1999d) were used preferentially as SVs. Soil screening benchmarks listed by USEPA Region 4 were used as SVs in their absence. Preliminary remedial goals, listed in Efroymson and others

(1997a), were used as SVs in the absence of data from USEPA (1999d), USEPA Region 4, and so on. The SVs for soil are presented in Table 3-4.

3.2. WATER COPECS

3.2.1. Comparison To Screening Levels

Chemicals of potential ecological concern for surface water were identified on a watershed basis. Maximum concentrations of constituents detected in surface water in each watershed were compared to the corresponding surface water SVs and are presented in Tables 3-5 through 3-8.

3.2.2. Evaluation of Laboratory Contamination

Dalapon, a pesticide, was detected in two of the 37 surface water samples used in the ERA. The laboratory determined that seven samples had dalapon contamination in laboratory blanks. Concentrations detected in the two investigative samples were lower than a sample identified to be blank contaminated. Dalapon was eliminated from further consideration because of possible blank contamination. No other laboratory contamination issues for surface water samples were identified.

3.2.3. Constituents without available SVs

Screening Values in surface water are not available for a number of compounds, including several explosives and metals detected in other media. These constituents were selected as COPECs in surface water. However, the herbicide dicamba was detected at trace levels (less than 1 part per billion (ppb) in four of the 37 surface water samples. A surface water screening value is not available for dicamba. Information on toxicity to birds and aquatic organisms is available in USEPA's Ecotox and Extoxnet, a cooperative project involving Cornell University, Oregon State University, University of Idaho, University of California at Davis, and Michigan State University, and funded by the U. S. Department of Agriculture. Based on avian toxicity studies, dicamba would be considered low in toxicity for avian species. Mallard and bobwhite quail LC50s (lethal concentration at which 50% of test animals die) were greater than 10,000 part per million (ppm). For aquatic insects and fish, available LC50 values are greater than 10,000 ppm. Based on these studies, dicamba was eliminated from consideration as a COPEC because it is anticipated that the trace concentrations detected would not be associated with toxic effects.

3.2.4. Constituents Detected at Low Frequency

Several chemicals were detected at a frequency of less than 5 percent in surface water, and not at all in other media. These include 2,4-D (one in 27 samples), 2,4-DB (one in 27), and pentachlorophenol (one in 27). The 2,4-D detection was at LC1, upgradient of Long Creek. None of these constituents were detected in any of the source areas. Therefore, they were eliminated as COPECs in surface water. There were several other constituents detected at low frequency (less than 5 percent) in surface water. However, these constituents were retained as COPECs because they were also detected in the source area.

3.3. SEDIMENT COPECS

3.3.1. Comparison to Screening Levels

Sediment COPECs were also identified on a watershed basis, based on a comparison of maximum detected concentrations to SVs, and are presented in Tables 3-9 through 3-12.

3.3.2. Constituents Without Available SVs

Screening values in sediment are not available for a number of compounds, including several explosives and metals detected in other media. These constituents were selected as COPECs in sediment.

3.3.3. Constituents Detected at Low Frequency

There were several constituents detected at a low frequency in sediment. However, these constituents were retained as COPECs because they were also detected in the source area.

3.4. SOIL COPECS

3.4.1. Comparison to Screening Levels

The soil data include analytical results of soil samples collected during the RI and the SI, including samples from drainageways termed sediment in the RI, but representative of soil. Data for soil samples collected from the top two feet were only used in the SLERA. The maximum soil concentrations of each constituent detected at each AOC were compared to soil SVs as discussed in Section 3.1. Resulting COPECs are presented in Tables 3-13 through 3-32.

3.4.2. Comparison to Background Levels

During the RI, over 100 soil samples were collected to establish background conditions for inorganic constituents at IAAAP (JAYCOR, 1996). Samples were collected from 28 locations at three depth intervals: 0-0.5 feet, 1.5-2.0 feet, and 3.0-3.5 feet, which were comparable to the depth interval of two feet selected for site-specific constituents. All samples were collected within IAAAP, but upgradient with respect to overland surface drainage and groundwater flow from all site features, production, and waste handling activities.

The results of the analysis for background inorganic constituents are summarized in Appendix C3 of the BERA, including minimum concentrations, maximum concentrations, mean, standard deviation, and mean plus several combinations of standard deviations. The mean plus two standard deviation value (approximately 95th percentile) for each inorganic in background soils is listed for each AOC in Tables 3-13 through 3-32. Constituents were not selected as COPECs at a specific AOC if the maximum concentration was less than the 95th percentile of the background value. Based on such comparison, several inorganics in several AOCs were eliminated as COPECs.

3.4.3. Constituents Without Available SVs

SVs in soil are not available for a number of compounds, including several explosives and metals detected in other media. These constituents were selected as COPECs in soil.

3.4.4. Aluminum Chemistry

U.S. Environmental Protection Agency (2000) recognizes that aluminum is often identified as a COPEC because it is ubiquitous in nature and the available soil screening levels are conservative. The aluminum data used in the SLERA is based on concentrations of total aluminum in soils and not soluble aluminum. Total aluminum in soil is not correlated with toxicity to plants and soil invertebrate; aluminum toxicity is associated with soluble aluminum. An indirect approach for determining the presence of soluble aluminum using soil pH data is available. Soluble aluminum is not present in soils at a pH higher than 5.5. USEPA (2000) states that aluminum should not be identified as a COPEC if soil pH is greater than 5.5.

Aluminum concentrations in soil at IAAAP exceeded the background concentration at four locations. Soil samples were collected in 2003 from near these RI sample locations and analyzed for pH. Sample locations, total aluminum concentrations, and soil pH data for these four samples are presented in Table 3-33. Soil pH at these locations ranged from 7.1 to 8.0, much higher than the 5.5 value cited by USEPA. Therefore, in accordance with USEPA (2000), aluminum was eliminated as a soil COPEC.

3.5. CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN

The screening level evaluation summarized above indicates a number of chemicals are present at IAAAP at levels that pose potential ecological risks. At most AOCs, metals and explosive chemicals are the primary COPECs, with pesticides, SVOCs, Aroclor 1260, and PAH of concern locally. The list of COPECs by media is summarized in Tables 3-34 and 3-35.

4.0 CONCLUSIONS

The screening level evaluation presented in this SLERA indicates that a number of chemicals are present at IAAAP at levels that indicate potential ecological risks.

The COPECs for surface water, sediment, and soil which are the result of this SLERA are listed in Tables 3-34 and 3-35. Metals and explosives are the primary COPECs. Pesticides and VOCs are COPECs at selected AOCs. Based on this, it appears that a BERA with the selected COPECs is required at IAAAP to more fully evaluate potential ecological risks.

There are several uncertainties associated with the conclusion of the SLERA. Uncertainties are introduced at various points throughout the process; a product of the uncertainties associated with the data and assumptions used. Several factors contribute to the selection of COPECs that are probably not of concern. These include:

- The relative lack of upstream data on constituent concentrations in surface water and sediment, possibly leading to the selection of COPECs which may not be site related;

- The lack of availability of SVs for several detected constituents in soil, surface water, and sediment, potentially leading to selection of COPECs which may not pose ecological risk; and,

- Uncertainties involved in extrapolating SVs derived from controlled studies conducted in laboratories to ecosystems in general. The derived SVs routinely incorporate conservative uncertainty factors.

A few chemicals were not detected, but their detection limits may be greater than their corresponding SVs. This could contribute to the elimination of a constituent as a COPEC, while it may be of concern. The impact of such elimination is expected to be small.

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Appendix A-1

Tables

Table 2-1.
Present Land Use/Land Cover at the IAAAP (acres[a])

	Brush Creek	**Skunk River**	**Long Creek**	**Spring Creek**	**Totals**
Forest	563	1,441	2,693	1,386	6,083
Flood Plain Forest	221	72	483	296	1,073
Old Field	981	258	1,073	590	2,901
Wetlands	7	0	2	27	35
Agriculture	1,909	412	2,487	1,100	5,908
Base Facilities	681	115	236	58	1,090
Open Water, Pond/Lake	15	5	128	7	155
Residential	0	0	69	0	69
Disturbed (barren)	107	4	0	46	157
Base Facilities/Old Fields	529	192	497	384	1,601
Totals	5,014	2,499	7,669	3,892	

a) Indicated acreages are approximate, based on estimates from air photos and maps. Totals do not equal actual IAAAP area of 19,011 acres due to cumulative measurement error.

Table 3-1
Surface Water Screening Values (ug/L)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	NAWQC[1]	PRGs[2]	Ecotox[3]		USEPA IV[4]	Supplemental Values [5,6,7,8,9]	Water EDQL[10]	Surface Water SV
			10% Aquire LOEL	Aquire NOEL				
1,1,1,2-Tetrachloroethane						2400 [5]	90.25	2400
1,1,1-Trichloroethane		11		1300	528		88	11
1,1,2,2-Tetrachloroethane		610	7230	8800	240		13	240
1,1,2-Trichloroethane		1200	7480	31000	940		650	940
1,1-Dichloroethane		47			303	47 [6]	47	47
1,1-Dichloroethene		25		56000			78	25
1,2,3-Trichloropropane							12.11	12.11
1,2,4-Trichlorobenzene		110	1130	5600	44.9		69.2	44.9
1,2-Dibromoethane			9620	5810			22.5	5810
1,2-Dichlorobenzene		14	1000	630	15.8		11	14
1,2-Dichloroethane		910		130000	2000		190	910
1,2-Dichloropropane				29000	525		380	525
1,3,5-Trinitrobenzene		14	100	80		11 [9]		9
1,3-Dichlorobenzene		71	2300	300	50.2		87	50.2
1,3-Dinitrobenzene		30	970	260		20 [9]	2.36	20
1,4-Dichlorobenzene		15	263	300	11.2		43	11.2
2,2'-Oxybis(1-Chloro)Propane							20	20
2,4,5-T							686.33	686.33
2,4,5-Trichlorophenol			34	62.5		63 [5]		5
2,4,6-Trichlorophenol			750		3.2	970 [5]	2	3.2
2,4,6-Trinitrotoluene		130	5000	2300		90 [9]		9
2,4-D			50000	10000				10000
2,4-Dichlorophenol					36.5		18	36.5
2,4-Dimethylphenol			4000	2000	21.2		100.17	21.2
2,4-Dinitrophenol			1050	500	6.2		4.07	6.2
2,4-Dinitrotoluene		230		20	310		230	20
2,6-Dinitrotoluene				60			42	60
2-Butanone		14000		400000			7100	14000

Table 3-1
Surface Water Screening Values (ug/L)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	NAWQC[1]	PRGs[2]	Ecotox[3] 10% Aquire LOEL	Ecotox[3] Aquire NOEL	USEPA IV[4]	Supplemental Values [5,6,7,8,9]	Water EDQL[10]	Surface Water SV
2-Chloronaphthalene							0.396	0.396
2-Chlorophenol				300	43.8		8.8	43.8
2-Hexanone		99					1710	99
2-Methylnaphthalene							329.55	329.55
2-Methylphenol		13				489 [7]		13
2-Nitroaniline				38000				38000
2-Nitrophenol				24000	3500		13.5	3500
2-Nitrotoluene			8700	4400				4400
3,3'-Dichlorobenzidine							99.75	99.75
3-Nitroaniline			54000	28000				28000
4,4'-DDD		0.000041	1000		0.0064		0.0011	0.000041
4,4'-DDE					15		4.96E-09	15
4,4'-DDT	0.001	0.000041	100		0.001		0.000952	0.000041
4,6-Dinitro-2-Methylphenol			407	183			2.3	183
4-Bromophenyl Phenyl Ether							1.5	1.5
4-Chloro-3-Methylphenol			5700	1300	0.3		20	0.3
4-Chloroaniline			1000	10		50 [5]	231.97	10
4-Chlorophenyl Phenyl Ether								NF
4-Methyl-2-Pentanone		170					3680	170
4-Methylphenol				1000		489 [8]		489
4-Nitroaniline								NF
4-Nitrophenol		300	100	300	82.8		35	82.8
Acenaphthene		23		1000	17		9.9	17
Acenaphthylene							4840	4840
Acetone		1500		16200			78000	1500
Aldrin			100		0.3		0.0185	0.3
Alpha BHC		0.004			5000		12.38	0.004
Alpha Endosulfan	0.056	0.051					0.003	0.051

Table 3-1
Surface Water Screening Values (ug/L)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	NAWQC[1]	PRGs[2]	Ecotox[3] 10% Aquire LOEL	Ecotox[3] Aquire NOEL	USEPA IV[4]	Supplemental Values [5,6,7,8,9]	Water EDQL[10]	Surface Water SV
Aluminum	87	87			87			87
Anthracene		0.73					0.029	0.73
Antimony		30		6200	160		31	30
Arochlor 1016		0.23			0.014			0.014
Arochlor 1221		0.28			0.014			0.014
Arochlor 1232		0.58			0.014			0.014
Arochlor 1242		0.047			0.014			0.014
Arochlor 1248		0.0019			0.014			0.0019
Arochlor 1254		0.0019			0.014			0.0019
Arochlor 1260		94			0.014			0.014
Arsenic	150	3.1		750	190		53	3.1
Barium		4		500000		3.9 [6]	5000	3.9
Benzene		130	17200	10200	53		114	53
Benzo(a)Anthracene		0.027					0.839	0.027
Benzo(a)Pyrene		0.014	10000				0.014	0.014
Benzo(b)Fluoranthene							9.07	9.07
Benzo(g,h,i)Perylene							7.64	7.64
Benzo(k)Fluoranthene							0.0056	0.0056
Benzoic Acid		42						42
Benzyl Alcohol		8.6					281.24	8.6
Benzyl Butyl Phthalate		19	1400	60			49	19
Beryllium		0.66			0.53		7.6	0.53
Beta BHC		0.004		32	50000		0.495	0.004
Beta Endosulfan	0.056	0.051					0.003	0.051
Bis(2-Chloroethoxy) Methane						11000 [5]	6400	11000
Bis(2-Chloroethyl) Ether					2380		1140	2380
Bis(2-Ethylhexyl) Phthalate		0.12	160	77	0.3		2.1	0.12
Bromodichloromethane						11000 [5]		11000

Table 3-1
Surface Water Screening Values (ug/L)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	NAWQC[1]	PRGs[2]	Ecotox[3]		USEPA IV[4]	Supplemental Values [5,6,7,8,9]	Water EDQL[10]	Surface Water SV
			10% Aquire LOEL	Aquire NOEL				
Bromoform				2900	293		466	293
Bromomethane				100				100
Cadmium	2.2	1	1.5	0.7	0.66		0.66	0.66
Carbazole				10000				10000
Carbon Disulfide		0.92					84.1	0.92
Carbon Tetrachloride		9.8	73200	37100	352		5.9	9.8
Chlordane	0.0043	0.037			0.0043		0.00029	0.0043
Chlorobenzene		64		1400	195		10	64
Chloroethane							230000	230000
Chloroform		28	1000	560	289		79	28
Chloromethane		2200			5500			2200
Chromium, Total	74	210	2400	2000			42	74
Chrysene							0.033	0.033
cis-1,3-Dichloropropene					24.4		7.9	24.4
Cobalt		23				3 [6]	5	3
Copper	9	12	7.7	3.1	6.54		5	3.1
Cyanide	5.2	5.2	44.6	29	5.2		5.2	5.2
Delta BHC		0.004					666.67	0.004
Di-N-Butyl Phthalate		1	190	100			3	1
Di-N-Octylphthalate							30	30
Dibenz(a,h)Anthracene							0.0016	0.0016
Dibenzofuran		3.7		1000			20	3.7
Dibromochloromethane							6400	6400
Dibromomethane								NF
Dichlorodifluoromethane						11000 [5]		11000
Dieldrin	0.056		0.6	0.06	0.0019		0.000026	0.0019
Diethyl Phthalate		210	59000	1650	521		3	210
Dimethyl Phthalate			23000	3200	330		73	330

Table 3-1
Surface Water Screening Values (ug/L)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	NAWQC[1]	PRGs[2]	Ecotox[3]		USEPA IV[4]	Supplemental Values [5,6,7,8,9]	Water EDQL[10]	Surface Water SV
			10% Aquire LOEL	Aquire NOEL				
Dinoseb			171	105			0.39	105
Endosulfan Sulfate							2.22	2.22
Endrin	0.036	0.061	100		0.0023		0.002	0.0023
Endrin Aldehyde							0.15	0.15
Ethylbenzene		7.3	2700	1000	453		17.2	7.3
Fluoranthene		6.2	14.7	3.5	39.8		8.1	3.5
Fluorene		3.9					3.9	3.9
Gamma BHC		0.08	0.6	0.2	0.08		0.01	0.08
Heptachlor	0.0038	0.0069	10		0.0038		0.00039	0.0038
Heptachlor Epoxide	0.0038				0.0038		0.00048	0.0038
Hexachlorobenzene				4.8		3.68 [5]	0.00000547	3.68
Hexachlorobutadiene					0.93		0.134	0.93
Hexachlorocyclopentadiene				9	0.07		77.04	0.07
Hexachloroethane		12		1000	9.8		30.5	9.8
HMX		330				330 [9]		330
Indeno(1,2,3-c,d)Pyrene							4.31	4.31
Iron	1000	1000			1000			1000
Isophorone				79000	1170		900	1170
Lead	2.5	3	7.6	4	1.32		1.3	1.32
M,P-Xylene		13	40000	20000			117	13
Manganese		120		28000		80 [6]		6
MCPA			2130	0				NF
Mercury	0.77	1.3		0.7	0.012		0.0013	0.012
Methoxychlor	0.03	0.019		360	0.03		0.005	0.019
Methylene Chloride		2200		56000	1930		430	1930
N-Nitrosodi-N-Propylamine								NF
N-Nitrosodiphenylamine		210			58.5		13	58.5
Naphthalene		12			62		44	12

Table 3-1
Surface Water Screening Values (ug/L)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	NAWQC[1]	PRGs[2]	Ecotox[3] 10% Aquire LOEL	Ecotox[3] Aquire NOEL	USEPA IV[4]	Supplemental Values [5,6,7,8,9]	Water EDQL[10]	Surface Water SV
Nickel	52	160			87.7		29	52
Nitrobenzene			10200	2600	270		740	270
Pentachlorophenol	15		5	5	13		5.23	5
Phenanthrene		6.3	38	19		6.3 [5]	2.1	6.3
Phenol		110	100	10	256		100	10
Pyrene							0.3	0.3
RDX		190	2360	500		190 [9]		9
Selenium	5	0.39	80	40	5		5	0.39
Silver		0.36		13.4	0.012		1	0.012
Silvex (2,4,5-TP)							326.64	326.64
Styrene			280	63			56	63
Tetrachloroethene		98	3100	17000	84		8.9	84
Tetryl								NF
Thallium		9		14000	4		0.56	4
Toluene		9.8	6000	1000	175		253	9.8
Toxaphene	0.0002		100	0.039	0.0002		0.0002	0.0002
trans-1,2-Dichloroethene		590			1350		310	590
trans-1,3-Dichloropropene					24.4		7.9	24.4
Trichloroethene		47	11000	40000		21900 [5]	75	47
Trichlorofluoromethane						11000 [5]		11000
Vanadium		20				19 [6]	19	19
Vinyl Chloride		782					9.2	782
Xylenes, Total		13	40000	20000			117	13
Zinc	120	110			5.2		58.9	5.2

Notes:

1) USEPA National Ambient Water Quality Criteria (NAWQC), USEPA, 1999a

2) Efroymson and others, 1997a

Table 3-1
Surface Water Screening Values (ug/L)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	NAWQC[1]	PRGs[2]	Ecotox[3]		USEPA IV[4]	Supplemental Values [5,6,7,8,9]	Water EDQL[10]	Surface Water SV
			10% Aquire LOEL	Aquire NOEL				

3) USEPA, 1996a

4) USEPA Region IV, 1999b Waste Management Division Freshwater Surface water Chronic Screening Values for Hazardous Waste sites

5) NOAA, 1999, Screening Quick Ref. Tables. Freshwater chronic ambient water quality criteria

6) OSWER Ecotox Thresholds. Presented in: ECO Update, 1996b. EPA 540/F-95/038

7) Lowest Chronic value for all species tested: Suter and Tsao, 1996

8) USEPA Region III, 1995, BTAG Ecological Screening values

9) Talmage, et.al., 1999. Nitroaromatic Munition Compounds: Environmental Effects and Screening values.

10) U.S. EPA, Region 5 EDQL, 1999c

NF: Not Found

Table 3-2
Data Summary of Total Organic Carbon in Sediment (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Station Descritpion	Analyte Name	Number of Samples	Number of Detects	Maximum Concentration	Minimum Concentration	Average Concentration	UCL	lnUCL	EPC	f_{oc}
Brush Creek	Total Organic Carbon	4	4	21700	7360	13815	21084.68	45197.65	21700	0.0217
Long Creek	Total Organic Carbon	5	5	23400	7310	12156	18720.52	26379.17	23400	0.0234
Spring Creek	Total Organic Carbon	4	4	11400	688	3747	9770.807	8185685	11400	0.0114

Table 3-3
Sediment Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values [4,5]	SEC[6]	Sediment EDQL[7]	Sediment SV
1,1,1,2-Tetrachloroethane					47.800	0.01089	47.800
1,1,1-Trichloroethane	0.03		0.03	0.17 [4]	0.078	0.24685	0.030
1,1,2,2-Tetrachloroethane			5.4	0.94 [4]	1.379	0.02908	5.400
1,1,2-Trichloroethane			1.257		2.468	0.67351	1.257
1,1-Dichloroethane			0.027		0.068	0.000575	0.027
1,1-Dichloroethene			0.031		0.079	0.02327	0.031
1,2,3-Trichloropropane					0.053	0.00835	0.053
1,2,4-Trichlorobenzene			9.7	0.64 [4]	10.751	11.7	9.700
1,2-Dibromoethane					12.399	0.01237	12.399
1,2-Dichlorobenzene			0.33	0.50 [4]	0.882	0.23132	0.330
1,2-Dichloroethane			0.256		0.628	0.05418	0.256
1,2-Dichloropropane					1.147	0.35161	1.147
1,3,5-Trinitrobenzene			0.002	0.24 [5]	0.006	0.000121	0.002
1,3-Dichlorobenzene			1.7	0.17 [4]	4.676	3.01	1.700
1,3-Dinitrobenzene			0.018	0.67 [5]	0.020	0.000924	0.018
1,4-Dichlorobenzene			0.35	0.12 [4]	0.689	1.45	0.350
2,2'-Oxybis(1-Chloro)Propane					0.141	0.06878	0.141
2,4,5-T					32.791	58.7	32.791
2,4,5-Trichlorophenol					6.320	0.08556	6.320
2,4,6-Trichlorophenol					0.375	0.08484	0.375
2,4,6-Trinitrotoluene			0.035	0.92 [5]	0.226		0.035
2,4-D					151.083	0.00579	151.083
2,4-Dichlorophenol					1.027	0.13363	1.027
2,4-Dimethylphenol					0.114	0.30453	0.114
2,4-Dinitrophenol					0.005	0.00133	0.005
2,4-Dinitrotoluene			0.214		0.048	0.07513	0.214
2,6-Dinitrotoluene					0.104	0.02062	0.104
2-Butanone			0.27		0.596	0.13696	0.270
2-Chloronaphthalene					0.088	0.41723	0.088

Table 3-3
Sediment Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values [4,5]	SEC[6]	Sediment EDQL[7]	Sediment SV
2-Chlorophenol					0.145	0.0117	0.145
2-Hexanone			0.023		0.056	1.01	0.023
2-Methylnaphthalene		0.33			99.343	0.0202	0.330
2-Methylphenol				0.63 [4]	0.030	0.000826	0.630
2-Nitroaniline					62.951	0.000222	62.951
2-Nitrophenol					5.050	0.00777	5.050
2-Nitrotoluene					20.543		20.543
3,3'-Dichlorobenzidine					7.553	0.02822	7.553
3-Nitroaniline					15.359	0.000222	15.359
4,4'-DDD		0.0033	0.0078		0.000	0.00553	0.003
4,4'-DDE		0.0033	0.0022		171.912	0.00142	0.003
4,4'-DDT		0.0033	0.052		0.001	0.00119	0.003
4,6-Dinitro-2-Methylphenol					0.565	0.01038	0.565
4-Bromophenyl Phenyl Ether			1.2		3.057	1.55	1.200
4-Chloro-3-Methylphenol					0.009	0.38818	0.009
4-Chloroaniline					0.017	0.14608	0.017
4-Chlorophenyl Phenyl Ether					NA	0.65612	0.656
4-Methyl-2-Pentanone			15		0.081	0.54437	15.000
4-Methylphenol			0.012	0.20 [4]	0.997	0.000808	0.012
4-Nitroaniline					NA	0.000222	0.000
4-Nitrophenol					0.157	0.00778	0.157
Acenaphthene		0.33	0.089		3.309	0.00671	0.330
Acenaphthylene		0.33	0.13		56.736	0.00587	0.330
Acetone			0.0091		0.020	0.45337	0.009
Aldrin			0.08		22.199	0.002	0.080
Alpha BHC			120		0.001	0.006	120.000
Alpha Endosulfan			0.0055		0.008	0.000175	0.006
Aluminum					NA		NF
Anthracene		0.33	0.25		0.606	0.0469	0.330

Table 3-3
Sediment Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values [4,5]	SEC[6]	Sediment EDQL[7]	Sediment SV
Antimony	2	12			NA		2.000
Arochlor 1016			0.53	0.33 [4]	0.160		0.530
Arochlor 1221		0.067	0.12		0.015		0.067
Arochlor 1232			0.6	0.33 [4]	0.008		0.600
Arochlor 1242			29	0.33 [4]	0.717		29.000
Arochlor 1248			1	0.33 [4]	0.070		1.000
Arochlor 1254			72	0.33 [4]	0.141		72.000
Arochlor 1260			63	0.33 [4]	2.663		63.000
Arsenic	7.2	7.24	42		NA	5.9	7.200
Barium					NA		NF
Benzene	0.16		0.16	0.57 [4]	0.167	0.14157	0.160
Benzo(a)Anthracene		0.33	0.69		0.317	0.0317	0.330
Benzo(a)Pyrene	0.089	0.33	0.394		0.422	0.0319	0.089
Benzo(b)Fluoranthene		0.655	4		336.375	10.4	0.655
Benzo(g,h,i)Perylene		0.655	6.3		762.622	0.17	0.655
Benzo(k)Fluoranthene		0.655	4		0.208	0.24	0.655
Benzoic Acid				0.65 [4]	0.071		0.650
Benzyl Alcohol			0.0011		0.003	0.03394	0.001
Benzyl Butyl Phthalate					30.759	4.19	30.759
Beryllium					NA		NF
Beta BHC			120		0.001	0.005	120.000
Beta Endosulfan			0.0055		0.008	0.000104	0.006
Bis(2-Chloroethoxy) Methane					5.136	0.34971	5.136
Bis(2-Chloroethyl) Ether					0.903	0.21196	0.903
Bis(2-Ethylhexyl) Phthalate	0.18	0.182	2.7		56.027	0.182	0.180
Bromodichloromethane					32.405	0.00113	32.405
Bromoform					1.535	0.99627	1.535
Bromomethane					0.036	0.000148	0.036
Cadmium	0.68	1	4.2		NA	0.596	0.680

Table 3-3
Sediment Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values [4,5]	SEC[6]	Sediment EDQL[7]	Sediment SV
Carbazole					910.366		910.366
Carbon Disulfide	0.00085		0.00086		0.002	0.13397	0.001
Carbon Tetrachloride			2		0.123	0.03573	2.000
Chlordane		0.0017	0.0048		0.101	0.0045	0.002
Chlorobenzene	0.41		0.417		1.085	0.06194	0.410
Chloroethane					144.858	58.6	144.858
Chloroform	0.022		0.96		0.054	0.027	0.022
Chloromethane			0.374		0.418	0.0000785	0.374
Chromium, Total	52	52	159		NA	26	52.000
Chrysene		0.33	0.85		0.387	0.0571	0.330
cis-1,3-Dichloropropene			0.23		0.057	0.00296	0.230
Cobalt					NA	50	50.000
Copper		18.7	77.7		NA	16	18.700
Cyanide					0.000	0.0001	0.000
Delta BHC			120		0.001	71.5	120.000
Di-N-Butyl Phthalate			240		0.953	0.1105	240.000
Di-N-Octylphthalate					80600.384	40.6	80600.384
Dibenz(a,h)Anthracene	0.0062	0.33	0.0282		0.183	0.00622	0.006
Dibenzofuran			0.42		1.141	1.52	0.420
Dibromochloromethane					22.151	0.26761	22.151
Dibromomethane					NA	0.0000859	0.000
Dichlorodifluoromethane					37.206	0.00133	37.206
Dieldrin		0.0033	0.0043		0.010	0.002	0.003
Diethyl Phthalate			0.61		1.554	0.00804	0.610
Dimethyl Phthalate					0.307	0.02495	0.307
Dinoseb					8.921	0.01178	8.921
Endosulfan Sulfate					0.237	0.0346	0.237
Endrin			0.00002		0.006	0.00267	0.000
Endrin Aldehyde					0.221	3.2	0.221

Table 3-3
Sediment Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values [4,5]	SEC[6]	Sediment EDQL[7]	Sediment SV
Ethylbenzene			5.4	3.60 [4]	0.236	0.0001	5.400
Fluoranthene		0.33	0.834		10.797	0.1113	0.330
Fluorene		0.33	0.14		1.480	0.0212	0.330
Gamma BHC			0.00099		0.010	0.00094	0.001
Heptachlor			13		0.162	0.0006	13.000
Heptachlor Epoxide				0.60 [4]	0.009	0.0006	0.600
Hexachlorobenzene					66.844	0.02	66.844
Hexachlorobutadiene					1.405	1.38	1.405
Hexachlorocyclopentadiene					0.402	0.90074	0.402
Hexachloroethane			1		2.293	2.23	1.000
HMX			0.006	0.47 [5]	0.011		0.006
Indeno(1,2,3-c,d)Pyrene		0.655	0.837		450.498	0.2	0.655
Iron			20000		NA		20000.000
Isophorone					1.372	0.4223	1.372
Lead	30	30	110		NA	31	30.000
M,P-Xylene			0.16	0.25 [4]	0.440	1.88	0.160
Manganese					NA		NF
MCPA					NA		NF
Mercury	0.13	0.13	0.7		NA	0.174	0.130
Methoxychlor	0.019		0.019		0.053	0.00359	0.019
Methylene Chloride	0.37		18		0.803	1.26	0.370
N-Nitrosodi-N-Propylamine					NA	0.000217	0.000
N-Nitrosodiphenylamine					1.979	0.15524	1.979
Naphthalene		0.33	0.39		0.643	0.0346	0.330
Nickel	16	15.1	38.5		NA	16	16.000
Nitrobenzene					0.437	0.4876	0.437
Pentachlorophenol				0.69 [4]	14.394	30.1	0.690
Phenanthrene		0.33	0.54		4.252	0.0419	0.330
Phenol	0.031		0.032		0.007	0.02726	0.031

Table 3-3
Sediment Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values [4,5]	SEC[6]	Sediment EDQL[7]	Sediment SV
Pyrene		0.33	1.4		0.904	0.053	0.330
RDX			4.682	0.13 [5]	0.031		4.682
Selenium					NA		NF
Silver	0.73	2	1.8		NA	0.5	0.730
Silvex (2,4,5-TP)					48.226	7.35	48.226
Styrene					1.284	0.44496	1.284
Tetrachloroethene			0.409		0.919	0.19583	0.409
Tetryl					NA		NF
Thallium					NA		NF
Toluene	0.05		0.05	0.67 [4]	0.129	52.5	0.050
Toxaphene					0.001	0.000109	0.001
trans-1,2-Dichloroethene			0.4		1.622	0.20894	0.400
trans-1,3-Dichloropropene			0.23		0.057	0.00296	0.230
Trichloroethene	0.22		0.215		0.564	0.17956	0.220
Trichlorofluoromethane					80.082	0.00307	80.082
Vanadium					NA		NF
Vinyl Chloride					0.579	0.002	0.579
Xylenes, Total			0.16		0.440	1.88	0.160
Zinc	120	124	270		NA	120	120.000

Notes:

1) Data Collection for the Hazardous Waste Identification Rule - Ecological Benchmarks EPA, 1999d

2) USEPA Region IV, 1999b Waste Management Division Chronic Screening Values for Hazardous Waste sites, online

3) Preliminary Remediation Goals, R. A. Efroymson and others, U.S. Depertment of Energy ES/ER/TM-162/R2 1997a

4) USEPA Region III, 1995, BTAG Ecological Screening values

5) Talmage, et.al., 1999. Nitroaromatic Munition Compounds: Environmental Effects and Screening values.

*6) Equilibrium Partitioning: Sediment SV = foc * Koc * Water SV; U.S. EPA, 1993*

8) U.S. EPA, Region 5 EDQL, 1999c

Table 3-3
Sediment Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values [4,5]	SEC[6]	Sediment EDQL[7]	Sediment SV

NA: Not Applicable

NF: Not Found

Table 3-4
Soil Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values[4,5]	Soil EDQL[6]	Terratox LOEL[7]	Terratox NOEL[7]	Soil SV
1,1,1,2-Tetrachloroethane		0.1			225			0.1
1,1,1-Trichloroethane		0.1			29.8			0.1
1,1,2,2-Tetrachloroethane		0.1			0.12722			0.1
1,1,2-Trichloroethane		0.1			28.6			0.1
1,1-Dichloroethane		0.1			20.1			0.1
1,1-Dichloroethene					8.28			8.28
1,2,3-Trichloropropane		0.1			3.36			0.1
1,2,4-Trichlorobenzene	20	0.01	20		11.1			20
1,2-Dibromoethane					1.23			1.23
1,2-Dichlorobenzene		0.01			2.96			0.01
1,2-Dichloroethane		0.4			21.2			0.4
1,2-Dichloropropane		700			32.7			700
1,3,5-Trinitrobenzene		0.01			0.37615			0.01
1,3-Dichlorobenzene		0.01			37.7			0.01
1,3-Dinitrobenzene					0.6547			0.6547
1,4-Dichlorobenzene		0.01	20		0.54559			0.01
1,2,4-Trimethylbenzene								NF
2,2'-Oxybis(1-Chloro)Propane					19.9			19.9
2,4,5-T		0.1			0.59634	1000		0.1
2,4,5-Trichlorophenol		4	9		14.1			4
2,4,6-Trichlorophenol		10	4		9.94		32	10
2,4,6-Trinitrotoluene				0.4 [5]		140	110	0.4
2,4-D		0.1			0.02725			0.1
2,4-Dichlorophenol				20 [4]	87.5			20
2,4-Dimethylphenol					0.01			0.01
2,4-Dinitrophenol		20	20		0.06086			20
2,4-Dinitrotoluene					1.28		3.2	1.28
2,6-Dinitrotoluene					0.03283			0.03283

Table 3-4
Soil Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values[4,5]	Soil EDQL[6]	Terratox LOEL[7]	Terratox NOEL[7]	Soil SV
2-Amino-4,6-Dinitrotoluene								NF
2-Butanone					89.6			89.6
2-Chloronaphthalene		1			0.01218			1
2-Chlorophenol				7 [4]	0.24266			7
2-Hexanone					12.6			12.6
2-Methylnaphthalene					3.24			3.24
2-Methylphenol		0.5			40.4			0.5
2-Nitroaniline					74.1			74.1
2-Nitrophenol				7 [4]	1.6			7
2-Nitrotoluene								NF
3,3'-Dichlorobenzidine					0.64636			0.64636
3-Nitroaniline					3.16			3.16
4,4'-DDD		0.0025			0.75815			0.0025
4,4'-DDE		0.0025			0.59587	10	5	0.0025
4,4'-DDT		0.0025			0.0175	5	50	0.0025
4,6-Dinitro-2-Methylphenol					0.14408			0.14408
4-Amino-2,6-Dinitrotoluene								NF
4-Bromophenyl Phenyl Ether								NF
4-Chloro-3-Methylphenol					7.95			7.95
4-Chloroaniline				20 [4]	1.1			20
4-Chlorophenyl Phenyl Ether								NF
4-Methyl-2-Pentanone					443			443
4-Methylphenol					163			163
4-Nitroaniline					21.9			21.9
4-Nitrophenol			7		5.12			7
Acenaphthene			20		682			20
Acenaphthylene					682			682
Acetone					2.5			2.5

Table 3-4
Soil Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values[4,5]	Soil EDQL[6]	Terratox LOEL[7]	Terratox NOEL[7]	Soil SV
Aldrin		0.0025			0.00332	0.05	0.05	0.0025
Alpha BHC		0.0025			0.09939			0.0025
Alpha Endosulfan					0.11927			0.11927
Aluminum		50						50
Anthracene		0.1			1480			0.1
Antimony	5	3.5	5		0.1423			5
Arochlor 1016		0.02						0.02
Arochlor 1221		0.02						0.02
Arochlor 1232		0.02						0.02
Arochlor 1242		0.02				150	150	0.02
Arochlor 1248		0.02				3	1	0.02
Arochlor 1254		0.02				0.64	5	0.02
Arochlor 1260		0.02				5	6.36	0.02
Arsenic	10	10	9.9		5.7	30	100	10
Barium	500	165	283		1.04			500
Benzene		0.05			0.25462			0.05
Benzo(a)Anthracene					5.21			5.21
Benzo(a)Pyrene		0.1			1.52			0.1
Benzo(b)Fluoranthene					59.8			59.8
Benzo(g,h,i)Perylene					119			119
Benzo(k)Fluoranthene					148			148
Benzoic Acid								NF
Benzyl Alcohol					65.8			65.8
Benzyl Butyl Phthalate					0.23889			0.23889
Beryllium	10	1.1	10		1.06			10
Beta BHC		0.001			0.00398			0.001
Beta Endosulfan					0.11927			0.11927
Bis(2-Chloroethoxy) Methane					0.30209			0.30209

Table 3-4
Soil Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values[4,5]	Soil EDQL[6]	Terratox LOEL[7]	Terratox NOEL[7]	Soil SV
Bis(2-Chloroethyl) Ether					23.7			23.7
Bis(2-Ethylhexyl) Phthalate					0.92594	25		0.92594
Bromodichloromethane		0.1			0.53978			0.1
Bromoform					15.9			15.9
Bromomethane					0.23516			0.23516
Cadmium	1	1.6	4		0.18095	75		1
Calcium								NF
Carbazole								NF
Carbon Disulfide					0.09412			0.09412
Carbon Tetrachloride		1000			2.98			1000
Chlordane		0.1			0.224			0.1
Chlorobenzene	40	0.05	40		13.1			40
Chloroethane		0.1						0.1
Chloroform		0.001			1.19			0.001
Chloromethane		0.1			10.4			0.1
Chromium, Total	0.4	0.4	0.4		0.4			0.4
Chrysene					4.73			4.73
cis-1,3-Dichloropropene		0.1			0.39786			0.1
Cobalt		20	20		0.14033		30000	20
Copper		40	60		0.3132		22000	40
Cyanide		5			1.33			5
Delta BHC					9.94			9.94
Di-N-Butyl Phthalate		200	200		0.14979			200
Di-N-Octylphthalate					709			709
Dibenz(a,h)Anthracene					18.4			18.4
Dibenzofuran								NF
Dibromochloromethane		0.1			2.05			0.1
Dibromomethane					65			65

Table 3-4
Soil Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values[4,5]	Soil EDQL[6]	Terratox LOEL[7]	Terratox NOEL[7]	Soil SV
Dichlorodifluoromethane		0.1			39.5			0.1
Dieldrin		0.0005				0.001	0.01	0.0005
Diethyl Phthalate		100	100		24.8			100
Dimethyl Phthalate		200			734			200
Dinoseb		0.1			0.0218			0.1
Endosulfan Sulfate					0.03578			0.03578
Endrin		0.001			0.0101	2	3	0.001
Endrin Aldehyde					0.0105			0.0105
Ethylbenzene		0.05			5.16			0.05
Fluoranthene		0.1			122			0.1
Fluorene					122			122
Gamma BHC		0.00005			0.005		40	0.00005
Heptachlor		0.1			0.00598			0.1
Heptachlor Epoxide					0.15188			0.15188
Hexachlorobenzene		0.0025			0.19878	5	1	0.0025
Hexachlorobutadiene					0.03976			0.03976
Hexachlorocyclopentadiene		10	10		0.75537			10
Hexachloroethane					0.59634			0.59634
HMX								NF
Indeno(1,2,3-c,d)Pyrene					109			109
Iron		200						200
Isophorone					139			139
Lead	28	50	40.5		0.45053			28
M,P-Xylene		0.05			10			0.05
Magnesium								NF
Manganese		100						100
MCPA		0.1						0.1
Mercury	0.1	0.1	0.00051		0.0079			0.1

Table 3-4
Soil Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values[4,5]	Soil EDQL[6]	Terratox LOEL[7]	Terratox NOEL[7]	Soil SV
Methoxychlor					0.01988	100		0.01988
Methylene Chloride		2			4.05			2
N-Nitrosodi-N-Propylamine					0.54368			0.54368
N-Nitrosodiphenylamine		20			0.54514			20
Naphthalene		0.1			0.09939			0.1
Nickel	30	30	30		13.6			30
Nitrobenzene	40	40			1.31			40
Pentachlorophenol	3	0.002	3		0.11927	10	10	3
Phenanthrene		0.1			45.7			0.1
Phenol	30	0.05	30		120			30
Pyrene		0.1			78.5			0.1
RDX								NF
Selenium	1	0.81	0.21		0.02765	8	2	1
Sodium								NF
Silver	2	2	0.2		4.04			2
Silvex (2,4,5-TP)					0.1088			0.1088
Styrene		0.1	300		4.69			0.1
Tetrachloroethene		0.01			9.92			0.01
Tetryl								NF
Thallium	1	1	1		0.05692			1
Toluene		0.05	200		5.45			0.05
Toxaphene					0.11927	5	5	0.11927
trans-1,2-Dichloroethene		0.1			0.78373			0.1
trans-1,3-Dichloropropene		0.1			0.39786			0.1
Trichloroethene		0.001			12.4			0.001
Trichlorofluoromethane		0.1			16.4			0.1
Vanadium	2	2	2		1.59			2
Vinyl Chloride		0.01			0.64614			0.01

Table 3-4
Soil Screening Values (mg/kg)
Iowa Army Ammunition Plant
Middleton, Iowa

Parameter	Ecological Benchmark[1]	USEPA IV [2]	PRGs[3]	Supplemental Values[4,5]	Soil EDQL[6]	Terratox LOEL[7]	Terratox NOEL[7]	Soil SV
Xylenes, Total		0.05			10			0.05
Zinc	50	50	8.5		6.62			50

Notes:

1) Data Collection for the Hazardous Waste Identification Rule - Ecological Benchmarks EPA, 1999d

2) USEPA Region IV, 1999b Waste Management Division Chronic Screening Values for Hazardous Waste sites, online

3) Preliminary Remediation Goals, R. A. Efroymson and others, U.S. Depertment of Energy ES/ER/TM-162/R2 1997a

4) USEPA Region III, 1995, BTAG Ecological Screening values

5) Talmage, et.al., 1999. Nitroaromatic Munition Compounds: Environmental Effects and Screening values

6) U.S. EPA, Region 5 EDQL, 1999c

7) EPA, 1996a. Ecotox Database.

NF: Not Found

Table 3-5
Brush Creek Surface Water COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/L)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
2,4,6-Trinitrotoluene	0.09	45	1	2	0.000068	<0.00016	0.0023	0.0001	0.0001	0.0001	0.03	
2-Amino-4,6-Dinitrotoluene	NA	44	8	18	0.000082	<0.00031	0.00033	0.0002	0.0002	0.0002	NA	**Yes**
4-Amino-2,6-Dinitrotoluene	NA	44	10	23	0.000138	<0.00031	0.00073	0.0002	0.0002	0.0002	NA	**Yes**
Aluminum	0.087	43	12	28	0.021	<0.0194	0.069	0.0369	0.0426	0.0426	0.79	
Antimony	0.03	44	13	30	0.0203	<0.0029	0.0178	0.0057	0.0070	0.0070	0.59	
Arsenic	0.0031	44	7	16	0.0022	<0.0022	0.008	0.0022	0.0025	0.0025	2.58	**Yes**
Barium	0.0039	44	44	100	0.0012	0.0714	0.133	0.1005	0.1052	0.1052	34.10	**Yes**
Beryllium	0.00053	44	6	14	0.00042	<0.0003	0.0011	0.0003	0.0003	0.0003	2.08	**Yes**
Bis(2-Ethylhexyl) Phthalate	0.00012	8	1	12	0.0056	<0.01	0.028	0.0079	0.0135	0.0135	233.33	**Yes**
Cadmium	0.00066	44	5	11	0.0002	<0.0002	0.0013	0.0003	0.0004	0.0004	1.97	**Yes**
Calcium	NA	44	44	100	0.0178	35.3	59.1	44.7114	46.2036	46.2036	NA	(1)
Chromium	0.074	44	34	77	0.0047	<0.0007	0.0056	0.0025	0.0034	0.0034	0.08	
Cobalt	0.003	44	16	36	0.001	<0.001	0.0058	0.0017	0.0022	0.0022	1.93	**Yes**
Copper	0.0031	44	25	57	0.0031	<0.0011	0.0105	0.0030	0.0040	0.0040	3.39	**Yes**
Dalapon	NA	9	3	33	0.0021	<0.0031	0.0031	0.0019	0.0024	0.0024	NA	(2)
Dicamba	NA	9	1	11	0.000022	<0.0001	0.00005	0.0001	0.0001	0.0001	NA	(3)
HMX	0.33	46	43	93	0.000225	<0.00039	0.014	0.0031	0.0043	0.0043	0.04	
Iron	1	41	3	7	0.0047	<0.0233	0.0967	0.0165	0.0177	0.0177	0.10	
Lead	0.00132	44	9	20	0.0013	<0.0013	0.0045	0.0012	0.0014	0.0014	3.41	**Yes**
Magnesium	NA	44	44	100	0.0214	10.8	22.7	16.3591	17.2680	17.2680	NA	(1)
Manganese	0.08	44	42	95	0.0013	<0.001	0.047	0.0106	0.0189	0.0189	0.59	
Mercury	0.000012	44	1	2	0.00015	<0.0001	0.00029	0.0001	0.0001	0.0001	24.17	**Yes**
Nickel	0.052	44	30	68	0.0087	<0.001	0.0304	0.0031	0.0039	0.0039	0.58	
Potassium	NA	44	44	100	0.968	0.486	3.89	2.1540	2.4086	2.4086	NA	(1)
RDX	0.19	46	43	93	0.000133	<0.00016	0.015	0.0051	0.0100	0.0100	0.08	
Selenium	0.00039	44	5	11	0.0033	<0.0026	0.009	0.0020	0.0022	0.0022	23.08	**Yes**
Silver	0.000012	44	29	66	0.0006	<0.0006	0.0087	0.0023	0.0031	0.0031	725.00	**Yes**
Sodium	NA	44	44	100	0.067	6.41	43.1	20.9325	24.5625	24.5625	NA	(1)
Thallium	0.004	44	16	36	0.0034	<0.0034	0.0116	0.0040	0.0049	0.0049	2.90	**Yes**
Vanadium	0.019	44	9	20	0.0027	<0.0015	0.0035	0.0011	0.0012	0.0012	0.18	
Zinc	0.0052	44	39	89	0.0029	<0.0017	0.0266	0.0038	0.0047	0.0047	5.12	**Yes**

Notes:
Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.
NA Not available.
(1) Compound is an essential nutrient.
(2) Dalapon contamination was found in laboratory blanks; Dalapon was determined to be eliminated for further consideration .
(3) Estimated detection of dicamba at trace level was not known to be associated with toxic effects.

Table 3-6
Long Creek Surface Water COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/L)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
1,3-Dinitrobenzene	0.02	21	1	5	0.000053	<0.00016	0.00011	0.0001	9.6E-05	9.6E-05	0.006	
2,4,6-Trinitrotoluene	0.09	21	3	14	0.000068	<0.00016	0.00082	0.0001	0.00018	0.00018	0.009	
2,4-Dinitrotoluene	0.02	29	2	7	0.0042	<0.00016	0.00071	0.0016	0.00654	0.00071	0.036	
2-Amino-4,6-Dinitrotoluene	NA	21	3	14	0.000082	<0.00031	0.008	0.0009	0.00131	0.00131	NA	**Yes**
4-Amino-2,6-Dinitrotoluene	NA	21	3	14	0.000138	<0.00031	0.021	0.0022	0.00395	0.00395	NA	**Yes**
Aluminum	0.087	21	6	29	0.021	<0.0194	0.0777	0.0327	0.04286	0.04286	0.893	
Antimony	0.03	21	1	5	0.0203	<0.0029	0.0096	0.0028	0.0035	0.0035	0.320	
Arsenic	0.0031	21	3	14	0.0022	<0.0022	0.0049	0.0021	0.00252	0.00252	1.581	**Yes**
Barium	0.0039	21	21	100	0.0012	0.0486	0.219	0.1043	0.12391	0.12391	56.154	**Yes**
Beryllium	0.00053	21	6	29	0.00042	<0.0003	0.0009	0.0003	0.00043	0.00043	1.698	**Yes**
Bis(2-Ethylhexyl) Phthalate	0.00012	8	3	38	0.0056	<0.01	0.02	0.0073	0.01135	0.01135	166.667	**Yes**
Cadmium	0.00066	21	3	14	0.0002	<0.0002	0.0003	0.0003	0.00036	0.0003	0.455	
Calcium	NA	21	21	100	0.0178	27.1	94.7	63.1571	72.3289	72.3289	NA	(1)
Chromium	0.074	21	5	24	0.0047	<0.0007	0.0357	0.0026	0.00326	0.00326	0.482	
Cobalt	0.003	21	4	19	0.001	<0.001	0.0042	0.0009	0.00118	0.00118	1.400	**Yes**
Copper	0.0031	21	9	43	0.0031	<0.0011	0.0043	0.0016	0.00217	0.00217	1.387	**Yes**
Dalapon	NA	11	3	27	0.0021	<0.003	0.0024	0.0018	0.00198	0.00198	NA	(2)
HMX	0.33	21	4	19	0.000225	<0.00039	0.0017	0.0004	0.00044	0.00044	0.005	
Iron	1	14	1	7	0.0047	<0.0233	0.0599	0.0156	0.01905	0.01905	0.060	
Lead	0.00132	21	4	19	0.0013	<0.0013	0.0049	0.0013	0.00163	0.00163	3.712	**Yes**
Magnesium	NA	21	21	100	0.0214	13	40.3	22.5524	25.7403	25.7403	NA	(1)
Manganese	0.08	20	19	95	0.0013	<0.0014	1.24	0.1457	1.80113	1.24	15.500	**Yes**
Nickel	0.052	21	15	71	0.0087	<0.001	0.0178	0.0028	0.00463	0.00463	0.342	
Nitrobenzene	0.27	29	3	10	0.0041	<0.00016	0.00094	0.0016	0.00624	0.00094	0.003	
Pentachlorophenol	0.005	14	2	14	0.004	<0.0001	0.000032	0.0152	320.301	3.2E-05	0.006	
Potassium	NA	21	21	100	0.968	0.388	7.47	3.2032	4.62166	4.62166	NA	(1)
RDX	0.19	21	2	10	0.000133	<0.00016	0.0091	0.0006	0.00047	0.00047	0.048	
Selenium	0.00039	21	5	24	0.0033	<0.0026	0.0048	0.0024	0.00282	0.00282	12.308	**Yes**
Silver	0.000012	21	4	19	0.0006	<0.0006	0.002	0.0010	0.00138	0.00138	166.667	**Yes**
Sodium	NA	21	21	100	0.067	7.4	32	16.4495	19.4784	19.4784	NA	(1)
Thallium	0.004	21	1	5	0.0034	<0.0034	0.0044	0.0024	0.00277	0.00277	1.100	**Yes**
Vanadium	0.019	21	12	57	0.0027	<0.0015	0.0052	0.0021	0.00317	0.00317	0.274	
Zinc	0.0052	21	18	86	0.0029	<0.0017	0.0366	0.0044	0.00663	0.00663	7.038	**Yes**

Notes:

Table 3-6
Long Creek Surface Water COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/L)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC

Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.
NA Not available.
(1) Compound is an essential nutrient.
(2) Dalapon contamination was found in laboratory blanks; Dalapon was determined to be eliminated for further consideration.

Table 3-7
Spring Creek Surface Water COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/L)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
1,3,5-Trinitrobenzene	0.011	23	1	4	0.00008	<0.00016	0.0001	8.370E-05	8.6E-05	8.63E-05	0.01	
2,4-DB	NA	9	1	18	0.00043	<0.001	0.00048	4.964E-04	0.00051	0.00048	NA	(1)
2,4,6-Trinitrotoluene	0.09	23	2	9	0.000068	<0.00016	0.00027	9.652E-05	0.00011	0.000108	0.00	
2-Nitrotoluene	4.4	23	5	22	0.000163	<0.00031	0.0018	4.224E-04	0.0006	0.000598	0.00	
Antimony	0.03	22	1	5	0.0203	<0.0055	0.0065	3.175E-03	0.00347	0.003468	0.22	
Arsenic	0.0031	22	3	14	0.0022	<0.0044	0.0068	2.632E-03	0.00295	0.002953	2.19	**Yes**
Barium	0.0039	22	22	100	0.0012	0.0322	0.336	1.014E-01	0.12099	0.12099	86.15	**Yes**
Beryllium	0.00053	22	9	41	0.00042	<0.0005	0.0008	4.023E-04	0.00049	0.00049	1.51	**Yes**
Calcium	NA	22	22	100	0.0178	25.5	74.9	5.017E+01	57.3831	57.38311	NA	(2)
Chromium	0.074	22	12	55	0.0047	<0.0007	0.0031	1.477E-03	0.00242	0.002417	0.04	
Cobalt	0.003	22	6	27	0.001	<0.0011	0.0033	1.164E-03	0.00156	0.001564	1.10	**Yes**
Copper	0.0031	22	13	59	0.0031	<0.0013	0.0051	2.648E-03	0.00416	0.004164	1.65	**Yes**
Dalapon	NA	9	2	18	0.0021	<0.003	0.0029	1.768E-03	0.00201	0.002005	NA	(3)
Dicamba	NA	9	2	18	0.000022	<0.0001	0.000051	4.845E-05	5.2E-05	0.000051	NA	(4)
4,4'-DDT	0.000041	9	1	11	0.000048	<0.000048	0.000059	5.211E-05	0.0001	0.000059	1.44	**Yes**
HMX	0.33	23	11	48	0.000225	<0.00039	0.0012	4.061E-04	0.00053	0.000535	0.00	
Lead	0.00132	22	3	14	0.0013	<0.0013	0.0033	1.184E-03	0.00148	0.00148	2.50	**Yes**
Magnesium	NA	22	22	100	0.0214	9.15	25.4	1.732E+01	20.0884	20.08842	NA	(2)
Manganese	0.08	22	22	100	0.0013	0.0045	0.546	9.157E-02	0.21826	0.218262	6.83	**Yes**
Nickel	0.052	22	20	91	0.0087	<0.0016	0.0055	3.664E-03	0.00477	0.004767	0.11	
Potassium	NA	22	22	100	0.968	1.1	15.3	6.862E+00	10.7633	10.76332	NA	(2)
RDX	0.19	23	16	70	0.000133	<0.00016	0.0089	1.401E-03	0.00449	0.004488	0.05	
Selenium	0.00039	22	6	27	0.0033	<0.0033	0.0078	2.645E-03	0.00321	0.003215	20.00	**Yes**
Silver	0.000012	22	12	55	0.0006	<0.0006	0.003	1.314E-03	0.00217	0.002166	250.00	**Yes**
Sodium	NA	22	22	100	0.067	11.9	70.3	3.556E+01	45.5192	45.51919	NA	(2)
Vanadium	0.019	22	9	41	0.0027	<0.0015	0.0036	1.430E-03	0.00187	0.001869	0.19	
Zinc	0.0052	22	21	95	0.0029	<0.0017	0.0144	0.004279545	0.00797	0.007967	2.77	**Yes**

Notes:

Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.

NA Not available.

(1) 2,4-DB was determined to be eliminated as COPEC in surface water.

(2) Compound is an essential nutrient.

(3) Dalapon contamination was found in laboratory blanks; Dalapon was determined to be eliminated as COPEC in surface water.

(4) Estimated detection of dicamba at trace level was not known to be associated with toxic effects.

Table 3-8
Skunk River Surface Water COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/L)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
Aluminum	0.087	4	2	50	0.021	<0.0727	0.0212	0.0287	0.0526	0.0212	0.24	
Arsenic	0.0031	4	1	25	0.0022	<0.0022	0.0025	0.0020	0.00444	0.0025	0.81	
Barium	0.0039	4	4	100	0.0012	0.0708	0.0747	0.0735	0.07608	0.0747	19.15	**Yes**
Beryllium	0.00053	4	1	25	0.00042	<0.0003	0.0007	0.0003	0.00569	0.0007	1.32	**Yes**
Cadmium	0.00066	4	1	25	0.0002	<0.0002	0.0002	0.0003	0.00178	0.0002	0.30	
Calcium	NA	4	4	100	0.0178	63.2	88	75.1250	92.0395	88	NA	(1)
HMX	0.33	4	2	50	0.000225	<0.00039	0.0026	0.0012	40.7632	0.0026	0.01	
Lead	0.00132	4	1	25	0.0013	<0.0013	0.003	0.0014	0.02579	0.003	2.27	**Yes**
Magnesium	NA	4	4	100	0.0214	20.7	31	25.2750	32.5811	31	NA	(1)
Manganese	0.08	3	3	100	0.0013	0.0213	0.0613	0.0386	0.59215	0.0613	0.77	
Nickel	0.052	4	2	50	0.0087	<0.001	0.0029	0.0015	0.18243	0.0029	0.06	
Potassium	NA	4	4	100	0.968	1.59	5.74	3.6225	19.0557	5.74	NA	(1)
RDX	0.19	4	2	50	0.000133	<0.00016	0.0088	0.0037	2.8E+13	0.0088	0.05	
Selenium	0.00039	4	2	50	0.0033	<0.0033	0.0063	0.0036	0.03417	0.0063	16.15	**Yes**
Sodium	NA	4	4	100	0.067	4.87	27.2	15.6150	1866.35	27.2	NA	(1)
Vanadium	0.019	4	3	75	0.0027	<0.0015	0.0035	0.0021	0.02236	0.0035	0.18	
Zinc	0.0052	4	4	100	0.0029	0.001	0.0136	0.0053	2.02719	0.0136	2.62	**Yes**

Notes:
Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.
NA Not available.
(1) Compound is an essential nutrient.

Table 3-9
Brush Creek Sediment COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
1,3,5-Trinitrobenzene	0.002	22	3	14	0.0175	<0.098	0.088	0.050	0.054	0.054	44.0	**Yes**
2,4,6-Trinitrotoluene	0.035	22	15	68	0.0338	<0.098	4.5	0.550	1.240	1.240	128.6	**Yes**
2,4-Dinitrotoluene	0.214	26	3	12	0.141	<0.098	0.29	0.100	0.130	0.130	1.4	**Yes**
2-Amino-4,6-Dinitrotoluene	NA	22	6	27	0.036	<0.2	2.4	0.375	0.555	0.555	NA	**Yes**
4-Amino-2,6-Dinitrotoluene	NA	22	6	27	0.0972	<0.2	0.66	0.178	0.226	0.226	NA	**Yes**
Aluminum	NA	22	22	100	5.2	2120	11600	5252	6294	6294	NA	**Yes**
Arsenic	7.2	22	22	100	2.1	2.2	6.3	3.945	4.448	4.448	0.9	
Barium	NA	22	22	100	0.47	70	283	131.5	152.7	152.7	NA	**Yes**
Beryllium	NA	22	22	100	0.04	0.15	0.75	0.425	0.496	0.496	NA	**Yes**
Cadmium	0.68	22	7	32	0.05	<0.06	0.28	0.067	0.084	0.084	0.4	
Calcium	NA	22	22	100	4.3	2030	23700	6136	7923	7923	NA	(1)
Chromium	52	22	22	100	0.19	7.5	27.9	12.768	14.628	14.628	0.5	
Cobalt	50	22	22	100	0.25	3.7	9.3	5.432	5.916	5.916	0.2	
Copper	18.7	22	22	100	0.34	3.8	12.6	8.023	9.270	9.270	0.7	
HMX	0.006	22	5	23	0.113	<0.24	1.2	0.203	0.241	0.241	200.0	**Yes**
Iron	20000	22	22	100	2.8	7110	15200	10275	11114	11114	0.8	(1)
Lead	30	22	22	100	1.5	7.3	12.3	9.450	10.137	10.137	0.4	
Magnesium	NA	22	22	100	1.7	843	9260	2132.682	2668	2668	NA	(1)
Manganese	NA	22	22	100	0.19	218	1000	435.4	510.8	510.8	NA	**Yes**
Mercury	0.13	22	8	36	0.023	<0.02	0.08	0.025	0.034	0.034	0.6	
Nickel	16	22	22	100	0.63	5.8	13.2	8.759	9.619	9.619	0.8	
Potassium	NA	22	22	100	NA	282	1080	587.3	691.2	691.2	NA	(1)
RDX	4.682	22	15	68	0.0586	<0.098	6.7	1.19	6.29	6.29	1.4	**Yes**
Selenium	NA	22	3	14	0.31	<0.35	0.92	0.43	0.51	0.51	NA	**Yes**
Silver	0.73	22	18	82	0.05	<0.06	2.5	0.70	2.47	2.47	3.4	**Yes**
Sodium	NA	22	22	100	15.8	379	1090	712.0	801.6	801.6	NA	(1)
Toxaphene	0.0015	4	1	25	0.0029	<0.24	0.26	0.333	15.146	0.260	175.7	**Yes**
Vanadium	NA	22	22	100	0.34	10.9	26.8	16.90	18.48	18.48	NA	**Yes**
Zinc	120	22	22	100	0.43	20.2	64.9	33.62	38.81	38.81	0.5	

Notes:
Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.
NA Not available.
(1) Compound is an essential nutrient.

Table 3-10
Long Creek Sediment COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
Aluminum	NA	12	12	100	5.2	1620	13100	5954	9892	9892	NA	**Yes**
Arsenic	7.2	12	12	100	2.1	3	14.7	6.16	8.15	8.15	2.0	**Yes**
Barium	NA	12	12	100	0.47	38.7	303	133.36	188.01	188.01	NA	**Yes**
Beryllium	NA	12	12	100	0.04	0.15	0.72	0.503	0.685	0.685	NA	**Yes**
Cadmium	0.68	12	10	83	0.05	<0.06	1.3	0.30	0.76	0.76	1.9	**Yes**
Calcium	NA	12	12	100	4.3	3360	82200	16586	31128	31128	NA	(1)
Chromium	52	12	12	100	0.19	4.4	18	10.37	14.0313	14.03126	0.3	
Cobalt	50	12	12	100	0.25	4	33.6	11.31	16.8305	16.83054	0.7	
Copper	18.7	12	12	100	0.34	2.8	45	13.2	22.7	22.7	2.4	**Yes**
Iron	20000	12	12	100	2.8	6730	22500	14519	17815	17815	1.1	(1)
Lead	30	12	12	100	1.5	4.3	42.9	16.33	24.04	24.04	1.4	**Yes**
Magnesium	NA	12	12	100	1.7	1010	10200	2962	4355	4355	NA	(1)
Manganese	NA	12	12	100	0.19	217	2730	850	1514	1514	NA	**Yes**
Mercury	0.13	12	7	58	0.023	<0.02	0.13	0.05	0.115	0.115	1.0	
Nickel	16	12	12	100	0.63	6	33.1	16.03	22.23	22.23	2.1	**Yes**
Potassium	NA	12	12	100	NA	190	2720	728.9	1267.06	1267.061	NA	(1)
RDX	4.682	12	1	8	0.0586	<0.098	0.27	0.105	0.175	0.175	0.1	
Selenium	NA	12	5	42	0.31	<0.33	1.4	0.67	1.08	1.08	NA	**Yes**
Silver	0.73	12	1	8	0.05	<0.05	0.69	0.108	0.217	0.217	0.9	
Sodium	NA	12	12	100	15.8	294	1190	762.1	1016.29	1016.288	NA	(1)
Thallium	NA	12	1	8	3.1	<0.51	0.95	0.61	0.92	0.92	NA	**Yes**
Vanadium	NA	12	12	100	0.34	10.6	34.2	22.94	27.88	27.88	NA	**Yes**
Zinc	120	12	12	100	0.43	11.4	118	58.08	106.11	106.11	1.0	

Notes:
Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.
NA Not available.
(1) Compound is an essential nutrient.

Table 3-11
Spring Creek Sediment COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
4-Methylphenol	0.012	5	1	25	0.121	<0.4	6.4	1.75	1.1E+07	6.40	533.3	**Yes**
Aluminum	NA	15	15	100	5.2	833	9750	3588	5869	5869	NA	**Yes**
Arsenic	7.2	15	15	100	2.1	1.2	16.3	7.2	14.3	14.3	2.3	**Yes**
Barium	NA	15	15	100	0.47	21.2	407	178.1	324.3	324.3	NA	**Yes**
Beryllium	NA	15	13	87	0.04	<0.04	0.78	0.4	1.0	0.8	NA	**Yes**
Bis(2-Ethylhexyl) Phthalate	0.18	5	1	25	0.137	<0.4	1.2	0.5	30.0	1.2	6.7	**Yes**
Cadmium	0.68	15	5	33	0.05	<0.05	0.86	0.2	0.5	0.5	1.3	**Yes**
Calcium	NA	15	15	100	4.3	1560	37200	8537	14492	14492	NA	(1)
Chromium	52	15	15	100	0.19	3.3	87.5	16.6	30.7	30.7	1.7	**Yes**
Cobalt	50	15	15	100	0.25	3.1	33.8	11.3	18.0	18.0	0.7	
Copper	18.7	15	15	100	0.34	0.97	290	41.0	220.3	220.3	15.5	**Yes**
Iron	20000	15	15	100	2.8	3530	22400	13172	18596	18596	1.1	(1)
Lead	30	15	15	100	1.5	2.6	52.9	16.7	28.3	28.3	1.8	**Yes**
Magnesium	NA	15	15	100	1.7	693	4130	1597	2135	2135	NA	(1)
Manganese	NA	15	15	100	0.19	135	3660	1026	2271	2271	NA	**Yes**
Mercury	0.13	15	3	21	0.023	<0.02	0.31	0.05	0.1	0.1	2.4	**Yes**
Nickel	16	15	15	100	0.63	3.8	19.6	10.6	13.8	13.8	1.2	**Yes**
Potassium	NA	15	15	100	NA	103	1040	390	607	607	NA	(1)
Selenium	NA	15	3	20	0.31	<0.31	1.9	0.5	0.7	0.7	NA	**Yes**
Silver	0.73	15	6	40	0.05	<0.05	65.6	8.1	3303.8	65.6	89.9	**Yes**
Sodium	NA	15	15	100	15.8	210	1430	599.5	823.3	823.3	NA	(1)
Vanadium	NA	15	15	100	0.34	4.6	32.3	18.77	26.41	26.41	NA	**Yes**
Zinc	120	15	15	100	0.43	7.6	387	65.86	141.137	141.14	3.2	**Yes**

Notes:
Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.
NA Not available.
(1) Compound is an essential nutrient.

Table 3-12
Skunk River Sediment COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Method Detection Limit	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	COPEC
Aluminum	NA	2	2	100	5.2	2920	3290	3105	NA	3290	NA	**Yes**
Arsenic	7.2	2	2	100	2.1	4.7	6.3	5.5	NA	6.3	0.9	
Barium	NA	2	2	100	0.47	35.8	89.9	62.85	NA	89.9	NA	**Yes**
Beryllium	NA	2	2	100	0.04	0.24	0.33	0.285	NA	0.33	NA	**Yes**
Cadmium	0.68	2	2	100	0.05	0.08	0.09	0.085	NA	0.09	0.1	
Calcium	NA	2	2	100	4.3	5600	10100	7850	NA	10100	NA	(1)
Chromium	52	2	2	100	0.19	5.7	8.4	7.05	NA	8.4	0.2	
Cobalt	50	2	2	100	0.25	4.1	8.2	6.15	NA	8.2	0.2	
Copper	18.7	2	2	100	0.34	4.7	5	4.85	NA	5	0.3	
Iron	20000	2	2	100	2.8	7460	11900	9680	NA	11900	0.6	(1)
Lead	30	2	2	100	1.5	6.3	9.2	7.75	NA	9.2	0.3	
Magnesium	NA	2	2	100	1.7	2010	2260	2135	NA	2260	NA	(1)
Manganese	NA	2	2	100	0.19	238	737	487.5	NA	737	NA	**Yes**
Nickel	16	2	2	100	0.63	7.1	10.9	9	NA	10.9	0.7	
Potassium	NA	2	2	100	NA	402	445	423.5	NA	445	NA	(1)
Silver	0.73	2	1	50	0.05	<0.06	5.7	2.865	NA	5.7	7.8	**Yes**
Sodium	NA	2	2	100	15.8	418	606	512	NA	606	NA	(1)
Vanadium	NA	2	2	100	0.34	10	14.7	12.35	NA	14.7	NA	**Yes**
Zinc	120	2	2	100	0.43	21.8	24.5	23.15	NA	24.5	0.2	

Notes:
Bold text marks compounds of which maximum concentration exceeds SV or SV is not available and these compounds are selected as COPECs.
NA Not available.
(1) Compound is an essential nutrient.

Table 3-13
R01 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
1,2,4-Trimethylbenzene	NA	48	1	2	<0.00105	0.0028	0.001	0.001	0.001	NA	NV	**Yes**
1,3,5-Trinitrobenzene	0.01	173	8	5	<0.263	110	1.245	0.457	0.457	11000	NV	**Yes**
1,3-Dinitrobenzene	0.6547	172	3	2	<0.263	2.77	0.244	0.247	0.247	4	NV	**Yes**
2,4,6-Trinitrotoluene	0.4	174	33	19	<0.263	200	2.919	1.024	1.024	500	NV	**Yes**
2,4-Dinitrotoluene	1.28	244	5	2	<0.14	7.45	0.291	0.275	0.275	6	NV	**Yes**
2-Amino-4,6-Dinitrotoluene	NA	48	1	2	<0.263	2.5	0.197	0.190	0.190	NA	NV	**Yes**
2-Methylnaphthalene	3.24	72	2	3	<0.032	1	0.144	0.191	0.191	0.3	NV	
4-Amino-2,6-Dinitrotoluene	NA	48	2	4	<0.263	1.25	0.185	0.192	0.192	NA	NV	**Yes**
Acenaphthene	20	72	5	7	<0.036	3	0.197	0.245	0.245	0.2	NV	
Acenaphthylene	682	72	7	10	<0.033	0.2	0.120	0.165	0.165	0.0003	NV	
Acetone	2.5	111	3	3	<0.00525	0.037	0.125	0.045	0.037	0.01	NV	
Aluminum	50	161	161	100	850	24400	9370	10515	10515	488	20917	
Anthracene	0.1	72	18	25	<0.033	20	0.604	0.705	0.705	200	NV	**Yes**
Antimony	5	168	20	12	<7.14	47.2	5.346	5.374	5.374	9	31	**Yes**
Arochlor 1260	0.02	9	1	11	<0.79	100	11.462	139.90	100.00	5000	NV	**Yes**
Arsenic	10	216	211	98	<0.5245	49	7.701	9.077	9.077	5	15	**Yes**
Barium	500	216	216	100	15.4	13000	681.0	515.956	515.956	26	368	**Yes**
Benzene	0.05	111	2	2	<0.00105	0.0079	0.004	0.002	0.002	0.2	NV	
Benzo(a)anthracene	5.21	72	12	17	<0.041	80	2.017	1.683	1.683	15	NV	**Yes**
Benzo(a)pyrene	0.1	72	8	11	<0.1965	100	2.437	1.508	1.508	1000	NV	**Yes**
Benzo(b)fluoranthene	59.8	72	16	22	<0.2035	100	2.781	1.914	1.914	2	NV	**Yes**
Benzo(g,h,i)perylene	119	72	5	7	<0.18	10	0.757	0.794	0.794	0.1	NV	
Benzo(k)fluoranthene	148	72	17	24	<0.066	30	0.890	0.755	0.755	0.2	NV	
Benzyl Butyl Phthalate	0.23889	72	1	1	<0.17	10	0.582	0.698	0.698	42	NV	**Yes**
Beryllium	10	168	101	60	<0.427	3.15	0.776	0.888	0.888	0.3	2	
Bis(2-Ethylhexyl) Phthalate	0.92594	72	1	1	<0.1855	2	1.150	1.399	1.399	2	NV	**Yes**
Cadmium	1	216	87	40	<0.515	69.4	2.343	2.025	2.025	69	1	**Yes**
Calcium	NA	161	161	100	2870	300000	42548	51331	51331	NA	NV	(1)
Carbazole	NA	24	15	62	<0.1855	20	1.339	2.095	2.095	NA	NV	**Yes**
Chromium	0.4	216	214	99	<4.05	1530	59.932	54.545	54.545	3825	35	**Yes**
Chrysene	4.73	72	19	26	<0.032	100	2.450	2.082	2.082	21	NV	**Yes**
Cobalt	20	161	161	100	1.83	58.6	11.97	13.026	13.026	3	26	**Yes**
Copper	40	168	168	100	3.21	2800	81.5	69.757	69.757	70	2445	**Yes**
Di-N-Butyl Phthalate	200	72	1	1	<0.061	1.3	0.231	0.332	0.332	0.01	NV	

Table 3-13
R01 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Dibenz(a,h)Anthracene	18.4	72	3	4	<0.1855	5	0.484	0.555	0.555	0.27	NV	
Dibenzofuran	NA	72	4	6	<0.035	1	0.137	0.189	0.189	NA	NV	**Yes**
Ethylbenzene	0.05	111	1	1	<0.00105	0.0025	0.008	0.003	0.003	0.05	NV	
Fluoranthene	0.1	72	32	44	<0.032	200	5.245	7.620	7.620	2000	NV	**Yes**
Fluorene	122	72	5	7	<0.033	3	0.186	0.218	0.218	0.02	NV	
HMX	NA	172	58	34	<0.263	1600	37.720	23.504	23.504	NA	NV	**Yes**
Indeno(1,2,3-cd)pyrene	109	72	5	7	<0.1965	30	1.386	1.362	1.362	0.28	NV	
Iron	200	161	161	100	2990	94000	19779	20991	20991	470	36496	(1)
Lead	28	216	216	100	2.25	13000	317	336.407	336.407	464	1210	**Yes**
Magnesium	NA	161	161	100	1530	40900	6223	#######	6592.322	NA	NV	(1)
Manganese	100	161	161	100	52.5	7000	895	947.911	947.911	70	1933	**Yes**
Mercury	0.1	216	73	34	<0.05	2000	11	0.388	0.388	20000	0.14	**Yes**
Methylene chloride	2	111	1	1	<0.00525	0.0669	0.163	0.044	0.044	0.03	NV	
Naphthalene	0.1	120	4	3	<0.00105	2	0.124	1.137	1.137	20	NV	**Yes**
Nickel	30	168	168	100	6.87	284	28.884	30.011	30.011	9	79	**Yes**
Phenanthrene	0.1	72	27	38	<0.032	60	1.861	2.593	2.593	600	NV	**Yes**
Potassium	NA	161	161	100	203	3810	970	#######	1038.466	NA	NV	(1)
Pyrene	0.1	72	34	47	<0.033	100	3.007	3.905	3.905	1000	NV	**Yes**
RDX	NA	172	36	21	<0.263	3700	57.432	5.730	5.730	NA	NV	**Yes**
Selenium	1	216	29	13	<0.25	1.86	0.261	0.261	0.261	2	1	**Yes**
Silver	2	216	19	9	<0.5095	100	1.084	0.583	0.583	50	1	**Yes**
Sodium	NA	161	159	99	<100	809	269	281.347	281.347	NA	NV	(1)
Thallium	1	168	91	54	<0.5	43	11.135	14.509	14.509	43	19	**Yes**
Toluene	0.05	111	1	1	<0.00078	0.8	0.011	0.003	0.003	16	NV	**Yes**
Vanadium	2	161	161	100	6.18	302	30.71	32.276	32.276	151	54	**Yes**
Xylenes, total	0.05	48	1	2	<0.00105	0.0062	0.001	0.001	0.001	0.12	NV	
Zinc	50	168	168	100	12.2	7650	325.1	335.234	335.234	153	1670	**Yes**

Notes:

Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs

NA Not available; NV: No value.

(1) Compound is an essential nutrient.

Table 3-14
R02 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
1,3,5-Trinitrobenzene	0.01	129	22	17	<0.488	350	4.133	1.178	1.178	35000	NV	**Yes**
1,3-Dinitrobenzene	0.6547	129	1	1	<0.496	2.56	0.268	0.269	0.269	4	NV	**Yes**
2,4,6-Trinitrotoluene	0.4	129	43	33	<0.456	270000	2170.026	39.101	39.101	675000	NV	**Yes**
2,4-Dinitrotoluene	1.28	165	10	6	<0.14	17.4	0.536	0.395	0.395	14	NV	**Yes**
2-Methylnaphthalene	3.24	36	1	3	<0.032	3	0.145	0.112	0.112	0.9	NV	
Acenaphthene	20	36	1	3	<0.036	9	0.309	0.141	0.141	0.45	NV	
Acetone	2.5	36	1	3	<0.017	0.11	0.331	0.977	0.110	0.04	NV	
Aluminum	50	157	157	100	974	210000	10589	11336	11336	4200	20917	
Anthracene	0.1	36	1	3	<0.033	10	0.401	0.494	0.494	100	NV	**Yes**
Antimony	5	164	20	12	<7.14	16.5	4.895	5.063	5.063	3	31	
Arsenic	10	164	162	99	<1.2	33	6.745	7.429	7.429	3	15	**Yes**
Barium	500	164	164	100	13.9	2330	194.9	213.0	213.0	5	368	**Yes**
Benzo(a)anthracene	5.21	36	1	3	<0.041	20	0.787	0.610	0.610	4	NV	**Yes**
Benzo(a)pyrene	0.1	36	1	3	<0.25	30	1.245	0.957	0.957	300	NV	**Yes**
Benzo(b)fluoranthene	59.8	36	1	3	<0.21	30	1.147	0.661	0.661	0.5	NV	
Benzo(g,h,i)perylene	119	36	1	3	<0.18	10	0.590	0.506	0.506	0.1	NV	
Benzo(k)fluoranthene	148	36	4	11	<0.066	8	0.328	0.222	0.222	0.1	NV	
Beryllium	10	164	102	62	<0.427	5.46	0.917	1.044	1.044	0.5	2	
Bis(2-Ethylhexyl) Phthalate	0.92594	36	4	11	<0.48	1.8	1.103	1.282	1.282	2	NV	**Yes**
Cadmium	1	164	64	39	<0.7	26.5	1.745	1.726	1.726	27	1	**Yes**
Calcium	NA	157	157	100	710	310000	37573	44198	44198	NA	NV	(1)
Carbazole	NA	1	1	100	10	10	10.000		10.000	NA	NV	**Yes**
Chromium	0.4	164	162	99	<4.05	257	32.819	34.681	34.681	643	35	**Yes**
Chrysene	4.73	36	3	8	<0.032	30	1.019	0.628	0.628	6	NV	**Yes**
Cobalt	20	157	157	100	1.91	55.2	9.224	9.869	9.869	3	26	**Yes**
Copper	40	164	164	100	4.73	564	40.976	40.789	40.789	14	2445	
Di-N-Butyl Phthalate	200	36	3	8	<0.061	6.2	0.407	0.763	0.763	0.03	NV	
Dibenz(a,h)Anthracene	18.4	36	1	3	<0.21	5	0.453	0.446	0.446	0.27	NV	
Dibenzofuran	NA	36	1	3	<0.035	7	0.253	0.132	0.132	NA	NV	**Yes**
Fluoranthene	0.1	36	12	33	<0.032	60	1.807	0.689	0.689	600	NV	**Yes**
Fluorene	122	36	1	3	<0.033	10	0.338	0.155	0.155	0.1	NV	
HMX	NA	129	53	41	<0.666	28000	340.434	97.227	97.227	NA	NV	**Yes**
Indeno(1,2,3-cd)pyrene	109	36	1	3	<0.29	30	1.373	1.325	1.325	0.3	NV	

Table 3-14
R02 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	**Screening Value**	**Number of Samples**	**Number of Detects**	**Detection Frequency (%)**	**Minimum Concentration**	**Maximum Concentration**	**Average Concentration**	**95% UCL**	**EPC**	**HQ**	**Background**	**COPEC**
Iron	200	157	157	100	4180	70100	16902	17993	17993	351	36496	(1)
Lead	28	164	164	100	2.21	4380	179.815	206.742	206.742	156	1210	**Yes**
Magnesium	NA	157	157	100	711	29700	4884	5243	5243	NA	NV	(1)
Manganese	100	157	157	100	88	7700	810.066	876.097	876.097	77	1933	**Yes**
Mercury	0.1	164	56	34	<0.05	160	1.797	0.303	0.303	1600	0.14	**Yes**
Naphthalene	0.1	36	1	3	<0.037	7	0.322	0.435	0.435	70	NV	**Yes**
Nickel	30	164	164	100	7.6	66.7	20.857	21.940	21.940	2	79	
Niobium	NA	165	2	1	<0.045	6.7	0.985	2.145	2.145	NA	NV	**Yes**
Phenanthrene	0.1	36	6	17	<0.032	50	1.462	0.338	0.338	500	NV	**Yes**
Potassium	NA	157	155	99	<100	2880	866	969	969	NA	NV	(1)
Pyrene	0.1	36	15	42	<0.033	40	1.263	0.667	0.667	400	NV	**Yes**
RDX	NA	129	34	26	<0.587	100000	912.500	43.232	43.232	NA	NV	**Yes**
Selenium	1	164	46	28	<0.25	3.29	0.401	0.425	0.425	3	1	**Yes**
Silver	2	164	11	7	<0.589	67	0.915	0.512	0.512	34	1	**Yes**
Sodium	NA	157	155	99	<100	820	290.363	302.875	302.875	NA	NV	(1)
Tetryl	NA	129	1	1	<0.25	8300	64.691	0.677	0.677	NA	NV	**Yes**
Thallium	1	164	71	43	<0.5	59.9	9.390	24.153	24.153	60	19	**Yes**
Toluene	0.05	35	1	3	<0.00078	0.72	0.031	0.079	0.079	14	NV	**Yes**
Vanadium	2	157	157	100	6.77	62.8	27.199	29.587	29.587	31	54	**Yes**
Zinc	50	164	164	100	21.5	5240	257.702	251.687	251.687	105	1670	**Yes**

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available; NV: No value.
(1) Compound is an essential nutrient.

Table 3-15
R03 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
1,3,5-Trinitrobenzene	0.01	89	26	29	<0.488	23000	267.487	10.270	10.270	2300000	NV	**Yes**
1,3-Dinitrobenzene	0.6547	89	5	6	<0.496	2.33	0.526	0.427	0.427	4	NV	**Yes**
2,4,6-Trinitrotoluene	0.4	89	44	49	<0.456	100000	4648.785	65383	65383	250000	NV	**Yes**
2,4-Dinitrotoluene	1.28	123	12	10	<0.14	210	4.544	1.172	1.172	164	NV	**Yes**
2,6-Dinitrotoluene	0.03283	123	1	1	<0.085	3.3	0.417	0.373	0.373	101	NV	**Yes**
2-Methylnaphthalene	3.24	34	1	3	<0.032	0.47	0.065	0.074	0.074	0.1	NV	
4,4'-DDT	0.0025	9	1	11	<0.1	0.1	0.056	0.065	0.065	40	NV	**Yes**
Acenaphthene	20	34	2	6	<0.036	5.1	0.202	0.134	0.134	0.26	NV	
Acenaphthylene	682	34	1	3	<0.033	0.12	0.041	0.046	0.046	0.00	NV	
Acetone	2.5	35	2	6	<0.017	0.12	0.436	2.963	0.120	0.05	NV	
Aldrin	0.0025	9	1	11	<1.3	0.00845	0.579	10.910	0.008	3	NV	**Yes**
Aluminum	50	110	110	100	1050	18800	9948	11354	11354	376	20917	
Anthracene	0.1	34	3	9	<0.033	11	0.435	0.526	0.526	110	NV	**Yes**
Antimony	5	120	16	13	<7.14	2820	29.222	7.914	7.914	564	31	**Yes**
Arsenic	10	120	118	98	<2.5	79	8.139	8.771	8.771	8	15	**Yes**
Barium	500	120	120	100	9.4	1280	211.4	251.4	251.4	3	368	**Yes**
Benzo(a)anthracene	5.21	34	3	9	<0.041	12	0.619	0.720	0.720	2	NV	**Yes**
Benzo(a)pyrene	0.1	34	2	6	<0.25	6.2	0.607	0.801	0.801	62	NV	**Yes**
Benzo(b)fluoranthene	59.8	34	4	12	<0.21	12	0.702	0.720	0.720	0.2	NV	
Benzo(g,h,i)perylene	119	34	2	6	<0.18	21	0.941	0.717	0.717	0.2	NV	
Benzo(k)fluoranthene	148	34	4	12	<0.066	20	0.754	0.471	0.471	0.1	NV	
Beryllium	10	120	72	60	<0.427	3.62	0.850	0.985	0.985	0.4	2	
Bis(2-Ethylhexyl) Phthalate	0.92594	34	3	9	<0.48	2.1	0.882	1.003	1.003	2	NV	**Yes**
Cadmium	1	120	43	36	<0.7	31.6	1.584	1.587	1.587	32	1	**Yes**
Calcium	NA	110	110	100	963	350000	35575	36974	36974	NA	NV	(1)
Carbazole	NA	2	2	100	0.073	0.081	0.077		0.081	NA	NV	**Yes**
Chromium	0.4	120	118	98	<4.05	1460	54.062	49.268	49.268	3650	35	**Yes**
Chrysene	4.73	34	4	12	<0.032	12	0.586	0.675	0.675	3	NV	**Yes**
Cobalt	20	110	109	99	<1.42	49.5	11.365	12.622	12.622	2	26	**Yes**
Copper	40	120	120	100	3.31	12000	268	101	101	300	2445	**Yes**
Di-N-Butyl Phthalate	200	34	6	18	<0.061	4.3	0.545	1.348	1.348	0.02	NV	
Dibenz(a,h)Anthracene	18.4	34	1	3	<0.21	3.8	0.359	0.382	0.382	0.2	NV	
Dibenzofuran	NA	34	1	3	<0.035	2	0.102	0.083	0.083	NA	NV	**Yes**
Dieldrin	0.0005	9	1	11	<0.079	0.0126	0.037	0.050	0.013	25	NV	**Yes**

Table 3-15
R03 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Endrin	0.001	9	1	11	<1.3	0.0126	0.579	6.467	0.013	13	NV	**Yes**
Fluoranthene	0.1	34	9	26	<0.032	6.2	0.446	0.728	0.728	62	NV	**Yes**
Fluorene	122	34	2	6	<0.033	6.3	0.237	0.142	0.142	0.1	NV	
gamma-BHC	0.00005	9	1	11	<0.1	0.00135	0.045	0.346	0.001	27	NV	**Yes**
HMX	NA	89	28	31	<0.666	610	22.343	11.661	11.661	NA	NV	**Yes**
Indeno(1,2,3-cd)pyrene	109	34	1	3	<0.29	12	0.900	1.266	1.266	0.1	NV	
Iron	200	110	110	100	2830	37700	17971	19401	19401	189	36496	(1)
Lead	28	121	121	100	4.34	5790	227.114	244	244	207	1210	**Yes**
Magnesium	NA	110	110	100	1510	25800	4114	4336	4336	NA	NV	(1)
Manganese	100	110	110	100	109	8640	1056.018	1142	1142	86	1933	**Yes**
Mercury	0.1	120	38	32	<0.05	10	0.207	0.124	0.124	100	0.14	**Yes**
Naphthalene	0.1	34	1	3	<0.037	2.6	0.193	0.361	0.361	26	NV	**Yes**
Nickel	30	120	120	100	4.42	193	23.927	25.385	25.385	6	79	**Yes**
Niobium	NA	123	2	2	<0.045	4.87	1.693	3.227	3.227	NA	NV	**Yes**
Phenanthrene	0.1	34	7	21	<0.032	12	0.580	0.450	0.450	120	NV	**Yes**
Phenol	30	34	1	3	<0.052	1.3	0.161	0.183	0.183	0.04	NV	
Potassium	NA	110	110	100	199	2230	904.482	990.736	990.736	NA	NV	(1)
Pyrene	0.1	34	10	29	<0.033	6.2	0.451	0.561	0.561	62	NV	**Yes**
RDX	NA	89	36	40	<0.587	2400	65.636	34.725	34.725	NA	NV	**Yes**
Selenium	1	120	30	25	<0.25	2.98	0.334	0.339	0.339	3	1	**Yes**
Silver	2	120	5	4	<0.589	260	2.572	0.547	0.547	130	1	**Yes**
Sodium	NA	110	108	98	<100	624	277.836	298.146	298.146	NA	NV	(1)
Thallium	1	120	60	50	<0.5	67.3	11.244	20.548	20.548	67	19	**Yes**
Toluene	0.05	35	1	3	<0.00078	0.0016	0.013	0.061	0.002	0.03	NV	
Vanadium	2	110	110	100	7.69	55.2	30.745	33.329	33.329	28	54	**Yes**
Zinc	50	120	120	100	22.1	5600	318.238	315.115	315.12	112	1670	**Yes**

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available.
NV: No value
(1) Compound is an essential nutrient.

Table 3-16
R04 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
1,3,5-Trinitrobenzene	0.01	35	11	31	<0.488	21	3.063	5.600	5.600	2100	NV	**Yes**
1,3-Dinitrobenzene	0.6547	35	2	6	<0.496	0.802	0.275	0.291	0.291	1	NV	**Yes**
2,4,6-Trinitrotoluene	0.4	35	18	51	<0.456	19000	1299.614	125286	19000	47500	NV	**Yes**
2,4-Dinitrotoluene	1.28	37	6	16	<0.42	13.2	1.16	1.11	1.11	10	NV	**Yes**
Aluminum	50	27	27	100	1280	19300	8917	11569	11569	386	20917	
Antimony	5	37	3	8	<7.14	13.2	5.879	6.871	6.871	3	31	
Arsenic	10	37	36	97	<2.5	15	7.670	9.263	9.263	2	15	
Barium	500	37	37	100	19.8	341	164.246	208.191	208.191	1	368	
Beryllium	10	37	25	68	<0.427	2.27	0.864	1.176	1.176	0	2	
Bis(2-Ethylhexyl) Phthalate	0.92594	2	1	50	<0.48	6.2	3.220		6.200	7	NV	**Yes**
Cadmium	1	37	11	30	<0.7	8.42	1.099	1.399	1.399	8	1	**Yes**
Calcium	NA	27	27	100	2870	270000	48269	110295	110295	NA	NV	(1)
Chromium	0.4	37	37	100	9.18	223	33.594	40.703	40.703	558	35	**Yes**
Cobalt	20	27	27	100	3.74	17.1	9.470	11.013	11.013	0.9	26	
Copper	40	37	37	100	7.55	976	80.712	99.697	99.697	24	2445	
HMX	NA	35	16	46	<0.666	1700	148	3175	1700	NA	NV	**Yes**
Iron	200	27	27	100	6290	23500	15871	18066	18066	118	36496	
Lead	28	37	37	100	15	1710	148	210	210	61	1210	**Yes**
Magnesium	NA	27	27	100	1480	34700	6553	8880	8880	NA	NV	(1)
Manganese	100	27	27	100	190	2460	895	1117	1117	25	1933	**Yes**
Mercury	0.1	37	12	32	<0.05	4	0.239	0.256	0.256	40	0.14	**Yes**
Nickel	30	37	37	100	6.88	57.8	19.544	21.709	21.709	2	79	
Niobium	NA	37	1	3	<0.42	0.677	0.959	1.333	0.677	NA	NV	**Yes**
Potassium	NA	27	27	100	240	1810	859	1046	1046	NA	NV	(1)
RDX	NA	35	19	54	<0.587	11000	658.5	30562	11000	NA	NV	**Yes**
Selenium	1	37	12	32	<0.25	1.4	0.334	0.416	0.416	1	1	**Yes**
Silver	2	37	13	35	<0.589	370	36.254	135.580	135.580	185	1	**Yes**
Sodium	NA	27	27	100	182	454	251.407	273.751	273.751	NA	NV	(1)
Thallium	1	37	16	43	<6.62	22.3	12.048	16.297	16.297	22	19	**Yes**
Vanadium	2	27	27	100	9.49	49.2	29.507	34.594	34.594	25	54	
Zinc	50	37	37	100	23.3	1180	198.627027	264.357	264.357	24	1670	

Notes:

Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs

NA: Not available; NV: No value

Table 3-16
R04 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background COPEC

(1) Compound is an essential nutrient.

Table 3-17
R05 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
2,4,6-Trinitrotoluene	0.4	43	2	5	<0.456	1.66	0.465	0.564	0.564	4	NV	**Yes**
Aluminum	50	37	37	100	1060	15300	9334	12766	12766	306	20917	
Arsenic	10	48	48	100	0.676	14.3	5.069	6.400	6.400	1.4	15	
Barium	500	48	48	100	11.4	526	190.91	273.42	273.42	1.1	368	**Yes**
Beryllium	10	48	34	71	<0.5	2.31	0.8	1.0	1.0	0.2	2	
Cadmium	1	48	5	10	<0.7	1.88	0.5	0.6	0.6	1.9	1	**Yes**
Calcium	NA	37	37	100	1100	76000	10448	13837	13837	NA	NV	(1)
Chromium	0.4	48	45	94	<4.05	39.8	16.55	21.13	21.13	100	35	**Yes**
Cobalt	20	37	37	100	2.11	41.2	8.25	10.54	10.54	2	26	**Yes**
Copper	40	48	48	100	2.57	155	18.60	21.75	21.75	4	2445	
Iron	200	37	37	100	3520	23600	14860.00	17886.09	17886.09	118	36496	(1)
Lead	28	48	48	100	1.42	1160	47.85	45.56	45.56	41	1210	
Magnesium	NA	37	37	100	698	13300	3084	3664	3664	NA	NV	(1)
Manganese	100	37	37	100	66.9	3230	656.4	995.0	995.0	32	1933	**Yes**
Mercury	0.1	48	11	23	<0.05	0.754	0.06	0.06	0.06	8	0.14	**Yes**
Nickel	30	48	48	100	4.22	68.5	17.86	21.06	21.06	2	79	
Potassium	NA	37	37	100	130	1380	696	866	866	NA	NV	(1)
Selenium	1	48	4	8	<0.25	0.497	0.17	0.18	0.18	0.50	1	
Silver	2	48	3	6	<0.589	1.31	0.366	0.390	0.390	0.7	1	
Sodium	NA	37	37	100	182	375	273	286	286	NA	NV	(1)
Thallium	1	48	8	17	<0.5	22.3	6.9	36.3	22.3	22	19	**Yes**
Vanadium	2	37	37	100	6.72	45.8	25.77	30.75	30.75	23	54	
Zinc	50	48	46	96	<8.03	456	83.73	115.99	115.99	9	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available.
NV: No value
(1) Compound is an essential nutrient.

Table 3-18
R07 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
2,4,6-Trinitrotoluene	0.4	24	1	4	<0.456	0.525	0.606	0.867	0.525	1	NV	**Yes**
Aluminum	50	12	12	100	9210	18500	14126	15902	15902	370	20917	
Antimony	5	24	3	12	<7.14	329	22.26	23.48	23.48	66	31	**Yes**
Arsenic	10	24	23	96	<2.5	16.9	6.0	7.5	7.5	2	15	**Yes**
Barium	500	24	24	100	146	860	283	324	324	2	368	**Yes**
Beryllium	10	24	21	88	<0.5	2.91	0.922	1.173	1.173	0.29	2	
Cadmium	1	24	2	8	<0.7	1.81	0.561	0.651	0.651	2	1	**Yes**
Calcium	NA	12	12	100	2880	7640	5093	6005	6005	NA	NV	(1)
Chromium	0.4	24	24	100	16.8	214	44.146	54.708	54.708	535	35	**Yes**
Cobalt	20	12	12	100	4.38	14.1	7.537	9.642	9.642	1	26	
Copper	40	24	24	100	14.4	120	38.675	49.911	49.911	3	2445	
HMX	NA	24	1	4	<0.666	0.765	0.489	0.560	0.560	NA	NV	**Yes**
Iron	200	12	12	100	13300	26400	20283	23010	23010	132	36496	(1)
Lead	28	24	24	100	13	13000	1106	5224	5224	464	1210	**Yes**
Magnesium	NA	12	12	100	2580	12700	3930	4950	4950	NA	NV	(1)
Manganese	100	12	12	100	127	544	373	507	507	5	1933	
Mercury	0.1	24	23	96	<0.05	130	21.8	1369.1	130.0	1300	0.14	**Yes**
Nickel	30	24	24	100	7.7	128	24.5	28.9	28.9	4	79	**Yes**
Potassium	NA	12	12	100	993	3060	1654	1986	1986	NA	NV	(1)
RDX	NA	24	3	12	<0.587	1.81	0.554	0.673	0.673	NA	NV	**Yes**
Selenium	1	24	4	17	<0.25	0.657	0.246	0.305	0.305	0.7	1	
Silver	2	24	6	25	<0.589	137	6.239	2.922	2.922	69	1	**Yes**
Sodium	NA	12	12	100	226	945	341	441	441	NA	NV	(1)
Thallium	1	24	4	17	<6.62	22.2	12.38	19.40	19.40	22	19	**Yes**
Vanadium	2	12	12	100	22.6	46.8	33.0	36.6	36.6	23	54	
Zinc	50	24	24	100	50.1	623	144.5	185.0	185.0	12	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available. NV: No Value
(1) Compound is an essential nutrient.

Table 3-19
R08 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
2,4,6-Trinitrotoluene	0.4	22	1	5	<0.456	4.13	0.838	1.282	1.282	10	NV	**Yes**
2-Methylnaphthalene	3.24	13	1	8	<0.032	0.46	0.050	0.067	0.067	0.1	NV	
4,4'-DDD	0.0025	13	2	15	<0.064	1.9	0.289	0.917	0.917	760	NV	**Yes**
4,4'-DDT	0.0025	14	1	7	<0.1	0.1	0.1	0.1	0.1	40	NV	**Yes**
Aldrin	0.0025	14	1	7	<1.3	0.0108	0.6	2.2	0.0	4	NV	**Yes**
Aluminum	50	13	13	100	3090	12300	9022	11858	11858	246	20917	
Antimony	5	26	1	4	<7.14	11.2	6.978	8.665	8.665	2	31	
Arochlor 1260	0.02	17	1	6	<0.0804	2.06	0.430	0.998	0.998	103	NV	**Yes**
Arsenic	10	26	23	88	<2.5	8.8	5.7	7.5	7.5	0.9	15	
Barium	500	26	26	100	17.6	242	174.5	234.4	234.4	0.5	368	
Benzo(a)anthracene	5.21	13	2	15	<0.041	0.31	0.054	0.092	0.092	0.1	NV	
Beryllium	10	26	16	62	<0.427	2.24	0.653	0.901	0.901	0.2	2	
Cadmium	1	26	6	23	<0.7	2.73	0.7	0.9	0.9	3	1	**Yes**
Calcium	NA	13	13	100	4130	170000	39957	194958	170000	NA	NV	(1)
Chromium	0.4	26	26	100	4.85	499	41.99	46.86	46.86	1248	35	**Yes**
Chrysene	4.73	13	1	8	<0.032	0.48	0.052	0.069	0.069	0.1	NV	
Cobalt	20	13	13	100	4.2	17.6	10.2	12.7	12.7	1	26	
Copper	40	26	25	96	<2.84	5200	297.60	501.71	501.71	130	2445	**Yes**
Di-N-Butyl Phthalate	200	13	2	15	<1.3	4.7	1.112	1.590	1.590	0.02	NV	
Dieldrin	0.0005	14	1	7	<0.079	0.0448	0.040	0.041	0.041	90	NV	**Yes**
Fluoranthene	0.1	13	1	8	<0.032	0.14	0.026	0.033	0.033	1	NV	**Yes**
Iron	200	13	13	100	7300	21700	16169	19234	19234	109	36496	(1)
Lead	28	26	26	100	3.4	302	56.2	102.2	102.2	11	1210	
Magnesium	NA	13	13	100	2160	11300	4345	6336	6336	NA	NV	(1)
Manganese	100	13	13	100	594	1690	974	1185	1185	17	1933	
Mercury	0.1	26	10	38	<0.05	2.3	0.168	0.204	0.204	23	0.14	**Yes**
Nickel	30	26	26	100	6.93	31.9	17.51	20.07	20.07	1	79	
Phenanthrene	0.1	13	1	8	<0.032	0.76	0.073	0.095	0.095	8	NV	**Yes**
Potassium	NA	13	13	100	403	1670	1013	1275	1275	NA	NV	(1)
Pyrene	0.1	13	1	8	<0.083	0.28	0.060	0.077	0.077	3	NV	**Yes**
RDX	NA	22	1	5	<0.587	0.89	0.437	0.493	0.493	NA	NV	**Yes**
Selenium	1	26	5	19	<0.25	0.694	0.24	0.29	0.29	0.7	1	
Silver	2	26	6	23	<0.589	1.26	0.510	0.601	0.601	0.6	1	
Sodium	NA	13	13	100	152	311	233	258	258	NA	NV	(1)
Thallium	1	26	3	12	<6.62	25.9	11.67	17.95	17.95	26	19	**Yes**

Table 3-19
R08 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Toluene	0.05	13	2	15	<0.1	0.49	0.09	0.13	0.13	10	NV	**Yes**
Vanadium	2	13	13	100	14.5	35	27.3	31.7	31.7	18	54	
Zinc	50	26	26	100	24.7	3270	292.1	447.8	447.8	65	1670	**Yes**

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available. NV: No Value
(1) Compound is an essential nutrient.

Table 3-20
R09 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Aluminum	50	11	11	100	1610	12600	5227	7956	7956	252	20917	
Antimony	5	19	5	26	<7.14	16.2	8.14	10.62	10.62	3	31	
Arochlor 1254	0.02	5	4	80	<0.082	0.28	0.174	0.837	0.280	14	NV	**Yes**
Arsenic	10	19	17	89	<2.5	15	5.6	8.0	8.0	2	15	
Barium	500	19	19	100	29.6	177	94.4	116.8	116.8	0.35	368	
Benzo(g,h,i)perylene	119	11	1	9	<0.25	2	1.35	7.27	2.00	0.02	NV	
Beryllium	10	19	7	37	<0.427	1.64	0.562	0.832	0.832	0.16	2	
Bis(2-Ethylhexyl) Phthalate	0.92594	11	1	9	<0.48	0.82	3.65	24.18	0.82	1	NV	
Cadmium	1	19	8	42	<0.7	5.18	1.5	2.7	2.7	5	1	**Yes**
Calcium	NA	11	11	100	3020	250000	72596	491376	250000	NA	NV	(1)
Chromium	0.4	19	18	95	<4.05	38	16.81	24.16	24.16	95	35	**Yes**
Chrysene	4.73	11	1	9	<0.12	0.46	0.68	3.49	0.46	0.1	NV	
Cobalt	20	11	11	100	4	12	9	11	11	0.6	26	
Copper	40	19	19	100	5.38	82.1	27.929	44.217	44.217	2	2445	
Fluoranthene	0.1	11	1	9	<0.068	0.052	0.382	2.521	0.052	0.5	NV	
Iron	200	11	11	100	4710	39400	17390	26232	26232	197	36496	(1)
Lead	28	19	19	100	13	2270	324.826	1587.00	1587.00	81	1210	**Yes**
Magnesium	NA	11	11	100	1780	15100	5760.909	10046.31	10046.31	NA	NV	(1)
Manganese	100	11	11	100	376	1520	885.182	1168.43	1168.43	15	1933	
Mercury	0.1	19	11	58	<0.05	1.3	0.250	0.773	0.773	13	0.14	**Yes**
Nickel	30	19	19	100	11.2	30.4	19.453	22.319	22.319	1.0	79	
Potassium	NA	11	11	100	173	916	531	779	779	NA	NV	(1)
Pyrene	0.1	11	2	18	<0.033	2	0.371	3.938	2.000	20	NV	**Yes**
Selenium	1	19	1	5	<0.25	0.51	0.19	0.22	0.22	0.5	1	
Sodium	NA	11	10	91	<100	349	245	370	349	NA	NV	(1)
Thallium	1	19	10	53	<6.62	36.4	16.60	21.40	21.40	36	19	**Yes**
Vanadium	2	11	11	100	10	37.7	21.25	26.96	26.96	19	54	
Zinc	50	19	19	100	33.5	656	221.39	457.72	457.72	13	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available. NV: No Value
(1) Compound is an essential nutrient.

Table 3-21
R10 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Aluminum	50	15	15	100	3200	19300	10769	14661	14661	386	20917	
Antimony	5	22	3	14	<7.14	13	6.61	8.46	8.46	3	31	
Arsenic	10	22	20	91	<2.5	20.3	7.744	11.359	11.359	2	15	**Yes**
Barium	500	22	22	100	53.5	421	199.3	253.4	253.4	0.8	368	
Beryllium	10	22	19	86	<0.427	100	5.442	4.229	4.229	10	2	**Yes**
Cadmium	1	22	3	14	<0.7	2.96	0.640	0.788	0.788	3	1	**Yes**
Calcium	NA	15	15	100	3420	190000	48852	240103	190000	NA	NV	(1)
Chromium	0.4	22	22	100	11.9	67.9	26.609	32.066	32.066	170	35	**Yes**
Cobalt	20	15	15	100	3.45	17.3	10.175	13.553	13.553	0.9	26	
Copper	40	22	22	100	11.4	130	32.564	41.282	41.282	3.3	2445	
Iron	200	15	15	100	7770	29300	18551	23647	23647	147	36496	(1)
Lead	28	22	22	100	15	833	134	240	240	30	1210	
Magnesium	NA	15	15	100	1970	12200	3839	4707	4707	NA	NV	(1)
Manganese	100	15	15	100	404	1830	868	1079	1079	18	1933	
Mercury	0.1	22	18	82	<0.05	10	1.728	16.637	10.000	100	0.14	**Yes**
Nickel	30	22	22	100	12	43.3	23.5	27.1	27.1	1.4	79	
Potassium	NA	15	15	100	425	1660	996	1231	1231	NA	NV	(1)
Selenium	1	22	5	23	<0.25	0.68	0.241	0.304	0.304	0.7	1	
Sodium	NA	15	15	100	163	1730	353	478	478	NA	NV	(1)
Thallium	1	22	5	23	<6.62	19.6	9.92	14.98	14.98	20	19	**Yes**
Vanadium	2	15	15	100	11.2	56.6	32.6	43.7	43.7	28	54	**Yes**
Zinc	50	22	22	100	51.9	337	117.4090909	147.886	147.886	7	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available. NV: No Value
(1) Compound is an essential nutrient.

Table 3-22
R11 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
1,1,1-Trichloroethane	0.1	16	1	6	<0.0013	0.83	0.078	1.141	0.830	8	NV	**Yes**
1,3,5-Trinitrobenzene	0.01	66	11	17	<0.255	120	2.993	1.620	1.620	12000	NV	**Yes**
1,3-Dinitrobenzene	0.6547	66	3	5	<0.255	1.4	0.506	0.363	0.363	2	NV	**Yes**
2,4,6-Trinitrotoluene	0.4	68	15	22	<0.255	2000	31.457	5.953	5.953	5000	NV	**Yes**
2,4-Dinitrotoluene	1.28	78	9	12	<0.14	7.91	0.804	0.595	0.595	6	NV	**Yes**
2,6-Dinitrotoluene	0.03283	78	2	3	<0.085	0.87	0.408	0.286	0.286	27	NV	**Yes**
2-Amino-4,6-Dinitrotoluene	NA	45	1	2	<0.255	5.15	0.640	0.375	0.375	NA	NV	**Yes**
4,4'-DDE	0.0025	9	2	22	<0.00765	0.0241	0.010	0.027	0.024	10	NV	**Yes**
4,4'-DDT	0.0025	9	3	33	<0.00707	0.0235	0.014	0.053	0.024	9	NV	**Yes**
Acetone	2.5	16	3	19	<0.017	0.0788	0.528	28.280	0.079	0.03	NV	
Aluminum	50	34	34	100	1030	21300	9126	12224	12224	426	20917	
Antimony	5	44	5	11	<7.14	14.3	5.86	6.73	6.73	3	31	
Arsenic	10	59	56	95	<2.5	18	5.7	6.9	6.9	2	15	**Yes**
Barium	500	59	59	100	13.447	639	174.352	259.579	259.579	1	368	**Yes**
Benzo(k)fluoranthene	148	12	1	8	<0.066	0.1	0.041	0.051	0.051	0.001	NV	
Beryllium	10	44	26	59	<0.427	2.85	0.770	1.004	1.004	0.29	2	
Bis(2-Ethylhexyl) Phthalate	0.92594	12	3	25	<0.48	4.6	0.96	2.11	2.11	5	NV	**Yes**
Cadmium	1	59	11	19	<0.502	757	14.070	2.460	2.460	757	1	**Yes**
Calcium	NA	34	34	100	1530	260000	33417	70794	70794	NA	NV	(1)
Chromium	0.4	59	58	98	<4.05	161	27.53	37.24	37.24	403	35	**Yes**
Chrysene	4.73	12	1	8	<0.032	0.13	0.062	0.085	0.085	0.03	NV	
Cobalt	20	34	34	100	2.77	27.7	8.68	10.17	10.17	1	26	**Yes**
Copper	40	44	44	100	2.21	1900	92.37	94.95	94.95	48	2445	
Di-N-Butyl Phthalate	200	12	1	8	<0.061	6.2	0.545	0.981	0.981	0.03	NV	
Fluoranthene	0.1	12	1	8	<0.032	0.23	0.049	0.069	0.069	2	NV	**Yes**
HMX	NA	66	26	39	<0.2605	933	26.144	43.109	43.109	NA	NV	**Yes**
Iron	200	34	34	100	4660	33100	15547	18282	18282	166	36496	(1)
Lead	28	59	59	100	3	1650	64	69	69	59	1210	**Yes**
Magnesium	NA	34	34	100	978	23700	4313	5338	5338	NA	NV	(1)
Manganese	100	34	34	100	123	3290	806	1014	1014	33	1933	**Yes**
Mercury	0.1	59	18	31	<0.05	7.8	0.30	0.15	0.15	78	0.14	**Yes**
Nickel	30	44	44	100	4.27	57.5	20.92	24.29	24.29	2	79	
Phenanthrene	0.1	12	1	8	<0.032	0.1	0.023	0.031	0.031	1.0	NV	
Phenol	30	12	1	8	<0.052	0.28	0.071	0.097	0.097	0.01	NV	

Table 3-22
R11 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Potassium	NA	34	34	100	125	1950	838	1074	1074	NA	NV	(1)
Pyrene	0.1	12	1	8	<0.033	0.17	0.031	0.046	0.046	2	NV	**Yes**
RDX	NA	66	17	26	<0.255	360	15.297	9.297	9.297	NA	NV	**Yes**
Selenium	1	59	8	14	<0.25	0.528	0.226	0.254	0.254	0.5	1	
Silver	2	59	3	5	<0.502	1.39	0.353	0.373	0.373	0.7	1	
Sodium	NA	34	34	100	162	401	260.824	284.419	284.419	NA	NV	(1)
Thallium	1	44	13	30	<0.5	41.5	10.47	46.15	41.50	42	19	**Yes**
Vanadium	2	34	34	100	3.46	44.1	27.51	33.84	33.84	22	54	
Zinc	50	44	44	100	15.6	10000	489.1	585.7	585.7	200	1670	**Yes**

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available. NV: No Value
(1) Compound is an essential nutrient.

Table 3-23
R16 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
2,4,6-Trinitrotoluene	0.4	5	1	20	<0.456	2.3	1.08	7.15	2.30	6	NV	**Yes**
Aluminum	50	6	6	100	5410	11900	8315.00	#######	11098.69	238	20917	
Arsenic	10	9	9	100	5.69	13	8.24	9.91	9.91	1	15	
Barium	500	9	9	100	151	371	206.89	247.44	247.44	1	368	
Beryllium	10	9	8	89	<0.5	1.64	0.93	1.55	1.55	0.2	2	
Calcium	NA	6	6	100	2400	4070	3210.00	3951.04	3951.04	NA	NV	(1)
Chromium	0.4	9	9	100	10.5	24.6	16.83	21.14	21.14	62	35	
Cobalt	20	6	6	100	8.11	13.9	11.64	14.07	13.90	1	26	
Copper	40	9	9	100	13.5	93.5	27.60	48.73	48.73	2	2445	
HMX	NA	5	1	20	<0.666	11.6	2.77	283.29	11.60	NA	NV	**Yes**
Iron	200	6	6	100	11600	17500	14866.67	#######	17208.79	88	36496	(1)
Lead	28	9	9	100	15	160	38.57	69.72	69.72	6	1210	
Magnesium	NA	6	6	100	1880	3450	2598.33	3200.14	3200.14	NA	NV	(1)
Manganese	100	6	6	100	493	1450	1150.50	1839.83	1450.00	15	1933	
Mercury	0.1	9	5	56	<0.05	0.104	0.05	0.08	0.08	1.0	0.14	
Nickel	30	9	9	100	12.9	25	17.34	19.96	19.96	0.8	79	
Potassium	NA	6	6	100	646	1500	942.00	1309.17	1309.17	NA	NV	(1)
RDX	NA	5	1	20	<0.587	2.26	0.80	3.61	2.26	NA	NV	**Yes**
Selenium	1	9	2	22	<0.25	0.47	0.22	0.33	0.33	0.5	1	
Sodium	NA	6	6	100	171	224	194.33	212.24	212.24	NA	NV	(1)
Vanadium	2	6	6	100	24.2	38.3	29.98	34.85	34.85	19	54	
Zinc	50	9	9	100	46.1	105	65.23	82.26	82.26	2	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available. NV: No Value
(1) Compound is an essential nutrient.

Table 3-24
R18 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
4,4'-DDT	0.0025	1	1	100	0.0839	0.0839	0.0839	NA	0.0839	34	NV	**Yes**
Aldrin	0.0025	1	1	100	0.00301	0.00301	0.00301	NA	0.00301	1	NV	**Yes**
Aluminum	50	3	3	100	1940	2800	2490	4044.43	2800	56	20917	
Arochlor 1260	0.02	1	1	100	0.288	0.288	0.288	NA	0.288	14	NV	**Yes**
Arsenic	10	5	4	80	<2.5	6.34	2.1562	11.2279	6.34	1	15	
Barium	500	5	5	100	38	202	93.62	313.805	202	0.4	368	
Beryllium	10	5	1	20	<0.427	0.7	0.3327	0.68136	0.68136	0.1	2	
Cadmium	1	5	2	40	<0.7	1.04	0.664	1.14061	1.04	1	1	**Yes**
Calcium	NA	3	3	100	1580	6780	4660	1850984	6780	NA	NV	(1)
Chromium	0.4	5	5	100	23.2	90.6	55.74	139.106	90.6	227	35	**Yes**
Cobalt	20	3	3	100	2.61	4.33	3.313	6.64087	4.33	0.22	26	
Copper	40	5	5	100	12.4	33	22.38	38.4433	33	1	2445	
Dieldrin	0.0005	1	1	100	0.00609	0.00609	0.00609	NA	0.00609	12	NV	**Yes**
Endrin	0.001	1	1	100	0.0113	0.0113	0.0113	NA	0.0113	11	NV	**Yes**
Iron	200	3	3	100	5450	7370	6660	9553.98	7370	37	36496	(1)
Lead	28	5	5	100	7.46	28	16.712	37.1426	28	1.0	1210	
Magnesium	NA	3	3	100	1190	1640	1473	2237.42	1640	NA	NV	(1)
Manganese	100	3	3	100	137	241	206	613.725	241	2	1933	
Mercury	0.1	5	5	100	0.0864	5.6	1.32708	601.872	5.6	56	0.14	**Yes**
Nickel	30	5	5	100	6.63	16.8	10.926	16.7717	16.7717	1	79	
Potassium	NA	3	3	100	198	263	241	344.211	263	NA	NV	(1)
Selenium	1	5	2	40	<0.25	0.753	0.3504	1.29201	0.753	0.8	0.7	
Silver	2	5	4	80	<0.803	139	47.5003	1.3E+08	139	70	1	**Yes**
Sodium	NA	3	3	100	164	302	253	805.121	302	NA	NV	(1)
Vanadium	2	3	3	100	7.72	14.9	10.83	32.9831	14.9	7	54	
Zinc	50	5	5	100	44.5	275	117.42	442.019	275	6	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available. NV: No Value
(1) Compound is an essential nutrient.

Table 3-25
R19 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Arsenic	10	3	3	100	6.43	99	38.74	1.5E+10	99	10	15	**Yes**
Barium	500	3	3	100	224	250	233.67	262.702	250	0.5	368	
Beryllium	10	3	3	100	1.06	5.6	2.61	10380.9	5.6	0.6	2	
Chromium	0.4	3	3	100	27.4	33.3	30.97	37.9975	33.3	83	35	
Copper	40	3	3	100	16.1	137	58.10	1.7E+07	137	3	2445	
Lead	28	3	3	100	18.8	97	47.60	45714.2	97	3	1210	
Mercury	0.1	3	1	33	<0.05	0.131	0.06	299.418	0.131	1.3	0.14	
Nickel	30	3	3	100	17.2	51.2	30.97	542.065	51.2	2	79	
Selenium	1	3	1	33	<0.449	13.5	4.65	3E+23	13.5	14	1	**Yes**
Zinc	50	3	3	100	63.1	74.2	68.43	80.2108	74.2	1.5	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA Not available.

Table 3-26
R20 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
1,3-Dinitrobenzene	0.6547	4	1	25	<0.496	0.966	0.451	4.01985	0.966	1	NV	**Yes**
4,4'-DDD	0.0025	13	2	15	<0.00826	0.0159	0.006	0.00719	0.007186	6	NV	**Yes**
4,4'-DDE	0.0025	13	1	8	<0.00765	0.00947	0.004	0.00485	0.004849	4	NV	**Yes**
4,4'-DDT	0.0025	13	1	8	<0.00707	0.0242	0.005	0.00661	0.00661	10	NV	**Yes**
alpha-Chlordane	0.1	1	1	100	0.0144	0.0144	0.014	NA	0.0144	0.1	NV	(1)
Arochlor 1254	0.02	1	1	100	0.365	0.365	0.365	NA	0.365	18	NV	**Yes**
Arsenic	10	3	3	100	5.59	7.12	6.227	8.16	7.12	1	15	
Barium	500	3	3	100	187	323	240.333	561	323	1	368	
Beryllium	10	3	3	100	0.637	0.717	0.673	0.756	0.717	0.07	2	
Chromium	0.4	3	3	100	17.7	24.5	20.333	29.6	24.5	61	35	
Copper	40	3	3	100	15.8	17.4	16.867	18.8	17.4	0.4	2445	
Dieldrin	0.0005	13	1	8	<0.00629	0.00939	0.004	0.00424	0.004235	19	NV	**Yes**
gamma-Chlordane	0.1	1	1	100	0.0186	0.0186	0.019	NA	0.0186	0.2	NV	(1)
HMX	NA	4	1	25	<0.666	0.746	0.587	1.260	0.746	NA	NV	**Yes**
Lead	28	3	3	100	18	23	20.000	26	23	0.8	1210	
Nickel	30	3	3	100	19.4	24.1	21.300	26.6	24.1	0.8	79	
Zinc	50	3	3	100	49	64	56.300	75	64	1.3	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available.
NV: No Value
(1) Screening value of chlordane isomer was compared to the sum of maximum concentration of alpha-chlordane and gamma-chlordane.

Table 3-27
R21 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
4,4'-DDT	0.0025	1	1	100	0.0473	0.0473	0.0473		0.0473	19	NV	**Yes**
Aluminum	50	3	3	100	1290	4700	2493	258237	4700	94	20917	
Arsenic	10	5	4	80	<2.5	8.47	2.81	55.672	8.47	1	15	
Barium	500	5	5	100	14.3	206	62.5	1620.8	206	0.4	368	
Calcium	NA	3	3	100	3110	20900	9073	7E+08	20900	NA	NV	(1)
Chromium	0.4	5	5	100	5.88	20.2	10.63	23.014	20.2	51	35	
Cobalt	20	3	3	100	3.08	6.5	4.38	19.372	6.5	0.3	26	
Copper	40	5	5	100	5.12	14	10.02	17.507	14	0.4	2445	
delta-BHC	9.94	1	1	100	0.0353	0.0353	0.0353		0.0353	0.004	NV	
Endrin	0.001	1	1	100	0.0109	0.0109	0.0109		0.0109	11	NV	**Yes**
Iron	200	3	3	100	4010	16300	8317	2E+06	16300	82	36496	(1)
Lead	28	6	5	83	<10.5	36	11.2	67.786	36	1	1210	
Magnesium	NA	3	3	100	1320	5210	2717	491417	5210	NA	NV	(1)
Manganese	100	3	3	100	142	508	274	24664	508	5	1933	
Mercury	0.1	5	3	60	<0.05	0.109	0.06	0.1844	0.109	1	0.14	
Naphthalene	0.1	1	1	100	0.004	0.004	0.004		0.004	0.04	NV	
Nickel	30	5	5	100	6.84	17.9	12.036	22.398	17.9	1	79	
Potassium	NA	3	3	100	167	738	380	128722	738	NA	NV	(1)
Silver	2	5	4	80	<0.803	15.5	7.3389	14088	15.5	8	1	**Yes**
Sodium	NA	3	3	100	160	269	231	555.29	269	NA	NV	(1)
Vanadium	2	3	3	100	7.34	21.2	12.69	217.12	21.2	11	54	
Zinc	50	5	5	100	23.8	270	79	1089.6	270	5	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available.
NV: No Value
(1) Compound is an essential nutrient.

Table 3-28
R22 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Aluminum	50	3	3	100	12000	18700	14300.00	27888.94	18700.00	374	20917	
Arsenic	10	14	14	100	3.88	21.3	8.54	11.26	11.26	2	15	**Yes**
Barium	500	14	14	100	14	722	286.41	1148.66	722.00	1.4	368	**Yes**
Beryllium	10	14	13	93	<0.5	2.36	1.08	1.53	1.53	0.24	2	
Cadmium	1	14	3	21	<0.7	3.32	1.01	1.62	1.62	3	1	**Yes**
Calcium	NA	3	3	100	6940	110000	41670.00	2.82E+14	########	NA	NV	(1)
Chromium	0.4	14	14	100	20.1	2800	266.56	654.95	654.95	7000	35	**Yes**
Cobalt	20	3	3	100	8.66	12.2	10.13	15.37	12.20	0.6	26	
Copper	40	14	14	100	15.4	8200	1635.49	36915.26	8200.00	205	2445	**Yes**
HMX	NA	12	1	8	<0.666	2.16	0.74	0.94	0.94	NA	NV	**Yes**
Iron	200	3	3	100	16100	22700	19233.33	27908.90	22700.00	114	36496	(1)
Lead	28	14	14	100	13	260	46.51	72.86	72.86	9	1210	
Magnesium	NA	3	3	100	2970	8530	5080.00	87853.80	8530.00	NA	NV	(1)
Manganese	100	3	3	100	481	847	664.67	1538.21	847.00	8	1933	
Mercury	0.1	14	3	21	<0.05	0.253	0.05	0.07	0.07	3	0.14	**Yes**
Nickel	30	14	14	100	18.6	1900	227.56	760.97	760.97	63	79	**Yes**
Potassium	NA	3	3	100	1140	1740	1350.00	2532.24	1740.00	NA	NV	(1)
RDX	NA	12	1	8	<0.587	15.6	1.73	2.60	2.60	NA	NV	**Yes**
Selenium	1	14	1	7	<0.25	0.681	0.24	0.29	0.29	0.7	1	
Silver	2	14	1	7	<0.589	4.72	0.69	0.89	0.89	2	1	**Yes**
Sodium	NA	3	3	100	190	269	228.33	332.76	269.00	NA	NV	(1)
Thallium	1	14	3	21	<34.3	20.3	16.97	17.85	17.85	20	19	**Yes**
Vanadium	2	3	3	100	31.8	46.7	37.73	60.72	46.70	23	54	
Zinc	50	14	14	100	42.3	3900	404.02	741.61	741.61	78	1670	**Yes**

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA Not available.
NV No Value
(1) Compound is an essential nutrient.

Table 3-29
R26 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Aluminum	50	3	3	100	11500	13300	12567	14601.9	13300	266	20917	
Arsenic	10	4	4	100	3.95	6.21	4.99	6.73805	6.21	1	15	
Barium	500	4	4	100	163	220	183.75	224.512	220	0	368	
Benzo(a)anthracene	5.21	4	1	25	<0.17	0.11	0.09	0.11068	0.11	0	NV	
Beryllium	10	4	2	50	<0.427	1.02	0.59	20.003	1.02	0	2	
Cadmium	1	4	2	50	<0.7	6.46	2.65	522337	6.46	6	1	**Yes**
Calcium	NA	3	3	100	3600	6400	4550	13653	6400	NA	NV	(1)
Chromium	0.4	4	4	100	17.8	88.4	40.4	573.696	88.4	221	35	**Yes**
Chrysene	4.73	4	1	25	<0.12	0.1	0.07	0.10964	0.1	0	NV	
Cobalt	20	3	3	100	4.11	8.16	6.36	21.0563	8.16	0	26	
Copper	40	4	4	100	13.7	31.5	19.58	47.6045	31.5	1	2445	
Fluoranthene	0.1	4	1	25	<0.068	0.15	0.06	1.20515	0.15	2	NV	**Yes**
Iron	200	3	3	100	16100	18300	17567	20302.3	18300	92	36496	(1)
Lead	28	4	4	100	17	28	21	31.6149	28	1	1210	
Magnesium	NA	3	3	100	2260	3040	2540	3622.65	3040	NA	NV	(1)
Manganese	100	3	3	100	223	464	335	1147.55	464	5	1933	
Mercury	0.1	4	4	100	0.128	4.8	1.454	542141	4.8	48	0	**Yes**
Nickel	30	4	4	100	15	26	19.73	33.7256	26	1	79	
Phenanthrene	0.1	4	1	25	<0.033	0.14	0.05	16.6657	0.14	1	NV	**Yes**
Potassium	NA	3	3	100	858	1130	1009	1369.77	1130	NA	NV	(1)
Selenium	1	4	2	50	<0.25	0.825	0.45	168.541	0.825	1	1	
Sodium	NA	3	3	100	252	404	310	604.707	404	NA	NV	(1)
Toluene	0.05	4	1	25	<0.00078	0.0072	0.01	2.3E+11	0.0072	0	NV	
Vanadium	2	3	3	100	31.9	33.7	32.60	34.5206	33.7	17	54	
Zinc	50	4	4	100	44.9	87.1	64.85	137.064	87.1	2	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NV: No Value
NA Not available.

Table 3-30
R28 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
4,4'-DDD	0.0025	26	1	4	<0.00826	0.0161	0.010	0.014	0.014	5	NV	**Yes**
4,4'-DDE	0.0025	26	3	12	<0.00765	0.073	0.013	0.021	0.021	8	NV	**Yes**
4,4'-DDT	0.0025	26	3	12	<0.0035	0.0329	0.006	0.007	0.007	3	NV	**Yes**
Aldrin	0.0025	26	1	4	<0.0014	0.00217	0.003	0.004	0.002	1	NV	
Arochlor 1260	0.02	16	9	56	<0.0479	60	6.356	942.582	60.000	3000	NV	**Yes**
Benzo(a)anthracene	5.21	5	1	20	<0.041	0.3	0.076	2.313	0.300	0.06	NV	
Benzo(b)fluoranthene	59.8	5	1	20	<0.31	1.3	0.384	3.471	1.300	0.02	NV	
Chrysene	4.73	5	1	20	<0.032	0.71	0.155	129.892	0.710	0.15	NV	
Dieldrin	0.0005	26	1	4	<0.0016	0.0169	0.003	0.004	0.004	9	NV	**Yes**
Endrin	0.001	26	1	4	<0.0065	0.00562	0.003	0.003	0.003	3	NV	**Yes**
Fluoranthene	0.1	5	1	20	<0.032	0.42	0.097	13.804	0.420	4	NV	**Yes**
Pyrene	0.1	5	1	20	<0.083	0.83	0.199	13.933	0.830	8	NV	**Yes**

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NV: No Value

Table 3-31
R29 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Aluminum	50	3	3	100	7110	8540	8063.33	9924.57	8540	171	20917	
Arsenic	10	3	3	100	6.4	10.8	8.97	20.34	10.8	1	15	
Barium	500	3	3	100	154	225	185.00	291.32	225	0.5	368	
Beryllium	10	3	3	100	1.15	1.2	1.17	1.22	1.2	0.1	2	
Calcium	NA	3	3	100	3800	7080	4920.00	16078.24	7080	NA	NV	(1)
Chromium	0.4	3	3	100	12.9	14.1	13.37	14.67	14.1	35	35	
Cobalt	20	3	3	100	9.11	46.3	22.47	22960.80	46.3	2	26	**Yes**
Copper	40	3	3	100	12.2	12.3	12.27	12.38	12.3	0.3	2445	
Iron	200	3	3	100	15700	18400	16966.67	19828.92	18400	92	36496	(1)
Lead	28	3	3	100	13.2	15	14.33	16.45	15	1	1210	
Magnesium	NA	3	3	100	1750	2450	2096.67	3018.82	2450	NA	NV	(1)
Manganese	100	3	3	100	746	2390	1325.67	64898.69	2390	24	1933	**Yes**
Nickel	30	3	3	100	14.1	20.8	16.83	27.11	20.8	1	79	
Potassium	NA	3	3	100	564	753	681.33	958.61	753	NA	NV	(1)
Sodium	NA	3	3	100	230	285	252.67	314.39	285	NA	NV	(1)
Vanadium	2	3	3	100	30.1	37.1	32.90	40.82	37.1	19	54	
Zinc	50	3	3	100	44.6	71.5	56.53	106.39	71.5	1	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NA: Not available.
NV: No Value
(1) Compound is an essential nutrient.

Table 3-32
R30 Soil COPECs Screening Values and Exposure Point Concentrations (EPCs)
(mg/kg)

Analyte Name	Screening Value	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Concentration	Maximum Concentration	Average Concentration	95% UCL	EPC	HQ	Background	COPEC
Arsenic	10	3	3	100	7.81	10.8	8.84	13.64	10.8	1.1	15	
Barium	500	3	3	100	163	220	187.00	260.96	220	0.4	368	
Beryllium	10	3	3	100	1.11	2.96	1.73	31.30	2.96	0.3	2	
Cadmium	1	3	1	33	<1.2	1.89	1.03	57.72	1.89	2	1	**Yes**
Chromium	0.4	3	3	100	20.3	28.7	24.37	35.46	28.7	72	35	
Copper	40	3	3	100	19.7	44.6	29.50	176.31	44.6	1.1	2445	
Lead	28	3	3	100	17	29	21.67	49.74	29	1.0	1210	
Mercury	0.1	3	3	100	0.09	0.217	0.14	1.29	0.217	2	0.14	**Yes**
Nickel	30	3	3	100	18.3	41.2	27.17	162.64	41.2	1.4	79	
Selenium	1	3	1	33	<0.449	0.997	0.48	455.04	0.997	1.0	1	
Zinc	50	3	3	100	67.5	236	127.20	11228.29	236	5	1670	

Notes:
Bold: Constituents for which the maximum detected concentration is above screening value and background value were identified as COPECs
NV: No Value

Table 3-33
Soil pH

Sample Location	Aluminum Concentration (mg/kg)	Sample Date	pH
R01SD6801	24400	5/22/2003	8
R02SS0301	21800	5/22/2003	7.1
SU12SD0101	210000	5/22/2003	7.7
R11SS2201	21300	5/22/2003	7.8

Table 3-34
Summary of COPECs – IAAAP Surface Water and Sediment

Brush Creek Sediment	Brush Creek Surface Water	Long Creek Sediment	Long Creek Surface Water
1,3,5-Trinitrobenzene	2-Amino-4,6-Dinitrotoluene	Aluminum	2-Amino-4,6-Dinitrotoluene
2,4,6-Trinitrotoluene	4-Amino-2,6-Dinitrotoluene	Arsenic	4-Amino-2,6-Dinitrotoluene
2,4-Dinitrotoluene	Arsenic	Barium	Arsenic
2-Amino-4,6-Dinitrotoluene	Barium	Beryllium	Barium
4-Amino-2,6-Dinitrotoluene	Beryllium	Cadmium	Beryllium
HMX	Bis(2-Ethylhexyl) Phthalate	Copper	Bis(2-Ethylhexyl) Phthalate
RDX	Cadmium	Lead	Cobalt
Aluminum	Cobalt	Manganese	Copper
Barium	Copper	Nickel	Lead
Beryllium	Lead	Selenium	Manganese
Manganese	Mercury	Thallium	Selenium
Selenium	Selenium	Vanadium	Silver
Silver	Silver		Thallium
Vanadium	Thallium		Zinc
Toxaphene	Zinc		

Table 3-34 (Continued)
Summary of COPECs – IAAAP Surface Water and Sediment

Spring Creek Sediment	Spring Creek Surface Water	Skunk River Sediment	Skunk River Surface Water
Bis(2-Ethylhexyl) Phthalate	Arsenic	Aluminum	Barium
Aluminum	Barium	Barium	Beryllium
Arsenic	Beryllium	Beryllium	Lead
Barium	Cobalt	Manganese	Selenium
Beryllium	Copper	Silver	Zinc
Cadmium	Lead	Vanadium	
Chromium	Manganese		
Copper	Selenium		
Lead	Silver		
Manganese	Zinc		
Mercury	4,4'-DDT		
Nickel			
Selenium			
Silver			
Vanadium			
Zinc			
4-methylphenol			

Table 3-35
Summary of COPECs – IAAAP Surface Soil

R01	R02	R03	R04	R05	R07
1,2,4-Trimethylbenzene	1,3,5-Trinitrobenzene	1,3,5-Trinitrobenzene	1,3,5-Trinitrobenzene	2,4,6-Trinitrotoluene	2,4,6-Trinitrotoluene
1,3,5-Trinitrobenzene	1,3-Dinitrobenzene	1,3-Dinitrobenzene	1,3-Dinitrobenzene		
1,3-Dinitrobenzene	2,4,6-Trinitrotoluene	2,4,6-Trinitrotoluene	2,4,6-Trinitrotoluene	Barium	Antimony
2,4,6-Trinitrotoluene	2,4-Dinitrotoluene	2,4-Dinitrotoluene	2,4-Dinitrotoluene	Cadmium	Arsenic
2,4-Dinitrotoluene	Anthracene	2,6-Dinitrotoluene	Bis(2-Ethylhexyl) Phthalate	Chromium	Barium
2-Amino-4,6-Dinitrotoluene	Arsenic	4,4'-DDT	Cadmium	Cobalt	Cadmium
4-Amino-2,6-Dinitrotoluene	Barium	Aldrin	Chromium	Manganese	Chromium
Anthracene	Benzo(a)anthracene	Anthracene	HMX	Mercury	HMX
Antimony	Benzo(a)pyrene	Antimony	Lead	Thallium	Lead
Aroclor 1260	Bis(2-Ethylhexyl) Phthalate	Arsenic	Manganese		Mercury
Arsenic	Cadmium	Barium	Mercury		Nickel
Barium	Carbazole	Benzo(a)anthracene	Niobium		RDX
Benzo(a)anthracene	Chromium	Benzo(a)pyrene	RDX		Silver
Benzo(a)pyrene	Chrysene	Bis(2-Ethylhexyl) Phthalate	Selenium		Thallium
Benzo(b)fluoranthene	Cobalt	Cadmium	Silver		
Benzyl Butyl Phthalate	Dibenzofuran	Carbazole	Thallium		
Bis(2-Ethylhexyl) Phthalate	Fluoranthene	Chromium			
Cadmium	HMX	Chrysene			
Carbazole	Lead	Cobalt			
Chromium	Manganese	Copper			
Chrysene	Mercury	Dibenzofuran			
Cobalt	Naphthalene	Dieldrin			
Copper		Endrin			
Dibenzofuran		Fluoranthene			

Table 3-35
Summary of COPECs – IAAAP Surface Soil

R01	R02	R03	R04	R05	R07
Fluoranthene	Niobium	Gamma-BHC			
HMX	Phenanthrene	HMX			
Lead	Pyrene	Lead			
Manganese	RDX	Manganese			
Mercury	Selenium	Mercury			
Naphthalene	Silver	Naphthalene			
Nickel	Tetryl	Nickel			
Phenanthrene	Thallium	Niobium			
Pyrene	Toluene	Phenanthrene			
RDX	Vanadium	Pyrene			
Selenium	Zinc	RDX			
Silver		Selenium			
Thallium		Silver			
Toluene		Thallium			
Vanadium		Vanadium			
Zinc		Zinc			

Table 3-35 (Continued)
Summary of COPECs - IAAAP Surface Soil

R08	R09	R10	R11	R16	R18	R19
2,4,6-Trinitrotoluene	Aroclor 1254	Arsenic	1,1,1-Trichloroethane	2,4,6-Trinitrotoluene	4,4'-DDT	Arsenic
4,4'-DDD	Cadmium	Beryllium	1,3,5-Trinitrobenzene	HMX	Aldrin	Selenium
4,4'-DDT	Chromium	Cadmium	1,3-Dinitrobenzene	RDX	Aroclor 1260	
Aldrin	Lead	Chromium	2,4,6-Trinitrotoluene		Cadmium	
Aroclor 1260	Mercury	Mercury	2,4-Dinitrotoluene		Chromium	
Cadmium	Pyrene	Thallium	2,6-Dinitrotoluene		Dieldrin	
Chromium	Thallium	Vanadium	2-Amino-4,6-Dinitrotoluene		Endrin	
Copper			4,4'-DDE		Mercury	
Dieldrin			4,4'-DDT		Silver	
Fluoranthene			Antimony			
Mercury			Arsenic			
Phenanthrene			Barium			
Pyrene			Bis(2-Ethylhexyl) Phthalate			
RDX			Cadmium			
Thallium			Chromium			
Toluene			Cobalt			
Zinc			Fluoranthene			
			HMX			
			Lead			
			Manganese			
			Mercury			
			Pyrene			
			RDX			
			Thallium			
			Zinc			

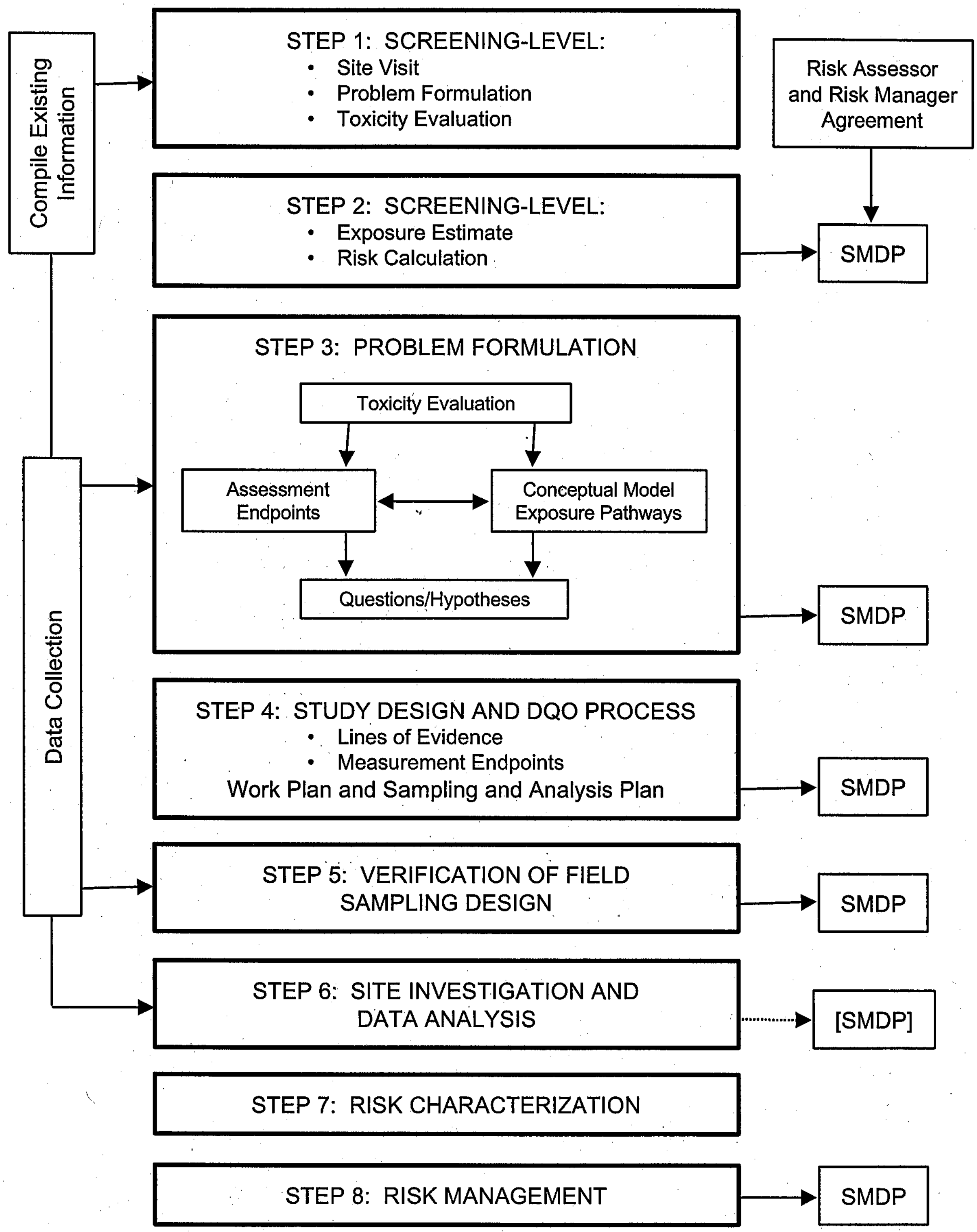
Table 3-35 (Continued)
Summary of COPECs - IAAAP Surface Soil

R20	R21	R22	R26	R28	R29	R30
1,3-Dinitrobenzene 4,4'-DDD 4,4'-DDE 4,4'-DDT Aroclor 1254 Dieldrin HMX	4,4'-DDT Endrin Silver	Arsenic Barium Cadmium Chromium Copper HMX Lead Mercury Nickel RDX Silver Thallium Zinc	Cadmium Chromium Fluoranthene Mercury Phenanthrene	4,4'-DDD 4,4'-DDE 4,4'-DDT Aroclor 1260 Dieldrin Endrin Fluoranthene Pyrene	Cobalt Manganese	Cadmium Mercury

Appendix A-1

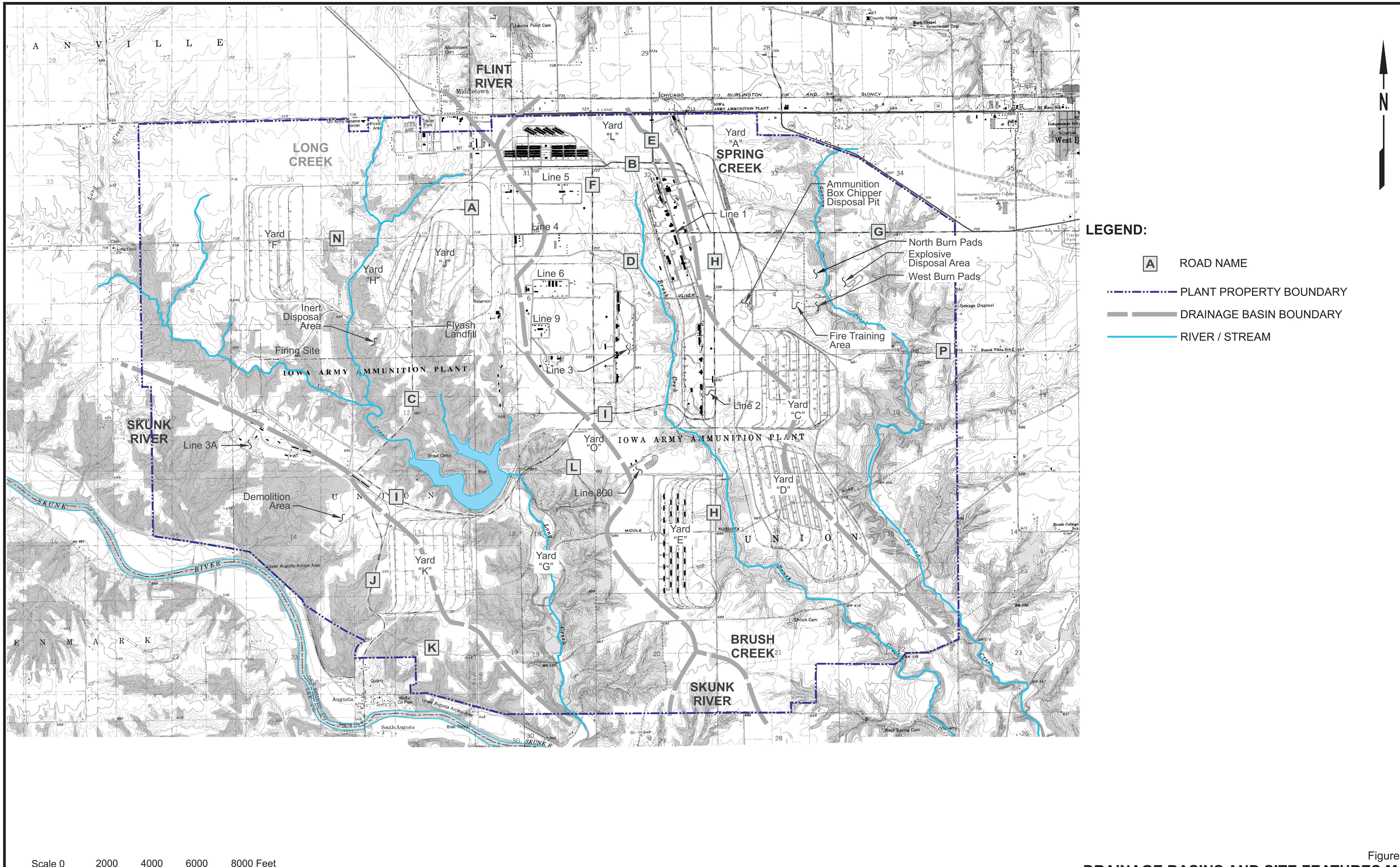
Figures

Figure 1-1
Eight-step Ecological Risk Assessment Process for Superfund



SMDP: Scientific/Management Decision Point

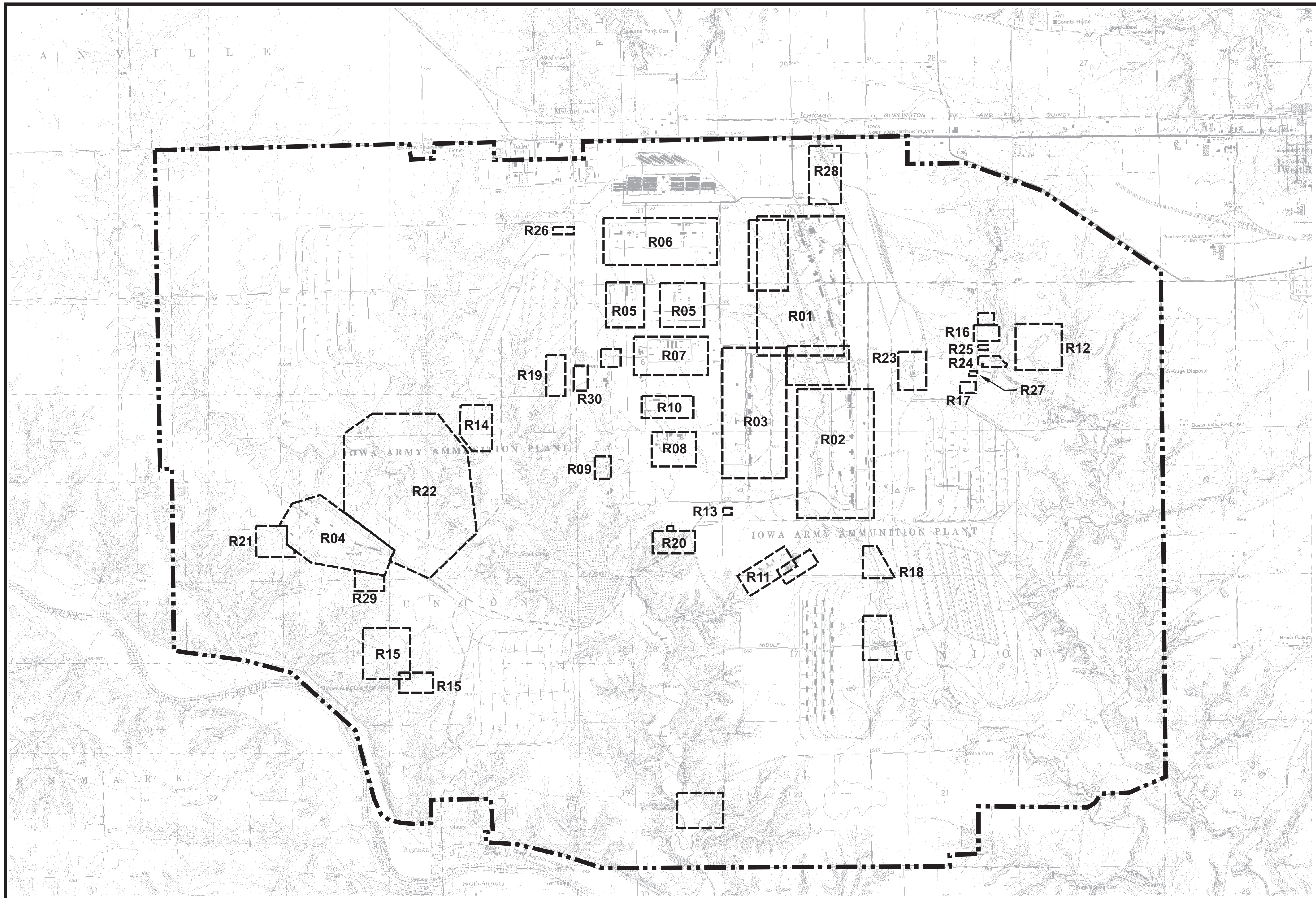
Source: USEPA, 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. June 5.



MWH

Figure 1-2
DRAINAGE BASINS AND SITE FEATURES MAP
SUPPLEMENTAL GROUNDWATER RI
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

O:/Iowa/Drainage Basins.cdr



N

Scale 0 2000 4000 6000 8000 Feet

MWH

Figure 2-1

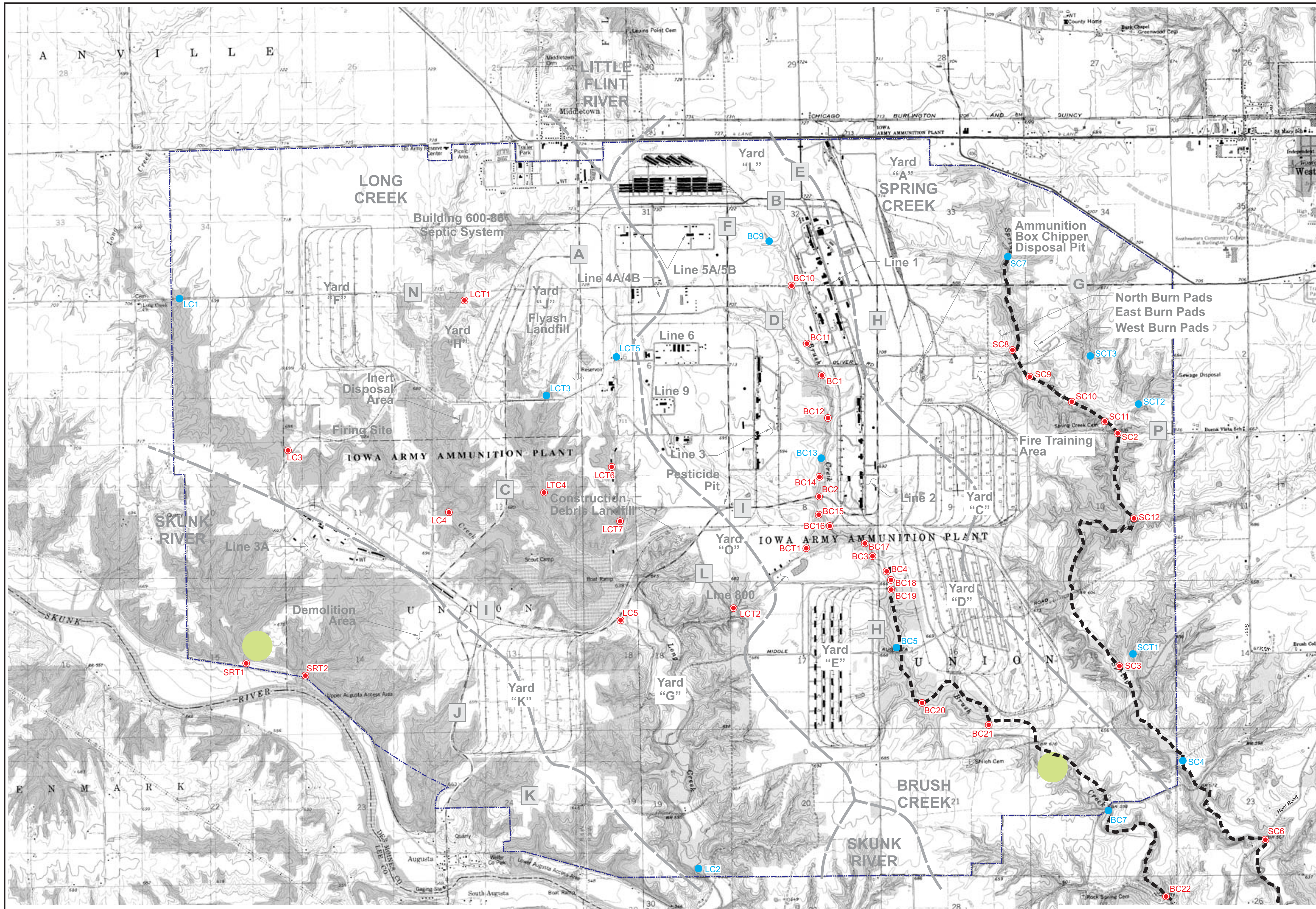
SITE LOCATION MAP

ECOLOGICAL RISK ASSESSMENT

IOWA ARMY AMMUNITION PLANT

Iowa

O:/iowa/addendum/figure2-1.cdr



LEGEND:

- SAMPLING LOCATIONS (See Note 2) (red)
- SAMPLING LOCATIONS (See Note 3) (blue)
- A — ROAD NAME
- PLANT PROPERTY BOUNDARY
- ORANGE THROAT DARTER DISTRIBUTION
- INDIANA BAT RECORD

NOTES:

1. BC8 - Brush Creek at Hunt Road, not shown on map.
2. Analysis for explosives and metals.
3. Analysis for explosives, metals, PCB, pesticides, herbicides and SVOC
4. Water samples from sites LC3 and LC4 were analyzed for uranium, gross alpha and gross beta under the Long Term Monitoring Program.

Scale 0 2000 4000 6000 8000 Feet

1997 ECOLOGICAL SAMPLING

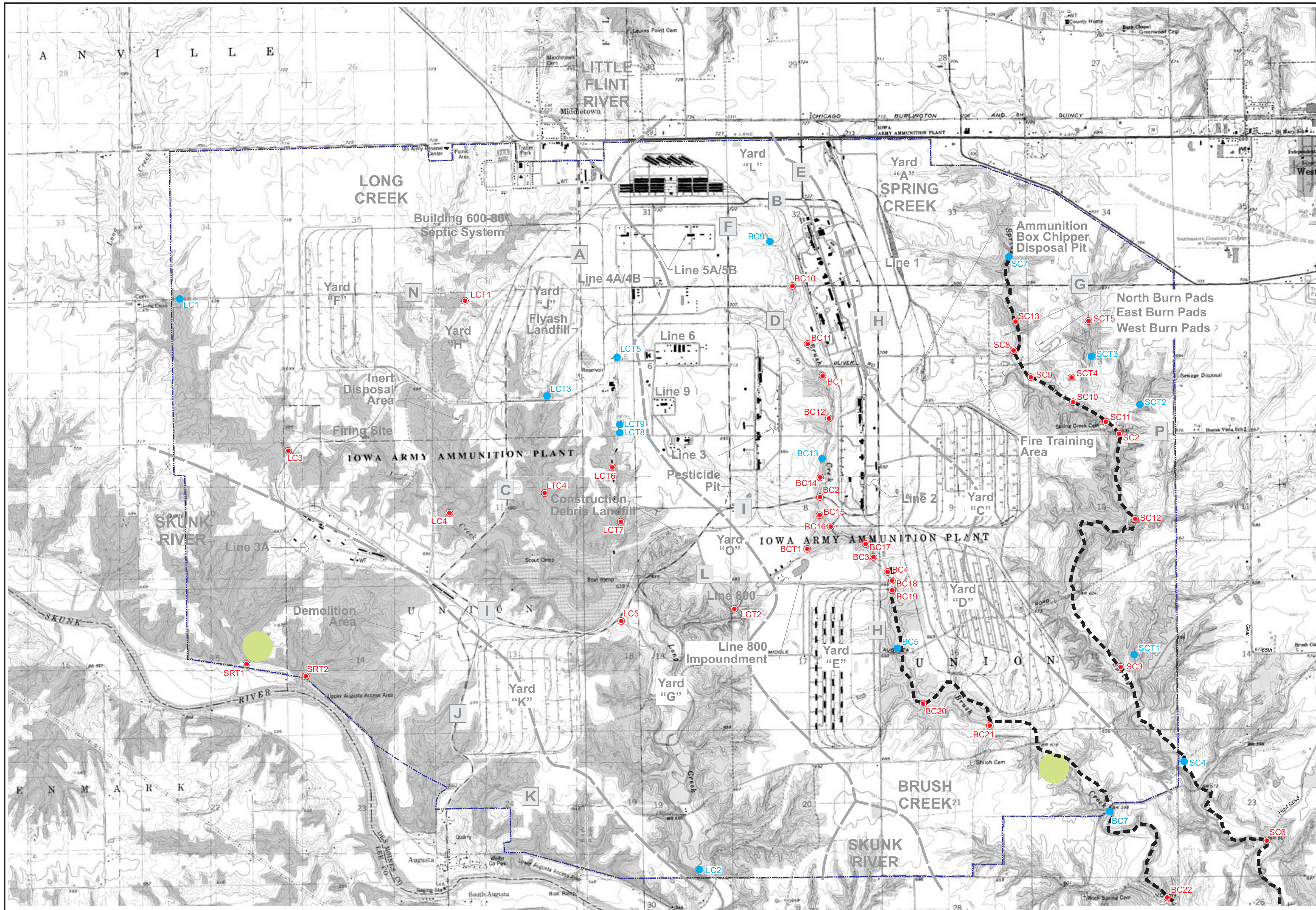
	SRT1	SRT2	LC1	LC2	LCT1	LCT2	LCT3	BC1	BC2	BC3	BC4	BC5	BC6	BC7	BC8	BC9	BC10	SC1	SC2	SC3	SC4	SC5	SC6
BENTHOS	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
FISH				•								•	•		•			•	•		•	•	•

O:\graphics\Iowa\Baseline Ecological RI\Exhibit 3-2.cdr

MWH

Figure 2-2

WATER SAMPLING LOCATIONS
MAY 2000
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa



LEGEND:

- SAMPLING LOCATIONS (See Note 2)
- SAMPLING LOCATIONS (See Note 3)
- A — ROAD NAME
- PLANT PROPERTY BOUNDARY
- ORANGE THROAT DARTER DISTRIBUTION
- INDIANA BAT RECORD

NOTES:

1. BC8 - Brush Creek at Hunt Road, not shown on map.
2. Analysis for explosives and metals.
3. Analysis for explosives, metals, PCB, pesticides, herbicides and SVOC
4. Water samples from sites LC3 and LC4 were analyzed for uranium, gross alpha and gross beta under the Long Term Monitoring Program.

Scale 0 2000 4000 6000 8000 Feet

1997 ECOLOGICAL SAMPLING

	SRT1	SRT2	LC1	LC2	LCT1	LCT2	LCT3	BC1	BC2	BC3	BC4	BC5	BC6	BC7	BC8	BC9	BC10	SC1	SC2	SC3	SC4	SC5	SC6
BENTHOS	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
FISH				•								•	•		•			•	•		•	•	•

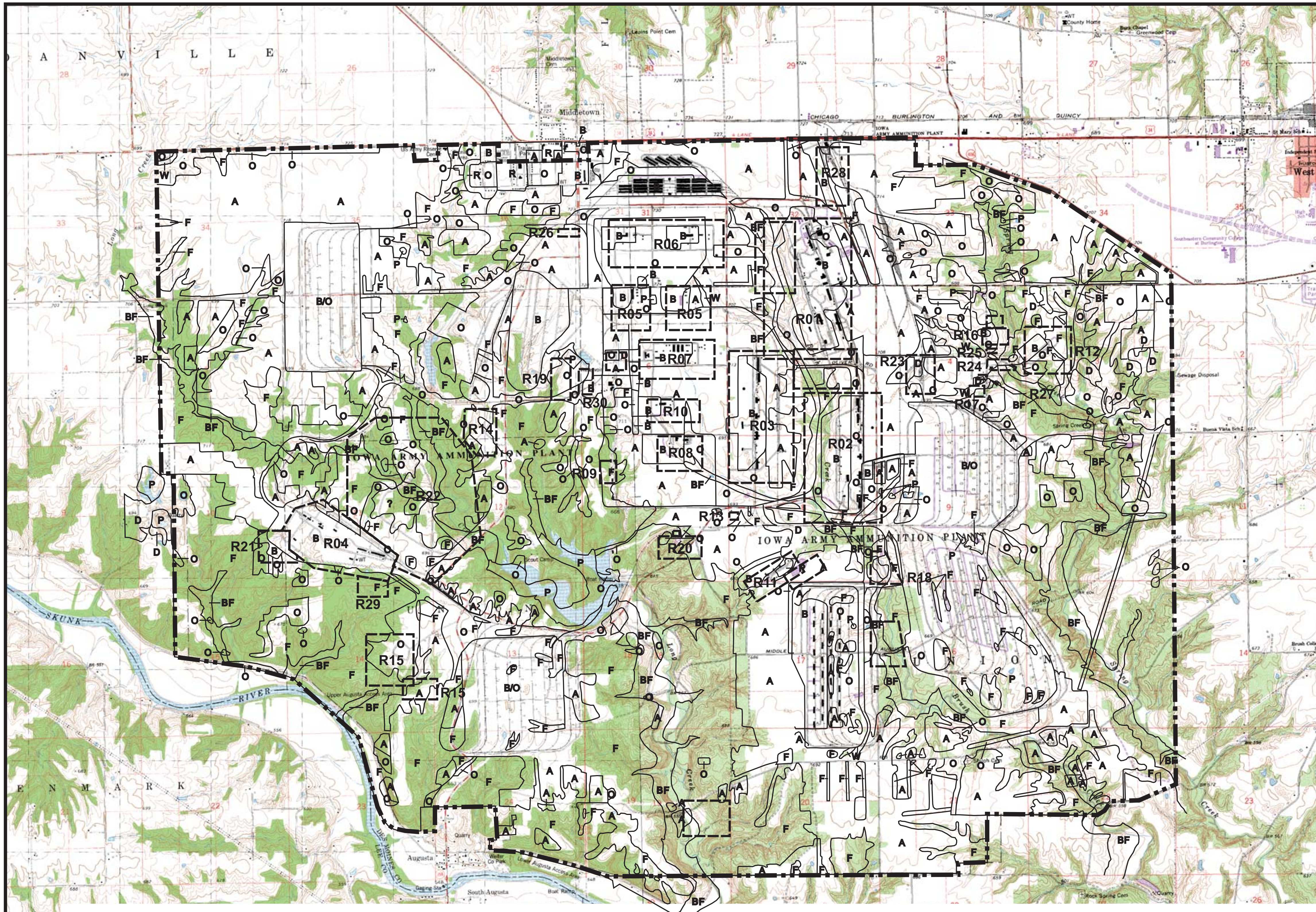
Figure 2-3

WATER AND SEDIMENT SAMPLING LOCATIONS
SEPTEMBER 2000

ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

MWH

O:\graphics\Iowa\Baseline Ecological RI\Exhibit 2-3.cdr



N

ABBREVIATIONS:

F	Forest
BF	Bottomland Forest (flood plain)
O	Old Field
W	Wetland
A	Agriculture
B	Base Facilities
P	Open Water, Pond/Lake
R	Residential
D	Disturbed (barren)

Scale 0 2000 4000 6000 8000 Feet

MWH

Figure 2-4

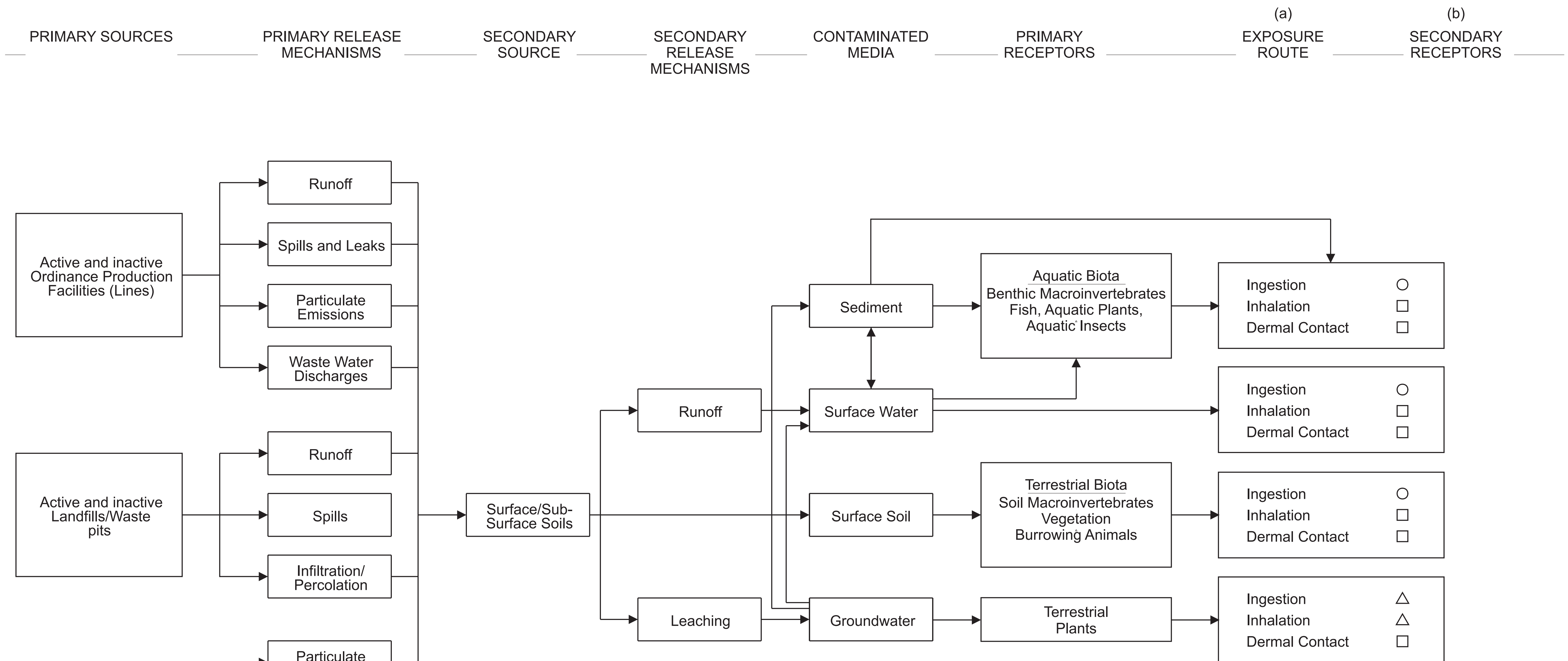
LAND USE MAP

ECOLOGICAL RISK ASSESSMENT

IOWA ARMY AMMUNITION PLANT

Iowa

O:/Iowa/Baseline Ecological RI/Exhbit 2-4.cdr



NOTES:

(a) For Exposure to Contaminated Media

(b) Exposure to Primary Receptor through Ingestion only

LEGEND:

○ Complete and Significant Exposure Pathway

□ Complete but Insignificant Exposure Pathway

△ Pathway Incomplete

o:/iowa/baseline ecological RI/figure 2-5.cdr

MWH

Figure 2-5

CONCEPTUAL SITE MODEL

ECOLOGICAL RISK ASSESSMENT

IOWA ARMY AMMUNITION PLANT

Iowa

Appendix A-2
Response To Comments

RESPONSE TO COMMENTS ON:
Draft Screening Level Risk Assessment, Ecological Risk Assessment,
Iowa Army Ammunition Plant
August 2001
COMMENTS SUBMITTED BY U. S. EPA, November 11, 2001

(Significant revisions were made to the Draft SLERA. Section numbers mentioned in some of the comments may not correspond with Section numbers in the Draft Final SLERA)

GENERAL COMMENTS

1. Selection of Chemicals of Potential Ecological Concern (COPECs). The Screening Level Risk Assessment (SLERA) includes a general list of COPECs and concludes that based on the results of the SLERA, a baseline ecological risk assessment (BERA) should be performed. Although the SLERA provides the general list of COPECs (Tables 4-1 and 4-2), and it is indicated that a BERA is recommended, the clear and transparent progression which documents the selection of COPECs and resulting hazard quotients has not been presented. The document does not present the standard frequency of detection tables typically associated with risk assessment and does not identify spatially where hazard quotients have been exceeded in the ecosystem. As outlined in U.S. Environmental Protection Agency (EPA) guidance, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Office of Solid Waste and Emergency Response, EPA/540/R-97/006, dated June 1997), one of three decisions (see page 2-5 of the guidance) are made at the end of the SLERA [i.e., the first scientific management decision point (SMDP)]. However, the manner in which the data are presented does not facilitate an understanding of the potential for ecological exposures at the site. It is recommended that location/habitat-specific frequency of detection tables and hazard quotients be presented as an amendment to the SLERA for use in risk management decisions. The EPA Risk Assessment website provides the template for an acceptable frequency of detection table at

(http://www.epa.gov/superfund/programs/risk/ragsd/index.htm).

Response: The screening process presented in the Draft Final SLERA (Appendix A1 to the BERA) incorporates changes suggested by the stakeholders. In Section 3 of the Draft Final SLERA, criteria for selection of COPECs in each media are discussed. Parameters required for identification of COPECs such as maximum, screening value, background level for inorganics, frequency of detection (FOD), and hazard quotients (HQ) for each soil constituent at each AOC are presented in tables in the Draft Final SLERA. Similarly, maximum concentrations, screening value benchmark, FOD, and HQ for each constituent in surface water and sediment at each watershed are also presented in the Draft Final SLERA.

Spatial distribution of HQ exceedances in the ecosystem is presented in Section 6 (Risk Characterization) of the BERA. Figures 6-10 through 6-17 illustrates spatial distribution of HQ values in each watershed. In the screening process, HQ values were determined as the ratio of maximum concentration of a constituent in a media to its corresponding screening value. In the BERA, HQ values were calculated by comparing modeled tissue doses to toxicity reference values (TRVs), which are doses that are protective of ecological receptors. Spatial distributions of HQ values for each AOC, where receptors are exposed in the terrestrial habitat, are provided for each watershed. At AOCs where clean up based on human health risks are not planned, further evaluation of ecological risks may be required. At such AOCs, HQ exceedances and spatial distribution for each constituent are presented with the receptors and toxicity endpoints noted. These figures also show the major streams and the tributaries to the streams where aquatic receptors are present. The information provided on these figures illustrate the spatial distribution of results in each watershed to determine if HQ exceedances are clustered in particular areas or spread across the site.

2. Chemical Data Used in Risk Assessment. Section 2.1.3, Environmental Setting and Contaminants at Soil AOCs (page 2-4), indicates that soil samples from the areas of concern (AOCs) were collected and analyzed during the remedial investigation (RI), and additional samples collected recently from Line 1 and Line 800 sumps, are combined for the purpose of the risk assessment. Appendix C1 presents a comprehensive output of all RI soil data, however, the data used in the risk assessment has not been clearly described or discussed. The depth of soil samples is not consistently noted in the text or indicated for the samples presented in Appendix C1. The depth of soil samples used for the SLERA should be specified. For example, the general discussion of contamination for some AOCs indicates soil contamination at depths to 15 feet or that contamination increased with depth, indicating the data for the SLERA may have combined and included all soil data. Soil analytical data for use in the SLERA should include depth intervals from zero (surface) to 6 inches, ranging to 24 inches. The specific analytical data used in SLERA should be clarified and presented on frequency of detection tables to facilitate an understanding of where data have been collected and where hazard quotient exceedances are concentrated. As indicated in General Comment No. 1, a frequency of detection table should be presented for each medium. In addition, sample locations with hazard quotient exceedances should also be correlated to the habitats on a figure in order to document where possible exposures are occurring, and to facilitate whether exposures have been adequately characterized within the ecosystem.

Response: Soil data from 0 (surface) to 24 inches were used in this assessment. This was the only soil depth interval for which data collected in the RI were used in the SLERA and the BERA. This information is included in Sections 2 and 3 of the Draft Final SLERA and the BERA in association with discussion of soil data. Soil data presented in Appendix C1 to the BERA only contain data from this interval. The FOD and HQ tables are presented in the Draft Final SLERA as stated in response to Comment No. 1. Sample locations with HQ exceedances are presented in Figures 6-10 through 6-17 in the BERA as stated in response to Comment No.1.

In order to provide clarity in RI data presentation, surface water and sediment data in each watershed and soil data at each Area of Concern (AOC) are summarized in table format in Appendix F to the BERA. The tables list media-specific screening values, number of samples, number of detects, FOD, minimum concentration, and maximum concentration values for each constituent analyzed. Then, discussion of contaminant characteristics at each watershed and AOC follows the tables by referring to the screening values to note constituents that may be of concern at the specific AOC or watershed.

3. Assessment and Measurement Endpoints. The manner in which receptors of concern and assessment and measurement endpoints have been selected and evaluated is unclear. For example, a detailed list of sensitive species is included in Section 2.7.1, however, most of these species are not mentioned in the context of the assessment endpoints or discussed further in any manner. The general population groups to be evaluated using the media-specific screening are not discussed prior to use of the benchmarks, and several assessment and measurement endpoints listed in Table 2-3 are not evaluated by the SLERA. The conceptual site model (CSM) indicates that contaminants may be taken up by plants and animals, but does not present the plant or animal bioaccumulation factors to be used, nor does it model the ingestion of plants to the upper trophic level populations. It is recommended that the document be revised to clearly present the potential populations or functional feeding guilds that may be exposed. The assessment and measurement endpoints should be clarified to present all receptor groups and clarify the measurement endpoints. The CSM, receptor selection, and assessment and measurement endpoints are not consistent with one another. The SLERA should clarify the media-specific screening evaluation through the use of media-specific frequency of detection, showing a comparison of the maximum detected concentration for each media to the screening benchmark with the resulting hazard quotient. If the Army is proposing to use dose modeling for the SLERA, then the input variables, including ingestion rates, food item assumptions, bioaccumulation factors, and toxicity reference values (TRVs), and dose spreadsheets should be clarified and presented, also to include the resulting hazard quotients.

Response: The text has been revised to present terrestrial or aquatic species expected to be present or observed at the IAAAP. This information has been included in Section 2 in the BERA. Discussions regarding sensitive species that are not associated with the IAAAP have been deleted. Table 2-3 referenced in the comment has been revised and presented as Table 2-3 in the BERA.

The plant and bioaccumulation factors and other input variables such as ingestion rates, TRVs, and food item assumptions were presented in the Development of Dose Estimation Models and Toxicity Reference values, a working memorandum developed previously to facilitate review of general approach for the BERA and reviewed by all stakeholders. The values are presented in sections 3 and 5, and Appendix G of the BERA and include revisions made to address comments from stakeholders.

Dose modeling was not used in the SLERA. Instead media-specific screening values available in the literature were used in the SLERA. The screening values were selected to cover a broad range of organisms, which is the typical approach used for a SLERA. Section 3 of the Draft Final SLERA describes how screening values were obtained.

Tables (Table 3-1 through 3-32) in the Draft Final SLERA have been provided to illustrate the media-specific screening evaluation through the use of media-specific frequency of detection, and to compare the maximum detected concentration for each media to the screening benchmark. The tables include the resulting hazard quotients.

4. Editorial. It is recommended that the list of appendices be included in the Table of Contents.

Response: It should be noted, many of the Appendices originally associated with the SLERA are now Appendices to the BERA. The Draft Final SLERA directs the reader to the appropriate Appendix in the BERA.

SPECIFIC COMMENTS

1. Section 2.1.3, Environmental Setting and Contaminants at Soil AOCs, (Pages 2-4 through 2-22). The document provides a detailed summary of activities associated with each AOC, and a general indication of the types and concentrations of detected chemicals. However the document does not indicate the number or the location of samples associated with each AOC relative to the ecological habitats. For example, the summary for the Fire Training Pit (R27) (page 2-20) indicates that storm water run off is directed towards an unnamed intermittent stream, with discharge to Spring Creek, and ultimately the Mississippi River. The general summary of contamination does not indicate whether sample locations were from within the pit itself or whether samples have been collected to document the possible migration pathway into the aquatic habitat. It is recommended that data be organized into a table or series of tables, with correlating figures to facilitate an understanding of where contamination is relative to ecological receptors/habitats.

Response: The requested level of detail was not added to the SLERA due to the BERA being a more appropriate document for providing this level of information. In the BERA, soil and sediment data from each AOC (Appendix C1) and surface water and sediment data from each watershed (Appendix D) have been summarized in Tables as requested. Soil sampling locations are shown in Appendix C2. Surface water and sediment sampling locations are shown on Figures 2-2 and 2-3 in the Draft Final SLERA. Potential migration pathways, habitats, and soil sampling locations at each AOC in each watershed are also presented in Figures F-1 through F-4 in Appendix F.

2. Section 2.1.4, Environmental Setting and Contaminants at the Four Watersheds, page 2-23. The text presents a discussion of the characteristics contributing to stream flow (e.g., rainfall, groundwater recharge) in the creeks associated with the facility. The fourth full paragraph indicates that surface water samples were collected in Spring and Fall 2000, however, there is no indication of the flow condition during the two sampling events. It is recommended that the document be revised to describe the flow conditions for each of the streams during each sampling event.

Response: Surface water flow at the IAAAP reflects a base flow regime for most of the year. Flow increases immediately following rainfall, but returns to the base flow regime within 24 hours. Base flow conditions existed during the sampling conducted in May and September 2000. Section 3 in the BERA has been revised to include this information, but has not been further elaborated upon in the Draft Final SLERA.

3. Section 2.1.4, Environmental Setting and Contaminants at the Four Watersheds, page 2-23, last paragraph. This section indicates that the impoundments at Line 1 and Line 800 are monitored on a monthly basis, and maximum concentrations have all been below corresponding ecological benchmarks. The text states, "Therefore, surface water at these impoundments does not have COPECs." The monitoring locations have not been presented and it is not clear how the impoundments relate to the aquatic resources at the site. Although surface water concentrations are below aquatic benchmarks, it is not evident whether sediment at the outfall of the impoundments may have been impacted and may be a continuing source of chronic exposure. The location of the monitoring stations should be described in the text and indicated on Exhibit 2-4.

Response: This comment has been addressed in the BERA rather than the Draft Final SLERA. Evaluation of aquatic resources in the BERA is based on comprehensive surface water and sediment sampling conducted during May and September 2000. Because the objective of this BERA is to evaluate impact on aquatic resources on a facility-wide basis, sampling was conducted specifically to address potential impact to the surface water and sediment at the site from all possible sources on the installation. For this reason, if there were impacts associated with the outfall that affected the stream they would have been captured by the sampling efforts that were completed in 2000. Text in Section 3 of the Draft Final SLERA includes the rationale and approach followed for selecting the surface water and sediment locations as follows. "USACE, Harza (now MWH), USEPA, and Techlaw (USEPA's contractor) personnel met on March 9, 2000 in Kansas City to select surface water and sediment sample locations. Locations were selected based upon known or suspected sources of aquatic pollution, identified locations of fine sediment deposition and threatened or endangered species records. For example, locations immediately downgradient of NPDES discharges, tributaries, sediment depositional areas, and groundwater discharge areas were identified. The selected locations provide coverage of all major streams across the plant property and included streams entering IAAAP on the west and east boundaries."

Brush Creek and its tributary at Line 1 and Line 800 have been sampled. Sediment, plant, and water data from 2 to 3 rounds of sampling conducted at Line 1 and Line 800 impoundments are available. Limited surface water data from monitoring showed maximum concentrations of all monitored constituents below surface water screening levels. The impoundments are active treatment units and were not meant for creating sustainable habitat. Therefore, the impoundments are not evaluated separately in the Draft Final SLERA or the BERA. As stated in Section 1.3 of the BERA (Scope of the BERA), the status of the impoundments may be reviewed as part of the 5-year review.

4. Sections 2.2 through 2.5, Brush Creek Watershed, Long Creek Watershed, Spring Creek Watershed, Skunk River Watershed, pages 2-24 through 2-25. The document presents a general summary of surface water and sediment sampling results. The summary provides a good overview of contamination in each watershed. However, it is not evident whether contamination is widespread throughout each of the watersheds or whether contamination can be related to

tertiary source discharges. It should be noted that efforts were made to select locations in each watershed to help identify potential discharges from sources located adjacent to or connected by an intermittent stream or surface drainage. Subsequent discussions (i.e., Section 2.6) briefly mention several specific, potentially contaminated groundwater discharges, however, the current presentation does not consider the specific sample selection decision criteria, and appears to limit the interpretation and identification of potential contaminant inputs to the watershed. It is recommended that locations with hazard quotient exceedances be denoted (e.g., boldface) on Exhibit 2-4, and the tertiary/secondary sources be discussed with regard to the rationale used to select the location as presented in Technical Memorandum 2.

Response: This comment has been addressed in part in the Draft Final SLERA and in part in the BERA. Section 3 of the Draft Final SLERA provides further discussion of the rationale and approach for surface water and sediment sampling as follows. USACE, Harza (now MWH), USEPA, and Techlaw (USEPA's contractor) personnel met on March 9, 2000 in Kansas City to select surface water and sediment sample locations. Locations were selected based upon known or suspected sources of aquatic pollution, identified locations of fine sediment deposition and threatened or endangered species records. For example, locations immediately downgradient of NPDES discharges, tributaries, sediment depositional areas, and groundwater discharge areas were identified. The selected locations provide coverage of all major streams across the plant property and included streams entering IAAAP on the west and east boundaries. Impact of secondary or tertiary sources on contaminant concentrations in the watersheds are not always evident. Section 3 of the BERA includes impact of secondary/tertiary sources on each of the watershed. Locations with HQ exceedances are presented in Figures 6-10 through 17 associated with Section 6 of the BERA.

5. Section 2.6.1, Distribution of Contaminants of Concern, Inorganics, page 2-26. This section states, "All of the inorganic contaminants of concern are naturally occurring." The statement is confusing since the terminology "contaminant of concern" implies that the contaminant has been identified and selected as a concern following a screening process. It should be clarified for casual readers of this document that the inorganic chemicals of potential concern may also be naturally occurring.

Response: The Draft Final SLERA states that inorganic chemicals of potential concern may also be naturally occurring. COPECs will be used as appropriate in the BERA, which also identifies contaminants of concern (COCs).

6. Section 2.6.2, Sources of Contamination to Surface Source, page 2-27. It is indicated that groundwater and wastewater discharges to surface water and the groundwater pathway were examined for individual AOCs within each watershed. However, specific information related to the individual AOCs for each watershed has not been discussed with regard to ecological exposures or hazard quotients. Generally the stated objective appears appropriate, however, the last sentence states, "Migration of contaminants to streams by overland runoff from AOCs and off-site migration of contaminants by remobilization and transport of sediments in streams were examined qualitatively only to the extent these pathways impact evaluation of the groundwater scenario." It is not clear how overland runoff and remobilized transport of sediments in streams

relate to or impact the groundwater scenario. Please clarify. It appears that continuing sources of contamination from tertiary sources, contaminated sediment sources, as well as groundwater discharges to the surface water should all be considered in the SLERA. It is recommended that concentrations detected in shallow groundwater associated with individual AOCs within each watershed be compared to surface water benchmarks to identify hazard quotient exceedances. This approach will facilitate the identification of potential continuing sources of contamination, regardless of the contributing media. For clarification, it is recommended that the subsection title be revised to "Sources of Contamination to Surface Water Bodies."

Response: This comment has been addressed in part in the Draft Final SLERA and in part in the BERA. All sources of contamination to surface water have been considered in the BERA. Stream flow within the IAAAP comprises three principal elements: surface runoff; groundwater inflow; and discharges under NPDES. Groundwater within the facility recharges surface water within the four watersheds. Concerns arose whether variations in groundwater flow are adequately reflected in surface water sampling conducted to date. Surface water flow at the IAAAP reflects a base flow regime for most of the year. Flow increases immediately following rainfall, but returns to the base flow regime within 24 hours. Monitored surface water data generated during comprehensive sampling conducted in spring and fall of 2000 should provide adequate characterization of contribution of groundwater to surface water. Contaminants present in groundwater have the potential to contaminate surface water and sediment. However, constituents such as explosives, that sorb weakly onto particulates, dissipate rapidly from the source as groundwater discharges into surface water. Surface water and sediment investigations conducted over the years appear to have accounted for variations in flow regime at the IAAAP. Contaminant concentrations monitored in surface water during various investigations are comparable. For example, highest RDX concentrations detected in Brush Creek during the supplemental groundwater investigation (Harza 1997), and the supplemental RI (Harza 2001) are 9.3 and 14 μg/L, respectively. These concentrations are comparable to the maximum RDX concentration of 15 μg/L observed during sampling for the ecological assessment in 2000. Most of these samplings were conducted during base flow conditions, when the surface water flow is primarily due to groundwater discharge. Therefore, it appears that surface water and sediment characterization conducted to date adequately accounts for groundwater contributions to surface water. Section 3 in the BERA includes the information presented in this paragraph.

Within the Draft Final SLERA, FOD and HQ for each soil constituent at each AOC are presented in Tables 3-13 through 3-32 as requested. FOD and HQs for surface water and sediment at each watershed are presented in Tables 3-5 through 3-12.

7. Section 2.6.2, Sources of Contamination to Surface Source, page 2-28. This section states "Similarly, plant areas in the Skunk River watershed are immediately adjacent to the plant boundary and off-site impacts are already known based on off-site groundwater investigations." It is not clear how or what information associated with the off-site groundwater investigation relates to the Skunk River watershed. The document should be clarified to indicate potential ecological exposure and contamination from source discharges into the Skunk River.

Response: The Skunk River watershed is evaluated only to the extent that some of the west-southwest part of the plant is drained by small intermittent tributaries to the Skunk River.

8. Section 2.6.2, Sources of Contamination to Surface Source, For the Brush Creek Watershed, page 2-28. The bullets provide a general summary of the most significant potential contaminant sources to the watershed and recommendations for further evaluation at selected locations. While the recommendations appear to be warranted, the information to support the decisions has not been clearly presented. For example, the second bullet suggests that of the six AOCs examined, "Line 800/Pink Water Lagoon is by far the most significant potential contributor." However, it is not clear what information was used to draw this conclusion. The section contains risk management decisions that should be supported with the presentation of hazard quotients in order for all risk managers to be able to evaluate the results objectively. It is recommended that statements regarding the significance of AOCs and their respective groundwater contributions be supported with a clear and transparent presentation of data and resulting hazard quotients, as outlined in General Comment Nos. 1 and 2. This comment also applies to the other watershed conclusions presented in the remainder of Section 2.6.2.

Response: This comment has been addressed in the BERA. The sentence referred to in the comment has also been revised in the BERA to state that "Line 800/Pink Water Lagoon……contributor of **explosives** to groundwater." The information used to reach this conclusion on sources of explosives is presented in the SLERA immediately preceding this sentence.

The requested level of detail was not added to the SLERA due to the BERA being a more appropriate document for providing this level of information. Calculated HQs for each AOC in each watershed along with illustrations (Figures 6-10 through 6-17) showing locations of HQ exceedances are presented in Section 6, Risk Characterization, of the BERA.

9. Section 2.7.1, Ecological Receptors, pages 2-29 through 2-31. The section provides a comprehensive list of sensitive species potentially associated with the facility. However, the section does not clearly indicate the general populations or functional feeding guilds that will be evaluated within the SLERA. While some population information is presented in a subsequent section (Section 2.9, Selection of Ecological Assessment and Measurement Endpoints), the presentation would benefit from a general discussion of representative receptor groups prior to the selection of assessment endpoints. This would also serve to provide the supporting background information and help clarify for the subsequent conceptual site model and assessment and measurement endpoints sections. It is recommended that a brief discussion of the primary potentially exposed populations be included. The information regarding sensitive species is also appropriate and should be presented, however, it should be included in addition to the general population groups to be evaluated. It is recommended that the information currently presented be identified in a subsection titled "Sensitive Species," rather than general "Ecological Receptors" as the current title suggests.

Response: The text has been revised to present terrestrial or aquatic species expected to be present or observed at the IAAAP. This information is included in Section 2 of the Draft Final SLERA. Discussions regarding sensitive species that are not associated with the IAAAP have been deleted. The remaining discussion on sensitive species is very limited and, therefore, a separate subsection did not appear necessary. The conceptual site model (CSM) presented in the Draft Final SLERA does not extend to specific receptors to be protected, but is rather based on a broad goal of protecting most organisms. The further elaboration that was requested concerning ecological receptors is provided in the BERA.

10. Section 2.9, Selection of Ecological Assessment and Measurement Endpoints, page 2-32. In general, the discussion of assessment and measurement endpoints does not clearly document which endpoints have been selected for the SLERA. For example, the first three paragraphs discuss potential aquatic receptors and indicate that the benthic community and an individual fish species will be evaluated as assessment endpoints. However, the text on page 2-32 does not mention the measurement endpoints to be associated with each assessment endpoint. The discussion of assessment and measurements on the following page then does not appear to be consistent as it indicates aquatic algae as an assessment endpoint. The aquatic endpoints should be clearly discussed indicating the assessment endpoints and associated media-specific benchmarks for the evaluation. The measurement endpoints for the individual fish species are appropriate, however, it should be clarified that the general fish populations will also be evaluated through the use of the media-specific surface water benchmarks.

Response: It should be clarified that only very broad assessment endpoints were selected in the SLERA as is normally done. More specific assessment endpoints (and related measurement endpoints) were selected as part of the BERA after the SLERA was complete. Keeping with that general approach, the screening values selected for use in the SLERA were based on a broad goal of protecting most organisms. The former Table 3-2, Assessment Endpoints and Measures of Effect from the SLERA, has been revised in this BERA. The specific measures of exposure and/or effect for each assessment endpoints are included in the table as requested. Evaluation of the general fish population through the use of media-specific benchmarks is listed as one measure of effect. It is MWH’s intention to address the health of the general fish population qualitatively based on measurement endpoints selected for evaluation in the BERA. This would include use of surface water benchmarks as one of the lines of evidence. However, as described above, these surface-water benchmarks are not specifically developed to protect only fish, and so are weaker lines of evidence than the measurement endpoints selected for specifically evaluating fish health within the BERA.

11. Section 2.9, Selection of Ecological Assessment and Measurement Endpoints, Page 2-32. The third paragraph presents a detailed discussion of the life requisites for the short-tailed shrew and the white-footed mouse. However, it is not clear why an equivalent discussion of the other receptor groups, waterfowl and the Indiana bat, have not been included. In addition, the assessment endpoints on the following page and on Table 2-3 are not consistent with the text on this page. Also, it does not appear that any dose modeling has been included in the SLERA. The presentation is confusing and has not clearly indicated how the small mammals are ultimately related to the screening benchmarks presented in Section 3.0. It is recommended that all of the general life-requisite information be moved and presented in Section 2.7. The

assessment and measurement selection as indicated on Page 2-33 should be clarified to be consistent with the screening benchmarks presented in Section 3.0.

Response: Further details about the aquatic receptors have been added in Section 2 in the BERA rather than in the SLERA. Dose modeling was not conducted in the SLERA. The selection of TRVs for use in dose modeling was based on receptor-specific information such as those available or derived for small mammals. In the BERA, life-requisite information on all assessment endpoints has been moved ahead of selection of assessment endpoints and measures of effect.

In the screening process presented in the SLERA, media-specific screening values available in the literature were used. The SLERA has been revised to add that the screening values were based on a broad goal of protecting most organisms and are not developed for the protection of specific species. Therefore, as part of the SLERA, a detailed discussion of the specific habits of each potential receptor is not included. These details are provided in the BERA as appropriate (i.e., for the selected ecological receptors).

12. Section 2.9, Selection of Ecological Assessment and Measurement Endpoints, page 2-32. This section indicates that proposed lists of assessment endpoints and measures of effects are presented on Table 2-3, however, the subsequent text does not correlate to the assessment and measurement endpoints on Table 2-3, or those receptors presented in the CSM. The second paragraph lists benthic community structure and aquatic algae under chronic exposures, as assessment endpoints, however, the method related to how the benthic structure will be assessed, as a measure of effect, has not been included. The text and tables should be clarified to indicate the metrics to be used for each of the assessment endpoints. It appears that some of the measurement endpoints may be suggested as lines of evidence for future BERA iterations. The SLERA should be revised to present a clear and transparent documentation of the initial media-specific evaluation included for this effort.

It is indicated that the belted kingfisher is selected as representative of the aquatic piscivore feeding guild. The document should include a brief discussion related to the representativeness of this receptor for the area and for the feeding guild. In addition, it is not evident that this is a sensitive species. This should be clarified.

Response: This comment has been addressed in the BERA. Measure of effect for the benthic community structure has been added to Table 2-3, Assessment Endpoints and Measures of Effect, in the BERA. Measures of effect for all assessment endpoints are included in the table. Details about the aquatic receptors have been added in Section 2 in the BERA. The table has been revised to state Goal 2 as “Protect Biological Integrity of Piscivorous Waterfowl Population.” The belted kigfisher is, therefore, no longer listed as a sensitive species.

13. Table 2-3, Assessment and Measurement Endpoints, page 2-34. The assessment and measurement endpoints are not consistent with the receptors indicated by the CSM (Exhibit 2-5). It is recommended that the assessment and measurement endpoints be revised to reflect the receptor groups indicated in the CSM.

Goals 2 and 4 are stated as “Protect sensitive species”, with the assessment endpoints listed as “Survival, growth, and reproduction of aquatic piscivores” and “Survival, growth and reproduction of terrestrial herbivores”, respectively. Table 2-3 indicates that the belted kingfisher and the white-footed mouse have been selected as representative species for Goals 2 and 4. Neither the belted kingfisher or the white-footed mouse is considered to be sensitive species. The goals should be clarified to protect biological integrity of piscivorous waterfowl populations and terrestrial herbivore populations or revise the assessment endpoints to indicate what sensitive species are to be modeled using these species as the measurement endpoints.

The measures of exposure for Goals 3, 4, and 5, include modeled vegetation or tissue concentrations. However, it is not evident what has been used to model the concentrations in these food items, and dose models are not presented in the SLERA. The assessment and measurement endpoints should be clarified based on what is intended for use in the SLERA. Page 3-2 indicates that media-specific soil benchmarks are to be used. The document should be clarified to present clear and consistent endpoints for the SLERA.

Response: The CSM presented in the Draft Final SLERA does not extend to specific receptors to be protected, but is rather based on a broad goal of protecting most organisms.
The CSM for the BERA has been revised to include the assessment endpoints. Goals 2 and 4 in Table 3-2, Assessment Endpoints and Measures of Effect, in the BERA have been revised to incorporate the changes suggested in this comment.

The screening process used in the SLERA was based on comparison of site-specific concentrations to literature derived media-specific benchmark values. Dose modeling was not conducted as part of the screening process.

14. Section 3.1.2, Derivation of Sediment SVs, page 3-2. It is indicated that sediment preliminary remediation goals (PRGs) based on equilibrium partitioning were used as screening benchmarks. However, the assumptions for total organic carbon (TOC) have not been presented. The TOC assumption and the basis for the assumption used for the site should be included in the discussion.

Response: The TOC values used in equilibrium partitioning model were measured values and not assumed. The section on selection of sediment screening values has been revised to add that the Total Organic Carbon (TOC) content was measured for each sediment sample collected in September 2000. The analytical results are presented in Table 3-2 in the Draft Final SLERA.

15. Section 3.2.1, Comparison with Screening Level Benchmarks, page 3-4. This section indicates that results of the comparison of maximum detected concentrations with correlated benchmarks are presented in Appendix H. The comparison provides the general list of COPECs, however, no hazard quotients (HQs) or sample locations have been provided. The evaluation of HQ exceedances within the ecosystem and sources is considered paramount for completing the first SMDP, and for the overall evaluation of whether the available data are considered representative of potential exposures. It should be noted that the identification of a data gap does

not necessarily imply additional data are required to complete the BERA. However, data gaps should be considered in the ultimate determination of exposure point concentrations for use in the BERA. It is recommended that hazard quotients be calculated and presented in the context of the ecosystem in order to evaluate the extent of potential exposures and determination of exposure point concentrations for use in the BERA.

Response: The media-specific frequency of detection, comparison of the maximum detected concentration for each media to the screening benchmarks, and the resulting hazard quotients are presented in Tables 3-5 through 3-32 in the Draft Final SLERA.

Spatial distribution of HQ exceedances in the ecosystem is presented in Section 6 (Risk Characterization) of the BERA. Figures 6-10 through 6-17 illustrates spatial distribution of HQ values in each watershed. In the screening process, HQ values were determined as the ratio of maximum concentration of a constituent in a media to its corresponding screening value. In the BERA, HQ values were calculated by comparing modeled tissue doses to literature reference values. Spatial distributions of HQ values at each AOCs, where receptors are exposed in the terrestrial habitat, are provided for each watershed. At AOCs where clean up based on human health risks are not planned, further evaluation of ecological risks may be required. At such AOCs, HQ exceedances and spatial distribution for each constituent are presented with the receptors and toxicity endpoints noted. These figures also show the major streams and the tributaries to the streams where aquatic receptors are present. The information provided on these figures illustrates the spatial distribution of results in each watershed to determine if HQ exceedances are clustered in particular areas or spread across the site.

16. Section 3.2.2, Determination of Site-specific Impact, page 3-4, first three bullets. This section indicates that there are surface water/sediment sample locations that are considered to be unimpacted by the facility, but that the detected inorganic compound concentrations are not used to eliminate any chemicals during the screening. The rationale for this approach and including this information in the SLERA is not clear. It is recommended that the unimpacted or background concentrations be presented in a column or a table for use in comparison to detected concentrations at impacted sites. If it can be clearly documented that an inorganic chemical is not occurring at elevated levels (is not a "release" to the environment), then these chemicals should not be carried through to the BERA. Since there are only two surface water/sediment locations, it is recommended that the minimum detected background concentration be used for the SLERA. However, it is noted that the Spring Creek locations may be within the vicinity of the Ammunition Box Chipper. Specific supporting documentation related to the potential for surface water runoff or other drainage from the AOC, relative to the upstream location should be provided to ensure the location has not been impacted.

Response: As noted in the comment, it is probable that the Spring Creek location may be affected by site activities. Appropriate background locations are not available for most of the watersheds because the headwaters are within or in close proximity to the AOCs. The only upstream surface water/sediment location is LC1 in Long Creek. Comparison of surface water/sediment concentrations on-site to upstream concentrations could not be conducted for three of the four watersheds. The SLERA has been revised to add that as a general approach in the screening process used in the SLERA, site-specific surface water/sediment concentrations, including those in Long Creek, were not compared against upstream concentrations. However, LC1 was still considered an upstream location for evaluation of impact on benthic community. Text in Section 4 of the BERA includes evaluation of benthic community structure at LC1 as an upstream location in Long Creek.

17. Section 3.2.2, Determination of Site-specific Impact, page 3-4, fourth bullet. This section indicates that over 100 soil samples were used to establish background concentrations at the site. It is noted that samples were collected from three depth intervals including 0 to 0.5 feet, 1.5 to 2.0 feet, and 3.0 to 3.5 feet. It is not clear whether the background concentrations were derived based on a combination of all data for all depths. However, background concentrations should be obtained separately for surface soil and each subsurface soil interval.

Response: The soil depth interval selected in the screening process is 0 to two feet. This depth interval is comparable to the interval of 0 to 3.5 feet for the background samples. This information is included in Section 3 of the SLERA.

18. Section 3.2.2, Determination of Site-specific Impact, page 3-4, fourth bullet. The screening approach for metals detected in soils is not clear. The steps presented indicate that inorganics were compared to background concentrations. It is further stated that all inorganic compounds were retained for further consideration. However, the approach includes a second step using statistical analysis to examine aluminum to allow elimination of the compound based on AOC-specific assessment. It appears this process was only conducted for aluminum because “the maximum for some sites was comparable to the 95th percentile value in background soil.” It is not clear what is meant by “comparable.” It should be noted, for the SLERA, if maximum detected aluminum concentrations are below the 95th percentile background concentrations, then it is not necessary to retain it as a COPC. If it is above background, then it should be retained as a COPC and evaluated in the BERA. Since the text indicates that all detected inorganics were above benchmarks and also above background, they should all be retained as COPCs. A screening table which includes a column of the soil benchmarks and background concentrations should be used to clarify the COPC selection process. Use of statistical analyses for the selection of AOC-specific COPCs should not be conducted until site-wide dose models have been run. The SLERA should calculate hazard quotients from the dose models based on maximum concentrations to determine whether aluminum should be retained as a COPC. If retained, the AOC-specific dose models should be used as part of the BERA to determine if it is a COC for each area.

Response: The SLERA has been revised to delete reference to the statistical test. 95^{th} percentile values of inorganics in background soil are listed on Tables 3-13 through 3-32 in Section 3 of the Draft Final SLERA along with maximum and screening values for each constituent at each AOC. Maximum concentrations of inorganics were compared to screening values first, and if found higher than the screening value, were compared to the 95^{th} percentile of background. Based on such comparison, several inorganics in several AOCs were eliminated as COPECs. For aluminum, maximum concentrations at only three AOCs, R01, R02, and R11, exceeded the 95^{th} percentile background concentration. USEPA’s Draft Ecological Soil Screening Level Guidance

(July 2000) states that aluminum should be identified as a contaminant of concern only if the soil pH is less than 5.5. Soil pH at locations where aluminum concentrations exceed its screening level were much higher than 5.5 based on recent soil pH measurements conducted by USACE. The pH data are presented in Table 3- 33 in the SLERA. Therefore, aluminum was not retained as a soil COPEC at any of the AOCs. The selected COPECs are bolded in the tables.

19. Section 3.2.2, Determination of Site-specific Impact, page 3-4, fifth bullet. This section indicates that aluminum was eliminated from further consideration from a list of specific AOCs (e.g., R01, R02). However, aluminum appears as a COPC for the AOCs listed on Table 4-2. The screening process is not consistent with the recommended EPA approach for conducting a SLERA, and should be revised as indicated in the previous comment.

Response: Please see Response to Specific comment No. 18. The table listing soil COPECs (Table 3-35 in the Draft Final SLERA) has been revised to be consistent with the screening process used in the SLERA.

20. Section 3.3.3, Evaluation of Frequency of Detection, page 3-5. It is indicated that chemicals that were detected infrequently and not at locations adjacent to each other were eliminated. The rationale for this approach is not supported by the information presented. If sample locations were selected based on a biased sampling scheme, then this is not a valid approach. For example, it is indicated that Dicamba was eliminated since it was only detected in 4 out of 60 soil samples. However, if only one area of the plant is suspected as a dump site for herbicides, and sample locations were biased to ensure that the most likely area was sampled, then 4 detections may actually be relevant in the context of the specific area. The rationale for grouping all 60 samples into one data set for a frequency of detection assessment has not been explained and does not appear to be valid. Elimination, based on frequency of detection, is not appropriate during the SLERA unless it can be documented that comprehensive sampling of all habitats for each source area has occurred. It is recommended that frequency of detection not be used as a step in screening COPECs in the SLERA. As indicated in General Comment No. 1, HQs should be presented in frequency of detection tables and in the context of the habitat and source area. Thus, a determination of data completeness, based on HQ exceedances can be made during the SMDP.
The following link provides useful information regarding the performance of a SLERA and discusses the use of frequency of detection during the SLERA
www.epa.gov/superfund/programs/risk/ecoup/slera0601

Response: Frequency of detection was not used as sole criteria for eliminating COPECs in surface water and sediment in this SLERA. Frequency of detect was not used at all as a criterion to select COPECs in soil. Section 3 of the Draft Final SLERA includes text that states as follows. "Constituents detected at low frequency in surface water and sediment were reviewed further to determine if they were also detected in the source area. Constituents detected at low frequency that were not detected in source areas were eliminated from further considerations as COPECs."

FOD and HQ for each soil constituent at each AOC are presented in Tables 3-13 through 3-32 in the Draft Final SLERA. Similarly, FOD and HQs for surface water and sediment at each watershed are presented in Tables 3-5 through 3-12 in the Draft Final SLERA. Spatial distribution of HQ values at each AOC, where receptors are exposed in terrestrial habitat, is provided for each watershed in Figures 6-10 through 6-17 associated with Section 6 in the BERA. The figures also show the major streams and the tributaries to the streams where aquatic receptors are present.

21. Section 3.2.6, Radionuclides, page 3-7. It is indicated that several detected concentrations were compared to, and exceeded corresponding available benchmarks. It is further stated that the "Tech Memos developed so far only focuses on impact of chemical contamination," and "Data should be further evaluated for developing an approach." Since it appears that the Army is not intending to evaluate ecological risks associated with radionuclides in the SLERA (and presumably the BERA), a schedule, pursuant to the FFA, should be provided to indicate when potential ecological risks associated with radionuclides at IAAP will be evaluated.

Response: Comment acknowledged. Comment to be addressed by the IAAAP specifically and will not be handled in this SLERA and/or BERA.

APPENDIX A – RI ANALYTICAL RESULTS

22. Appendix A presents hundreds of samples and analytical results, however the locations, dates of sample collection, and relevance and use of the analytical results in the SLERA have not been discussed in the text. It is recommended that the use of the data and corresponding data tables be clarified in order to document the relevance to the ecological risk assessment.

Response: Slip-sheets were added in the Draft Final SLERA indicating that this information is provided in Appendix C1 to the BERA. SLERA and BERA share this Appendix. Page numbers have been added to Appendix C1. References in the text explain appropriate use of data.

23. Table 1 of Appendix B presents 1995 analytical results from samples collected in Stump Lake. The lake has not been previously discussed in the text. For some samples, the results indicate detected concentrations in surface water above ambient water quality criteria (AWQC) for lead, cadmium, and chromium. Stump Lake and the surface water and sediment results presented in this table should be discussed in the context of the SLERA.

Response: Subsequent information received from USACE indicated that uncontaminated fill material was used at these AOCs, instead of sediment from Stump Lake. Therefore, reference to Stump Lake has not been included in the Draft Final SLERA and the BERA.

APPENDIX F - ECOLOGICAL SCREENING VALUES

24. Table F-1, Surface Water Screening Values for Stream Systems at Iowa Army Ammunition Plant. This table presents a comprehensive listing of available benchmarks. However, some of the resources listed in the footnotes to this table include the lowest observed adverse effect level

(LOAEL). The SLERA should be conducted using the no observed adverse effects level (NOAEL). In some cases, the citation for the selected screening value is not completely evident. For example, the "Supplemental Values" column indicates that screening values presented in this column may have been obtained from any of five resources (which are identified in table footnotes 5 through 9). However, it is not possible to distinguish which resource is used for the selected screening value. It is recommended that the appropriate individual footnote be presented with each selected value, rather than as a group at the top of the column. This is also recommended for Tables F-2 and F-3.

It should be noted that citation number 5, NOAA, 1999 Screening Quick Reference Table, is also a compilation of various benchmarks, and for surface water primarily include the EPA AWQC. The table should be clarified to include the original citation for the selected benchmarks.

Response: The screening value tables (Tables 3-1, 3-3, and 3-4) have been revised to specifically identify each source. Text has been added in Section 3 of the Draft Final SLERA to note that USEPA (1999a) is the primary source of values in NOAA (1999). If screening values were not available from any other sources, LOAEL values, if available, were used to derive NOAEL

25. Table F-2, Sediment Screening Values for Stream Systems at Iowa Army Ammunition Plant. Equilibrium partitioning benchmarks have been presented as one potential benchmark for selection. The benchmark presented includes an assumption for TOC. The site-specific TOC should be included in the corresponding footnote. If possible, the text should indicate how the organic carbon content used to calculate the benchmarks relates to representative, site-specific organic carbon values.

Response: Please see response to Specific Comment No. 14.

Appendix B
Technical Memos

Appendix B Table of Content

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Appendix B-1
Technical Memo No. 1

TECHNICAL MEMO NO. 1 - DRAFT
DEVELOPMENT OF ASSESSMENT AND MEASUREMENT ENDPOINTS FOR ECOLOGICAL RISK ASSESSMENT AT THE IOWA ARMY AMMUNITION PLANT

April 8, 1999

Introduction

The Omaha District of the U. S. Army Corps of Engineers (USACE) has directed Harza Engineering Company (Harza) to update the existing Ecological Risk Assessment (ERA) for the Iowa Army Ammunition Plant (IAAAP), Middletown, Iowa. The ERA update will address issues raised by the Army, regulatory agencies, and natural resource trustees, specifically with respect to guidance used for the previous ERAA, development of preliminary ecological remediation goals (PRGs) and uncertainty in surface water and sediment contamination.

As the initial step in the ERA update process, Harza was tasked with preparing a series of Technical Memoranda (TM). TM are planned around the following topics:

1. Development of Assessment and Measurement Endpoints
2. Water and Sediment Data Collection
3. Development of Hazard Models and Ecological PRGs
4. Contaminant Screening Process

The final memoranda will be the principal planning documents for the ERA update and will reflect consensus among all reviewers as to the methods to be used. Reviewers are:

- Scott Marquess, EPA Region VII
- Michael Coffey, USFWS
- Janet Whaley, Matt Bazar, CHPPM
- Randy Sellers, USACE, Omaha
- Rodger Allison, Joe Hafner, IAAAP

This is the first TM and proposes assessment and measurement endpoints to be used in the ERA update. Individual sections summarize contaminants of concern, potential pathways and receptors, IAAAP resource management goals and, finally, potential assessment and measurement endpoints. Relevant information contained in existing documents is incorporated by reference where appropriate.

Contaminants of Concern

Information on contaminants of potential concern is taken from the draft final ERAA (Table 1) where hazard quotients (HQ) exceeding unity may pose unacceptable risks to ecological receptors. Additional contaminants may be identified as posing ecological risks later, as the updated ERA will utilize alternative screening algorithms (TM. 4), an expanded database, and updated toxicity information and dose models (TM 3).

In general, aquatic systems are exposed to concentrations of some metals that may be affecting orangethroat darters or other fishes in Spring and Brush Creeks. Thallium, silver, barium, copper and lead are contaminants of concern. Additionally, explosives continue to enter these aquatic systems through groundwater seeps and other mechanisms. Expanded water and sediment quality sampling is planned during this update (TM 2).

The draft final ERAA identified silver and dibenzofuran as contaminants of concern in terrestrial ecosystems. The terrestrial assessment will be completely revised in the update, as the watershed-approach will not be applied here. Additional COCs are expected to be identified around production areas and may include explosives, agricultural chemicals (pesticides) and metals.

Table 1. Summary of ERAA Findings

Watershed	Darter Viability	Small Mammal Viability
Brush Creek	Silver HQ = 14 Thallium HQ = 1.7 Lead HQ = 1.1	Silver HQ = 0.4 to 1.4 Dibenzofuran HQ = 1.2
	Uncertainty = high to moderate	Uncertainty = moderate to high
Long Creek	FONSI	FONSI
	Uncertainty = high	Uncertainty = moderate to high
Spring Creek	Barium HQ = 27 Copper HQ = 3.5 Lead HQ = 1.3	FONSI
	Uncertainty = high	Uncertainty = moderate to high
Skunk River tributaries	N/A	FONSI
	N/A	Uncertainty = high

FONSI = Finding of No Significant Impact
N/A = Not Applicable

Identification of Potential Pathways and Receptors

The ERAA identified habitats and populations present at the IAAAP. Most of the land is either upland oak-hickory forest or agricultural use (Table 2). Lesser areas of land use types include old fields, production areas, and floodplain forest.

Table 2. Present Land Use/Land Cover Area (ac) at IAAAP (by watershed)

	Brush Creek	Skunk River	Long Creek	Spring Creek	Totals
Upland Forest	563	1,441	2,693	1,386	6,083
Flood Plain Forest	221	72	483	296	1,073
Old Field	981	258	1,073	590	2,901
Other Wetlands	7	0	2	27	35
Agriculture	1,909	412	2,487	1,100	5,908
Base Facilities	681	115	236	58	1,090
Open Water, Pond/Lake	15	5	128	7	155
Residential	0	0	69	0	69
Disturbed (barren)	107	4	0	46	157
Base Facilities/Old Fields	529	192	497	384	1,601
Totals	5,014	2,499	7,669	3,892	19,074

Two federal-listed threatened or endangered species are recorded on the IAAAP property. The bald eagle (*Haliaeetus leucocephalus*), listed as threatened, has been recorded to feed at Mathes Lake. Indiana bats (*Myotis sodalis*) have also been recorded to feed on the property, and may have maternal roosts in the floodplain forests. State listed endangered, threatened, and special concern species found by Horton *et al.* (1996) are tabulated below. The orangethroat darter (*Etheostoma spectabile*) is common in Spring and Brush Creeks and is considered a threatened species in Iowa. Several threatened plants were found in the upland or floodplain forests by Horton and co-workers.

Table 3. State Protected Species Known to Occur on the IAAAP

Common name	Scientific Name	Status[1]
Plants		
Virginia snakeroot	*Aristolochia serpentaria*	T
Downy wood-mint	*Blephilia ciliata*	T
Blue ash	*Fraxinus quadrangulata*	T
Sharpwing monkeyflower	*Mimulus alatus*	T
Ragged fringed orchid	*Platanthera lacera*	SC
Slender ladies tresses	*Spiranthes lacera*	T
False hellebore	*Veratrum woodi*	T
Animals		
Orangethroat darter	*Etheostoma spectabile*	T

[1] SC=special concern, T=threatened, E=endangered

An exposure pathway traces the contaminant from the source to ecological receptors, where it is taken up via an exposure route. A matrix identifying complete and significant exposure pathways are shown in Figure 1. Aquatic organisms are potentially exposed to metals and explosives in contaminated surface water, sediment, groundwater seeps, food chain sources. Terrestrial organisms are potentially exposed in contaminated soils, groundwater seeps and food chain sources.

Figure 1. Potential Exposure Pathways

Source/Pathway	Aquatic plants	Invertebrates	Fishes	Aquatic herbivores	Piscivorous wildlife	Terrestrial plants	Herbivores	Omnivores	Carnivores	Insectivores
Groundwater	●	●	●	◖	○	●	○	○	○	○
Soil	○	●	○	○	○	●	◖	◖	○	○
Surface Water	●	●	●	◖	◖	○	○	○	○	○
Sediment	●	●	●	◖	○	○	○	○	○	○
Air	○	○	○	○	○	○	○	○	○	○
Food Chain	○	◖	◖	◖	◖	○	●	◖	◖	◖

Legend

○ Incomplete/Insignificant

◖ Complete/Insignificant

● Complete/Significant

IAAAP Resource Management Goals

The IAAAP is currently finalizing an Integrated Natural Resource Management Plan. The draft natural resource management plan includes the following environmental stewardship and compliance policies:

- Monitor and manage soils, vegetation, and wildlife on IAAAP considering the biological communities and values associated with these resources.
- Provide economic and other products of renewable natural resources when such products can be produced in a sustainable fashion without significant negative impacts on the military mission.
- Ensure that IAAAP's natural resources program is coordinated with federal, state, and local agencies, as well as conservation organizations with similar interests.
- Involve the surrounding community in IAAAP's natural resources management program.
- Manage natural and cultural resources within both the spirit and letter of environmental laws.
- Implement the management plan within the framework of Army policies and regulations.

- Emphasize protection, restoration, and management of sensitive species and habitats. The management plan calls for, among other actions, the restoration of 500 acres of prairie at IAAAP.

Selection of Assessment and Measurement Endpoints

EPA's three criteria for selecting and defining assessment endpoints are:

1. Ecological Relevance.
2. Susceptibility to Known or Potential Stressors.
3. Relevance to Management Goals.

An assessment endpoint is defined by the EPA to be "an explicit expression of the environmental value that is to be protected". A measurement endpoint is defined to be "a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint." Measurement endpoints differ from assessment endpoints in that they involve a specific species. Proposed lists of assessment and measurement endpoints are given in Table 4.

Table 4. Management Goals, Proposed Assessment Endpoints and Measures

1. Goal: **Protect the biological, physical and chemical integrity of IAAAP aquatic habitats**

Assessment Endpoint: Survival, growth, and reproduction of fish, aquatic macroinvertebrates, and algal species under chronic exposure *(representative species: - orangethroat darter, Ephemeroptera, Plecoptera, and Trichoptera larvae)*

Measures of exposure:	*measures of effect:*	*measures of ecosystem and receptor characteristics:*
- total and dissolved water concentrations - sediment concentrations - fish tissue concentrations	- Iowa chronic water quality standards - laboratory-derived chronic effects levels - BTAG guidance - RBP II metrics - tissue residue effects benchmarks	- stream physical habitat measurements - fish DELTs - surface water DO, temp., and conductivity - benthic macroinvertebrate abundance and diversity

2. Goal: **Protect sensitive species**

Assessment Endpoint: Survival, growth, and reproduction of aquatic piscivores *(representative species – belted kingfisher)*

Measures of exposure:	*Measures of effect:*	*Measures of ecosystem and receptor characteristics:*
- fish tissue concentrations - water and sediment concentrations	- laboratory derived chronic effects levels	- life history habits and exposure factors

3. Goal: **Protect sensitive species**

Assessment Endpoint: Survival, growth, and reproduction of aquatic insectivores *(representative species – Indiana bat)*

Measures of exposure:	*Measures of effect:*	*Measures of ecosystem and receptor characteristics:*
- water and sediment concentrations - modeled insect concentrations	- laboratory derived chronic effects levels	- life history habits and exposure factors

4. Goal: **Sustainable native wildlife species**

Assessment Endpoint: Survival, growth, and reproduction terrestrial herbivores *(representative species – white-footed mouse)*

Measures of exposure:	*Measures of effect:*	*Measures of ecosystem and receptor characteristics:*
- soil concentrations - modeled vegetation concentrations - tissue concentrations	- laboratory derived chronic effects levels - tissue residue effects benchmarks	- life history habits and exposure factors

5. Goal: **Sustainable native wildlife species**

Assessment Endpoint: Survival, growth, and reproduction of terrestrial carnivores *(representative species – short-tailed shrew)*

Measures of exposure:	*Measures of effect:*	*Measures of ecosystem and receptor characteristics:*
- soil concentrations - modeled vegetation and invertebrate concentrations - tissue concentrations	- laboratory derived chronic effects levels - tissue residue effects benchmarks	- life history habits and exposure factors

Appendix B-2
Technical Memo No. 2

TECHNICAL MEMO NO. 2 - DRAFT
COLLECTION OF WATER AND SEDIMENT QUALITY DATA
FOR ECOLOGICAL RISK ASSESSMENT
AT THE IOWA ARMY AMMUNITION PLANT

April 7, 2000

Introduction

The Omaha District of the U. S. Army Corps of Engineers (USACE) has directed Harza Engineering Company (Harza) to update the existing Ecological Risk Assessment (ERA) for the Iowa Army Ammunition Plant (IAAAP), Middletown, Iowa. The ERA update will address issues raised by the Army, regulatory agencies, and natural resource trustees, specifically with respect to guidance used for the previous ERA, development of ecological remediation goals (PRGs) and uncertainty in surface water and sediment contamination.

As the initial step in the ERA update process, Harza was tasked with preparing a series of Technical Memoranda (TM). TM are planned around the following topics:

1. Development of Assessment and Measurement Endpoints
2. Water and Sediment Data Collection
3. Development of Hazard Models and Ecological PRGs
4. Contaminant Screening Process

These memoranda will be the principal planning documents for the ERA update and will reflect consensus among all reviewers as to the methods to be used. Reviewers are:

- Scott Marquess, EPA Region VII
- Brian Wiebler, USFWS
- Janet Whaley, Matt Bazar, CHPPM
- Randy Sellers, USACE, Omaha
- Rodger Allison, Joe Hafner, IAAAP

This is the second TM and proposes methods and data quality objectives for collection of information on contaminants of concern in surface water and sediment at the IAAAP. Relevant information contained in existing documents is incorporated by reference where appropriate.

Background

Earlier ecological risk assessments compared (maximum or 95% upper confidence) concentrations of contaminants in sediment and surface waters to ecological effects benchmarks (JAYCOR 1996, Harza 1998). The resulting hazard quotients exceeded unity for some contaminants in both studies. Other lines of evidence for ecological stress, namely biotic population and/or community indicators, did not support impacts, and rather suggested the presence of balanced communities of benthic macroinvertebrates. Further, in the two most contaminated streams, Brush Creek and Spring Creek, there are abundant populations of a state-listed threatened fish, the orangethroat darter (*Etheostoma spectabile*).

In summer, 1998, Indiana bat (*Myotis sodalis*) was recorded on the IAAAP property. This animal is listed as an endangered species by the U.S. Fish and Wildlife Service. Indiana bats feed on flying insects in mature riparian forests and much of its diet consists of aquatic insects (*e.g.* dipterans, tricopterans, plecopterans). During their larval stages, aquatic insects would be exposed to contaminants in water and sediment, and expose Indiana bats feeding on them.

The draft Supplemental Groundwater RI Report (Harza 1997) contained the following conclusions regarding sediment contamination at IAAAP:

1. Sampling in the Spring Creek drainage indicates low concentrations of RDX in surface water; explosives were not detected in sediments.

2. Sediment coring along Brush Creek also indicates the presence of explosive contamination. Concentrations are high in middle reaches within IAAAP, particularly the area immediately downstream from Lines 2 and 3.

3. Sampling on Long Creek did not indicate the presence of explosives or other contamination in either surface water or sediment.

4. Sampling in one of two unnamed creeks draining the southwest part of IAAAP identified trace concentrations of the explosives RDX and HMX in surface water. No apparent contamination was detected in the sediment or in samples from the other unnamed creek.

5. Generally, based on all sediment sampling, explosives contamination, where present, is prevalent in the near-surface sediments rather than deeper sediments.

Investigations of offsite contamination in 1999 included sampling of surface sediments in Brush Creek, Flint Creek, and the unnamed tributaries on the southwest side of the IAAAP (Harza 2000). Nearly all analyses of explosives in stream sediments were near or below reporting limits. The sole exception was one sample from Brush Creek about ½ mile south of US61, 0-6 inches depth, containing 620 µg/kg. In surface water, RDX and HMX were detected at concentrations up to 3 µg/L and 5.8 µg/L, respectively. All other explosives were either not detected or detected at concentrations below their respective reporting limits.

Surface water quality data are limited for IAAAP. Stream flow within the IAAAP is comprised of surface runoff, groundwater inflow, and NPDES discharges. Based on Supplemental RI evaluations, groundwater contributions to the streams, primarily Brush Creek, appear to increase significantly from upstream to downstream across IAAAP. Other conclusions from the Supplemental RI that bear on additional surface water sampling include the following:

1. Shallow groundwater beneath Line 2 is contaminated with RDX, HMX and 1,3-DNB. Contaminants are judged to have reached Brush Creek.

2. While groundwater beneath Line 3 is also contaminated, the contaminants do not appear to have reached Brush Creek.

In addition, recent RI and contaminant fate and transport studies (Harza 1999a,c) provide insight into the design of a surface water sampling program:

1. Groundwater and NPDES discharges were the principal sources of contaminants for Brush Creek. Groundwater is the only quantifiable source for Spring Creek. Surface water and sediment pathways are considered negligible in both watersheds under low flow conditions.

2. Line 800 groundwater, together with sanitary wastewater, represent more than 96% of the RDX and 100% of the HMX and TNT loadings to Brush Creek. Sediments draining Line 800 and the former pinkwater lagoon contain as much as 1,100 μg/kg TNT.

3. The West Burn Pads account for nearly all of the RDX, HMX, and TNT loadings to Spring Creek.

4. NPDES sanitary and process discharge loadings to Brush Creek have a rather high uncertainty. But, for explosives, point source discharges to surface water may be as much as 150% of groundwater loadings.

In the context of ecological risk assessment, the surface water and sediment data collected to date at IAAAP are not sufficient. In particular, earlier sediment samples were not intended to not reflect ecological exposure pathways (*i.e.* sludges from sumps, sediment cores three feet in depth) and use of those data is a significant contributor to uncertainty. These data were collected in pursuit of different objectives than ecological risk assessment. Aquatic organisms are limited in their exposure to surficial stream sediment, and this memorandum proposes a program to expand our understanding of ecological risk in IAAAP stream waters and sediments. This sampling program was developed with these historical data as a general guide to the nature and extent of aquatic contamination at IAAAP.

Data Objectives

The objectives of the ecological risk assessment are:

1. To delineate the nature and extent of contamination for ecological receptors.
2. To estimate the exposure of aquatic organisms to contaminants in streams at the IAAAP.
3. To estimate contaminant doses to terrestrial organisms drinking water at the site and preying on aquatic insects or fish.

The sampling and analysis program for the ecological risk assessment is designed to meet these objectives through further characterization of surface water and sediment. Appropriate sediment and water parameters are being studied to allow predictions of contaminant burdens in aquatic prey of terrestrial predators (i.e. Indiana bats feeding on aquatic insects; belted kingfisher feeding on fish).

Sample Types, Locations, and Frequency

All water samples will be analyzed for explosives and total and dissolved TAL metals. All sediment samples will be analyzed for explosives, TAL metals and organic carbon. In 25% of the sediment and water samples, PCBs, pesticides, herbicides and SVOCs will also be analyzed.

Exhibit 1 tabulates sampling sites, sampling rationales, and analytical parameters. Harza personnel conducted reconnaissance of the IAAAP property on November 1 and 2, 1999, to aid identification of sampling sites by locating fine sediment deposition areas. USACE, Harza, USEPA, and Techlaw (USEPA's contractor) personnel met on March 9, 2000 in Kansas City to select sample locations. Locations were selected based upon known or suspected sources of aquatic pollution, identified locations of fine sediment deposition, and threatened or endangered species records. For example, locations immediately downgradient of NPDES discharges, tributaries, and groundwater discharge areas were identified. Similarly, locations with flow patterns that are favorable for sediment deposits were observed and noted in the field. The selected locations provide some coverage of all major streams across the plant property and included streams entering IAAAP on the west and east boundaries. The sampling locations also included eight sites identified in the Long-Term Monitoring Events: Fall 1999 and Spring 2000, Work Plan Addendum, IAAAP, Middletown, Iowa, Harza, 1999b). Field staff may modify sampling locations locally in order to sample fine sediment (rather than gravels or sands).

Fifty sampling locations were identified (Exhibit 2---presented as Figure 2-2 in the SLERA). Sediment samples will be collected during low flow period. At the same locations, water samples will be taken on each of two occasions, once during low flow period and once during high flow period. Both low and high flow conditions represent potential worst case condition for the following reasons. During low flow periods, concentrations in surface water largely represent groundwater loadings. Concentrations of metals in underlying sediments could increase due to precipitation from the stagnant water column. On the contrary, during high flow period, surface runoff transports soil particles with attached contaminants to the streams.

Sampling Equipment and Procedures

There is an approved Work Plan/Sampling and Analysis Plan (SAP) for this project, containing a Quality Assurance Project Plan (QAPP), Field Sampling Plan and Site Health and Safety Plan (Harza 1999b). All portions of this approved SAP will be applicable to this water and sediment sampling exercise, except as amended specifically for this additional sampling.

As provided for in the SAP, water samples will be collected prior to disturbance of the sediment. Bottles will be filled manually, with minimal entrainment of surface films or bottom sediments. Water for analysis of dissolved metals will be filtered at the laboratory using acid-washed 0.45-:m pore filters.

Sediment samples will be collected using an Ekman dredge or a stainless steel scoop or trowel. Care will be taken to collect sediment no deeper than two inches. Samples will generally be grab samples. However, composite samples may be collected at locations with multiple accumulation points or at locations with insufficient available fine sediment quantity. Samples for compositing will be collected from area in immediate vicinity of the intended sampling site (e.g. within the same pool).

Sediment and water samples will be labeled and placed in a cooler with "blue ice", for next-day shipment to the contract laboratory.

Analytical Methods and Procedures

Analytical detection limits are given in the QAPP and are reprinted in Exhibit 3. Detection limits are required to be at levels that are protective of the environment. The analytical laboratory for this project, Katalyst Analytical Technologies, Inc. (KAT). KAT is certified by the USACE and is currently undergoing the process for renewal of that certification.

KAT has developed analytical detection limits in accordance with EPA's guidelines in 40 CFR, Part 136, Appendix B. The detection limits are based upon the best laboratory technology currently available. The detection limits for proposed analytical methods are expected to meet ecological PRGs, but the PRGs are not yet developed. U.S. EPA Region 5 has EDQLs (ecological data quality levels) that may be used for comparison to MDLs. EDQLs represent conservative criteria representing a broad range of indicator species. It should be noted that ecological screening levels such as EDQLs for some compounds are determined through extrapolation of toxicity or bioaccumulation data. Based upon comparison to the Region 5 EDQLs, some contaminant detection limits may exceed screening levels or proposed PRGs (Table 1). For such compounds, ecological screening levels will need to be set at the MDL. The laboratory will establish Method Reporting Limits (MRL) for each target analyte at a level 3 to 10 times the MDL, in accordance with EPA-SW846 protocols. Estimates of MDLs for laboratory sample analyses are tabulated below. Attempts will be made to achieve MRLs for the target analytes.

Table 1
ANALYTES WITH MDL EXCEEDING EDQL (in ppb)

Analyte	Medium	MDL	EDQL	Comment
1,3,5-TNB	sediment	39.93	0.121	
1,3-DNB	sediment	49.1	0.92	Water MDL<EDQL
2,6-DNT (Method 8330)	sediment	70.3	20.62	Method 8270C has MDL = 15.04
2-chlorophenol	sediment	18.13	11.7	Water MDL<EDQL; not expected to be a COC
2-nitrophenol	sediment	9.97	7.77	Water MDL<EDQL
2-nitroaniline	sediment	8.64	0.222	
3-nitroaniline	sediment	4.57	0.222	
2,4-dinitrophenol	sediment	192.28	1.33	Water MDL<EDQL

Table 1
ANALYTES WITH MDL EXCEEDING EDQL (in ppb)

Analyte	Medium	MDL	EDQL	Comment
4-nitrophenol	sediment	17.07	7.78	Water MDL<EDQL
4-nitroaniline	sediment	4.67	0.222	
Hexachlorobenzene	water	0.12	5.47E-6	Sediment MDL < EDQL
Anthracene	water	0.31	0.029	Sediment MDL<EDQL
Pyrene	water	0.36	0.3	Sediment MDL<EDQL
3,3'-dichlorobenzidene	sediment	136.79	28.22	Water MDL<EDQL; not expected to be a COC
Bis(2-ethylhexyl)phthalate	sediment	15.58	8.04	Water MDL < EDQL
Benzo(k)fluoranthene	water	0.43	0.0056	Sediment MDL<EDQL
Benzo(a)pyrene	water	0.38	0.0148	Sediment MDL<EDQL
Dibenzo(a,h)anthracene	sediment	10.72	6.22	
Dibenzo(a,h)anthracene	water	0.31	0.0016	
Heptachlor	water	0.0037	0.00039	Sediment MDL<EDQL
Heptachlor epoxide	water	0.0085	0.00048	Sediment MDL<EDQL
Endosulfan I	water	0.0052	0.0030	Sediment MDL<EDQL
Dieldrin	water	0.0083	0.00005	Sediment MDL<EDQL
4,4'DDE	water	0.0057	5E-9	Sediment MDL<EDQL
Endrin	water	0.0099	0.002	Sediment MDL<EDQL
Endosulfan II	water	0.0057	0.003	Sediment MDL<EDQL
4,4'-DDD	water	0.0094	0.0011	Sediment MDL<EDQL
Methoxychlor	water	0.0866	0.005	Sediment MDL<EDQL
∀-chlordane	water	0.0050	0.0003	Sediment MDL<EDQL
(-chlordane	water	0.0103	0.0003	Sediment MDL<EDQL
Toxaphene	sediment	10.84	0.109	
PCB-1016	water	0.051	0.00003	Sediment MDL<EDQL
PCB-1221	water	0.0872	0.00003	Sediment MDL<EDQL
PCB-1232	water	0.1411	0.00003	Sediment MDL<EDQL
PCB-1242	water	0.1042	0.00003	Sediment MDL<EDQL
PCB-1248	water	0.0512	0.00003	Sediment MDL<EDQL
PCB-1254	water	0.0821	0.00003	Sediment MDL<EDQL
PCB-1260	water	0.069	0.00003	Sediment MDL<EDQL
Lead	water	1.42	1.3	Sediment MDL<EDQL
Silver	water	1.07	1	Sediment MDL<EDQL
Thallium	water	2.28	0.56	Sediment MDL<EDQL
Mercury	water	0.058	0.0013	Sediment MDL<EDQL

References

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Exhibit 1
WATER AND SEDIMENT SAMPLING LOCATIONS
FOR ECOLOGICAL RISK ASSESSMENT

Watershed	Designation	Rationale	Analytical Parameters
Skunk River tributaries	SRT1	Rapid Bioassessment Protocol (RBP) site "unimpaired", NPDES outfall 014, Indiana bat record	Explosives, metals
Skunk River tributaries	SRT2	RBP site "slightly impaired", sediment sample 7P contained 23 mg/kg As, potential Indiana bat habitat	Explosives, metals
Long Creek	LC1 (IAAAP boundary)	West boundary of IAAAP, agricultural runoff/pollutants, RBP reference site	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Long Creek	LC2 (IAAAP boundary)	RBP site, potential Indiana bat habitats, downstream of uncharacterized demolition area (new site)	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Long Creek	LC3	Upstream from firing site	Explosives, metals [uranium, gross alpha, gross beta in LTM program]
Long Creek	LC4	Downstream from firing site and downstream from 14,000:g/g RDX in sediment found by JAYCOR near 3A-70-1. Downstream from IDA	Explosives, metals [uranium, gross alpha, gross beta in LTM program]
Long Creek	LC5	Downstream from Line 800	Explosives, metals
Long Creek tributary	LCT3	Downstream of flyash disposal area. Sulfate in surface water found at a maximum concentration of 90,900 µg/L during the RI	Explosives, metals, PCBs, pesticides, herbicides, SVOCs, sulfate
Long Creek tributary	LCT2	RBP site "slightly impaired", potentially affected by Line 800 groundwater discharges	Explosives, metals
Long Creek tributary	LCT4	area	Explosives, metals
Long Creek tributary	LCT5	Upstream of flyash disposal area	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Long Creek tributary	LCT6	Downstream of flyash disposal area and upstream of construction debris landfill	Explosives, metals
Long Creek tributary	LCT7	Downstream of Line 8where RDX and HMX detected at 12.9 and 4.94 µg/L, respectively during the RI	Explosives, metals
Brush Creek	BC9	RBP reference site, upstream of discharges	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Brush Creek	BC10	Upstream of discharges, possibly influenced by Line 1/5A/4A discharges	Explosives, metals
Brush Creek	BC11	Downstream of several process outfalls, RBP "unimpaired" site (but stream has been relocated due to phytoremediation wetland construction)	Explosives, metals
Brush Creek	BC1	Immediately downstream of phytoremediation wetland, RBP "slightly impaired" site, sediment 7E	Explosives, metals

Exhibit 1
WATER AND SEDIMENT SAMPLING LOCATIONS
FOR ECOLOGICAL RISK ASSESSMENT

Watershed	Designation	Rationale	Analytical Parameters
		contained 470 µg/kg RDX and 31 mg/kg arsenic, sediment RBW-SD-43 contained 5.8 mg/kg 2,6-DNT	
Brush Creek	BC12	Sediment 7E contained 470 µg/kg RDX and 31 mg/kg arsenic, influenced by Line 1 and 2 discharges	Explosives, metals
Brush Creek	BC13	Downstream of sediment RBW-SD-39 containing 3 mg/kg PCB-1254. This area apparently increases in streamflow, noticed during Nov 1-2, 1999 drought reconnaissance	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Brush Creek	BC14	This area apparently increases in streamflow, noticed during Nov 1-2, 1999 drought reconnaissance	Explosives, metals
Brush Creek	BC2 (O Road)	Sediment 7F1 contained 400 µg/kg RDX and 11 mg/kg As, RBP "unimpaired" site	Explosives, metals
Brush Creek	BC15	Muck and odors from sediment	Explosives, metals
Brush Creek	BC16	Deep hole on downstream side of RR culvert containing fine silt	Explosives, metals
Brush Creek	BC17	Leaf litter on sand and log jams with some fines. Downstream of Line 800 tributary and 7H sediment sample (330 µg/kg RDX, 1.3 mg/kg Cd)	Explosives, metals
Brush Creek	BC3	RBP site "slightly impaired", upstream of WWTP, sediment sample 7I1 contained 9,900 µg/kg RDX and other explosives	Explosives, metals
Brush Creek	BC4	RBP site "slightly impaired", downstream of WWTP	Explosives, metals
Brush Creek	BC18	Silt deposits downstream of WWTP	Explosives, metals
Brush Creek	BC19	Deep hole below RR culvert containing fine silt, orangethroat darter range	Explosives, metals
Brush Creek	BC5 (Middle Augusta Rd)	Log jam with silt deposits, RBP site "unimpaired", downstream of old fly ash waste pile by Yard E. Sediment RBW-SD-32 contained 2.6 mg/kg Ag	Explosives, metals, PCBs, pesticides, herbicides, SVOCs, sulfate
Brush Creek	BC20	Downstream of old fly ash waste pile. Sediment sample 7J1 contained 760 µg/kg HMX, orangethroat darter habitat, deep pool with sand and leaf litter substrate	Explosives, metals, sulfate
Brush Creek	BC21	Deep run with leaf litter and silt, potential Indiana bat habitat, orangethroat darter habitat	Explosives, metals
Brush Creek	BC7 (IAAAP boundary)	Probable Indiana bat habitat, orangethroat darter, RBP site "slightly impaired"	Explosives, metals, SVOCs, PCBs, pesticides, herbicides
Brush Creek	BC22 (offsite)	Potential Indiana bat habitat, orangethroat darter, sediment sample 7L was clean	Explosives, metals, sulfate
Brush Creek	BC8 (Hunt Rd)	RBP site "unimpaired", 8.8 µg/kg dieldrin in darter tissue, orangethroat darter habitat	Explosives, metals
Brush Creek	BCT1	Tributary draining Line 800, pinkwater lagoon/phytoremediation wetland, collocated with Line	Explosives, metals

Exhibit 1
WATER AND SEDIMENT SAMPLING LOCATIONS FOR ECOLOGICAL RISK ASSESSMENT

Watershed	Designation	Rationale	Analytical Parameters
Tributary		800 RI sample CK02 containing 1,100 µg/kg 2,4,6-TNT	
Spring Creek	SC7	Upstream of all discharges (background), probable orangethroat darter habitat	Explosives, metals, SVOCs, PCBs, pesticides, herbicides
Spring Creek	SC8	Potentially affected by North Burn Pads, pool habitat with bedrock & sand substrate, orangethroat darter range	Explosives, metals
Spring Creek	SC9	Downstream of EDA, West Burn Pad landfill, and West Burn Pads, orangethroat darter range, sandy substrate, downstream of sediment RBW-SD-15 containing 34 mg/kg Cu and 349 mg/kg Zn	Explosives, metals
Spring Creek	SC10, SC11	Downstream of EDA and West Burn Pads, downstream of sediment RBW-SD-15, orangethroat darter range, localized silt deposits in pools and oxbows	Explosives, metals
Spring Creek	SC2 (P Road)	Localized deposits of silt, RBP site "unimpaired", orangethroat darter range, 36 µg/kg dieldrin in darter tissue, downstream of the confluence with West Burlington WWTP tributary	Explosives, metals
Spring Creek	SC12	Orangethroat darter range, probable silt deposits	Explosives, metals
Spring Creek	SC3	Orangethroat darter range, localized deposits of silt, RBP site "unimpaired", potential Indiana bat habitat	Explosives, metals
Spring Creek	SC4 (IAAAP boundary)	RBP site "slightly impaired", depressed EPT/chironomid ratio, orangethroat darter range, 23 µg/kg dieldrin in darter tissue, potential Indiana bat habitat	Explosives, metals, SVOCs, PCBs, pesticides, herbicides
Spring Creek	SC6 (Hunt Road)	RBP site "slightly impaired", orangethroat darter range, 7D1 sediment sample was clean, 21 µg/kg dieldrin in darter tissue, silty sand substrate	Explosives, metals
Spring Creek tributary	SCT1	Channel draining to Spring Creek to the east of SC3	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Spring Creek tributary	SCT2	Effluent from West Burlington WWTP, potential orangethroat darter and/or Indiana bat habitat, three household pesticide application bottles found in stream during Nov 2, 1999 reconnaissance	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Spring Creek tributary	SCT3	Channel draining to Spring Creek to the east of east burn pads	Explosives, metals, PCBs, pesticides, herbicides, SVOCs
Mathes Lake	ML1, ML2	Within Mathes Lake near Boat ramp and Scout camp, respectively	Explosives, metals

Exhibit 3
COMPARISON OF METHOD DETECTION LIMITS (MDL) WITH ECOLOGICAL DATA QUALITY LEVELS (EDQL)

Parameters (Methods)	Sediment (µg/kg)		Water (µg/L)	
	MDL	EDQL	MDL	EDQL
Explosives (EPA Method 8330)				
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	32.8		0.04666	
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	64.9		0.02856	
2,4,6-Trinitrotoluene (2,4,6-TNT)	68.1		0.02743	
1,3,5-Trinitrobenzene (1,3,5-TNB)	***39.91***	***0.121***	0.03964	
1,3-Dinitrobenzene (1,3-DNB)	***49.1***	***0.92***	0.01551	2.36
2,4-Dinitrotoluene (2,4-DNT)	50.7	75.13	0.04757	230
2,6-Dinitrotoluene (2,6-DNT)	***70.3***	***20.62***	0.02828	42
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	66.6		0.01432	
Nitrobenzene (NB)	63.4	487	0.03506	740
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	49.5		0.02595	
2-Amino-2-dinitrotoluene (2-Am-DNT)	51.9		0.01702	
2-Nitrotoluene (2-NT)	91.3		0.0422	
3-Nitrotoluene (3-NT)	183		0.0319	
4-Nitrotoluene (4-NT)	131		0.02566	
Semivolatile Organics (EPA Method 8270C)				
Phenol	19.21	27.26	0.26	100
bis (2-Chloroethyl)ether	18.67	211.96	0.34	1.14 E.+03
2-Chlorophenol	***18.13***	***11.7***	0.41	8.8
1,3-Dichlorobenzene	8.61	3.01 E+03	0.11	87
1,4-Dichlorobenzene	5.78	1.45 E+03	0.31	43
1,2-Dichlorobenezene	8.47	231.32	0.28	11
2-Methylphenol	32.45		0.49	
4-Methylphenol	25.44		0.53	
N-Nitroso-di-n-propylamine	14.87		0.58	
Hexachloroethane	9.61	2.23 E+03	0.34	30.5
Nitrobenzene	7.52	487.6	0.31	740
Isophorone	6.58	422.3	0.29	900
2-Nitrophenol	***9.97***	***7.77***	0.22	13.5
2,4-Dimethylphenol	87.05		0.66	
bis (2-Chloroethoxy)methane	4.07		0.30	
2,4-Dichlorophenol	4.86	133.63	0.26	18
1,2,4-Trichlorobenzene	2.89	1.17 E+04	0.34	69.2
Naphthalene	16.06	34.6	0.17	44
4-Chloroaniline	19.72	146.08	0.92	231.97
Hexachlorobutadiene	9.11	1.38 E+03	***0.26***	***0.134***
4-Chloro-3-methylphenol	4.32		0.29	
2-Methylnaphthalene	5.36		0.22	
Hexachlorocyclopentadiene	7.22	900.74	0.17	77.04
2,4,6-Trichlorophenol	4.63	84.84	0.20	2
2,4,5-Trichlorophenol	10.45	85.56	0.30	
2-Chloronaphthalene	6.76	417.23	0.18	0.396
2-Nitroaniline	***8.64***	***0.222***	0.23	
Acenaphthylene	4.20	5.87	0.21	4.84 E+03
2,6-Dinitrotoluene	15.04	20.62	0.23	230
3-Nitroaniline	***4.57***	***0.222***	0.18	
Acenaphthene	5.44	6.71	0.15	
2,4-Dinitrophenol	***192.28***	***1.33***	3.08	4.07
4-Nitrophenol	***17.07***	***7.78***	0.17	35

Exhibit 3
COMPARISON OF METHOD DETECTION LIMITS (MDL) WITH ECOLOGICAL DATA QUALITY LEVELS (EDQL)

Parameters (Methods)	Sediment (µg/kg)		Water (µg/L)	
	MDL	EDQL	MDL	EDQL
Dibenzofuran	6.64	1.52 E+03	0.09	20
2,4-Dinitrotoluene	15.42	78.13	0.25	230
4-Chlorophenyl-phenyl ether	9.01		0.24	
Fluorene	6.87	21.2	0.22	3.9
4-Nitroaniline	***4.67***	***0.22***	0.28	
4,6-Dinitro-2-methylphenol	149.48		0.19	
N-Nitrosodiphenylamine	10.81	155.24	1.03	13
4-Bromophenyl-phenyl-ether	12.34	1.55 E+03	0.17	1.5
Hexachlorobenzene	15.49	20	***0.12***	***5.47 E-06***
Pentachlorophenol	14.62	3.01 E+04	0.69	5.23
Phenanthrene	7.63	41.9	0.12	2.1
Anthracene	7.98	46.9	***0.31***	***0.029***
Di-n-butylphthalate	14.72	110.5	0.40	3
Fluoranthene	10.37	111.3	0.36	8.1
Pyrene	16.92	53	***0.36***	***0.3***
Butyl benzyl phthalate	9.25	4.19 E+03	0.15	49
3,3'-Dichlorobenzidene	***136.79***	***28.22***	0.32	99.75
Benzo (a) anthracene	4.26	31.7	0.25	0.839
Chrysene	7.89	57.1	0.17	0.033
Bis (2-ethylhexyl) phthalate	***15.58***	***8.04***	0.66	3
Di-n-octyl phthalate	16.59	4.6 E+04	0.64	30
Benzo (b) fluoranthene	13.31	1.04 E+04	0.28	9.07
Benzo (k) fluoranthene	7.92	240	***0.43***	***5.6 E-03***
Benzo (a) pyrene	9.22	31.9	***0.38***	***1.48 E-02***
Indeno (1,2,3-cd) pyrene	10.03	200	0.32	4.31
Dibenzo (a,h) anthracene	***10.72***	***6.22***	***0.31***	***1.6 E-03***
Benzo (g,hi) perylene	5.96	170	0.24	7.64
Herbicides (EPA Method 8151A)	18.84		0.52	
2,4-D	24.18		0.42	
2,4-DB	4.78		0.23	
2,4,5-T	21.04		0.93	
Dalapon	9.69		0.38	
Dicamba	15.02		0.33	
Dichlorprop	5.7	11.78	0.08	0.39
Dinoseb	4.51	7358	0.34	326.64
Silvex	3436		54.19	
MCPA	1781		21.86	
MCPP				

Exhibit 3
COMPARISON OF METHOD DETECTION LIMITS (MDL) WITH ECOLOGICAL DATA QUALITY LEVELS (EDQL)

	Sediment (µg/kg)		Water (µg/L)	
Parameters (Methods)	**MDL**	**EDQL**	**MDL**	**EDQL**
Pesticide/PCBs (EPA Method 8081A/8082)				
Alpha-BHC	0.262	6	0.00787	12.38
beta-BHC	0.238	5	0.0035	0.495
delta-BHC	0.112	7.15 E+04	0.00307	666.67
Lindane (gamma-BHC)	0.221	.94	0.0066	0.01
Heptachlor	0.124	0.6	***0.0037***	***3.9 E-04***
Aldrin	0.158	2	0.004	0.0185
Heptachlor epoxide	0.131	0.6	***0.0085***	***4.8 E-04***
Endosulfan I	0.174	0.175	***0.00523***	***0.003***
Dieldrin	0.277	2	***0.00831***	***2.6 E-05***
4,4'-DDE	0.201	1.42	***0.00574***	***4.96 E-09***
Endrin	0.329	2.67	***0.0099***	***0.002***
Endosulfan II	0.245	.14	***0.0057***	***0.003***
4,4'-DDD	0.312	5.53	***0.00935***	***0.0011***
Endosulfan sulfate	0.295	34.6	0.03952	2.22
4,4'-DDT	0.392	1.19	0.01176	
Methoxychlor	2.89	3.59	***0.08662***	***0.005***
Endrin ketone	0.27529		0.01058	
Endrin aldehyde	0.418	3.2 E+03	0.0145	0.15
alpha-Chlordane	0.145	4.5	***0.00504***	***2.9 E-04***
gamma-Chlordane	0.158	4.5	***0.01033***	***2.9 E-04***
Toxaphene	***10.84***	***0.109***	0.22412	
Aroclor-1016	2.76	34.1	***0.051***	***2.9 E-05***
Aroclor-1221	2.43	34.1	***0.0872***	***2.9 E-05***
Aroclor-1232	4.77	34.1	***0.1411***	***2.9 E-05***
Aroclor-1242	3.98	34.1	***0.1042***	***2.9 E-05***
Aroclor-1248	7.16	34.1	***0.0512***	***2.9 E-05***
Aroclor-1254	2.62	34.1	***0.0821***	***2.9 E-05***
Aroclor-1260	2.48	34.1	***0.069***	***2.9 E-05***

Exhibit 3
COMPARISON OF METHOD DETECTION LIMITS (MDL) WITH ECOLOGICAL DATA QUALITY LEVELS (EDQL)

Parameters (Methods)	Sediment (µg/kg)		Water (µg/L)	
	MDL	EDQL	MDL	EDQL
Other Parameters				
Total Organic Carbon (Method 9060)	200,000			
Metals (EPA Method 6010/7471)				
Aluminum	3600		36.67	
Antimony -	320		2.12	
Arsenic	310	5900	2.74	53
Barium	126		1.31	5000
Beryllium	120.21		0.76	7.6
Cadmium	39.96	596	0.64	0.66
Calcium	14.5		65.19	
Chromium	174.11	26000	1.24	42
Cobalt	564.33	5000	1.47	5
Copper	450.56	16000	1.27	5
Iron	700		15.37	
Lead	196.8	31000	***1.42***	***1.3***
Magnesium	7100		34.8	
Manganese	230		1.54	
Mercury	0.11	174	***0.058***	***1.3 E-03***
Nickel	113.62	16000	2.25	29
Potassium	10716		134.2	
Selenium	237.07		2.87	5
Silver	100	500	***1.07***	***1***
Sodium	30500		106.59	
Thallium	299.35		***2.28***	***0.56***
Vanadium	86.66		1.33	19
Zinc	1100	120000	12.73	58.6

Notes:

µg/kg -Micrograms per kilogram

µg/L -Micrograms per liter

Except where noted, values are wet weight method detection limits furnished by KAT, Inc. of Peoria, Illinois. Actual reporting limits for the soil/sediment samples may be higher or lower than listed due to matrix effects and moisture contents of individual samples.

* - Method not amendable to MDL performance.

\+ - Reporting Limit. No MDL is available.

Values in bold italics indicate that the EDQL is less than the MDL for that contaminants in that medium

Appendix B-3
Technical Memo No. 3

TECHNICAL MEMO NO. 3 - DRAFT
DEVELOPMENT OF HAZARD MODELS AND ECOLOGICAL PRGS FOR ECOLOGICAL RISK ASSESSMENT AT THE IOWA ARMY AMMUNITION PLANT

September 15, 2000

Introduction

The Omaha District of the U. S. Army Corps of Engineers (USACE) has directed Harza Engineering Company (Harza) to update the existing Ecological Risk Assessment (ERA) for the Iowa Army Ammunition Plant (IAAAP), Middletown, Iowa. The ERA update will address issues raised by the Army, regulatory agencies, and natural resource trustees, specifically with respect to guidance used for the previous ERA, development of ecological remediation goals (PRGs) and uncertainty in surface water and sediment contamination.

As the initial step in the ERA update process, Harza was tasked with preparing a series of Technical Memoranda (TM). TM are planned around the following topics:

1. Development of Assessment and Measurement Endpoints
2. Water and Sediment Data Collection
3. Development of Hazard Models and Ecological PRGs
4. Contaminant Screening Process

The final memoranda will be the principal planning documents for the ERA update and will reflect consensus among all reviewers as to the methods to be used. Reviewers are:

- Scott Marquess, EPA Region VII
- Michael Coffey, USFWS
- Matt Bazar, CHPPM
- Randy Sellers, USACE, Omaha
- Rodger Allison, Joe Haffner, IAAAP

This is the third TM and proposes models for evaluating exposure and risk to ecological receptors, as well as a set of ecological PRGs. The ecological PRGs are intended for use as screening benchmarks for the purpose of identifying contaminants of ecological concern (COEC). Relevant information contained in existing documents is incorporated by reference where appropriate.

Uptake factors for fish, vegetation, and aquatic and terrestrial invertebrates will be developed for the identified COECs. Endpoint receptor-specific No and Low Observed Adverse Effects Level (NOAELs and LOAELs) to be used as reference doses will also be developed. A memorandum containing proposed uptake factors and reference doses for the COECs selected will be developed and distributed for review by the eco team immediately following selection of COECs.

Assessment and Measurement Endpoints

Assessment endpoints and measures of effects were established in TM No. 1. While some measures of effects are made directly, other will require the use of predictive models. This TM lays the foundation of the modeling required to predict risk under the measures established in TM No. 1.

To protect ecological integrity in IAAAP streams, the proposed assessment endpoints are:

1. Survival, growth, and reproduction of orangethroat darters under chronic exposure
2. Benthic community structure
3. Survival, growth, and reproduction of aquatic algae under chronic exposure

Effects and exposure data to evaluate these endpoints currently exist, with the exception of the planned water and sediment quality sampling. No predictive models are required.

To protect sensitive species at the plant, the proposed assessment endpoints are:

1. Survival, growth, and reproduction of aquatic piscivores, using the belted kingfisher as the representative of this feeding guild
2. Survival, growth, and reproduction of aquatic insectivores, using the Indiana bat as the representative of this feeding guild

As with the first set of assessment endpoints, the effects and exposure data needed to evaluate these include the additional water and sediment quality information. Food chain modeling will be required to estimate contaminant doses for belted kingfisher and Indiana bat.

There are two assessment endpoints for addressing the IAAAP's natural resource management goal of sustaining native wildlife species:

1. Survival, growth, and reproduction of terrestrial herbivores, using the white-footed mouse as the representative of this feeding guild
2. Survival, growth, and reproduction of terrestrial carnivores, using the short-tailed shrew as the representative of this feeding guild

Effects and exposure data required to evaluate these two endpoints include the existing soils contaminant data for the IAAAP. No additional data are proposed to be collected at this time. Food chain modeling will be required to estimate contaminant doses for white-footed mouse and short-tailed shrew.

Food Chain Models

Procedures for estimating exposures of four wildlife feeding guilds are required for completing this risk assessment. The feeding guilds are:

1. A piscivore represented by belted kingfisher
2. An aquatic insectivore, represented by Indiana bat
3. A terrestrial herbivore, represented by white-footed mouse
4. A terrestrial carnivore, represented by short-tailed shrew

Exposure to contaminants experienced by an endpoint species may come from multiple sources. The sources include food (plant or animal), water, soil, and sediment. The generalized equation for estimating daily contaminant dose an endpoint receptor may receive from a particular contaminant in a particular medium may be expressed as

$$E_j = \sum_{i=1}^{m} P_{ik}\left(IR_i X C_{ijk}\right)/(\mathrm{BW}) \text{----------------------------} (1)$$

where,

Ej = Total exposure to contaminant j, mg/kg/d
m = Total number of ingested media
Pik = Proportion of type (k) of medium (i) consumed
IRi = Consumption rate for medium (i), kg/d or L/d
Cijk = Concentration of contaminant (j) in type (k) of medium (i), mg/kg or mg/L
BW = Body weight, kg

Specific models for estimating doses to the four feeding guilds are presented below.

Piscivore-Belted Kingfisher

Belted Kingfishers are exposed to contaminants through ingestion of water and food. Information presented in EPA (1993) indicates that its diet consists primarily of fish. The exposure model for the aquatic piscivore may be expressed as

$$\mathrm{Ej} = (\mathrm{IR_w} \text{ x } \mathrm{C_{w\text{-}j}})/(\mathrm{BW}) + (\mathrm{IR_f} \text{ x } \mathrm{C_{f\text{-}j}})/(\mathrm{BW}) \text{-------------------------} (2)$$

Where,

IR_w = Ingestion rate of water, L/d
C_{w-j} = Contaminant concentration (j) in water, mg/L
IR_f = Ingestion rate of fish, kg/d
C_{f-j} = Contaminant concentration (j) in fish, mg/kg

Parameter values required for estimating dose for all four feeding guilds are presented in Table 1.

Contaminant concentrations in fish at the IAAAP are needed for estimating exposure dose. Whole fish samples were collected from Brush Creek, Spring Creek, and Long Creek. These samples were analyzed for mercury, explosives, and pesticide/PCBs. The results were presented in the Ecological Risk Assessment Addendum (Harza 1997). Mercury and dieldrin were the only two compounds detected in fish tissue. Mercury and dieldrin in actual fish tissue concentrations in each watershed together with half the detection limits for the other analyzed constituents will be used. Literature derived fish bioconcentration factors (BCF) will be used for other constituents. In the absence of values available in the literature, fish BCF values will be estimated from octanol-water coefficients (Kow), using an equation developed by Veith and others (1980) based on results of several investigations with a variety of fish species,

$$\text{Log BCF} = 0.76 \times \log \text{Kow} - 0.23 \text{-----------------------------(3)}$$

Insectivore- Indiana Bat

The exposure model for the aquatic insectivore may be expressed as

$$Ej = (IR_w \times C_{w\text{-}j})/(BW) + (IR_{in} \times C_{in\text{-}j})/(BW) \text{-------------------------(4)}$$

Where,

IR_w = Ingestion rate of water, L/d
$C_{w\text{-}j}$ = Contaminant concentration (j) in water, mg/L
IR_{in} = Ingestion rate of insect, kg/d
$C_{in\text{-}j}$ = Contaminant concentration (j) in insect, mg/kg

It was assumed that the diet consists primarily of aquatic insects. Available literature will be reviewed for insect uptake factors. In the absence of available literature value, organic contaminant concentrations in insects will be estimated using empirical relationships such as the one based on Kow developed by Belfroid and others (1992)

$$\log \text{BCF} = 1.06 \log \text{Kow} - 2.36 \text{-------------------------------(5)}$$

Terrestrial Herbivore- White Footed Mouse

Terrestrial herbivores are exposed to contaminants via ingestion of soil, plants, and terrestrial invertebrate. The exposure model may be expressed as

$$Ej = (P_s \times F \times C_{s\text{-}j})/(BW) + (P_v \times F \times C_{v\text{-}j})/(BW) + (P_{inv} \times F \times C_{inv\text{-}j})/(BW) \text{---------(6)}$$

Where,

P_s = Fraction soil ingested, unitless
F = Food intake, kg/d

C_{s-j} = Contaminant concentration (j) in soil, mg/kg
P_v = Fraction vegetation ingested, unitless
C_{v-j} = Contaminant concentration (j) in vegetation, mg/kg
P_{inv} = Fraction invertebrate ingested, unitless
C_{inv-j} = Contaminant concentration (j) in vegetation, mg/kg

Available literature will be reviewed for plant uptake factors. In the absence of available literature value, organic contaminant concentrations in vegetation will be estimated from relationships such as the one based on Kow developed by Travis and Arms (1988)

$$\log U_{s-v} = 1.588-0.578 (\log Kow) \text{-------------------------(7)}$$

U_{s-v} = Soil-vegetation uptake factor

Terrestrial Carnivore- Short-Tailed Shrew

Terrestrial carnivores are exposed to contaminants via ingestion of soil and terrestrial invertebrate. The exposure model may be expressed as

$$Ej = (P_s \times F \times C_{s-j})/(BW) + (P_{inv} \times F \times C_{inv-j})/(BW) \text{---------(8)}$$

Ecological PRGs

The objective of this task is to establish screening values for identification of COEC at the IAAAP. The foundation for setting the screening values are based on available ecotoxicity benchmarks. Tables 2 through 4 list screening values for surface water, sediment, and soil proposed for use at the IAAAP (These tables are not provided. Revised screening values are presented in Section 3 of the SLERA). Chemicals for which media-specific screening values are not available will be retained as COECs. However, it should be noted that information required for conducting quantitative risk assessment may not be available for such chemicals.

Recommended Method for Deriving Surface Water PRGs

ARARS (Applicable, Relevant, and/or Appropriate Requirements) are available from federal and state sources for surface water. The National Recommended Water Quality Criteria – Correction (EPA 1999a) are available for 157 pollutants. The criterion continuous concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The State of Iowa has also published Water Quality Standards for surface water bodies within the state (Iowa Administartive Code 1994). We recommend that the lowest of these ARARs, when available, be used as PRGs or screening values (SV) for selection of COECs.

Efroymson and others (1997a) define aquatic PRGs as the upper concentration limits for contaminants in surface water and sediments that are anticipated to protect aquatic life, and should correspond with an acceptable level of effect on aquatic ecological assessment endpoints. These authors derived ecological PRGs for contaminants of concern at the Oak Ridge Reservation in Tennessee using two types of toxicological benchmarks: toxicity test endpoints and ARARs. Some of the toxicity test endpoints used by Efroymson and others (1997a) for a given chemical were combined and used to compute Tier II water quality values (USEPA 1995). Tier II values should be considered as potential ARARs. Tier II values (secondary chronic values, or SCVs) have been calculated by Oak Ridge National Laboratory for several other chemicals: 1,3,5-TNB, 2,4,6-TNT, HMX, RDX, 1,3-DNB, 1,1-dichloroethene, 1,1-dichloroethane, bis(2-ethylhexyl)phthalate, 1,2-dichloroethane, chloromethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene, tetrachloroethene, and barium. SCVs are equivalent to the CCC values, but are established using fewer data. When ARARs are not available for a contaminant, we recommend that values listed in Efroymson and others (1997a) be used as SVs.

Media-specific NOAELs and LOAELs for single chemicals are available from EPA's Ecotox database (1996a). The database for surface water (Aquire) lists NOAEL and/or LOAELs for different organisms. The Aquire database was queried to identify the lowest NOAEL or 10% of the LOAEL values for each chemical.

EPA Region 5 has published Ecological Data Quality levels (EDQL) for chemicals in surface water, soil, and sediment (EPA 1998). The EDQL values appear to have been developed based on conservative assumptions. However, EPA (1998) did not present a discussion on how these values were developed. We propose to use EDQLs as screening values in the absence of other benchmarks.

Recommended Method for Deriving Sediment PRGs

EPA (1999b) has developed ecological benchmarks for several chemicals in sediment. The sediment benchmarks are primarily based on measured sediment concentrations that resulted in minimal effects to biota. The sources for measured sediment benchmarks in this document are the national Oceanic and Atmospheric Administration (NOAA) and the Florida Department of Environmental Protection (FDEP) sediment documents. When measured sediment effects data were not available for organic constituents, benchmarks in EPA (1999b) were developed from equilibrium partitioning approach from surface water benchmarks. We propose that sediment benchmarks listed in EPA (1999b) be used preferentially as screening values.

Efroymson and others (1997a) developed sediment benchmarks from sources similar to those used in EPA (1999b). They suggested the minimum of the following benchmarks be used as sediment PRGs :

- X NOAA Effects Range-Median (ER-M)
- X Florida DEP Probable Effect Level (PEL)
- X USEPA ARCS Program Probable Effects Concentration (PEC)

We suggest that PRGs listed in Efroymson and others (1997) are used as screening values in the absence of data from EPA (1999b).

The sediment PRG can be estimated based on equilibrium partitioning as the product of the water quality PRG, the fraction of organic carbon in sediment (foc) and the organic carbon partition coefficient (Koc). Sediment benchmarks were developed assuming a total organic carbon content of one percent, Koc values available in the literature (EPA 1996b, EPA 1990, SRC 2000), water screening values. It should be noted that sediment organic carbon will be measured in fifty sites in streams draining IAAAP during fall 2000. The sediment benchmarks listed in Table 3 based on equilibrium partitioning may be revised based on measured foc data. In the absence of data from the previous two sources, we propose to use sediment benchmarks developed based on equilibrium partitioning.

EPA Region 5 has published EDQLs for chemicals in sediment (EPA 1998). We propose to use EDQLs as screening values in the absence of other benchmarks.

Recommended Method for Deriving Soil PRGs

EPA (1999b) has developed ecological benchmarks for several chemicals in soil. The soil benchmarks were derived for the terrestrial plant community and soil community. For the terrestrial plant community, benchmarks were developed from Efroymson and others (1997b) based primarily on phytotoxic effects. For the soil community, benchmarks were developed based on No Observed Effects Concentration (NOEC) to reproductive and developmental endpoints. A second set of benchmarks for soil community were developed based on Low Observed Effects Concentration (LOEC) for earthworms and microbial endpoints using the Effects-Range Low (ER-L). The lowest of the benchmarks were selected for listing on Table 4. We propose that soil benchmarks listed in EPA (1999b) be used preferentially as screening values.

Efroymson and others (1997a) developed soil benchmarks from sources similar to those used in EPA (1999b). We suggest that PRGs listed in Efroymson and others (1997a) be used as screening values in the absence of data from EPA (1999b).

Media-specific NOAELs and LOAELs for single chemicals are available from EPA's ecotox database (1996b). The database for soil (Terratox) lists NOAEL and/or LOAELs for different organisms. The Terratox database was queried to identify the lowest NOAEL or 10% of the LOAEL values for each chemical.

EPA Region 5 has published EDQLs for chemicals in soil (EPA 1998). We propose to use EDQLs as screening values in the absence of other benchmarks.

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TABLE 1

EXPOSURE PARAMETER VALUES[a]

Parameter	Short-tailed Shrew	White-footed Mouse	Belted Kingfisher	Indiana Bat
Body Weight (kg)	0.015	0.022[d]	0.136	0.0072g
Food Intake (kg/d)	0.008	0.0034[d]	0.068	0.0025[h]
Water Intake (L/d)	0.0033	0.0066[e]	0.015	0.0012[h]
Soil Intake in diet, %	13[b]	2[f]	0	0
Terrestrial invertebrate in diet, %	87[c]	49[c]	0	0
Fish in diet, %	0	0	100[c]	0
Aquatic invertebrate in diet, %	0	0	0	100[c]
Vegetation in diet, %	0	49[c]	0	0

Note:

a Values from EPA (1993), unless otherwise mentioned
b Talmage and Walton (1993)
c Assumed
d Green and Miller (1987)
e Oswald and others (1993)
f Beyer and others (1994)
g USAMC (1998)

Appendix B-4
Technical Memo No. 4

TECHNICAL MEMO NO. 4 - DRAFT
CONTAMINANT SCREENING PROCESS
FOR ECOLOGICAL RISK ASSESSMENT
AT THE IOWA ARMY AMMUNITION PLANT

August 31, 2000

Introduction

The Omaha District of the U. S. Army Corps of Engineers (USACE) has directed Harza Engineering Company (Harza) to update the existing Ecological Risk Assessment (ERA) for the Iowa Army Ammunition Plant (IAAAP), Middletown, Iowa. The ERA update will address issues raised by the Army, regulatory agencies, and natural resource trustees, specifically with respect to guidance used for the previous ERA, development of ecological remediation goals (PRGs) and uncertainty in surface water and sediment contamination.

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The final memoranda will be the principal planning documents for the ERA update and will reflect consensus among all reviewers as to the methods to be used. Reviewers are:

- Scott Marquess, EPA Region VII
- Michael Coffey, USFWS
- Matt Bazar, CHPPM
- Randy Sellers, USACE, Omaha
- Rodger Allison, Joe Haffner, IAAAP

This is the fourth TM and proposes a methodology for screening the IAAAP chemical database to identify contaminants of ecological concern (COEC). Relevant information contained in existing documents is incorporated by reference where appropriate.

Data Evaluation

In place of the IAAAP contaminant database used in the ERAA (Harza 1997), Harza will use the most complete, up-to-date contaminant database for IAAAP, obtained from Omaha USACE. The database for screening and ERA will reflect removal and remedial actions taken to date at IAAAP. The database will include the most recent surface water and sediment data collected by Harza and others.

For this ERA, contaminant data will be evaluated in two phases. First, Harza will perform a screening-level risk assessment that will culminate in a scientific/management decision point (SMDP). This SMDP will define the need for a full ERA. The SMDP must result in agreement between IAAAP, USFWS, EPA, USACE, CHHPM, and Harza regarding selection of assessment and measurement endpoints, selection of COECs, identification of complete and significant exposure pathways, and hazard models. Currently, we assume that a full ERA will be needed and propose to utilize the screening-level phase to identify contaminants of concern. The screening evaluation and the SMDP will be documented in a working paper that will serve as an opportunity for communication between ERA preparers, reviewers and risk managers. The second phase of data evaluation will be a baseline ERA.

The watershed approach, as taken in the ERAA, will be limited to aquatic systems. Terrestrial endpoints will be assessed on the basis of Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) investigated during the remedial investigations (RI). Maximum contaminant concentrations in each watershed and/or SWMU-AOC will be used in the risk screening evaluation.

Exhibit 1 is a flow chart of the proposed screening process. We propose the following process to identify COECs and reach the SMDP:

1. Groundwater, and soils deeper than 24 inches, generally, do not present a significant exposure pathway to ecological receptors. Groundwater on the IAAAP does enter streams and seepage wetlands and then becomes an exposure point. But, such contaminants would be implicitly represented in surface water data.

2. Probable laboratory contaminants will be eliminated from consideration. Rationale for identifying laboratory contaminants will be provided on a chemical-by-chemical basis. Justifications will be provided for data used in the RI, as well as data collected since the RI.

3. Essential nutrients generally do not present a hazard and can be eliminated from consideration if levels are less than those known to cause problems; e.g., ammonia nitrogen less than water quality standards.

4. MDLs in the database should be less than the associated Ecotoxicity Threshold (ET) benchmark values. In some cases, such as bioaccumulative chemicals, the MDL may not be lower than the ET; in these cases, we will assume that the concentration exceeds the ET and proceed to the baseline risk assessment step.

5. For inorganics, analytical results are to be compared to natural background (using the Student's t-test or other appropriate statistical procedure) and to ETs to identify COECs for evaluation in the baseline risk assessment.

ETs are media-specific contaminant concentrations above which there is sufficient concern regarding adverse ecological effects to warrant further investigation (EPA 1996a). Available literature will be reviewed to compile No and Lowest Observed Adverse Effects Levels (NOAELs and LOAELs) for each chemical in each media. Preferred ETs will be based on NOAELs. If NOAELs are not available, ETs will be based on 10% of the LOAELs. Primary resource for ETs will be U.S. EPA's Ecotox Database (EPA 1996b). ETs for chemicals not readily available will be developed using available media-specific benchmarks. The lowest reported benchmark will be selected as the preferred ET.

For surface water, resources to be evaluated for selection of benchmarks include National ambient water quality criteria (chronic), State of Iowa chronic water quality standards for limited resource waters, or USEPA Region 5's Ecological Data Quality Levels (EDQL)(EPA 1998).

For sediment, the preferred ETs for organics will be those developed from water ETs using equilibrium partitioning:

$$ET_{sed} = f_{oc} \times K_{oc} \times ET_{water}$$

where f_{oc} is the mass fraction of organic carbon in the sediment and K_{oc} is the organic carbon partition coefficient. K_{oc} will be obtained from the literature, or, estimated from relationships available in the literature based on octanol-water partition coefficient and water solubility. If available information is not adequate for developing ETs for organics based on equilibrium partitioning, and for metals, sediment ETs will be based on minimum of available benchmarks. As suggested by Efroymson and others (1997a), benchmarks may be obtained from NOAA Effects Range-Median (ER-M), Florida Department of Environmental Protection Probable Effect Level (PEL), and USEPA ARCS Program Probable Effects Concentration (PEC). Additional resources for sediment benchmarks include Ontario Ministry of the Environment Lowest Effect Level (Persaud and others, 1993), USEPA Region 5's EDQL, and toxicological benchmarks developed at Oak Ridge National Laboratory (Suter and Tsao, 1996; Jones and Others, 1997).

Resources for soil ETs may include USEPA Region 5's EDQL and toxicological benchmarks developed at Oak Ridge National Laboratory (Sample and others, 1996; Efroymson and others, 1997b.

Background levels of metals measured at IAAAP will be used to screen COECs. Metal concentrations in over 100 background soil samples are available (e-mail from Kevin Howe, dated April 10, 2000 with attached file RI-MTLS.XLS). For surface water and sediment, we propose to use samples from locations LC1 (in Long Creek) and SC1 (in Spring Creek), shown on Exhibit 4 in the SAP Addendum, dated August 17, 2000. These locations are upgradient from any site-related activities.

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Appendix B-5
TRV Memorandum

DEVELOPMENT OF DOSE ESTIMATION MODELS AND TOXICITY REFERENCE VALUES ECOLOGICAL RISK ASSESSMENT

IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

Prepared for

U.S. Army Corps of Engineers
Omaha District

By

MWH
MONTGOMERY WATSON HARZA

August 31, 2001

DEVELOPMENT OF DOSE ESTIMATION MODELS AND
TOXICITY REFERENCE VALUES
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT

The purpose of this report is to present models to be used for estimating doses to the four representative feeding guilds (White-footed Mouse, Short-tailed Shrew, Belted Kingfisher, and Indiana Bat) at the Iowa Army Ammunition Plant (IAAAP). Toxicity Reference Values (TRVs) for the selected ecological receptors for exposure to each of the COPECs are proposed in this memorandum. Methods for deriving values for the water-biota, sediment-biota, and plant-biota accumulation factors for the contaminants of potential ecological concern (COPECs) are also presented.

DERIVATION OF TRVs

Research for the TRVs on each COPEC began with searches of published toxicity studies on mammals and birds in several databases. The databases searched for papers on toxicological effects of the specific COPECs include Current Content, Agency of Toxic Substance and Disease Registry (ATSDR) toxicological profiles, National Library of Medicine's Hazardous Substance Database (Toxline), Oak Ridge National Laboratory's Risk Assessment Information System (RAIS), U.S. Environmental protection Agency's (EPA) Integrated Risk Information System (IRIS) and EPA's ECOTOX. Several comprehensive reports such as EPA Region 6 Screening Level Ecological Risk Assessment Protocol (EPA 1999), Toxicological Benchmarks for Wildlife (Sample and others. 1996), and CH2MHILL and USACE's review of TRVs (2000) were reviewed.

Several selection criteria were used to identify relevant literature. Literature that provided information on study design such as duration, handling of test species, physical information on test species, and dose route, was selected over literature with limited information. Chronic toxicity studies were considered preferentially because at most sites receptors are exposed over a long period. For study on laboratory rodents at least over one year is considered to be a chronic exposure (Sample and others. 1996). For avian study, exposure duration greater than ten weeks is considered to be chronic study (Sample and others. 1996). Toxicity endpoints that correlate with significant ecological impact such as reproduction, development, and survival, were preferred over systemic and acute effects. Dose administered through oral route (diet, water, gavage) was preferred over other routes.

The literature search focused on laboratory studies to obtain information on the lowest observed adverse effect level (LOAEL) and the no observed adverse effect level (NOAEL). The lowest chronic LOAEL value is used as the TRV, if both LOAEL and NOAEL data are available; otherwise, the NOAEL value is used. LOAEL and NOAEL values available only from subchronic studies were adjusted by dividing the value by an uncertainty factor of 10. If a LOAEL or NOAEL is available for a mammalian or avian test species, then the equivalent LOAEL or NOAEL for a mammalian or avian wildlife species was calculated by using the adjustment factor for differences in body weight (Sample and others. 1996). The equations for the adjustment are as follows:

$$LOAEL_w = LOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4}$$

$$NOAEL_w = NOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4}$$

Where the subscripts w and t refer to the wildlife species of interest and the test species, respectively. The body weight scale factors used to derive TRVs for the species of interest and the test species are presented in Appendix A, Table A-1. The derived TRVs for each receptor are presented in Appendix A, Tables A-2 through Table A-5 (The Appendices and Tables listed in this document have since been revised. The revised tables are presented in Appendix G of the BERA).

DEVELOPMENT OF DOSE MODELS

Procedures for estimating exposures of four wildlife-feeding guilds are required for completing this risk assessment. The feeding guilds are:

1. A piscivore represented by the Belted Kingfisher
2. An aquatic insectivore, represented by the Indiana Bat
3. A terrestrial herbivore, represented by the White-footed Mouse
4. A terrestrial carnivore, represented by the Short-tailed Shrew

Exposure to contaminants experienced by an endpoint species may come from multiple sources. The sources include food (plant or animal), water, soil, and sediment. Figure 1 through Figure 4 represent the ecorisk pathways for the four ecological receptors. The generalized equation for estimating daily contaminant dose that an endpoint receptor may receive from a particular contaminant in a particular medium may be expressed as

$$E_j = \sum_{i=1}^{m} P_{ik} \left(IR_i \times C_{ijk} \right) / (\mathrm{BW}) \qquad (1)$$

Where:
E_j = Total exposure to contaminant j, mg/kg/d
m = Total number of ingested media
P_{ik} = Proportion of type (k) of medium (i) consumed
IR_i = Consumption rate for medium (i), kg/d or L/d
C_{ijk} = Concentration of contaminant (j) in type (k) of medium (i), mg/kg or mg/L
BW = Body weight, kg

Parameter values required for estimating dose for all four feeding guilds are presented in Table 1.

Table 1. Exposure Parameter Values [a]

Parameter	Short-tailed Shrew	White-footed Mouse	Belted Kingfisher	Indiana Bat
Body Weight (kg)	0.0150	0.0220[d]	0.1360	0.0072[f]
Food Intake (kg/d)	0.0080	0.0034[d]	0.0680	0.0025[g]
Water Intake (L/d)	0.0033	0.0066[d]	0.0150	0.0012[g]
Soil Intake in diet, %	13[b]	2[e]	0	0
Terrestrial invertebrate in diet, %	87[c]	49[c]	0	0
Fish in diet, %	0	0	100[c]	0
Aquatic invertebrate in diet, %	0	0	0	100[c]
Vegetation in diet, %	0	49[c]	0	0

Notes:

a Values from EPA (1993), unless otherwise mentioned
b Talmage and Walton (1993)
c Assumed
d Sample and others (1996)
e Beyer and others (1994)
f USAMC (1998)
g Values for the Brown Bat (Sample and others, 1996)

Specific models for estimating doses to the four feeding guilds are presented below.

Belted Kingfisher

Belted Kingfishers are exposed to contaminants through ingestion of water and food. Information presented in EPA (1993) indicates that its diet consists primarily of fish. The exposure model for the aquatic piscivore may be expressed as

$$E_j = (IR_w \times C_w - j)/(BW) + (IR_f \times C_{fish-j})/(BW) \qquad (2)$$

Where:
IR_w = Ingestion rate of water, L/d
C_{w-j} = Contaminant concentration (j) in water, mg/L
IR_f = Ingestion rate of fish, kg/d
C_{fish-j} = Contaminant concentration (j) in fish, mg/kg
BW = Body Weight, kg

Contaminant concentrations in fish at the IAAAP are needed for estimating exposure dose. Whole fish samples were collected from Brush Creek, Spring Creek, and Long Creek. These samples were analyzed for mercury, explosives, and pesticide/PCBs. The results were presented in the Ecological Risk Assessment Addendum (Harza 1998). Mercury and dieldrin were the only two compounds detected in fish tissue. Actual fish tissue concentrations in each watershed for mercury and dieldrin will be used in the risk assessment. The analytical procedures including detection limits for the compounds were in accordance with the approved work plan and were lower than the corresponding available LOAELs or NOAELs. Therefore, chemicals that were not detected in the fish tissue samples will not be considered as contaminants of potential ecological concern (COPEC).

For other contaminants that were not analyzed in fish sample, the contaminants concentration in fish (C_{fish}) will be calculated using the following equation:

$$C_{fish-j} = C_{w-j} \times BAF_{fish} + C_{se-j} \times BSAF_{fish} \times \frac{F_l}{F_{oc}} \qquad (3)$$

Where:
C_{w-j} = Contaminant concentration (j) in water, mg/kg (one liter of water assumed to weigh one kg)
C_{se-j} = Contaminant concentration (j) in sediment, mg/kg
BAF_{fish} = Bioaccumulation Factor (Water-To-Fish)
= Concentration in fish tissue/Concentration in water, unitless
$BSAF_{fish}$ = Bioaccumulation Factor (Sediment-To-Fish)
= Concentration in fish tissue/Concentration in sediment, unitless
F_l = Fraction of lipid in fish, unitless
F_{oc} = Fraction of organic carbon in the sediment = Total organic carbon (TOC)/100, unitless

F_l is estimated to be 0.05 (Leblanc, 1995). Sediment samples collected from Spring Creek, Brush Creek, and Long Creek were analyzed for TOC. The lowest measured TOC value in each watershed will be used. The lowest measured TOC value of all watersheds will be used as the default value for the Skunk River watershed. A $BSAF_{fish}$ value of 1.7 will be used for organic chemicals (Konemann and van Leeuwen, 1980, Karickhoff, 1981, cited in McFarland and Clarke, 1987). The $BSAF_{fish}$ and BAF_{fish} values of inorganic chemicals were obtained from available literature. The organic BAF_{fish} values were estimated from octanol-water coefficients (Kow), using an equation developed by Meglan and others (1999).

$$\text{Log BAF}_{\text{fish}} = 0.76 \times \log \text{Kow} - 0.39 \qquad (4)$$

The values of logKow, BAF_{fish} and $BSAF_{fish}$ are listed in Appendix B, Table B-1.

<u>Insectivore- Indiana Bat</u>

It was assumed that the diet for Indiana bat consists primarily of aquatic insects. The exposure model for the aquatic insectivore may be expressed as

$$E_j = (IR_w \times C_{w-j})/(BW) + (IR_{in} \times C_{insect-j})/(BW) \qquad (5)$$

Where:
IR_w = Ingestion rate of water, L/d
C_{w-j} = Contaminant concentration (j) in water, mg/L

IR_{in} = Ingestion rate of insect, kg/d
$C_{insect-j}$ = Contaminant concentration (j) in insect, mg/kg
BW = Body weight, kg

The contaminant concentrations in insect (C_{insect}) is calculated by the following equation:

$$C_{insect-j} = C_{w-j} \times BAF_{invert} + C_{se-j} \times BSAF_{invert} \qquad (6)$$

Where:
C_{w-j} = Contaminant concentration (j) in water, mg/kg
C_{se-j} = Contaminant concentration (j) in sediment, mg/kg
BAF_{invert} = Bioaccumulation Factor (Water-To-Aquatic invertebrate)
= Concentration in invertebrate tissue/Concentration in water, unitless
$BSAF_{invert}$ = Bioaccumulation Factor (Sediment-To-Aquatic invertebrate)
= Concentration in invertebrate tissue/Concentration in sediment, unitless

A $BSAF_{invert}$ value of 1.7 will be used for organic chemicals (Konemann and van Leeuwen, 1980, Karickhoff, 1981, cited in McFarland and Clarke, 1987). The $BSAF_{invert}$ and BAF_{invert} values of inorganic chemicals were obtained from the available literature. The organic BAF_{invert} values were calculated by multiplying the bioconcentration factor (BCF) for the contaminant by the aquatic food chain multiplying factor (FCM).

The BCFs were estimated from octanol-water coefficients (Kow), using the following equation (Lyman and others, 1990)

$$\log BCF = 0.76 \log Kow - 0.23 \qquad (7)$$

The FCM for Indiana Bat is 1 (Sample and others. 1996).

The values of logKow, BCF, BAF_{invert} and $BSAF_{invert}$ are listed in Appendix B, Table B-2.

<u>Terrestrial Herbivore-White-footed Mouse</u>

Terrestrial herbivores are exposed to contaminants via ingestion of soil, plants and terrestrial invertebrate. The exposure model may be expressed as

$$E_j = (P_s \times F \times C_{s-j})/(BW) + (P_v \times F \times C_{v-j})/(BW) + (P_{inv} \times F \times C_{inv-j})/(BW) \qquad (8)$$

Where:
P_s = Fraction soil ingested, unitless
F = Food intake, kg/d
C_{s-j} = Contaminant concentration (j) in soil, mg/kg
P_v = Fraction vegetation ingested, unitless
C_{v-j} = Contaminant concentration (j) in vegetation, mg/kg
P_{inv} = Fraction invertebrate ingested, unitless
C_{inv-j} = Contaminant concentration (j) in invertebrate, mg/kg

BW = Body weight, kg

The contaminant concentrations in vegetation and invertebrate are calculated by the following equations:

$$C_{v-j} = C_{s-j} \times U_{s-v} \quad (9)$$

$$C_{inv-j} = C_{s-j} \times BAF_{ti} \quad (10)$$

Where:
U_{s-v} = Bioaccumulation Factor (Soil-To-Vegetation), unitless
BAF_{ti} = Bioaccumulation Factor (Soil-To-Terrestrial invertebrate), unitless

For organic contaminant concentration in vegetation, the U_{s-v} values were estimated from relationships based on Kow developed by Travis and Arms (1988).

$$\log U_{s-v} = 1.588\text{-}0.578\ (\log Kow) \quad (11)$$

The BAF_{ti} values for organic contaminants were derived using the following equation, developed by Connell and Markwell (1990).

$$BAF_{ti} = \frac{Y_1 \times \log K_{ow}{}^{b-a}}{x \times f_{oc}} \quad (12)$$

Where:
Y_1 = Terrestrial invertebrate lipid content = 0.02 (Stafford and Tacon, 1988), unitless
logKow = Octanol-water partition coefficient, unitless
b-a = Nonlinearity constant = 0.05
x = Proportionality constant = 0.66
foc = Site-Specific of organic carbon in soil = 0.006, unitless (EPA 1996)

The value of inorganic contaminant U_{s-v} and BAF_{ti} were obtained from the available literature. The values of logKow, BAF_{ti}, and U_{s-v} are listed in Appendix B, Table B-3.

<u>Terrestrial Carnivore-Short-Tailed Shrew</u>

Terrestrial carnivores are exposed to contaminants via ingestion of soil and terrestrial invertebrate. The exposure model may be expressed as

$$E_j = (P_s \times F \times C_{s-j})/(BW) + (P_{inv} \times F \times C_{inv-j})/(BW) \quad (13)$$

Where:
P_s = Fraction soil ingested, unitless
F = Food intake, kg/d
C_{s-j} = Contaminant concentration (j) in soil, mg/kg
P_{inv} = Fraction invertebrate ingested, unitless

C_{inv-j} = Contaminant concentration (j) in invertebrate, mg/kg
IR_w = Ingestion rate of water, L/d
BW = Body weight, kg

The contaminant concentrations in invertebrate are calculated by Equation (10) and the BAF_{ti} values for organics were derived by Equation (12). The inorganic BAF_{ti} values were obtained from the available literature.

The values of logKow and BAF_{ti} are listed in Appendix B, Table B-4.

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Appendix B-6
Technical Memo No. 5

TECHNICAL MEMORANDUM NO. 5
APPROACH TO ADDRESS USFWS COMMENTS ON THE DRAFT BERA
BASELINE ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT

Introduction

The Omaha District of the U. S. Army Corps of Engineers (USACE) has directed MWH Americas, Inc. (MWH) to revise the Draft Baseline Ecological Risk Assessment (BERA) for the Iowa Army Ammunition Plant (IAAAP), outside Middletown, Iowa. The Draft Final BERA will address issues raised by the Army, regulatory agencies, and natural resource trustees. MWH was tasked with preparing a series of Technical Memoranda (TM) that constitutes the planning documents for this BERA. Four TMs were developed prior to the preparation and submittal of the Draft BERA around the following topics:

1. Development of Assessment and Measurement Endpoints
2. Water and Sediment Data Collection
3. Development of Hazard Models and Ecological PRGs
4. Contaminant Screening Process

The fifth TM was developed in response to comments on the Draft BERA. It addresses three separate topics recommended by the United States Fish and Wildlife Services (USFWS) for inclusion in the Draft Final BERA. The USFWS recommendations were as follows:

- The explosives toxicity reference values (TRVs) published by the U.S. Army Center for Health Promotion and Preventative Medicine (USACHPMM) be used for the risk calculations for Indiana bat.

- Critical aquatic sediment and surface water concentrations be derived for the mammalian and avian receptors in the aquatic conceptual model.

- The Indiana bat be considered as an ecological receptor in the terrestrial conceptual model.

In response to the USFWS recommendations, the Army prepared three e-mailed memoranda detailing how each of the recommendations will be implemented in preparing the Draft Final BERA. The Army received further comments from the USFWS regarding the procedures detailed in the memoranda. Two conference calls were held on April 26th and 27th, 2004 to discuss USFWS comments and reach consensus regarding the procedures. The attendees on the conference calls with their affiliations are listed below:

Rodger Allison	:	Iowa Army Ammunition Plant
Steve Bellrichard	:	Iowa Army Ammunition Plant
Kevin Howe	:	US Army Corps of Engineers
Randy Sellers	:	US Army Corps of Engineers

Terry Walker	:	US Army Corps of Engineers
Lia Gaizick	:	USACHPPM
Roger Walton	:	US Army Environmental Center
Pinaki Banerjee	:	MWH
Mike Kierski	:	MWH
Melenie Mutchler	:	MKM
Scott Marquess	:	US Environmental Protection Agency
Mike Coffey	:	USFWS
Ginger Molitor	:	USFWS
Dan Cook	:	Iowa Department of Natural Resources

The procedures agreed to by the attendees for addressing each of the three topics are presented below.

SELECTION OF TOXICITY REFERENCE VALUE FOR INDIANA BAT FOR EXPOSURE TO EXPLOSIVES

The TRVs used in the Draft BERA, dated October 2003, are based on protection of receptors at the community level. The Lowest observed Adverse Effects Level (LOAEL) or the No observed Adverse Effects Level (NOAEL) based TRVs were selected from studies that used reproduction or growth as endpoints. However, for an Indiana bat, a threatened and endangered species, protection at the individual level may be desirable. Studies that generate TRVs based on protection of individuals are not readily available. USACHPPM. (2000) conducted studies with explosives, such as TNT and RDX, to determine ED10 (an effect or response in 10% of the population) and LED 10 (95% lower confidence limit for not exceeding a benchmark response) values. The study data used to calculate the values were based on changes in body weight, hemoglobin, and hematocrit in dogs. These were determined to be the most sensitive endpoints and may be ecologically significant to sensitive species. The USACHPPM derived ED 10 value of 0.2 mg/kg-d for TNT is proposed for use as the TRV in the hazard quotient (HQ) calculation for the endangered Indiana bat in the Draft Final BERA.

The ED10 value for RDX in the USACHPPM study was found to be 1.19 mg/kg-d. The NOAEL value used in the BERA for RDX was 1.38 mg/kg-d. Because the two values are comparable, the NOAEL and LOAEL based TRVs for RDX will be used in the Draft Final BERA.

PROCEDURE FOR CALCULATING SURFACE WATER AND SEDIMENT CRITICAL CONCENTRATIONS

The BERA will be revised to add critical concentrations (CC) of contaminants of potential ecological concern (COPEC) to Indiana bat and Belted kingfisher from exposure to constituents in surface water and sediment. The CCs are to be used as a management tool by the risk managers for making remedial decisions. The CCs are not meant to be used as clean-up goals, but are rather one line of evidence to be used to evaluate if a site poses a potential risk to ecological receptors.

Critical Concentrations are COPEC concentrations that may pose a risk to a specific receptor. The CCs are calculated analyte concentrations in surface water and sediment that equate to a LOAEL based HQ of one. The LOAEL based CCs will be back calculated based on the dose models presented as Equations 2 and 5 in Section 3.3 of the Draft BERA. For each analyte, exposure doses are set equal to the LOAEL based TRV and solved for Cw-j or Cse-j, which represents the COPEC concentrations in surface water and sediment, respectively. The resulting CC values are the COPEC concentrations that correspond to LOAEL based HQ of one for Indiana bat and Belted kingfisher.

Exposure to surface water or sediment, containing COPECs at or below the LOAEL based CCs, should not result in unacceptable levels of risk to ecological receptors. Further evaluation will be conducted for constituents with LOAEL based HQs exceeding one. No observed Adverse Effects Level (NOAEL) based CCs will be calculated for such constituents to provide risk managers with additional information regarding sensitivity of the HQ estimates. The ED 10 value of 0.2 mg/kg-d and LOAEL value of 8 mg/kg-d determined in the USACHPPM study for TNT will be used for calculating CCs for Indiana bat. Tables will be presented with range of risk estimates calculated based on LOAEL and NOAEL (ED10 for TNT for Indiana bat) based TRVs for some of the COPECs (when HQs exceed one based on LOAEL based TRVs).

<u>Calculation of Surface Water CC</u>

1) *The following equation will be used for Belted kingfisher:*

$$CC_{w\text{-}j} = \frac{TRV \times BW}{IR_w + IR_f \times P_f \times BAF_{fish}}$$

where,

$CC_{w\text{-}j}$ = Critical concentration of COPEC (j) in water, mg/L
IR_w = Ingestion rate of water, L/d
IR_f = Ingestion rate of food, kg/d
P_f = Fraction of fish ingested as proportion of total food intake, unitless
BW = Body weight, kg
BAF_{fish} = Bioconcentration factor (water-to-fish)

The Kingfisher's food consumption consists of 2% sediment and 98% fish. Calculation of CCs in water will be based on the assumption that COPEC concentration in fish tissue is bioaccumulated from COPEC concentration in water and that contaminants in sediment do not contribute to the bioaccumulation in fish tissue. Also, COPEC concentrations in sediment will not be considered for calculating surface water CC. Values for all parameters in this and all other equations are as listed in the Draft BERA.

2) The following equation will be used for Indiana bat:

$$CC_{w\text{-}j} = \frac{TRV \times BW}{IR_w + IR_f \times P_{insect} \times BAF_{aq-inv}}$$

where,

P_{insect} = Fraction of insect ingested as a proportion of total diet, unitless
$BAF_{aq\text{-}inv}$ = Bioaccumulation factor (water-to-aquatic invertebrate)

For calculating water CC, it is assumed that food consumption for Indiana bats consists of 100% aquatic invertebrate. To calculate surface water CC, COPEC concentrations in sediment will not be considered. The selected surface water CC will be the lower of the CCs calculated for Belted kingfisher and Indiana bat.

Calculation of Sediment CC

For calculating sediment CCs, COPEC concentrations in water will not be considered. The selected sediment CC will be the lower of the CCs calculated for Belted kingfisher and Indiana bat.

1) *The following equation will be used for Belted kingfisher:*

$$CC_{se\text{-}j} = \frac{TRV \times BW}{IR_f \times P_{se} \times CF_{se}}$$

where,

$CC_{se\text{-}j}$ = Critical concentration of COPEC (j) in sediment, mg/kg
P_{se} = Fraction of sediment ingested as a proportion of total food intake, unitless (as proportion of food ingested)
CF_{se} = Conversion factor (sediment dry weight to wet weight), (mg/kg wet sediment)/(mg/kg dry sediment)

2) *The following equation will be used for Indiana bat:*

$$CC_{se\text{-}j} = \frac{TRV \times BW}{IR_f \times P_{insect} \times BSAF_{aq-inv}}$$

DEVELOPMENT OF DOSE MODEL FOR INDIANA BAT EXPOSURE VIA TERRESTRIAL PATHWAY

Remedial management decisions at IAAAP are expected to be made for individual areas of concern (AOCs). Risk estimates developed for each AOCs may be used as a management tool for making such decisions. The proposed dose model for the Indiana bat is focused towards developing risk estimates for exposure to COPECs in soil at each AOC. A revised Conceptual Site Model (CSM) and the ecorisk pathway for Indiana bat are presented in Figures 1 and 2.

Indiana bat's diet consists of 100% flying insects. USACE (2001) notes that Indiana bat eats both aquatic and terrestrial insects. The exposure dose model for the Indiana bat via the aquatic pathway was developed based on the assumption that it exclusively consumes aquatic insects. Similarly, for development of exposure dose model via the terrestrial pathway, it will be assumed that Indiana bat only consumes terrestrial insects. This approach allows evaluation of exposure to Indiana bat from COPECs in soil at particular AOCs.

The proposed exposure dose model for Indiana bat as a terrestrial insectivore may be expressed as:

$$E_j = (IR_w \times C_{w\text{-}j})/(BW) + [(IR_f \times P_{terr\text{-}insect} \times C_{terr\text{-}insect\text{-}j})/(BW)] \times AUF$$

Where,

E_j	=	Exposure dose from COPEC (j), mg/kg/d
IR_w	=	Ingestion rate of water, L/d
$C_{w\text{-}j}$	=	COPEC concentration (j) in water, mg/L
IR_f	=	Ingestion rate of food, kg/d
$P_{terr\text{-}insect}$	=	Fraction of insect ingested as a proportion of total diet, unitless
$C_{terr\text{-}insect\text{-}j}$	=	COPEC concentration (j) in aquatic insect, mg/kg
BW	=	Body weight, kg
AUF	=	Area use factor

The COPEC concentrations in terrestrial insects will be estimated using the following equation:

$$C_{terr\text{-}inv\text{-}j} = C_{s\text{-}j} \times BAF_{terr\text{-}inv}$$

Where,

$C_{terr\text{-}inv\text{-}j}$	=	COPEC concentration (j) in terrestrial invertebrate, mg/kg
$C_{s\text{-}j}$	=	COPEC concentration (j) in soil, mg/kg
$BAF_{terr\text{-}inv}$	=	Bioaccumulation factor (soil-to-terrestrial invertebrate), (mg/kg dry tissue)/(mg/kg dry soil)

Soil-to-terrestrial invertebrate bioaccumulation factor (BAF) values account for uptake of COPECs from soil by terrestrial invertebrates. Significant uncertainties are associated with empirical models that could describe the soil to plant to insect uptake of food that is partly obtained from soil and partly obtained from plants. Literature that specifically provides values (or approach for estimation) for uptake of chemicals from soil by flying terrestrial insects is not available. As a conservative approach, the soil-to-terrestrial invertebrate BAF values will be used. $BAF_{terr\text{-}inv}$ values are primarily developed based on uptake by worms, which is expected to overestimate uptake compared to those by flying insects because worms are in contact with the soil during 100 % of their life cycle. The procedure to estimate $BAF_{terr\text{-}inv}$ values was provided in Section 3.5 of the Draft BERA.

Uncertainties related to using the soil-to-worm based BAF values will be discussed in the Draft Final BERA as a sensitivity analysis. The sensitivity analysis will evaluate exposure parameters such as TRV and BAF. Range of HQ estimates will be presented for

COPECs for which the HQs exceed one when literature based BAFs are used. The HQ values estimated based on the literature-based BAF values represent the upper end of the risk estimates. Concentrations of selected constituents in soil and flying insects were monitored at the Savanna Army Depot (Savanna) in Illinois and Badger Army Ammunition Plant (Badger) in Wisconsin. Ecological characteristics and activities conducted at Savanna and Badger are similar to those at the IAAAP and data available from these two facilities are expected to reasonably reflect conditions at the IAAAP. Savanna is located little over 100 miles north of the IAAAP in the Mississippi River floodplain, approximately equidistant from the river as is the IAAAP. The two facilities have similar general ecological characteristics including flora, fauna, and habitat. Badger, another Army Ammunition Plant in the Midwestern United States, was used for activities similar to those conducted at the IAAAP. Sample collection and analytical procedures used at Badger and Savanna were reviewed by the USEPA and state regulatory agencies and the data quality were considered to be adequate. Available data from savanna and Badger will be reviewed to determine BAF values for the insects. Risk estimates will be developed based on these measured values, when available, to represent HQ estimates that are less conservative than those based on BAF values developed using soil to worm model. Tables will be presented with range of risk estimates calculated for some of the COPECs with two BAF values, one based on the soil to worm model and the other BAF value based on measured insect concentrations.

The Indiana bat is expected to drink water at the rate of 0.0012 L/day (as listed on Table 3-2 in the Draft BERA). Receptors at specific AOCs may also receive intake of COPECs through ingestion of water. The exposure point concentrations of each COPECs in the watershed in which the specific AOC is located will be used to estimate exposure dose.

IAAAP (2003) discusses foraging and roosting behavior of Indiana Bat at the IAAAP. The Indiana bats were found primarily foraging along edges of agricultural fields, along and in the floodplain of the water bodies, and in forested areas around headwaters of the surface water bodies. The bats were found to spend some time around a stone quarry, although it is not clear if they are foraging or roosting in that area. Some of the bats were found to fly across an open field, but not forage there. The bats were not specifically found to forage near the production lines. The nature and extent of contamination around the production lines are limited to areas close to the lines that are not forested. Based on the foraging and roosting characteristics described in IAAAP (2003), the bats are not expected to forage around the AOCs. However, as a conservative approach, it is assumed that the bats are foraging in the AOCs.

The IAAAP is a 19,000-acre facility. The AOCs, and therefore, soil contamination by COPECs, cover only a small portion of the site. Garner and Gardner (1992, as cited in Evans and Others, 1998) monitored foraging activities of Indiana bat. Foraging territory ranged from 70 acres for juveniles to 526 acres for females. An Indiana bat is primarily expected to catch insects from areas outside the AOCs, with only a fraction from near the AOCs. Area of most AOCs is lower than the average home range of a juvenile Indiana bat. Therefore, an AUF will be used for the bat, which is equivalent to the ratio of the area of an AOC to the average foraging area of a juvenile bat. The areal extent of sampling constitutes the exposure area for each AOC.

The USFWS believed that the nightly foraging ranges within a habitat unit, that may contain an AOC patch, could be much smaller compared to the species territory range of 70 to 526 acres. IAAAP (2003) noted that the core foraging area of an individual Indiana bat (Sodalis 824) was found to be in a field south of K-road. This is the only terrestrial area identified in the report, which could be significant part of a bat's diet. It was postulated that this area could be used to represent an alternate estimate of AUF and characterize the sensitivity associated with AUF estimates, if found to be smaller than the average foraging area of 70 acres for juvenile bat. However, the area of this field was found to be more than 200 acres. Therefore, it was determined that AUFs will only be calculated based on an average foraging area of 70 acres.

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USACHPPM, 2000. Wildlife Toxicity Assessment for 2,4,6-Trinitrotoluene. Project Number 39-EJ-1138-00. Aberdeen Proving Ground, Maryland. October.

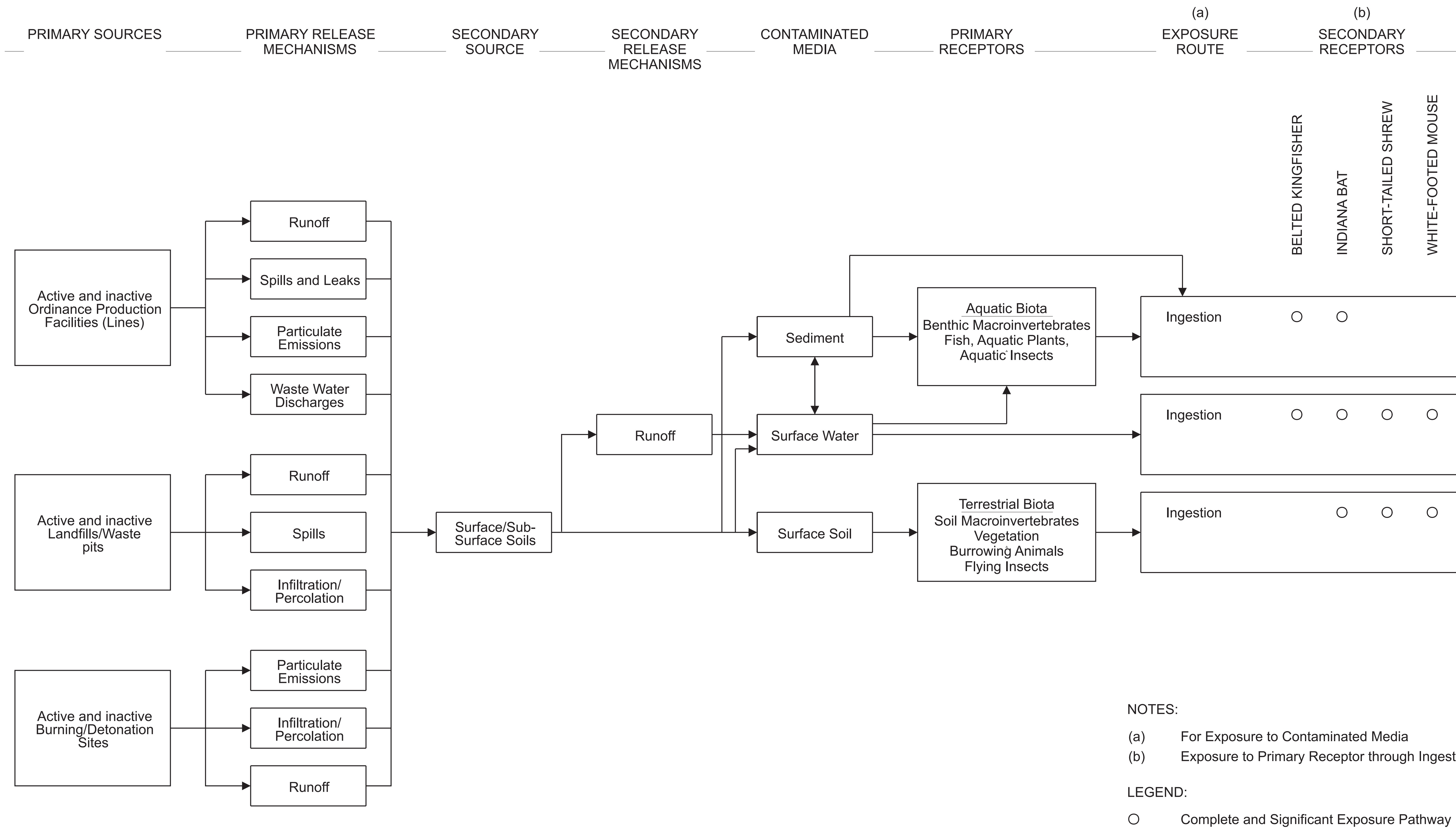

Figure 1
CONCEPTUAL SITE MODEL
BASELINE ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

MWH

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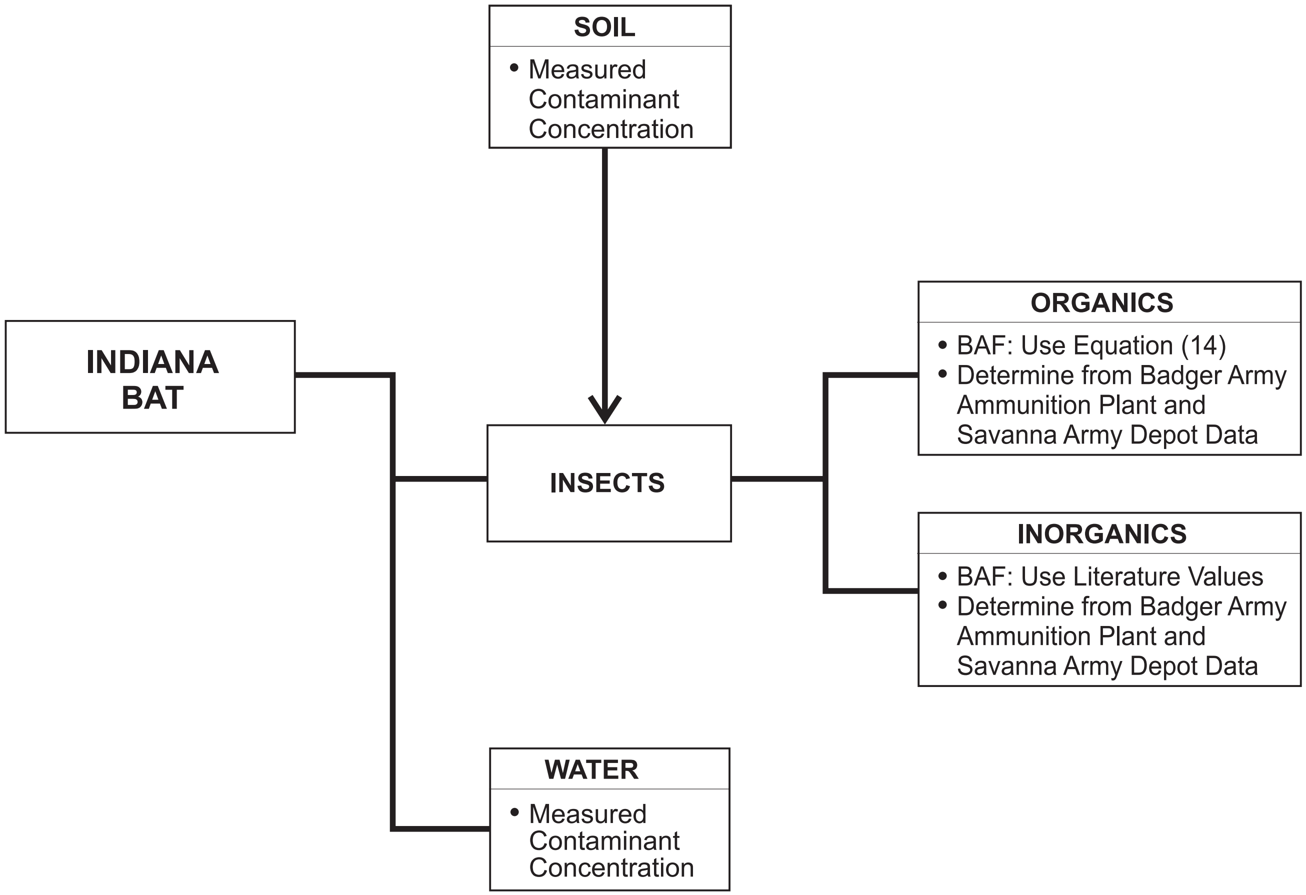

Figure 2

ECORISK PATHWAY FOR INDIANA BAT VIA THE TERRESTRIAL PATHWAY

ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Iowa

MWH