**Per the Federal Facility Agreement for Iowa Army Ammunition Plant, Article X.B.1, the attached document is the final version of the submitted document.**

# DRAFT TECHNICAL MEMORANDUMS
# NO. 1 – 4
# FOR THE ECOLOGICAL RISK
# ASSESSMENT

# TECHNICAL MEMO NO. 1 - DRAFT
# DEVELOPMENT OF ASSESSMENT AND MEASUREMENT ENDPOINTS FOR ECOLOGICAL RISK ASSESSMENT AT THE IOWA ARMY AMMUNITION PLANT

## 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<br>Thallium HQ = 1.7<br>Lead HQ = 1.1 | Silver HQ = 0.4 to 1.4<br>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<br>Copper HQ = 3.5<br>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**<br>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:*<br>- total and dissolved water concentrations<br>- sediment concentrations<br>- fish tissue concentrations | *measures of effect:*<br>- Iowa chronic water quality standards<br>- laboratory-derived chronic effects levels<br>- BTAG guidance<br>- RBP II metrics<br>- tissue residue effects benchmarks | *measures of ecosystem and receptor characteristics:*<br>- stream physical habitat measurements<br>- fish DELTs<br>- surface water DO, temp., and conductivity<br>- benthic macroinvertebrate abundance and diversity |
| 2. Goal: **Protect sensitive species**<br>Assessment Endpoint: Survival, growth, and reproduction of aquatic piscivores *(representative species – belted kingfisher)* | | |
| *Measures of exposure:*<br>- fish tissue concentrations<br>- water and sediment concentrations | *Measures of effect:*<br>- laboratory derived chronic effects levels | *Measures of ecosystem and receptor characteristics:*<br>- life history habits and exposure factors |
| 3. Goal: **Protect sensitive species**<br>Assessment Endpoint: Survival, growth, and reproduction of aquatic insectivores *(representative species – Indiana bat)* | | |
| *Measures of exposure:*<br>- water and sediment concentrations<br>- modeled insect concentrations | *Measures of effect:*<br>- laboratory derived chronic effects levels | *Measures of ecosystem and receptor characteristics:*<br>- life history habits and exposure factors |
| 4. Goal: **Sustainable native wildlife species**<br>Assessment Endpoint: Survival, growth, and reproduction terrestrial herbivores *(representative species – white-footed mouse)* | | |
| *Measures of exposure:*<br>- soil concentrations<br>- modeled vegetation concentrations<br>- tissue concentrations | *Measures of effect:*<br>- laboratory derived chronic effects levels<br>- tissue residue effects benchmarks | *Measures of ecosystem and receptor characteristics:*<br>- life history habits and exposure factors |
| 5. Goal: **Sustainable native wildlife species**<br>Assessment Endpoint: Survival, growth, and reproduction of terrestrial carnivores *(representative species – short-tailed shrew)* | | |
| *Measures of exposure:*<br>- soil concentrations<br>- modeled vegetation and invertebrate concentrations<br>- tissue concentrations | *Measures of effect:*<br>- laboratory derived chronic effects levels<br>- tissue residue effects benchmarks | *Measures of ecosystem and receptor characteristics:*<br>- life history habits and exposure factors |

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 :g/kg. In surface water, RDX and HMX were detected at concentrations up to 3 :g/L and 5.8 :g/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 :g/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). 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 |
| 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 |

## Table 1
## ANALYTES WITH MDL EXCEEDING EDQL (in ppb)

| Analyte | Medium | MDL | EDQL | Comment |
|---|---|---|---|---|
| 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 |

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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 :g/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 | rea | 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 :g/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 :g/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 :g/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:g/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:g/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:g/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:g/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:g/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 :g/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:g/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:g/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:g/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)

| Parameters (Methods) | Sediment (µg/kg) | | Water (µg/L) | |
|---|---|---|---|---|
| | 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

File Eco-Risk 28

# TECHNICAL MEMO NO. 2 - DRAFT
# COLLECTION OF WATER AND SEDIMENT QUALITY DATA FOR ECOLOGICAL RISK ASSESSMENT AT THE IOWA ARMY AMMUNITION PLANT

December 17, 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 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. Nearly all analyses of explosives in stream sediments were near or below quantitation limits. The sole exception was one sample from Brush Creek about ½ mile south of US61, 0-6 inches depth, containing 620 μg/kg.

Surface water quality data are also 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. 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). Fifty sediment samples will be collected during January, 2000. At the same locations, water samples will be taken on each of two occasions, once during low flow period in January, 2000, and once during high flow period in the following spring. 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-µm 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 exrapolation 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 compopunds, 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 |
| 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 |

**Table 1**
**ANALYTES WITH MDL EXCEEDING EDQL (in ppb)**

| Analyte | Medium | MDL | EDQL | Comment |
|---|---|---|---|---|
| 3,3'-dichlorobenzidene | sediment | 136.79 | 28.22 | Water MDL<EDQL; not expected to be a COC |
| Bis(2-ethylhexyl)phthlate | 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 |
| α-chlordane | water | 0.0050 | 0.0003 | Sediment MDL<EDQL |
| γ-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 |

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Harza Environmental Services, Inc. 1997. Supplemental Groundwater Remedial Investigation Report, Iowa Army Ammunition Plant, Middletown, Iowa. Prepared for the Omaha District. U.S. Army Corps of Engineers, Omaha, Nebraska by Harza, Chicago, Illinois.

Harza 1998. Ecological Risk Assessment Addendum, Draft Final, Iowa Army Ammunition Plant, Middletown, Iowa. Prepared for the Omaha District, U.S. Army Corps of Engineers, Omaha, Nebraska by Harza, Chicago, Illinois.

Harza 1999a. Recommendations for Additional Remedial Investigations, Line 800/Pink Water Lagoon, Iowa Army Ammunition Plant, Middletown, Iowa. Memorandum by R. P. Kewer dated May 10, 1999.

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U.S. Environmental Protection Agency, Region 5. 1998. RCRA QAPP Instructions, Revision April 1998, Appendix C Ecological Data Quality Levels. Waste, Pesticides and Toxics Division, Chicago, Illinois.

U.S. EPA. SW-846 On-line Test Methods for Evaluating Solid Waste Physical/Chemical Methods. http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm

## 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, PCB, pesticides, herbicides, SVOC |
| Long Creek | LC2 (K Road) | RBP site, potential Indiana bat habitats | Explosives, metals |
| 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 14,000µg/g RDX in sediment found by JAYCOR near 3A-70-1. Downstream from IDA. | Explosives, metals, PCB, pesticides, herbicides, SVOC [uranium, gross alpha, gross beta in LTM program] |
| Long Creek tributary | LCT2 | RBP site "slightly impaired", potentially affected by Line 800 groundwater discharges | Explosives, metals |
| Brush Creek | BC9 | RBP reference site, upstream of discharges | Explosives, metals |
| Brush Creek | BC11 | Upstream of discharges, possibly influenced by Line 1/5A/4A discharges | Explosives, metals |
| Brush Creek | BC10 | 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 contained 470 µg/kg RDX and 31 mg/kg arsenic, sediment RBW-SD-43 contained 5.8 mg/kg 2,6-DNT | Explosives, metals, PCB, pesticides, herbicides, SVOC |
| 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, PCB, pesticides, herbicides, SVOC |
| Brush Creek | BC14 | This area apparently increases in streamflow, noticed during Nov 1-2, 1999 drought reconnaissance | Explosives, metals |

**Exhibit 1**
**WATER AND SEDIMENT SAMPLING LOCATIONS FOR ECOLOGICAL RISK ASSESSMENT**

| Watershed | Designation | Rationale | Analytical Parameters |
|---|---|---|---|
| Brush Creek | BC2 (O Road) | Sediment 7F1 contained 400µg/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 | Deep hole with fine silt present, tributary drains Line 800 phytoremediation wetland | Explosives, metals |
| Brush Creek | BC18 | Leaf litter on sand and log jams with some fines. Downstream of Line 800 tributary and 7H sediment sample (330µg/kg RDX, 1.3 mg/kg Cd) | Explosives, metals |
| Brush Creek | BC3 | RBP site "slightly impaired", upstream of WWTP, sediment sample 7I1 contained 9,900µg/kg RDX and other explosives | Explosives, metals, SVOC, PCB, pesticides, herbicides |
| Brush Creek | BC19 | Upstream of WWTP, likely upstream limit of orangethroat darter distribution | Explosives, metals, SVOC, PCB, pesticides, herbicides |
| Brush Creek | BC4 | RBP site "slightly impaired", downstream of WWTP | Explosives, metals |
| Brush Creek | BC20 | Silt deposits downstream of WWTP | Explosives, metals, SVOC, PCB, pesticides, herbicides |
| Brush Creek | BC21 | 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, PCB, pesticides, herbicides, SVOC |
| Brush Creek | BC22 | Downstream of old fly ash waste pile. Sediment sample 7J1 contained 760µg/kg HMX, orangethroat darter habitat, deep pool with sand and leaf litter substrate | Explosives, metals |
| Brush Creek | BC23 | Deep run with leaf litter and silt, potential Indiana bat habitat, orangethroat darter habitat | Explosives, metals |
| Brush Creek | BC6 (K Road) | RBP site "unimpaired", sediment sample 7K was clean, Indiana bat record, orangethroat darter habitat | Explosives, metals |
| Brush Creek | BC7 (IAAAP boundary) | Probable Indiana bat habitat, orangethroat darter, RBP site "slightly impaired" | Explosives, metals |
| Brush Creek | BC24 | Potential Indiana bat habitat, orangethroat darter, | Explosives, metals |

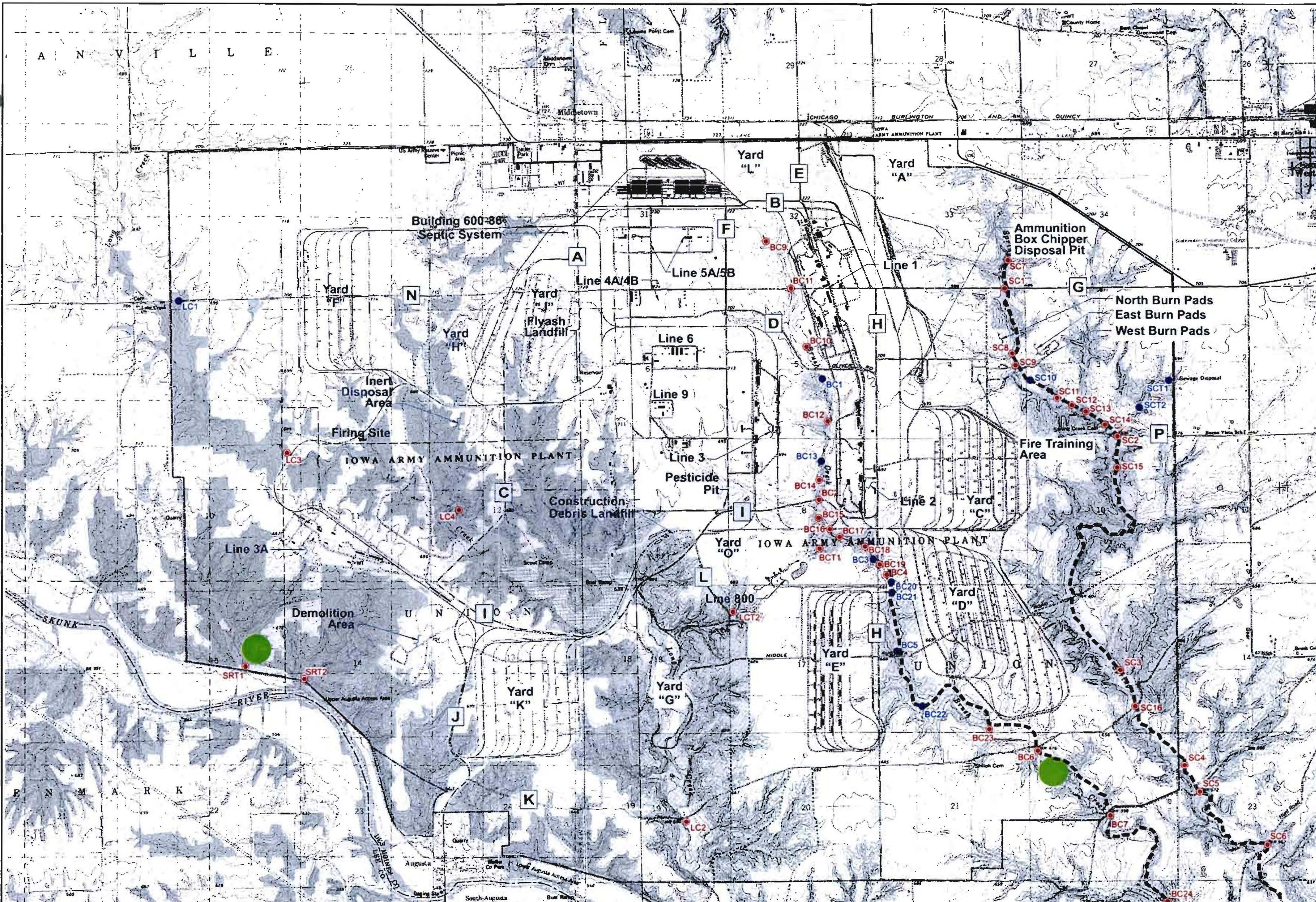
**Exhibit 1**
**WATER AND SEDIMENT SAMPLING LOCATIONS FOR ECOLOGICAL RISK ASSESSMENT**

| Watershed | Designation | Rationale | Analytical Parameters |
|---|---|---|---|
| | (offsite) | sediment sample 7L was clean | |
| Brush Creek | BC8 (Hunt Rd) | RBP site "unimpaired", 8.8µg/kg dieldrin in darter tissue, orangethroat darter habitat | Explosives, metals, SVOC, PCB, pesticides, herbicides |
| Brush Creek Tributary | BCT1 | Tributary draining Line 800, pinkwater lagoon/phytoremediation wetland, collocated with Line 800 RI sample CK02 containing 1,100 µg/kg 2,4,6-TNT | Explosives, metals |
| Spring Creek | SC7 | Upstream of all discharges (background), probable orangethroat darter habitat | Explosives, metals |
| Spring Creek | SC1 (G Road) | RBP reference site, 12µg/kg dieldrin in darter tissue, silt deposits in pool downstream of G bridge, orangethroat darter range | Explosives, metals |
| Spring Creek | SC8 | Potentially affected by North Burn Pads, pool habitat with bedrock & sand substrate, orangethroat darter range | Explosives, metals |
| Spring Creek | SC9 (d/s bridge) | Immediately downstream of EDA, orangethroat darter range | Explosives, metals |
| Spring Creek | SC10 | 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, SVOC, PCB, pesticides, herbicides |
| Spring Creek | SC11 – SC14 | 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, 36µg/kg dieldrin in darter tissue, downstream of the confluence with West Burlington WWTP tributary | Explosives, metals |
| Spring Creek | SC15 | Orangethroat darter range, 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 | SC16 (K Road) | Sediment 7C clean, leaf litter over sand and gravel, orangethroat darter range, potential Indiana bat habitat | Explosives, metals |
| Spring Creek | SC4 (IAAAP boundary) | RBP site "slightly impaired", depressed EPT/chironomid ratio, orangethroat darter range, | Explosives, metals |

## Exhibit 1
## WATER AND SEDIMENT SAMPLING LOCATIONS FOR ECOLOGICAL RISK ASSESSMENT

| Watershed | Designation | Rationale | Analytical Parameters |
|---|---|---|---|
| | | 23µg/kg dieldrin in darter tissue, potential Indiana bat habitat | |
| Spring Creek | SC5 (Brush Coll Rd) | RBP site "slightly impaired", orangethroat darter range, 5.5µg/kg dieldrin in darter tissue, silty sand substrate | Explosives, metals |
| Spring Creek | SC6 (Hunt Road) | RBP site "slightly impaired", orangethroat darter range, 7D1 sediment sample was clean, 21µg/kg dieldrin in darter tissue, silty sand substrate | Explosives, metals |
| Spring Creek tributary | SCT1 (IAAAP boundary) | Effluent from West Burlington WWTP, potential orangethroat darter habitat | Explosives, metals, PCB, pesticides, herbicides, SVOC |
| 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, PCB, pesticides, herbicides, SVOC |
| | | | |

EXHIBIT 2

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**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. Sites LC3 and LC4 will also be analyzed for uranium, gross water samples from 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAMMALS | | | • | • | | | | | | • | • | | • | | | • | • | • | • | | • | | |
| SOILS | | | • | • | | | | | | • | • | | • | | | • | • | • | • | | • | | |
| BENTHOS | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| FISH | | | | • | | | | | | | | • | • | | • | | | • | • | | • | • | • |

**WATER AND SEDIMENT SAMPLING LOCATIONS**
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

HARZA Consulting Engineers and Scientists

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## 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)

| Parameters (Methods) | Sediment (µg/kg) | | Water (µg/L) | |
|---|---|---|---|---|
| | 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

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# TECHNICAL MEMO NO. 3 - DRAFT
# DEVELOPMENT OF HAZARD MODELS AND ECOLOGICAL PRGS FOR ECOLOGICAL RISK ASSESSMENT AT THE IOWA ARMY AMMUNITION PLANT

## 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

$$\mathrm{Ej} = (\mathrm{IR_w} \times C_{w\text{-}j})/(\mathrm{BW}) + (\mathrm{IR_f} \times C_{f\text{-}j})/(\mathrm{BW}) \text{------------------------(2)}$$

Where,

$IR_w$ = Ingestion rate of water, L/d
$C_{w\text{-}j}$ = Contaminant concentration (j) in water, mg/L
$IR_f$ = Ingestion rate of fish, kg/d
$C_{f\text{-}j}$ = 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
$C_{s\text{-}j}$ = Contaminant concentration (j) in soil, mg/kg

$P_v$ = Fraction vegetation ingested, unitless
$C_{v\text{-}j}$ = Contaminant concentration (j) in vegetation, mg/kg
$P_{inv}$ = Fraction invertebrate ingested, unitless
$C_{inv\text{-}j}$ = 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)

$$\log U_{s\text{-}v} = 1.588 - 0.578\ (\log Kow) \text{------------------------} (7)$$

$U_{s\text{-}v}$ = 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

$$Ej = (P_s \times F \times C_{s\text{-}j})/(BW) + (P_{inv} \times F \times C_{inv\text{-}j})/(BW) \text{---------} (8)$$

## 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. 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**

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## 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)

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## TECHNICAL MEMORANDUM NO. 3

**U.S. Army Center for Health Promotion and Preventive Medicine Comments and Recommendations:**

1. Page 1, M. Bazar
   Introduction
   Comment: It is stated that the ecological PRGs are intended for use as screening benchmarks for the purpose of identifying contaminants of ecological concern. Although a minor point if the intent of their use is clearly defined, it may be more appropriate to call the values screening level benchmarks throughout the document rather than PRGs. The connotation is similar to that of a remediation goal objective (RGO), which can have engineering limitations and financial and political adjustments that are not necessarily conservative and prevent its use as a screening level value. It is a frequent USACHPPM comment on screening level assessments relying on PRGs or RGOs that they are typically not risk based and should not be used at the screening level.
   Recommendation: Consider renaming the tech memo "Development of hazard models and ecological screening levels" and make the terminology consistent throughout the document (i.e. pg 5 and Table 2).

2. Page 4, M. Bazar
   Piscivore-Belted Kingfisher
   Comment: It is stated that half the detection limits will be used for other analyzed constituents for modeling fish tissue concentrations. This may inappropriately imply that the method detection limits were not low enough. Some of these compounds may in fact fall out depending on the contaminant screening process revisions in Tech Memo 4. If the method detection limit is appropriate, substances with a detection frequency of less than 5% should be dropped.
   Recommendation: Rephrase this section to state that depending on the contaminant screening process agreed upon, half the method detection limit will only be used for modeling uptake of substances suspected to have a detection limit that was not low enough.

3. Page 4, M. McAtee
   Piscivore-Belted Kingfisher
   Comment: The fish bioaccumulation approach for inorganics is not presented. More importantly, the proposed log $K_{ow}$ based approach for organics should not be used, as it is out of date. Also, COCs tending to sorb to sediments should be modeled using a BSAF approach. Non-ionic organic compound accumulation from sediment into aquatic organisms can be estimated using equilibrium partitioning (Di Toro et al. 1991, Lee 1992). The EqP theory and BSAF approach has been determined to apply across different habitats, feeding types, and species (Tracey and Hansen 1996). Using this methodology, the following equation calculates an estimate of the fish concentration—

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$$C_f = C_s \times BSAF \times \left( \frac{F_l}{F_{oc}} \right)$$

where, $C_f$ is the wet weight concentration of the chemical in the fish (mg/kg), BSAF (unitless) is the appropriate value discussed below, $F_l$ is the fraction of lipid in the fish (estimated to be 0.05; Leblanc 1995), and $F_{oc}$ is fraction of organic carbon in the sediment (selected to be 0.05; see Section 5.1). For organic chemicals other than PAHs, we used a BSAF value of 1.7 based on the work of Konemann and van Leeuwen (1980) and Karickhoff (1981), as they are cited in McFarland and Clarke (1987). This approach is consistent with common practice (Lee, 1992) and is based on observed relationships of non-ionic organic chemical partitioning between water, octanol (assumed to represent lipid), and sediment organic carbon. It represents the "theoretical" ratio of fugacity coefficients between organism lipid and sediment organic carbon, and it can used to predict accumulation across a wide range of chemicals, sediment types, and species (Lee, 1992). For PAHs, used a lower BSAF of 0.29 based on the work reported by Tracey and Hansen (1996) that indicates that PAH accumulation from sediment into biota is less than that predicted using a BSAF of 1.7. Note that explosives should not be handled with BSAFs because of their chemical properties—they are more water-soluble.


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4. Page 4, M. McAtee

Insectivore-Indiana Bat

Comment: The aquatic invertebrate bioaccumulation approach for inorganics was not presented. More importantly, the proposed log $K_{ow}$ based approach for organics does not seem to be the most relevant for the invertebrates that the bat is most likely to consume. Sediment-based invertebrates that, as adults, emerge up through the water column for release into the air where they are consumed by bats, are most likely to accumulate COCs from the sediment. This is the case, because of their long contact with sediment during the early life stages relative to their short exposure to the water column as they emerge as adults. Therefore, the model should be based on a sediment-invertebrate-invertebrate emergence as adult-bat feeding pathway that would only model COCs that sorb to sediments. This would eliminate explosives and other water-soluble substances from consideration in this pathway and focus upon the most likely to exist in the bat diet. They exact same approach as described for the fish above, should be used.

5. Pages 4-5, M. Bazar

Ingestion Rates

Comments: The exposure models should use an ingestion rate normalized by the bodyweight, rather than dividing the ingestion rate and contaminant concentration by bodyweight as currently shown.

Recommendation: Revise all exposure equations with ingestion rates normalized by bodyweight as noted.

6. Page 5, M. McAtee

Terrestrial Herbivore-White Footed Mouse

Comment: The plant bioaccumulation approach for inorganics was not presented. The approach proposed for the organics is appropriate, and is the same used in our office.

7. Page 6, M. McAtee

Terrestrial Carnivore-Short-Tailed Shrew

Comment: A bioaccumulation model for the terrestrial invertebrate portion of the shrew and mouse diet is missing.

8. Page 6, M. McAtee

Recommended Method for Deriving Surface Water PRGs

Comment: The EPA Region V Ecological Data Quality Levels (EDQLs) were designed by Region V for use in planned analytical detection limits as part of quality assurance plans (personal communication with Ms. Brenda Jones EPA Region V BTAG Coordinator). These values should not be used for screening purposes.

**U.S. Fish and Wildlife Service**

**Comment:**

We recommend that the media specific direct exposure screening values for the explosive compounds be reconsidered to include values presented in other available ecotoxicological databases. We compared the explosives screening values for soil, sediment and water media to screening values in use for other Superfund projects at active and past military installations in Illinois. We noticed that for a couple of explosive compounds there are differences in the screening values for these media between projects. Of particular interest is that the proposed 110 parts per million TNT for the soil media does not seem to be a conservative toxicity reference value to screen for ecological risks at the Plant.

## TECHNICAL MEMORANDUM NO. 4

**U.S. Army Center for Health Promotion and Preventive Medicine Comments and Recommendations:**

1. Page 2, M. Bazar
   Screening Process
   Comment: Steps 1 and 2 screen the database for relevant data. The following steps include elimination of essential nutrients and comparison to background before comparison to ecotoxicity thresholds (ETs). While these later steps are reasonable, they are considered a refinement of preliminary contaminants of concern per *Ecological Risk Assessment Guidance for Superfund* (ERAGS) after comparison to ETs. The order of steps in the screening process is dependent on the flexibility of the stakeholders. A related issue is the allowance in ERAGS for screening level food chain models with bioavailability and area-use factors of 100 percent. Presumably, site-specific values should be used if food chain modeling does not occur until the baseline ERA.
   Recommendation: Have the first paragraph of page 2 indicate that the baseline ERA will incorporate site-specific exposure values where possible.

2. Page 2, M. Bazar
   Screening Process
   Comment: Frequency of detection should be included to further refine the contaminants of concern at sites with large data sets.
   Recommendation: Use a 5% frequency of detection cutoff for identifying contaminants of concern per *Risk Assessment Guidance for Superfund.*

3. Page 2, M. Bazar
   #5. Background Screen
   Comment: How will non-detects be treated in the statistical comparison to background? EPA guidance for evaluating non-detects includes the *Statistical Training Course for Groundwater Monitoring Data Analysis* and *Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities*.
   Recommendation: A non-parametric analysis should be used if non-detects are

greater than 15%, while half the method detection limit should be used otherwise.

**U.S. Fish and Wildlife Service**
**Comment:**

We recommend that the proposed order of screening and indentification of contaminants of ecological concern be reversed. The media specific toxicity reference value screen should be first to identify contaminants of ecological concern. Screens for lab contamination, nutrient and background could be secondary and presented as uncertainties or considerations for the risk managers as part of the scientific and management decision point discussions.

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HARZA

Consulting Engineers and Scientists

September 15, 2000

Mr. Alvin Kam
USACE, Omaha District
Attn: CENWO-PM-HB
215 North 17th Street
Omaha, Nebraska 68102-4978

Subject: Technical Memorandum No. 3
Development of Hazard Models and Ecological PRGs
Ecological Risk Assessment
Iowa Army Ammunition Plant (IAAAP)
Harza Project 5644.GN.1

Dear Mr. Kam:

Harza Engineering Company (Harza) is pleased to submit Technical Memorandum No. 3. This memorandum discusses the development of hazard models and ecological PRGs.

If there are any questions, please contact Pinaki Banerjee at 312-831-3452 or David Pott at 312-831-3043.

Very truly yours,

Pinaki Banerjee for

R. P. Kewer
Senior Partner

cc: R. Allison, IAAAP
K. Howe, USACE
J. Haffner, IAAAP
M, Bazar, CHPPM
M, Coffey, US Fish and Wildlife
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# TECHNICAL MEMO NO. 3 - DRAFT
# DEVELOPMENT OF HAZARD MODELS AND ECOLOGICAL PRGS FOR ECOLOGICAL RISK ASSESSMENT AT THE IOWA ARMY AMMUNITION PLANT

## 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

$$\mathrm{Ej} = (IR_w \text{ x } C_{w\text{-}j})/(\mathrm{BW}) + (IR_f \text{ x } C_{f\text{-}j})/(\mathrm{BW})\text{------------------------}(2)$$

Where,

$IR_w$ = Ingestion rate of water, L/d
$C_{w\text{-}j}$ = Contaminant concentration (j) in water, mg/L
$IR_f$ = Ingestion rate of fish, kg/d
$C_{f\text{-}j}$ = 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. 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 :

- NOAA Effects Range-Median (ER-M)
- Florida DEP Probable Effect Level (PEL)
- 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)

## Table 2
## Surface Water Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | National Water Quality Criteria (ug/L)[1] | Iowa Water Quality Standards (ug/L)[2] | PRGs (ug/L)[3] | 10% Aquire LOEL (ug/l)[4] | Aquire NOEL (ug/l)[5] | Water EDQL (ug/L)[6] | Proposed Water SV (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| 1,1,1,2-Tetrachloroethane | 630-20-6 | | | | | | 90.25 | 90.25 |
| 1,1,1-Trichloroethane | 71-55-6 | | | 11 | | 1300 | 88 | 11 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | | | 610 | 7230 | 8800 | 13 | 610 |
| 1,1,2-Trichloroethane | 79-00-5 | | | 1200 | 7480 | 31000 | 650 | 1200 |
| 1,1-Dichloroethane | 75-34-3 | | | 47 | | | 47 | 47 |
| 1,1-Dichloroethene | 75-35-4 | | | 25 | | 56000 | 78 | 25 |
| 1,2,3-Trichloropropane | 96-18-4 | | | | | | 12.11 | 12.11 |
| 1,2,4-Trichlorobenzene | 120-82-1 | | | 110 | 1130 | 5600 | 69.2 | 110 |
| 1,2-Dibromoethane | 106-93-4 | | | | 9620 | 5810 | 22.5 | 5810 |
| 1,2-Dichlorobenzene | 95-50-1 | | | 14 | 1000 | 630 | 11 | 14 |
| 1,2-Dichloroethane | 107-06-2 | | | 910 | | 130000 | 190 | 910 |
| 1,2-Dichloropropane | 78-87-5 | | | | | 29000 | 380 | 29000 |
| 1,3,5-Trinitrobenzene | 99-35-4 | | | 14 | 100 | 80 | | 14 |
| 1,3-Dichlorobenzene | 541-73-1 | | | 71 | 2300 | 300 | 87 | 71 |
| 1,3-Dinitrobenzene | 99-65-0 | | | 30 | 970 | 260 | 2.36 | 30 |
| 1,4-Dichlorobenzene | 106-46-7 | | | 15 | 263 | 300 | 43 | 15 |
| 2,2'-Oxybis(1-Chloro)Propane | 108-60-1 | | | | | | 20 | 20 |
| 2,4,5-T | 93-76-5 | | | | | | 686.33 | 686.33 |
| 2,4,5-Trichlorophenol | 95-95-4 | | | | 34 | 62.5 | | 34 |
| 2,4,6-Trichlorophenol | 88-06-2 | | | | 750 | | 2 | 750 |
| 2,4,6-Trinitrotoluene | 118-96-7 | | | 130 | 5000 | 2300 | | 130 |
| 2,4-D | 94-75-7 | | | | 50000 | 10000 | | 10000 |
| 2,4-Dichlorophenol | 120-83-2 | | | | | | 18 | 18 |
| 2,4-Dimethylphenol | 105-67-9 | | | | 4000 | 2000 | 100.17 | 2000 |
| 2,4-Dinitrophenol | 51-28-5 | | | | 1050 | 500 | 4.07 | 500 |
| 2,4-Dinitrotoluene | 121-14-2 | | | 230 | | 20 | 230 | 230 |
| 2,6-Dinitrotoluene | 606-20-2 | | | | | 60 | 42 | 60 |
| 2-Butanone | 78-93-3 | | | 14000 | | 400000 | 7100 | 14000 |
| 2-Chloronaphthalene | 91-58-7 | | | | | | 0.396 | 0.396 |
| 2-Chlorophenol | 95-57-8 | | | | | 300 | 8.8 | 300 |
| 2-Hexanone | 591-78-6 | | | 99 | | | 1710 | 99 |
| 2-Methylnaphthalene | 91-57-6 | | | | | | 329.55 | 329.55 |

## Table 2
## Surface Water Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | National Water Quality Criteria (ug/L)[1] | Iowa Water Quality Standards (ug/L)[2] | PRGs (ug/L)[3] | 10% Aquire LOEL (ug/l)[4] | Aquire NOEL (ug/l)[5] | Water EDQL (ug/L)[6] | Proposed Water SV (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| 2-Methylphenol | 95-48-7 | | | 13 | | | | 13 |
| 2-Nitroaniline | 88-74-4 | | | | | 38000 | | 38000 |
| 2-Nitrophenol | 88-75-5 | | | | | 24000 | 13.5 | 24000 |
| 2-Nitrotoluene | 88-72-2 | | | | 8700 | 4400 | | 4400 |
| 3,3'-Dichlorobenzidine | 91-94-1 | | | | | | 99.75 | 99.75 |
| 3-Nitroaniline | 99-09-2 | | | | 54000 | 28000 | | 28000 |
| 4,4'-DDD | 72-54-8 | | | 0.000041 | 1000 | | 0.0011 | 0.000041 |
| 4,4'-DDE | 72-55-9 | | | | | | 4.96E-09 | 4.96E-09 |
| 4,4'-DDT | 50-29-3 | 0.001 | 0.001 | 0.000041 | 100 | | 0.000952 | 0.001 |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | | | | 407 | 183 | 2.3 | 183 |
| 4-Bromophenyl Phenyl Ether | 101-55-3 | | | | | | 1.5 | 1.5 |
| 4-Chloro-3-Methylphenol | 59-50-7 | | | | 5700 | 1300 | 20 | 1300 |
| 4-Chloroaniline | 106-47-8 | | | | 1000 | 10 | 231.97 | 10 |
| 4-Chlorophenyl Phenyl Ether | 7005-72-3 | | | | | | | NF |
| 4-Methyl-2-Pentanone | 108-10-1 | | | 170 | | | 3680 | 170 |
| 4-Methylphenol | 106-44-5 | | | | | 1000 | | 1000 |
| 4-Nitroaniline | 100-01-6 | | | | | | | NF |
| 4-Nitrophenol | 100-02-7 | | | 300 | 100 | 300 | 35 | 300 |
| Acenaphthene | 83-32-9 | | | 23 | | 1000 | 9.9 | 23 |
| Acenaphthylene | 208-96-8 | | | | | | 4840 | 4840 |
| Acetone | 67-64-1 | | | 1500 | | 16200 | 78000 | 1500 |
| Aldrin | 309-00-2 | | | | 100 | | 0.0185 | 100 |
| Alpha BHC | 319-84-6 | | | 0.004 | | | 12.38 | 0.004 |
| Alpha Endosulfan | 959-98-8 | 0.056 | 0.056 | 0.051 | | | 0.003 | 0.056 |
| Aluminum | 7429-90-5 | 87 | 87 | 87 | | | | 87 |
| Anthracene | 120-12-7 | | | 0.73 | | | 0.029 | 0.73 |
| Antimony | 7440-36-0 | | | 30 | | 6200 | 31 | 30 |
| Arochlor 1016 | 12674-11-2 | | | 0.23 | | | | 0.23 |
| Arochlor 1221 | 11104-28-2 | | | 0.28 | | | | 0.28 |
| Arochlor 1232 | 11141-16-5 | | | 0.58 | | | | 0.58 |
| Arochlor 1242 | 53469-21-9 | | | 0.047 | | | | 0.047 |
| Arochlor 1248 | 12672-29-6 | | | 0.0019 | | | | 0.0019 |

**Table 2**
**Surface Water Screening Values**
**for Stream Systems at Iowa Army Ammunition Plant**
**Middleton, Iowa**

| ParameterDescription | CAS | National Water Quality Criteria (ug/L)[1] | Iowa Water Quality Standards (ug/L)[2] | PRGs (ug/L)[3] | 10% Aquire LOEL (ug/l)[4] | Aquire NOEL (ug/l)[5] | Water EDQL (ug/L)[6] | Proposed Water SV (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Arochlor 1254 | 11097-69-1 | | | 0.0019 | | | | 0.0019 |
| Arochlor 1260 | 11096-82-5 | | | 94 | | | | 94 |
| Arsenic | 7440-38-2 | 150 | 200 | 3.1 | | 750 | 53 | 150 |
| Barium | 7440-39-3 | | | 4 | | 500000 | 5000 | 4 |
| Benzene | 71-43-2 | | | 130 | 17200 | 10200 | 114 | 130 |
| Benzo(a)Anthracene | 56-55-3 | | | 0.027 | | | 0.839 | 0.027 |
| Benzo(a)Pyrene | 50-32-8 | | | 0.014 | 10000 | | 0.014 | 0.014 |
| Benzo(b)Fluoranthene | 205-99-2 | | | | | | 9.07 | 9.07 |
| Benzo(g,h,i)Perylene | 191-24-2 | | | | | | 7.64 | 7.64 |
| Benzo(k)Fluoranthene | 207-08-9 | | | | | | 0.0056 | 0.0056 |
| Benzoic Acid | 65-85-0 | | | 42 | | | | 42 |
| Benzyl Alcohol | 100-51-6 | | | 8.6 | | | 281.24 | 8.6 |
| Benzyl Butyl Phthalate | 85-68-7 | | | 19 | 1400 | 60 | 49 | 19 |
| Beryllium | 7440-41-7 | | | 0.66 | | | 7.6 | 0.66 |
| Beta BHC | 319-85-7 | | | 0.004 | | 32 | 0.495 | 0.004 |
| Beta Endosulfan | 33213-65-9 | 0.056 | | 0.051 | | | 0.003 | 0.056 |
| Bis(2-Chloroethoxy) Methane | 111-91-1 | | | | | | 6400 | 6400 |
| Bis(2-Chloroethyl) Ether | 111-44-4 | | | | | | 1140 | 1140 |
| Bis(2-Ethylhexyl) Phthalate | 117-81-7 | | | 0.12 | 160 | 77 | 2.1 | 0.12 |
| Bromodichloromethane | 75-27-4 | | | | | | | NF |
| Bromoform | 75-25-2 | | | | | 2900 | 466 | 2900 |
| Bromomethane | 74-83-9 | | | | | 100 | | 100 |
| Cadmium | 7440-43-9 | 2.2 | 1 | 1 | 1.5 | 0.7 | 0.66 | 1 |
| Carbazole | 86-74-8 | | | | | 10000 | | 10000 |
| Carbon Disulfide | 75-15-0 | | | 0.92 | | | 84.1 | 0.92 |
| Carbon Tetrachloride | 56-23-5 | | | 9.8 | 73200 | 37100 | 5.9 | 9.8 |
| Chlordane | 57-74-9 | 0.0043 | 0.004 | 0.037 | | | 0.00029 | 0.004 |
| Chlorobenzene | 108-90-7 | | 20 | 64 | | 1400 | 10 | 20 |
| Chloroethane | 75-00-3 | | | | | | 230000 | 230000 |
| Chloroform | 67-66-3 | | | 28 | 1000 | 560 | 79 | 28 |
| Chloromethane | 74-87-3 | | | 2200 | | | | 2200 |
| Chromium, Total | 7440-47-3 | 74 | 10 | 210 | 2400 | 2000 | 42 | 10 |

## Table 2
## Surface Water Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | National Water Quality Criteria (ug/L)[1] | Iowa Water Quality Standards (ug/L)[2] | PRGs (ug/L)[3] | 10% Aquire LOEL (ug/l)[4] | Aquire NOEL (ug/l)[5] | Water EDQL (ug/L)[6] | Proposed Water SV (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Chrysene | 218-01-9 | | | | | | 0.033 | 0.033 |
| cis-1,3-Dichloropropene | 10061-01-5 | | | | | | 7.9 | 7.9 |
| Cobalt | 7440-48-4 | | | 23 | | | 5 | 23 |
| Copper | 7440-50-8 | 9 | 10 | 12 | 7.7 | 3.1 | 5 | 9 |
| Cyanide | 57-12-5 | 5.2 | 5 | 5.2 | 44.6 | 29 | 5.2 | 5 |
| Delta BHC | 319-86-8 | | | 0.004 | | | 666.67 | 0.004 |
| Di-N-Butyl Phthalate | 84-74-2 | | | 1 | 190 | 100 | 3 | 1 |
| Di-N-Octylphthalate | 117-84-0 | | | | | | 30 | 30 |
| Dibenz(a,h)Anthracene | 53-70-3 | | | | | | 0.0016 | 0.0016 |
| Dibenzofuran | 132-64-9 | | | 3.7 | | 1000 | 20 | 3.7 |
| Dibromochloromethane | 124-48-1 | | | | | | 6400 | 6400 |
| Dibromomethane | 74-95-3 | | | | | | | NF |
| Dichlorodifluoromethane | 75-71-8 | | | | | | | NF |
| Dieldrin | 60-57-1 | 0.056 | 0.0019 | | 0.6 | 0.06 | 0.000026 | 0.0019 |
| Diethyl Phthalate | 84-66-2 | | | 210 | 59000 | 1650 | 3 | 210 |
| Dimethyl Phthalate | 131-11-3 | | | | 23000 | 3200 | 73 | 3200 |
| Dinoseb | 88-85-7 | | | | 171 | 105 | 0.39 | 105 |
| Endosulfan Sulfate | 1031-07-8 | | | | | | 2.22 | 2.22 |
| Endrin | 72-20-8 | 0.036 | 0.0023 | 0.061 | 100 | | 0.002 | 0.0023 |
| Endrin Aldehyde | 7421-93-4 | | | | | | 0.15 | 0.15 |
| Ethylbenzene | 100-41-4 | | | 7.3 | 2700 | 1000 | 17.2 | 7.3 |
| Fluoranthene | 206-44-0 | | | 6.2 | 14.7 | 3.5 | 8.1 | 6.2 |
| Fluorene | 86-73-7 | | | 3.9 | | | 3.9 | 3.9 |
| Gamma BHC | 58-89-9 | | 0.25 | 0.08 | 0.6 | 0.2 | 0.01 | 0.25 |
| Heptachlor | 76-44-8 | 0.0038 | 0.0038 | 0.0069 | 10 | | 0.00039 | 0.0038 |
| Heptachlor Epoxide | 1024-57-3 | 0.0038 | | | | | 0.00048 | 0.0038 |
| Hexachlorobenzene | 118-74-1 | | | | | 4.8 | 5.47E-06 | 4.8 |
| Hexachlorobutadiene | 87-68-3 | | | | | | 0.134 | 0.134 |
| Hexachlorocyclopentadiene | 77-47-4 | | | | | 9 | 77.04 | 9 |
| Hexachloroethane | 67-72-1 | | | 12 | | 1000 | 30.5 | 12 |
| HMX | 2691-41-0 | | | 330 | | | | 330 |
| Indeno(1,2,3-c,d)Pyrene | 193-39-5 | | | | | | 4.31 | 4.31 |

# Table 2
## Surface Water Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | National Water Quality Criteria (ug/L)[1] | Iowa Water Quality Standards (ug/L)[2] | PRGs (ug/L)[3] | 10% Aquire LOEL (ug/l)[4] | Aquire NOEL (ug/l)[5] | Water EDQL (ug/L)[6] | Proposed Water SV (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Iron | 7439-89-6 | 1000 | | 1000 | | | | 1000 |
| Isophorone | 78-59-1 | | | | | 79000 | 900 | 79000 |
| Lead | 7439-92-1 | 2.5 | 3 | 3 | 7.6 | 4 | 1.3 | 2.5 |
| M,P-Xylene | 1330-20-7 | | | 13 | 40000 | 20000 | 117 | 13 |
| Manganese | 7439-96-5 | | | 120 | | 28000 | | 120 |
| MCPA | 94-74-6 | | | | 2130 | 0 | | NF |
| Mercury | 7439-97-6 | 0.77 | 0.05 | 1.3 | | 0.7 | 0.0013 | 0.05 |
| Methoxychlor | 72-43-5 | 0.03 | | 0.019 | | 360 | 0.005 | 0.03 |
| Methylene Chloride | 75-09-2 | | | 2200 | | 56000 | 430 | 2200 |
| N-Nitrosodi-N-Propylamine | 621-64-7 | | | | | | | NF |
| N-Nitrosodiphenylamine | 86-30-6 | | | 210 | | | 13 | 210 |
| Naphthalene | 91-20-3 | | | 12 | | | 44 | 12 |
| Nickel | 7440-02-0 | 52 | 150 | 160 | | | 29 | 52 |
| Nitrobenzene | 98-95-3 | | | | 10200 | 2600 | 740 | 2600 |
| Pentachlorophenol | 87-86-5 | 15 | | | 5 | 5 | 5.23 | 15 |
| Phenanthrene | 85-01-8 | | | 6.3 | 38 | 19 | 2.1 | 6.3 |
| Phenol | 108-95-2 | | 50 | 110 | 100 | 10 | 100 | 50 |
| Pyrene | 129-00-0 | | | | | | 0.3 | 0.3 |
| RDX | 121-82-4 | | | 190 | 2360 | 500 | | 190 |
| Selenium | 7782-49-2 | 5 | 10 | 0.39 | 80 | 40 | 5 | 5 |
| Silver | 7440-22-4 | | 0.35 | 0.36 | | 13.4 | 1 | 0.35 |
| Silvex (2,4,5-TP) | 93-72-1 | | | | | | 326.64 | 326.64 |
| Styrene | 100-42-5 | | | | 280 | 63 | 56 | 63 |
| Tetrachloroethene | 127-18-4 | | | 98 | 3100 | 17000 | 8.9 | 98 |
| Tetryl | 479-45-8 | | | | | | | NF |
| Thallium | 7440-28-0 | | | 9 | | 14000 | 0.56 | 9 |
| Toluene | 108-88-3 | | 50 | 9.8 | 6000 | 1000 | 253 | 50 |
| Toxaphene | 8001-35-2 | 0.0002 | 0.0002 | | 100 | 0.039 | 0.0002 | 0.0002 |
| trans-1,2-Dichloroethene | 156-60-5 | | | 590 | | | 310 | 590 |
| trans-1,3-Dichloropropene | 10061-02-6 | | | | | | 7.9 | 7.9 |
| Trichloroethene | 79-01-6 | | 80 | 47 | 11000 | 40000 | 75 | 80 |
| Trichlorofluoromethane | 75-69-4 | | | | | | | NF |

## Table 2
## Surface Water Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | National Water Quality Criteria (ug/L)[1] | Iowa Water Quality Standards (ug/L)[2] | PRGs (ug/L)[3] | 10% Aquire LOEL (ug/l)[4] | Aquire NOEL (ug/l)[5] | Water EDQL (ug/L)[6] | Proposed Water SV (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Vanadium | 7440-62-2 | | | 20 | | | 19 | 20 |
| Vinyl Chloride | 75-01-4 | | | 782 | | | 9.2 | 782 |
| Xylenes, Total | 1330-20-7 | | | 13 | 40000 | 20000 | 117 | 13 |
| Zinc | 7440-66-6 | 120 | 100 | 110 | | | 58.9 | 100 |

Notes:
1)EPA, 1999
2)IAC, 1994
3)Efroymson and others, 1997a
4)EPA, 1996a
5)EPA, 1996a
6)EPA, 1998
Water Screening Values were selected based on:
1) National Water Quality Criteria and Iowa Water Quality Critieria
2) Water PRGs
3) Ecotoxicology NOEL/LOEL
4) EDQL

NF: Not Found

**Table 3**
**Sediment Screening Values**
**for Stream Systems at Iowa Army Ammunition Plant**
**Middleton, Iowa**

| ParameterDescription | CAS | Ecological Benchmark (mg/kg)[1] | PRGs (mg/kg)[2] | Sediment EDQL (mg/kg)[3] | Equilibrium Partitioning (mg/kg)[4] | Proposed Sediment SV (mg/kg) |
|---|---|---|---|---|---|---|
| 1,1,1,2-Tetrachloroethane | 630-20-6 | | | 0.01089 | 0.6853576 | 0.685358 |
| 1,1,1-Trichloroethane | 71-55-6 | 0.03 | 0.03 | 0.24685 | 0.0086595 | 0.03 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | | 5.4 | 0.02908 | 1.3645198 | 5.4 |
| 1,1,2-Trichloroethane | 79-00-5 | | 1.257 | 0.67351 | 1.2434011 | 1.257 |
| 1,1-Dichloroethane | 75-34-3 | | 0.027 | 0.000575 | 0.0270363 | 0.027 |
| 1,1-Dichloroethene | 75-35-4 | | 0.031 | 0.02327 | 0.0094111 | 0.031 |
| 1,2,3-Trichloropropane | 96-18-4 | | | 0.00835 | 0.0206459 | 0.020646 |
| 1,2,4-Trichlorobenzene | 120-82-1 | | 9.7 | 11.7 | 9.6272597 | 9.7 |
| 1,2-Dibromoethane | 106-93-4 | | | 0.01237 | 5.4033 | 5.4033 |
| 1,2-Dichlorobenzene | 95-50-1 | | 0.33 | 0.23132 | 0.3296841 | 0.33 |
| 1,2-Dichloroethane | 107-06-2 | | 0.256 | 0.05418 | 0.2537064 | 0.256 |
| 1,2-Dichloropropane | 78-87-5 | | | 0.35161 | 25.071943 | 25.07194 |
| 1,3,5-Trinitrobenzene | 99-35-4 | | 0.002 | 0.000121 | 0.0007522 | 0.002 |
| 1,3-Dichlorobenzene | 541-73-1 | | 1.7 | 3.01 | 2.4566221 | 1.7 |
| 1,3-Dinitrobenzene | 99-65-0 | | 0.018 | 0.000924 | 0.0057428 | 0.018 |
| 1,4-Dichlorobenzene | 106-46-7 | | 0.35 | 1.45 | 0.3453276 | 0.35 |
| 2,2'-Oxybis(1-Chloro)Propane | 108-60-1 | | | 0.06878 | 0.0548466 | 0.054847 |
| 2,4,5-T | 93-76-5 | | | 58.7 | 12.318079 | 12.31808 |
| 2,4,5-Trichlorophenol | 95-95-4 | | | 0.08556 | 2.3198447 | 2.319845 |
| 2,4,6-Trichlorophenol | 88-06-2 | | | 0.08484 | 32.541777 | 32.54178 |
| 2,4,6-Trinitrotoluene | 118-96-7 | | 0.035 | | 0.0123978 | 0.035 |
| 2,4-D | 94-75-7 | | | 0.00579 | 45.1 | 45.1 |
| 2,4-Dichlorophenol | 120-83-2 | | | 0.13363 | 0.1919519 | 0.191952 |
| 2,4-Dimethylphenol | 105-67-9 | | | 0.30453 | 4.180132 | 4.180132 |
| 2,4-Dinitrophenol | 51-28-5 | | | 0.00133 | 0.1670706 | 0.167071 |
| 2,4-Dinitrotoluene | 121-14-2 | | 0.214 | 0.07513 | 0.0663327 | 0.214 |
| 2,6-Dinitrotoluene | 606-20-2 | | | 0.02062 | 0.0173042 | 0.017304 |
| 2-Butanone | 78-93-3 | | 0.27 | 0.13696 | 0.2523411 | 0.27 |
| 2-Chloronaphthalene | 91-58-7 | | | 0.41723 | 0.0323829 | 0.032383 |
| 2-Chlorophenol | 95-57-8 | | | 0.0117 | 0.3898085 | 0.389808 |
| 2-Hexanone | 591-78-6 | | 0.023 | 1.01 | 0.0225141 | 0.023 |
| 2-Methylnaphthalene | 91-57-6 | | | 0.0202 | 7.1749903 | 7.17499 |

## Table 3
## Sediment Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | Ecological Benchmark (mg/kg)[1] | PRGs (mg/kg)[2] | Sediment EDQL (mg/kg)[3] | Equilibrium Partitioning (mg/kg)[4] | Proposed Sediment SV (mg/kg) |
|---|---|---|---|---|---|---|
| 2-Methylphenol | 95-48-7 | | | 0.000826 | 0.0117596 | 0.01176 |
| 2-Nitroaniline | 88-74-4 | | | 0.000222 | 25.038805 | 25.0388 |
| 2-Nitrophenol | 88-75-5 | | | 0.00777 | 13.805789 | 13.80579 |
| 2-Nitrotoluene | 88-72-2 | | | | 8.0284679 | 8.028468 |
| 3,3'-Dichlorobenzidine | 91-94-1 | | | 0.02822 | 2.8152885 | 2.815288 |
| 3-Nitroaniline | 99-09-2 | | | 0.000222 | 6.2251244 | 6.225124 |
| 4,4'-DDD | 72-54-8 | | 0.0078 | 0.00553 | 4.694E-06 | 0.0078 |
| 4,4'-DDE | 72-55-9 | | 0.027 | 0.00142 | 2.752E-09 | 0.027 |
| 4,4'-DDT | 50-29-3 | | 0.052 | 0.00119 | 0.0006021 | 0.052 |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | | | 0.01038 | 0.2221729 | 0.222173 |
| 4-Bromophenyl Phenyl Ether | 101-55-3 | | 1.2 | 1.55 | 1.0774354 | 1.2 |
| 4-Chloro-3-Methylphenol | 59-50-7 | | | 0.38818 | 14.505188 | 14.50519 |
| 4-Chloroaniline | 106-47-8 | | | 0.14608 | 0.0065892 | 0.006589 |
| 4-Chlorophenyl Phenyl Ether | 7005-72-3 | | | 0.65612 | NA | 0.65612 |
| 4-Methyl-2-Pentanone | 108-10-1 | | 15 | 0.54437 | 0.0329958 | 15 |
| 4-Methylphenol | 106-44-5 | | 0.012 | 0.000808 | 0.8077928 | 0.012 |
| 4-Nitroaniline | 100-01-6 | | | 0.000222 | NA | 0.000222 |
| 4-Nitrophenol | 100-02-7 | | | 0.00778 | 0.2264286 | 0.226429 |
| Acenaphthene | 83-32-9 | | 0.089 | 0.00671 | 1.6419799 | 0.089 |
| Acenaphthylene | 208-96-8 | | 0.13 | 0.00587 | 120.98885 | 0.13 |
| Acetone | 67-64-1 | | 0.0091 | 0.45337 | 0.0087187 | 0.0091 |
| Aldrin | 309-00-2 | | 0.08 | 0.002 | 2453.4658 | 0.08 |
| Alpha BHC | 319-84-6 | | 120 | 0.006 | 0.0002176 | 120 |
| Alpha Endosulfan | 959-98-8 | | 0.0055 | 0.000175 | 0.0032611 | 0.0055 |
| Aluminum | 7429-90-5 | | | | NA | NF |
| Anthracene | 120-12-7 | | 0.25 | 0.0469 | 0.2168967 | 0.25 |
| Antimony | 7440-36-0 | 2 | | | NA | 2 |
| Arochlor 1016 | 12674-11-2 | | 0.53 | | 0.9021481 | 0.53 |
| Arochlor 1221 | 11104-28-2 | | 0.12 | | 0.1043249 | 0.12 |
| Arochlor 1232 | 11141-16-5 | | 0.6 | | 0.1227179 | 0.6 |
| Arochlor 1242 | 53469-21-9 | | 29 | | 0.8027824 | 29 |
| Arochlor 1248 | 12672-29-6 | | 1 | | 0.0236392 | 1 |

## Table 3
## Sediment Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | Ecological Benchmark (mg/kg)[1] | PRGs (mg/kg)[2] | Sediment EDQL (mg/kg)[3] | Equilibrium Partitioning (mg/kg)[4] | Proposed Sediment SV (mg/kg) |
|---|---|---|---|---|---|---|
| Arochlor 1254 | 11097-69-1 | | 72 | | 0.0466158 | 72 |
| Arochlor 1260 | 11096-82-5 | | 63 | | 635.37168 | 63 |
| Arsenic | 7440-38-2 | 7.2 | 42 | 5.9 | NA | 7.2 |
| Barium | 7440-39-3 | | | | NA | NF |
| Benzene | 71-43-2 | 0.16 | 0.16 | 0.14157 | 0.0345417 | 0.16 |
| Benzo(a)Anthracene | 56-55-3 | | 0.69 | 0.0317 | 0.0152885 | 0.69 |
| Benzo(a)Pyrene | 50-32-8 | 0.089 | 0.394 | 0.0319 | 0.0183666 | 0.089 |
| Benzo(b)Fluoranthene | 205-99-2 | | 4 | 10.4 | 14.308934 | 4 |
| Benzo(g,h,i)Perylene | 191-24-2 | | 6.3 | 0.17 | 251.57261 | 6.3 |
| Benzo(k)Fluoranthene | 207-08-9 | | 4 | 0.24 | 0.0696736 | 4 |
| Benzoic Acid | 65-85-0 | | | | 0.028308 | 0.028308 |
| Benzyl Alcohol | 100-51-6 | | 0.0011 | 0.03394 | 0.0010377 | 0.0011 |
| Benzyl Butyl Phthalate | 85-68-7 | | | 4.19 | 10.883125 | 10.88312 |
| Beryllium | 7440-41-7 | | | | NA | NF |
| Beta BHC | 319-85-7 | | 120 | 0.005 | 0.0002226 | 120 |
| Beta Endosulfan | 33213-65-9 | | 0.0055 | 0.000104 | 0.0032611 | 0.0055 |
| Bis(2-Chloroethoxy) Methane | 111-91-1 | | | 0.34971 | 1.214395 | 1.214395 |
| Bis(2-Chloroethyl) Ether | 111-44-4 | | | 0.21196 | 0.1764472 | 0.176447 |
| Bis(2-Ethylhexyl) Phthalate | 117-81-7 | 0.18 | 2.7 | 0.182 | 0.0202806 | 0.18 |
| Bromodichloromethane | 75-27-4 | | | 0.00113 | NA | 0.00113 |
| Bromoform | 75-25-2 | | | 0.99627 | 5.9255409 | 5.925541 |
| Bromomethane | 74-83-9 | | | 0.000148 | 0.0147928 | 0.014793 |
| Cadmium | 7440-43-9 | 0.68 | 4.2 | 0.596 | NA | 0.68 |
| Carbazole | 86-74-8 | | | | 338.2595 | 338.2595 |
| Carbon Disulfide | 75-15-0 | 0.00085 | 0.00086 | 0.13397 | 0.1241046 | 0.00085 |
| Carbon Tetrachloride | 56-23-5 | | 2 | 0.03573 | 0.0473256 | 2 |
| Chlordane | 57-74-9 | | 0.0048 | 0.0045 | 0.0041885 | 0.0048 |
| Chlorobenzene | 108-90-7 | 0.41 | 0.417 | 0.06194 | 0.1296254 | 0.41 |
| Chloroethane | 75-00-3 | | | 58.6 | 58.57305 | 58.57305 |
| Chloroform | 67-66-3 | 0.022 | 0.96 | 0.027 | 0.0216171 | 0.022 |
| Chloromethane | 74-87-3 | | 0.374 | 0.0000785 | 0.1890396 | 0.374 |
| Chromium, Total | 7440-47-3 | 52 | 159 | 26 | NA | 52 |

## Table 3
## Sediment Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| ParameterDescription | CAS | Ecological Benchmark (mg/kg)[1] | PRGs (mg/kg)[2] | Sediment EDQL (mg/kg)[3] | Equilibrium Partitioning (mg/kg)[4] | Proposed Sediment SV (mg/kg) |
|---|---|---|---|---|---|---|
| Chrysene | 218-01-9 | | 0.85 | 0.0571 | 0.0155387 | 0.85 |
| cis-1,3-Dichloropropene | 10061-01-5 | | 0.23 | 0.00296 | 0.0073098 | 0.23 |
| Cobalt | 7440-48-4 | | | 50 | NA | 50 |
| Copper | 7440-50-8 | | 77.7 | 16 | NA | 77.7 |
| Cyanide | 57-12-5 | | | 0.0001 | NA | 0.0001 |
| Delta BHC | 319-86-8 | | 120 | 71.5 | 0.0004699 | 120 |
| Di-N-Butyl Phthalate | 84-74-2 | | 240 | 0.1105 | 0.0484172 | 240 |
| Di-N-Octylphthalate | 117-84-0 | | | 40.6 | 25140.925 | 25140.93 |
| Dibenz(a,h)Anthracene | 53-70-3 | 0.0062 | 0.0282 | 0.00622 | 0.00689 | 0.0062 |
| Dibenzofuran | 132-64-9 | | 0.42 | 1.52 | 0.0822246 | 0.42 |
| Dibromochloromethane | 124-48-1 | | | 0.26761 | 8.7010161 | 8.701016 |
| Dibromomethane | 74-95-3 | | | 0.0000859 | NA | 8.59E-05 |
| Dichlorodifluoromethane | 75-71-8 | | | 0.00133 | NA | 0.00133 |
| Dieldrin | 60-57-1 | | 0.0043 | 0.002 | 0.0005471 | 0.0043 |
| Diethyl Phthalate | 84-66-2 | | 0.61 | 0.00804 | 0.6025586 | 0.61 |
| Dimethyl Phthalate | 131-11-3 | | | 0.02495 | 1.1973744 | 1.197374 |
| Dinoseb | 88-85-7 | | | 0.01178 | 1.176 | 1.176 |
| Endosulfan Sulfate | 1031-07-8 | | | 0.0346 | 0.0879859 | 0.087986 |
| Endrin | 72-20-8 | | 0.045 | 0.00267 | 0.0021676 | 0.045 |
| Endrin Aldehyde | 7421-93-4 | | | 3.2 | 0.0784822 | 0.078482 |
| Ethylbenzene | 100-41-4 | | 5.4 | 0.0001 | 0.0891708 | 5.4 |
| Fluoranthene | 206-44-0 | | 0.834 | 0.1113 | 6.6931674 | 0.834 |
| Fluorene | 86-73-7 | | 0.14 | 0.0212 | 0.5367532 | 0.14 |
| Gamma BHC | 58-89-9 | | 0.00099 | 0.00094 | 0.0116094 | 0.00099 |
| Heptachlor | 76-44-8 | | 13 | 0.0006 | 0.0541556 | 13 |
| Heptachlor Epoxide | 1024-57-3 | | | 0.0006 | 0.0031265 | 0.003127 |
| Hexachlorobenzene | 118-74-1 | | | 0.02 | 29.606784 | 29.60678 |
| Hexachlorobutadiene | 87-68-3 | | | 1.38 | 0.0717158 | 0.071716 |
| Hexachlorocyclopentadiene | 77-47-4 | | | 0.90074 | 17.901627 | 17.90163 |
| Hexachloroethane | 67-72-1 | | 1 | 2.23 | 1.0267418 | 1 |
| HMX | 2691-41-0 | | 0.006 | | 0.0211278 | 0.006 |
| Indeno(1,2,3-c,d)Pyrene | 193-39-5 | | 0.837 | 0.2 | 17.099258 | 0.837 |

Table 3
**Sediment Screening Values**
**for Stream Systems at Iowa Army Ammunition Plant**
**Middleton, Iowa**

| ParameterDescription | CAS | Ecological Benchmark (mg/kg)[1] | PRGs (mg/kg)[2] | Sediment EDQL (mg/kg)[3] | Equilibrium Partitioning (mg/kg)[4] | Proposed Sediment SV (mg/kg) |
|---|---|---|---|---|---|---|
| Iron | 7439-89-6 | | 20000 | | NA | 20000 |
| Isophorone | 78-59-1 | | | 0.4223 | 37.068677 | 37.06868 |
| Lead | 7439-92-1 | 30 | 110 | 31 | NA | 30 |
| M,P-Xylene | 1330-20-7 | | 0.16 | 1.88 | 0.0338 | 0.16 |
| Manganese | 7439-96-5 | | | | NA | NA |
| MCPA | 94-74-6 | | | | NA | NF |
| Mercury | 7439-97-6 | 0.13 | 0.7 | 0.174 | NA | 0.13 |
| Methoxychlor | 72-43-5 | 0.019 | 0.019 | 0.00359 | 0.0047678 | 0.019 |
| Methylene Chloride | 75-09-2 | 0.37 | 18 | 1.26 | 0.3727801 | 0.37 |
| N-Nitrosodi-N-Propylamine | 621-64-7 | | | 0.000217 | NA | 0.000217 |
| N-Nitrosodiphenylamine | 86-30-6 | | | 0.15524 | 2.6839801 | 2.68398 |
| Naphthalene | 91-20-3 | | 0.39 | 0.0346 | 0.0573431 | 0.39 |
| Nickel | 7440-02-0 | 16 | 38.5 | 16 | NA | 16 |
| Nitrobenzene | 98-95-3 | | | 0.4876 | 1.6748401 | 1.67484 |
| Pentachlorophenol | 87-86-5 | | | 30.1 | 15.130081 | 15.13008 |
| Phenanthrene | 85-01-8 | | 0.54 | 0.0419 | 1.5268647 | 0.54 |
| Phenol | 108-95-2 | 0.031 | 0.032 | 0.02726 | 0.014259 | 0.031 |
| Pyrene | 129-00-0 | | 1.4 | 0.053 | 0.3166148 | 1.4 |
| RDX | 121-82-4 | | 4.682 | | 1.0696793 | 4.682 |
| Selenium | 7782-49-2 | | | | NA | NF |
| Silver | 7440-22-4 | 0.73 | 1.8 | 0.5 | NA | 0.73 |
| Silvex (2,4,5-TP) | 93-72-1 | | | 7.35 | 17.769216 | 17.76922 |
| Styrene | 100-42-5 | | | 0.44496 | 0.4893736 | 0.489374 |
| Tetrachloroethene | 127-18-4 | | 0.409 | 0.19583 | 0.4131579 | 0.409 |
| Tetryl | 479-45-8 | | | | NA | NF |
| Thallium | 7440-28-0 | | | | NA | NF |
| Toluene | 108-88-3 | 0.05 | 0.05 | 52.5 | 0.2526388 | 0.05 |
| Toxaphene | 8001-35-2 | | | 0.000109 | 0.0005103 | 0.00051 |
| trans-1,2-Dichloroethene | 156-60-5 | | 0.4 | 0.20894 | 0.6396494 | 0.4 |
| trans-1,3-Dichloropropene | 10061-02-6 | | 0.23 | 0.00296 | 0.0073098 | 0.23 |
| Trichloroethene | 79-01-6 | 0.22 | 0.215 | 0.17956 | 0.3692326 | 0.22 |
| Trichlorofluoromethane | 75-69-4 | | | 0.00307 | NA | 0.00307 |

**Table 3**
**Sediment Screening Values**
**for Stream Systems at Iowa Army Ammunition Plant**
**Middleton, Iowa**

| ParameterDescription | CAS | Ecological Benchmark (mg/kg)[1] | PRGs (mg/kg)[2] | Sediment EDQL (mg/kg)[3] | Equilibrium Partitioning (mg/kg)[4] | Proposed Sediment SV (mg/kg) |
|---|---|---|---|---|---|---|
| Vanadium | 7440-62-2 | | | | NA | NF |
| Vinyl Chloride | 75-01-4 | | | 0.002 | 0.2333387 | 0.233339 |
| Xylenes, Total | 1330-20-7 | | 0.16 | 1.88 | 0.0338 | 0.16 |
| Zinc | 7440-66-6 | 120 | 270 | 120 | NA | 120 |

Notes:
1)EPA, 1999b
2)Efroymson and others, 1997b
3)EPA, 1998
4) Equilibrium Partitioning: Sediment SV = foc * Koc * Water SV; U
Water Screening Values were selected based on:
1) Ecological Benchmarks
2) Sediment PRGs
3) Equilibrium Partitioning
4) EDQL

NA: Not Applicable
NF: Not Found

# Table 4
## Soil Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| Parameter | CAS | Ecological Benchmark (mg/kg)[1] | Terratox LOEL (mg/kg)[2] | Terratox NOEL (mg/kg)[3] | PRGs (mg/kg)[4] | Soil EDQL (mg/kg)[5] | Prposed Soil SV (mg/kg) |
|---|---|---|---|---|---|---|---|
| 1,1,1,2-Tetrachloroethane | 630-20-6 | | | | | 225 | 225 |
| 1,1,1-Trichloroethane | 71-55-6 | | | | | 29.8 | 29.8 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | | | | | 0.12722 | 0.12722 |
| 1,1,2-Trichloroethane | 79-00-5 | | | | | 28.6 | 28.6 |
| 1,1-Dichloroethane | 75-34-3 | | | | | 20.1 | 20.1 |
| 1,1-Dichloroethene | 75-35-4 | | | | | 8.28 | 8.28 |
| 1,2,3-Trichloropropane | 96-18-4 | | | | | 3.36 | 3.36 |
| 1,2,4-Trichlorobenzene | 120-82-1 | 20 | | | 20 | 11.1 | 20 |
| 1,2-Dibromoethane | 106-93-4 | | | | | 1.23 | 1.23 |
| 1,2-Dichlorobenzene | 95-50-1 | | | | | 2.96 | 2.96 |
| 1,2-Dichloroethane | 107-06-2 | | | | | 21.2 | 21.2 |
| 1,2-Dichloropropane | 78-87-5 | | | | | 32.7 | 32.7 |
| 1,3,5-Trinitrobenzene | 99-35-4 | | | | | 0.37615 | 0.37615 |
| 1,3-Dichlorobenzene | 541-73-1 | | | | | 37.7 | 37.7 |
| 1,3-Dinitrobenzene | 99-65-0 | | | | | 0.6547 | 0.6547 |
| 1,4-Dichlorobenzene | 106-46-7 | | | | 20 | 0.54559 | 20 |
| 2,2'-Oxybis(1-Chloro)Propane | 108-60-1 | | | | | 19.9 | 19.9 |
| 2,4,5-T | 93-76-5 | | 1000 | | | 0.59634 | 1000 |
| 2,4,5-Trichlorophenol | 95-95-4 | | | | 9 | 14.1 | 9 |
| 2,4,6-Trichlorophenol | 88-06-2 | | | 32 | 4 | 9.94 | 4 |
| 2,4,6-Trinitrotoluene | 118-96-7 | | 140 | 110 | | | 110 |
| 2,4-D | 94-75-7 | | | | | 0.02725 | 0.02725 |
| 2,4-Dichlorophenol | 120-83-2 | | | | | 87.5 | 87.5 |
| 2,4-Dimethylphenol | 105-67-9 | | | | | 0.01 | 0.01 |
| 2,4-Dinitrophenol | 51-28-5 | | | | 20 | 0.06086 | 20 |
| 2,4-Dinitrotoluene | 121-14-2 | | | 3.2 | | 1.28 | 3.2 |
| 2,6-Dinitrotoluene | 606-20-2 | | | | | 0.03283 | 0.03283 |
| 2-Butanone | 78-93-3 | | | | | 89.6 | 89.6 |
| 2-Chloronaphthalene | 91-58-7 | | | | | 0.01218 | 0.01218 |
| 2-Chlorophenol | 95-57-8 | | | | | 0.24266 | 0.24266 |
| 2-Hexanone | 591-78-6 | | | | | 12.6 | 12.6 |
| 2-Methylnaphthalene | 91-57-6 | | | | | 3.24 | 3.24 |
| 2-Methylphenol | 95-48-7 | | | | | 40.4 | 40.4 |

## Table 4
## Soil Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| Parameter | CAS | Ecological Benchmark (mg/kg)[1] | Terratox LOEL (mg/kg)[2] | Terratox NOEL (mg/kg)[3] | PRGs (mg/kg)[4] | Soil EDQL (mg/kg)[5] | Prposed Soil SV (mg/kg) |
|---|---|---|---|---|---|---|---|
| 2-Nitroaniline | 88-74-4 | | | | | 74.1 | 74.1 |
| 2-Nitrophenol | 88-75-5 | | | | | 1.6 | 1.6 |
| 2-Nitrotoluene | 88-72-2 | | | | | | NF |
| 3,3'-Dichlorobenzidine | 91-94-1 | | | | | 0.64636 | 0.64636 |
| 3-Nitroaniline | 99-09-2 | | | | | 3.16 | 3.16 |
| 4,4'-DDD | 72-54-8 | | | | | 0.75815 | 0.75815 |
| 4,4'-DDE | 72-55-9 | | 10 | 5 | | 0.59587 | 5 |
| 4,4'-DDT | 50-29-3 | | 5 | 50 | | 0.0175 | 5 |
| 4,6-Dinitro-2-Methylphenol | 534-52-1 | | | | | 0.14408 | 0.14408 |
| 4-Bromophenyl Phenyl Ether | 101-55-3 | | | | | | NF |
| 4-Chloro-3-Methylphenol | 59-50-7 | | | | | 7.95 | 7.95 |
| 4-Chloroaniline | 106-47-8 | | | | | 1.1 | 1.1 |
| 4-Chlorophenyl Phenyl Ether | 7005-72-3 | | | | | | NF |
| 4-Methyl-2-Pentanone | 108-10-1 | | | | | 443 | 443 |
| 4-Methylphenol | 106-44-5 | | | | | 163 | 163 |
| 4-Nitroaniline | 100-01-6 | | | | | 21.9 | 21.9 |
| 4-Nitrophenol | 100-02-7 | | | | 7 | 5.12 | 7 |
| Acenaphthene | 83-32-9 | | | | 20 | 682 | 20 |
| Acenaphthylene | 208-96-8 | | | | | 682 | 682 |
| Acetone | 67-64-1 | | | | | 2.5 | 2.5 |
| Aldrin | 309-00-2 | | 0.05 | 0.05 | | 0.00332 | 0.05 |
| Alpha BHC | 319-84-6 | | | | | 0.09939 | 0.09939 |
| Alpha Endosulfan | 959-98-8 | | | | | 0.11927 | 0.11927 |
| Aluminum | 7429-90-5 | | | | | | NF |
| Anthracene | 120-12-7 | | | | | 1480 | 1480 |
| Antimony | 7440-36-0 | 5 | | | 5 | 0.1423 | 5 |
| Arochlor 1016 | 12674-11-2 | | | | | | NF |
| Arochlor 1221 | 11104-28-2 | | | | | | NF |
| Arochlor 1232 | 11141-16-5 | | | | | | NF |
| Arochlor 1242 | 53469-21-9 | | 150 | 150 | | | 150 |
| Arochlor 1248 | 12672-29-6 | | 3 | 1 | | | 1 |
| Arochlor 1254 | 11097-69-1 | | 0.64 | 5 | | | 0.64 |
| Arochlor 1260 | 11096-82-5 | | 5 | 6.36 | | | 5 |

# Table 4
## Soil Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| Parameter | CAS | Ecological Benchmark (mg/kg)[1] | Terratox LOEL (mg/kg)[2] | Terratox NOEL (mg/kg)[3] | PRGs (mg/kg)[4] | Soil EDQL (mg/kg)[5] | Prposed Soil SV (mg/kg) |
|---|---|---|---|---|---|---|---|
| Arsenic | 7440-38-2 | 10 | 30 | 100 | 9.9 | 5.7 | 10 |
| Barium | 7440-39-3 | 500 | | | 283 | 1.04 | 500 |
| Benzene | 71-43-2 | | | | | 0.25462 | 0.25462 |
| Benzo(a)Anthracene | 56-55-3 | | | | | 5.21 | 5.21 |
| Benzo(a)Pyrene | 50-32-8 | | | | | 1.52 | 1.52 |
| Benzo(b)Fluoranthene | 205-99-2 | | | | | 59.8 | 59.8 |
| Benzo(g,h,i)Perylene | 191-24-2 | | | | | 119 | 119 |
| Benzo(k)Fluoranthene | 207-08-9 | | | | | 148 | 148 |
| Benzoic Acid | 65-85-0 | | | | | | NF |
| Benzyl Alcohol | 100-51-6 | | | | | 65.8 | 65.8 |
| Benzyl Butyl Phthalate | 85-68-7 | | | | | 0.23889 | 0.23889 |
| Beryllium | 7440-41-7 | 10 | | | 10 | 1.06 | 10 |
| Beta BHC | 319-85-7 | | | | | 0.00398 | 0.00398 |
| Beta Endosulfan | 33213-65-9 | | | | | 0.11927 | 0.11927 |
| Bis(2-Chloroethoxy) Methane | 111-91-1 | | | | | 0.30209 | 0.30209 |
| Bis(2-Chloroethyl) Ether | 111-44-4 | | | | | 23.7 | 23.7 |
| Bis(2-Ethylhexyl) Phthalate | 117-81-7 | | 25 | | | 0.92594 | 25 |
| Bromodichloromethane | 75-27-4 | | | | | 0.53978 | 0.53978 |
| Bromoform | 75-25-2 | | | | | 15.9 | 15.9 |
| Bromomethane | 74-83-9 | | | | | 0.23516 | 0.23516 |
| Cadmium | 7440-43-9 | 1 | 75 | | 4 | 0.18095 | 1 |
| Carbazole | 86-74-8 | | | | | | NF |
| Carbon Disulfide | 75-15-0 | | | | | 0.09412 | 0.09412 |
| Carbon Tetrachloride | 56-23-5 | | | | | 2.98 | 2.98 |
| Chlordane | 57-74-9 | | | | | 0.224 | 0.224 |
| Chlorobenzene | 108-90-7 | 40 | | | 40 | 13.1 | 40 |
| Chloroethane | 75-00-3 | | | | | | NF |
| Chloroform | 67-66-3 | | | | | 1.19 | 1.19 |
| Chloromethane | 74-87-3 | | | | | 10.4 | 10.4 |
| Chromium, Total | 7440-47-3 | 0.4 | | | 0.4 | 0.4 | 0.4 |
| Chrysene | 218-01-9 | | | | | 4.73 | 4.73 |
| cis-1,3-Dichloropropene | 10061-01-5 | | | | | 0.39786 | 0.39786 |
| Cobalt | 7440-48-4 | | | 30000 | 20 | 0.14033 | 20 |

## Table 4
## Soil Screening Values
## for Stream Systems at Iowa Army Ammunition Plant
## Middleton, Iowa

| Parameter | CAS | Ecological Benchmark (mg/kg)[1] | Terratox LOEL (mg/kg)[2] | Terratox NOEL (mg/kg)[3] | PRGs (mg/kg)[4] | Soil EDQL (mg/kg)[5] | Prposed Soil SV (mg/kg) |
|---|---|---|---|---|---|---|---|
| Copper | 7440-50-8 | | | 22000 | 60 | 0.3132 | 60 |
| Cyanide | 57-12-5 | | | | | 1.33 | 1.33 |
| Delta BHC | 319-86-8 | | | | | 9.94 | 9.94 |
| Di-N-Butyl Phthalate | 84-74-2 | | | | 200 | 0.14979 | 200 |
| Di-N-Octylphthalate | 117-84-0 | | | | | 709 | 709 |
| Dibenz(a,h)Anthracene | 53-70-3 | | | | | 18.4 | 18.4 |
| Dibenzofuran | 132-64-9 | | | | | | NF |
| Dibromochloromethane | 124-48-1 | | | | | 2.05 | 2.05 |
| Dibromomethane | 74-95-3 | | | | | 65 | 65 |
| Dichlorodifluoromethane | 75-71-8 | | | | | 39.5 | 39.5 |
| Dieldrin | 60-57-1 | | 0.001 | 0.01 | | 0.00238 | 0.001 |
| Diethyl Phthalate | 84-66-2 | | | | 100 | 24.8 | 100 |
| Dimethyl Phthalate | 131-11-3 | | | | | 734 | 734 |
| Dinoseb | 88-85-7 | | | | | 0.0218 | 0.0218 |
| Endosulfan Sulfate | 1031-07-8 | | | | | 0.03578 | 0.03578 |
| Endrin | 72-20-8 | | 2 | 3 | | 0.0101 | 2 |
| Endrin Aldehyde | 7421-93-4 | | | | | 0.0105 | 0.0105 |
| Ethylbenzene | 100-41-4 | | | | | 5.16 | 5.16 |
| Fluoranthene | 206-44-0 | | | | | 122 | 122 |
| Fluorene | 86-73-7 | | | | | 122 | 122 |
| Gamma BHC | 58-89-9 | | | 40 | | 0.005 | 40 |
| Heptachlor | 76-44-8 | | | | | 0.00598 | 0.00598 |
| Heptachlor Epoxide | 1024-57-3 | | | | | 0.15188 | 0.15188 |
| Hexachlorobenzene | 118-74-1 | | 5 | 1 | | 0.19878 | 1 |
| Hexachlorobutadiene | 87-68-3 | | | | | 0.03976 | 0.03976 |
| Hexachlorocyclopentadiene | 77-47-4 | | | | 10 | 0.75537 | 10 |
| Hexachloroethane | 67-72-1 | | | | | 0.59634 | 0.59634 |
| HMX | 2691-41-0 | | | | | | NF |
| Indeno(1,2,3-c,d)Pyrene | 193-39-5 | | | | | 109 | 109 |
| Iron | 7439-89-6 | | | | | | NF |
| Isophorone | 78-59-1 | | | | | 139 | 139 |
| Lead | 7439-92-1 | 28 | | | 40.5 | 0.45053 | 28 |
| M,P-Xylene | 1330-20-7 | | | | | 10 | 10 |

**Table 4**
**Soil Screening Values**
**for Stream Systems at Iowa Army Ammunition Plant**
**Middleton, Iowa**

| Parameter | CAS | Ecological Benchmark (mg/kg)[1] | Terratox LOEL (mg/kg)[2] | Terratox NOEL (mg/kg)[3] | PRGs (mg/kg)[4] | Soil EDQL (mg/kg)[5] | Prposed Soil SV (mg/kg) |
|---|---|---|---|---|---|---|---|
| Manganese | 7439-96-5 | | | | | | NF |
| MCPA | 94-74-6 | | | | | | NF |
| Mercury | 7439-97-6 | 0.1 | | | 0.00051 | 0.0079 | 0.1 |
| Methoxychlor | 72-43-5 | | 100 | | | 0.01988 | 100 |
| Methylene Chloride | 75-09-2 | | | | | 4.05 | 4.05 |
| N-Nitrosodi-N-Propylamine | 621-64-7 | | | | | 0.54368 | 0.54368 |
| N-Nitrosodiphenylamine | 86-30-6 | | | | | 0.54514 | 0.54514 |
| Naphthalene | 91-20-3 | | | | | 0.09939 | 0.09939 |
| Nickel | 7440-02-0 | 30 | | | 30 | 13.6 | 30 |
| Nitrobenzene | 98-95-3 | 40 | | | | 1.31 | 40 |
| Pentachlorophenol | 87-86-5 | 3 | 10 | 10 | 3 | 0.11927 | 3 |
| Phenanthrene | 85-01-8 | | | | | 45.7 | 45.7 |
| Phenol | 108-95-2 | 30 | | | 30 | 120 | 30 |
| Pyrene | 129-00-0 | | | | | 78.5 | 78.5 |
| RDX | 121-82-4 | | | | | | NF |
| Selenium | 7782-49-2 | 1 | 8 | 2 | 0.21 | 0.02765 | 1 |
| Silver | 7440-22-4 | 2 | | | 0.2 | 4.04 | 2 |
| Silvex (2,4,5-TP) | 93-72-1 | | | | | 0.1088 | 0.1088 |
| Styrene | 100-42-5 | | | | 300 | 4.69 | 300 |
| Tetrachloroethene | 127-18-4 | | | | | 9.92 | 9.92 |
| Tetryl | 479-45-8 | | | | | | NF |
| Thallium | 7440-28-0 | 1 | | | 1 | 0.05692 | 1 |
| Toluene | 108-88-3 | | | | 200 | 5.45 | 200 |
| Toxaphene | 8001-35-2 | | 5 | 5 | | 0.11927 | 5 |
| trans-1,2-Dichloroethene | 156-60-5 | | | | | 0.78373 | 0.78373 |
| trans-1,3-Dichloropropene | 10061-02-6 | | | | | 0.39786 | 0.39786 |
| Trichloroethene | 79-01-6 | | | | | 12.4 | 12.4 |
| Trichlorofluoromethane | 75-69-4 | | | | | 16.4 | 16.4 |
| Vanadium | 7440-62-2 | 2 | | | 2 | 1.59 | 2 |
| Vinyl Chloride | 75-01-4 | | | | | 0.64614 | 0.64614 |
| Xylenes, Total | 1330-20-7 | | | | | 10 | 10 |
| Zinc | 7440-66-6 | 50 | | | 8.5 | 6.62 | 50 |

Notes:

**Table 4**
**Soil Screening Values**
**for Stream Systems at Iowa Army Ammunition Plant**
**Middleton, Iowa**

| Parameter | CAS | Ecological Benchmark (mg/kg)[1] | Terratox LOEL (mg/kg)[2] | Terratox NOEL (mg/kg)[3] | PRGs (mg/kg)[4] | Soil EDQL (mg/kg)[5] | Prposed Soil SV (mg/kg) |
|---|---|---|---|---|---|---|---|

1)EPA, 1999a
2)EPA, 1996a
3)EPA, 1996a
4)Efroymson, 1997a
5)EPA, 1998
Water Screening Values were selected based on:
1) Ecological Benchmark
2) Soil PRGs
3) Ecotoxicology NOEL/LOEL
4) EDQL

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# TECHNICAL MEMO NO. 4 - DRAFT
# CONTAMINANT SCREENING PROCESS
# FOR ECOLOGICAL RISK ASSESSMENT
# AT THE IOWA ARMY AMMUNITION PLANT

## 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 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.

## References

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United States Environmental Protection Agency (USEPA). 1998. USEPA Region 5, RCRA QAPP Instruction.

HARZA ENGINEERING COMPANY, INC.

WATER & ENVIRONMENT

August 31, 2000

Mr. Alvin Kam
USACE, Omaha District
Attn: CENWO-PM-HB
215 North 17th Street
Omaha, Nebraska 68102-4978

Subject: Technical Memorandum No. 4
Contaminant Screening Process
Ecological Risk Assessment
Iowa Army Ammunition Plant (IAAAP)
Harza Project 5644.GN.1

Dear Mr. Kam:

Harza Engineering Company (Harza) is pleased to submit Technical Memorandum No. 4. This memorandum discusses the proposed methodology for screening the database to identify contaminants of ecological concern.

If there are any questions, please contact Pinaki Banerjee at 312-831-3452 or David Pott at 312-831-3043.

Very truly yours,

Pinaki Banerjee for

R. P. Kewer
Senior Partner

cc: R. Allison, IAAAP
K. Howe, USACE
J. Haffner, IAAAP
M, Bazar, CHPPM
M, Coffey, US Fish and Wildlife
P, Thomason, USACE
R. Sellers, USACE
S, Sorensen, USACE
S. Marquess, USEPA
R, Blackburn, Techlaw

# TECHNICAL MEMO NO. 4 - DRAFT CONTAMINANT SCREENING PROCESS FOR ECOLOGICAL RISK ASSESSMENT AT THE IOWA ARMY AMMUNITION PLANT

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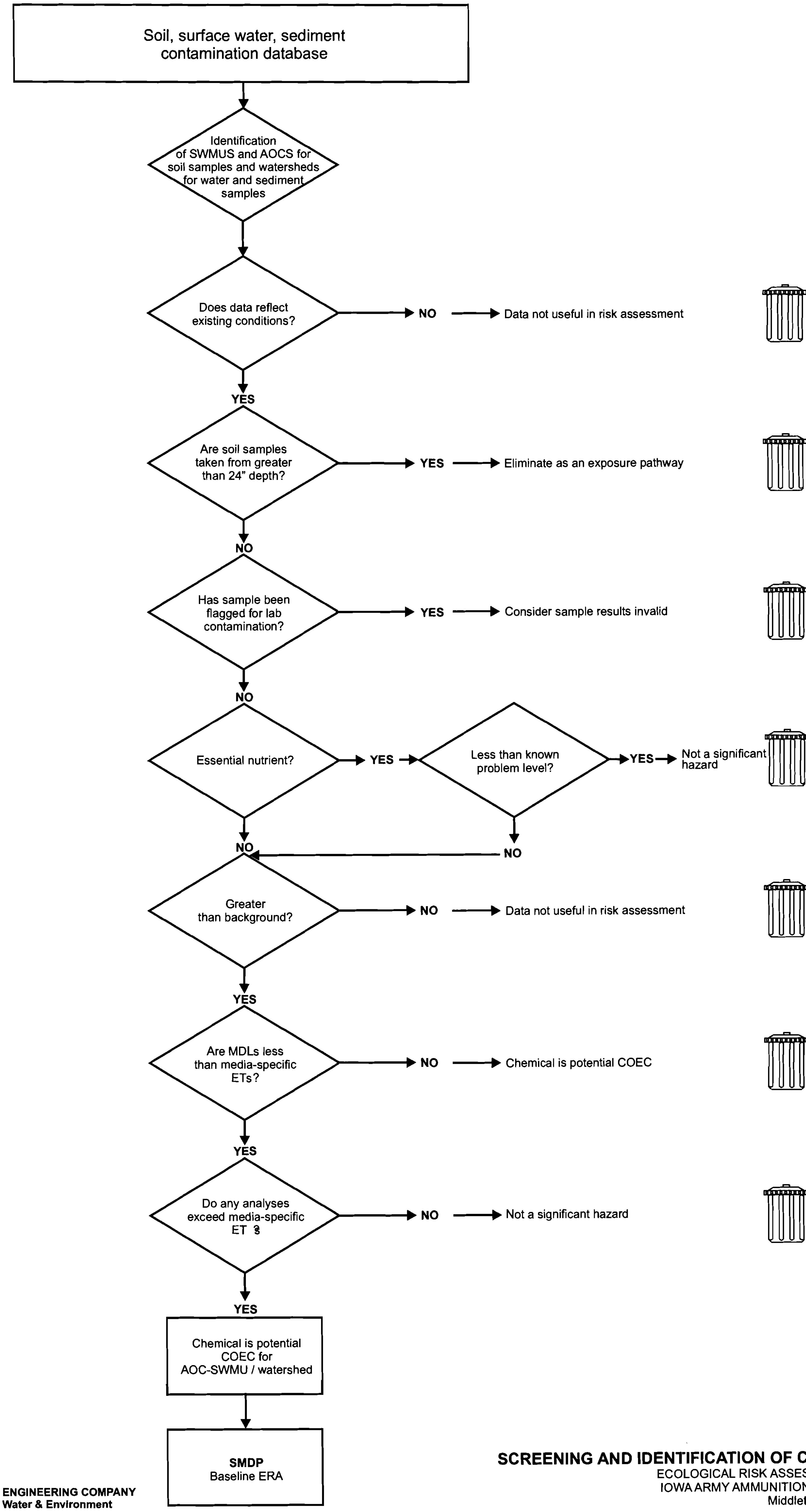


**SCREENING AND IDENTIFICATION OF COECs**
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middleton, Iowa

EXHIBIT 1

HARZA ENGINEERING COMPANY
Water & Environment