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April 23, 1997
WCFS Project No. F93506

Department of the Air Force
Headquarters Oklahoma City Air Logistics Center (AFMC)
OC-ALC/PKOSS
ATTN: Sharon Beatty
7858 5th Street, Suite 1
Tinker AFB, Oklahoma 73145-9106

Subject: Submittal of Final Ecological Assessment Report
Ecological Assessment of Soldier Creek
Contract No. F34650-93-D-0109, Order No. 5005
WCFS Document Control No. F93506.119

Dear Ms. Beatty:

This letter transmits twelve copies of the Final Ecological Assessment Report prepared by Woodward-Clyde Federal Services (WCFS) for the Ecological Assessment of Soldier Creek. Appendix K, copies of toxicity testing laboratory logs, have been provided in the report. No further revisions have been made to the report. Eleven copies of the report were delivered to James Dawson.

If you have any questions regarding this submittal, please contact the undersigned.

Sincerely,

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Senior Staff Scientist

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Project Manager

tinker\do6\2ecorpt.dfl\ecofin.ltr 4/23/97

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FINAL
Volume I of VI

ECOLOGICAL ASSESSMENT REPORT, FOR OCTOBER, 1995 ECOLOGICAL ASSESSMENT OF SOLDIER CREEK TINKER AFB OKLAHOMA CITY, OKLAHOMA

CONTRACT NO. F34650-93-D-0109
ORDER 5005

Prepared for
Department of the Air Force
Tinker AFB
Oklahoma City, Oklahoma

April 1997

FINAL

ECOLOGICAL ASSESSMENT REPORT

FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT

Document Prepared for:

Tinker Air Force Base

Environmental Directorate

OC-ALC/EM

Tinker AFB, Oklahoma

(405) 734-3058

This Final Ecological Assessment Report is intended for review by Tinker and regulatory personnel.

Outline of Document.

- Executive Summary
- Introduction
- Problem Formulation
- Methods
- Exposure and Toxicity Assessment
- Risk Characterization
- Conclusions
- Literature Cited

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This report presents results of an ecological risk assessment of the Soldier Creek Sediment and Surface Water Operable Unit at Tinker Air Force Base, Oklahoma. Tinker Air Force Base (Tinker) is an active military industrial facility located in Oklahoma County, Oklahoma. On July 22, 1987, the Building 3001 Site and the Soldier Creek Site in the northeast corner of Tinker were added to the National Priorities List under CERCLA. In 1988, the U.S. Environmental Protection Agency, Region VI (EPA); the Oklahoma State Department of Health (now the Oklahoma Department of Environmental Quality [ODEQ]); and Tinker signed a Federal Facilities Agreement (FFA) under Section 102 of CERCLA. A Remedial Investigation (RI) was performed in 1990 and 1991 to determine the extent of sediment and surface water contamination along East, West, and Main Soldier Creek, and the RI Report was finalized in 1993. A Record of Decision (ROD) was signed in September, 1993. The ROD mandated a long-term monitoring program for Soldier Creek at on-base and off-base locations and an ecological investigation of Soldier Creek sediment and surface water to further define the risk to the environment. The ecological investigation was subsequently designated an Ecological Assessment (EA), and has been determined to be equivalent to an ecological risk assessment as defined in current federal guidance.

The boundaries of Soldier Creek for the EA are (1) all sediment and surface water of East Soldier Creek from its origin on Tinker to the intersection of East Soldier Creek and Interstate Highway 40 (I-40) north of Tinker; and (2) all sediment and surface water of West Soldier Creek from its origin on Tinker to the intersection of West Soldier Creek and I-40 north of Tinker. The study area encompasses 50 feet of riparian habitat from either bank of the stream. The study area boundary was determined by comparing Phase I and Phase II RI sampling results to one-tenth of the risk-based clean-up levels established in the baseline health risk assessment.

As part of workplan development, two site reconnaissance visits were performed; sediment and surface-water data were screened to identify 35 preliminary contaminants of ecological concern (COECs); and a preliminary site conceptual model of exposures to ecological receptors was developed. Design of the EA included surveys of aquatic vascular plants,

riparian terrestrial vegetation, quantitative and qualitative sampling of benthic invertebrates, population surveys of fish, and surveys of terrestrial wildlife populations in East and West Soldier Creek and a reference stream. The initial designated reference stream was Crooked Oak Creek, located about 5 miles west of Tinker, but it was determined to be unsuitable and was replaced by a portion of Crutcho Creek, located about 1.5 miles west of Building 3001. Collocated samples of bulk sediment, surface water, and crayfish (*Orconectes* sp.) were collected for analyses of COECs, and sediments and surface water were collected from the same locations for standardized toxicity testing. Formal field work was performed in October 1994 and June 1995. For purposes of sampling and biological surveys, East Soldier Creek was divided into 10 sections, West Soldier Creek into three sections, and Crutcho Creek into 2 sections.

Ecological and quarterly-monitoring sampling resulted in the detection and quantitation of more than 600 chemical substances in bulk sediments, surface water, and/or whole-body crayfish samples from East and West Soldier Creeks and the reference streams. Final selection of COECs was based on comparison of bulk-sediment and surface-water concentrations to ecotoxicological benchmarks. This screening process ultimately identified 46 elements, compounds, or groups as COECs -- 30 in bulk sediment only, 2 in surface water only, and 14 in both media. These were referred to 12 categories based on chemical classification: metals, metalloids, other inorganics, volatile organics, chlorinated benzenes, naphthalenes, phenols and substituted phenols, phthalates, polychlorinated biphenyls (PCBs), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), and other organics.

Some of the COECs were ubiquitous in at least one medium in one or both branches of Soldier Creek (e.g., aluminum, barium, chromium, copper, iron, lead, manganese, molybdenum, nickel, zinc, bis(2-ethylhexyl)phthalate [DEHP], PCBs, and PAHs). Concentrations of several of the ubiquitous forms showed a distinct upstream-to-downstream gradient in West Soldier Creek, whereas the patterns of distribution in East Soldier Creek were more complex. Impoundment of East Soldier Creek between Bradley Street and Douglas Boulevard (Tinker's eastern boundary) has created a lentic situation with depositional, organically-rich sediments and sluggish flows, which appears to be a significant repository for contaminants released upstream. This ponded area also has a tributary (Outfall F) entering from the west, the lower portion of which (designated study section EE05) had

noticeably-elevated (or the only detected) bulk-sediment concentrations of many COECs (e.g., most of the naphthalenes and pesticides). Below the ponded area of East Soldier Creek, the bulk-sediment concentrations of most of the COECs markedly diminished. But in this and the immediate off-base portions, which is dominated by flows from the Industrial Waste Water Treatment Plant (IWTP), a few additional COECs (primarily phenolics and pesticides) appeared.

COEC concentrations in whole-body crayfish samples from Soldier Creek, collected primarily in June 1995, generally showed little variation among study sections. PCBs and DEHP were the only COECs that were noticeably elevated in/on Soldier Creek crayfish compared to those from Crutcho Creek. The most remarkable analytical results for crayfish were elevated levels of volatile organics (e.g., acetone, toluene, methylene chloride) in the June 1995 samples from both Soldier Creek and Crutcho Creek.

Based on the reconnaissance visits and formal survey activities it was determined that there are four distinct aquatic habitat types in East Soldier Creek, with three associated riparian terrestrial habitats, and two aquatic habitat types in West Soldier Creek, with two associated terrestrial habitats. The general setting is a mixture of industrial, commercial, transportation-related, and residential land-use. There is very little, if any, undisturbed natural habitat in either the streams themselves or their immediately-adjacent riparian areas within the Operable Unit. The stream invertebrate and fish communities are characterized by low diversity; indeed, fish are virtually absent, although most of East Soldier Creek overtly appears capable of supporting fish populations. Dense cattail marshes exist along portions of the middle study sections of East Soldier Creek and the uppermost section of West Soldier Creek. These marshy areas support a variety of small terrestrial/semiaquatic amphibians, reptiles, birds, and mammals. Forested areas along the uppermost and lowermost study sections of East Soldier Creek (particularly the latter) are inhabited by several woodland mammals, most of which appear to be resident, and numerous small birds, most of which are seasonal transients. Because the terrestrial habitats are relatively small and insular, they lack the potential to support resident populations of large predatory birds (e.g., raptors) or mammals (e.g., fox, bobcat). The only resident predators (aside from insectivorous and/or vermivorous birds) appear to be amphibians (e.g., bullfrog) and reptiles (e.g., snapping turtle, water snakes).

Information about the nature and distribution of the COECs, their environmental behavior (fate/transport), their anticipated effects ("mechanisms of toxicity"), and the ecological resources present or potentially-present was used to develop endpoints to focus the remainder of the EA. The process entailed identification of broad, ecologically-relevant issues which gave rise to seven general assessment endpoints (GAEs): (1) protection of *primary producers* (algae and aquatic vascular plants); (2) protection of *aquatic primary consumers* (benthic and water-column invertebrates); (3) protection of *aquatic secondary consumers* (fish community); (4) protection of *terrestrial primary consumers* (herbivorous mammals); (5) protection of *terrestrial secondary consumers* (omnivorous birds and mammals); (6) protection of *terrestrial tertiary/quaternary consumers* (carnivorous birds); and (7) protection of *aquatic microbial decomposers* (bacteria/fungi). The GAEs were translated into 10 specific assessment endpoints (SAEs) which explicitly express the values to be protected in the context of the various vulnerable ecological components, as well as the mechanisms of exposure to, and anticipated toxic effects of, the COECs. The SAEs were thus, in a sense, conceptual models of how the COECs could affect representative receptors, so that the endpoint could be expressed as one or more hypotheses for subsequent testing in the analysis phase. Each of the SAEs gave rise to one or more related measurement endpoints to resolve the hypotheses. In aggregate, 25 such measurement endpoints were established, although most involve editorial consolidation of numerous (200+) individual evaluations (measurements) related to respective COEC/exposure pathway/receptor/response combinations.

In the analysis phase of the EA, exposure and toxicity (effects) assessments were performed for the various receptor groups. For the strictly-aquatic components, direct *exposures* to bulk sediment, sediment pore water, or surface water were evaluated (as appropriate for the respective receptor categories)[1], whereas both direct and indirect *effects* were assessed for endpoints involving consumers. For the terrestrial/semiaquatic (air-breathing) receptors,

[1] **Aquatic consumers (e.g., invertebrates and fish) are also subject to indirect exposures via their diets; however, there are insufficient toxicological data available to adequately evaluate the effects of such exposures.**

indirect exposures via the ingestion pathway were evaluated[2], and both direct and indirect effects were considered for the receptors (all consumers). The EA is best described as a modified "desktop" ecological risk assessment in the context of current CERCLA guidance -- in that limited site-specific measurements (i.e., of COECs in media, biological surveys, and toxicity testing) were performed but many critical values for characterizing both exposures and effects were assumed, based on literature and/or professional judgement. Owing to the lack of these key values, the assumptions were developed with a conscious preference toward overestimation of both exposures and effects -- so as to minimize the possibility of false-negative conclusions in the subsequent risk characterization. For example, even though many COECs were not actually detected in surface-water samples, exposure-point concentrations were assumed to be half of the analytical detection (quantitation) limit.

Strictly-aquatic receptors were evaluated as groups (e.g., algae, benthic invertebrates, fish), whereas a species was selected to represent each of the categories of terrestrial/semiaquatic vertebrate consumers: the muskrat (*Ondatra zibethicus*, herbivorous mammal); the red-winged blackbird (*Agelaius phoeniceus*, omnivorous bird); the raccoon (*Procyon lotor*, omnivorous mammal); and the green heron (*Butorides virescens*, carnivorous bird). It was reasoned that essentially carnivorous amphibians and reptiles (e.g., bullfrog, snapping turtle) are probably the most vulnerable quaternary consumers, at least to exposures, in the Soldier Creek ecosystem, but there are insufficient toxicological data available to adequately evaluate the effects of COECs on such receptors.

Ecotoxicological profiles were developed for the various COECs, from which ranges of conservative toxicity reference values (TRVs) were identified for subsequent use in risk estimation. TRVs for aquatic receptors were generally the most relevant No-Observed-Adverse-Effects Concentrations (NOAECs) and Lowest-Observed-Adverse-Effects Concentrations (LOAECs), expressed as bulk-sediment or surface-water concentrations. TRVs for terrestrial/semiaquatic receptors were generally the most relevant No-Observed-Adverse-Effects Levels (NOAELs) and Lowest-Observed-Adverse-Effects Levels (LOAELs), expressed as doses (rates). Ranges were identified to "bracket" the potential risk,

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[2]**Terrestrial receptors are subject to direct exposures (e.g., dermal contact with media), but there are insufficient toxicological data available to evaluate the effects of such exposures. Moreover, there are insufficient data to accurately predict relevant exposure-point concentrations (e.g., soil concentrations).**

in support of remedial decision making (beyond the scope of this EA) and identification of site-specific, ecologically-protective, bulk-sediment and surface-water concentrations.

Laboratory bulk-sediment tests indicated that samples from selected locations in East and West Soldier Creek were acutely or chronically toxic to the benthic amphipod *Hyalella azteca*. Effects from exposures to bulk-sediments were more pervasive and severe in samples collected in October 1994 than in those obtained in June 1995. Surface-water toxicity tests with the cladoceran *Ceriodaphnia dubia* (a water-column invertebrate) and the fathead minnow (*Pimephales promelas*) produced similar results in both years, although toxicity in West Soldier Creek appeared to decrease in 1995. The spatial patterns of toxicity to bulk sediments and surface water (both years) were different; indeed, they were roughly complementary (Section 4.2.3). For example, under laboratory conditions, the most toxic sediments (in general) were those from EE07, whereas surface water from that section elicited no chronic responses in either *C. dubia* or *P. promelas*.

Risk characterization relied heavily on interpretation of deterministic ratios known as hazard quotients (HQs) and hazard indices (HIs). It was concluded that exposures via all pathways pose some risk of both acute and chronic effects to certain individual ecological receptors or members of receptor classes. The quotient method estimates, toxicity-testing results, and benthic invertebrate studies all show that the magnitude of actual or potential adverse effects is COEC- and location dependent. The apparent and estimated adverse effects of several of the COECs, based on results of this study, suggest impacts of potential ecological significance (i.e., at the population and community level, primarily involving strictly-aquatic communities and smaller vertebrate consumers). Some degree of actual or potential effects is suggested by evaluation of each of the 25 measurement endpoints. That is, reductions in survival, reproduction, development, and/or growth, attributable to site-related COECs, are likely among primary producers (algae and vascular plants), primary consumers (aquatic invertebrates, some fish, and herbivorous mammals), secondary consumers (fish, omnivorous birds, omnivorous mammals), tertiary/quaternary consumers (carnivorous birds), and microbial decomposers. Consumers are subject to both direct and indirect effects. The most significant COECs depend upon the exposure pathway and receptor, and include several metals (barium, cadmium, chromium, copper, lead, molybdenum, nickel, and zinc); a few pesticides (dieldrin, alpha-chlordane, heptachlor epoxide); PCBs; and PAHs. There are also

some COECs that pose risks in relatively localized areas, such as nonylphenols, which are apparently being released via the IWTP effluent.

There was substantial uncertainty associated with various aspects of the EA, but it was concluded that *the likelihood of underestimating the risk was very slight.* Indeed, the conservatism built into most of the exposure assumptions and the selection of TRVs probably ensured that risks were overestimated, at least on balance. The weight of evidence was in favor of a general conclusion that the risks were not understated.

The following EA is presented for the purpose of Risk Assessment and is not specially tailored for risk management decisions even though preliminary risk-based remedial goals are presented in Appendix L. Risk management is outside the scope of this EA, however, any ultimate remedial action will satisfy Applicable or Relevant and Appropriate Requirements (ARARs).

1.0
INTRODUCTION

This report presents the results and conclusions of an Ecological Assessment for the Soldier Creek Sediment and Surface Water Operable Unit at Tinker Air Force Base, Oklahoma City, Oklahoma, as mandated by a Record of Decision (ROD) dated September 1993. A brief discussion of the background, purpose and intent, and overall report organization is included in this section.

1.1 BACKGROUND

1.1.1 General Setting and Site Description

Tinker Air Force Base (Tinker) is an active military industrial facility located in Oklahoma County, Oklahoma. The base was activated in March, 1942, as the Midwest Air Depot. During World War II, the depot was responsible for reconditioning, modifying, and modernizing aircraft, vehicles, and equipment. Tinker's primary mission has not changed; it remains a major industrial complex for overhauling, modifying, and repairing military aircraft, aircraft engines, and accessory items.

The base is located within the corporate limits of Oklahoma City, approximately 7 miles east-southeast of the central business district (Figure 1-1). Tinker is bounded by Midwest City on the north, Del City on the northwest, and Oklahoma City on the east, south, and southwest. The specific boundaries are defined by Sooner Road to the west, Douglas Boulevard to the east, Southeast 29th Street to the north, and Southeast 74th Street to the south. Midwest City and Del City are densely populated with mixed residential and commercial areas. The area under Oklahoma City jurisdiction is lightly-developed residential.

The northeastern portion of Tinker Air Force Base (Figure 1-2) is drained by two previously-unnamed tributaries of Soldier Creek. For purposes of this study, the tributaries east and west of Building 3001 are designated East and West Soldier Creek, respectively. These streams are first-order (headwater) tributaries that have been substantially modified

over the years. East Soldier Creek now originates where several storm sewers emerge from under the north side of 44th Street (north of Building 3705). It then flows northward along the east side of Building 3001, past the Industrial Waste Water Treatment Plant (IWTP), and passes under Douglas Boulevard to exit the base. Below Douglas Boulevard, East Soldier Creek flows through a mixed commercial/residential area, is joined by an intermittent stream known as Tributary B from the south, and continues under Interstate Highway 40 (I-40) to a confluence with the mainstem of Soldier Creek. The latter originates off-base near Southeast 59th Street, about 1.5 miles south-southeast of the Building 3001 complex. West Soldier Creek originates as a broad swale between the Tinker North/South runway and the southern end of Building 3001. This drainage continues to a point opposite the north end of Building 3001, enters a buried sewer, and emerges off-base from under Industrial Road to flow parallel to and then cross under I-40. North of I-40, West Soldier Creek flows northeastward through a mixed residential/commercial area and joins the mainstem of Soldier Creek just west of Douglas Boulevard. From this point, Soldier Creek flows north-northwest approximately 3 miles to join Crutcho Creek, which continues northward about 2 miles and enters the North Fork of the Canadian River.

On Tinker, the headwater branches of Soldier Creek receive point-source discharges and runoff from the easternmost runway area, the Building 3001 Complex, and the IWTP. The Building 3001 Complex consists of an aircraft overhaul and modification facility to support the mission of the Oklahoma City Air Logistics Center. The IWTP receives industrial process wastewaters from the Building 3001 Complex, as well as process wastewaters from other industrial sources in the northeast quadrant of Tinker, via a network of underground piping. Once received by the plant, these waters are treated and combined with treated sanitary wastewater prior to discharge to East Soldier Creek under National Pollutant Discharge Elimination System (NPDES) Permit OK1571724391. Details of the requirements of NPDES Permit OK1571724391 and a summary of recent compliance history are presented in Appendix F.

The boundaries of Soldier Creek for this Ecological Assessment (EA) are (1): all sediment and surface water of East Soldier Creek from its origin on Tinker to the intersection of East Soldier Creek and I-40 north of Tinker; and (2): all sediment and surface water of West Soldier Creek from its origin on Tinker to the intersection of West Soldier Creek and I-40

north of Tinker. Since all portions of the study area as herein defined are well upstream of the 100-year floodplain of the Crutcho/Soldier Creek system, the width of the study area encompassed 50 feet from either bank of the stream. The study area boundary was determined by comparing the Phase I and II Remedial Investigation (RI) sampling results to one-tenth of the risk-based clean-up levels established in the baseline health risk assessment. Sediment and surface water of Soldier Creek with greater than 1/10 the risk-based clean-up levels are included in the study area boundary.

1.1.2 Previous Investigations

Table 1-1 presents a brief summary of previous activities conducted at Tinker under the Installation Restoration Program (IRP) at or near Soldier Creek (B&V 1993). As part of the overall IRP, Tinker began a preliminary assessment of previously-used waste disposal sites in 1981. As a result of a basewide sampling program in 1983, which detected trichloroethene (TCE) in the groundwater, extensive investigations were conducted in and around Building 3001. On July 22, 1987, the Building 3001 Site and the Soldier Creek Site were added to the National Priorities List (NPL) of the National Contingency Plan (NCP; 40CFR300). On December 8, 1988, U.S. Environmental Protection Agency Region VI (EPA), the Oklahoma State Department of Health (now the Department of Environmental Quality [ODEQ]), and Tinker signed a Federal Facilities Agreement (FFA) under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, also known as Superfund). In 1990 and 1991, B&V Waste Science Technology (B&V) conducted Phase I and Phase II Remedial Investigation/Feasibility Studies (RI/FS) to determine the extent of sediment and surface water contamination along East, West, and Main Soldier Creek. The RI/FS reports were finalized in February, 1993 (B&V 1993). The associated baseline health risk assessment determined that Soldier Creek sediment and surface water do not pose a risk to human health in excess of acceptable risk-based exposure levels established by EPA.

1.1.3 Record of Decision

A Record of Decision (ROD) was developed to identify the selected remedial action for the site in accordance with CERCLA and the NCP. The ROD was signed in September, 1993. The remedial action incorporates the following components of the ROD:

- Five-year monitoring program for Soldier Creek sediment and surface water at on-base and off-base locations

- Ecological investigation (qualitative and quantitative) of Soldier Creek sediment and surface water to further define the risk to the environment

- Yearly monitoring report

- Five-year review

1.2 PURPOSE AND INTENT

The "ecological investigation" mandated by the ROD was subsequently described as an Ecological Assessment in a Statement of Work (SOW) issued by Tinker. Although the scope and level of effort indicated by Table 9-1 of the signed ROD were clearly limited, the description on page 9-2 states:

> "The ecological investigation of Soldier Creek sediment and surface water conducted as part of the environmental monitoring program will be used to determine the effects of existing contaminant concentrations on the biological environment of the creek. An ecological assessment of the aquatic plants, aquatic invertebrates, and fish that inhabit Soldier Creek will be performed. The assessment will include a biological survey of both on-base and off-base portions of Soldier Creek to determine the number, identity, and approximate population size of the species living within the Soldier Creek Sediment and Surface Water Operable Unit area. Aquatic plants will be identified in the field, fish will be sampled with a seine and identified in the field, and benthic species will be collected and analyzed in a laboratory to identify aquatic invertebrates. The investigation will include all living organisms other than humans and domesticated animals that may come into contact with Soldier Creek sediment and surface water. The assessment will also be quantitative and include an exposure assessment to identify potential contaminant pathways, a toxicity assessment to identify contaminants of concern to potential aquatic organisms, and a risk characterization to quantify the overall potential or actual effects of the contaminants on the plants and animals that inhabit Soldier Creek. The ecological assessment will also address any existing or potential risk to the environment from PCBs."

The foregoing passage was subsequently interpreted to mean that the Ecological Assessment was to include all elements of an ecological risk assessment as described in the 1992 *Framework for Ecological Risk Assessment* (EPA/630/R-92/001; hereinafter referred to as the *Framework* or USEPA [1992]). Therefore, for purposes of this report the terms "ecological investigation," "ecological assessment," and "ecological risk assessment" are considered synonymous. For the sake of consistency, the term Ecological Assessment (EA) will be used in this document.

Prior to the late 1980s there was no official federal guidance for performance of ecological risk assessments of the sort needed at CERCLA sites. In 1989, *Risk Assessment Guidance for Superfund: Volume II - Environmental Evaluation Manual, Interim Final* (commonly referred to as RAGS II; EPA/540/1-89/001A [USEPA 1989a]) and a companion document, *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference* (EPA/600/3-89/013 [USEPA 1989b]), were issued. RAGS II, as labeled, was generally regarded as interim guidance while the EPA Risk Assessment Forum developed a basic structure and consistent approach for an agency-wide process. This came in the form of the *Framework* mentioned above (USEPA 1992). The EPA Environmental Response Team (ERT) is developing official guidance, based on the *Framework* but tailored primarily for CERCLA, which has been released in various review draft versions (e.g., as part of a workshop held in conjunction with the 1993 meeting of the Society of Environmental Toxicology and Chemistry). On August 12, 1994, the EPA Office of Solid Waste and Emergency Response (OSWER) issued a directive which explicitly stated that ecological risk assessments will be conducted at all CERCLA sites consistent with the *Framework* (OSWER Directive No. 9285.7-17). The OSWER Directive also noted that guidance for such assessments would be provided by ERT, the most recent form of which was issued as a review draft dated September 24, 1994. That document, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (herein referred to as ERAGS or USEPA [1994]), was officially made available to Tinker in March, 1995.

Accordingly, Tinker has attempted to follow the *Framework* and (more recently) ERAGS in designing and conducting this EA. The *Framework* (USEPA 1992) includes three basic components: (1) problem formulation; (2) analysis (characterization of exposure and

ecological effects); and (3) risk characterization. ERAGS (USEPA 1994) presents a process of eight steps, the first four of which address problem formulation and the last of which addresses the separate activity of risk management. The major thrust of ERAGS is identification of the anticipated or potential problem(s), focusing the investigation on ecologically-relevant *endpoints*, and establishing the methods by which the endpoints will be evaluated -- all prior to commitment to intensive collection of new information.

The overall ERAGS approach is geared to starting in the early phases of a RI, which in the case of the Soldier Creek Sediment and Surface Water Operable Unit was completed prior to the availability of ERAGS. Nevertheless, it is possible to retrospectively adapt the basic process to the Soldier Creek EA to some extent. The result is best described as a "desktop" ecological risk assessment in the context of ERAGS -- that is, the analysis phase retains many of the conservative elements (and hence additional uncertainty) of a preliminary-screening approach but also incorporates some "new" information on the ecological setting (e.g., biological surveys), nature and extent of contamination, and results of toxicity testing.

1.3 REPORT ORGANIZATION

The remainder of this EA report contains the following sections:

- Section 2.0, Problem Formulation - Establishes the goals, scope, and focus of the assessment. This includes evaluating the ecosystem potentially at risk, the ecotoxicology of contaminants known or suspected to be present, and observed or anticipated ecological effects. Then, ecologically-relevant endpoints to be assessed and/or measured are identified. The process culminates in a group of conceptual models describing how the contaminants might affect receptors, the relationships among the assessment and measurement endpoints, new information needed, and the methods for evaluating the information.

- Section 3.0, Methods - Describes the methods for collection of new information, including biological surveys; sampling and analyses of sediment, surface water, and biota; and toxicity testing.

- Section 4.0, Exposure and Toxicity Assessment - Corresponds to the "analysis" phase of the EA, and consists of the respective characterizations of potential exposure and potential effects (in this case, toxicity). Exposure

assessment consists of defining exposure factors and assumptions that will later be used in estimation of potential risk. Toxicity assessment consists of identifying "effects levels" associated with the contaminants of ecological concern (COECs), as well as summarizing the results of bulk-sediment and surface-water toxicity testing.

- Section 5.0, Risk Characterization - Provides a qualitative and semi-quantitative assessment of risks to ecological receptors based on exposure and toxicological profiles developed during problem formulation; evaluates the uncertainty associated with these estimates; and summarizes the estimated risks and interprets their ecological significance.

- Section 6.0, Conclusions - Summarizes the major conclusions of the EA.

- Section 7.0, Literature Cited - Lists documents cited in the report.

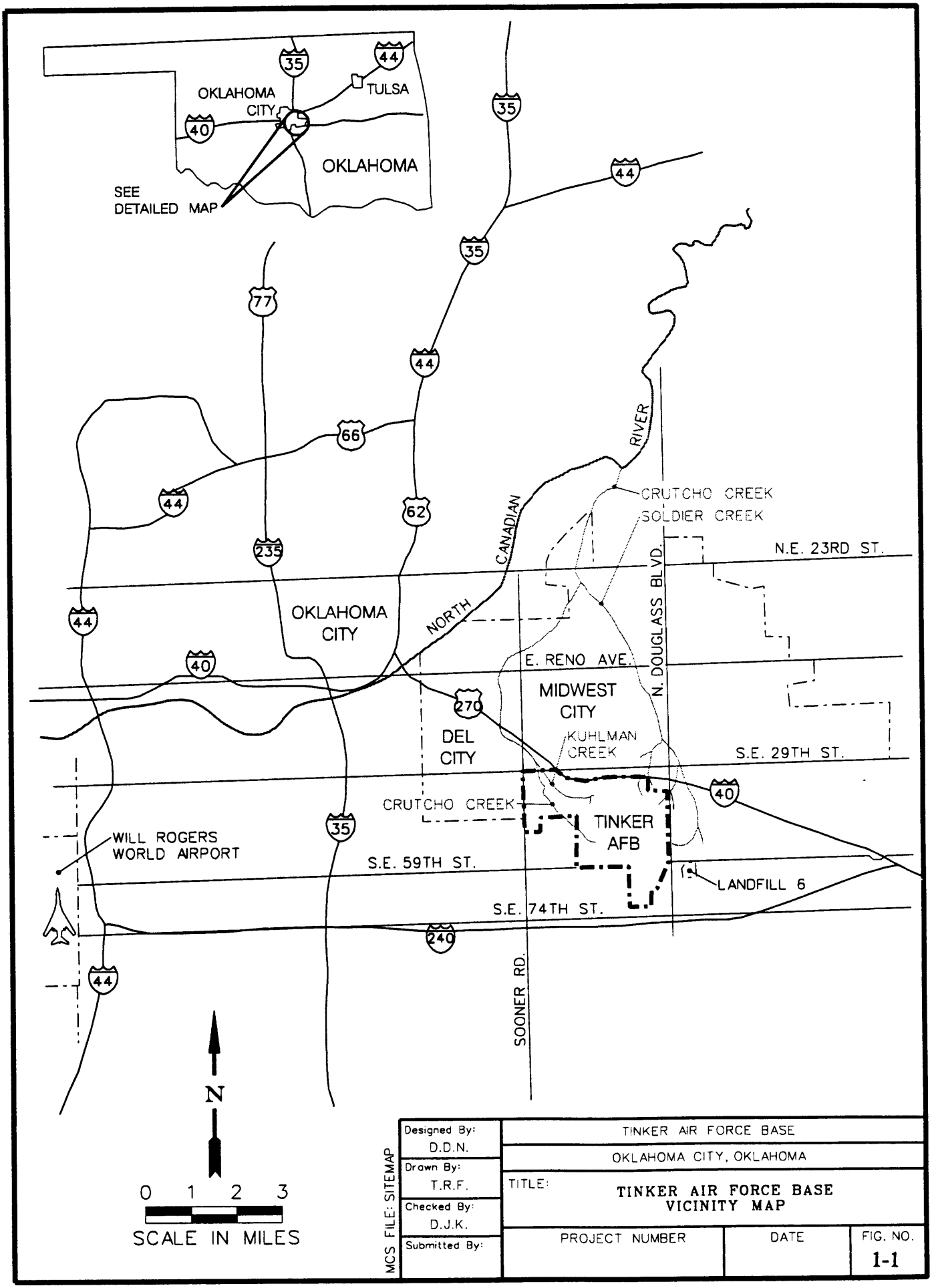
TABLE 1-1
SUMMARY OF PREVIOUS INVESTIGATIONS AND ACTIVITIES
SOLDIER CREEK SEDIMENT AND SURFACE WATER
OPERABLE UNITS

INVESTIGATION/REPORT	ORGANIZATION	DATE
Quarterly Groundwater Sampling	Tulsa COE	December 1987 - March 1989, March and October 1988
Surface Water Sampling	Tinker AFB	March - September 1987
Sediment and Surface Water Sampling	Oklahoma State Department of Health	June 1987
NPDES Surface Water Sampling	Tinker AFB	September 1986 - July 1987
Sediment and Surface Water Sampling	EPA	October 1984, November 1984
Sediment Sampling and Dredging	Harry Keith & Sons, Inc.	October 1985, April and May 1986
Final Storm Sewer Investigation for Soldier Creek	NUS Corporation	October 1989
Industrial Wastewater Treatment Plant Remedial Investigation	Tulsa COE	March 1988 - September 1990
Soldier Creek Remedial Investigation, Phase I and II	B&V Waste Science and Technology Corporation	July 1990, June 1991
Soldier Creek Baseline Risk Assessment	B&V Waste Science and Technology Corporation	February 1993
Soldier Creek Record of Decision	B&V Waste Science and Technology Corporation	August 1993
Workplans for Long-Term Monitoring and Ecological Assessment of Soldier Creek	Woodward-Clyde Federal Services	July 1995
Internal Draft Ecological Assessment	Woodward-Clyde Federal Services	November 1995
Quarterly Monitoring of Sediment and Surface Water	Woodward-Clyde Federal Services	October 1994, January, April, and July 1995
Soldier Creek/Off-Base Groundwater Operable Unit, Remedial Investigation	Parsons Engineering Science	July 1995

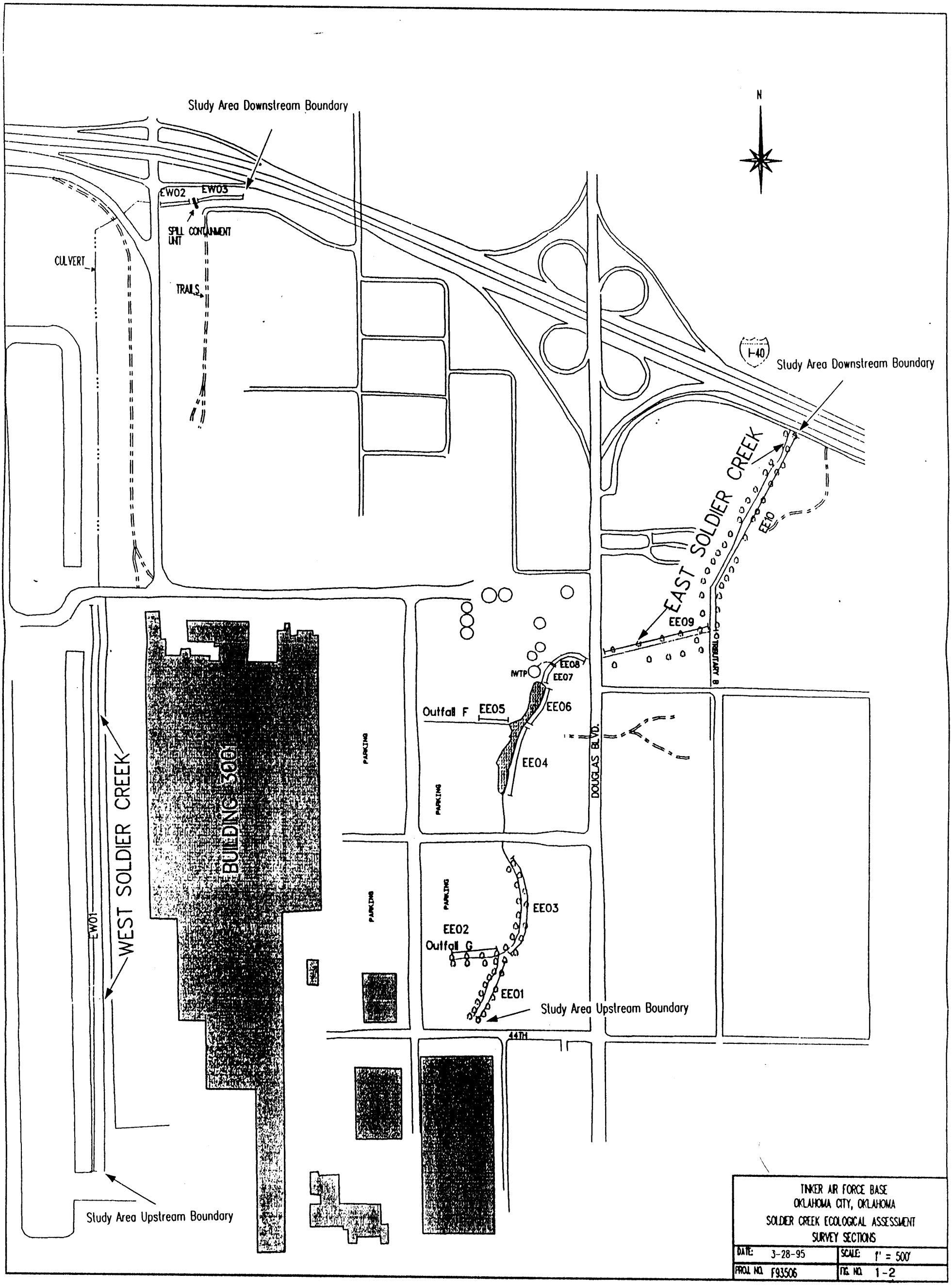
IWTP RCRA OPERABLE UNIT

INVESTIGATION/REPORT	ORGANIZATION	DATE
Installation Restoration Program Phase I Records Search	Engineering Science	1982
Industrial Wastewater Treatment Plant Remedial Investigations Report	U.S. Army Corp of Engineers	March 1988 - March 1990
Industrial Wastewater Treatment Plant RCRA	PRC	1989
Tinker AFB Industrial Wastewater Treatment Plant/Sanitary Waste Treatment Plant RFI	Engineering Science	August 1993

source: B&V 1993, and PES 1995



MCS FILE: SITEMAP	Designed By: D.D.N.	TINKER AIR FORCE BASE
	Drawn By: T.R.F.	OKLAHOMA CITY, OKLAHOMA
	Checked By: D.J.K.	TITLE: TINKER AIR FORCE BASE VICINITY MAP
	Submitted By:	PROJECT NUMBER / DATE / FIG. NO. 1-1



TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA
SOLDIER CREEK ECOLOGICAL ASSESSMENT
SURVEY SECTIONS

DATE: 3-28-95	SCALE: 1" = 500'
PROJ. NO. F93506	FIG. NO. 1-2

2.0
PROBLEM FORMULATION

Under the *Framework* (USEPA 1992), the initial phase of ecological risk assessment is a systematic planning process that establishes the goals, scope, and focus of the assessment. Problem formulation begins with identification and preliminary characterization of: (1) the ecosystem potentially at risk; (2) the contaminants known or suspected to be present; and (3) the observed or anticipated ecological effects. This leads to the identification of ecologically-relevant endpoints which are the actual values to be protected (*assessment endpoints*) and attributes that are related to the assessment endpoints (*measurement endpoints*). The process culminates in development of a conceptual model of how each contaminant might affect ecological receptors. Each such model forms the basis for one or more working hypotheses which are tested in the analysis phase of the assessment.

2.1 ECOSYSTEM POTENTIALLY AT RISK

As noted in Section 1.1, the Soldier Creek Sediment and Surface Water Operable Unit lies within an urban area (Figures 1-1 and 1-2), where the general land-use reflects a mixture of industrial, commercial, and human residential activities which have existed for at least 50 years. The streams herein designated East and West Soldier Creek are headwater (first-order) tributaries of mainstem Soldier Creek, which joins Crutcho Creek about 4 miles north of Tinker. The combined flows of Crutcho and Soldier Creek enter the North Fork of the Canadian River (ultimately tributary to the Red River Drainage of the Lower Mississippi River Basin) about 6 miles north of Tinker.

Very little, if any, natural habitat exists in and along East and West Soldier Creek because of a long history of intense human use of the area and physical modifications to the streams. These physical alterations include channelization; installation of culverts, weirs, and "drop-structures;" deposition of manmade debris (particularly in East Soldier Creek downstream from Douglas Boulevard); landscaping of major portions of the riparian areas (particularly on-base); and effluent-dominated flows during most of the time (in East Soldier Creek downstream of the IWTP, at the time of the field efforts). The result of these alterations has

been the establishment of four major aquatic habitat types in and along East Soldier Creek and two major aquatic habitat types in and along West Soldier Creek within the study area boundaries. Certain of the physical modifications (e.g., weirs, drop-structures) present substantial barriers to upstream migration of fish.

Chemical contaminants have entered the system from a variety of sources, including permitted NPDES effluents (see Appendix F). In terms of flows, East Soldier Creek appears to be effluent-dominated, particularly below the IWTP at the time of the field efforts. The releases other than permitted effluents are the focus of this EA, but the pervasive physical modifications and NPDES outfalls are noteworthy because: (1) they inevitably confound interpretation of the results of any ecological investigation of the system; and (2) they were major factors considered in the subdivision of the streams as part of the sampling design (see Subsection 2.1.1 and Section 3.0).

One of the explicit objectives of the ecological investigation mandated by the ROD was a relatively detailed biological survey in and along the streams to characterize biota (other than humans and domesticated animals) that do or may come in contact with Soldier Creek sediment and surface water. This was accomplished by two reconnaissance visits (December 1993 and June 1994); two formal ecological sampling events (October 1994 and June 1995); and anecdotal observations made during the first two quarterly monitoring events (October 1994 and January 1995). The formal biological surveys during the two ecological sampling events were performed in accordance with the methods described in Section 3.0 (see also Appendix A) of this report.

The Workplan (WCFS 1994) initially designated a portion of Crooked Oak Creek about 5 miles west of Tinker as a reference stream. However, results of the October 1994 ecological sampling event indicated that Crooked Oak Creek is unsuitable as a reference stream (Appendix G). After preliminary qualitative benthic invertebrate sampling and screening-level toxicity testing in several local streams, a portion of Crutcho Creek on Tinker and about 1.5 miles west of Building 3001 was selected as a reference stream for the June 1995 ecological sampling event.

2.1.1 Physical Characteristics

The primary study area is the Soldier Creek Sediment and Surface Water Operable Unit as defined in Section 1.0, lying in the extreme northeast corner of Tinker and immediately off-base areas (Figure 1-2). The Operable Unit and both reference streams are in gently-rolling terrain. The climate is temperate, with an average annual air temperature of 60.1°F (B&V 1993). Monthly mean air temperatures range from 81.6°F (June) to 25.2°F (January). Mean annual precipitation is about 32 inches, with the wettest period generally in late spring and early summer and the driest period in the winter. Average yearly snowfall is 9.4 inches, typically occurring from November through March (maximum monthly average is January). Prevailing winds are from the south-southeast, except during January and February when north winds predominate.

2.1.1.1 East Soldier Creek

East Soldier Creek originates where several storm sewers emerge from under the north side of 44th Street (north of Building 3705). Its source is from runoff via storm drains from the main vehicle maintenance area of Tinker, virtually all of which is paved with either asphalt or concrete. The emerged portion of East Soldier Creek flows northward about 500 feet and then is joined by a tributary from the west which is fed by a process effluent (Outfall G). The combined flow continues about 630 feet northward to a culvert at Bradley Road, near which two storm water ditches (Outfalls M and L) enter from the west. The uppermost portion of East Soldier Creek, between 44th street and Bradley Road, is in similar terrain but is divided into three study sections (EE01, EE02, and EE03) to account for the presence of Outfall G. This portion of the creek flows in a narrow channel through dense woods. The substrate is mainly bedrock (sandstone), with occasional areas of gravel and sand; virtually no fine-grained depositional sediment is present in the uppermost portion (EE01-EE03) of East Soldier Creek.

After crossing under Bradley Road, East Soldier Creek has a short stretch of flowing water and then becomes an elongate pond, about 600 feet long by 75 feet wide and terminating at a dam. Approximately midway along the pond a storm water ditch (Outfall F) enters from the west. The ponded portion of East Soldier Creek is bounded on both sides by landscaped

lawn, and is divided into three study sections (EE04, EE05, and EE06) to account for the presence of Outfall F. The upper (southern) section, EE04, is shallow (generally less than a foot deep), whereas the lower section, EE06, ranges up to 6 feet deep near its midline. Except for the flowing stretch near Bradley Road, the entire ponded portion of East Soldier Creek is depositional, with relatively thick organically-rich silt and fine sand sediments.

Normal flows from the ponded portion of East Soldier Creek are diverted via underground piping through a concrete detention basin (former oil/water separator). Downstream from the dam the stream has a divided channel, the easternmost of which is fed by the culvert from the detention basin. Between the dam and Douglas Boulevard, East Soldier Creek bends eastward. This stretch is about 400 feet long, varying from about 20 to 40 feet in width, with sand, silt, and gravel substrate and moderate flows. About a third of the way between the dam and Douglas Boulevard, the effluent of the IWTP enters from the west. Near where the stream exits Tinker under Douglas Boulevard, a large storm water conveyance enters from the north. This stretch of East Soldier Creek is generally bounded by landscaped lawns (with a few scattered trees); it is divided into two study sections, EE07 and EE08, to account for the presence of the IWTP discharge which contributes most of the flow in the stream under low-water conditions. At the time of the field efforts, the IWTP discharged to East Soldier Creek. IWTP discharge was rerouted in April 1996 to the public owned treatment works.

Beyond Douglas Boulevard, East Soldier Creek flows east-northeastward about 800 feet and is joined by an intermittent tributary (Tributary B) from the south. The stream then flows north-northeast about 1,200 feet to I-40. This off-base stretch is in a deeply-incised channel with steep clay banks, surrounded by commercial and residential property near Douglas Boulevard and riparian woodlands beyond Tributary B. The stream begins to assume a quasi-natural, riffle-and-pool configuration in this stretch, with natural substrates predominated by gravel, sand, and silt. There are also substantial amounts of concrete rubble and other anthropogenic debris (e.g., discarded appliances, automobile parts/fragments, household trash). Although the general terrain is similar, this reach of East Soldier Creek is divided into two study sections, EE09 and EE10, to account for Tributary B (the headwaters of which are in the vicinity of a commercial sanitary landfill).

2.1.1.2 West Soldier Creek

West Soldier Creek starts between the Tinker North/South runway and Building 3001 in a broad grassy swale. It flows northward about 3,500 feet and is fed by runoff from the runways and the area west of Building 3001. The east bank is extensively disturbed due to monitoring-well activity, gravel driveways, and construction activities. The stream is small with thick, organically-rich sediment deposits and little flow except during rainfall events. This upper portion of West Soldier Creek, which ends by entering a buried drain opposite the north end of Building 3001, is designated study section EW01.

West Soldier Creek emerges off-base from culverts under Industrial Road, flowing (normally) as a trickle through an area between the base and an access ramp for I-40. This lower reach is moderately incised, with substrates consisting of bedrock, gravel, sand, and substantial amounts of concrete rubble. Riparian habitat consists of a narrow band of trees along most of the highway side and a wooded slope on the base side. The reach of interest is about 500 feet in length. The portions above and below a spill-control gate are designated study sections EW02 and EW03, respectively.

2.1.2 Ecology

Detailed results of the biological surveys in East and West Soldier Creek and the reference streams are presented in Appendix G. This subsection provides a summary of the major biological communities of the aquatic and riparian terrestrial habitats found in the Soldier Creek Sediment and Surface Water Operable Unit for purposes of understanding ecological components that may be exposed to contaminants associated with the Operable Unit. Table 2-1 summarizes the characteristics of the major aquatic and riparian terrestrial habitats of the study area.

2.1.2.1 Aquatic Vascular Plants

The existing aquatic biological communities, in both the Operable Unit and the reference streams, reflect the local gradient, substrates, and the long history of intensive human activities along the streams. Aquatic vascular plants are essentially limited to shallow

portions of East and West Soldier Creek with gently-sloping banks, sluggish to moderate flows, soft depositional sediments, and little or no shading. Such areas include the edges and upper third of the ponded portion of East Soldier Creek (sections EE04, EE05, and EE06); the edges and a low island in the stretch below the ponded portion (EE07 and EE08); and the uppermost section of West Soldier Creek (EW01). The upper (southern) end of the ponded area (EE04) has extensive growth of cattails (*Typha latifolia*) along both margins and a large mat of smartweed (*Polygonum amphibium*) between the cattail marshes. Cattails are also established along the edges of the lower pools of EE05 and a portion of the west shore of EE06. The shores of sections EE07 and EE08 (below the dam) are dominated by cattails, intermixed with scattered clumps of smartweed. A few small black willows (*Salix nigra*) occur among the cattails on the marshy island in EE07. In upper West Soldier Creek (EW01), once the water tends to follow a relatively defined channel, cattails, spikerush (*Eleocharis* sp.), young cottonwoods (*Populus deltoides*), and small black willows clog the stream to form a virtually continuous marsh.

2.1.2.2 Benthic Invertebrates

Table 2-2 summarizes the occurrence of benthic invertebrate taxa by combining standardized grab (quantitative) and qualitative kicknet results from both ecological field sampling events. Overall, 106 recognizable "kinds" (taxa) were encountered -- 66 in October 1994 and 78 in June 1995. Eighty-eight (88) of the total taxa were encountered in the Operable Unit, more than half of which occurred only in East and/or West Soldier Creek. Except within certain groups of study sections with similar gradient, substrate, and aquatic vegetation (or lack thereof), there was substantial variability in community composition among the designated aquatic study sections. Despite the differences among locations, diversity at most sampling sites (hence overall) was low. Oligochaetes (freshwater segmented worms) and chironomids (midges) dominated all of the samples, both in terms of relative abundance (densities) and diversity (as taxonomic richness). Invertebrates generally recognized as pollution-sensitive (e.g., bivalve mollusks, amphipods, water mites, mayflies, stoneflies, caddisflies, and certain chironomids) were absent or very uncommon, and were generally encountered in the off-base sections of West Soldier Creek and/or Crutcho Creek. Based on the criteria established in USEPA (1990), all of the study streams would be considered "impaired," although West

Soldier Creek and Crutcho Creek appeared to have relatively much "healthier" benthic invertebrate communities than all study sections of East Soldier Creek.

2.1.2.3 Fish and Crayfish

Only a few fish, representing three species (golden shiner, green sunfish, bluegill), were encountered in the Operable Unit during the reconnaissance and formal sampling activities. It appears that there are small, localized colonies of fishes (primarily green sunfish) in off-base West Soldier Creek (EWO2 and EWO3), in the lower end of the pond (EE06) in East Soldier Creek, and immediately below the ponded area (EE07). Considering the small size, limited flow, and barriers in the form of spill control structures, the presence of fish in any numbers in West Soldier Creek is remarkable. Much more suitable physical habitat is available in East Soldier Creek, although it also has substantial barriers (particularly on-base above Douglas Boulevard). The off-base sections EE09 and EE10 overtly appear habitable to fish, but intensive efforts during reconnaissance activities and both ecological field events yielded no specimens.

Crayfish (*Orconectes* sp., all believed to be *O. virilis*) were relatively much more abundant throughout all of the permanently-flowing portions of East and West Soldier Creek in June 1995 as compared to the previous October. When available, crayfish are important prey for a wide variety of aquatic and terrestrial vertebrate carnivores. Considering the virtual absence of finfish in East and West Soldier Creeks, crayfish are probably the major source of forage, at least seasonally, for certain local predators that are essentially resident in the Operable Unit (e.g., bullfrogs, snapping turtles, water snakes).

2.1.2.4 Riparian Terrestrial Vegetation

Biogeographically, central Oklahoma is a transitional zone, or ecotone, between the Low Plains or Tall Grass Prairie, and the (naturally) wooded hills of the Quachita Physiographic Province. The region is characterized by small streams and gently-rolling hills with large areas of little or no relief. The terrestrial biological communities are a mixture from the respective physiographic regions, with plains and woodland species found in the same or adjacent habitats.

The uppermost sections of East Soldier Creek (EE01, EE02, and EE03) traverse a thickly-wooded area. The overstory of these riparian woods consists of elm (*Ulmus americana*), black willow, oaks (*Quercus* spp.), maples (*Acer* sp.), and hackberry (*Celtis occidentalis*). The understory is a mixture of honeysuckle (*Lonicera japonica*), grasses, blackberry (*Rubus allegheniensis*), and bush poison ivy (*Toxicodendron radicans*). The ponded portion of East Soldier Creek and the reach immediately downstream (EE04-EE08) flows through an area of landscaped lawns with very little natural terrestrial vegetation other than grass and "weeds" (i.e., assorted forbs) along some portions of the shoreline. Two large cottonwood trees grow in the lower area (EE08) along with several smaller oaks. Several elms grow on the high ground above the upper section of the pond (EE04). Along the steep banks of EE05, sunflower (*Helianthus annuus*) and yellow goatsbeard (*Tragopogom pratensis*) are the dominant species with a few grasses mixed among the larger plants. The lower portion of EE09 and all of EE10 are bounded by second- or third-growth hardwood forest that appears not to have been cleared in the last 20 or so years. There is a mixture of oak, hickory (*Carya* sp.), elm, hackberry, boxelder (*Acer negundo*), black cherry (*Prunus serotina*), and black locust (*Robinia pseudoacacia*). The upper portion of section EE09 flows through a developed area with commercial and residential influences, where open fields and landscaped yards replace the forest with a narrow band of heavy growth along the creek. This streamside "thicket" consists of black willow, boxelder, elm, cottonwood, and hackberry. Open areas are dominated by tall grasses and the bush form of poison ivy.

The headwater section of West Soldier Creek (EW01) has a mixture of disturbed ground species along the upper banks and aquatic growth (marsh) in the creek channel. Most of the disturbed ground vegetation consists of grasses, sunflower, and Spanish needles (*Bidens bipinnata*). The off-base sections of West Soldier Creek (EW02 and EW03) occupy an area with a mixture of mowed roadside, riparian woods, and open fields. The vegetation along the upper banks of the stream consists of mowed highway rights-of-way on the north and open fields (Tinker property) on the south. The lower banks have a moderate growth of trees with elm, oak, boxelder, and black willow predominating. Other species present are hackberry, black locust, and hickory. The most prevalent understory plant is poison ivy, accompanied by some privet (*Ligustrum vulgare*).

2.1.2.5 Terrestrial/Semiaquatic Vertebrates ("Wildlife")

Each study section or group of adjacent sections on- and off-base varies substantially in vegetation, topography, and land-use, creating five major habitat types (Table 2-1) from the perspective of terrestrial and semiaquatic vertebrates ("wildlife"). Because of the sharp contrasts among some of the macrohabitats there was marked variation in the observed composition of terrestrial vertebrate communities. Some species tended to be limited to certain macrohabitats, while others (especially birds and mammals) were more wide-ranging, at least on a local scale. Appendix G includes the results of the formal "flush counts" described in Subsection 3.1 (see also SOP-E5 in Appendix A). Some additional species or their "sign" were observed outside the context of the formal flush counts. Results of both the anecdotal and formal observations are summarized in Table 2-3. Overall, evidence of the presence of five species of amphibians; eight species of reptiles (mainly turtles); 40 species of birds; and 15 species of mammals was recorded. There are undoubtedly representatives of other species, both transient and resident, that occur in most of the macrohabitats. Birds in particular include many species that move locally in relation to seasonal variation in availability of forage and cover, as well as many which have well-documented regional or even transcontinental migrations. Amphibians, reptiles, and mammals are generally very cryptic; many representatives of these groups (especially the amphibians and reptiles) are much less conspicuous during late autumn, winter, and early spring at the latitude of Tinker, due to the fact that they remain in dens, burrows, or other hiding places. The addition of several species of amphibians and reptiles to the inventory during the June 1995 field activities was probably attributable to the fact that they became more active and conspicuous. Relatively few bird species were noted during both the October 1994 and June 1995 events, presumably due to differing migratory activities and availability of food supplies in the respective seasons. Those few species which were common during both sampling events probably represent the main resident forms in the area. On the other hand, the mammals noted during June 1995 were mainly the same species as had been recorded during the previous October. A few of those species (e.g., beaver, raccoon) appeared to be more abundant and widely-distributed in the on-base sections of East Soldier Creek in June, suggesting that some individuals may expand their activities upstream (from off-base) seasonally. Raccoons, for example, may visit upper East Soldier Creek more frequently in

the late spring and summer when crayfish (a preferred prey; USEPA 1993b) are more available.

Amphibians and reptiles generally appear to be scarce except in the ponded portion of East Soldier Creek. Note that although their tadpoles were seen in pools of the off-base sections of West Soldier Creek, no terrestrial stages of toads (*Bufo* sp.) were observed. Only two predominantly-terrestrial reptiles were seen (solitary specimens of a box turtle and a brown snake, respectively). As noted above, there appear to be relatively few resident birds in the Operable Unit. These include American crows, red-winged blackbirds, rock doves, mourning doves, bluejays, mockingbirds, red-bellied woodpeckers, and starlings. Most of the mammals that are relatively abundant (gray squirrels, mice, gophers, voles, rats) are largely confined to localized areas. Although in some cases they live relatively close to the streams (and drink the water), these small mammals are predominantly herbivorous and probably do not rely heavily, if at all, on aquatic vascular plants as forage. Certain of the medium-sized herbivores (beaver, muskrat), on the other hand, would be expected to forage primarily on the hydrophytes. Medium- to large-sized omnivores or carnivores (e.g., raccoons, coyotes) tend to be relatively wide-ranging and do not occur in large densities. Other than raccoons, there do not appear to be any other mammals in the area that are likely to consume aquatic animals from the streams of the Operable Unit on a regular basis.

2.1.3 Summary of Ecological Resources Potentially at Risk

Although there is very little, if any, undisturbed natural habitat in either the streams themselves or their immediately-adjacent riparian areas within the Operable Unit, there are viable plant and animal communities associated with all areas. The amount of space and the quality of physical habitats are limited to varying degrees depending upon the land-use. Because of its overall small size, intermittent flows, and intensive adjacent transportation activities (i.e., the main North/South Tinker runway, Industrial Boulevard, and I-40), West Soldier Creek has limited potential for sustaining balanced aquatic communities or dense terrestrial "wildlife" populations -- other than in the marshy area near Building 3001. EW01 provides cover and forage for many small birds and mammals, which in turn attract occasional predators (e.g., red-tailed hawk, coyote). In this sense, the marshy area of upper West Soldier Creek constitutes an attractive nuisance that opens a pathway for incidental

exposures to a few large carnivores. Since larger predatory birds (e.g., raptors) and mammals (e.g., coyote, foxes, bobcat) must forage over vast acreages, no single individual is likely to spend sufficient time in EW01 to receive significant chronic exposures. And, even if a particular raptor or coyote were to derive a significant portion of its overall diet from the area (i.e., enough to constitute a major threat to its health), this would be unlikely to have a discernible effect on local populations of large avian or mammalian predators.

East Soldier Creek has the physical potential to support much larger and more balanced aquatic communities. The riparian woods along the uppermost and off-base reaches (particularly the latter) are sufficiently extensive, luxuriant in vegetation, and isolated from human encroachment to provide attractive habitat to a variety of woodland wildlife. The ponded area and immediately below (EE04-EE08) currently support a valuable resource in the form of the extensive beds of cattails and smartweed. This marsh in turn provides (or could provide) cover and forage for a wide variety of amphibians, reptiles, small birds, and small mammals, in much the same way as does the marsh in EW01. The East Soldier Creek marsh has much greater potential, however, because of its size, configuration (e.g., variable vegetative cover-types), and the presence of adjacent deepwater aquatic habitat. This marsh has been identified as a jurisdictional wetland in the context of Section 404 of the Clean Water Act (see letter, Appendix F). In East Soldier Creek in general there are many more actual or potential exposure pathways of concern for ecological receptors. Even here, however, the significance of pathways to larger terrestrial animals is probably not very great at higher levels of organization than individuals (i.e., populations and communities), largely because of the fragmentation of the covertypes.

No evidence was found of the occurrence of federally-listed threatened or endangered species or their habitat within the Soldier Creek Sediment and Surface Water Operable Unit. An inquiry was sent to the U.S. Department of the Interior, Fish and Wildlife Service, regarding the need for a formal consultation under Section 7 of the Endangered Species Act. The inquiry was returned with a stamp indicating that such a consultation is unnecessary (see letter, Appendix F).

2.2 NATURE AND EXTENT OF CONTAMINATION

As noted above (Subsections 1.1.2 and 2.1), efforts related to the Tinker IRP and the RI/FS (B&V 1993) revealed the occurrence of chemical contaminants within the Soldier Creek Sediment and Surface Water Operable Unit. The ROD mandated further sampling and analyses of bulk sediments and surface water, in the form of a quarterly monitoring program, and the Workplan (WCFS 1994) established the procedures for quarterly monitoring in 18 *segments* along East and West Soldier Creek. To support this EA, the Workplan also provided for additional sampling/analyses of bulk surficial sediments, surface water, and biological tissue (crayfish) in 10 *sections* along East Soldier Creek, three *sections* along West Soldier Creek, and in two *sections* in a reference stream. It is important to note that while some of the ecological sampling locations were in the general vicinity of points for quarterly monitoring the former were established primarily to ensure collocation with other samples (e.g., of benthic invertebrates and sediment/water for toxicity testing). Sediment samples collected specifically for the EA were taken from the upper few inches, so as to represent the actual matrix with which organisms come in contact (and in some cases ingest), as well as the layer from which desorption of contaminants to the water column will occur. Where sediments are sufficiently deep, quarterly samples are taken of subsurface as well as surface layers.

A screening-level evaluation (of RI/FS data) during Workplan development identified 35 preliminary contaminants of ecological concern (COECs), including polychlorinated biphenyls (PCBs; which had not been previously analyzed, but were identified in the ROD). A major facet of this EA was the additional sampling/analyses of bulk sediments and surface water throughout the Operable Unit and reference streams to develop a more definitive list of COECs and characterize the extent of their occurrence. This subsection summarizes the results of chemical analyses of media sampled during the formal ecological field activities as well as the first four quarterly monitoring efforts, and identifies the COECs to be used in characterizing potential risks to ecological receptors.

2.2.1 Chemical Analytical Results

Ecological and quarterly-monitoring sampling resulted in the detection and quantitation of more than 600 chemical substances in bulk sediments, surface water, and/or biological tissue (whole-body crayfish) from East and West Soldier Creeks and the reference streams. Tables 2-4 and 2-5, respectively, summarize the results of all ecological and quarterly sampling of bulk sediments and surface water in the Operable Unit. Complete listings of analytical results from the October 1994 and June 1995 ecological sampling, respectively, are provided in Appendices C and D, and the associated Data Validation Reports are included as Appendix E. Further details on the spatial and seasonal distribution of detected contaminants are presented in tables in Appendix H and are discussed in following subsections of the body of the report. For a complete listing of quarterly-monitoring results, please refer to the *First Yearly Monitoring Report for the Soldier Creek Sediment and Surface Water Operable Unit* (WCFS 1995).

In this EA, the quarterly-monitoring data were used in the final screening for COECs but were not used in the estimation of exposures to ecological receptors (Section 4.1). This is because some of the quarterly sediment samples were from deeper layers, well beyond the likely zone of interaction between sediments and overlying water. The approach is conservative because a number of COECs were identified based solely on concentrations measured in quarterly samples. Most of the COECs identified on the basis of quarterly data were seldom, if at all, encountered in ecological samples. Nevertheless, such COECs were carried through the remainder of the assessment, using half of their respective method detection limits (when not actually quantitated in ecological samples) in estimating exposures.

Nearly 500 constituents were identified and quantitated (i.e., "detected") in ecological and quarterly bulk-sediment samples (Table 2-4; see also Appendix I), although many of the organic analytes were isomers, metabolites, or other forms of compounds which were ultimately grouped for assessment. About 175 constituents (a few as groups) were identified and quantitated in ecological and quarterly surface-water samples (Table 2-5; see also Appendix I).

2.2.2 Contaminants of Ecological Concern (COECs)

Final selection of COECs was based on comparison of bulk-sediment and surface-water concentrations to ecotoxicological benchmarks obtained from a variety of sources. No single set of benchmarks was available that provided values for all of the substances detected. The following sources were used:

Sediments

- The *National Sediment Contaminant Source Inventory: Point Source Analysis* (NSCSI; a USEPA draft dated March 1994b).
- Netherlands Sediment Quality Targets (NSQT; Denneman *et al.* 1991).
- Levels proposed by Beak Consulting (BEAK) for the Ontario Ministry of Environment (MOE).
- Lowest freshwater values listed in the National Oceanographic and Atmospheric Administration, National Status and Trends Program (NOAA FW; Long and Morgan 1990; note that the several more recent versions of NSTP materials were also reviewed, but they contained only marine data).
- Lowest effects levels used by the Ontario MOE (MOE-L; Persaud *et al.* 1992).
- State of Wisconsin benchmarks based on a background concentration method (Giesy and Hoke 1990).
- The New York State *Technical Guidance for Contaminated Sediment Evaluation* (NYS 1993).
- Oak Ridge National Laboratory (ORNL) screening levels (Hull and Suter 1994).

Surface Water

- Federal Ambient Water Quality Criteria (AWQCs; USEPA 1986, 1991a).
- Oklahoma Water Resources Board (OWRB) Ambient Water Quality Criteria (OAC 785:45-5-12).
- Lowest chronic toxic effects levels reported by ORNL (Suter and Mabrey 1994).
- Exposure/response levels reported in peer-reviewed scientific literature and/or online computer databases (e.g., ASTER, AQUIRE, HSDB, OHM/TADS).

There were numerous specific organic analytes for which ecotoxicological benchmarks in sediments could not be located. In such cases a conservative benchmark was derived using the equilibrium partitioning approach (EqP; USEPA 1993a; EPA-822-R-93-011).

Basically, a constituent was selected as a COEC if it was detected in any ecological or quarterly-monitoring sample at a concentration which exceeded the lowest available ecotoxicological benchmark for the medium in question (including, as noted, benchmarks derived by EqP). Never was frequency of detection considered as part of this screening process nor was background concentration used to exclude chemicals for further evaluation. The rationale for excluding a constituent was that it never occurred at a concentration exceeding any available benchmark. In general, this was an extremely conservative approach, owing to the facts that:

- 100% bioavailability was assumed (except in the cases where benchmarks were estimated using EqP);
- for hardness-dependent inorganics, a benchmark (e.g., AWQC) was derived assuming a hardness of 100 mg/l (as $CaCO_3$), which is well below the range normally encountered in local surface waters according to OWRB;
- most of the available sediment-quality benchmarks are based on perceived toxicological responses associated with ambient levels in bulk-sediments (e.g. "apparent effects thresholds"), rather than assurance via empirical measurements under controlled conditions that the exposure/response

relationship is valid and unambiguous; in the face of such inherent uncertainty, those who develop the benchmarks must incorporate conservatism into the estimates; and

- when an array of applicable benchmarks was available, the lowest was consistently applied.

On the other hand, it is important to note that many of the more obscure constituents could not be decisively eliminated as having a potential to adversely affect ecological resources (i.e., those flagged with an asterisk mark in Tables 2-4 and 2-5). This is due to two main factors: (1) lack of relevant toxicological information about many constituents; and/or (2) lack of sufficient analytical sensitivity relative to some constituents (virtually all of which involved organic compounds in the sediment matrix). There are many cases, for example, where the lower quantitation (detection) limits were well below the screening values, but matrix effects or other factors resulted in one or a few upper (maximum) detection limits that were above the benchmarks. Hence many of the nondetects ("NDs") cannot be confidently interpreted to reflect innocuous concentrations of the constituents in the specific samples in question.

The potential for some constituents other than (or in addition to) those definitely selected as COECs to contribute to the overall risk must be acknowledged as a major element of uncertainty. However, in the case of this particular Operable Unit, it must also be remembered that there is a substantial assemblage of COECs with well-documented ecologically-hazardous properties and well-documented abundance in the physical media (primarily in the near-field or on-base sections of both streams). It is highly unlikely that any of the individual constituents which are inconclusively eliminated from further detailed evaluation would eclipse the actual or potential effects of some (probably most) of the selected COECs. Moreover, remedial actions, if any, that would be selected to address the problems posed by the definitive COECs would likely mitigate the effects/risks associated with the questionable constituents.

Finally, it should be noted at this point that the screening criteria (benchmarks) used at this stage of the assessment should in no way be construed as remedial goals. One of the objectives of this EA is to identify preliminary remedial goal options (RGOs; see Appendix

L), which must incorporate numerous *additional* considerations, as is consistent with ERAGS (USEPA 1994).

2.2.2.1 Screening and Selection of COECs

The screening process ultimately identified 46 elements, compounds, or groups as COECs -- 30 in bulk sediment only, 1 in surface water only, and 15 in both media (Tables 2-4 and 2-5; that is, only those constituents categorized as *Yes* in the **COEC ?** column). Conversely, the rationale for excluding a constituent was that it never occurred at a concentration exceeding any available benchmark (Tables 2-4 and 2-5; that is, the constituents categorized as *No* in the **COEC ?** column). The COECs are referable to 12 categories based on chemical classification: metals, metalloids, other inorganics, miscellaneous volatile organics, chlorinated benzenes, chlorinated aromatic hydrocarbons (naphthalenes), phenols and substituted phenols, phthalates, PCBs, organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), and other organics. The following subsections provide brief narrative discussions of the rationale for COEC selection.

METALS

Several surface-water concentrations of **aluminum** from both East and West Soldier Creek exceeded the Federal AWQC (0.087 mg/l) and the ORNL benchmark (0.146 mg/l). There does not appear to be any available sediment benchmark for aluminum.

Several bulk-sediment concentrations of **barium** from both East and West Soldier Creek exceeded the NSQT, Wisconsin, and ORNL benchmarks (which range from 20-500 mg/l). Surface-water concentrations of barium never approached the only available benchmark (5.8 mg/l; ORNL).

Most bulk-sediment concentrations of **cadmium** from both East and West Soldier Creek exceeded most of the available sediment benchmarks (which range from 0.6-10.6 mg/l). One surface-water concentration of cadmium from EE05 and the maximum surface-water concentration from all quarterly samples exceeded the OWRB and ORNL water benchmarks (which range from 0.0015-0.011 mg/l).

Most bulk-sediment concentrations of **chromium** from both East and West Soldier Creek exceeded some of the more conservative sediment benchmarks (which range from 26-380 mg/kg). The maximum surface-water concentration of chromium from quarterly samples exceeded all three of the available water benchmarks (which range from 0.011-0.050 mg/l). Note that the chromium was assumed to be in the hexavalent state, upon which the more conservative benchmarks are based.

A few bulk-sediment concentrations of **cobalt** from both East and West Soldier Creek met or slightly exceeded the NSQT and MOE-L benchmarks (which are 20 mg/kg and 50 mg/kg, respectively). Cobalt was never detected in surface-water samples at levels exceeding the aqueous toxicity thresholds.

Many bulk-sediment concentrations of **copper** from both East and West Soldier Creek exceeded most of the available sediment benchmarks (which range from 16-390 mg/kg). Most surface-water concentrations of copper from East and West Soldier Creek exceeded the ORNL water benchmark (0.001 mg/l); several of the surface-water concentrations of copper from on-base portions of East Soldier Creek exceeded the Federal AWQC (0.012 mg/l, based on a hardness of 100 mg/l as $CaCO_3$).

Two bulk-sediment concentrations of **iron** exceeded the lowest available sediment benchmark (20,000 mg/kg). Many of the surface-water concentrations of iron exceeded the lowest water benchmark (0.158 mg/l; ORNL) and a few exceeded the Federal AWQC (1 mg/l).

Many of the bulk-sediment concentrations of **lead** from both East and West Soldier Creek (especially in on-base sections) exceeded the more conservative sediment benchmarks (which range from 31-530 mg/kg). Several surface-water concentrations of lead from both East and West Soldier Creek exceeded the Federal AWQC (0.0032 mg/l), and a few surface-water concentrations exceeded the less-conservative OWRB AWQC (0.0149 mg/l).

A few bulk-sediment concentrations of **manganese** from both East and West Soldier Creek exceeded the more conservative available sediment benchmark (460 mg/kg). Surface-water

concentrations of manganese never approached the only available water benchmark (1.1 mg/l; ORNL).

Most of the bulk-sediment concentrations (when detected) of **mercury** from both East and West Soldier Creek exceeded most of the available sediment benchmarks (which range from 0.08-1.3 mg/kg). At least one quarterly surface-water concentration of mercury exceeded the Federal AWQC (0.000012 mg/l). Note that the AWQC is a final residue value (FRV), derived from the U.S. Food and Drug Administration (FDA) action level of 1.0 mg/kg for fish tissue and a bioconcentration factor of 81,700 for methylmercury in the fathead minnow (Olson *et al.* 1975). The FRV is quite conservative in that it is considerably lower than the Final Chronic Value (FCV), the level of mercury in water that would be expected to cause statistically-significant effects on sensitive aquatic life (USEPA 1986, 1991a). Both bulk-sediment concentrations of **molybdenum** from ecological sampling at EE06 slightly exceeded the only available sediment benchmark (16 mg/kg, NSQT), and one bulk-sediment concentration at EW01 substantially exceeded that benchmark. Surface-water concentrations of molybdenum only rarely approached (and never exceeded) the only available water benchmark (0.88 mg/l; ORNL).

Most bulk-sediment concentrations of **nickel** from both East and West Soldier Creek exceeded most of the available sediment benchmarks (which range from 10-100 mg/kg). Two surface-water concentrations from East Soldier Creek below the ponded area and all of the detected surface-water concentrations in West Soldier Creek exceeded ORNL benchmark of 0.005 mg/l.

Most bulk-sediment concentrations (when detected) of **silver** from both East and West Soldier Creek substantially exceeded all of the available sediment benchmarks (which range from 0.5-2.2 mg/kg). Some surface-water concentrations of silver met or slightly exceeded the Federal AWQC and ORNL benchmark (0.00012 mg/l), and one quarterly-monitoring sample concentration was substantially higher than that benchmark.

Most bulk-sediment concentrations of **vanadium** from both East and West Soldier Creek substantially exceeded the only available sediment benchmark (2.2 mg/kg, NSQT). Surface-

water concentrations of vanadium were all below the only available water benchmark (0.08 mg/l; ORNL).

Virtually all of the bulk-sediment concentrations of **zinc** exceeded the lowest available sediment benchmark (5.9 mg/kg; the lowest NOAA freshwater value). All of the other available sediment benchmarks for zinc are greater than 100 mg/kg (ranging up to 270 mg/kg), and these were exceeded only in the lower ponded portion of East Soldier Creek (EE05, EE06) and the on-base portion of West Soldier Creek (EW01). Surface-water concentrations of zinc from EE02 and EE05 (both sampling events) exceeded the conservative ORNL "lowest chronic value" of 0.03 mg/l (Suter and Mabrey 1994). Other water benchmarks (0.11 and 0.29 mg/l, respectively) for zinc are somewhat higher than the ORNL value.

METALLOIDS

Two bulk-sediment concentrations (the only detections) of **antimony** from East Soldier Creek exceeded the lowest available sediment benchmark (2 mg/kg, ORNL and New York State). Antimony was only detected once in surface water, at a concentration well below the only available water benchmark (610 mg/l; ORNL).

A few bulk-sediment concentrations of **arsenic** from East Soldier Creek (7.3-9.0 mg/kg) slightly exceeded the lowest available sediment benchmark (6 mg/kg; MOE-L, NY, ORNL). One surface-water concentration of arsenic from EE10 (0.23 mg/l) slightly exceeded the federal and OWRB AWQC (0.19 mg/l).

A few bulk-sediment concentrations of **selenium** from West Soldier Creek exceeded the only available sediment benchmark (1.6 mg/kg; MOE-L). One surface-water concentration of selenium exceeded the federal and OWRB AWQC (0.005 mg/l).

OTHER INORGANICS

The two bulk-sediment concentrations of **cyanide** exceeded the lower available sediment benchmark (0.1 mg/kg; ORNL, MOE-L). Cyanide was never detected in surface-water samples.

MISCELLANEOUS VOLATILE ORGANICS

Two bulk-sediment concentrations of **acetone** exceeded the only available sediment benchmark (64 µg; ORNL). All surface-water concentrations of acetone were well below the lowest water benchmark (507,640 µg/l; ORNL).

One quarterly bulk-sediment concentration of **carbon disulfide** (21 µg/kg) exceeded the lowest available benchmark (13 µg/kg from ORNL). Carbon disulfide was only detected once in a surface-water sample, at 1 µg/l, which is well below the most ecologically-relevant benchmark (244 µg/l) and even below the ultraconservative "secondary chronic value" (SCV; Suter and Mabrey 1994).
One bulk-sediment concentration of **methylene chloride** exceeded the only available sediment benchmark (427 µg/kg; ORNL). Methylene chloride was detected at relatively low concentrations in surface water (well below the aquatic benchmark of 42,667 µg/l; ORNL).

One quarterly bulk-sediment concentration of **toluene** exceeded the more conservative sediment benchmarks (50 µg/kg of NSQT and 786 µg/kg of ORNL). Although detected in several surface-water samples, concentrations of toluene were orders of magnitude below the aquatic screening thresholds.

One quarterly bulk-sediment concentration of **total xylenes** exceeded the conservative sediment benchmark of the NSQT (50 µg/kg). Xylenes were not detected in surface-water samples.

CHLORINATED BENZENES

Bulk-sediment concentrations of **chlorobenzene** from EE06 (both years) exceeded the conservative sediment benchmark (35 µg/kg; New York State), and some quarterly bulk-sediment samples had even more elevated concentrations that exceeded the less conservative ORNL and NSCSI benchmarks. Chlorobenzene was detected only a few times in quarterly surface-water samples, at concentrations that are orders of magnitude below the appropriate water benchmarks.

One quarterly bulk-sediment concentration of **1,4-dichlorobenzene** was 280 µg/kg, which barely exceeded the only available sediment benchmark (180 µg/kg; NSCSI). Dichlorobenzene was never detected in surface-water samples.

CHLORINATED AROMATIC HYDROCARBONS (NAPHTHALENES)

One bulk-sediment concentration of a **chlorinated napthalene** (2,3,6-trichloronaphthalene) from EE05 was 8,000 µg/kg, which exceeded an EqP-derived benchmark of 4,015 µg/kg. Chlorinated naphthalenes were not detected in surface-water samples.

PHENOLS AND SUBSTITUTED PHENOLS/NONYLPHENOL

One bulk-sediment concentration of **2,4-dimethylphenol** (350 µg/kg) exceeded the only available sediment benchmark of 29 µg/kg (NSCSI and ORNL). 2,4-dimethylphenol was not detected in surface-water samples.

One quarterly bulk-sediment concentration of **pentachlorophenol (PCP)** slightly exceeded the most conservative available sediment benchmark (20 µg/kg; NSQT). PCP was not detected in surface-water samples.

One bulk-sediment concentration of **phenol** from EE09 exceeded the most conservative sediment benchmark (50 µg/kg; NSQT). Phenol and various of the substituted phenols were detected in some surface-water samples, but always at concentrations substantially below the available aqueous toxicity benchmarks.

A bulk-sediment concentration of a **nonylphenol** from EE08 exceeded an EqP-derived benchmark of 8,687 µg/kg. Furthermore, several other nonylphenol concentrations in off-base sections of East Soldier Creek were at or slightly above EqP-derived benchmarks based on the measured total organic carbon (TOC) concentrations at the time. Nonylphenols were not detected in surface-water samples.

PHTHALATES

Several bulk-sediment concentrations of **bis(2-ethylhexyl)phthalate (DEHP)** from both East and West Soldier Creek exceeded the only available sediment benchmark (1,995 µg/kg; New York State). A surface-water sample from each of EE01 and EW03 contained 5 µg/l and 58 µg/l, respectively, which exceeded the Federal AWQC and ORNL benchmark (3 µg/l).

TOTAL POLYCHLORINATED BIPHENYLS (PCBs)

Most bulk-sediment concentrations of **Aroclor 1254** and some other Aroclors or PCB congeners exceeded most of the available sediment benchmarks for total PCBs (which range from 0.14 to 20,520 µg/kg). PCB concentrations in bulk sediments were particularly elevated in the upper portions of East Soldier Creek (EE01-EE02) and the on-base section of West Soldier Creek (EW01). PCBs were not detected in surface-water samples, but this is one of the cases where analytical sensitivity is a problem. Some of the more conservative aqueous toxicity benchmarks are well below practical quantitation limits that are achievable given the current state of analytical technology.

ORGANOCHLORINE PESTICIDES

Bulk-sediment concentrations of **aldrin** from EE06, EE07, and EE08 generally exceeded most of the available sediment benchmarks, which range from 0.2 µg/kg (NSCSI) to 40 µg/kg (NSQT). Aldrin was occasionally detected in quarterly surface-water samples, but always below the ASTER Maximum Acceptable Toxicant Concentration (MATC) of 0.37 µg/l.

Bulk-sediment concentrations of **dieldrin** from EE05 were 17,000-23,000 µg/kg, which exceeded the available sediment benchmarks (2-110 µg/kg). One surface-water sample (the only detection) from EE05 contained 0.072 µg/l of dieldrin, which exceeded the Federal AWQC of 0.0019 µg/l.

One bulk-sediment concentration of **alpha-chlordane** from EE05 (the only detection) was 9,400 µg/kg, which exceeded all available sediment benchmarks. Alpha-chlordane was not detected in surface-water samples.

Several bulk-sediment concentrations of **heptachlor** from EE05 through EE10 exceeded most of the available sediment benchmarks (which range from 0.04-437 µg/kg). Heptachlor was not detected in surface-water samples.

Surface-water concentrations of **heptachlor epoxide** from EE08 through EE10 in October 1994 exceeded the Federal AWQC of 0.0038 µg/l.

The maximum quarterly bulk-sediment concentration of **alpha- and delta-BHC** was 2 µg/kg, which exceeded the conservative sediment benchmark of 0.9 µg/kg (NSCSI). These compounds were not detected in surface-water samples.

The maximum quarterly bulk-sediment concentration of **endosulfan sulfate** was 41 µg/kg, which exceeded all of the available sediment benchmarks (0.3-10 µg/kg). Endosulfan sulfate was not detected in surface-water samples.

The maximum quarterly bulk-sediment concentration of **methoxychlor** was 19 µg/kg, which exceeded all of the available sediment benchmarks (6.0-6.3 µg/kg). Methoxychlor was not detected in surface-water samples.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

Several bulk-sediment concentrations of **low molecular weight PAHs** (e.g., acenaphthene, anthracene, fluorene, phenanthrene) in upper and middle East Soldier Creek exceeded most available sediment benchmarks for the individual compounds, as well as the more

conservative screening levels for total PAHs (600 μg/kg). Also, bulk-sediment concentrations of anthracene and phenanthrene in West Soldier Creek exceeded some of the benchmarks for the individual compounds and the total PAH benchmarks. To the extent that they were detected in surface-water samples (which was rare), the low molecular weight PAHs were orders of magnitude below the most conservative aqueous toxicity thresholds.

Virtually all of the bulk-sediment concentrations of **medium molecular weight PAHs** (e.g., fluoranthene, pyrene) from both East and West Soldier Creek exceeded the more conservative available sediment benchmarks for individual compounds and/or total PAHs. Fluoranthene and pyrene were occasionally detected in surface-water samples, but always below the appropriate water benchmarks.

Most bulk-sediment concentrations of **high molecular weight PAHs** (e.g., benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene) exceeded at least the most conservative available sediment benchmarks for individual compounds and/or total PAHs. Also, the only detections in surface water of benzo(a)anthracene and benzo(a)pyrene (1.5 μg/l and 1.3 μg/l, respectively, at EE05) exceeded the ORNL benchmarks for these compounds (0.65 μg/l and 0.3 μg/l, respectively).

OTHER ORGANICS

A bulk-sediment concentration of **benzidine** in EE02 exceeded both available sediment benchmarks (8 μg/kg and 30 μg/kg). Benzidine was not detected in surface-water samples.
A bulk-sediment concentration of **triphenyl phosphine sulfide (TPS)** in EE09 exceeded the most conservative available sediment benchmark (1,560 μg/kg; New York State). Bulk-sediment concentrations of TPS from EE08 and EE10 also approached this benchmark. This compound was also detected several times in surface water throughout lower East Soldier Creek; however, no relevant aqueous toxicity information was available.

2.2.2.2 Summary of Distribution of COECs in Physical Media

The foregoing discussion and the tables presented in Appendix I indicate substantial variability in the occurrence and relative concentrations of COECs throughout the Operable Unit. Such variation was anticipated in light of the major differences in basic physical conditions (e.g., gradient, flow, substrate type) in various portions of East and West Soldier Creeks. In some cases, the patterns of occurrence and concentrations of COECs also appear to reflect sources of the substances.

For example, in West Soldier Creek, a distinct gradient is evident in the presence of maximum bulk-sediment concentrations at EW01, intermediate levels at EW02, and minimum concentrations at EW03 for several of the COECs. Such constituents include aluminum, cadmium, chromium, copper, lead, nickel, zinc, DEHP, PCBs, and PAHs. Surface-water concentrations of most of these substances (to the extent detected) generally reflect the same pattern of upstream-to-downstream diminution. This pattern suggests that the sources of the listed COECs are related to activities associated with Building 3001, the North/South runway, or both.

The patterns of COEC distribution are much more complex in East Soldier Creek. Maximum bulk-sediment concentrations of some of the substances tend to be in the ponded portion encompassed by study sections EE04, EE05, and EE06 (e.g., chromium, lead, nickel, zinc, acetone, chlorobenzene, DEHP, PCBs, aldrin, dieldrin, heptachlor). Both bulk-sediment and surface-water concentrations (if detected) of several COECs (arsenic, barium, nickel, zinc, PCBs, most PAHs, benzidine) strongly suggest that Outfall G and its immediate watershed have historically -- and probably continuously -- contributed to the section designated EE02. Most COEC levels in section EE03 (and EE04) appear to reflect a slight dilution of the quantities entering the stream from sources to EE02. Impoundment of East Soldier Creek has created a lentic situation, which -- with its depositional, organically-rich sediments and sluggish flows -- appears to be a significant repository for contaminants released upstream. It is also noteworthy that section EE05 appears to be a "hot spot" for several COECs (antimony, cadmium, cyanide, nickel, silver, chlorinated naphthalenes, alpha-chlordane, dieldrin, heptachlor).

Below the ponded area, the bulk-sediment concentrations of most of the COECs markedly diminish. However, such is not the case for aluminum, barium, manganese, phenols and substituted phenols, and TPS. The phenolics and triphenyl-phosphine sulfide occurred primarily in sections EE08 through EE10, suggesting that their presence is related to the IWTP discharge.

The distribution of COECs in surface-water samples (as well as sediments) is further discussed in Subsection 4.2.2 in connection with toxicity-testing results.

2.2.2.3 COECs in Crayfish

The limited data obtained from a few whole-body crayfish samples collected in October 1994 revealed no elevated levels of COECs in Soldier Creek crayfish, relative to Crooked Oak Creek.

The most remarkable results of June 1995 whole-body crayfish analyses (Table 2-6) were the pervasively elevated concentrations of volatile organic compounds (acetone, toluene, methylene chloride) in on-base sections of East Soldier Creek and both sections of West Soldier Creek, as well as in both sections of Crutcho Creek. The highest concentrations of all of those solvents were measured in the crayfish from the reference stream. The compounds in question have very little propensity to bioaccumulate (see the following subsection), at least in aquatic organisms in general, and yet the levels measured in crayfish were much higher than those observed in the physical media. None of the volatile organics was measured in any of the crayfish samples collected in October 1994. In contrast to the mainly large-adult and senescent individuals comprising the October samples, the crayfish collected in June were immature (probably only a few weeks old). Perhaps there were behavioral and/or physiological factors that affected the results. The most plausible explanation is that the chemicals (and/or sediments containing them) were adhering to the exoskeletons of the crayfish. From the perspective of a carnivorous animal preying on crayfish, the exact location in/on the prey is irrelevant in the context of the conservative assumptions used in this EA (but see discussion in Subsection 5.2.2 regarding uncertainty). For this reason, the crayfish were deliberately not rinsed or otherwise cleaned prior to processing for analysis. Because of their intimate association with the substrate, crayfish typically have large amounts

of fine-grained sediments (mud) adhering to their carapaces (hence the colloquial name "mudbugs" in some areas). It should be noted that, although identified as COECs, the VOCs in question are not particularly toxic to vertebrates via the ingestion pathway (see Subsections 2.2.3.2 and 4.2).

PCBs and DEHP were the only contaminants that were noticeably elevated in/on Soldier Creek crayfish, as compared to those from Crutcho Creek. Heptachlor was detected in crayfish from the middle reaches of Soldier Creek (ponded portion and just below) and in the upper study section of Crutcho Creek, where two other organochlorine pesticides (aldrin and dieldrin) also appeared.

Metals in general showed no remarkable pattern in the crayfish samples. Copper was measured at slightly higher levels in the upper reaches of East and West Soldier Creek than in the reference stream. On the other hand, barium, chromium, cobalt, and lead were distinctly elevated in Crutcho Creek crayfish relative to those from Soldier Creek.

2.2.3 Environmental Behavior and Relative Toxicity of COECs

Evaluation of the potential effects of the COECs on ecological receptors requires consideration of the availability of the contaminants for contact with, or uptake by, the various organisms. The fate and transport of chemicals in environmental media is affected by numerous of their properties (Table 2-7 and 2-8). The values presented in Tables 2-7 and 2-8 were obtained from: the Hazardous Substance Database (HSDB); the ASTER Database (Assessment Tools for the Analyst of Risk); and/or USEPA (1979). This information, together with consideration of the relative sensitivities of the major phylogenetic categories of potential receptors, will provide a basis for identifying the most important anticipated ecological effects of the COECs (Table 2-9 and Appendix H).

2.2.3.1 Exposure Mechanisms

For any COEC to elicit a toxicological/pathological effect there must be exposure (Suter 1993; USEPA 1992, 1994). The first three columns of Table 2-9 address the issue of exposure and refer to: (1) bioconcentration/bioaccumulation; (2) the media in which

ecological receptors may be exposed to the COEC; and (3) how that exposure could occur. The issue of bioconcentration and/or bioaccumulation is important as it is one of the most significant exposure pathways for higher-trophic-level organisms. For many of the COECs, bioaccumulation represents the only link between occurrence in aquatic media (sediment and surface water) and flux into terrestrial communities and their food webs[1].

Bioaccumulation is a general term describing the net uptake of chemicals from the environment by any or all of the possible routes (i.e., respiration, diet, dermal) from any source in the aquatic environment where chemicals are present (i.e., water, dissolved, colloidal or particulate organic carbon, sediment, other organisms) (Spacie *et al.* 1995). *Bioconcentration* is a more specific term reserved for describing accumulation from water alone (Spacie *et al.* 1995).

The "Trophic Level" block of columns in Table 2-9 refers to the bioaccumulation process and the potential for "biomagnification" along a food-chain or within a food web. *Biomagnification* (BM in Table 2-9), is herein defined as the phenomenon in which a COEC increases in concentration along progressively-higher trophic levels within a food web, and does not always occur as a consequence of bioconcentration or bioaccumulation in lower trophic levels.

Many of the COECs bioconcentrate and/or bioaccumulate, but not always in *both* aquatic animals (AqA in Table 2-9) *and* aquatic plants (AqP in Table 2-9). This is due to the differences in metabolism or biological organization and, specifically with the metals and metalloids, a difference in "bio-necessity" (i.e., the COEC is necessary for some life process, often referred to as an essential nutrient). Animals and plants, respectively, exhibit different requirements for metals and metalloids. Moreover, the major life-forms (animals and plants) have respectively developed their own physiologically-based mechanisms for regulating the uptake and excretion of most of the metals/metalloids. Owing to bio-necessity, bioconcentration/bioaccumulation is common, but biomagnification rarely occurs, since

[1]**All of the aspects described herein regarding metabolism in animals and excretion in plants are applied *only* in the context of Table 2-9 and as part of this Problem Formulation. Neither animal metabolism nor plant excretion is taken into account in the exposure assessment (Subsection 4.1) for calculating/estimating exposure point concentration of the COECs.**

elimination can be physiologically controlled. In fact, of the metals and metalloids herein selected as COECs, the only one with conclusive evidence for biomagnification (mercury) has no known biological function (i.e., is not an essential element). The only other inorganic COEC which shows some evidence for biomagnification is selenium.

Another significant difference between aquatic animals and aquatic plants is the latter's connection to the atmosphere. Some of the organic COECs are volatiles or semivolatiles (Table 2-8). By having a connection with the atmosphere, plants can and do excrete, via respiration, many volatiles or semivolatiles (e.g., chlorinated naphthalenes) and thus show little to no bioconcentration (because the excretion process outpaces the accumulation process).

Higher-trophic-level receptors represent more organized forms of life with more sophisticated or developed physiology. For example, aquatic mollusks have a very limited capacity to metabolize and excrete (PAHs) and therefore typically bioconcentrate these materials from water. Most vertebrates (fish, birds, mammals), on the other hand, readily metabolize PAHs, especially the lower-molecular-weight forms, so that these PAHS are not significantly bioconcentrated (by fish) or bioaccumulated (by birds birds/mammals). Thus, while bioconcentration may occur in a group of animals within a lower trophic level, the concentration does not increase via a food-chain. The ability to metabolize a given COEC has a direct impact on biomagnification, as does the availability of the material within the organisms (i.e., distribution in various organs/tissues) for metabolism and/or excretion. Many of the organic COECs are lipophilic ("fat-loving", also termed hydrophobic) and have a propensity to concentrate in the lipids of plant and animal tissue. As the lipids most often represent a significant storage compartment for plants and animals, the hydrophobic substances tend to bioconcentrate. Additionally, as a consequence of this storage, such constituents can, and often are, transferred within the food web resulting in biomagnification. The more hydrophobic a COEC is (see Table 2-8), the greater its propensity for biomagnification. Those organic COECs with low to moderate lipophilicity tend to be more available for metabolism and excretion (e.g., phenols and chlorinated naphthalenes), thereby having less propensity for biomagnification. Certain other substances (e.g., some of the pesticides and the PCBs) are more hydrophobic (Table 2-8), and therefore less readily metabolized; these have the greatest potential for biomagnification.

"Media" in the context of Table 2-9 relates to: (1) the evaluation of bioaccumulation of the COECs as described above; and (2) the environmental fate and transport of the COECs. While there are significant differences in solubility, sorption to sediments and/or suspended solids, volatility, and so forth, all COECs can be found in water under some conditions. Therefore as part of this Problem Formulation all COECs are conservatively assumed to be "available" in water (even though they may not have been detected in surface-water samples). The same consideration is applied to sediment (Sed. in Table 2-9).

"Contact Mode" refers to the specific mechanisms whereby exposure to the COEC can occur. These include:

Direct (D)	-	referring to intimate physical contact between the COEC and receptor tissue (most often the skin [dermis] in terrestrial receptors, but also respiratory tissue [gills and/or integument] in aquatic receptors)
Ingestion (I)	-	referring to the mechanism whereby the COEC is ingested (intentionally or otherwise) and the receptor is exposed via transfer in the gastro-intestinal tract or its analogue in simple animals
Respiration (R)	-	referring to inhalation from air (i.e., only applies to terrestrial or "air-breathing" receptors)

2.2.3.2 Potential Receptors and Their Relative Sensitivities

The "Potential Receptor Group" block of columns in Table 2-9 summarizes available information about the *relative sensitivity* of major phylogenetic categories of organisms in the aquatic and terrestrial components of the Soldier Creek ecosystems. Sensitivity may not be the best term for the evaluation presented in Table 2-9, but it is functional for the *purpose of this Problem Formulation.* To identify those receptors at relatively greater potential risk based on exposure to the COECs, some indication of the relative degree of response is required. The definitions of sensitivity are, by necessity, somewhat arbitrary since there are differences in modes of exposure, modes of toxicity, physiological targets for toxicity, and so forth. Placed in the context of "bulk" environmental concentrations (as opposed to delivered

dosages) the questions were asked, "Which receptor shows a significant response?" and "How does this level compare to that of the other receptors?". The degrees of response entered in Table 2-9 are: HR (highly resistant); R (resistant); S (sensitive); HS (highly-sensitive); and ES (extremely-sensitive). "DG" (data gap) was entered in cases where no credible toxicological data could be found. The main sources of information were online databases (e.g., ASTER, AQUIRE, HSDB, OHM/TADS) and classical toxicological references (e.g., Verschueren 1982; USEPA 1979, 1986; the Merck MS series; the U.S. Fish and Wildlife Service *Synoptic Review* series [the "Eisler documents]; ATSDR profiles). Additionally, recent (1990+) review articles from several journals such as *Environmental Toxicology and Chemistry*, as available, were reviewed in an attempt to capture information unlikely to have already been incorporated in the aforementioned databases and classical references. In aquatic bacteria/fungi, algae, vascular plants, invertebrates, and fish, the arbitrary scale for sensitivity (based on the concentrations at which a significant toxicological response occurs) is as follows: HR > 100 ppm; R > 50 ppm; S > 100 ppb; HS > 1 ppb; and ES < 1 ppb. In amphibians/reptiles, birds, and mammals (i.e., those receptors exposed via the ingestion pathway): R > 10 mg/kgBW/day; S > 1 mg/kgBW/day; and HS < 1 mg/kgBW/day.

The purpose of this admittedly arbitrary scale is to narrow the focus of the overall assessment to a manageable group of ecologically-relevant assessment endpoints (see below).

2.2.3.3 Most Significant Chronic Exposure Effects

The "most significant chronic exposure effect(s)" entries in Table 2-9 are those effects which: (1) occur at the lowest exposure levels; and (2) are relevant to population dynamics. That is, growth may be reduced at relatively higher concentrations than those associated with impaired reproduction and the latter is deemed more significant from an ecological perspective (e.g., population-level impacts). Effects considered relevant to population dynamics include survival, reproduction, development, and growth (in that order of diminishing significance). If different effects occur at or near the same exposure level, survival (Su) was considered most significant followed by reproduction (Re), development (De), and growth (Gr). This hierarchy was not invoked in the screening for selection of the COECs (see Subsection 2.2.2). A detailed summary of the specific mechanisms of toxicity of the 46 COECs (or COEC groups) is presented in the following subsection.

2.2.3.4 Mechanisms of Toxicity and Potential Receptors

A "mechanism" or mode of toxicity includes the target organ or process within a receptor that is toxicologically or pathologically affected by the presence of a poison. Often a toxin or poison can affect multiple target organs and/or processes. What follows is a short summary of what is known regarding the modes of toxicity for the COECs and the most significant chronic toxicological response(s) (i.e., the input to Table 2-9), insofar as discernible, for each COEC. An attempt was made to consider most significant chronic response(s) within the context of the toxicological mechanism whenever possible. That is, if the mechanism is an estrogenic effect the most significant response is expected to be reproduction, or if the mechanism is an interference with adenosine triphosphate (ATP), the response expected would be in growth and/or development. This can only be done for those materials where the level of understanding of the toxic mode and target is high. For some of the COECs there is only rudimentary, if any, understanding of exact mechanism(s) of toxicity. In virtually all of those cases where there is a significant level of understanding, the toxicants are best understood within mammalian models and the relationship to other ecological receptors is poorly defined, if at all. The information that follows is compiled from toxicological excerpts from the online databases HSBD, MEDTEC, ASTER, and AQUIRE; available ASTDR Toxicological Profiles; US Fish and Wildlife Contaminant Hazard Reviews; several basic texts on environmental toxicology (e.g., Rand and Petrocelli 1985; Cockerham and Shane 1994; Rand 1995); as well as the professional experience of personnel in Woodward-Clyde's Toxicological Laboratory. Again, the reader is reminded that "significance" in the present context is relative to comparison among broad receptor categories, for prioritizing anticipated effects in selection of ecologically-relevant endpoints.

Metals

Aluminum is basically a cytotoxin characterized by inhibition of enzyme function. Such interference includes those enzymes associated with adenosine triphosphate (ATP) (e.g., cytochromoxidase, Na-K ATPase, and Mg ATPase). Aluminum also interferes with synaptosomal uptake of gamma-aminobutyric acid (GABA) and acetylcholinesterase (ACHe), as well as enzymatic maintenance of other neurotransmitters. Aluminum can affect bone formation through interaction with osteoblast function and extracellar mineralization.

Aluminum-induced anemia can occur due to enzymatic interaction with the synthesis of hemoglobin.

- In aquatic animals aluminum attacks gill and respiratory organs as a contact irritant, the most significant chronic exposure result is survival.

- In plants aluminum may cause osmotic stress and perhaps metabolic disruption of enzymatic reactions. The most significant chronic exposure endpoint is survival.

- In terrestrial vertebrates aluminum is a gastro-intestinal irritant which can affect metabolic distribution of enzymes, neurotransmitters and osteblast function. The most significant chronic exposure endpoint is aluminum's affect on pre- and postnatal development (survival and development).

Barium cytotoxicity is associated with potassium metabolism and stimulation of striated, smooth, and cardiac muscle cells. Barium is believed to clog the exit channels for potassium ions in muscle cells, which can affect peristalsis and induce arterial hypertension and arrhythmias.

- In aquatic animals barium is not overtly toxic; no information was obtained regarding the potential modes of toxicity. It is postulated, given the low toxicity, that barium acts primarily as a contact irritant focusing on gill and respiratory tissues. Barium may also affect osmoregulation. The most significant chronic exposure endpoint is survival.

- Plant data regarding barium toxicity are limited. Barium does not appear to be overtly phytotoxic, although it may act via osmotic stress to exert a toxic response. Sufficient data were available to conclude that certain vascular aquatic plants may be sensitive to barium. The most significant chronic exposure endpoint appears to be growth.

- In terrestrial vertebrates barium is a gastro-intestinal irritant. It is believed to affect smooth, striated, and cardiac muscle tissue via interference with potassium exchange. The most significant exposure endpoint is survival, often expressed in terms of longevity.

Cadmium disrupts zinc-dependent enzyme systems and protein synthesis. This can directly affect growth, developmental, reproductive, and neurological processes of all life forms.

- In aquatic animals the most significant chronic exposure endpoint for cadmium appears to be reproduction.

- Algae are more sensitive to cadmium poisoning than aquatic angiosperms. This is believed to be due to direct effects on cellular metabolism that can be better compensated for by a greater biological organization (e.g., in higher plants). The most significant chronic exposure endpoint is growth.

- The most significant chronic exposure endpoint for cadmium in terrestrial vertebrates appears to be reproduction.

Chromium is an essential biological element for glucose, lipid, and protein metabolism. Toxicity due to chromium exposure is related to its oxidative state and membrane permeability; the hexavalent form (Cr^{VI}) is the environmentally relevant form. Acute toxicity is characterized by oxidation of tissue. Chronic toxicity may be related to non-specific protein/enzyme binding or perhaps oxidative stress within cells.

- In aquatic animals chromium's non-specific binding and potential cellular oxidative stress results in non-specific toxicology. Based on review of the available data rather than a specific toxicology, reproduction appears to be the most significant chronic exposure endpoint.

- In plants chromium appears to interfere with the transport and mobilization of essential minerals, especially Ca, K, Mg, B, and Cu. The most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates chromium appears to be mainly a contact poison, by actively attacking respiratory tissue. Oral exposure appears to be innocuous. Reproductive, growth, and/or developmental chronic oral exposure endpoints have not been established. The most significant chronic exposure endpoint appears to be survival.

Cobalt is an essential biological element for, at least, its role with vitamin B12. The bionecessity and/or function of cobalt is presently unclear. Sublethal cobalt toxicity is believed to be associated with: (1) high solubility in proteins and subsequent interstitial fibrosis; (2) enzyme inhibition and resultant oxidative stress and/or effects associated with mixed function monoxygenases; and (3) localized irritations within kidney and liver tissue.

- In aquatic animals, a review of the data on cobalt indicates that invertebrates are more susceptible to reproductive effects than are fish. The reason for this is unknown. Thus the most significant chronic endpoint in invertebrates appears to be reproduction, whereas in fish the most significant chronic exposure endpoint appears to be growth.

- In plants cobalt has been shown to interfere with sugar transport into the phloem. The most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates cobalt shows some, albeit inconclusive, evidence for teratogenic effects. The most significant chronic exposure endpoint appears to be reproduction; survival also appears to be a significant chronic exposure endpoint for some test species.

Copper is an essential biological nutrient required for protein formulation including hemoglobin formation, carbohydrate metabolism, catecholamine biosynthesis and oxygen transport in many invertebrate tissues. The mechanism for toxicity due to over-exposure to copper is not clear but is believed to be related to cellular oxidative stress via cellular membrane hypoxia and/or an accumulation in hepatocytes leading to degeneration of the mitochondria and necrosis.

- In aquatic animals, particularly fish, copper toxicity is believed to dominated by the relationship between gill tissue damage (contact irritation) and hematological effects on osmoregulation. Specific sublethal, chronic exposure endpoints have not been fully established in aquatic animals and a basic review of the data suggest that survival is the most significant chronic exposure endpoint for copper.

- In plants copper exhibits significant toxicity and has been used as a herbicide and algicide. Algae appear to be hypersensitive. It has been postulated that copper causes a toxic imbalance by interfering with other metal-mediated enzymatic reactions within plant cells. The most significant chronic exposure endpoint regarding plants is survival.

- In terrestrial vertebrates, copper is: (1) a contact irritant within the gastro-intestinal tract; and (2) a potential inducer of cellular oxidative stress. No specific developmental or reproductive effects have been identified, conclusively, for copper and the most significant chronic exposure endpoint is survival.

Iron is an essential biological nutrient required for manufacture of blood cells in animals and protein formulation in plants. Iron toxicity appears to be related directly with cellular oxidative stress. Peroxide formation within cells appears to be regulated by the presence of iron radicals, leading to cellular dysfunction and toxicity. Acute iron toxicity is basically a contact irritating syndrome.

- In aquatic animals, plants, and terrestrial vertebrates the most significant chronic exposure endpoint for iron is survival.

Lead in its inorganic form is well known for its inhibition of hemoglobin synthesis and resultant anemia, which has been well-correlated with lead-associated alpha-aminolevulinic acid dehyrogenase (ALAD) inhibition. Neurotoxicity and kidney dysfunction due to lead poisoning are also well-documented but are generally associated with overt/acute exposures. The cytotoxic mechanisms for lead include: (1) interference with acetylcholine release and impulse transmission in nerve cells; (2) impaired cellular absorption of glucose, amino-acids and phosphate; (3) inhibition of heme biosynthesis; and (4) inhibition of several inter-cellular enzyme systems crucial for cellular oxidation.

- In aquatic animals acute lead exposure affects invertebrates much more severely than the vertebrates. This is believed to be associated with the differences in hepatic-related enzyme function (e.g., metal-binding proteins). Crustaceans (e.g., crayfish) are at the most risk due to the interference with metal mobilization processes during molting events. Chronic exposure elicits significant reproductive impairment. The most significant chronic exposure endpoint for aquatic animals is reproduction.

- In plants, the higher forms appear to be resistant when compared to algae, although both groups are considered "sensitive" in the context of this EA. The most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates, fertility and development appear to be the most significant effects in mammals, while neurological, behavioral, and metabolic effects (sometimes manifested as reduced growth) appear to be the most significant endpoints for birds. Thus the most significant chronic endpoint for mammals is reproduction, whereas the most important chronic effects on birds relate to growth and/or development.

Manganese in overt doses attacks nerve cells by causing a dopamine depletion. Manganese is a micro-nutrient as a co-factor in enzymatic activity. Over-exposure to manganese may interfere with other enzymatic processes (e.g., protein synthesis).

- In aquatic animals, manganese has been shown to affect reproduction and growth. The mechanism for these effects is not clear at this time. The most significant chronic exposure endpoint appears to be reproduction.

- In plants, manganese elicits a strong toxicity response. The most significant chronic exposure endpoint is survival.

- In terrestrial vertebrates, manganese is a required nutrient which undergoes metabolic regulation. This results in a relatively low toxicity compared to aquatic species (especially plants). Over-exposure appears to have an affect on growth and development. The most significant chronic exposure endpoint is growth.

Mercury is an extremely toxic metal, especially considering organo-mercurials such as methylmercury. The general toxic mechanism of methylmercury is based on its affinity towards sulfhydryl ligands (-SH), which carry it into the bloodstream and deliver it into the central nervous system. Once within the nerve cells, methylmercury can bind with intercellular -SH groups and disrupt enzymatic reactions and protein synthesis. Additional binding to -SH groups on surface membrane proteins can effect membrane permeability which results in sodium leaking in and potassium leaking out. Aside from the neurotoxic effect, ingestion of inorganic mercury can result in necrosis of the intestinal tract, kidney nephrons, and liver tissue.

- In aquatic animals the data suggest that survival and reproduction are the most significant chronic exposure endpoints.

- In plants, mercury predominantly disrupts protein synthesis. The most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates, mercury exhibits direct effects on reproduction and fetal development. The most significant chronic exposure endpoint is reproduction.

Molybdenum toxicity is related to copper levels within an organism. Molybdenum's relationship with copper involves a promotion of copper binding to serum proteins, resulting in copper deficiencies and/or related toxicities.

- In aquatic species, molybdenum can elicit reproductive effects in invertebrates, but only at near-lethal concentrations. Reproductive impairment has not been conclusively established in fish, for which the most significant chronic exposure endpoint appears to be survival.

- In plants, molybdenum is required for the fixation of nitrogen, thus plants have adapted physiological control mechanisms which appear to have resulted in a high resistance to elevated molybdenum. Nevertheless, there are some data which suggest that certain plants are sensitive. The most significant chronic exposure endpoint (aside from deficiency) is growth.

- In terrestrial vertebrates, molybdenum is primarily a gastro-intestinal irritant. Ruminants are especially sensitive to acute exposure due to the presence of multiple stomachs. Sublethal effects of molybdenum have been related to interference with hepatic (liver) enzyme reactions. Such effects are most pronounced in young, developing birds and mammals. Thus the most significant chronic exposure endpoint for molybdenum in higher vertebrates is development.

Nickel is a micronutrient functional in many enzymatic reactions, but at significantly-elevated concentrations and/or doses it acts as a cytotoxin. Overloading in the kidneys can also occur, resulting in toxicity. The cytotoxic action of nickel is interference with cellular metabolism via disruption of enzymatic reactions.

- In aquatic animals the most significant chronic exposure endpoint appears to be growth.

- In plants, the most significant chronic exposure endpoint appears to be survival.

- In terrestrial vertebrates, chronic oral exposure data are limited. Some evidence exists for teratogenic effects, but the most consistently significant chronic exposure endpoint is growth.

Silver is a cytotoxin, with a strong affinity for sulfhydryl groups and proteins. Silver may also bind to chlorides and precipitate in the cells. Tissue damage occurs when the cells' binding ability is overwhelmed.

- In aquatic plants and animals, symptoms of silver intoxication are associated with hyperplasia leading to, or due to, hematological osmotic imbalances. The most significant chronic exposure endpoint for aquatic animals and plants is survival.

- In terrestrial vertebrates, the most significant chronic exposure endpoint for silver appears to be growth.

Vanadium may be an essential biological element. Several reports suggest this for chickens, rats, plants, and some invertebrates. No specific physiological role, however, has been identified for vanadium and the conditions that produce apparent vanadium deficiencies are unknown. Vanadium exerts disruptive effects on Na+ and K= ATPase enzymatic function as well as monoamine oxidase, tyrosinase, chloinesterase, and cholesterol synthetase. Such a capacity for enzymatic inhibition is believed to be the specific mechanism of toxicity for vanadium, at least for higher vertebrates.

- In aquatic animals, vanadium is suggested as an oxygen-carrying metal in some invertebrates. Few data are available regarding the toxicity of vanadium in aquatic animals. The most significant chronic exposure endpoint appears to be survival.

- In plants, vanadium is reported to: (1) stimulate photosynthesis; and (2) promote iron deficiency chlorosis by interfering with iron absorption. The most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates chronic oral vanadium toxicity data are limited. The most consistently-significant chronic exposure endpoints appears to be survival and growth.

Zinc is an essential metal for normal cell differentiation and growth as well as for the synthesis of a number of metalloenzymes, enzymatic co-factors, and DNA and RNA polymerases. Cellular zinc concentrations affect the regulation of many of the cell's metabolic processes. Sublethal intoxication of zinc is most often manifested by anemia and

histopathological effects. The toxicity of zinc, however, is highly dependent on the concentration ratio of zinc and copper.

- In aquatic animals the most significant chronic exposure endpoints for zinc appear to be either survival or growth.
- In plants, the most significant chronic exposure endpoint is growth.
- In terrestrial vertebrates, zinc is shown to produce significant reproductive effects as well as effects on survival and growth. The most significant chronic exposure endpoint appears to be reproduction.

Based on the information discussed in the previous paragraphs, Table 2-9, and Appendix H, the mechanisms of toxicity for potential receptors varies. Those organisms where direct effects on survival, reproduction, development, and/or growth are possible will be more susceptible to the toxicity mechanism of the metals. The terrestrial vertebrates (e.g., birds and mammals) generally appear to be less sensitive especially to the direct toxicological effects of many metals, specifically aluminum, barium, copper, iron, manganese, molybdenum, and zinc because of the inability to transfer up through the food chain to higher trophic levels. Several of these metals (copper, iron, manganese, vanadium, and zinc) are also essential biological elements that birds and mammals self-regulate. The toxicity mechanisms together with ecological considerations are used in Section 2.3 to produce ecological endpoints to protect the potential receptors.

Metalloids

Antimony toxicity is similar to that of arsenic; both are cytotoxins whose mechanism of action involves the replacement of phosphate and in ATP synthesis resulting in the inhibition of most cellular functions and enzyme systems. Teratogenic effects, while well identified for arsenic, have not been established for antimony. Standard teratogenic assays of chick embryos, rat, and sheep development have failed to reveal teratogensis. Antimony's effect on reproduction is most likely associated with metabolic disruption of ATP.

- In aquatic animals, antimony shows a significant effect on reproduction. The most significant chronic exposure endpoint is reproduction.

- In plants, the most significant chronic exposure endpoint for antimony is growth.

- In terrestrial vertebrates the most significant chronic exposure endpoint appears to be longevity or survival.

Arsenic is a cytotoxin whose mechanism of action involves the replacement of phosphate by arsenate, the usual form of arsenic found in biological tissues, and in ATP synthesis resulting in the inhibition of most cellular functions and enzyme systems. There are significant teratogenic effects observed due to arsenic which include fetotoxicity as well as malformations.

- In aquatic animals, the most significant chronic exposure endpoint for arsenic is reproduction. Survival endpoints are comparable, however.

- In plants, arsenic causes reproduction failure in angiosperms and survival and growth effects in algae. The most significant chronic endpoint for algae is survival. For higher plants, the most significant chronic exposure endpoint is reproduction.

- In terrestrial vertebrates the most significant chronic exposure endpoint is reproduction.

Selenium is an essential micronutrient for enzyme function and protein synthesis. High concentrations of selenium result in a toxicity similar to that of arsenic, in that the sulfhydryl groups of enzymes are inactivated. Selenium is also known to act antagonistically to mercury toxicity, as the two elements compete for -SH sites. As with arsenic, selenium has been observed to produce significant teratogenic effects.

- In aquatic animals the most significant endpoint is reproduction. Survival is also significantly affected at levels associated with reproductive effects.

- In plants, selenium toxicity is highly variable. For the more sensitive vascular species and algae in general, survival is the most significant chronic exposure endpoint.

- In terrestrial vertebrates, reproduction and development are the most significant chronic exposure endpoints for selenium.

The organisms where direct effects on survival, reproduction, development, and/or growth are possible are most susceptible to selenium toxicity. Data shows that biomagnification (ability to transfer up through the food chain to higher trophic levels) of selenium is questionable and as with several metals previously discussed, in general herbivorous mammals appear to be less sensitive to the direct toxicological effects. Conversely, birds are extremely sensitive to selenium. Further discussion is presented in Section 2.3 with ecological considerations and toxicity mechanisms to produce ecological endpoints for protection of potential receptors.

Other Inorganics

Cyanide is a contact poison that elicits toxicity through nonpolar narcosis. Nonpolar narcosis is generally considered a nonspecific toxicologically-induced, reversible, disruption of neural activity (i.e., anesthesia). There are presently two theories regarding how narcosis occurs within an organism. The "critical volume" theory involves a swelling or volume change due to dissolved toxicant in nerve cells that results in changes in the structure of lipid bilayers within the cell membrane. The "protein binding" theory involves the toxicant binding to specific receptor sites of specific dimensions within the nerve cells, resulting in narcosis. Chronic toxicity is difficult to establish due to the rapid elimination and detoxification profiles of cyanide. The very limited database suggests that the narcosis produced is effective in disruption of normal reproduction.

- In aquatic animals cyanide acts as a contact irritant on respiratory tissue. The toxicity threshold is such that chronic exposure effects are elicited only at levels near the lethal threshold. The most significant chronic exposure endpoint for cyanide is survival.

- In plants, cyanide acts as an oxidative irritant. The most significant chronic exposure endpoint is survival.

- In terrestrial vertebrates, the difference between oral exposure and inhalation, regarding toxic efficiency, is great. Oral exposure chronic toxicity is much less than inhalation for cyanide. The most significant chronic exposure endpoint for cyanide is reproduction and development.

Miscellaneous Volatile Organics

Acetone, carbon disulfide, methylene chloride, toluene, and **xylenes** exhibit toxicity through nonpolar narcosis. Nonpolar narcosis is generally considered a nonspecific toxicologically-induced, reversible, disruption of neural activity, and is discussed above in connection with cyanide (i.e., anesthesia).

- In aquatic animals and in plants the most significant chronic exposure endpoints for VOCs relate to survival.

- In terrestrial vertebrates there are suggestions of chronic toxicity endpoints other than survival (developmental) and as such, the most significant chronic exposure endpoints include effects on development as well as survival.

Data presented in Table 2-9 and Appendix H shows that volatile organics are not bioaccumulated; therefore, the chemicals are not transferred up the food chain to higher trophic levels. Terrestrial vertebrates are the least sensitive of the potential receptor groups to the direct effects of the toxicity mechanisms of the chemicals. The ecological endpoints in Section 2.3 further discuss the effects of the organics on the potential receptor groups.

Chlorinated Benzenes

Chlorobenzene and **1,4-dichlorobenzene** exhibit toxicity through nonpolar narcosis, as previously described. The most significant chronic exposure endpoints relate to survival and development. There are suggestions that some of these compounds are capable of teratogenic effects, but the effects on parental units are most often the direct cause rather than a direct effect due to the chlorinated benzene.

Chlorinated Aromatic Hydrocarbons (Naphthalenes)

All of the organics within this group exhibit toxicity through nonpolar narcosis, as previously described. The most significant chronic exposure endpoints relate to survival and development

Phenols and Substituted Phenols/Nonylphenols

All of the organics (**2,4-dimethyl phenol, pentachlorophenol [PCP], phenol**, and **nonylphenol**) within this group exhibit toxicity through nonpolar narcosis, as previously described. The most significant chronic exposure endpoints relate to survival and development.

Phthalates

The only phthalate of concern is **bis (2-ethylhexyl) phthalate (DEHP)** which like all of the organics discussed previously exhibits toxicity through nonpolar narcosis. There is no evidence of any developmental effect due to bis (2-ethylhexyl) phthalate, but there is a significant effect on growth. Thus the most significant chronic exposure endpoint includes survival and growth.

Several chemicals discussed previously (specifically, chlorobenzene, naphthalenes, phenols, and nonylphenols) do not appear to biomagnify (are not transferred up through the food chain to higher trophic levels). Although the toxicity mechanisms for these chemicals vary, the most sensitive potential receptors are those organisms where direct effects on survival, reproduction, development, and/or growth occur. The terrestrial vertebrates (e.g., birds and mammals) generally appear to be less sensitive to the direct toxicological effects of the chemicals.

A similar phenomenon is true for PCP and DEHP in that although the chemicals have the ability to biomagnify in the food chain, the terrestrial vertebrates are generally less sensitive to the direct toxicological effects of the two chemicals. This information in conjunction with further ecological considerations is used in Section 2.3 to produce ecological endpoints to protect the potential receptor groups.

Polychlorinated Biphenyls (PCBs)

PCBs are capable of eliciting a wide variety of toxic responses. Polychlorinated biphenyls are, however, structurally-specific toxicants, requiring that they combine with and/or

stimulate specific biochemical receptors to initiate a reaction that results in the expression of toxicity. As Aroclors 1254 and 1260 are mixtures of PCBs, they are capable of a variety of toxic effects and the toxicities associated with these mixtures are not necessarily the same as other specific PCBs or other mixtures of PCBs (e.g., other Aroclors). Note that the most frequently encountered and concentrated polychlorinated biphenyl in Soldier Creek was the mixture Aroclor 1254. The most significant syndromes associated with PCB toxicity regarding effects at the population level are reproduction (especially in higher vertebrates). The reproductive effects produced by PCBs are generally believed to be due to a disruption of steroids and other estrogenic hormones cycling within the organism.

- In aquatic animals the data regarding chronic exposure endpoints for PCBs has focused on reproduction such that an interpretation of other potentially relevant chronic endpoints is difficult. The effects on reproduction in aquatic animals are often (especially considering the invertebrates) in close proximity to the lethal threshold. The most significant chronic exposure endpoint is reproduction.

- In plants substantially-elevated exposures to PCBs tend to disrupt normal control over growth; as such the most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates the reproductive endpoint has been extensively studied and is the most significant chronic exposure endpoint.

Organochlorine Pesticides

All of the pesticides selected as COECs (**aldrin, dieldrin, alpha-chlordane, heptachlor, heptachlor epoxide, alpha- and delta-BHC, endosulfan sulfate**, and **methoxychlor**) generally have the same mechanism associated with toxic effects, which is neurotoxicity at the synaptic gap. Neurotoxicity is expressed through interference with the normal flux of Na+ and K+ across the axon membrane within the nerve cells. Acute toxicity is generally due to a suppression of respiratory function. The chronic effects associated with the organochlorine pesticides are due to interferences with enzymatic function in the liver. Interferences with estrogen and other steroids are believed to be factors causing reproductive failures in wildlife.

- In aquatic animals the data regarding chronic exposure endpoints has focused on survival and bioconcentration from water such that an interpretation of other potentially relevant chronic endpoints is difficult. The most significant chronic exposure endpoint, based on the available database, is survival.

- In plants, organochlorine pesticides are generally well-tolerated. This is believed to be due to the lack of the sensitive organs and pathways normally associated with these pesticides; thus the most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates, only reproductive endpoints have been extensively studied (in chronic testing). The most significant chronic exposure endpoint is reproduction.

Although the organochlorine pesticides discussed above generally produce similar toxicological effects, terrestrial vertebrates (e.g., birds and mammals) appear to be less sensitive to alpha- and delta-BHC and methoxychlor than the remaining organochlorine pesticides (Table 2-9 and Appendix H). The toxicity mechanisms together with ecological considerations are used in Section 2.3 to produce ecological endpoints to protect the potential receptor species.

Polycyclic Aromatic Hydrocarbons (PAHs)

Many of the **PAHs** (e.g., benzo(a)pyrene) are known or suspected to be relatively potent carcinogens. However, carcinogenic effects are generally not considered significant at higher levels of biological organization (i.e., populations and above) and therefore are not regarded as ecologically-relevant. The non-carcinogenic toxicity of polynuclear aromatic hydrocarbons is believed to act through polar narcosis. Most PAHs are believed capable of eliciting basic metabolic disruptions in animals. Non-specific binding to proteins is a probable feature associated with PAH toxicosis, and there is a hierarchical pattern regarding such a toxicology. Narcosis as described earlier is a nonspecific toxicologically-induced, reversible, disruption of neural activity (i.e., anesthesia). There are presently two theories regarding how narcosis occurs within an organism. The "critical volume" theory involves a swelling or volume change due to dissolved toxicant in nerve cells that results in changes in the structure of lipid bilayers within the cell membrane. The "protein binding" theory involves the toxicant binding to specific receptor sites of specific dimensions within the

nerve cells, resulting in narcosis. Whichever theory is implied, the molecular weight of the PAH will determine the effective concentration and/or dose. The available toxicity data bear this hierarchy out. Thus the PAHs as a general class have been separated into three subclasses based on the mechanism of toxicity as it relates to their structure: (1) low molecular weight PAHs (MW<200); (2) medium molecular weight (200 to <220); (3) and high molecular weight PAHs (MW>220).

Low Molecular Weight PAHs

- In aquatic animals the most significant chronic exposure endpoints are survival and growth.

- In plants, the low molecular weight PAHs may serve as a carbon source to higher plants and as such, there are suggestions that they enhance productivity. Algae, however, are highly sensitive to the PAHs, perhaps due to direct cell wall effects on permeability. Over-exposure to the low molecular weight PAHs can reduce growth. Thus the most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates, the low molecular weight PAHs are well tolerated and the most significant chronic exposure endpoint includes survival and growth.

Medium Molecular Weight PAHs

- In aquatic animals the most significant chronic exposure endpoints are survival and growth.

- In plants, the medium molecular weight PAHs are not tolerated as well as the low. As noted, algae are highly sensitive. The most significant chronic exposure endpoint is growth.

- In terrestrial vertebrates, the medium molecular weight PAHs are well-tolerated, but the most significant endpoints associated with excessive chronic exposures relate to survival and growth.

High Molecular Weight PAHs

- In aquatic animals the most significant chronic exposure endpoints are survival and growth.

- In plants, the high molecular weight PAHs are not well tolerated. The most significant chronic exposure endpoint is survival and growth.

- In terrestrial vertebrates, the high molecular weight PAHs appear capable of eliciting developmental and reproductive effects. The most significant chronic exposure endpoint include reproduction and development.

Because most vertebrates (e.g., fish, birds, and mammals) readily metabolize PAHs (especially, the low- and medium-molecular weight PAHs), these chemicals are not significantly bioconcentrated or bioaccumulated (Appendix H and Table 2-9). Therefore, the toxicity mechanisms of the PAHs have little effect on the organisms, and the chemicals are not transferred up through the food chain to higher trophic levels. Consideration of these toxicity mechanisms along with additional ecological considerations of the potential receptor groups are used in Section 2.3 to determine appropriate ecological endpoints.

Other Organics

The remaining two organic contaminants are more associated with carcinogenesis than with ecotoxicological impacts. Benzidine is a potent carcinogen in mammals via inhibition of DNA synthesis. There is virtually no information available regarding aquatic receptor toxicities, let alone mechanisms for an adequate assessment. There is even less information available regarding triphenyl-phosphine sulfide (TPS).

Based upon analysis of the toxicological effects (including mechanisms of, exposure to, and toxic effects of the contaminants) of the COECs and ecological considerations of the potential receptor groups, relevant COECs assessed for the potential receptor groups may vary. Table 2-10 provides a summary of the potential receptor groups and the relevant COECs.

2.3 ECOLOGICAL ENDPOINTS

This subsection sets forth the endpoints by which actual or potential effects on ecological resources in the Soldier Creek Sediment and Surface Water Operable Unit will be evaluated in Section 5.0. Under the *Framework* (1992), problem formulation culminates in the

identification of ecologically-based endpoints that are relevant to decisions about protecting the environment. Such an endpoint can be any attribute of an ecological component that may be adversely affected by exposure to a contaminant (Suter 1990, 1993; ASTM 1995). Two types of ecological endpoints are distinguished in the *Framework*: (1) assessment endpoints, or "explicit expressions of the environmental values that are to be protected," and (2) measurement endpoints, or "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint."

2.3.1 Assessment Endpoints

Assessment endpoints are the ultimate focus in an ecological risk assessment and link the measurement endpoints to the risk-management process (i.e., remedial decision making). According to the *Framework*, the general considerations for selecting assessment endpoints are ecological relevance, susceptibility to the types of effects associated with the contaminant(s), and policy goals and societal values. Under the evolving guidance for applying the process under CERCLA (ERAGS; USEPA 1994), these basic considerations have been refined to include:

- the fate and transport of the contaminant(s) within the ecosystems at the site;
- the specific mechanisms of toxicity of the contaminant(s) to different groups of organisms; and
- the presence of sensitive receptors, representative of major functional groups, at or near the site.

In identifying ecologically-relevant assessment endpoints it is useful to consider the basic properties that are required for a system to exist and function as an *ecosystem*: (1) structure, which is normally thought of in terms of biological diversity (i.e., structure in the sense of taxonomic components); (2) function, which addresses how the various components (insofar as present) interact; and (3) dynamics, which deals with how energy and nutrients (the "fuel" in a biological system) are processed by the system. As discussed in Section 2.1, the physical and ecological setting of the Soldier Creek Sediment and Surface Water Operable Unit is such that there are limitations on the potential biological diversity that can exist in the local ecosystem regardless of the occurrence and effects of COECs. For example, whether or not

COECs are present there are unlikely to be significant populations, if any, of larger terrestrial vertebrate carnivores (e.g., raptors, foxes, coyotes, bobcats, mink, otters) present because of inadequate space and other resources. The functional roles of such quaternary consumers, which are essential because they exert control over other trophic levels, are nevertheless fulfilled -- and, with or without the COECs, would continue to be performed -- by smaller and more opportunistic omnivores and carnivores (e.g., bullfrogs, snapping turtles, crows, opossums, raccoons, feral dogs and cats).

To address the actual or potential effects of the COECs on the ecosystems and environs of Tinker it is necessary to consider the aforementioned basic properties (structure, function, dynamics) as broad, ecologically-relevant issues. These issues, in turn, will point to general assessment endpoints (GAEs), or *major components that are essential.* From a structural and functional perspective, the dynamics of the Soldier Creek ecosystem are regulated by components that fall into three basic *trophic categories*:

- ***producers***, or organisms that use radiant energy (sunlight) to manufacture organic matter (biomass) from inorganic chemicals -- i.e., green plants

- ***consumers***, or organisms that feed on other organisms -- i.e., animals [consumers are in turn classified as primary (eating plants), secondary, tertiary, or quaternary ("top" carnivores or predators)]

- ***decomposers***, or organisms that convert dead biological tissue and biological waste materials into simpler organic molecules -- i.e., bacteria and fungi

The need to ensure the protection of these basic functions gives rise to the following GAEs:

1. *Protection of aquatic primary producers*, which include algae and vascular plants, from potential direct effects of COECs that might impair survival, reproduction, development, and/or growth (i.e., production of "biomass").

2. *Protection of aquatic primary consumers*, which mainly are benthic and other invertebrates, from potential direct and indirect effects of COECs that might impair survival, reproduction, development, and/or growth.

3. *Protection of aquatic secondary consumers*, which include primarily fish, from potential direct and indirect effects of COECs that might impair survival, reproduction, development, and/or growth.

4. *Protection of terrestrial primary consumers*, which include certain herbivorous vertebrates, from potential direct and indirect effects of COECs that might impair survival, reproduction, development, and/or growth.

5. *Protection of terrestrial secondary consumers*, which include certain omnivorous vertebrates, from potential direct and indirect effects of COECs that might impair survival, reproduction, development, and/or growth.

6. *Protection of tertiary/quaternary terrestrial consumers*, which include a few essentially carnivorous amphibians, reptiles, and birds, from potential direct and indirect effects of COECs that might impair survival, reproduction, development, and/or growth.

7. *Protection of aquatic decomposers*, bacteria/fungi, from potential direct effects that might impair survival.

Each of these general assessment endpoints must be translated into one or more specific assessment endpoints (SAEs) that will explicitly express the values to be protected in the context of the various vulnerable ecological components, as well as the mechanisms of exposure to, and toxic effects of, the contaminants. Tables 2-10 and 2-11 provide a summary of the assessment endpoints prepared for each of the potential receptor groups.

Although they are both primary producers, algae and vascular aquatic plants have sufficiently different anatomy, physiology, growth habits, and relative sensitivities to the COECs to warrant separate consideration. Algae are much simpler organisms which are essentially immersed in surface water (whether attached to a substrate as periphyton or suspended as phytoplankton) and thereby susceptible to direct aqueous toxicity. Most algae in the Soldier Creek ecosystem exist in the form of periphyton, although significant populations of planktonic forms would be expected to exist in the lentic situation provided by the ponded area of East Soldier Creek (EE04-EE06). Algae (particularly periphyton) are important in providing cover and/or food for certain aquatic invertebrates (e.g., snails), certain fishes (e.g., golden shiner), virtually all larval amphibians (tadpoles), and some turtles. Therefore, a SAE is established as follows:

1.1 Protection of periphyton and phytoplankton communities from direct toxicity due to exposures to aqueous concentrations of aluminum, antimony, arsenic, barium, cadmium, chromium, copper, cyanide, iron, lead, manganese,

mercury, nickel, silver, zinc, selenium, acetone, carbon disulfide, toluene, 1,4-dichlorobenzene, DEHP, PCBs, dieldrin, PCP, low molecular weight PAHs, medium molecular weight PAHs, and high molecular weight PAHs.

Vascular aquatic plant communities, albeit localized and limited by hydraulic and other physical or chemical factors, are an important functional component of the Soldier Creek ecosystem. The marshy areas in sections EE04-EE08 of East Soldier Creek and EW01 of West Soldier Creek provide cover and forage for a wide variety of animals. Accordingly, macrophytes which essentially grow with their roots in contact with the pore water of the contaminated sediments are selected (collectively; i.e., as a community) as a SAE as follows:

1.2 Protection of vascular aquatic plant communities from direct toxicity due to exposures to sediment pore-water concentrations of aluminum, barium cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, vanadium, arsenic, 2,4-dimethylphenol, and PCP.

Two broad categories of strictly-aquatic consumers are selected for evaluation in this EA, invertebrates and fish. The invertebrates, in turn, are separated into two groups based on microhabitat associations that affect potential exposure pathways:

1) *infaunal benthic forms* which live in direct contact with the bottom sediments (i.e., simplistically considered to be "immersed" in the sediment matrix and essentially receiving their exposure directly from pore water); and

2) *epifaunal or nektonic forms* which may live on (but not in) the sediment, on free surfaces (e.g., stones, plant stems/foliage, fallen parts of woody plants ["snags"]), or swimming freely in the water column (i.e., receiving their exposure directly from surface water).

The former are hereinafter referred to as *benthic invertebrates* and the latter as *water-column invertebrates*.

The two invertebrate groups and the fish represent higher levels of ecological organization, or assemblages of populations considered herein to constitute *communities*. The ecological relevance of the three communities lies primarily in that they are responsible for a significant increment (virtually all) of the secondary production (animal biomass) in the aquatic

ecosystem. Thus they form a forage-base for most higher consumers in the aquatic food-web. As discussed in Subsection 2.2 and Appendix G, there is substantial evidence that aquatic-animal communities in both East and West Soldier Creek (particularly the former) are stressed. Animals in all three communities spend virtually all of their lives immersed in water and respire primarily by gaseous transfer directly across gills and/or integumentary tissues ("skin"). Benthic invertebrates, particularly the types predominating in the Operable Unit (oligochaete worms and chironomid insect larvae) live more or less continuously in direct contact with the aquatic sediments, whereas some of the fishes that might inhabit Soldier Creek (e.g., those listed in Crutcho Creek, such as bullheads and silvery minnows) are frequently in partial contact with sediments. Many of the benthic invertebrates (oligochaetes) and a few kinds of fishes ingest sediments as part of their normal feeding behavior. Other invertebrates (both communities) and some fishes feed by filtering particulate matter, including suspended sediments. Many of the fishes feed primarily on invertebrates (both communities) and/or other fishes. Thus, most of the strictly-aquatic animal inhabitants of Soldier Creek are susceptible to both direct (dermal contact, respiration) and indirect (ingestion) exposures to the COECs. But ingestion-pathway exposures to invertebrates and fishes cannot be adequately evaluated because there are insufficient toxicological data. In terms of anticipated effects, the three aquatic-animal communities include receptors that are subject to potential direct toxicity from some of the COECs -- in the form of acute (e.g., lethality) or chronic (e.g., reduced longevity, as well as impaired reproduction, development, and/or growth) responses. Because they are comprised of consumers, the aquatic-animal communities are also subject to potential indirect effects[2] in that their habitat and/or (especially) forage bases may be altered as addressed in SAEs 1.1 and 1.2. Specific assessment endpoints are established for each of the selected aquatic-animal communities as follows:

2.1 Protection of the benthic invertebrate community from direct toxicity due to exposures to sediment pore-water concentrations of aluminum, antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury,

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[2]**The reader is reminded that the terms *direct* and *indirect* are used in the contexts of both exposures and effects. Direct/indirect exposures relate to the mode of contact between the receptor and the COEC. Direct effects refer to immediate (acute) or delayed (chronic/subchronic) responses due to the receptor's exposure to the contaminant. An indirect effect is a response related to another receptor's exposure(s) to COECs. That is, the first receptor may not be directly affected by its exposure, but it might still be indirectly affected if food upon which it depends is diminished in quality or quantity.**

molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, cyanide, acetone, carbon disulfide, methylene chloride, toluene, xylenes, 1,4-dichlorobenzene, naphthalenes, PCP, phenol, 2,4-dimethylphenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, low and medium molecular weight PAHs, and benzidine, as well as indirect effects of the COECs on other ecological components.

2.2 Protection of the water-column invertebrate community from direct toxicity due to exposures to surface-water concentrations of aluminum, antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, cyanide, acetone, carbon disulfide, methylene chloride, toluene, xylenes, 1,4-dichlorobenzene, naphthalenes, PCP, phenol, 2,4-dimethylphenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, low and medium molecular weight PAHs, and benzidine, as well as indirect effects of the COECs on other ecological components.

3.1 Protection of the fish community (in East Soldier Creek and off-base sections of West Soldier Creek) from direct toxicity due to exposures to surface-water concentrations of aluminum, antimony, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, cyanide, carbon disulfide, methylene chloride, toluene, xylenes, chlorobenzene, 1,4-dichlorobenzene, naphthalenes, PCP, phenol, 2,4-dimethylphenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, low and medium molecular weight PAHs, benzidine, and TPS, as well as indirect effects of the COECs on other ecological components.

Evaluation of the terrestrial components of the Soldier Creek ecosystem will focus on several groupings based on phylogenetic affinity and trophic similarities. Owing to the tendency for many of the COECs to bioaccumulate and, in some cases, biomagnify, the assessment will address several categories of higher vertebrate (tetrapod) consumers. Relevant endpoints are based on important attributes/roles of these groups in the structure and function (integrity) of the ecosystem. Considering the available habitats and the trophic relations of some of their more prominent vertebrate inhabitants, the following receptor categories are selected: herbivorous mammals, omnivorous birds, omnivorous mammals, and carnivorous (predatory) birds. All such receptors are potentially vulnerable to indirect effects related to the toxicity of COECs to other ecological components (i.e., reduction in the quality or quantity of cover and/or food).

Essentially herbivorous mammals which have small home ranges and feed extensively on vascular plants with roots directly exposed to sediment pore water (e.g., muskrat, *Ondatra zibethicus*) are likely to be among the most vulnerable mammalian receptors to the COECs. Other herbivorous mammals (e.g., beaver, rabbits, deer) are much less vulnerable, so it is assumed that protection of a receptor such as the muskrat would ensure protection of all herbivorous mammals. Accordingly, a SAE is established as follows:

4.1 Protection of herbivorous mammals from direct toxicity due to ingestion of aquatic plant tissues, sediment, and surface water containing cadmium, chromium, cobalt, lead, mercury, molybdenum, nickel, silver, antimony, arsenic, selenium, cyanide, PCP, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), high molecular weight PAHs, and benzidine, as well as indirect effects of the COECs on other ecological components.

Omnivorous birds, particularly those that have small home ranges and exhibit territorial nesting in close proximity to the streams (e.g., red-winged blackbird, *Agelaius phoeniceus*), are likely to be the most vulnerable of the avian species to contaminants which have a propensity to accumulate in plants and/or aquatic invertebrates, such as the larvae of emergent insects (e.g., chironomids). Other omnivorous birds (i.e., those with larger home ranges and/or more catholic diets) are much less vulnerable, so it is assumed that protection of a receptor such as the red-winged blackbird would ensure protection of all other omnivorous birds. Accordingly, a SAE is established as follows:

5.1 Protection of omnivorous birds from direct toxicity due to ingestion of aquatic plant tissues and aquatic animal tissues (i.e., emerged terrestrial stages), and surface water containing cadmium, chromium, cobalt, lead, mercury, nickel, silver, arsenic, selenium, cyanide, PCBs, organochlorine pesticides, and high molecular weight PAHs, as well as indirect effects of the COECs on other ecological components.

Since the Operable Unit is seldom visited (if ever) by large mammalian predators other than feral "domesticated" forms (dogs/cats), it is likely that an omnivorous species, such as the raccoon (*Procyon lotor*), would be the only mammal that would prey significantly upon aquatic organisms that have accumulated COECs in their tissues. Accordingly, a SAE is established as follows:

5.2 Protection of omnivorous mammals from direct toxicity due to ingestion of aquatic plant tissues, aquatic and semiaquatic animal tissues, sediment, and surface water containing cadmium, chromium, cobalt, lead, mercury, molybdenum, nickel, silver, antimony, arsenic, selenium, cyanide, PCP, PCBs, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), high molecular weight PAHs, and benzidine, as well as indirect effects of the COECs on other ecological components.

Wading birds that rely heavily on larger aquatic organisms for food represent another category of particularly vulnerable receptors. Such birds (e.g., green heron, *Butorides virescens*) are likely to be the main avian carnivores for which crayfish, fish, and other small animals in intimate contact with the creeks (e.g., amphibians and reptiles) are a food source. Accordingly, a SAE is established as follows:

6.1 Protection of carnivorous (predatory) birds from direct and indirect toxicity due to ingestion of aquatic and semiaquatic animal tissues, sediment, and surface water containing cadmium, chromium, cobalt, lead, mercury, nickel, silver, antimony, arsenic, selenium, cyanide, PCBS, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), and high molecular weight PAHs, as well as indirect effects of the COECs on other ecological components.

In terms of ingestion-pathway exposures, certain amphibians and/or reptiles are perhaps the most vulnerable of all terrestrial/semiaquatic vertebrates. Either the bullfrog (*Rana catesbaeiana*) or the common snapping turtle (*Chelydra serpentina*) would probably be the best representatives of tertiary/quaternary consumers in the Operable Unit. However, there are insufficient toxicological data available to properly evaluate dietary doses to either amphibians or reptiles. Since larval amphibians (tadpoles) are members of the nekton community, and somewhat similar, physiologically, to the fishes (at least herbivorous fishes), SAE 3.1 (Protection of Fish Community) will address this concern to a certain degree.

Microbial decomposer communities are important components of aquatic ecosystems because bacteria and fungi provide a critical mechanism for transfer of energy to certain primary consumers (i.e., detritivores, such as some insect larvae [certain chironomids] and some fish and larval amphibians). Accordingly, a SAE is established as follows:

7.1 Protection of microbial decomposers (bacteria/fungi) from direct toxicity due to aqueous concentrations of chromium, copper, lead, nickel, silver, and zinc.

2.3.2 Testable Hypotheses

Based on the characteristics of the COECs and the specific assessment endpoints identified for Soldier Creek, the following general questions (hypotheses) are posed for evaluation in this EA:

- Are concentrations of aluminum, antimony, arsenic, barium, cadmium, chromium, copper, cyanide, iron, lead, manganese, mercury, nickel, silver, zinc, selenium, acetone, carbon disulfide, toluene, PCP, PCBs, dieldrin, and PAHs in surface waters of East and West Soldier Creek sufficiently elevated to impair the structure and integrity of algal communities? [SAE 1.1]

- Are concentrations of aluminum, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, vanadium, zinc, arsenic, selenium, 2,4-dimethylphenol, and PCP in sediment pore-waters of East and West Soldier Creek sufficiently elevated to impair the structure and integrity of aquatic vascular plant communities? [SAE 1.2]

- Are concentrations of aluminum, antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, cyanide, acetone, carbon disulfide, methylene chloride, toluene, xylenes, 1,4-dichlorobenzene, naphthalenes, 2,4-dimethylphenol, PCP, phenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, all PAHs, and benzidine in sediment pore-waters of East and West Soldier Creek sufficiently elevated to impair the structure and integrity of benthic invertebrate communities? [SAE 2.1]

- Are benthic invertebrates indirectly affected by the toxicity of COECs to aquatic primary producers and/or microbial decomposers? [SAE 2.1]

- Are concentrations of aluminum, antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, cyanide, acetone, carbon disulfide, methylene chloride, toluene, xylenes, 1,4-dichlorobenzene, naphthalenes, 2,4-dimethylphenol, PCP, phenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, all PAHs, and benzidine in surface waters of East and West Soldier Creek sufficiently elevated to impair the structure and integrity of water-column invertebrate communities? [SAE 2.2]

- Are water-column invertebrates indirectly affected by the toxicity of COECs to aquatic primary producers and/or microbial decomposers? [SAE 2.2]

- Are concentrations of aluminum, antimony, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, carbon disulfide, methylene chloride, cyanide, toluene, xylenes, chlorobenzene, 1,4-dichlorobenzene, naphthalenes, PCP, phenol, 2,4-dimethylphenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, low and medium molecular weight PAHs, benzidine, and TPS in surface waters of East Soldier Creek and off-base sections of West Soldier Creek sufficiently elevated to impair the structure and integrity of fish communities? [SAE 3.1]

- Are fish communities indirectly affected by the toxicity of COECs to other aquatic ecological components? [SAE 3.1]

- Are concentrations of cadmium, chromium, cobalt, lead, mercury, molybdenum, nickel, silver, antimony, arsenic, selenium, cyanide, PCP, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), high molecular weight PAHs, and benzidine in surface water, bulk sediments, and aquatic vascular plant tissues of East and West Soldier Creek sufficiently elevated to impair the survival, reproduction, development and/or growth of herbivorous mammals? [SAE 4.1]

- Are herbivorous mammals indirectly affected by the toxicity of COECs to aquatic primary producers? [SAE 4.1]

- Are concentrations of cadmium, chromium, cobalt, lead, mercury, nickel, silver, arsenic, selenium, cyanide, PCBs, organochlorine pesticides, and high molecular weight PAHs in surface water, bulk sediments, and biological tissues in East and West Soldier Creek sufficiently elevated to impair the survival, reproduction, development, and/or growth of omnivorous birds? [SAE 5.1]

- Are omnivorous birds indirectly affected by the toxicity of COECs to aquatic vascular plants, benthic invertebrates, and/or water-column invertebrates? [SAE 5.1]

- Are concentrations of cadmium, chromium, cobalt, lead, mercury, molybdenum, nickel, silver, antimony, arsenic, selenium, cyanide, PCP, PCBs, organochlorine pesticides (other than BHCs and methoxychlor), high molecular weight PAHs, and benzidine in surface water, bulk sediments, and biological tissues in East and West Soldier Creek sufficiently elevated to

impair the survival, reproduction, development, and/or growth of omnivorous mammals? [SAE 5.2]

- Are omnivorous mammals indirectly affected by the toxicity of COECs to aquatic vascular plants, benthic invertebrates, water-column invertebrates, and/or fish? [SAE 5.2]

- Are concentrations of cadmium, chromium, cobalt, lead, mercury, nickel, silver, antimony, arsenic, selenium, cyanide, PCBs, organochlorine pesticides (other than BHCs and methoxychlor), and high molecular weight PAHs in surface water, bulk sediments, and animal tissues in East and West Soldier Creek sufficiently elevated to impair the survival, reproduction, development, and/or growth of carnivorous birds? [SAE 6.1]

- Are carnivorous birds indirectly affected by the toxicity of COECs to benthic invertebrates, water-column invertebrates, and/or fish? [SAE 6.1]

- Are concentrations of chromium, copper, lead, nickel, silver, and zinc in surface waters of East and West Soldier Creek sufficiently elevated to impair the survival of microbial decomposers? [SAE 7.1]

The more appropriate scientific (i.e., truly "testable") configuration of each of the foregoing questions would be as a pair of null and alternative hypotheses. For example:

H_o: *Concentrations of* _____ [appropriate COECs] *in surface waters of East and West Soldier Creek are not sufficiently elevated to impair the survival of microbial decomposers.*

H_a: *Concentrations of* _____ [appropriate COECs] *in surface waters of East and West Soldier Creek are sufficiently elevated to impair the survival of microbial decomposers.*

2.3.3 Conceptual Models and Measurement Endpoints

None of the 10 ecological values established as specific assessment endpoints is directly measurable in quantitative terms, at least within the time scale available for remedial decision making. Information gathered during the ecological field sampling activities, together with relevant toxicological data from the literature, provides conceptual exposure/response scenarios that are related to the specific assessment endpoints.

2.3.3.1 Protection of Aquatic Primary Producers

There are three measurement endpoints related to SAEs 1.1 and 1.2:

M1.1.1 Is survival of sensitive algae potentially reduced as a result of individual or additive direct exposures to surface-water concentrations of aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, zinc, selenium, acetone, carbon disulfide, 1,4-dichlorobenzene, DEHP, PCP, PCBs, dieldrin, and PAHs? This measurement endpoint will be evaluated by comparison of location-specific surface-water concentrations to a range of appropriate, literature-based toxicity reference values (TRVs; also aqueous concentrations) for sensitive algal species using a quotient approach which produces a ratio that is deterministic rather than a measurement *per se*. The individual hazard quotients (HQs) for the respective COECs will be also be summed to produce a similar deterministic ratio, the hazard index (HI), to evaluate potential additive effects.

M1.2.1 Is survival of sensitive aquatic vascular plants reduced as a result of individual or additive direct exposures (via roots) to bulk-sediment pore-water concentrations of PCP and 2,4-dimethylphenol? This measurement endpoint will be evaluated using the quotient approach described above, with estimated pore-water concentrations and TRVs related to sensitive aquatic macrophytes.

M1.2.2 Is survival of sensitive aquatic vascular plants reduced as a result of individual or additive direct exposures (via roots) to bulk-sediment concentrations of aluminum, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, vanadium, zinc, arsenic, and selenium? This measurement endpoint will be evaluated using the quotient approach described above, with bulk-sediment concentrations[3] and TRVs related to sensitive aquatic macrophytes.

2.3.3.2 Protection of Aquatic Invertebrate Communities

There are nine measurement endpoints related to SAEs 2.1 and 2.2:

[3]**There is no reliable method for estimating sediment pore-water concentrations of inorganic COECs.**

M2.1.1 Are survival, reproduction, development, and/or growth of sensitive benthic invertebrates reduced as a result of individual or additive direct exposures to sediment pore-water concentrations of acetone, methylene chloride, toluene, xylenes, 1,4-dichlorobenzene, naphthalenes, PCP, phenol, 2,4-dimethylphenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, low and medium molecular weight PAHs, and benzidine? This measurement endpoint will be evaluated using the quotient approach described above, with estimated pore-water concentrations and TRVs related to sensitive aquatic invertebrates.

M2.1.2 Are survival, reproduction, development, and/or growth of sensitive benthic invertebrates reduced as a result of individual or additive direct exposures to bulk-sediment concentrations of aluminum, antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, and cyanide? This measurement endpoint will be evaluated using the quotient approach described above, with bulk-sediment concentrations (see footnote on previous page) and TRVs related to sensitive aquatic invertebrates.

M2.1.3 Are survival, reproduction, and/or growth of sensitive benthic invertebrates reduced as a result of direct exposure to sediments, pore-water, and overlying surface water from selected locations in Soldier Creek? This measurement endpoint will be evaluated through the results of laboratory bulk-sediment toxicity testing, as described in Subsection 3.3.

M2.1.4 Are survival, reproduction, and/or growth of benthic invertebrates reduced as an indirect result of the toxicity of COECs to other ecological components (primary producers and microbial decomposers). This measurement endpoint will be evaluated qualitatively by reviewing the results of measurement endpoints related to SAEs 1.1, 1.2, and 7.1.

M2.1.5 Is the diversity (a reflection of the structure and integrity) of benthic invertebrate communities in selected portions of East and West Soldier Creek reduced in comparison with that of similar streams in the region? This measurement endpoint will be evaluated using results of the benthic invertebrate surveys performed in October 1994 and June 1995, as described in Section 3.0.

M2.2.1 Are survival, reproduction, development, and/or growth of water-column invertebrates reduced as a result of individual or additive direct exposures to surface-water concentrations of aluminum, antimony, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, cyanide, acetone, carbon disulfide, methylene chloride, toluene, xylenes, 1,4-dichlorobenzene, naphthalenes, PCP, phenol, 2,4-dimethylphenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, low and medium molecular weight PAHs, and benzidine? This measurement endpoint will be evaluated using the quotient approach described above, with surface-water concentrations and TRVs related to sensitive aquatic invertebrates.

M2.2.2 Are survival, reproduction, and/or growth of sensitive aquatic invertebrates reduced as a result of direct exposure to sediments, pore-water, and overlying surface water from selected locations in Soldier Creek? This measurement endpoint will be evaluated through the results of laboratory bulk-sediment toxicity testing, as described in Subsection 3.3.

M2.2.3 Are survival, reproduction, and/or growth of water-column invertebrates reduced as an indirect result of the toxicity of COECs to other ecological components (primary producers and microbial decomposers). This measurement endpoint will be evaluated qualitatively by reviewing the results of measurement endpoints related to SAEs 1.1, 1.2, and 7.1.

M2.2.4 Is the diversity (a reflection of the structure and integrity) of water-column invertebrate communities in selected portions of East and West Soldier Creek reduced in comparison with that of similar streams in the region? This measurement endpoint will be evaluated using results of the benthic invertebrate surveys performed in October 1994 and June 1995, as described in Section 3.0.

2.3.3.3 Protection of Fish Communities

There are four measurement endpoints related to SAE 3.1:

M3.1.1 Are survival, reproduction, development, and/or growth of sensitive fishes reduced as a result of individual or additive direct exposures to surface-water concentrations of aluminum, antimony, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, vanadium, zinc, arsenic, selenium, cyanide, acetone, carbon disulfide,

methylene chloride, toluene, xylenes, chlorobenzene, naphthalenes, 1,4-dichlorobenzene, PCP, phenol, 2,4-dimethylphenol, nonylphenol, DEHP, PCBs, organochlorine pesticides, low and medium molecular weight PAHs, benzidine, and TPS? This measurement endpoint will be evaluated using the quotient approach described above, with surface-water concentrations and TRVs related to sensitive fishes.

M3.1.2 Are survival, reproduction, and/or growth of sensitive fishes reduced as a result of direct exposure to surface water from selected locations in Soldier Creek? This measurement endpoint will be evaluated through the results of laboratory surface-water toxicity testing, as described in Subsection 3.3.

M3.1.3 Are survival, reproduction, and/or growth of fish reduced as an indirect result of the toxicity of COECs to other ecological components (primary producers, aquatic invertebrates, and microbial decomposers). This measurement endpoint will be evaluated qualitatively by reviewing the results of measurement endpoints related to SAEs 1.1, 1.2, 2.1, 2.2, 2.3, and 7.1.

M3.1.4 Is the diversity (a reflection of the structure and integrity) of fish communities in selected portions of East and West Soldier Creek reduced in comparison with that of similar streams in the region? This measurement endpoint will be evaluated using results of the fish population surveys performed in October 1994 and June 1995, as described in Section 3.0.

2.3.3.4 Protection of Terrestrial Herbivorous Vertebrates

There are two measurement endpoints related to SAE 4.1/4.2:

M4.1.1 Are survival, reproduction, development, and/or growth of herbivorous mammals reduced as a result of ingesting aquatic plant tissues, sediments, and surface water containing cadmium, chromium, cobalt, lead, mercury, molybdenum, nickel, silver, antimony, arsenic, selenium, cyanide, PCP, PCBs, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), high molecular weight PAHs, and benzidine? This measurement endpoint will be evaluated using the quotient method described above, with estimated exposures and TRVs (based on mammalian toxicity data) in the form of doses (rates).

M4.1.2 Are survival, reproduction, and/or growth of herbivorous mammals reduced as an indirect result of the toxicity of COECs to other ecological components (primary producers). This measurement endpoint will be evaluated qualitatively by reviewing the results of measurement endpoints related to SAEs 1.1 and 1.2.

2.3.3.5 Protection of Terrestrial Omnivorous Vertebrates

There are four measurement endpoints related to SAEs 5.1 and 5.2:

M5.1.1 Are survival, reproduction, development, and/or growth of omnivorous birds reduced as a result of ingesting aquatic plant tissues, aquatic animal tissues, and surface water containing cadmium, chromium, cobalt, lead, mercury, nickel, silver, arsenic, selenium, cyanide, PCBs, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), high molecular weight PAHs, and benzidine? This measurement endpoint will be evaluated using the quotient method described above, with estimated exposures and TRVs (based on avian toxicity data or converted mammalian values) in the form of doses (rates).

M5.1.2 Are survival, reproduction, and/or growth of omnivorous birds reduced as an indirect result of the toxicity of COECs to other ecological components (aquatic vascular plants, aquatic invertebrates). This measurement endpoint will be evaluated qualitatively by reviewing the results of measurement endpoints related to SAEs 1.2, 2.1, and 2.2.

M5.2.1 Are survival, reproduction, development, and/or growth of omnivorous mammals reduced as a result of ingesting aquatic plant tissues, aquatic and semiaquatic animal tissues, sediments, and surface water containing cadmium, chromium, cobalt, lead, mercury, molybdenum, nickel, silver, antimony, arsenic, selenium, cyanide, PCP, PCBs, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), high molecular weight PAHs, and benzidine? This measurement endpoint will be evaluated using the quotient method described above, with estimated exposures and TRVs (based on mammalian toxicity data) in the form of doses (rates).

M5.2.2 Are survival, reproduction, and/or growth of omnivorous mammals reduced as an indirect result of the toxicity of COECs to other ecological components (aquatic vascular plants, aquatic invertebrates, fish). This measurement endpoint will be evaluated qualitatively by

reviewing the results of measurement endpoints related to SAEs 1.2, 2.1, 2.2, and 3.1.

2.3.3.6 Protection of Carnivorous Vertebrates

There are two measurement endpoints related to SAEs 6.1:

M6.1.1 Are survival, reproduction, development, and/or growth of carnivorous (predatory) birds reduced as a result of ingesting aquatic and semiaquatic animal tissues, sediment, and surface water containing cadmium, chromium, cobalt, lead, mercury, nickel, silver, antimony, arsenic, selenium, cyanide, PCBs, organochlorine pesticides (excluding alpha/delta BHC and methoxychlor), and high molecular weight PAHs? This measurement endpoint will be evaluated using the quotient method described above, with estimated exposures and TRVs (based on avian toxicity data or converted mammalian values) in the form of doses (rates).

M6.1.2 Are survival, reproduction, and/or growth of piscivorous birds reduced as an indirect result of the toxicity of COECs to other ecological components (aquatic invertebrates, fish). This measurement endpoint will be evaluated qualitatively by reviewing the results of measurement endpoints related to SAEs 2.1, 2.2, and 3.1.

2.3.3.7 Protection of Aquatic Microbial Decomposers

There is one measurement endpoint related to SAE 7.1:

M7.1.1 Is survival of sensitive bacteria or fungi reduced as a result of individual or additive direct exposures to surface-water concentrations of chromium, copper, lead, nickel, silver, and zinc? This measurement endpoint will be evaluated using the quotient approach described above, with surface-water concentrations and TRVs related to sensitive microbial test organisms (insofar as available).

2.3.4 Endpoint Summary

As organized above and summarized in Table 2-11, there are 25 measurement endpoints related to 10 specific assessment endpoints (SAEs), that in turn address seven general

assessment endpoints which reflect fundamental, ecologically-relevant issues (GAEs). The 25 measurement endpoints are established primarily for editorial reasons (to avoid proliferation of text); however, it should be noted that there are actually more than 200 *individual* measurement endpoints when one considers that some level of evaluation (i.e., interpretation of a deterministic ratio [HQ]) will be performed for each potential direct response associated with the respective COEC/receptor/pathway scenarios[4]. It is acknowledged in foregoing text that the deterministic ratios derived through the quotient approach, hazard quotients and indices (HQs, HIs), are not measurements *per se*. Nevertheless, it is common practice to interpret the ratios as if they have some "quantitative" relevance (see Section 5.0; also USEPA [1992], Suter [1993], and ERAGs). Use of the ratios is merely a rhetorical or editorial means by which the *magnitude* of the exposure (an environmental concentration or a dose) is compared with a *level* known or predicted to be associated with a particular response. The exposure concentrations (or doses) and the TRVs *are* measured or estimated values, and it is these measurements or estimates that are actually being evaluated.

[4] Note that the COECs evaluated for the respective assessment endpoints vary, as summarized in Tables 2-10 and 2-11.

TABLE 2-1

SUMMARY OF MAJOR HABITATS ASSOCIATED WITH SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT

Study Section	Aquatic Habitat	Riparian Terrestrial Habitat
	East Soldier Creek	
EE01	Narrow, deep, steep-sided channel (banks undercut in several areas); moderate current through a series of runs and pools; substrate mainly bedrock (sandstone), overlain with gravel and coarse to medium sand in several locations; no aquatic vegetation.	Dense forest; overstory dominated by elm, oaks, maples, and hackberry; understory a mixture of honeysuckle, grasses, blackberry, and bush poison ivy.
EE02 (Outfall G)		
EE03		
EE04	Ponded area with gently sloping banks; slow to imperceptible flow; broad shallow portion in upper portion of EE04, deepening into elongate pool (generally about 6 ft deep along midline); basically a depositional area with thick organically-rich silt/fine sand sediments; cattail marsh fringing (and encroaching into) upper portion, with mat of smartweed in shallow channel; cattails along lower pool of EE05 and a portion of west shore of EE06.	Landscaped; mowed lawns with scattered trees (cottonwood, elm, oaks).
EE05 (Outfall F)		
EE06		
EE07	Broad, shallow channel (divided by island in most of EE07) with gently-sloping banks; moderate flow over gravel, sand, silt substrates; margins and island dominated by cattail marsh, with occasional patches of smartweed.	
EE08		
EE09	Narrow, deeply-incised channel between steep clay banks; sluggish to moderate flow through alternating pools, runs, and riffles; occasional bedrock exposure, but substrates primarily gravel, sand, and silt; large amounts of anthropogenic debris/trash; no aquatic vegetation (except few cattails around pool at Douglas Boulevard.	Mainly second- or third-growth hardwood forest, dominated by oaks, hickory, elm, and hackberry. Upper portion (much of EE09) with narrow band of thicket along stream and open fields or landscaped residential lots.
EE10		

TABLE 2-1

SUMMARY OF MAJOR HABITATS ASSOCIATED WITH SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT

Study Section	Aquatic Habitat	Riparian Terrestrial Habitat
	West Soldier Creek	
EW01	Narrow, braided channel with thick organically-rich sediments; intermittent or sluggish flow (except during storm events) through thick cattail and spikerush marsh with intermixture of small black willows and cottonwoods.	Open fields with extensive disturbed areas (particularly along east bank), dominated by grasses and forbs.
EW02	Shallow, moderately-incised channel; normally trickling flow over bedrock, gravel, sand, and concrete rubble; small pool above spill control weir with some depositional sediment and few cattails.	Mainly streamside forest, dominated by elm, oaks, boxelder, and black willow; understory mainly bush poison ivy and privet. Beyond to north is mowed I-40 right-of-way and to south are open fields.
EW03		

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
PLATYHELMINTHES	F	F,S	F,S				S				F,S	F,S	F,S		
NEMATODA	S	F	F,S	F,S	F,S	F,S	F,S	F,S	F,S	S	F,S	F,S	F,S	F	S
ANNELIDA															
Hirudinea					F										
Oligochaeta															
Naididae															
Bratislavia unidentata															S
Dero digitata	S	S			S	S			S	S	S	S			S
Dero lodeni	F	F,S	F	F	F	F	F,S	F,S	F,S	F	F,S	F,S	F,S	F	
Dero nevia						F									
Dero obtusa		S							S						
Dero sp.		S			S		S	S	S	S	S	S	S		S
Nais pardalis															S
Nais variabilis						F	F	F		S		S	F		
Pristina leidyi														F	
Pristina synclites												F	F	F	

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
Pristina sp.												S	S		S
Pristinella sp.															S
Tubificidae															
Aulodrilus pigueti						S	F,S			S					
Branchiura sowerbyi															S
Ilyodrilus templetoni				F,S	F,S	F,S	F,S		S		F				
Limnodrilus cervix				S		S									S
Limnodrilus hoffmeisteri		S		F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F	S
Limnodrilus tortilipenis														F	
Limnodrilus udekemianus															S
Tubifex tubifex											S	S			
Immature bifids	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F	S
Immature w/hair/pectinate	F,S			F,S	F,S	F,S	F,S	S	S		F,S	F,S	S	F	S
Enchytraeidae	S	F,S	F,S	S			S				F	F	F,S		S
Megadrili (Large semiaquatic worms)	S	S										S	S		S
MOLLUSCA															

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
Gastropoda (*Physella*)			F	F	S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F,S	F	S
Pelecypoda															
Corbiculidae (*Corbicula*)															S
Sphaeriidae							S								S
Unionidae (*Toxolasma*)															S
ARTHROPODA															
Crustacea															
Ostracoda					F	F	F,S				F	F,S	F,S		
Isopoda								F							
Decapoda (*Orconectes*)								F							S
Arachnida (Hydracarina)														F	
Insecta															
Collembola (springtails)	S	S	S	F,S	S						S	F,S	S	F	S
Hemiptera (bugs)															
Notonectidae (water striders)				F											
Corixiidae (water boatmen)					S										

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
Herbridae (*Hebrus*)											S				
Belostomatidae (*Belostoma*)											S				
Coleoptera (beetles)			F												
Curculionidae (weevils)				F											
Dytiscidae (diving beetles)		F		F	S	F					S			F	
Copelatus											S				
Hydroporus															S
Elmidae (*Stenelmis*)															S
Haliplidae (*Peltodytes*)												S	S		
Hydrophilidae				F										F	
Berosus												S			
Enochrus												S			
Heloechares											S				
Odonata (odonates)															
Coenagrionidae (damselflies)															
Argia		F					F	F		F			F	F	

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
Argiallagma				F	F	S			S		S	S	S		
Coenagrion								F	F	F	F	F	F	F	
Enallagma					S	F	F				F	F			
Lestidae (damselflies)															
Archilestes	F		S	F											
Lestes	F		F									F,S			
Aeshnidae (dragonflies)												F	F		
Gomphidae (dragonflies)										F			F		
Libellulidae (dragonflies)															
Erythemis														F	
Orthemis				F								F			
Sympetrum				F	F			F			F				
Unid. early instars		F									F	F	F	F	
Ephemeroptera (mayflies)															
Caenidae (*Caenis*)														F	S
Baetidae (*Baetis*)											F	F,S	F		

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
Lepidoptera (aquatic moths)													F		
Diptera (flies, etc.)															
Ceratopogonidae				F,S	F	F,S	F,S	F	F		S	F,S		F	S
Chironomidae (larvae)															
Ablabesmyia							F	F		S		F	F	F	S
Chironomus	F	F		F	F			F		F	F,S	F,S	F	F	
Clinotanypus												S			
Conchapelopia															S
Cricotopus	S		S	F,S	F,S	S	F,S	S		S	F,S	F,S	F,S	F	S
Cryptochironomus												F		F	S
Dicrotendipes	F										F	F	F	F	
Endochironomus												F	F		
Eukiefferiella											F	F			
Goeldichironomus					F						F,S		F	F	
Fittkauimyia	F		F	F			F,S					F	F		
Larsia					F						F,S	F,S	F,S	F	S

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
Microspectra												S	S		
Nanocladius					F										S
Natarsia					S						S				
Orthocladius														F	
Paracricotopus				F											
Paratanytarsus												S	S		
Polypedilum			F	F	F	F		F		F		F	F	F	S
Procladius				F	F		F					S			
Psectrotanypus				F								S			
Pseudosmittia											S	S			
Smittia												S			
Strictochironomus													S		S
Tanypus			F	F	F	F,S	S	F,S	F,S			F,S			
Tanytarsus							S								
Thienemanniella															S
Chironomid pupae			S	F,S	F,S	S	F,S	F,S		F,S	F,S	F,S	F,S		S

TABLE 2-2

SUMMARY OF BENTHIC INVERTEBRATE TAXA OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Group	East Soldier Creek										West Soldier Creek			Reference Streams	
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	W1	W2	W3	1994	1995
Canaceidae															S
Culicidae (mosquitoes)		S			F						F,S		S		
Dolichopodidae											S		F		S
Empididae													F		S
Ephydridae											S		F		
Muscidae											S	S			
Psychodidae											S	S			
Stratiomyidae		S									S				
Syrphidae											S				
Tipulidae					S						S				S
Tabanidae										F	F		F		
TOTAL TAXA	15	17	15	26	30	21	24	20	45	18	44	50	42	28	39
EXCLUSIVE TAXA	0	0	1	3	2	1	1	1	0	0	5	4	1	5	12

F = Fall (10/94); S = Spring (6/95)

TABLE 2-3

SUMMARY OF TERRESTRIAL AND SEMIAQUATIC VERTEBRATES OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Species	Stream Section of Group of Sections With Similar Habitat					
	EE01-EE03	EE04-EE08	EE09-EE10	EWO1	EW02-EWO3	Reference Streams
AMPHIBIANS						
Bufo sp. (toad, tadpoles only)					*	*
Acris crepitans (cricket frog)		*		*		
Rana catesbeiana (bullfrog)		*				*
Rana areolata (crawfish frog)		*				
Rana pipiens (leopard frog)		*				
REPTILES						
Chelydra serpentina (snapping turtle)	*	*	*			
Chrysemys scripta (red-eared turtle)	*	*	*			*
Deirochelys reticularia (chicken turtle)		*				
Terrapene carolina (box turtle)			*			
Trionyx spinifer (spiny softshell turtle)		*				*
Storeria dekayi (brown snake)				*		
Nerodia erythrogaster (blotched water snake)						*

TABLE 2-3

SUMMARY OF TERRESTRIAL AND SEMIAQUATIC VERTEBRATES OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Species	Stream Section of Group of Sections With Similar Habitat					
	EE01-EE03	EE04-EE08	EE09-EE10	EWO1	EW02-EWO3	Reference Streams
Nerodia sipedon (northern water snake)		*	*			
BIRDS						
Fulica americana (American coot)		*				
Casmerodius albus (great egret)		*				*
Egretta thula (snowy egret)						*
Nyctanassa violacea (yellow-crowned night heron)		*				
Butorides virescens (green heron)		*				
Charadrius vociferus (killdeer)		*		*		
Ictinia mississippiensis (Mississippi kite)						*
Buteo jamaicensis (red-tailed hawk)	*		*	*		*
Columba livia (rock dove)				*	*	
Zenaida macroura (mourning dove)	*					*
Chordeiles minor (nightawk)						*
Colaptes auratus (common flicker)						*

TABLE 2-3

SUMMARY OF TERRESTRIAL AND SEMIAQUATIC VERTEBRATES OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Species	Stream Section of Group of Sections With Similar Habitat					
	EE01-EE03	EE04-EE08	EE09-EE10	EWO1	EW02-EWO3	Reference Streams
Megaceryle alcyon (belted kingfisher)						*
Melanerpes carolinus (red-bellied woodpecker)			*			*
Picoides pubescens (downy woodpecker)			*			
Muscivora forficata (scissor-tailed flycatcher)	*	*			*	
Tyrannus tyrannus (eastern kinghird)	*	*				*
Contopus virens (eastern pewee)	*					
Riparia riparia (bank swallow)	*			*		
Corvus brachrhynchos (American crow)	*	*	*		*	*
Cyanocitta cristata (bluejay)	*	*	*		*	*
Parus carolinensis (Carolina chickadee)	*					*
Parus bicolor (tufted titmouse)	*					
Thryothorus ludovicianus (Carolina wren)		*				*
Regulus satrapa (golden-crowned kinglet)						*
Toxostoma rufum (brown thrasher)	*					*

TABLE 2-3

SUMMARY OF TERRESTRIAL AND SEMIAQUATIC VERTEBRATES OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Species	Stream Section of Group of Sections With Similar Habitat					
	EE01-EE03	EE04-EE08	EE09-EE10	EWO1	EW02-EWO3	Reference Streams
Mimus polyglottos (northern mockingbird)	*					*
Myadestes townsendi (Townsend's solitaire)						*
Turdus migratorius (American robin)		*				*
Agelaius phoeniceus (red-winged blackbird)		*	*	*		
Molothrus ater (brown-headed cowbird)		*				*
Quiscalus quiscula (common grackle)			*		*	*
Quiscalus major (boat-tailed grackle)		*				
Dolichonyx oryzivorus (bobolink)	*					
Sturnella magna (eastern meadowlark)				*		*
Sturnus vulgaris (European starling)	*	*	*		*	
Cardinalis cardinalis (cardinal)	*		*			*
Pipilio erythrophthalmus (rufous-sided towhee)		*	*			*
Melospiza georgiana (swamp sparrow)		*		*		
Ammodramus savannarum (grasshopper sparrow)						*

TABLE 2-3

SUMMARY OF TERRESTRIAL AND SEMIAQUATIC VERTEBRATES OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Species	Stream Section of Group of Sections With Similar Habitat					
	EE01-EE03	EE04-EE08	EE09-EE10	EWO1	EW02-EWO3	Reference Streams
MAMMALS						
Didelphis virginiana (Virginia opossum)						*
Marmota monax (woodchuck)			*			
Sciurus carolinensis (gray squirrel)	*				*	
Sciurus niger (eastern fox squirrel)						*
Geomys bursarius (plains pocket gopher)	*				*	
Peromyscus maniculatus (deer mouse)				*		
Sigmodon hispidus (hispid cotton rat)				*		
Microtus ochrogaster (prairie vole)				*		
Ondatra zibethicus (muskrat)	*	*		*		*
Castor canadensis (beaver)	*	*	*			*
Lepus californicus (blacktail jackrabbit)				*		
Sylvilagus floridanus (eastern cottontail)	*	*	*	*		*
Procyon lotor (raccoon)			*		*	*

TABLE 2-3

SUMMARY OF TERRESTRIAL AND SEMIAQUATIC VERTEBRATES OBSERVED IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM, OKLAHOMA, 1994/1995

Species	Stream Section of Group of Sections With Similar Habitat					
	EE01-EE03	EE04-EE08	EE09-EE10	EWO1	EW02-EWO3	Reference Streams
Canis latrans (coyote)					*	
Odocoileus virginianus (whitetail deer)			*			

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Aluminum	7429905	163	163	55800	mg/kg	59.2	10.5	NA		*(B)
Antimony	7440360	163	14	9.8	mg/kg	35.5	6.3	2	NYS	Yes
Arsenic	7440382	163	161	9	mg/kg	12.9	0.52	6	MOE-L	Yes
Barium	7440393	163	163	4700	mg/kg	5.9	1	20	ORNL	Yes
Beryllium	7440417	163	124	1.9	mg/kg	1.2	0.21	5.3	ORNL	No
Cadmium	7440439	163	134	415	mg/kg	3	0.52	0.6	ORNL	Yes
Calcium	7440702	163	163	270000	mg/kg	118	20.9	NA	CS	No
Chromium	7440473	163	163	3210	mg/kg	5.9	1	26	MOE-L	Yes
Cobalt	7440484	163	155	134	mg/kg	5.9	1	20	NSQT	Yes
Copper	7440508	163	163	2400	mg/kg	11.8	2.1	16	MOE-L	Yes
Cyanide	5955700	163	2	6.2	mg/kg	1.2	0.57	0.1	MOE-L	Yes
Iron	7439896	163	163	37100	mg/kg	59.2	10.5	20000	NYS	Yes
Lead	7439921	163	151	4400	mg/kg	29.6	5.2	31	MOE-L	Yes
Magnesium	7439954	163	163	30600	mg/kg	118	20.9	NA	CS	No
Manganese	7439965	163	163	4250	mg/kg	5.9	1	460	MOE-L	Yes
Molybdenum	7439987	163	91	97	mg/kg	11.8	2.1	10	NSQT	Yes
Nickel	7440020	163	162	4170	mg/kg	23.7	4.2	16	MOE-L	Yes
Potassium	7440097	163	148	4880	mg/kg	2960	523	NA	CS	No
Selenium	77824892	163	39	12	mg/kg	4.8	0.55	1.6	MOE-L	Yes
Silver	7440224	163	94	205	mg/kg	5.9	1	0.5	MOE-L	Yes
Sodium	7440235	163	34	2680	mg/kg	2690	523	NA	CS	No
Thallium	7440280	163	16	0.38	mg/kg	6.4	0.52	9.6*	Eqp	No
Vanadium	7440622	163	163	95.7	mg/kg	5.9	1	2.2	NSQT	Yes
Zinc	7440666	163	163	1790	mg/kg	11.8	2.1	5.9	NOAA (fw)	Yes
Mercury	7439976	163	77	0.95	mg/kg	0.33	0.1	0.08	NOAA (fw)	Yes
4,4'-DDD	72548	163	0	ND	ug/kg	16000	3.5	63	ORNL	*(D)
4,4'-DDE	72559	163	0	ND	ug/kg	16000	3.5	5	MOE-L	*(D)
4,4'-DDT	50293	163	0	ND	ug/kg	16000	3.5	745	ORNL	*(D)
Aldrin	309002	163	28	840	ug/kg	8100	1.8	0.2	NSCSI	Yes
Aroclor 1016	12674112	163	0	ND	ug/kg	160000	35	7	MOE-L	Yes
Aroclor 1221	11104282	163	0	ND	ug/kg	160000	35	28.27	ORNL	Yes
Aroclor 1232	11141165	163	0	ND	ug/kg	160000	35	56.54	ORNL	Yes
Aroclor 1242	53469219	163	0	ND	ug/kg	160000	35	6.28	ORNL	Yes
Aroclor 1248	12672296	163	0	ND	ug/kg	160000	35	1.05	ORNL	Yes
Aroclor 1254	11097691	163	102	40000	ug/kg	160000	35	0.14	NSQT (Total PCB)	Yes
Aroclor 1260	11096825	163	1	740	ug/kg	160000	35	0.14	NSQT (Total PCB)	Yes
Dieldrin	60571	163	3	23000	ug/kg	16000	3.5	2	MOE-L	Yes
Endosulfan I	959988	163	0	ND	ug/kg	8100	1.8	1.9	NSCSI	*(D)

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Endosulfan II	33213659	163	0	ND	ug/kg	16000	3.5	1.9	NSCSI	*(D)
Endosulfan sulfate	1031078	163	1	41	ug/kg	16000	3.5	0.3	NYS	Yes
Endrin	72208	163	1	2	ug/kg	16000	3.5	3	MOE-L	No
Endrin aldehyde	7421934	163	0	ND	ug/kg	16000	3.5	NA		*(B)
Heptachlor	76448	163	31	52000	ug/kg	8100	1.8	0.04	NSCSI	Yes
Heptachlor epoxide	1024573	163	2	210	ug/kg	8100	1.8	0.04	NSCSI	Yes
Methoxychlor	72435	163	1	19	ug/kg	81000	18	6	NYS	Yes
Toxaphene	8001352	163	0	ND	ug/kg	81000	180	0.1	NSCSI	*(D)
alpha-BHC	319846	163	2	2	ug/kg	8100	1.8	0.9	NSCSI	Yes
alpha-Chlordane	5103719	163	2	9400	ug/kg	8100	1.8	0.3	NYS	Yes
beta-BHC	319857	163	0	ND	ug/kg	8100	1.8	3.9	NCSI	*(D)
delta-BHC	319868	163	4	370	ug/kg	8100	1.8	110	NSCSI	Yes
gamma-BHC (Lindane)	58899	163	0	ND	ug/kg	8100	1.8	3.7	ORNL	*(D)
gamma-Chlordane	5103742	163	3	3.1	ug/kg	8100	1.8	NA		*(B)
1,1,1,2-Tetrachloroethane	630206	163	0	ND	ug/kg	1200	5.5	38581.081	EqP	No
1,1,1-Trichloroethane	71556	163	0	ND	ug/kg	1200	5.2	179	ORNL	*(D)
1,1,2,2-Tetrachloroethane	79345	163	2	2.6	ug/kg	1200	5.2	25	NSCSI	No
1,1,2-Trichloroethane	79005	163	0	ND	ug/kg	1200	5.2	1310	ORNL	No
1,1-Dichloroethane	75343	163	0	ND	ug/kg	1200	5.2	27	ORNL	*(D)
1,1-Dichloroethene	75354	163	0	ND	ug/kg	1200	5.2	57	ORNL	*(D)
1,2,3-Trichloropropane	96184	163	1	1.7	ug/kg	1200	5.2	44056	EqP	No
1,2-Dichloroethane	107062	163	3	6.8	ug/kg	1200	5.2	325	ORNL	No
1,2-Dichloropropane	78875	163	0	ND	ug/kg	1200	5.2	48462.688	EqP	No
2-Butanone (MEK)	78933	163	56	2900	ug/kg	2300	0	297521	EqP	No
2-Hexanone	591786	163	1	14	ug/kg	2300	10	49187	EqP	No
4-Methyl-2-pentanone ^(MIBK)	108101	163	1	5	ug/kg	2300	10	NA		*(B)
Acetone	67641	163	106	950	ug/kg	2300	10	64	ORNL	Yes
Acrolein	107028	163	1	10	ug/kg	23000	100	10.2	EqP	No
Acrylonitrile	107131	163	2	4.5	ug/kg	23000	100	2682	EqP	No
Benzene	71432	163	6	5.6	ug/kg	1200	5.2	8.2	NSCSI	No
Bromodichloromethane	75274	163	0	ND	ug/kg	1200	5.2	8.8	NSCSI	*(D)
Bromoform	75252	163	0	ND	ug/kg	1200	5.2	95645.74	EqP	No
Bromomethane	74839	163	0	ND	ug/kg	2300	10	94246.092	EqP	No
Carbon disulfide	75150	163	24	21	ug/kg	1200	5.2	13	ORNL	Yes
Carbon tetrachloride	56235	163	0	ND	ug/kg	1200	5.2	1290	ORNL	No
Chlorobenzene	108907	163	37	18000	ug/kg	1200	5.2	35	NYS	Yes
Chloroethane	75003	163	0	ND	ug/kg	2300	10	47605.676	EqP	No
Chloroform	67663	163	1	2.5	ug/kg	1200	5.2	175	ORNL	No

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Chloromethane	74873	163	2	8.6	ug/kg	2300	10	33723	Eqp	No
Dibromochloromethane	124481	163	0	ND	ug/kg	1200	5.2	6.4	NSCSI	*(D)
Dibromomethane	74953	163	0	ND	ug/kg	1200	5.2	123706.86	EqP	No
Dichlorodifluoromethane	75718	163	0	ND	ug/kg	4700	21	60098.139	EqP	No
Ethyl methacrylate	97632	163	0	ND	ug/kg	4700	21	83742.388	EqP	No
Ethylbenzene	100414	163	4	35	ug/kg	1200	5.2	4360	ORNL	No
Iodomethane	74884	163	0	ND	ug/kg	1200	5.2	104527.32	EqP	No
Methylene chloride	75092	163	111	600	ug/kg	1200	5.2	427	ORNL	Yes
Styrene	100425	163	0	ND	ug/kg	1200	5.2	48000	NSCSI	No
Tetrachloroethene (PCE)	127184	163	13	17	ug/kg	1200	5.2	2730	ORNL	No
Toluene	108883	163	44	1100	ug/kg	1200	5.2	50	NSQT	Yes
Trichlorotrifluoromethane	75694	163	0	ND	ug/kg	1200	5.2	18000	NSCSI	No
Vinyl acetate	108054	163	0	ND	ug/kg	2300	10	8968.0936	EqP	No
Vinyl chloride	75014	163	3	19	ug/kg	2300	10	21	ORNL	No
Xylenes (total)	1330207	163	6	84	ug/kg	1200	5.2	50	NSQT	Yes
cis-1,3-Dichloropropene	10061015	163	0	ND	ug/kg	1200	5.2	NA		*(B)
trans-1,2-Dichloroethene	156605	163	1	1.5	ug/kg	1200	5.2	41478	EqP	No
trans-1,3-Dichloropropene	10061026	163	0	ND	ug/kg	1200	5.2	15484.232	EqP	No
trans-1,4-Dichloro-2-butene	110576	163	2	2.3	ug/kg	1200	5.2	NA		*(B)
1,2-Dichlorobenzene	95501	163	11	2200	ug/kg	11000	3.6	17000	NSCSI	No
1,3-Dichlorobenzene	541731	163	2	100	ug/kg	11000	2.5	26000	NSCSI	No
1,4-Dichlorobenzene	106467	163	8	280	ug/kg	11000	2.5	180	NSCSI	Yes
1-Chloronaphthalene	90131	163	20	5200	ug/kg	83000	2.4	3466	EqP	Yes
1-Naphthylamine	134327	163	0	ND	ug/kg	11000	350	6777.2306	EqP	*(D)
2,3,4,6-Tetrachlorophenol	58902	163	0	ND	ug/kg	53000	1700	7301.3777	EqP	*(D)
2,4,5-Trichlorophenol	95954	163	0	ND	ug/kg	53000	1700	11901.967	EqP	*(D)
2,4,6-Trichlorophenol	88062	163	0	ND	ug/kg	11000	350	12702.754	EqP	No
2,4-Dichlorophenol	120832	163	0	ND	ug/kg	11000	350	11809.569	EqP	No
2,4-Dimethylphenol	105679	163	5	350	ug/kg	11000	350	29	NSCSI	Yes
2,4-Dinitrophenol	51285	163	6	ND	ug/kg	53000	1700	2808.6136	EqP	*(D)
2,4-Dinitrotoluene	121142	163	0	ND	ug/kg	11000	350	3.9	NSCSI	*(D)
2,6-Dichlorophenol	87650	163	0	ND	ug/kg	11000	350	12296.841	EqP	No
2,6-Dinitrotoluene	606202	163	0	ND	ug/kg	11000	350	NA		*(B)
2-Chloronaphthalene	91587	163	14	1400	ug/kg	11000	350	33000	NSCSI	No
2-Chlorophenol	95578	163	0	ND	ug/kg	11000	350	11098.787	EqP	No
2-Methylnaphthalene	91576	163	22	1200	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
2-Methylphenol	95487	163	0	ND	ug/kg	11000	350	63	ORNL	*(D)
2-Naphthylamine	91598	163	0	ND	ug/kg	11000	350	67787.136	EqP	No

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
2-Nitrophenol	88755	163	0	ND	ug/kg	11000	350	12940.76	EqP	No
2-Picoline	109068	163	0	ND	ug/kg	11000	350	77375.991	EqP	No
3,3'-Dichlorobenzidine	91941	163	0	ND	ug/kg	22000	690	7629.0648	EqP	*(D)
3-Methylcholanthrene	56495	163	0	ND	ug/kg	11000	350	NA		*(B)
3-Nitroaniline	99092	163	0	ND	ug/kg	53000	1700	116617.46	EqP	No
3/4-Methylphenol	7820600	163	9	220	ug/kg	11000	350	670	ORNL	No
4,6-Dinitro-^2-methylphenol	534521	163	0	ND	ug/kg	53000	1700	3652.0847	EqP	*(D)
4-Aminobiphenyl	92671	163	0	ND	ug/kg	11000	350	6467.5831	EqP	*(D)
4-Bromophenyl^phenyl ether	101553	163	0	ND	ug/kg	11000	350	10895.925	EqP	*(D)
4-Chloro-3-methylphenol	59507	163	0	ND	ug/kg	11000	350	10027.841	EqP	*(D)
4-Chloroaniline	106478	163	0	ND	ug/kg	11000	350	6430.6009	EqP	*(D)
4-Chlorophenyl^phenyl ether	7005723	163	1	2700	ug/kg	11000	350	46600	NSCSI	No
4-Nitroaniline	100016	163	0	ND	ug/kg	53000	1700	8118.9255	EqP	*(D)
4-Nitrophenol	100027	163	0	ND	ug/kg	53000	1700	4349.8352	EqP	*(D)
7,12-Dimethylbenz(a)-^anthracene	57976	163	0	ND	ug/kg	11000	350	NA		*(B)
Acenaphthene	83329	163	59	8000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Acenaphthylene	208968	163	1	44	ug/kg	11000	350	NA		*(B)
Acetophenone	98862	163	2	130	ug/kg	11000	350	49281	EqP	No
Aniline	62533	163	1	310	ug/kg	11000	350	NA		*(B)
Anthracene	120127	163	85	26000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Azobenzene	103333	163	0	ND	ug/kg	83000	2600	22451.438	EqP	*(D)
Benzidine	92875	163	3	430	ug/kg	83000	2600	0.03	NYS	Yes
Benzo(a)anthracene	56553	163	118	39000	ug/kg	11000	2.3	600	NSQT (Total PAH)	Yes
Benzo(a)pyrene [BAP]	50328	163	115	26000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Benzo(b)fluoranthene	205992	163	120	31000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Benzo(g,h,i)perylene	191242	163	94	17000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Benzo(k)fluoranthene	207089	163	28	39000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Benzoic acid	65850	163	6	170	ug/kg	83000	2600	650	ORNL	No
Benzyl alcohol	100516	163	0	ND	ug/kg	11000	350	57	ORNL	*(D)
Butyl benzyl phthalate	85687	163	11	6000	ug/kg	11000	2.7	171000	NSCSI	No
Chrysene	218019	163	127	35000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Di-n-butyl phthalate	84742	163	8	4600	ug/kg	11000	350	42100	ORNL	No
Di-n-octyl phthalate	117840	163	15	11000	ug/kg	11000	350	7800000	ORNL	No
Dibenz(a,h)anthracene	53703	163	36	10000	ug/kg	11000	2.7	600	NSQT (Total PAH)	Yes
Dibenz(a,j)acridine	224420	163	2	1400	ug/kg			600	NSQT (Total PAH)	Yes
Dibenzofuran	132649	163	41	5500	ug/kg	11000	350	2290	ORNL	Yes
Diethyl phthalate	84662	163	0	ND	ug/kg	11000	350	634	ORNL	*(D)
Dimethyl phthalate	131113	163	9	660	ug/kg	11000	350	47699	EqP	No

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Diphenylamine	122394	163	0	ND	ug/kg	11000	350	25102.47	EqP	No
Ethyl methanesulfonate	62500	163	0	ND	ug/kg	11000	350	NA		*(B)
Fluoranthene	206440	163	138	53000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Fluorene	86737	163	57	12000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Hexachlorobenzene	118741	163	0	ND	ug/kg	11000	350	4	NSQT	*(D)
Hexachlorobutadiene	87683	163	0	ND	ug/kg	11000	350	3100	NSCSI	*(D)
Hexachlorocyclopentadiene	77474	163	0	ND	ug/kg	11000	350	440	NSCSI	*(D)
Hexachloroethane	67721	163	0	ND	ug/kg	11000	350	600	NSCSI	*(D)
Indeno(1,2.3-cd)pyrene	193395	163	94	19000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Isophorone	78591	163	2	98	ug/kg	11000	350	34566	EqP	No
Methyl methanesulfonate	66273	163	0	ND	ug/kg	11000	350	NA		*(B)
N-Nitroso-di-^n-butylamine	924163	163	0	ND	ug/kg	11000	350	NA		*(B)
N-Nitrosodiphenylamine	86306	163	2	150	ug/kg	11000	350	NA		*(B)
N-Nitrosopiperidine	100754	163	0	ND	ug/kg	11000	350	202220.22	EqP	No
Naphthalene	91203	163	49	5900	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Nitrobenzene	98953	163	0	ND	ug/kg	11000	350	66448.85	EqP	No
Pentachlorobenzene	608935	163	0	ND	ug/kg	11000	350	300	NSQT	*(D)
Pentachloronitrobenzene (PCNB)	82688	163	0	ND	ug/kg	53000	1700	10000	NSCSI	*(D)
Pentachlorophenol (PCP)	87865	163	2	100	ug/kg	53000	1700	20	NSQT	Yes
Phenacetin	62442	163	0	ND	ug/kg	11000	350	103763.52	EqP	No
Phenanthrene	85018	163	110	58000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
Phenol	108952	163	3	83	ug/kg	11000	350	50	NSQT	Yes
Pronamide	23950585	163	0	ND	mg/kg	11000	350	62410.202	EqP	No
Pyrene	129000	163	134	55000	ug/kg	11000	350	600	NSQT (Total PAH)	Yes
a,a-Dimethylphenethyl-^amine	122098	163	0	ND	ug/kg	11000	350	66538.591	EqP	No
bis(2-Chloroethoxy)^methane	111911	163	0	ND	ug/kg	11000	350	NA		*(B)
bis(2-Chloroethyl)ether	111444	163	0	ND	ug/kg	11000	350	NA		*(B)
bis(2-Chloroisopropyl)^ether	108601	163	0	ND	ug/kg	11000	350	115181.35	EqP	No
bis(2-Ethylhexyl)^phthalate	117817	163	134	23000	ug/kg	11000	350	1995	NYS	Yes
p-Dimethylaminoazobenzene	60117	163	0	ND	ug/kg	11000	350	24160.624	EqP	No
1,2,4,5-Tetrachloro-^benzene	95943	163	0	ND	ug/kg	11000	350	11088.347	EqP	No
1,2,4-Trichlorobenzene	120821	163	0	ND	ug/kg	11000	350	16374.238	EqP	No
2-Chloroethyl vinyl ether	110758	163	0	ND	ug/kg			113711.37	EqP	No
Trichloroethene	79016	163	9	77	ug/kg	1200	5.2	230	NSCSI	No
N-Nitroso-di-^n-propylamine	621647	163	0	ND	ug/kg	11000	350	NA		*(B)
(+-)-15-Hexadecanolide		163	1	520	ug/kg			NA		*
(Z)14-Tricosenyl formate		163	1	480	ug/kg			NA		*
.Psi.,.psi.-Carotene, 7,7',8,8',11,^11',12,12',11		163	1	420	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
1,1'-Bicyclopentyl-1,1'-diol		163	1	470	ug/kg			NA		*
1,1'-Biphenyl, 2,2',3',4,5-^pentachloro-		163	2	1100	ug/kg			NA		*
1,1'-Biphenyl, 2,2',3,3',4,4'-hexachloro-		163	1	1100	ug/kg			NA		*
1,1'-Biphenyl, 2,2',3,3',4,5-hexachloro-		163	1	740	ug/kg			NA		*
1,1'-Biphenyl, 2,2',3,4,4',6-hexachloro-		163	2	2600	ug/kg			NA		*
1,1'-Biphenyl, 2,2',3,4,5'-^pentachloro-		163	1	500	ug/kg			NA		*
1,1'-Biphenyl, 2,2',3,4,5'-pentachloro-		163	1	790	ug/kg			0.14	NSQT (Total PCB)	Yes
1,1'-Biphenyl, 2,2',3,5',6-pentachloro-		163	1	2200	ug/kg			NA		*
1,1'-Biphenyl, 2,2',4,4',5-^pentachloro-		163	2	4000	ug/kg			0.14	NSQT (Total PCB)	Yes
1,1'-Biphenyl, 2,2',4,5,5'-pentachloro-		163	1	2000	ug/kg			NA		*
1,1'-Biphenyl, 2,3,4,4',5-pentachloro-		163	1	290	ug/kg			0.14	NSQT (Total PCB)	Yes
1,1'-Biphenyl, 2,3,4,4',6-pentachloro-		163	1	450	ug/kg			NA		*
1,1'-Biphenyl, pentachloro-		163	1	2900	ug/kg			NA		*
1,1'-Biphenyl, tetrachloro-		163	1	1200	ug/kg			NA		*
1,1'-Biphenyl,2,2',4,4',6,6'-^hexachloro-		163	1	1100	ug/kg			NA		*
1,1'-Biphenyl,2,2',4,4',6-^pentachloro-		163	1	1200	ug/kg			NA		*
1,1-Biphenyl, 2,2',3,4,5,5'-hexachloro-		163	1	4400	ug/kg			NA		*
1,12-Benzperylene		163	1	700	ug/kg			NA		*
1,2-Benzenedicarboxylic acid, diheptyl^ester		163	1	2900	ug/kg			NA		*
1,2-Benzenedicarboxylic acid, diisodecyl ester		163	1	60000	ug/kg			$38*10^6$	EqP	No
1,2-Benzenedicarboxylic acid, ditridecyl ester		163	1	16000	ug/kg			NA		*
1,2-Benzenedicarboxylic acid,^ dipropyl ester		163	2	9300	ug/kg			184000	EqP	No
1,2-Benzenedicarboxylic acid,^bis(8-methylnonyl)!		163	1	2700	ug/kg			NA		*
1,2-Benzenedicarboxylic acid,^diisononyl ester		163	1	1300	ug/kg			NA		*
1,2-Benzisothiazole		163	1	1200	ug/kg			41732	EqP	No
1,2-Benzoperylene		163	2	14000	ug/kg			NA		*
1,2-Cyclohexanediol		163	1	410	ug/kg			NA		*
1,2-Dichloroethene ^(cis)		163	2	39	ug/kg			NA		*
1,3-Cyclohexadiene, 5-(1,5-dimethyl-4-hexenyl)-2-m		163	1	350	ug/kg			NA		*
1,6,10-Dodecatriene, 7,11-^dimethyl-3-methylene!		163	1	240	ug/kg			NA		*
1,6-Dimethyldibenzothiophene		163	1	1300	ug/kg			NA		*
1,7-Dimethyldibenzothiophene		163	2	2800	ug/kg			NA		*
1-(2,3,5,6-Tetramethylpyridyl)-^2-propanone		163	1	4400	ug/kg			NA		*
1-Docosanol		163	1	1000	ug/kg			NA		*
1-Dodecanamine, N,N-dimethyl-		163	1	2200	ug/kg			NA		*
1-Eicosanol		163	2	1100	ug/kg			NA		*
1-Eicosyne		163	1	2000	ug/kg			NA		*
1-Heneicosyl formate		163	2	3100	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
1-Heptadecanol, acetate		163	1	1800	ug/kg			NA		*
1-Heptadecene		163	1	420	ug/kg			NA		*
1-Hexadecanol		163	1	1700	ug/kg			NA		*
1-Hexadecanol, 2-Methyl-		163	1	820	ug/kg			NA		*
1-Methylnaphthalene		163	2	1900	ug/kg			NA		*
1-Naphthalenecarboxaldehyde, 2-hydroxy-		163	1	430	ug/kg			NA		*
1-Nonadecene		163	1	240	ug/kg			NA		*
1-Octadecene		163	3	770	ug/kg			NA		*
1-Penten-3-one, 2-methyl		163	5	430	ug/kg			54307	EqP	No
1-Penten-3-one, 2-methyl-		163	3	430	ug/kg			NA		*
1-Propanone, 1-cyclopropyl		163	2	220	ug/kg			9647	EqP	No
1-Tetradecanamine, N,N-dimethyl-		163	1	1700	ug/kg			NA		*
11-Tricosene		163	1	1100	ug/kg			NA		*
11H-Benzo(a)fluorene		163	4	3200	ug/kg			600	NSQT (Total PAH)	Yes
11H-Benzo(b)fluorene		163	15	4400	ug/kg			600	NSQT (Total PAH)	Yes
12-Octadecenal		163	1	2300	ug/kg			NA		*
13-Octadecenal		163	2	700	ug/kg			NA		*
14-Octadecenal		163	2	970	ug/kg			NA		*
14-Octadecenoic acid, butyl ester		163	1	300	ug/kg			NA		*
17-Octadecenal		163	1	270	ug/kg			NA		*
1H-3a,7-Methanoazulene, 2,3,4,7,8,8a,-hexahydro-3,		163	1	240	ug/kg			NA		*
1H-3a,7-Methanoazulene, 2,3,4,7,8,8a,^-hexahydro-1		163	1	160	ug/kg			NA		*
1H-Indene, octahydro-2,2,4,4,7,7-^hexamethyl-		163	1	1200	ug/kg			NA		*
1H-Pyrido[3,4-b]indole, 2,3,4,9-tetrahydro-		163	1	780	ug/kg			16827	EqP	No
2(3H)-Furanone, dihydro-5-propyl-		163	1	1300	ug/kg			139362	EqP	No
2,4-Pentadienenitrile		163	1	7900	ug/kg			NA		*
2,5-Furandione, 3-(dodecenyl)dihydro-		163	2	2500	ug/kg			NA		*
2,8-Dimethyldibenzo(B,D)thiophene		163	1	330	ug/kg			600	NSQT (Total PAH)	No
2-Butenal, 3-methyl-		163	1	430	ug/kg			NA		*
2-Docosene		163	2	1500	ug/kg			NA		*
2-Dodecen-1-yl(-)succinic anhydride		163	1	850	ug/kg			NA		*
2-Hexene, 4,4,5-trimethyl-		163	1	440	ug/kg			664	EqP	No
2-Methyl-2-pentanone (MIBK)		163	1	5	ug/kg			NA		*
2-Naphthalenol, 1,6-dibromo-		163	1	1700	ug/kg			NA		*
2-Nonylphenol		163	4	8900	ug/kg			200	ORNL	Yes
2-Pentanone, 4-hydroxy-4-methyl-		163	4	14000	ug/kg			424919	EqP	No
2-Phenanthrenol, 4b,5,6,7,8,8a,9,10-octahydro-4b,8		163	1	2800	ug/kg			NA		*
2-Phenylnaphthalene		163	2	2200	ug/kg			600	NSQT (Total PAH)	Yes

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
2-Propen-1-one, 1-(2-hydroxyphenyl)-3-^(4-hydrox!		163	1	5400	ug/kg			NA		*
2-Propenoic acid, 3-[2,3-dihydro-^3-[(4-methoxyph!		163	1	1600	ug/kg			NA		*
2-Pyridinecarboxylic acid, 5-butyl		163	1	9600	ug/kg			14605	EqP	No
24.XI.-Ethylchloest-5-en-3.beta.-ol		163	1	300	ug/kg			NA		*
28-Nor-17.alpha.(H)-hopane		163	4	870	ug/kg			NA		*
28-Nor-17.beta.(H)-hopane		163	18	14000	ug/kg			NA		*
2H-1,2,3-Triazole-4-carboxaldehyde, 2-(2-fluorophe		163	1	2000	ug/kg			NA		*
2H-pyran-2-carboxylic acid, 3,6-dihydro-6-propoxy-		163	1	11000	ug/kg			NA		*
3,3-Dimethyl-2-isopropyl-cyclopentane		163	1	1300	ug/kg			NA		*
3,4-Dihydrocyclopenta(cd)pyrene (acepyrene)		163	3	2800	ug/kg			600	NSQT (Total PAH)	Yes
3,5-Dihydroxytoluene		163	1	220	ug/kg			NA		*
3,7,11,15-Tetramethyl-2-hexadecen-1-ol		163	1	1100	ug/kg			NA		*
3-(3-Pyridyl)propenoic acid		163	1	690	ug/kg			NA		*
3-Fluoranthenamine		163	3	4600	ug/kg			600	NSQT (Total PAH)	Yes
3-Hexadecene, (z)-		163	1	1400	ug/kg			NA		*
3-Methyl-p-anisaldehyde		163	1	2600	ug/kg			NA		*
3-Octadecene, (E)-		163	1	1200	ug/kg			NA		*
3-Penten-2-one, 4-methyl-		163	3	260	ug/kg			NA		*
3/4-Methylphenol		163	9	220	ug/kg			NA		*
4,7-Methano-1H-indene, octahydro-		163	3	1200	ug/kg			7606	EqP	No
4-Hexenoic acid, 3-methyl-2,6-dioxo-		163	3	1800	ug/kg			NA		*
4-Methylnaphtho[2,1-b]thiophene		163	1	2300	ug/kg			NA		*
4H-Cyclopenta[def]phenanthrene		163	18	5200	ug/kg			600	NSQT (Total PAH)	Yes
5,12-Naphthacenedione		163	1	270	ug/kg			NA		*
5-Nonanone, 2,2,8,8-tetramethyl-		163	1	520	ug/kg			NA		*
5.alpha.-Stigmast-3-one-		163	4	2000	ug/kg			NA		*
6-Hydroxymethyl-1,4,4-trimethyl-^bicyclo(3.1.0.)!		163	1	170	ug/kg			NA		*
6-Methylchrysene		163	1	6100	ug/kg			NA		*
6H,8H-Benzo[10,11]chryseno[1,12-cd]^pyran-6,8-dio!		163	3	11000	ug/kg			NA		*
7,11-Dimethyl-3-Methylen-1,6,10-dodecatriene		163	1	220	ug/kg			NA		*
7H-Benz[de]anthracen-7-one		163	4	4300	ug/kg			NA		*
8-Heptadecanol, 8-methyl-		163	2	930	ug/kg			NA		*
9,10-Anthracendione, 1,5-dimethoxy-		163	1	3300	ug/kg			NA		*
9,10-Anthracenedione		163	9	4300	ug/kg			600	NSQT (Total PAH)	Yes
9,10-Dimethylanthracene		163	1	350	ug/kg			600	NSQT (Total PAH)	No
9-Hexadecenoic acid		163	2	760	ug/kg			NA		*
9-Octadecenamide, N,N-dimethyl-		163	1	2100	ug/kg			NA		*
9-Tricosene, (z)-		163	1	220	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
a'-Neogammacer-22(29)-en-3-ol,^(3.beta.,21.beta.)-		163	1	500	ug/kg			NA		*
Acetamide		163	1	180	ug/kg			NA		*
Acetamide, N,N-diethyl-		163	4	620	ug/kg			NA		*
Acetamide, N-(2,6-dimethylphenyl)-		163	2	4400	ug/kg			64132	EqP	No
Acetamide, N-(3-methylphenyl)-		163	1	1200	ug/kg			47851	EqP	No
Acridine		163	1	1900	ug/kg			NA		*
Adenine		163	1	3200	ug/kg			39475	EqP	No
Amide		163	1	1400	ug/kg			NA		*
Anthracene, 1-methyl-		163	1	370	ug/kg			600	NSQT (Total PAH)	No
Anthracene, 2-methyl-		163	5	1600	ug/kg			600	NSQT (Total PAH)	Yes
Anthracene, 9-dodecyltetradecahydro-		163	1	2600	ug/kg			NA		*
Anthracene, 9-methyl-		163	3	690	ug/kg			600	NSQT (Total PAH)	Yes
Baccharane		163	1	270	ug/kg			NA		*
Benz(a)anthracene,-7,12-dione		163	1	280	ug/kg			NA		*
Benz[a]anthracene, 3-methyl-		163	2	3000	ug/kg			NA		*
Benz[a]anthracene, 7-methyl-		163	4	2600	ug/kg			NA		*
Benz[a]anthracene, 8-methyl-		163	1	220	ug/kg			600	NSQT (Total PAH)	No
Benz[j]aceanthrylene, 3-methyl-		163	1	1000	ug/kg			NA		*
Benzaldehyde, 4-methyl-, oxime		163	1	490	ug/kg			NA		*
Benzene, (2-bromoethenyl)-		163	1	850	ug/kg			NA		*
Benzene, (pentachloroethoxy)-		163	1	2400	ug/kg			NA		*
Benzene, [(1,1-dimethylethoxy)methyl]-		163	1	7800	ug/kg			NA		*
Benzene, 1-ethyl-2,3-dimethyl-		163	1	39	ug/kg			NA		*
Benzene, 1-methyl-2-(1-methylethyl)-		163	1	170	ug/kg			1480	EqP	No
Benzene, 1-methyl-2-(2-propenyl)-		163	1	530	ug/kg			NA		*
Benzene, 1-methyl-3-(1-methylethyl)-		163	2	84	ug/kg			NA		*
Benzene, methyl(1-methylethyl)-		163	1	28	ug/kg			NA		*
Benzenesulfonamide, 4-methyl-		163	2	4600	ug/kg			NA		*
Benzo(a)acridine		163	1	190	ug/kg			NA		*
Benzo(a)carbazole		163	1	4100	ug/kg			600	NSQT (Total PAH)	Yes
Benzo(b)naphtho(2,1-d)thiophene		163	8	4000	ug/kg			600	NSQT (Total PAH)	Yes
Benzo(c)carbazole		163	1	1100	ug/kg			600	NSQT (Total PAH)	Yes
Benzo(c)phenanthrene		163	10	9000	ug/kg			600	NSQT (Total PAH)	Yes
Benzo(e)pyrene		163	23	9200	ug/kg			NA		*
Benzo(j)fluoranthene		163	16	12000	ug/kg			600	NSQT (Total PAH)	Yes
Benzo[b]naphtho[1,2-d]thiophene		163	4	5900	ug/kg			600	NSQT (Total PAH)	Yes
Benzo[b]naphtho[2,3-d]furan		163	1	850	ug/kg			NA		*
Benzo[b]naptho[2,1-d]thiophene		163	8	4000	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Benzo[c]phenanthrene, 3-methyl-		163	1	4100	ug/kg			600	NSQT (Total PAH)	Yes
Benzo[c]phenanthrene, 5-methyl-		163	1	370	ug/kg			NA		*
Benzo[ghi]fluoranthene		163	3	9800	ug/kg			NA		*
Bicyclo[2.2.1]heptan-2-one, 1,3,3^-trimethyl-		163	1	88	ug/kg			NA		*
Bicyclo[3.1.1]hept-2-ene, 2,6-^dimethyl-6-(4-methy		163	1	660	ug/kg			NA		*
bis(2-Ethylhexyl)^phthalate		163	134	23000	ug/kg			NA		*
Butanoic acid, 2-butoxy-1-methyl-^2-oxoethyl ester		163	2	1100	ug/kg			NA		*
Butanoic acid, 2-methyl-		163	1	400	ug/kg			NA		*
Caprolactam		163	1	1100	ug/kg			331488	EqP	No
Carbazole		163	14	6400	ug/kg			600	NSQT (Total PAH)	Yes
Cedrol		163	1	6500	ug/kg			NA		*
Cholesterol		163	15	12000	ug/kg			NA		*
Chromone, 3,5-dibromo-6-hydroxy-2-^methyl-		163	4	1100	ug/kg			NA		*
Chrysene, 3-methyl-		163	1	320	ug/kg			600	NSQT (Total PAH)	Yes
Chrysene, 5-methyl-		163	1	190	ug/kg			NA		*
Chrysin		163	1	4000	ug/kg			600	NSQT (Total PAH)	Yes
cis-1,2-Dichloroethene		163	4	250	ug/kg			9538	ORNL	No
cis-9, 10-Epoxyoctadecan-1-ol		163	1	560	ug/kg			NA		*
Cyclododecanemethanol		163	1	390	ug/kg			NA		*
Cycloheptadecanol		163	1	430	ug/kg			NA		*
Cyclohexadecane		163	2	1100	ug/kg			NA		*
Cyclohexane, 1,2,4-trimethyl-		163	1	150	ug/kg			NA		*
Cyclohexane, 1,2-diethyl-3-methyl-		163	2	3200	ug/kg			14000[1]	NCSCI[1]	No[1]
Cyclohexane, 1,2-dimethyl-, trans-		163	1	49	ug/kg			NA		*
Cyclohexane, 1-(1,5-dimethylhexyl)-^4-(4-methylpe!		163	2	3100	ug/kg			14000[1]	NCSCI[1]	No[1]
Cyclohexane, 1-ethyl-4-methyl-,^trans-		163	1	150	ug/kg			NA		*
Cyclohexane, 1-propenyl-		163	1	5900	ug/kg			NA		*
Cyclohexane, butyl-		163	1	970	ug/kg			NA		*
Cyclohexane, methyl-		163	1	170	ug/kg			NA		*
Cyclohexane, methyl-		163	3	10000	ug/kg			NA		*
Cyclohexane, octyl-		163	1	230	ug/kg			NA		*
Cyclohexane, pentyl-		163	1	3000	ug/kg			NA		*
Cyclohexanone, 5-methyl-2-(1-methylethenyl)-, tran		163	1	9500	ug/kg			171051	EqP	No
Cyclopenta[cd]pyrene		163	1	910	ug/kg			NA		*
Cyclopentadecane		163	1	390	ug/kg			NA		*
Cyclopentane, 1,2-dimethyl-, trans-		163	1	4200	ug/kg			NA		*
Cyclopentane, ethyl-		163	4	1300	ug/kg			1625[3]	EqP	No[3]
Cyclotetracosane		163	3	1100	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Cyclotetradecane		163	1	620	ug/kg			NA		*
d-Dihomoandrostane, (5.alpha.)-		163	1	2200	ug/kg			NA		*
D-Friedoolean-14-ene, 3-methoxy-,^(3.beta.)-		163	9	2100	ug/kg			NA		*
d-Galactitol, 2-(acetylmethylamino)-^2-deoxy-3,4,!		163	1	290	ug/kg			NA		*
D:A-Friedooleanan-3-one		163	2	860	ug/kg			NA		*
Decahydro-4,4,8,9,10-^pentamethylnaphthalene		163	1	1200	ug/kg			NA		*
Decane 2-cyclohexyl-, 2-cyclohexyl-		163	1	1100	ug/kg			NA		*
Decane, 2,3,7-trimethyl-		163	1	15	ug/kg			NA		*
Decane, 3-methyl-		163	1	46	ug/kg			NA		*
Decanoic acid, 2-hydroxy-1-^(hydroxymethyl)ethyl!		163	1	1800	ug/kg			147749	EqP	No
Decanoic Acid, Decyl Ester		163	1	800	ug/kg			NA		*
Desmosterol		163	1	190	ug/kg			NA		*
Dibenz(a,c)anthracene		163	7	26000	ug/kg			600	NSQT (Total PAH)	Yes
Dibenzo(B-def)carbazole		163	1	5600	ug/kg			600	NSQT (Total PAH)	Yes
Dibenzo[def,mno]chrysene		163	3	13000	ug/kg			NA		*
Dibenzofuran, 4-methyl-		163	1	680	ug/kg			15021	EqP	No
Dibenzothiophene		163	8	3100	ug/kg			600	NSQT (Total PAH)	Yes
Dibenzothiophene, 3-methyl-		163	3	2700	ug/kg			600	NSQT (Total PAH)	Yes
Diethylphosphinothioic azide		163	1	1100	ug/kg			NA		*
Dimethyl phthalate		163	9	660	ug/kg			NA		*
Disulfide, dimethyl		163	1	14	ug/kg			NA		*
Dodecane		163	1	2100	ug/kg			NA		*
Dodecane, 1,2-dibromo-		163	2	2400	ug/kg			NA		*
Dodecane, 4,6-dimethyl-		163	1	1600	ug/kg			NA		*
Eicosane		163	1	180	ug/kg			NA		*
Epifriedelinol		163	2	430	ug/kg			NA		*
Ergost-5-en-3-ol, (3.beta.)-		163	2	1100	ug/kg			NA		*
Ergost-7-en-3-ol, (3,.beta.)-		163	2	500	ug/kg			NA		*
Ergosta-14,22-dien-3-ol, (3.beta.,^5.alpha.,22E)-		163	1	250	ug/kg			NA		*
Ergosta-5,22-dien-3-ol,^(3.beta.,22E,24S)-		163	1	690	ug/kg			NA		*
Ergostanol		163	2	390	ug/kg			NA		*
Ethanethioic acid, S,S'-[thiobis^(methylene)] est!		163	1	510	ug/kg			58205	EqP	No
Ethanoic acid, S-methyl ester		163	7	1400	ug/kg			27979	Eqp	No
Ethanol, 2-(diethylamino)-		163	1	1000	ug/kg			NA		*
Ethanol, 2-(tetradecyloxy)-		163	1	2100	ug/kg			NA		*
Ethanol, 2-butoxy-, phosphate (3:1)		163	1	420	ug/kg			NA		*
Heneicosane, 11-(1-ethylpropyl)-		163	1	170	ug/kg			NA		*
Heptadecane, 2,6-dimethyl-		163	1	210	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Heptane		163	1	7900	ug/kg			NA		*
Heptane, 4-propyl-		163	1	110	ug/kg			10361	EqP	No
Heptane, 5-ethyl-2-methyl-		163	1	290	ug/kg			11338	EqP	No
Heptanoic acid, 3-nitrophenyl ester		163	2	2700	ug/kg			NA		*
Heptanoic acid, anhydride		163	5	5100	ug/kg			128747[1]	EqP	No
Hexadecane		163	1	92	ug/kg			NA		*
Hexadecane, 1-(ethenyloxy)-		163	1	530	ug/kg			NA		*
Hexadecane-1,2-diol		163	1	2700	ug/kg			NA		*
Hexadecanoic acid		163	10	1500	ug/kg			NA		*
Hexadecanoic acid, 2-oxo-, methyl^ester		163	1	1900	ug/kg			NA		*
Hexadecanoic acid, butyl ester		163	3	290	ug/kg			NA		*
Hexanal		163	1	170	ug/kg			11449	EqP	No
Hexane		163	2	2900	ug/kg			NA		*
Hexane, 1-isocyano-		163	1	510	ug/kg			NA		*
Hexane, 2,3,4-trimethyl-		163	2	2700	ug/kg			NA		*
Hexane, 2,5-dimethyl-		163	1	73	ug/kg			NA		*
Hexane, 3-methyl-		163	1	3300	ug/kg			NA		*
Hexanedioic acid, bis(2-ethylhexyl)^ester		163	1	1100	ug/kg			NA		*
Hexanedioic acid, dioctyl ester		163	1	1200	ug/kg			NA		*
Hexanedioic acid, mono(2-^ethylhexyl)ester		163	2	1300	ug/kg			NA		*
Hexanoic acid, 2-ethyl-		163	1	64	ug/kg			NA		*
Hexathiepane		163	1	360	ug/kg			NA		*
Hydroxylamine, o-decyl-		163	1	360	ug/kg			NA		*
Indolo[3,2-c]cinnoline		163	1	4700	ug/kg			600	NSQT (Total PAH)	No
Iso-.alpha.-cedren-15-al		163	1	1500	ug/kg			NA		*
Isolongifolene		163	1	3200	ug/kg			NA		*
N,N,N'N'-Tetramethyl[3.3]paracyclophan-^5,8-diam!		163	1	230	ug/kg			NA		*
N,N-Dimethyloctylamine		163	1	240	ug/kg			NA		*
n-Pentadecylcyclohexane		163	1	360	ug/kg			NA		*
Naphthalene, 1,2,3,4,4a,5,6,8a-^octahydro-4a,8-di!		163	1	250	ug/kg			NA		*
Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-7-methyl-		163	1	190	ug/kg			NA		*
Naphthalene, 1,2,3,4-tetrachloro-		163	12	4100	ug/kg			NA		*
Naphthalene, 1,2,3,5,6,7,8,8a-^octahydro-1,8a-di!		163	1	3000	ug/kg			NA		*
Naphthalene, 1,2-dichloro-		163	1	1800	ug/kg			NA		*
Naphthalene, 1,2-dimethyl-		163	1	930	ug/kg			NA		*
Naphthalene, 1,3,5,7-tetrachloro-		163	6	1900	ug/kg			NA		*
Naphthalene, 1,3,7-trichloro-		163	16	12000	ug/kg			4015[2]	EqP	Yes
Naphthalene, 1,3-dimethyl-		163	1	1200	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Naphthalene, 1,4,6,7-tetrachloro-		163	12	20000	ug/kg			NA		*
Naphthalene, 1,4,6-trimethyl-		163	1	1600	ug/kg			NA		*
Naphthalene, 1,4-dichloro-		163	1	1000	ug/kg			NA		*
Naphthalene, 1,5-dichloro-		163	1	470	ug/kg			NA		*
Naphthalene, 2,3,6-trichloro-		163	3	9500	ug/kg			4015[3]	EqP	Yes
Naphthalene, 2,3,6-trimethyl-		163	1	1500	ug/kg			NA		*
Naphthalene, 2,3-dichloro-		163	4	2100	ug/kg			NA		*
Naphthalene, 2,3-dimethyl-		163	3	2400	ug/kg			NA		*
Naphthalene, 2,7-dichloro-		163	1	1000	ug/kg			NA		*
Naphthalene, 2-phenyl-		163	2	2100	ug/kg			NA		*
Naphthalene, decahydro-, trans-		163	1	4600	ug/kg			NA		*
Naphthalene, decahydro-2,6-dimethyl-^3-octyl-		163	1	180	ug/kg			NA		*
Naphthalene, decahydro-2-methyl-		163	4	3700	ug/kg			600	NSQT (Total PAH)	No
Naphthalene, heptachloro-		163	5	20000	ug/kg			NA		*
Naphtho[2,3-b]thiophene, 4,9-dimethyl-		163	1	190	ug/kg			600	NSQT (Total PAH)	No
Nonadecane, 2,3-dimethyl-		163	1	500	ug/kg			NA		*
Nonane, 2-methyl-3-methylene-		163	1	920	ug/kg			NA		*
Nonane, 5-(2-methylpropyl)-		163	1	3800	ug/kg			NA		*
Octadecanal		163	5	1300	ug/kg			NA		*
Octadecanoic acid		163	1	200	ug/kg			NA		*
Octadecanoic acid, 2-methylpropyl^ester		163	2	2200	ug/kg			NA		*
Octadecanoic acid, butyl ester		163	6	3500	ug/kg			NA		*
Octane		163	1	130	ug/kg			NA		*
Octanethioic acid, S-hexyl ester		163	1	320	ug/kg			NA		*
Octanoic acid, 1-methyltridecyl ester		163	2	930	ug/kg			NA		*
Olean-12-ene		163	1	7000	ug/kg			NA		*
Oleic Acid		163	4	990	ug/kg			NA		*
Osthole		163	1	170	ug/kg			NA		*
Oxacyclohexadecan-2-one, 16-methyl-		163	1	1900	ug/kg			NA		*
Oxirane, hexadecyl-		163	1	620	ug/kg			NA		*
P-Terphenyl, 2,5-dichloro-		163	1	2400	ug/kg			NA		*
Pentacene		163	1	12000	ug/kg			NA		*
Pentadecanal		163	1	370	ug/kg			NA		*
Pentalene, octahydro-1-(2-octyldecyl)-		163	3	3000	ug/kg			NA		*
Pentanoic acid, 2,2-dimethyl-,^ethenyl ester		163	1	400	ug/kg			NA		*
Perylene		163	18	17000	ug/kg			600	NSQT (Total PAH)	Yes
Phenanthrene, 2,3,5-trimethyl-		163	1	460	ug/kg			600	NSQT (Total PAH)	No
Phenanthrene, 2,5-dimethyl-		163	1	550	ug/kg			600	NSQT (Total PAH)	No

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Phenanthrene, 2-methyl-		163	1	2100	ug/kg			NA		*
Phenanthrene, 3,6-dimethyl-		163	1	350	ug/kg			600	NSQT (Total PAH)	No
Phenanthrene, 3-methyl-		163	1	250	ug/kg			600	NSQT (Total PAH)	No
Phenanthrene, 9,10-dimethyl-		163	1	300	ug/kg			600	NSQT (Total PAH)	No
Phenanthrene, 9-methyl-		163	2	740	ug/kg			NA		*
Phenol, 2-(1,1-dimethylethyl)-4-^methyl-		163	1	2200	ug/kg			3161	EqP	No
Phenol, 4-(1,1,3,3-tetramethylbutyl)-		163	15	12000	ug/kg			13965	EqP	No
Phenol, 4-(2,2,3,3,-tetramethylbutyl)-		163	9	6300	ug/kg			3215	EqP	Yes
Phenol, 4-4'-(1,2-diethyl-1,2-^ethanediyl)bis-		163	2	960	ug/kg			NA		*
Phenol, 4-dodecyl-		163	1	4800	ug/kg			NA		*
Phenol, 4-nonyl-		163	7	3700	ug/kg			47996	EqP	No
Phenol, nonyl-		163	24	12000	ug/kg			8687	EqP	Yes
Phosphine Sulfide, triphenyl		163	11	2500	ug/kg			1560	NYS	Yes
Phosphoric acid, 2-ethylhexyl^diphenyl ester		163	9	2500	ug/kg			NA		*
Phosphoric acid, octyl diphenyl ester		163	1	3500	ug/kg			NA		*
Phthalate		163	9	41000	ug/kg			NA		*
Phthalic acid, didecyl ester		163	3	11000	ug/kg			NA		*
Prasterone		163	1	450	ug/kg			NA		*
Propanoic acid		163	1	430	ug/kg			NA		*
Propanoyl chloride, 2,2-dichloro-		163	1	1500	ug/kg			NA		*
Pyrazine, 3,5-diethyl-2-methyl-		163	1	5400	ug/kg			75437	EqP	No
Pyrene, 1-methyl-		163	3	10000	ug/kg			NA		*
Pyrene, 2-methyl-		163	2	3900	ug/kg			600	NSQT (Total PAH)	Yes
Pyrene, 4-methyl-		163	1	1300	ug/kg			600	NSQT (Total PAH)	Yes
Silacyclohexane, 1,1-dimethyl-		163	1	980	ug/kg			NA		*
Silicic acid (H4SIO4), tetrakis^(2-ethylbutyl) es!		163	2	880	ug/kg			NA		*
Siloxane		163	92	17000	ug/kg			NA		*
Stannane, bromodibutyl(1-methylethyl)-		163	3	1000	ug/kg			NA		*
Stannane, bromotributyl-		163	2	970	ug/kg			NA		*
Stannane, chlorotris(2-methylpropyl)-		163	8	2200	ug/kg			NA		*
Stannane, tributylchloro-		163	5	2800	ug/kg			NA		*
Sterol		163	3	1400	ug/kg			NA		*
Stigmast-4-en-3-one		163	12	5000	ug/kg			NA		*
Stigmast-5-en-3-ol-, (3.beta.,24S)-		163	17	29000	ug/kg			NA		*
Stigmastane		163	2	3400	ug/kg			NA		*
Stigmasterol		163	3	1300	ug/kg			NA		*
Sulfur (S)		163	3	6300	ug/kg			NA	CS	No
Sulfur, mol. (S8)		163	8	7000	ug/kg			NA		*

TABLE 2-4
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR BULK-SEDIMENT ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Tetradecanal		163	2	740	ug/kg			NA		*
Tetradecane		163	1	14	ug/kg			NA		*
Tetradecanoic acid		163	1	390	ug/kg			NA		*
Thiazole, 4,5-dihydro-2-methyl-		163	1	650	ug/kg			NA		*
trans-1,4-Dichloro-^2-butene		163	1	1.2	ug/kg			NA		*
Tridecanal		163	1	2000	ug/kg			NA		*
Tridecane 7-cyclohexyl-, 7-cyclohexyl-		163	1	4200	ug/kg			NA		*
Triphenylene		163	2	17000	ug/kg			600	NSQT (Total PAH)	Yes
Triphenylene, 2-methyl-		163	2	5600	ug/kg			600	NSQT (Total PAH)	Yes
Undecanal, 2-methyl-		163	1	590	ug/kg			NA		*
Undecane, 2-methyl-		163	1	170	ug/kg			NA		*
Undecane, 3,6-dimethyl-		163	2	2400	ug/kg			NA		*
Urs-20-en-16-ol, (16.beta.,18.^alpha.,19.alpha.)-		163	1	230	ug/kg			NA		*
Urs-20-en-16-ol, (16.beta.,18.alpha.,19.alpha.)-		163	1	940	ug/kg			NA		*
Valerophenone, 2'-(trimethylsiloxy)-		163	1	230	ug/kg			NA		*
Vitamin E		163	7	14000	ug/kg			NA		*
Zinc, bis[2-(1,1-dimethylethyl)-^3,3-dimethylcycl!		163	1	3800	ug/kg			NA		*

Constituents in *italics* represent tentatively identified compounds (TICS). An attempt was made to locate benchmarks for TICs measured during the ecological studies. These chemicals were included in the assessment of chemicals of potential concern. This includes TICs qualified as Level 2, Level 3, or unqualified but not listed on the sample analyte list specified in the work plan. The table above includes TICs from both the ecological and quarterly studies.
Level 2 TICs are "confidently indentified", i.e., good agreement was observed between the unknown compound and a specific library spectrum. Level 3 TICs are confirmed identification", i.e., the identiication is based on the analysis of an authentic standard. Quantitation of TICs is based on the total inoization peak area relative to an internal standard, assuming a response factor of one. Accordingly, the reported concentration is an estimate and should be considered as an uncertainty in the overall assessment of risk.

Benchmarks developed using equilibrium partitioning are based on a water benchmark.
Equilibrium partitioning was used to calculate a benchmark based on the maximum concentration and location-specific organic carbon concentration.

[1] Value based on a maximum concentration of 1,000 ug/kg measured during the ecological studies
[2] Value based on a maximum concentration of 2,200 ug/kg measured during the ecological studies
[3] Value based on a maximum concentration of 8,000 ug/kg measured during the ecological studies
[a] Thallium benchmark based on lowest AQUIRE value of 130ug/L and a desorption coefficient of 74.
NA - No benchmark available
"*" with a "B" in parentheses indicates that no benchmark is available and with a "D" indicates the benchmark is lower than at least one detection limit, hence the chemical remains an uncertainty with respect to evaluation of risk. This is also discussed in Section 5.3.2 and Table 5-19.

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Aluminum	7429905	85	58	4.3	mg/l	0.1	0.1	0.087	EPA-AWQC	Yes
Antimony ,	7440360	85	1	0.045	mg/l	0.06	0.06	610	ORNL	No
Arsenic	7440382	85	44	0.23	mg/l	0.05	0.005	0.19	EPA AWQC	Yes
Barium	7440393	85	85	0.68	mg/l	0.01	0.01	5.8	ORNL	No
Beryllium	7440417	85	0	ND	ug/l	0.002	0.002	5.3	EPA AWQC	No
Cadmium	7440439	85	27	0.0098	mg/l	0.005	0.0003	0.0015	ORNL	Yes
Calcium	7440702	85	85	99.6	mg/l	0.2	0.2	116	ORNL	No
Chromium	7440473	85	43	0.52	mg/l	0.01	0.01	0.011	EPA AWQC	Yes
Cobalt	7440484	85	5	0.031	mg/l	0.01	0.01	5.1	ORNL	No
Copper	7440508	85	85	0.3	mg/l	0.02	0.002	0.001	ORNL	Yes
Cyanide	5955700	85	0	ND	mg/l	0.01	0.01	5.2	EPA AWQC	No
Iron	7439896	85	82	3.4	mg/l	0.1	0.1	0.158	ORNL	Yes
Lead	7439921	85	59	0.03	mg/l	0.02	0.001	0.0032	EPA AWQC	Yes
Magnesium	7439954	85	85	45.7	mg/l	0.2	0.2	82	ORNL	No
Manganese	7439965	85	85	0.5	mg/l	0.01	0.01	1.1	ORNL	No
Mercury	7439976	85	1	0.00018	mg/l	0.0002	0.0002	0.000012	EPA AWQC	Yes
Molybdenum	7439987	85	61	0.85	mg/l	0.02	0.02	0.88	ORNL	No
Nickel	7440020	85	24	0.33	mg/l	0.04	0.04	0.005	ORNL	Yes
Potassium	7440097	85	83	5.7	mg/l	5	5	53	ORNL	No
Selenium	7782492	85	12	0.044	mg/l	0.01	0.005	0.005	EPA AWQC	Yes
Silver	7440224	85	10	0.0056	mg/l	0.01	0.0001	0.00012	ORNL	Yes
Sodium	7440235	85	84	203	mg/l	5	5	680	ORNL	No
Thallium	7440280	85	2	0.0012	mg/l	0.05	0.005	0.13	AQUIRE	No
Vanadium	7440622	85	69	0.031	mg/l	0.01	0.01	0.08	NSQT	No
Zinc	7440666	85	85	0.085	mg/l	0.02	0.02	0.03	NOAA FW	No
1,1,1,2-Tetrachloroethane	630206	85	0	ND	ug/l	5	5	2357	ASTER	No
1,1,1-Tricholorethane	71556	85	0	ND	ug/l	5	5	1770	ORNL	No
1,1,2,2-Trichloroethane	79345	85	0	ND	ug/l	5	5	2400	ORNL	No
1,1,2-Trichloroethane	79005	85	0	ND	ug/l	5	5	7257	ORNL	No
1,1-Dichloroethane	75343	85	0	ND	ug/l	5	5	14680	ORNL	No
1,1-Dichloroethene	75354	85	0	ND	ug/l	5	5	2800	ORNL	No
1,2,3-Trichloropropane	96184	85	0	ND	ug/l	5	5	17140	ASTER	No
1,2,4,5-Tetrachloro-^benzene	95943	85	0	ND	ug/l	10	10	59	ASTER	No

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
1,2,4-Trichlorobenzene	120821	85	0	ND	ug/l	10	10	209	ASTER	No
1,2-Dichlorobenzene	95501	85	0	ND	ug/l	10	10	707	ASTER	No
1,2-Dichloroethane	107062	85	0	ND	ug/l	5	5	15200	ORNL	No
1,2-Dichloropropane	78875	85	0	ND	ug/l	5	5	11000	ASTER	No
1,3-Dichlorobenzene	541731	85	0	ND	ug/l	10	10	707	ASTER	No
1,4-Dichlorobenzene	106467	85	0	ND	ug/l	10	10	570	ASTER	No
1-Chloronaphthalene	90131	85	0	ND	ug/l	50	50	310	ASTER	No
1-Naphthylamine	134327	85	0	ND	ug/l	10	10	13890	ASTER	No
2,3,4,6-Tetrachlorophenol	58902	85	0	ND	ug/l	50	50	89	ASTER	No
2,4,5-Trichlorophenol	95954	85	0	ND	ug/l	50	50	264	ASTER	No
2,4,6-Trichlorophenol	88062	85	0	ND	ug/l	10	10	398	ASTER	No
2,4-Dichlorophenol	120832	85	0	ND	ug/l	10	10	365L	EPA AWQC	No
2,4-Dimethylphenol	105679	85	0	ND	ug/l	10	10	792	ASTER	No
2,4-Dinitrophenol	51285	85	0	ND	ug/l	50	50	699	ASTER	No
2,4-Dinitrotoluene	121142	85	0	ND	ug/l	10	10	230L	EPA AWQC	No
2,6-Dichlorophenol	87650	85	0	ND	ug/l	10	10	1037	ASTER	No
2,6-Dinitrotoluene	606202	85	0	ND	ug/l	10	10	NA		*(B)
2-Butanone [MEK]	78933	85	2	2.8	ug/l	10	10	282170	ORNL	No
2-Chloroethyl vinyl ether	110758	85	0	ND	ug/l			89493	ASTER	No
2-Chloronaphthalene	91587	85	0	ND	ug/l	10	10	310	ASTER	No
2-Chlorophenol	95578	85	0	ND	ug/l	10	10	1911	ASTER	No
2-Hexanone	591786	85	0	ND	ug/l	10	10	43838	ASTER	No
2-Methylnaphthalene	91576	85	0	ND	ug/l	10	10	309	ASTER	No
2-Methylphenol	95487	85	1	1.2	ug/l	10	10	489	ORNL	No
2-Naphthylamine	91598	85	0	ND	ug/l	10	10	13713	ASTER	No
2-Nitrophenol	88755	85	0	ND	ug/l	10	10	3451	ASTER	No
2-Picoline	109068	85	0	ND	ug/l	10	10	41171	ASTER	No
3,3'-Dichlorobenzidine	91941	85	0	ND	ug/l	20	20	218	ASTER	No
3,3'-Dimethylbenzidine	91941	85	0	ND	ug/l	10	10	3386	ASTER	No
3-Methylcholanthrene	56495	85	0	ND	ug/l	10	10	NA		*(B)
3-Nitroaniline	99092	85	0	ND	ug/l	50	50	62051	ASTER	No
3/4-Methylphenol	7820600	85	2	1.7	ug/l	10	10	NA		*(B)
4,4'-DDD	72548	85	0	ND	ug/l	0.1	0.1	1.69	ORNL	No

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
4,4'-DDE	72559	85	0	ND	ug/l	0.1	0.1	1050AL	EPA AWQC	No
4,4'-DDT	50293	85	0	ND	ug/l	0.1	0.1	0.001	EPA AWQC	*(D)
4,6-Dinitro-^2-methylphenol	534521	85	0	ND	ug/l	50	50	406	ASTER	No
4-Aminobiphenyl	92671	85	0	ND	ug/l	10	10	533	ASTER	No
4-Bromophenyl^phenyl ether	101553	85	0	ND	ug/l	10	10	42	ASTER	No
4-Chloro-3-methylphenol	59507	85	1	2	ug/l	10	10	546	ASTER	No
4-Chloroaniline	106478	85	0	ND	ug/l	10	10	1564	ASTER	No
4-Chlorophenyl^phenyl ether	7005723	85	0	ND	ug/l	10	10	46	ASTER	No
4-Methyl-2-pentanone^[MIBK]	108101	85	0	ND	ug/l	10	10	56896	ASTER	No
4-Nitroaniline	100016	85	0	ND	ug/l	50	50	4320	ASTER	No
4-Nitrophenol	100027	85	5	2	ug/l	50	50	NA		*(B)
7,12-Dimethylbenz(a)-^anthracene	57976	85	0	ND	ug/l	10	10	NA		*(B)
Acenaphthene	83329	85	0	ND	ug/l	10	10	74	ORNL	No
Acenaphthylene	208968	85	0	ND	ug/l	10	10	665	ASTER	No
Acetone	67641	85	28	19	ug/l	10	10	507640	ORNL	No
Acetophenone	98862	85	0	ND	ug/l	10	10	31094	ASTER	No
Acrolein	107028	85	0	ND	ug/l	100	100	21L	EPA AWQC	*(D)
Acrylonitrile	107131	85	0	ND	ug/l	100	100	2600L	EPA AWQC	No
Aldrin	309002	85	2	0.086	ug/l	0.05	0.05	0.37	ASTER	No
Aniline	62533	85	0	ND	ug/l	10	10	33.9	ASTER	No
Anthracene	120127	85	0	ND	ug/l	10	10	0.09	ORNL	*(D)
Aroclor 1016	12674112	85	0	ND	ug/l	1	1	NA		*(B)
Aroclor 1221	11104282	85	0	ND	ug/l	1	1	60	ORNL	No
Aroclor 1232	11141165	85	0	ND	ug/l	1	1	124	ORNL	No
Aroclor 1242	53469219	85	0	ND	ug/l	1	1	4.9	ORNL	No
Aroclor 1248	12672296	85	0	ND	ug/l	1	1	0.2	ORNL	*(D)
Aroclor 1254	11097691	85	0	ND	ug/l	1	1	0.1	ORNL	*(D)
Aroclor 1260	11096825	85	0	ND	ug/l	1	1	<1.3	ORNL	*(D)
Azobenzene	103333	85	0	ND	ug/l	50	50	498	ASTER	No
Benzene	71432	85	0	ND	ug/l	5	5	2200	OK AWQC	No
Benzidine	92875	85	0	ND	ug/l	50	50	134	ORNL	No
Benzo(a)anthracene	56533	85	1	1.5	ug/l	10	10	0.65	ORNL	Yes
Benzo(a)pyrene	50328	85	1	1.3	ug/l	10	10	0.3	ORNL	Yes

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Benzo(b)fluoranthene	205992	85	1	1.3	ug/l	10	10	NA		*(B)
Benzo(g,h,i)perylene	191242	85	0	ND	ug/l	10	10	NA		*(B)
Benzo(k)fluoranthene	207089	85	1	1.7	ug/l	10	10	NA		*(B)
Benzoic acid	65850	85	7	4.6	ug/l	50	50	12976	ORNL	No
Benzyl alcohol	100516	85	3	1.7	ug/l	10	10	NA		*(B)
Bromodichloromethane	75274	85	0	ND	ug/l	5	5	15215	ASTER	No
Bromoform	75252	85	10	2.6	ug/l	5	5	11000	EPA AWQC	No
Bromomethane	74839	85	0	ND	ug/l	10	10	67647	ASTER	No
Butyl benzylphthalate	85687	85	0	ND	ug/l	10	10	260	ASTER	No
Carbon disulfide	75150	85	1	1	ug/l	5	5	244	ORNL	No
Carbon tetrachloride	56235	85	0	ND	ug/l	5	5	1970	ORNL	No
Chlorobenzene	108907	85	2	1.8	ug/l	5	5	1203	ORNL	No
Chloroethane	75003	85	0	ND	ug/l	10	10	21069	ASTER	No
Chloroform	67663	85	2	1.8	ug/l	5	5	1240	ORNL	No
Chloromethane	74873	85	0	ND	ug/l	10	10	47635	ASTER	No
Chrysene	218019	85	1	1.9	ug/l	10	10	16	ASTER	No
Di-n-butyl-phthalate	84742	85	0	ND	ug/l	10	10	697	ORNL	No
Di-n-octyl-phthalate	117840	85	0	ND	ug/l	10	10	708	ORNL	No
Dibenz(a,h)anthracene	53703	85	0	ND	ug/l	10	10	NA		*(B)
Dibenz(a,j)acridine	224420	85	0	ND	ug/l			NA		*(B)
Dibenzofuran	132649	85	0	ND	ug/l	10	10	1003	ORNL	No
Dibromochloromethane	124481	85	0	ND	ug/l	5	5	14607	ASTER	No
Dibromomethane	74953	85	0	ND	ug/l	5	5	49932	ASTER	No
Dichlorodifluoromethane	75718	85	0	ND	ug/l	20	20	13641	ASTER	No
Dieldrin	60751	85	1	0.072	ug/l	0.1	0.1	0.0019	EPA AWQC	Yes
Diethyl phthalate	84662	85	1	1.2	ug/l	10	10	85600	ORNL	No
Dimethyl phthalate	131113	85	2	1.5	ug/l	10	10	121000	ASTER	No
Diphenylamine	122394	85	0	ND	ug/l	10	10	734	ASTER	No
Endosulfan I	959988	85	0	ND	ug/l	0.05	0.05	0.056	EPA AWQC	No
Endosulfan II	33213659	85	0	ND	ug/l	0.1	0.1	0.056	EPA AWQC	*(D)
Endosulfan sulfate	1031078	85	0	ND	ug/l	0.1	0.1	NA		*(B)
Endrin	72208	85	0	ND	ug/l	0.1	0.1	0.0023	EPA AWQC	*(D)
Endrin aldehyde	7421934	85	0	ND	ug/l	0.1	0.1	NA		*(B)

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Ethyl methacrylate	97632	85	0	ND	ug/l	20	20	31545	ASTER	No
Ethyl methanesulfonate	62500	85	0	ND	ug/l	10	10	NA		*(B)
Ethylbenzene	100414	85	0	ND	ug/l	5	5	440	ORNL	No
Fluoranthene	206440	85	4	5	ug/l	10	10	6.6	EPA AWQC	No
Fluorene	86737	85	0	ND	ug/l	10	10	214	ASTER	No
Heptachlor	76448	85	0	ND	ug/l	0.05	0.05	0.0038	EPA AWQC	*(D)
Heptachlor epoxide	1024573	85	3	0.14	ug/l	0.05	0.05	0.0038	EPA AWQC	Yes
Hexachlorobenzene	118741	85	0	ND	ug/l	10	10	3.68 (prop)	EPA AWQC	*(D)
Hexachlorobutadiene	87683	85	0	ND	ug/l	10	10	9.3	ASTER	No
Hexachlorocyclopentadiene	77474	85	0	ND	ug/l	10	10	5.2L	EPA AWQC	*(D)
Hexachloroethane	67721	85	0	ND	ug/l	10	10	141	ASTER	No
Indeno(1,2,3-cd)pyrene	193395	85	0	ND	ug/l	10	10	NA		*(B)
Iodomethane	74884	85	0	ND	ug/l	5	5	46261	ASTER	No
Isophorone	78591	85	0	ND	ug/l	10	10	9969	ASTER	No
Methoxychlor	72435	85	0	ND	ug/l	0.5	0.5	0.03	EPA AWQC	*(D)
Methyl methanesulfonate	66273	85	0	ND	ug/l	10	10	NA		*(B)
Methylene chloride	75092	85	56	150	ug/l	5	5	42667	ORNL	No
N-Nitroso-di-^n-propylamine	621647	85	1	1.8	ug/l	10	10	NA		*(B)
N-Nitroso-di-n-butylamine	924163	85	0	ND	ug/l	10	10	NA		*(B)
N-Nitrosodiphenylamine	86306	85	0	ND	ug/l	10	10	332	ORNL	No
N-Nitrosopiperidine	100754	85	0	ND	ug/l	10	10	381777	ASTER	No
Naphthalene	91203	85	0	ND	ug/l	10	10	620	ORNL	No
Nitrobenzene	98953	85	0	ND	ug/l	10	10	17317	ASTER	No
Pentachlorobenzene	608935	85	0	ND	ug/l	10	10	17	ASTER	No
Pentachloronitrobenzene [PCNB]	82688	85	0	ND	ug/l	50	50	100	ASTER	No
Pentachlorophenol [PCP]	87865	85	0	ND	ug/l	50	50	13 (pH dep)	EPA AWQC	*(D)
Phenactin	62442	85	0	ND	ug/l	10	10	30341	ASTER	No
Phenanthrene	85018	85	2	2.2	ug/l	10	10	135	ASTER	No
Phenol	108952	85	10	3.5	ug/l	10	10	200	ORNL	No
Pronamide	23950585	85	0	ND	ug/l	10	10	4278	ASTER	No
Pyrene	129000	85	1	4.2	ug/l	10	10	61	ASTER	No
Styrene	100425	85	0	ND	ug/l	5	5	4020	ASTER	No
Tetrachloroethene	127184	85	11	26	ug/l	5	5	750	ORNL	No

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Toluene	108883	85	4	2.3	ug/l	5	5	1269	ORNL	No
Toxaphene	8001352	85	0	ND	ug/l	5	5	0.0002	EPA AWQC	*(D)
Trichloroethene	79016	85	5	14	ug/l	5	5	7257	ORNL	No
Trichlorofluoromethane	75694	85	0	ND	ug/l	5	5	6412	ASTER	No
a,a-Dimethylphenethyl-^amine	122098	85	0	ND	ug/l	10	10	12562	ASTER	No
alpha-BHC	319846	85	0	ND	ug/l	0.05	0.05	95	ORNL	No
alpha-Chlordane	5103719	85	0	ND	ug/l	0.05	0.05	NA		*(B)
beta-BHC	319857	85	0	ND	ug/l	0.05	0.05	95	ORNL	No
bis(2-Chloroethoxy)^methane	111911	85	0	ND	ug/l	10	10	NA		*(B)
bis(2-Chloroethyl)ether	111444	85	1	10	ug/l	10	10	19000	ASTER	No
bis(2-Chloroisopropyl)^ether	108601	85	0	ND	ug/l	10	10	41435	ASTER	No
bis(2-Ethylhexyl)^phthalate	117817	85	12	58	ug/l	10	10	3	EPA AWQC	Yes
cis-1,3-Dichloropropene	10061015	85	0	ND	ug/l	5	5	5700	ASTER	No
delta-BHC	319868	85	1	0.034	ug/l	0.05	0.05	95	ORNL	No
gamma-BHC (Lindane)	58899	85	0	ND	ug/l	0.05	0.05	0.08	EPA AWQC	No
gamma-Chlordane	5103742	85	0	ND	ug/l	0.05	0.05	NA		*(B)
p-Dimethylaminoazobenzene	60117	85	0	ND	ug/l	10	10	416	ASTER	No
trans-1,2-Dichloroethene	156605	85	0	ND	ug/l	5	5	9538	ORNL	No
trans-1,3-Dichloropropene	10061026	85	0	ND	ug/l	5	5	244	ORNL	No
trans-1,4-Dichloro-2-butene	110576	85	0	ND	ug/l	5	5	NA		*(B)
Vinyl acetate	108054	85	0	ND	ug/l	10	10	810	ORNL	No
Vinyl chloride	75014	85	2	8.6	ug/L	10	10	NA		*(B)
Xylenes (total)	1330207	85	0	ND	ug/L	5	5	62308	ORNL	No
(+-)-15-Hexadecanolide		85	3	6.6	ug/l			NA		*
1,1'-Biphenyl, 4,4'-difluoro-		85	1	3.9	ug/L			NA		*
1,2-Ethanediamine, N,N-diethyl		85	3	26	ug/l			NA		*
1,3-Cyclopentanedione,2-bromo		85	5	79	ug/l			87900	ASTER	No
1,3-Propanediol, 2,2-dimethyl-		85	2	29	ug/L			NA		*
1-(1,2-Dichloro-2-(5-methoxy-4-^phenyl-1,2,4-tria!		85	1	5.6	ug/L			NA		*
1-Imidazolidinemethanol, 4,4-^dimethyl-2,5-dioxo-		85	2	10	ug/L			NA		*
1-Propanol, 2-(2-hydroxypropoxy)-		85	4	19	ug/L			NA		*
1-Propanol, 2-(2-methoxypropoxy)-		85	3	5.7	ug/L			NA		*
1-Propanol, 2-methoxy-		85	2	4.3	ug/L			NA		*

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
1-Propene, 1,1,2-trichloro-		85	1	4.2	ug/L			NA		*
1-Propene, 1,2,3-trichloro-		85	1	4.7	ug/L			NA		*
14-Pentadecenoic acid		85	1	8.9	ug/L			NA		*
15-Crown-5		85	1	6.3	ug/L			NA		*
1H-Indol-5-ol		85	1	7.9	ug/L			NA		*
1H-Indole, 2,3-dihydro-4-methyl-		85	1	6.6	ug/L			NA		*
2(5H)-Furanone, 3-methyl-		85	1	6.3	ug/L			NA		*
2(5H)-Furanone, 5-methyl-		85	2	9.5	ug/L			NA		*
2,4-Imidazolidinedione, 1,3-dichloro-5,5-dimethyl-		85	1	6.1	ug/L			NA		*
2,4-Imidazolidinedione, 1-(hydroxymethyl)-5,5-dime		85	4	49	ug/L			NA		*
2,4-Imidazolidinedione, 1-^(hydroxymethyl)-5,5-di!		85	16	100	ug/L			NA		*
2,4-Imidazolidinedione, 5,5-dimethyl-		85	10	50	ug/L			NA		*
2,4-Pentanediol, 2-methyl-		85	2	230	ug/L			NA		*
2,5,8,11,14-Pentaoxahexadecan-16-ol		85	1	8.2	ug/L			NA		*
2,5-Hexanedione		85	1	4.8	ug/L			NA		*
2-Bromo-2'methoxyacetophenone		85	1	4.4	ug/L			NA		*
2-Butanol, 3,3'-oxybis-		85	3	25	ug/L			NA		*
2-Butanol, 3-methyl-		85	1	14	ug/L			NA		*
2-Chlorocyclohexanol		85	1	16	ug/L			NA		*
2-Cyclohexen-1-ol		85	8	8.2	ug/L			NA		*
2-Cyclohexen-1-one		85	7	7	ug/L			NA		*
2-Hexene, 4,4,5-trimethyl-		85	1	5.4	ug/L			NA		*
2-Nonadecanone, o-methyloxime		85	1	3.9	ug/L			NA		*
2-Nonanone, O-methyloxime		85	2	16	ug/L			NA		*
2-Octanone, O-methyloxime		85	1	6.3	ug/L			NA		*
2-Pentanone, 4-hydroxy-4-methyl-		85	1	16	ug/L			NA		*
2-Pentene, 4,4-dimethyl-,(E)-		85	1	6.2	ug/L			NA		*
2-Propanol, 1,1'-[(1-methyl-1,2-^ethanediyl)bis!		85	1	5.4	ug/L			NA		*
2-Propanol, 1,1'-oxybis-		85	1	16	ug/L			NA		*
2-Propanol, 1-(2-methoxy-1-^methylethoxy)-		85	5	55	ug/L			NA		*
2-Propanol, 1-(2-methoxypropoxy)-		85	5	150	ug/L			NA		*
2-Propanol, 1-(diethylamino)-		85	1	8.2	ug/L			NA		*
2-Propanol, 1-[1-methyl-2-(2-^propenyloxy)ethoxy]-		85	2	7.9	ug/L			NA		*

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
2-Propanol, 1-[2-(2-methoxy-1-methyl-^ethoxy)-1-m!		85	1	4.3	ug/L			NA		*
2-Pyridinecarbonitrile		85	6	21	ug/L			NA		*
2-Pyrrolidinone, 1-methyl		85	3	15	ug/l			2626837	ASTER	No
2-Tridecanone, O-methyloxime		85	1	14	ug/L			NA		*
2H-1-Benzopyran-2-one, 7-(diethylamino)-		85	3	10	ug/l			NA		*
2H-Indol-2-one, 1,3-dihydro		85	24	52	ug/l			125376	ASTER	No
3,6,9,12-Tetraoxahexadecan-1-ol		85	1	6.4	ug/L			NA		*
3-Pentanol		85	1	4.5	ug/l			56137	ASTER	No
4-Penten-2-ol		85	3	16	ug/l			NA		*
4-Pryidinecarbonitrile		85	1	21	ug/l			NA		*
9,10-Anthracenedione		85	1	5.1	ug/l			240	ASTER	No
9,12,15-Octadecatrien-o-ol		85	1	14	ug/l			NA		*
9,12-Octadecadienoic acid (Z,Z)-		85	1	6.2	ug/l			NA		*
9-Hexadecenoic acid		85	7	15	ug/l			NA		*
9-Octadecenamide, N,N-dimethyl-		85	1	5.1	ug/l			NA		*
Acetamide, N,N-diethyl-		85	2	5.8	ug/l			NA		*
Benzene, (1-methylnonyl)-		85	1	5.5	ug/L			NA		*
Benzene, (2-bromoethenyl)-		85	2	6.5	ug/L			NA		*
Benzene, 1-isocyanato-2-methyl-		85	5	28	ug/L			NA		*
Benzene, 1-isocyanato-3-methyl-		85	3	12	ug/L			NA		*
Benzene, 1-isocyanato-4-methyl-		85	2	11	ug/L			NA		*
Benzenesulfonamide, 4-methyl		85	3	34	ug/l			NA		*
Butanamide, N-ethyl-		85	1	13	ug/L			NA		*
Butanoic acid		85	1	9.2	ug/l			104065	ASTER	No
Caffeine		85	3	11	ug/L			NA		*
Cholestanol		85	1	7.5	ug/L			NA		*
cis-1,2-Dichloroethene		85	4	39	ug/l			28696	ASTER	No
Cyclohexane, bromo-		85	1	5	ug/L			NA		*
Cyclohexane, hexyl-		85	1	18	ug/L			NA		*
Cyclohexane, methyl-		85	2	5.9	ug/L			NA		*
Cyclohexanol, 2-bromo-, cis-		85	4	32	ug/L			NA		*
Cyclohexanol, 2-bromo-, trans-		85	1	4.3	ug/L			NA		*
Cyclooctene, 5,6-diethenyl-, trans-		85	1	7.5	ug/L			NA		*

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Cyclopentane, ethyl-		85	1	3.9	ug/L			NA		*
Cyclotetradecane		85	1	3.8	ug/L			NA		*
Eicosane, 7-hexyl-		85	1	3.9	ug/L			NA		*
Ethanamine, N-ethyl-		85	1	20	ug/L			NA		*
Ethane, 1,2-dimethoxy-		85	1	6.6	ug/L			NA		*
Ethanol, 2-(2-butoxyethoxy)-		85	2	5.4	ug/L			NA		*
Ethanol, 2-(2-ethoxyethoxy)-		85	5	11	ug/L			NA		*
Ethanol, 2-(2-methoxyethoxy)-		85	2	14	ug/L			NA		*
Ethanol, 2-(diethylamino)-		85	18	3200	ug/L			NA		*
Ethanol, 2-(dodecyloxy)-		85	1	4.7	ug/L			NA		*
Ethanol, 2-[2-[4-(1,1,3,3-tetramethylbutyl)phenoxy		85	3	15	ug/L			NA		*
Ethanol, 2-[4-(1,1-dimethylethyl)^phenoxy]-		85	3	13	ug/L			NA		*
Ethanol, 2-butoxy-		85	7	18	ug/L			NA		*
Ethanol, 2-butoxy-, phosphate (3:1)		85	10	26	ug/L			NA		*
Ethene, 1,2-dichloro-,(Z)		85	1	41	ug/L			NA		*
Formamide, N,N'-diethyl-		85	2	16	ug/L			NA		*
Formamide, N-methyl-		85	1	9.8	ug/L			NA		*
Heneicosane		85	1	4.3	ug/L			NA		*
Heptadecane, 2,6,10,15-tetramethyl-		85	1	7.7	ug/L			2030	ASTER	No
Heptadecane, 4-methyl-		85	1	7.8	ug/L			2030	ASTER	No
Hexadecane, 3-methyl-		85	1	7.9	ug/L			NA		*
Hexadecanoic acid		85	8	14	ug/L			NA		*
Hexanoic acid, 3,5,5-trimethyl-		85	2	16	ug/L			NA		*
Hexylene Glycol		85	1	92	ug/L			NA		*
Hydroperoxide, 1,1-dimethylethyl-		85	1	9	ug/L			NA		*
Morpholine, 4-ethyl-		85	7	24	ug/L			NA		*
Octadecanoic acid, 12-hexyl-,^methyl ester		85	1	5.7	ug/L			NA		*
Octadecanoic acid, butyl ester		85	1	5.4	ug/L			NA		*
Oleic Acid		85	4	9.5	ug/L			NA		*
Oxacycloheptadecan-2-one		85	2	12	ug/L			NA		*
Oxacyclohexadecan-2-one, 16-methyl-		85	1	12	ug/L			NA		*
Oxygenated Hydrocarbon		85	24	35	ug/L			NA		*
p-tert-Amyl phenoxy ethanol		85	2	4.7	ug/L			NA		*

TABLE 2-5
SUMMARY OF ECOLOGICAL AND QUARTERLY MONITORING DATA FOR SURFACE-WATER ANALYSES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	CAS Number	Number of Samples	Frequency of Detection	Maximum Concentration	Units	Detection Limit		Lowest Benchmark	Reference	COEC ?
						Maximum	Minimum			
Pentanamide, N-ethyl-		85	1	18	ug/L			NA		*
Pentane, 1,4-dibromo-		85	1	5.8	ug/L			NA		*
Pentane, 2,4-dibromo-		85	2	6.1	ug/L			NA		*
Phenol, nonyl-		85	1	5.4	ug/l			24	ASTER	No
Phenol,2-(1,1-dimethlethyl)-		85	1	4.3	ug/l			362	ASTER	No
Phenol,4-(1,1,3,3-tetramethylbutyl)-		85	1	6.2	ug/l			33	ASTER	No
Phenol,4-(2,2,3,3-tetramethylbutyl)-		85	2	4.3	ug/l			33	ASTER	No
Phosphine oxide, triphenyl-		85	17	140	ug/l			5164	ASTER	No
Phosphine sulfide, triphenyl		85	16	18	ug/l			NA		*
Phosphoric acid ester		85	1	23	ug/l			NA		*
Propane,1-(1-methylethoxy)-		85	1	4.9	ug/l			20497	ASTER	No
Siloxane		85	5	20	ug/L			NA		*
Tetratetracontane		85	1	4.3	ug/L			NA		*
Triethylamine		85	1	12	ug/L			NA		*
Undecane, 2 3-dimethyl-		85	1	6.1	ug/L			NA		*
Undecane, 4,6-dimethyl-		85	1	8.9	ug/L			NA		*

Constituents in *italics* represent tentatively identified compounds (TICs). An attempt was made to locate benchmarks for TICs measured during the ecological studies. They were included in the assessment of chemicals of potenti
This includes TICs qualified as Level 2, Level 3, or unqualified but not listed on the sample analyte list specified in the work plan. The table above includes TICs from both the ecological and quaterly studies.
Level 2 TICs are "confidently identified", i.e., good agreement was observed between the unknown compound and a specific library spectrum. Level 3 TICs are "confirmed identification", i.e., the identification is based on the an
standard. Quantitation of TICs is based on the total ionization peak area relative to an internal standard, assuming a response factor of one. Accordingly, the reported concentration is an estimate and should be considered as an un
overall assessment of risk.
NA - No benchmark available
"*" with a "B" in parentheses indicates that no benchmark is available and with a "D" indicates the benchmark is lower than at least one detection limit, hence the chemical
remains an uncertainty with respect to evaluation of risk. This is also discussed in Section 5.3.2 and Table 5-19.

TABLE 2-6

AVERAGES AND RANGES OF CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN (COECs) IN COMPOSITE CRAYFISH COLLECTED JUNE 1995, SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM

	Section							Reference Stream	
COPECs	EE01-EE03[a]	EE04-EE06[b]	EE07[c]	EE08[d]	EE9-EE10[e]	EW02[f]	EW03[g]	CR-EC01	CR-EC02
Inorganics (mg/kg)									
Aluminum	69.03 (30.6-97.8)	181.67 (140-205)	101.03 (76.1-119)	127 (127)	56.2(42.7-74.8)	30.93 (25.8-36.6)	79.3 (66.5-94.9)	190.87 (59.5-433)	86.63 (73.9-111)
Antimony	ND	ND	ND	ND	ND	ND	ND	60.6 (60.6)	ND
Arsenic	0.52 (0.52)	0.62 (0.62)	0.72 (0.72)	ND	ND	ND	ND	54.4 (54.4)	ND
Barium	105.9 (19.7-154)	200.33 (135-267)	162.67 (140-191)	185 (185)	116 (51-174)	33.17 (19.7-50.2)	109.3 (72.9-138)	253.3 (148-412)	211 (148-251)
Cadmium	2.2 (1.4-2.9)	6.9 (6.2-8)	1.7 (1.1-2.3)	3.5 (3.5)	4.6 (4.4-4.8)	2.63 (1.7-3.3)	2.63 (1.6-3.4)	5.5 (5.5)	ND
Chromium	2.73 (2.4-3.1)	2.87 (2.4-3.6)	3.8 (3.5-4.1)	4.9 (4.9)	3.67 (2.7-4)	1.56 (0.99-2.7)	1.357 (0.84-2.3)	21.4 (21.4)	ND
Cobalt	ND	1.2 (1.2)	ND	ND	ND	ND	1 (1)	28.46 (0.82-56.1)	ND
Copper	85.3 (50.5-104)	81.87 (77.1-85.3)	98.43 (90.8-108)	82 (82)	64.13 (58.3-67.8)	59.33 (50.5-65.3)	61.63 (51.1-75.6)	43.53 (28-65.4)	36.03 (33.8-39.5)
Cyanide	ND	ND	ND	ND	ND	ND	ND	9.3 (9.3)	ND
Iron	121.17 (50.5-178)	243.67 (200-270)	171.67 (131-203)	218 (218)	162.27 (99.8-199)	59.97 (50-79.4)	147 (116-204)	160.57 (84.7-283)	137.33 (11-158)
Lead	1.64 (.97-2.1)	3.94 (1.6-5.6)	1.7 (1.3-2.5)	2.3 (2.3)	1.63 (1.4-2)	0.84 (0.8-0.91)	1.18 (0.85-1.6)	19.14 (0.48-56.4)	0.77 (0.64-0.86)
Manganese	17.1 (14.2-18.6)	38.13 (26.6-52.7)	52.37 (31.7-69)	67.3 (67.3)	78.4 (39.5-120)	17.9 (14.2-20.1)	157.9 (32.1-376)	85.93 (52.1-134)	134.2 (53.6-205)
Mercury	ND	ND	ND	ND	ND	ND	ND	0.45 (0.45)	ND
Molybdenum	ND	ND	ND	ND	ND	ND	ND	55.1 (55.1)	ND
Nickel	1.2 (1.2)	1.57 (1.3-2.1)	1.7 (1.3-2.1)	1.8 (1.8)	1.53 (1.2-2)	1 (1)	1.9 (1.9)	(55.4 (55.4)	ND
Selenium	0.65 (0.65-0.65)	0.96 (0.46-1.7)	0.51 (0.51-0.51)	(0.67-0.67)	1.28 (0.83-1.7)	ND	0.47 (0.38-0.6)	5.3 (5.3-5.3)	0.8 (0.46-1.1)
Silver	1.21 (0.92-1.5)	0.823 (0.61-1)	ND	ND	(0.32-)	0.747 (0.65-0.82)	1.017 (0.85-1.1)	28.54 (0.58-56.5)	ND
Vanadium	0.365 (0.3-0.43)	0.32 (0.32-0.32)	0.49 (0.45-0.51)	0.51 (0.51-0.51)	26.03 (24.5-27.5)	22.03 (20.1-23.4)	0.467 (0.32-0.73)	28.55 (0.4-28.55)	0.545 (0.42-0.67)
Zinc	24.8 (20.1-27.9)	28 (26.6-29.9)	61.2 (23.5-133)	26.9 (26.9-26.9)	0.71 (0.44-0.98)	0.375 (0.3-0.45)	27.4 (22.9-32.4)	42.067 (21.4-77.6)	28.23 (26.4-29.6)
Organics (ug/kg)									
Acetone	2700 (1100-4200)	913.33 (240-1300)	1466.67 (1200-1800)	ND	ND	1766.67 (1100-2800)	610 (610-610)	2220 (260-3600)	3900 (3200-4600)
Carbon disulfide	ND	ND	1.1 (1.1)	ND	ND	ND	ND	ND	ND
Toluene	7400 (4800-10000)	2.1 (1.2-3)	1.65 (1.1-2.2)	ND	ND	1.8 (1.6-2)	ND	54 (54-54)	1.4 (1.4-1.4)
Methylene chloride	47.33 (36-61)	33.13 (6.4-72)	15.67 (7.2-32)	ND	ND	51.67 (24-70)	15 (15-15)	105.17 (5.5-280)	56 (15-97)
Total Xylenes	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	46 (46-46)	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	1200 (1200-1200)	ND
Chlorinated Aromatic Hydrocarbons									
Naphthalene, 1,2,3,4-tetrachloro-	ND	ND	ND	ND	1400 (1400-1400)	ND	ND	ND	ND
Naphthalene, 1,3,5,7-tetrachloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene, 1,4,6,7-tetrachloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene, 2,3,6-trichloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene, heptachloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND

AVERAGES AND RANGES OF CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN (COECs) IN COMPOSITE CRAYFISH COLLECTED JUNE 1995, SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM

	Section							Reference Stream	
COPECs	EE01-EE03[a]	EE04-EE06[b]	EE07[c]	EE08[d]	EE9-EE10[e]	EW02[f]	EW03[g]	CR-EC01	CR-EC02
Phenols and Substituted Phenols									
2,4 Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	2400 (2400-2400)	ND
2-Nonylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol, nonyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	265 (250-280)	195 (150-240)	323.33 (160-500)	ND	ND	ND	ND	2900 (2900-2900)	ND
Phenol, 4-(2,2,3,3,-tetramethylbutyl)-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol, 4-4'-(1,2-diethyl-1,2-^ethanediyl)bis-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol, 4-dodecyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Ethylhexyl)^phthalate	330 (330-330)	ND	ND	ND	ND	660 (660-660)	ND	180 (180-180)	ND
PCBs									
Aroclor 1254	1833.33 (1100-3300)	2616.67 (1700-3800)	535 (450-760)	1500 (1400-1600)	601.67 (470-800)	2850 (2100-3400)	1650 (1400-2000)	41.83 (23-48)	63 (31-91)
Aroclor 1260	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Biphenyl, 2,2',3,4,5,5'-hexachloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1'-Biphenyl, 2,2',3',4,5-^pentachloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1'-Biphenyl, 2,2',4,4',5-^pentachloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1'-Biphenyl, 2,3,4,4',6-pentachloro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides									
Aldrin	ND	ND	ND	ND	ND	ND	ND	23 (23-23)	ND
alpha-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	59 (59-59)	ND
Heptachlor	ND	78 (75-81)	13.33 (12-16)	41.5 (41-42)	ND	ND	ND	25 (25-25)	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND	ND	ND
alpha- BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND
delta-BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan Sulfate	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND	ND

AVERAGES AND RANGES OF CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN (COECs) IN COMPOSITE CRAYFISH COLLECTED JUNE 1995, SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM

	Section							Reference Stream	
COPECs	EE01-EE03[a]	EE04-EE06[b]	EE07[c]	EE08[d]	EE9-EE10[e]	EW02[f]	EW03[g]	CR-EC01	CR-EC02
Benzidine	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphine sulfide, triphenyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
PAHs									
Low Molecular Weight									
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene, decahydro-2-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	1500 (1500-1500)	ND
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbazole	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	196.67 (14-240)	ND	ND	ND	ND	ND	ND	ND
Dibenzothiophene, 3-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
4H-Cyclopenta[def]phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene, 1-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene, 2-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene, 9-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene, 3-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Medium Molecular Weight									
Fluoranthene	ND	433.33 (230-560)	150 (150-150)	ND	ND	ND	ND	ND	ND
Pyrene	ND	ND	ND	ND	ND	ND	ND	1300 (1300-1300)	ND
9,10-Dimethylanthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene, 2,5-dimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene, 3,6-dimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene, 9,10-dimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
9,10-Anthracenedione	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphtho[2,3-b]thiophene, 4,9-dimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
11H-Benzo[b]fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene, 2-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrene, 4-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)carbazole	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 2-6

AVERAGES AND RANGES OF CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN (COECs) IN COMPOSITE CRAYFISH COLLECTED JUNE 1995, SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM

	Section							Reference Stream	
COPECs	EE01-EE03[a]	EE04-EE06[b]	EE07[c]	EE08[d]	EE9-EE10[e]	EW02[f]	EW03[g]	CR-EC01	CR-EC02
High Molecular Weight									
Phenanthrene, 2,3,5-trimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[c]phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	ND	200 (160-240)	ND	ND	ND	ND	ND	ND	ND
Triphenylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]naptho[2,1-d]thiophene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[c]phenanthrene, 3-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Triphenylene, 2-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	150 (150-150)	ND	ND	ND	ND	ND	ND	ND
Benzo(e)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysin	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenz(a,c)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo[b]naptho[2,1-d]thiophene	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Phenylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,4-Dihydrocyclopenta(cd)pyrene (acepyrene)	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-Fluoranthenamine	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,8-Dimethyldibenzo(B,D)thiophene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz[j]aceanthrylene, 3-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(c)carbazole	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene, 3-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzo(B-def)carbazole	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzothiophene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indolo[3,2-c]cinnoline	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 2-6

AVERAGES AND RANGES OF CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN (COECs) IN COMPOSITE CRAYFISH COLLECTED JUNE 1995, SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM

	Section							Reference Stream	
COPECs	EE01-EE03[a]	EE04-EE06[b]	EE07[c]	EE08[d]	EE9-EE10[e]	EW02[f]	EW03[g]	CR-EC01	CR-EC02
Hexanoic acid, 3,5,5-trimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Butanoic acid	ND	ND	ND	ND	ND	ND	ND	ND	ND
9,12-Octadecadienoic acid (Z,Z)-	ND	52000 (52000-52000)	69000 (60000-78000)	ND	32000 (2000-62000)	110000 (110000-110000)	44550 (3100-86000)	2800 (2800-2800)	64900 (4400-130000)
Octadecanoic acid, butyl ester	ND	ND	ND	ND	ND	ND	ND	ND	ND
14-Pentadecenoic acid	ND	3200 (3200-3200)	ND	ND	ND	ND	ND	ND	ND
Hexadecanoic acid	ND	65666.67 (40000-93000)	61000 (53000-69000)	ND	44500 (38000-51000)	ND	21666.67 (7000-30000)	38333.33 (36000-40000)	38333.33 (35000-42000)
9-Hexadecenoic acid	30000 (30000-30000)	33500 (6000-61000)	4200 (4200-4200)	ND	30000 (30000-30000)	23500 (17000-30000)	3300 (3300-3300)	2800 (2800-2800)	9275 (2100-17000)
1,3-Cyclopentanedione, 2-bromo-	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-(1,2-Dichloro-2-(5-methoxy-4-^phenyl-1,2,4-tria!	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cyclopentane, ethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Imidazolidinemethanol, 4,4-^dimethyl-2,5-dioxo-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Imidazolidinedione, 1-^(hydroxymethyl)-5,5-di!	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Imidazolidinedione, 5,5-dimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Pentanediol, 2-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanol, 3-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Cyclohexen-1-ol	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Cyclohexen-1-one	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cyclohexane, bromo-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Pyrrolidinone, 1-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2H-Indol-2-one, 1,3-dihydro-	ND	ND	ND	ND	ND	ND	ND	ND	ND
3,6,9,12-Tetraoxahexadecan-1-ol	ND	ND	ND	ND	ND	ND	ND	ND	ND
3-Pentanol	ND	ND	ND	ND	ND	ND	ND	ND	ND
bis(2-Chloroethyl) ether	ND	ND	ND	ND	ND	ND	ND	ND	ND
Caffeine	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cyclohexanol, 2-bromo-, cis-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol, 2-(2-ethoxyethoxy)-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol, 2-(diethylamino)-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol, 2-butoxy-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol, 2-[2-[4-(1,1,3,3-tetramethylbutyl)phenoxy	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol, 2-butoxy-, phosphate (3:1)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Formamide, N-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heneicosane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptadecane, 2,6,10,15-tetramethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND

AVERAGES AND RANGES OF CONCENTRATIONS OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN (COECs) IN COMPOSITE CRAYFISH COLLECTED JUNE 1995, SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT AND REFERENCE STREAM

	Section							Reference Stream	
COPECs	EE01-EE03[a]	EE04-EE06[b]	EE07[c]	EE08[d]	EE9-EE10[e]	EW02[f]	EW03[g]	CR-EC01	CR-EC02
Phosphoric acid, 2-ethylhexyl^diphenyl ester	ND	ND	ND	ND	ND	ND	ND	ND	ND
Propane, 1-(1-methylethoxy)-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Hexene, 4,4,5-trimethyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Pentene, 4,4-dimethyl-,(E)-	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Propanol, 1-[2-(2-methoxy-1-methyl-^ethoxy)-1-ml	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Pyridinecarbonitrile	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene, 1-isocyanato-2-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene, 1-isocyanato-4-methyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol, 2-[2-[4-(1,1,3,3-tetramethylbutyl)phenoxy	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol, 2-butoxy-, phosphate (3:1)	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-tert-Amyl phenoxy ethanol	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Bromo-2'methoxyacetophenone	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phosphine oxide, triphenyl-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Siloxane	ND	ND	ND	ND	ND	ND	ND	ND	ND

[a] Corresponds to biological section designation EE01

[b] Corresponds to biological section designation EE02

[c] Corresponds to biological section designation EE03

[d] Corresponds to biological section designation EE04

[e] Corresponds to biological section designation EE05

[f] Corresponds to biological section designation EW01

[g] Corresponds to biological section designation EW02

TABLE 2-7

SUMMARY OF PHYSICAL AND CHEMICAL PROPERTIES OF INORGANIC CHEMICALS OF ECOLOGICAL CONCERN (COECs) IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Compound	Molecular Weight	Melting Point (deg C)	Boiling Point (deg C) @ 1atm	Vapor Pressure (mm Hg) @ 25 deg C	Aqueous Solubility (mg/l)
METALS					
Aluminum	26.98	660	NA	NA	Extremely Low
Barium	137.34	710	1600	NA	NA
Cadmium	112.41	321	765	Extremely Low	Insoluble
Chromium	51.996	1900	2672	Extremely Low	Insoluble
Cobalt	58.93	1493	2870	0 at 20 deg C	Insoluble
Copper	63.546	1083	2595	Extremely Low	Insoluble
Iron	55.85	1535	3000	Extremely Low	Insoluble
Lead	207.19	327	1744	NA	Insoluble
Manganese	54.94	1244	1962	Extremely Low	NA
Mercury	200.59	-39	357	0.002	Extremely Low
Molybdenum	95.94	2622	4825	Extremely Low	Insoluble
Nickel	58.7	1455	2730	Extremely Low	Insoluble
Silver	107.37	960.5	2000	NA	Insoluble
Vanadium	50.94	1917	3380	Extremely Low	Insoluble
Zinc	65.38	419.5	908	Extremely Low	Insoluble
METALLOIDS					
Antimony	121.75	630	1635	Extremely Low	Insoluble
Arsenic	74.9	817	613	Extremely Low	Insoluble
Selenium	78.96	217	685	NA	Extremely Low

TABLE 2-8

SUMMARY OF PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC CHEMICALS OF ECOLOGICAL CONCERN (COECs) FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Compound	Molecular Weight	Melting Point (deg C)	Boiling Point (deg C) @ 1atm	Vapor Pressure (mm Hg) @ 25 deg C	Henry's Law Constant (atm m^3 /mole)	Log Kow	LogKoc	Aqueous Solubility (mg/l)
MISCELLANEOUS VOLATILE ORGANICS								
Acetone	41	-95.35	56.2	227 (Calc.)	2.88E-05	-0.27	1.19	6.02E+05
Methylene Chloride	84.93 (calc)	-95	39.75	400	3.18E-03 (calc)	1.25	2.02	15300 (calc)
Toluene	92.13	-95	111	28.4	0.00665 (Calc)	2.79	2.86	518
Xylene	106.16	NA	137-140	5.87	NA	3.20	1.76	200
CHLORINATED BENZENES								
Chlorobenzene	112.56	-45.6	132	11.8	4.24E-03	2.86	2.89	448
1,4 Dichlorobenzene	147.01	53.1	174	10 @ 54.8 deg C	0.0111 (calc)	3.57	3.28	65.3
CHLORINATED AROMATIC HYDROCARBONS								
Napthalene, 2,3,6 - Trichloro	162.61	-2.5	259.3	0.029	0.000355	5.45	4.30	17.4
PHENOLS AND SUBSTITUTED PHENOLS								
2,4-Dimethylphenol	122.16	25.4-26	211.5	10 @ 92.3 deg C	6.97E-05	2.77	2.85	376
Pentachlorophenol	266.3	190-191	309-310	1.10E-04	NA	5.06	4.09	1.40E+01
Phenol	94.11	43	181.75	0.3513	0.0000103 (calc)	148.00	2.14	6.67E+04
2-Nonylphenol	220.4	-10	293-297	0.0000804 (Calc.)	NA	6.36	4.79	2.07E-02
PTHALATES								
bis (2-Ethylexyl)phthalate	390.54	-50	230 @ 5mm Hg	1.32 @ 200 deg C	NA	4.89	5.00	1.78E-04
POLYCHLORINATED BIPHENYLS (PCBs)								
Aroclor 1254	327	NA	365-390	7.70E-05	NA	6.30	4.63	0.0057
ORGANOCHLORIDE PESTICIDES								
Aldrin	364.9	104	409	6.00E-06	2.76E-09	5.09	4.10	0.20
alpha Chlordane	409.8	103-105	175@ 2 mm Hg	1.00E-05	8.60E-04	5.54	4.35	0.056
Dieldrin	380.9	175	417	7.78E-07	1.88E-11	2.92	2.92	0.186
Heptachlor	373.3	95	145	0.0003	0.00000000108	4.61	3.84	0.056
Heptachlor epoxide	389.4	160-161.5	412	2.11E-09 (Calc)	3.20E-05	4.61	3.84	0.35
alpha-BHC	290.85	158	288	0.02 @ 20 deg C	1.51E-05	2.78	2.85	10
delta-BHC	290.83	141	301	0.02 @ 20 deg C	8.61E-06	3.75	3.38	7.28
Endosulfan Sulfate	422.95	181	NA	1.00E-05	NA	3.75	3.38	0.22
Methoxyclor	345.65	89	411 (calc)	Very Low	NA	5.33	4.23	0.1

TABLE 2-8

SUMMARY OF PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC CHEMICALS OF ECOLOGICAL CONCERN (COECs)
FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Compound	Molecular Weight	Melting Point (deg C)	Boiling Point (deg C) @ 1atm	Vapor Pressure (mm Hg) @ 25 deg C	Henry's Law Constant (atm m^3 /mole)	Log Kow	LogKoc	Aqueous Solubility (mg/l)
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)								
Low Molecular Weight PAHs								
Naphthalene	128.2	80.55	217.9	0.0492 @ 20 deg C		3.32	3.14	31.7
Acenaphthene	154.2	96	279	0.001-0.01 @ 20 deg		4.07	3.55	3.42
Flourene	116.15	116-117		0.001-0.01 @ 20 deg		4.23	3.64	1.9
Anthracene	178.23	216	342	0.000195 @ 20 deg		4.49	3.78	0.073
Phenanthrene	178.23	101	340	0.00068 @ 20 deg C		4.49	3.78	1.29
Medium Molecular Weight PAHs								
Flouranthene	202.26	111	250	1E-06 - 1E-04 @ 20		4.95	4.03	0.26
Pyrene	202	150	404	6.85E-07 @ 20 deg		4.95	4.03	0.171
High Molecular Weight PAHs								
Benzo(a)Anthracene	228.28	155-157		5E-09 @ 20 deg C		5.66	4.42	0.009
Chrysene	228.28	256	448	1E-11 - 1E-06 @ 20		5.66	4.42	0.002
Benzo(a)pyrene	252	179	311	5.00E-09		6.12	4.67	0.0038
Benzo(b)flouranthene	252.32	167-168	NA	1E-11 - 1E-06 @ 20 deg C		6.12	4.64	0.0012
Benzo(k)flouranthene	252.32	217	NA	9.59E-11 @ 20 deg		6.12	4.67	0.00055
Benzo(g,h,i)perylene	276	222	NA	approx. 1E-10 @ 20 deg C		6.58	4.92	0.00026
Indeno(1,2,3-cd)pyrene	276.34	162.5-164	536	approx. 1E-10 @ 20 deg C		6.58	4.92	0.062
Dibenzo(a,h)anthracene	278.36	270	524	approx. 1E-10 @ 20 deg C		6.84	5.06	0.0005
OTHER ORGANICS								
Benzidene	184.23	115-120	400	0.0000666 (calc.)	9.84E-09	1.58	NA	400

Note: NA indicates that no data were available.
Calc. indicates values that have been calculated.

TABLE 2-9
SUMMARY OF FATE AND POTENTIAL EFFECTS OF COECs FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	Trophic Level[1]			Occurrence in Medium[2]				Contact Mode[3]			Potential Receptor Group[4]								Most Significant Chronic Exposure Effect(s)[5]						
											Aquatic					Terrestrial									
	AqA	AqP	BM	Wat	Sed	Pla	Ani	D	R	I	Mic	Alg	Vas. Pla.	AqI	Fl	AR	Bir	Mam	Mic	AqP	AqI	Fl	AR	Bir	Mam
INORGANICS																									
Aluminum	N0	YES	NO	YES	YES	YES	NO	Y	N	Y	DG	S	S	S	S	HS	DG	R	Su	Su	Su	Su	De	De	De
Barium	NO	YES	NO	YES	YES	YES	NO	Y	N	Y	DG	DG	S	S	DG	DG	R	R	Su	Gr	Su	Su	Su	Su	Su
Cadmium	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	DG	HS	HS	ES	HS	S	S	S	Su	Gr	Re	Re	Re	Re	Re
Chromium	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	S	HS	S	HS	HS	HS	S	S	Su	Gr	Re	Re	Su	Su	Su
Cobalt	NO	NO	NO	YES	YES	NO	NO	Y	N	N	DG	DG	S	HS	S	DG	S	S	Su	Gr	Re	Gr	Re	Re	Re
Copper	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	S	ES	S	HS	ES	S	R	R	Su	Su	Su	Su	Su	Su	Su
Iron	NO	NO	NO	YES	YES	NO	NO	Y	N	N	R	S	R	HR	S	DG	R	R	Su	Su	Su	Su	Su	Su	Su
Lead	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	HS	S	S	ES	HS	S	S	S	Su	Gr	Re	Re	?	Gr,De	Re
Manganese	NO	NO	NO	YES	YES	NO	NO	Y	N	N	DG	DG	S	HS	HS	DG	R	R	Su	Su	Re	Re	Gr	Gr	Gr
Mercury	YES	YES	YES	YES	YES	YES	YES	Y	Y	Y	DG	ES	S	ES	HS	HS	HS	HS	Su	Gr	Re,De	Re,De	Re	Re	Re
Molybdenum	NO	YES	NO	YES	YES	YES	NO	Y	N	Y	DG	DG	HS	S	DG	DG	R	S	Su	Gr	Su	Su	De	De	De
Nickel	NO	NO	NO	YES	YES	NO	NO	Y	N	Y	S	S	S	HS	HS	DG	HS	HS	Su	Su	Gr	Gr	Gr	Gr	Gr
Silver	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	HS	S	DG	HS	HS	HS	S	S	Su	Su	Su	Su	Gr	Gr	Gr
Vanadium	NO	NO	NO	YES	YES	NO	NO	Y	N	Y	R	DG	S	S	HS	DG	R	R	Su	Gr	Su	Su	Su,Gr	Su,Gr	Su,Gr
Zinc	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	S	HS	S	HS	HS	DG	R	R	Su	Gr	Su,Gr	Su,Gr	Re	Re	Re
Antimony	NO	NO	NO	YES	YES	NO	NO	Y	N	N	DG	S	DG	S	S	DG	DG	S	Su	Gr	Re	Re	Su	Su	Su
Arsenic	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	DG	HS	S	S	S	HS	S	S	Su	Su,Re	Re,Su	Re,Su	Re	Re	Re
Selenium	YES	YES	??	YES	YES	YES	YES	Y	N	Y	DG	S	HS	HS	HS	DG	HS	HS	Su	Su	Re,Su	Re,Su	Re,De	Re,De	Re,De
Cyanide	NO	NO	NO	YES	YES	NO	NO	Y	Y	N	DG	HS	DG	HS	HS	DG	S	S	Su	Su	Su	Su	Su,De	Su,De	Su,De
ORGANICS																									
Acetone	NO	NO	NO	YES	YES	NO	NO	Y	Y	N	HR	S	DG	S	HR	HR	R	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Carbon Disulfide	NO	NO	NO	YES	YES	NO	NO	Y	Y	N	DG	S	DG	S	S	DG	DG	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Methylene Chloride	NO	NO	NO	YES	YES	NO	NO	Y	Y	N	HR	HR	HR	S	S	R	R	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Toluene	NO	NO	NO	YES	YES	NO	NO	Y	Y	N	HR	S	DG	S	S	DG	R	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Xylenes	NO	NO	NO	YES	YES	NO	NO	Y	N	N	HR	DG	DG	S	S	DG	R	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Chlorobenzene	NO	YES	NO	YES	YES	YES	NO	Y	Y	Y	HR	HR	DG	S	HS	DG	DG	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
1,4-Dichlorobenzene	NO	YES	NO	YES	YES	YES	NO	Y	Y	Y	HR	S	DG	S	S	DG	DG	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Naphthalenes	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	HR	DG	R	S	S	DG	DG	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
2,4-Dimethylphenol	YES	YES	NO	YES	YES	YES	YES	Y	Y	Y	HR	DG	S	S	R	DG	DG	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Pentachlorophenol (PCP)	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	HR	HS	HS	HS	HS	HS	R	S	Su	Su	Su	Su	Su,De	Su,De	Su,De
Phenol	NO	NO	NO	YES	YES	YES	YES	Y	N	Y	HR	HR	S	HS	HS	HS	DG	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
Nonylphenol	YES	YES	NO	YES	YES	YES	YES	Y	N	Y	DG	DG	DG	HS	HS	DG	DG	R	Su	Su	Su	Su	Su,De	Su,De	Su,De
DEHP	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	HS	DG	HS	S	R	R	R	Su	Su	Su	Su	Su,Gr	Su,Gr	Su,Gr
Total PCBs	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	ES	DG	ES	ES	HS	S	HS	Su	Gr	Re	Re	Re	Re	Re
Aldrin	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	R	DG	DG	ES	ES	HS	HS	HS	Su	Gr	Su	Su	Re	Re	Re

TABLE 2-9
SUMMARY OF FATE AND POTENTIAL EFFECTS OF COECs FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	Trophic Level[1]			Occurrence in Medium[2]				Contact Mode[3]			Potential Receptor Group[4]								Most Significant Chronic Exposure Effect(s)[5]						
											Aquatic					Terrestrial										
	AqA	AqP	BM	Wat	Sed	Pla	Ani	D	R	I	Mic	Alg	Vas. Pla.	AqI	Fi	AR	Bir	Mam	Mic	AqP	AqI	Fi	AR	Bir	Mam
alpha-Chlordane	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	R	DG	DG	ES	ES	DG	S	S	Su	Gr	Su	Su	Re	Re	Re
Dieldrin	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	HS	DG	ES	ES	HS	HS	HS	Su	Gr	Su	Su	Re	Re	Re
Heptachlor	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	R	HS	DG	ES	ES	S	S	S	Su	Gr	Su	Su	Re	Re	Re
Heptachlor epoxide	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	DG	DG	HS	ES	DG	S	HS	Su	Gr	Su	Su	Re	Re	Re
BHC (alpha/delta)	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	S	S	HS	HS	S	R	R	Su	Gr	Su	Su	Re	Re	Re
Endosulfan sulfate	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	DG	DG	DG	ES	DG	S	S	Su	Gr	Su	Su	Re	Re	Re
Methoxychlor	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	R	DG	DG	ES	ES	S	R	R	Su	Gr	Su	Su	Re	Re	Re
Low Molecular Wt. PAHs	YES	NO	NO	YES	YES	NO	NO	Y	N	N	DG	ES	DG	ES	ES	DG	R	R	Su	Gr	Su,Gr	Su,Gr	Su,Gr	Su,Gr	Su.Gr
Med. Molecular Wt. PAHs	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	S	DG	ES	ES	DG	R	R	Su	Gr	Su,Gr	Su,Gr	Su,Gr	Su,Gr	Su,Gr
High Molecular Wt. PAHs	YES	YES	YES	YES	YES	YES	YES	Y	N	Y	DG	ES	DG	ES	DG	DG	S	S	Su	Gr	Su,Gr	Su,Gr	Re,De	Re,De	Re,De
Benzidine	NO	NO	NO	NO	YES	NO	NO	Y	N	Y	DG	DG	DG	HS	S	DG	DG	S	Su	Su	Su	Su	Su	Su	Su
Triphenyl-phosphine sulfide	??	??	??	NO	YES	NO	NO	Y	N	Y	DG	DG	DG	DG	S	DG	R	R	Su	Su	Su	Su	Su	Su	Su

Note:

1. Coding reflects the constituent's propensity for accumulation and trophic transfer. AqA refers to aquatic animals, AqP refers aquatic plants, and BM refers to "biomagnification ," or transfer from the aquatic organisms up through food chains. That is, an entry such as that for aluminum (NO/YES/NO) indicates that the element is not significantly bioconcentrated or bioaccumulated by aquatic animals; it is taken up by aquatic plants; and it is not significantly transferred up through the food chain to higher trophic levels.
2. Entries in this column list the media likely to serve the sources or transport vehicles to receptors. Wat. refers to water, Sed. refers to sediment, Pla. refers to Plants, and Ani. refers to animals.
3. Contact Mode. This refers to the actual mechanism whereby receptors receive exposures; i.e., through direct (dermal/integumentary) contact (D), inhalation or respiration (R), and dietary ingestion (I).
4. These columns compare the relative sensitivities of the various major groups of organisms associated with either aquatic (Mica = microbial decomposers; Alg = algae; Vas. Pla. = vascular plants; Aql = aquatic invertebrates; and Fi = fish) or terrestrial (AR = amphibians/reptiles; Bir = birds; and Mam = mammals). Individual entries are symbolized by : HR = highly resistant (> 100 ppm for aquatic); R = resistent (>50 ppm for aquatic and > 10 mg/kgBW/day for terristrial); S = sensitive (>100 ppb for aquatic and > 1mg/kgBW/day for terristrial); HS = highly sensitive (1 ppb for aquatic and < 1mg/kgBW/day for terrestrial); and ES = extremely sensitive (< 1ppb for aquatic). DG refers to "data gap" (i.e., there is insufficient information to develop a generalization). Please see the text for explanation of the categories.
5. This column presents types of biological effects such as Su = survival; Gr = growth; Re = reproduction; and De = development.

TABLE 2-10
SUMMARY OF THE POTENTIAL RECEPTOR GROUPS AND ASSESSMENT ENDPOINTS FOR THE COECS IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	Potential Receptor Group[1]							
	Aquatic					Terrestrial		
	Microbial Decomposers	Algae	Vascular Plants	Aquatic Invertebrates	Fish	Amphibians/ Reptiles[2]	Birds	Mammals
INORGANICS								
Aluminum	N	Y	Y	Y	Y	N	N	N
Barium	N	Y	Y	Y	N	N	N	N
Cadmium	N	Y	Y	Y	Y	N	Y	Y
Chromium	Y	Y	Y	Y	Y	N	Y	Y
Cobalt	N	N	Y	Y	Y	N	Y	Y
Copper	Y	Y	Y	Y	Y	N	N	N
Iron	N	Y	Y	N	N	N	N	N
Lead	Y	Y	Y	Y	Y	N	Y	Y
Manganese	N	Y	Y	Y	N	N	N	N
Mercury	N	Y	Y	Y	Y	N	Y	Y
Molybdenum	N	N	Y	Y	Y	N	N	Y
Nickel	Y	Y	Y	Y	Y	N	Y	Y
Silver	Y	Y	N	Y	Y	N	Y	Y
Vanadium	N	N	Y	Y	Y	N	N	N
Zinc	Y	Y	N	Y	Y	N	N	N
Antimony	N	Y	N	Y	Y	N	Y	Y
Arsenic	N	Y	Y	Y	Y	N	Y	Y
Selenium	N	Y	Y	Y	Y	N	Y	Y
Cyanide	N	Y	N	Y	Y	N	Y	Y
ORGANICS								
Acetone	N	Y	N	Y	N	N	N	N
Carbon Disulfide	N	Y	N	Y	Y	N	N	N
Methylene Chloride	N	N	N	Y	Y	N	N	N
Toluene	N	Y	N	Y	Y	N	N	N
Xylenes	N	N	N	Y	Y	N	N	N
Chlorobenzene	N	N	N	N	Y	N	N	N
1,4-Dichlorobenzene	N	Y	N	Y	Y	N	N	N
Naphthalenes	N	N	N	Y	Y	N	N	N
2,4-Dimethylphenol	N	N	Y	Y	Y	N	N	N
Pentachlorophenol (PCP)	N	Y	Y	Y	Y	N	N	Y
Phenol	N	N	N	Y	Y	N	N	N
Nonylphenol	N	N	N	Y	Y	N	N	N
DEHP	N	Y	N	Y	Y	N	N	N
Total PCBs	N	Y	N	Y	Y	N	Y	Y
Aldrin	N	N	N	Y	Y	N	Y	Y
alpha-Chlordane	N	N	N	Y	Y	N	Y	Y
Dieldrin	N	Y	N	Y	Y	N	Y	Y
Heptachlor	N	N	N	Y	Y	N	Y	Y
Heptachlor epoxide	N	N	N	Y	Y	N	Y	Y
BHC (alpha/delta)	N	N	N	Y	Y	N	Y	N
Endosulfan sulfate	N	N	N	Y	Y	N	Y	Y
Methoxychlor	N	N	N	Y	Y	N	Y	N
Low Molecular Wt. PAHs	N	Y	N	Y	Y	N	N	N
Med. Molecular Wt. PAHs	N	Y	N	Y	Y	N	N	N
High Molecular Wt. PAHs	N	Y	N	N	N	N	Y	Y
Benzidine	N	N	N	Y	Y	N	N	Y
Triphenyl-phosphine sulfide	N	N	N	N	Y	N	N	N

Note: Y = Yes, an assessment endpoint was prepared for the potential receptor group.

N = No assessment endpoint was prepared for the potential receptor group.

[1] The assessment endpoints were prepared for the potential receptor groups most sensitive to the toxic effects of the COECs based on mechanisms of, exposure to, and toxic effects of the contaminants.

[2] Due to the lack of available toxicological data, no assessment endpoints were prepared for amphibians or reptiles.

TABLE 2-11

SUMMARY OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Comment(s)
GAE 1. Protection of primary producers	SAE 1.1 Protection of periphyton and phytoplankton communities	M1.1.1 Reduced survival of sensitive algae due to direct toxicity of COECs in surface water?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
	SAE 1.2 Protection of aquatic vascular plant communities	M1.2.1 Reduced survival of aquatic vascular plants due to direct toxicity of organic COECs in sediment pore water?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
		M1.2.2 Reduced survival of aquatic vascular plants due to direct toxicity of inorganic COECs in bulk sediments?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
GAE 2. Protection of aquatic primary consumers	SAE 2.1 Protection of benthic invertebrate community	M2.1.1 Reduced survival, reproduction, development, and/or growth of sensitive benthic invertebrates due to direct toxicity of organic COECs in sediment pore water?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
GAE 2. (Continued)	SAE 2.1 (Continued)	M2.1.2 Reduced survival, reproduction, development, and/or growth of sensitive	Interpretation of hazard quotients (HQs) and hazard indices (HIs)

TABLE 2-11

SUMMARY OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Comment(s)
		benthic invertebrates due to direct toxicity of inorganic COECs in bulk sediments?	
		M2.1.3 Reduced survival, reproduction, and/or growth of sensitive benthic invertebrates due to direct exposure to bulk sediments?	Interpretation of results of bulk-sediment toxicity tests with *Lumbriculus variegatus* and *Hyalella azteca*.
		M2.1.4 Reduced survival, reproduction, and/or growth of benthic invertebrates due to effects of COECs on other ecological components?	Interpretation of resolution of SAE 1.1, 1.2, and 7.1
		M2.1.5 Reduced diversity of benthic invertebrate communities?	Interpretation of biological survey results.
GAE 2. (Continued)	SAE 2.2 Protection of water-column invertebrate community	M2.2.1 Reduced survival, reproduction, development, and/or growth of sensitive water-column invertebrates due to direct toxicity of COECs in surface water?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)

TABLE 2-11

SUMMARY OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Comment(s)
		M2.2.2 Reduced survival, reproduction, and/or growth of sensitive water-column invertebrates due to direct exposure to surface water?	Interpretation of results of surface-water toxicity tests with *Ceriodaphnia dubia.*
		M2.2.3 Reduced survival, reproduction, and/or growth of water-column invertebrates due to effects of COECs on other ecological components?	Interpretation of resolution of SAE 1.1, 1.2, and 7.1
		M2.2.4 Reduced diversity of water-column invertebrate communities?	Interpretation of biological survey results.
GAE 3. Protection of aquatic secondary consumers	SAE 3.1 Protection of fish community	M3.1.1 Reduced survival, reproduction, development, and/or growth of sensitive fishes due to direct toxicity of COECs in surface water?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
GAE 3. (Continued)	SAE 3.1 (Continued)	M3.1.2 Reduced survival, reproduction, and/or growth of sensitive fish due to direct exposure to	Interpretation of results of surface-water toxicity tests with *Pimephales promelas.*

TABLE 2-11

SUMMARY OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Comment(s)
		surface water?	
		M3.1.3 Reduced survival, reproduction, and/or growth of fishes due to effects of COECs on other ecological components?	Interpretation of resolution of SAE 2.1 and 2.2
		M3.1.4 Reduced diversity in fish community?	Interpretation of biological survey results.
GAE 4. Protection of terrestrial primary consumers	SAE 4.1 Protection of herbivorous mammals	M4.1.1 Reduced survival, reproduction, development, and/or growth of muskrat due to ingestion of contaminated media?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
GAE 4. (Cont.)	SAE 4.1 (Cont.)	M4.1.2 Reduced survival, reproduction, and/or growth of muskrat due to effects of COECs on other ecological components?	Interpretation of resolution of SAE 1.2
GAE 5. Protection of terrestrial secondary consumers	SAE 5.1 Protection of omnivorous birds	M5.1.1 Reduced survival, reproduction, development, and/or growth of red-winged blackbird due to ingestion of contaminated media?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)

TABLE 2-11

SUMMARY OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Comment(s)
		M5.1.2 Reduced survival, reproduction, and/or growth of red-winged blackbird due to effects of COECs on other ecological components?	Interpretation of resolution of SAE 1.2, 2.1, and 2.2
	SAE 5.2 Protection of omnivorous mammals	M5.2.1 Reduced survival, reproduction, development, and/or growth of raccoon due to ingestion of contaminated media?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
GAE 5. (Cont)	SAE 5.2 (Cont.)	M5.2.2 Reduced survival, reproduction, and/or growth of raccoon due to effects of COECs on other ecological components?	Interpretation of resolution of SAE 1.2, 2.1, 2.2, and 3.1
GAE 6. Protection of terrestrial tertiary/quaternary consumers	SAE 6.1 Protection of carnivorous birds	M6.1.1 Reduced survival, reproduction, development, and/or growth of green heron due to ingestion of contaminated media?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)
GAE 6. (Continued)	SAE 6.1 (Continued)	M6.1.2 Reduced survival, reproduction, and/or growth of green heron due	Interpretation of resolution of SAE 2.1, 2.2, and 3.1

TABLE 2-11

SUMMARY OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Comment(s)
		to effects of COECs on other ecological components?	
GAE 7. Protection of aquatic microbial decomposers	SAE 7.1 Protection of aquatic microbial decomposers	M7.1.1 Reduced survival of sensitive bacteria and fungi due to direct toxicity of COECs in surface water?	Interpretation of hazard quotients (HQs) and hazard indices (HIs)

3.0
METHODS

Details of the overall design, sampling methods, and analytical methods are presented in the Workplan (WCFS 1994). Standard Operating Procedures (SOPs) for specific ecological sampling, *in situ* measurements, sample processing, and toxicity testing are presented in Appendix A of this report. This section summarizes the overall approach and methodology, and notes regarding deviations from the Workplan/SOPs.

The main ecological assessment field activities were conducted during the third and fourth weeks of October 1994 and during the second and third weeks of June 1995. Additional observations were made during the first Quarterly Monitoring event (immediately prior to the ecological field activities in October 1994) and during the second Quarterly Monitoring event (third week of January 1995).

East and West Soldier Creeks were divided into study sections based on hydrographic and ecological factors (e.g., gradient, flow, depth, substrate type) anticipated to reflect major habitat differences (Figure 1-2, Table 2-1). There were 10 sections in East Soldier Creek (designated EE01-EE10); three sections in West Soldier Creek (designated EW01-EW03); and two sections in each reference stream. Note that these ecological study *sections* are generally not equivalent to the *segments* established for Quarterly Monitoring of sediments and surface waters. Specific locations at which individual point samples and/or measurements were taken (i.e., field water-quality measurements, surface-water and bulk-sediment samples for chemical analyses and toxicity testing, benthic invertebrate samples) for this EA are illustrated in the diagrams presented in Figures 3-1 through 3-6.

3.1 BIOLOGICAL SURVEYS

3.1.1 Vascular Aquatic Plants

Each stream section was thoroughly inspected to determine the presence of vascular aquatic plants as prescribed in SOP-E1 (Appendix A). Where extensive colonies of such plants were

found, the species composition and densities were recorded for three 0.5-meter square quadrat plots. References used to identify aquatic plants included Fassett (1957), Correll and Correll (1972), and Nelson and Couch (1985).

3.1.2 Aquatic Invertebrates

Sampling for aquatic invertebrates (other than crayfish) followed SOP-E3 (Appendix A) and was performed at the same time surface-water and bulk-sediment samples were collected for toxicity testing and chemical analyses. In each stream section, three standardized quantitative samples were collected with a petite Ponar grab sampler, where sufficient finer-grained depositional sediment was available, or by scooping of comparable volumes of coarser substrates (gravel, rubble) with a stainless-steel bowl, where use of the grab was precluded. [**Note that all sediment samples for chemical analyses were obtained with the petite Ponar grab; the scooping method was only used for invertebrate sampling.**] The invertebrate samples were rinsed in a 250 μm mesh (ASTM #60) sieve and retained materials were placed in a resealable plastic bag and fixed in 10% formalin solution containing a histological stain (Phloxine B).

To supplement each group of standardized grab samples, a qualitative kicknet (250 μm mesh) sample was collected and processed as described in SOP-E3. All invertebrate samples were shipped under chain-of-custody to the Woodward-Clyde Ecological Laboratory in Franklin, Tennessee. Laboratory processing and analyses of benthic invertebrate samples are discussed in Subsection 3.2.

3.1.3 Fish and Crayfish

Fish populations were assessed by conducting "depletion surveys" in each study section with sufficient water (i.e., all sections except EW01). As described in SOP-E4 (Appendix A), the upper end of each study section was barricaded with a black net, if a physical barrier did not already exist. A pass was made with a backpack electrofishing unit and any observed stunned fish were dipnetted and placed in a bucket of stream water. A second pass was made to collect any fish missed. Fish from each pass were kept separate while identification and

counts were performed, after which all fish were released in the section from which they were caught. Fishes were identified using Eddy and Underhill (1978) and Page and Burr (1991). Crayfish (*Orconectes* sp., all of which appeared to be *O. virilis*) were the only large aquatic animals available in sufficient numbers to be used for COEC analyses. The crustaceans were collected by hand, dipnetting, electrofishing, or funnel traps. Very few crayfish were caught during the October 1994 sampling event, when the presence of numerous fresh burrows indicated that most individuals surviving predation had retreated underground. Numerous small crayfish were collected during June 1995 and were prepared as composite samples in accordance with SOP-E6 (Appendix A).

3.1.4 Riparian Terrestrial Vegetation

The distribution and composition of streamside (riparian) vascular plant communities was evaluated as prescribed in SOP-E2 (Appendix A). Major vegetative cover types (forest, thicket, shrub/scrub, open field) were mapped by stream sections or groups of sections with similar terrain and habitat. Within each cover type, the dominant species in the overstory and understory strata were identified. Harlow (1957) and Peterson and McKenny (1968) were used to identify terrestrial vascular plants.

3.1.5 Terrestrial/Semiaquatic Vertebrates

Several methods were used to assess the occurrence and distribution of amphibians, reptiles, birds, and mammals ("wildlife") in and along the study streams. Observations of wildlife and vegetation were made during standardized transect surveys as well as anecdotally during sampling activities in the streams, and other field activities. Each stream section or group of similar sections was subject two formal transect surveys or "flush counts" (on separate days) during each ecological sampling period (October 1994 and June 1995). A transect survey was conducted by two trained biologists, who recorded observations on wildlife, vegetation, and other relevant conditions (e.g., visibility, weather, sources of disturbance). Visual sightings, tracks, calls, scat, feeding areas, and burrows were all used to determine the species of wildlife in a section. The methods used followed criteria established in SOP-E5 (Appendix A), to the extent practicable under prevailing conditions.

The following references were used to identify terrestrial/semiaquatic vertebrates or their "sign": amphibians and reptiles (Black and Sievert 1989; Sievert and Sievert 1993; Conant 1975); birds (Peterson 1961, 1980); mammals (Burt and Grossenheider 1976).

3.2 ANALYSIS OF BENTHIC INVERTEBRATE SAMPLES

All benthic invertebrate samples were received via overnight courier in good condition by the Woodward-Clyde Ecological Laboratory in Franklin, Tennessee, for processing. Each sample was washed in a 250-μm mesh sieve to remove excess sediment and formalin. Small aliquots of each sample were placed in a gridded petri dish and examined under a stereomicroscope. Except as noted below, all of the benthic invertebrates were counted, removed, and placed in vials of 70 percent ethanol. This procedure was repeated until the entire sample had been examined. In a sample having more than 200 specimens of any major taxonomic group, only the first 200 individuals of that group were removed for further identification. However, all individuals of the group(s) were counted in the quantitative (grab) samples.

Invertebrates were identified to the lowest practicable taxon (usually family or genus). Oligochaetes (segmented worms) were identified to the species level. Oligochaetes and chironomids (midges) were mounted on slides using CMC-10 mounting medium for microscopic evaluation. Both of these groups were subsampled randomly for detailed identification if there were more than 60 individuals in a given sample. The benthic macroinvertebrates were identified using available current references such as Brinkhurst (1986), Edmunds *et al.* (1976), Merritt and Cummins (1984), Pennak (1989), Thorp and Covich (1991), and Wiederholm (1983).

The basic information on identities and numbers of individuals collected was tabulated for comparisons. The descriptive analyses included taxonomic richness, relative abundance, and presence or absence of certain pollution-sensitive benthic taxa. The quantitative (standardized grab sample) data were subsequently examined using Cluster and Sigtree analysis (Nemec 1991a, b). Cluster analysis results in a similarity index which uses the Bray-Curtis coefficient with unweighted average linkage and the distance linkage scales. The software groups replicate samples according to both taxonomic composition and abundance

to evaluate their similarity. These same data were then subjected to Sigtree analysis which determines the significance of the clusters and indicates the level of branching which constitutes a significant grouping. An hypothesis is formulated to test statistically whether two clusters within the overall cluster analysis are sufficiently alike to represent the "same" community. In addition to the statistical analysis described above for quantitative samples, the Cluster analysis was performed on qualitative kick-net data. This analysis uses the Jaccard Coefficient to develop a similarity index based on presence or absence of individual taxa in each sample.

3.3 SAMPLING AND ANALYSES OF CHEMICAL CONSTITUENTS

Bulk-sediment and surface-water samples were collected as described above (Subsection 3.1) at the same times and locations as the toxicity-testing samples (Figures 3-1 through 3-6). The Field Sampling Plan (FSP; WCFS 1994) called for collection of triplicate samples of crayfish (*Orconectes*) from each of five parts (sections or groups of adjacent sections) of East Soldier Creek (EE01-03, EE04-06, EE07, EE08, and EE09-10); each of the two lower sections of West Soldier Creek (EW02, EW03); and each of the two sections in the reference streams. This was essentially accomplished when crayfish were abundant in June 1995. However, due to the scarcity of crayfish in October 1994, only five samples were obtained -- one from each of EE04, EE08, EE09, EC01, and EC02.

Sediment samples were collected according to the procedures described in Subsection 5.1 of the FSP; however, for the EA only surficial sediments (upper 6 inches) were taken. Surface water was collected according to the procedures described in Subsection 5.2 of the FSP. In all stream sections the bulk-sediment, surface-water, and toxicity-testing samples (both media) were collected within a few feet or less from the point at which one or more of the benthic invertebrate grab samples were taken.

All samples for analyses of chemical constituents (sediment, surface water, crayfish) were processed and handled in accordance with the procedures specified in Section 5.0 of the FSP prior to packaging and shipment under chain-of-custody (COC) to the Quanterra (formerly ENSECO) Rocky Mountain Analytical Laboratory in Arvada, Colorado. Analyses

performed and methods are listed in Table 3-1. Quantitation (detection) limits are summarized in Tables 2-4 and 2-5.

To assist in subsequent interpretation of chemical-analytical, aquatic-biological results, and other observations, *in situ* measurements of selected water-quality characteristics were taken at the time of surface-water sampling. These measurements included temperature, specific conductance (conductivity), pH, and dissolved oxygen (D.O.) concentration. Results of these measurements are presented in Table G-7 (Appendix G).

3.4 TOXICITY TESTING

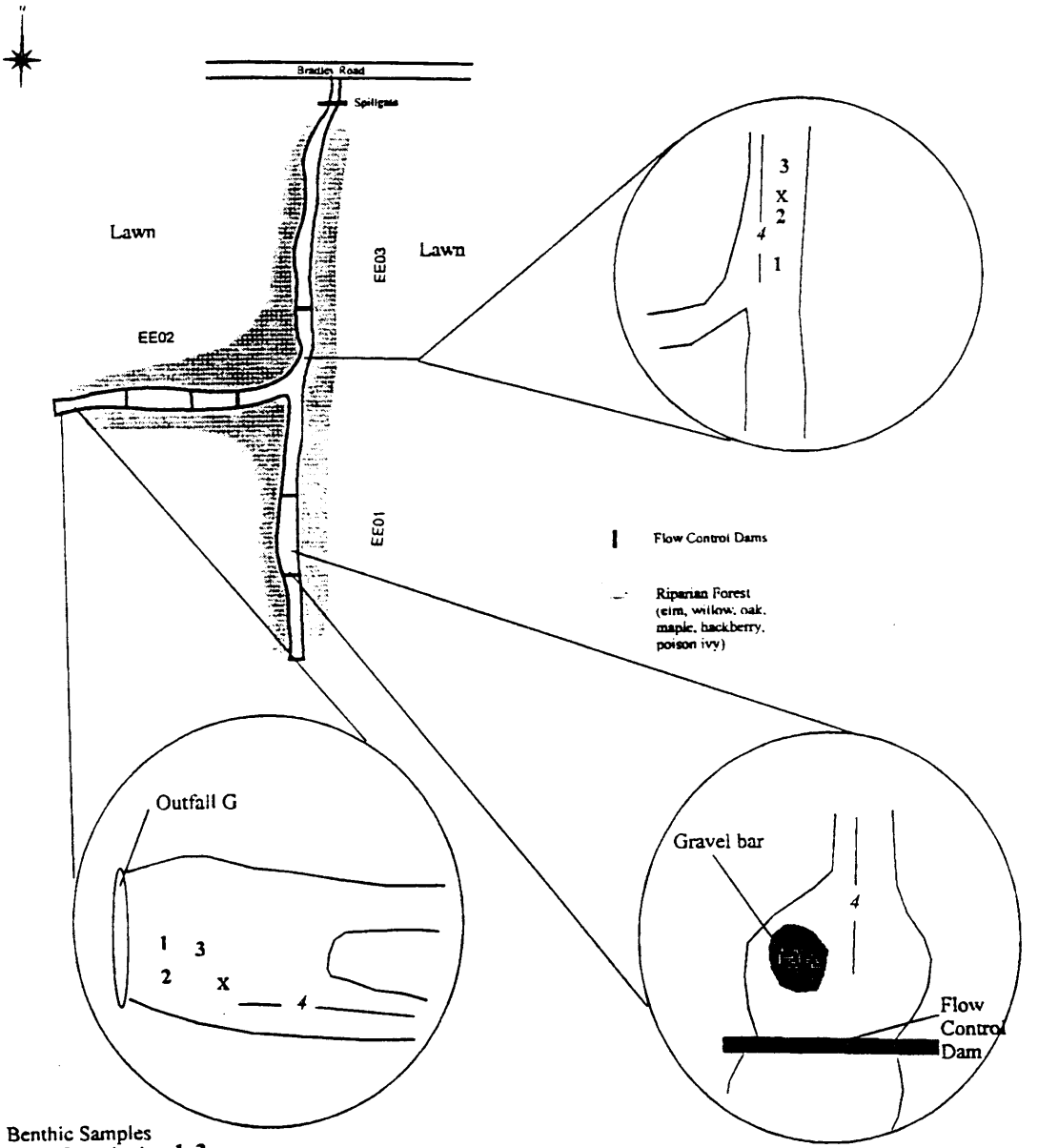
Standard operating procedures (SOPs) for toxicity testing of bulk-sediment and surface-water samples are presented in Appendix A. SOP-E7, SOP-E8, SOP-E9, and SOP-E10 were used for acute and chronic testing of bulk-sediment and surface-water samples taken from 10 stations in East Soldier Creek, three stations in West Soldier Creek, and two stations in each of the reference streams.

Bulk-sediment samples were subjected to acute screening tests using an oligochaete worm (*Lumbriculus variegatus*) and an amphipod (*Hyalella azteca*), after which the more sensitive animal (*H. azteca*) was used in 28-day chronic tests as specified in Subsection 5.3.9.3 of the FSP (WCFS 1994). Water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephales promelas*) were used in both acute and chronic testing of surface water.

TABLE 3-1

CHEMICAL ANALYTICAL METHODS FOR ECOLOGICAL ASSESSMENT SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

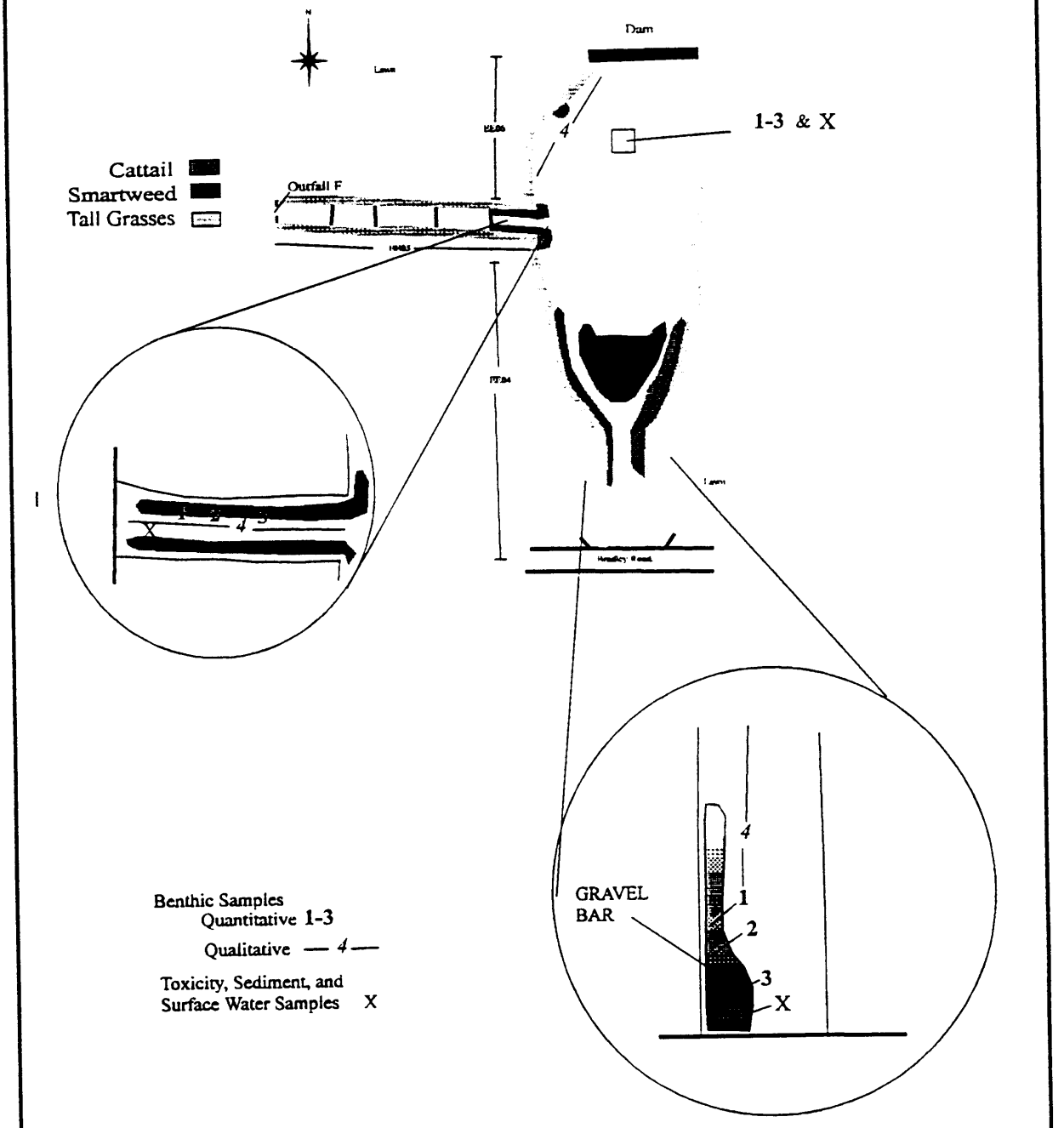
Medium	Analyte(s)	Methods
Sediment	Volatile Organics	SW-846 8240
Sediment	Metals	SW-846 6010/7000
Sediment	Semivolatile Organics	SW-846 8270
Sediment	PCBs	SW-846 8080
Sediment	Pesticides (with PCBs)	SW-846 8080
Sediment	Cyanide	SW-846 9012
Water	Volatile Organics	SW-846 8240
Water	Metals excluding Hg	SW-846 6010/7000 ICP-MS
Water	Semivolatile Organics	SW-846 8270
Water	PCBs	SW-846 8080
Water	Pesticides (with PCBs)	SW-846 8080
Water	Cyanide	SW-846 9012
Water	Hg	SW-846 7000
Crayfish	Volatile Organics	SW-846 8240
Crayfish	Metals + Cyanide	SW-846 6010/7000/9010
Crayfish	Semivolatile Organics	SW-846 8270
Crayfish	PCBs	SW-846 8080
Crayfish	PAHs	SW-846 8310



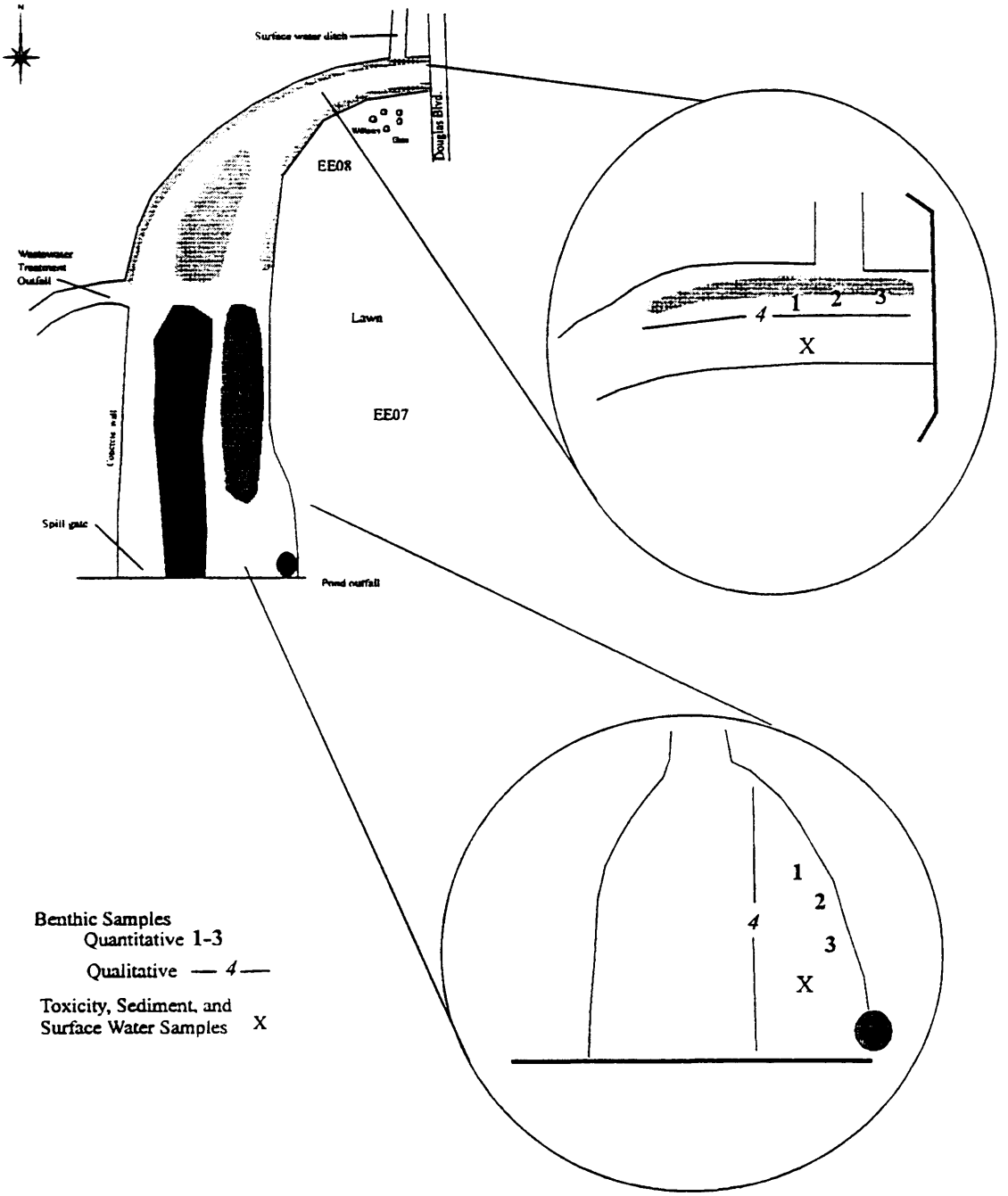
Benthic Samples
Quantitative 1-3
Qualitative — 4 —

Toxicity, Sediment, and
Surface Water Samples X

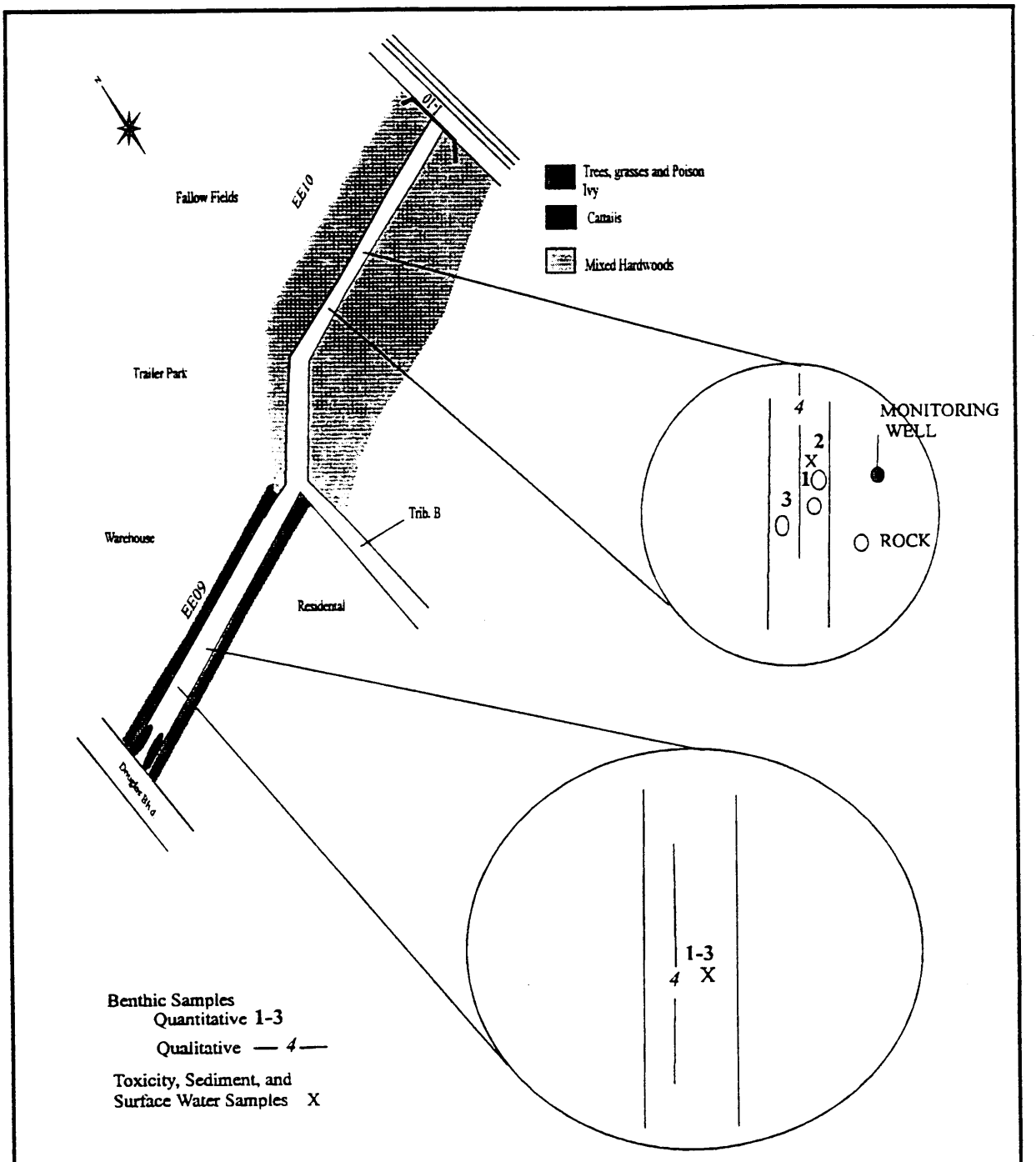
Woodward-Clyde Consultants 357 Riverside Drive (37064) - P.O. Box 681059 (37068-1059) - Franklin, TN Tel: (615) 790-0003 Fax: (615) 790-0023		**ECOLOGICAL ASSESSMENT SAMPLING LOCATIONS UPPER EAST SOLDIER CREEK (EE01, EE02, and EE03), October 1994**	FILE. NO. F93506
DRAWN BY: DLS	DATE: 01/95		FIG. NO. 3-1



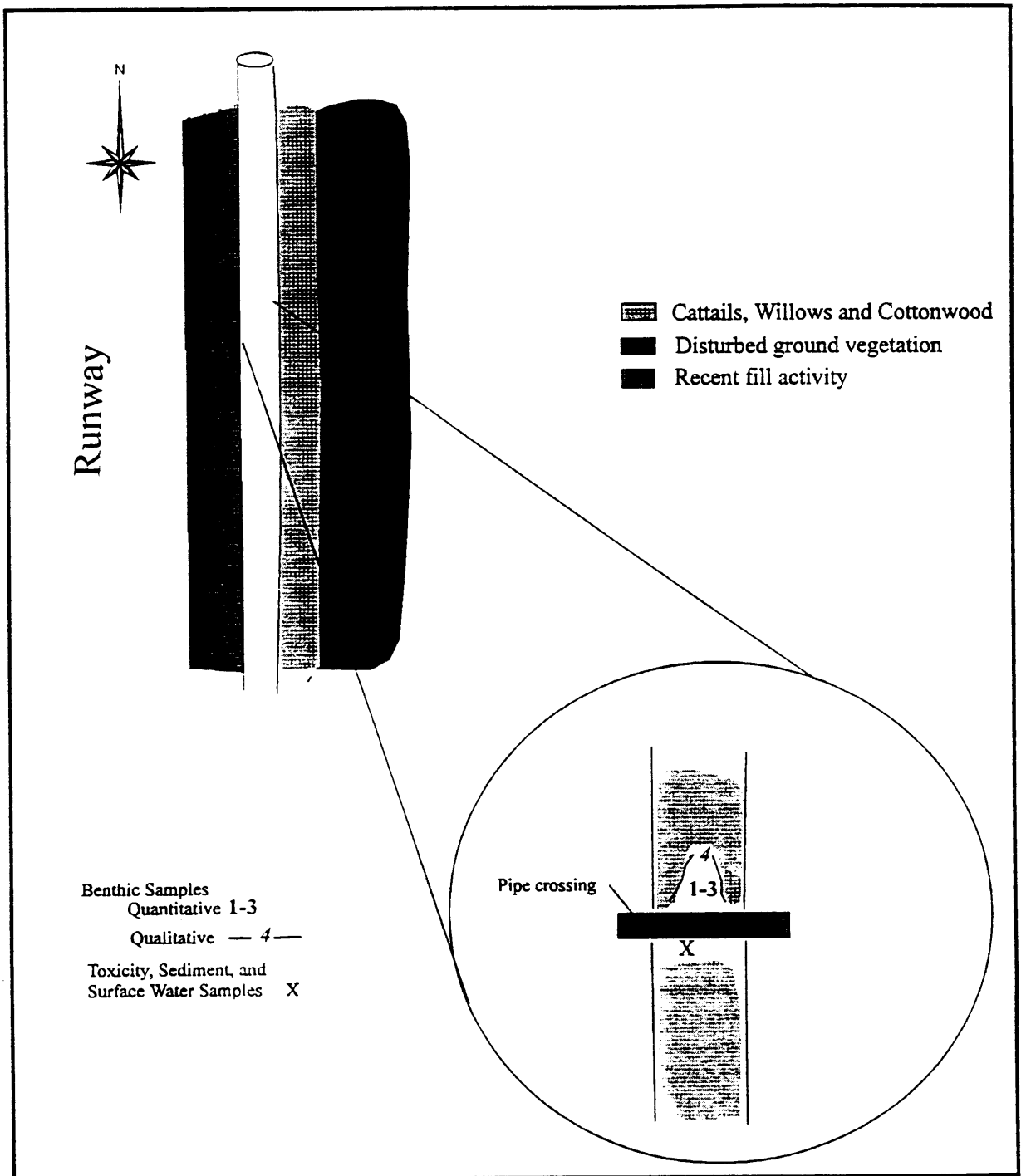
Woodward-Clyde Consultants 357 Riverside Drive (37064) - P.O. Box 681059 (37068-1059) - Franklin, TN Tel: (615) 790-0003 Fax: (615) 790-0023		**ECOLOGICAL ASSESSMENT SAMPLING LOCATIONS PONDED AREA OF EAST SOLDIER CREEK (EE04, EE05, AND EE06), October 1994**	FILE. NO. F93506
DRAWN BY: DLS	DATE: 01/95		FIG. NO. 3-2



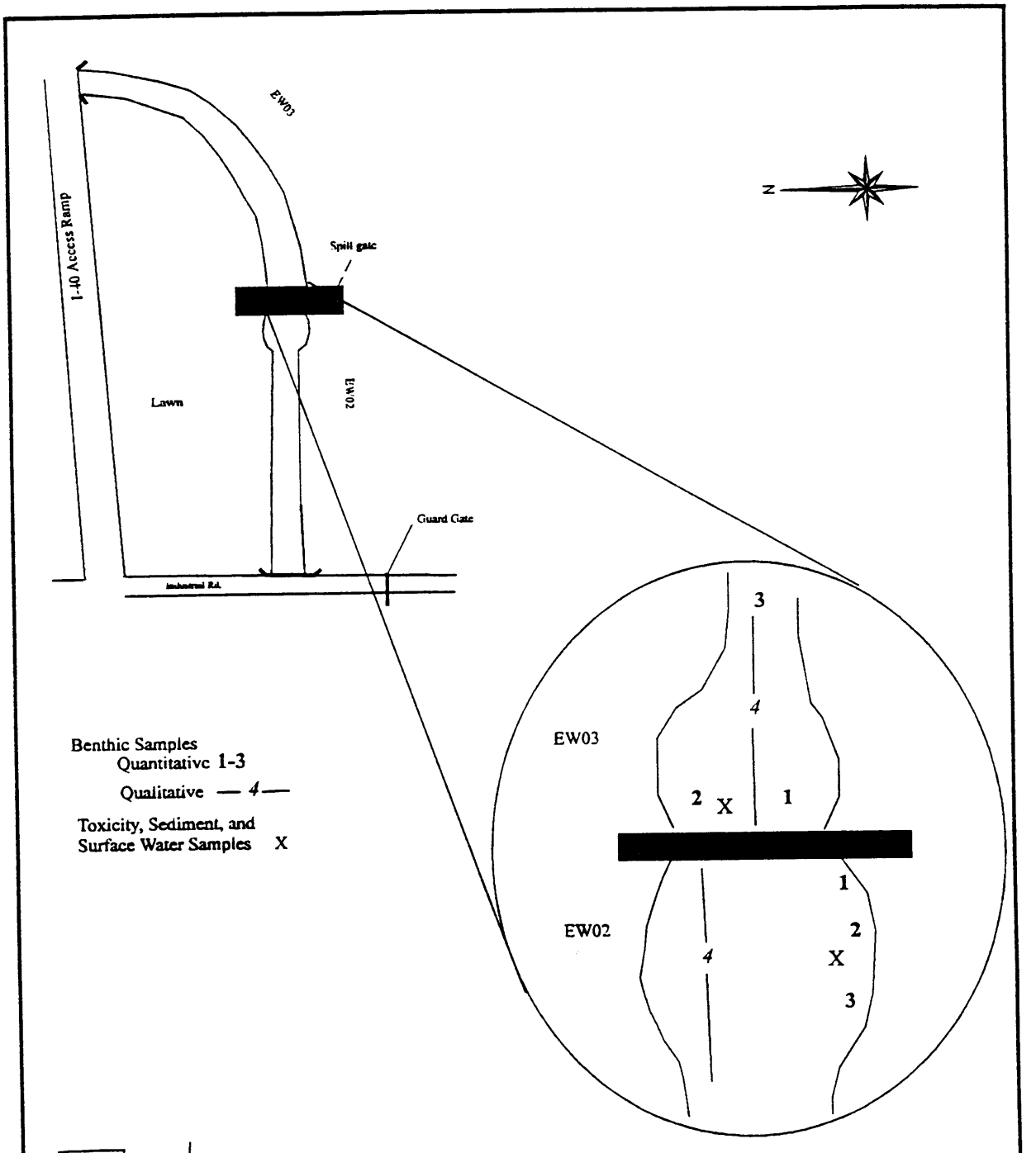
Woodward-Clyde Consultants 357 Riverside Drive (37064) - P.O. Box 681059 (37068-1059) - Franklin, TN Tel: (615) 790-0003 Fax: (615) 790-0023		**ECOLOGICAL ASSESSMENT SAMPLING LOCATIONS BELOW PONDED AREA OF EAST SOLDIER CREEK (EE07 and EE08), October 1994**	FILE. NO. F93506
DRAWN BY: DLS	DATE: 01/95		FIG. NO. 3-3



Woodward-Clyde Consultants 357 Riverside Drive (37064) - P.O. Box 681059 (37068-1059) - Franklin, TN Tel: (615) 790-0003 Fax: (615) 790-0023		**ECOLOGICAL ASSESSMENT SAMPLING LOCATIONS OFF-BASE EAST SOLDIER CREEK (EE09 AND EE10), October 1994**	FILE. NO. F93506
DRAWN BY: DLS	DATE: 01/95		FIG. NO. 3-4



Woodward-Clyde Consultants 357 Riverside Drive (37064) - P.O. Box 681059 (37068-1059) - Franklin, TN Tel: (615) 790-0003 Fax: (615) 790-0023		**ECOLOGICAL ASSESSMENT SAMPLING LOCATIONS UPPER WEST SOLDIER CREEK (EW01), October 1994**	FILE. NO. F93506
DRAWN BY: DLS	DATE: 01/95		FIG. NO. 3-5



Woodward-Clyde Consultants 357 Riverside Drive (37064) - P.O. Box 681059 (37068-1059) - Franklin, TN Tel: (615) 790-0003 Fax: (615) 790-0023		**ECOLOGICAL ASSESSMENT SAMPLING LOCATIONS OFF-BASE WEST SOLDIER CREEK (EW02 and EW03), October 1994**	FILE NO. F93506
DRAWN BY: DLS	DATE: 01/95		FIG. NO. 3-6

In the context of the *Framework* (USEPA 1992), this section corresponds to the "analysis phase" of the EA and consists of the respective characterizations of exposure (Subsection 4.1) and ecological effects (in this case toxicity; Subsection 4.2). These two elements constitute the exposure profile and effects profile which are integrated in the "risk characterization" phase (Section 5.0).

4.1 EXPOSURE ASSESSMENT

Exposure assessment consists of defining exposure factors and assumptions that will later be used in estimation of potential risks (Section 5.0). This is a point at which the "desktop" approach to assessment is modified in this EA to a limited extent to address tangible site-specific information. For example, the receptors selected to represent consumer species are not hypothetical animals conceptualized to illustrate "what-if?" scenarios; rather, they are species that actually occur (or might occur) locally. More to the point, the behavioral and physiological characteristics attributed to these receptors in the form of exposure assumptions are consistent with facts established in the scientific literature, in which sense they are realistic or "credible." But, as discussed at some length below, the assumptions are consciously simplified (generalized) to ensure that *exposures* are ultimately over-estimated, so as to virtually eliminate the possibility of false-negative conclusions (due to under-estimation of exposures) in Section 5.0.

4.1.1 Ingestion-Pathway Exposure Factors/Assumptions

One of the reasons for selecting multiple indicator species (i.e., key receptors) in ecological risk assessment is the fact that exposures vary substantially even within a given pathway. For example, individuals of some of the receptor species are unlikely to obtain all ingested media from the Soldier Creek Sediment and Surface Water Operable Unit. The following ingestion-pathway exposure factors (assumptions) have been identified for each of the four terrestrial or semiaquatic vertebrate receptors:

- Area use factor (F)
- Composition of the diet
- Rate of ingestion of food (kilograms/day; IR_{food})
- Rate of ingestion of water (liters/day; IR_{water})
- Rate of ingestion of sediment (kilograms/day; IR_{sed})
- Body weight (kilograms; BW)

All of the foregoing are developed in the context of a hypothetical individual of the representative receptor species. Relatively few empirical measurements of these attributes in wildlife species are available, and those that are available are often based on captive specimens. For these and many other reasons, *assumed* values for these attributes are fraught with uncertainty. Uncertainty can never be totally eliminated, but prudent application of well-documented information about the behavior and physiology of the receptors can help. For this reason, EPA commissioned the compilation of the *Wildlife Exposure Factors Handbook* (USEPA 1993b). This valuable reference warns its readers that in any given ecological risk assessment it is crucial to apply site- or region-specific knowledge whenever possible. The assumptions used in this EA are all based on formally-published information for the species, or plausible surrogate species. Generally-accepted principles and qualified professional judgement are used to derive from relevant literature (mainly USEPA [1993b] and primary sources cited therein) assumptions that are realistic. At the same time, to avoid underestimating exposures, whenever ranges of values are available, a value at or near the conservative end of the range is selected.

4.1.1.1 Area Use Factor (F)

To account for the fraction of ingested media derived from the Soldier Creek Sediment and Surface Water Operable Unit, behavioral information from the literature (such as home ranges or feeding territories) is considered in light of certain relevant dimensions. For example, if a receptor is known to forage over a greater area than is available in the Operable Unit, the latter is divided by the former to yield the assumed percentage of ingested media containing site-related COECs. In cases where behavioral data indicate that an individual receptor forages within an area smaller than that available in the Operable Unit, the

conservative assumption is made that 100 percent of the ingested media is contaminated. Area use factors for the four terrestrial receptors are presented in Table 4-1.

4.1.1.2 Dietary Composition

In nature, the diets of most vertebrates vary considerably (Allee *et al.* 1951; Martin *et al.* 1951). Some have morphological, physiological, and/or behavioral adaptations which limit their ability to use certain broad categories of food. Hence herbivorous, omnivorous, and carnivorous forms are recognized. Within these types there are some species which are *relatively* more specialized, such as piscivores, detritivores, granivores, frugivores, and so forth. However, even these more specialized forms seldom subsist on a single species of forage or prey -- except during brief periods when a particular item is readily accessible (Allee *et al.* 1951). There is a wealth of anecdotal information in the literature regarding the food habits of most common North American birds and mammals. In general, however, there is a paucity of detailed quantitative dietary studies, and these relate primarily to localized populations of only a few species (USEPA 1993b). One clear pattern is the tendency for most birds and mammals to be highly opportunistic within the constraints of their respective feeding adaptations. Thus, in the absence of direct observation, it is reasonable to assume that a given bird or mammal will "preferentially" feed upon the more available (i.e., abundant and accessible) items in a given time and place (Allee *et al.* 1951).

For assessment of ingestion-pathway exposures to a given receptor one would ideally have site-specific information upon which to base a representative diet, characterized in terms of percentages by weight of the various major components. Since site-specific studies of the food habits of the selected receptors for the Soldier Creek Sediment and Surface Water Operable Unit have not been performed, an appropriate breakdown of the diet for each species must be based on interpretation of the largely-anecdotal literature. This interpretation should be based on professional judgement, common sense, and an awareness of what forage and prey items are most available (or might be most available absent contamination) in the Operable Unit.

Major categories to be used in characterizing the diets of selected receptors in the Soldier Creek Sediment and Surface Water Operable Unit are:

Plants. - Mainly foliage and fruits of terrestrial and emergent aquatic vascular plants. (Please refer to the descriptions of vegetative communities in Subsection 2.1 and Appendix G.)

Crayfish. - Primarily members of the genus *Orconectes*, which were observed to be present, at least seasonally, throughout most of the permanently-flowing portions of East and West Soldier Creek.

Other Aquatic Invertebrates. - Mainly worms (Oligochaeta) and dipterous (e.g., Chironomidae) insect larvae. (Please refer to the descriptions of benthic community composition in Subsection 2.1 and Appendix G)

Fish. - Mainly small fishes (e.g., minnows) normally associated with first-order tributary streams of the region. (See the account of fishes observed in Crutcho Creek, Appendix G.) **Note that although fish are not actually a significant component of the diet of any receptor under existing conditions, for purposes of the exposure assessment it is conservatively assumed that they are eaten (by receptors known to consume fish under normal conditions; e.g., green heron and raccoon).**

Terrestrial Invertebrates. - Mainly crawling, climbing, and flying adult insects (Insecta); as well as other arthropods such as spiders (Arachnida) and sowbugs (Isopoda); and earthworms (Annelida). **Note that for purposes of the exposure assessment it is conservatively assumed that all "terrestrial invertebrates" consumed by receptors are emergent adult insects that have bioaccumulated COECs from sediment pore water.**

Amphibians and Reptiles. - Members of the vertebrate Classes Amphibia and Reptilia. (Please refer to descriptions of amphibian and reptilian community composition in Subsection 2.1 and Appendix G.)

Birds. - Members of the vertebrate Class Aves (primarily passerines). (Please refer to descriptions of avian community composition in Subsection 2.1 and Appendix G.)

Mammals. - Members of the vertebrate Class Mammalia (primarily small rodents). (Please refer to descriptions of mammalian community composition in Subsection 2.1 and Appendix G.)

These categories are based on site-specific knowledge developed during the reconnaissances and formal field sampling activities, as well as consideration of the feeding patterns of the

selected receptors and the way food habits are commonly described in the literature. For some of the selected receptors, there are proportional breakdowns of the diet which conform to (or can be readily converted to) the above categories. In other cases, it is necessary to infer categorical allocations from qualitative descriptions. Dietary composition breakdowns for the selected receptors are presented in Table 4-2.

4.1.1.3 Food Ingestion Rate (IR_{food})

There are three general sources of food ingestion rates for wildlife:

- Expressions based on a percentage of body weight, derived from collective experience (including some empirical measurements) of researchers familiar with the types of organisms in question (e.g., Newell *et al.* 1987; and sources cited therein).

- Empirical measurements, usually obtained from a relatively small "sample" of animals fed *ad libitum* in captivity.

- Allometric equations based on a combination of empirical measurements from a wide variety of representatives of a category of animals as well as bioenergetic principles and theory (e.g., Nagy 1987; see also USEPA 1993b).

Direct empirical measurements for the specific receptor in question are most desirable, but unfortunately there appear to be none for the receptors selected in this study. The food ingestion rates in Table 4-1 are based on allometric relationships developed by Nagy (1987; all reproduced in USEPA 1993b) or Kushlan (1978; for wading birds). In the absence of empirical measurements specific to the selected receptors, use of the allometric equations is deemed appropriate because these are widely-accepted, empirically-derived relationships. Body weights at the low end of the range reported in the available literature were used in the equations to derive the food ingestion rate (see Subsection 4.1.1.6).

4.1.1.4 Water Ingestion Rate (IR_{water})

The applicable equations of Calder and Braun (1983; also available in USEPA 1993b) were used to calculate the ingestion of water in liters per day. Water ingestion rates for the selected receptors are shown in Table 4-1.

4.1.1.5 Sediment Ingestion Rate (IR_{sed})

Many higher vertebrates are known to ingest sediment and/or soil, usually incidental to feeding or grooming (USEPA 1993b; Beyer *et al.* 1994). The quantities are often a function of the animal's feeding habits; for example, some small mammals which feed extensively on soil invertebrates ingest relatively high amounts of soil. For some of the designated receptors (e.g., raccoon), the literature provides directly-measured rates that may reflect conditions in the Soldier Creek Sediment and Surface Water Operable Unit. Otherwise, professional judgement has been used in interpreting reported rates, or extrapolating from surrogate species. The rate is normally estimated as a percentage of the overall diet, and then converted to mass/day. The assumed sediment ingestion rates (IR_{sed}) are included in Table 4-1. Note that soil ingestion rates for this assessment were assumed to be zero due to the absence of soil contamination data.

4.1.1.6 Body Weight (BW)

Body weight is an extremely important factor because it is often used in calculating other exposure assumptions when realistic direct measurements are not available (e.g., food and water ingestion rates). When a range is reported, values are adopted from the literature which, based on professional judgement, are representative of the low extreme for wild adults in Southern Great Plains habitats. Assumed body weights for the four terrestrial or semiaquatic receptors are presented in Table 4-1.

4.1.2 Receptor Profiles

As noted in Subsection 2.1, biological diversity is relatively low throughout the aquatic and riparian terrestrial habitats of East and West Soldier Creek within study area boundaries.

Among the larger aquatic organisms sampled, there was no individual taxon found throughout all study sections, although the crayfish (*Orconectes*) was observed, at least in low densities, everywhere except upper West Soldier Creek (EW01). Aquatic organisms in general are evaluated indirectly as communities (Subsection 2.3), through biological surveys (Appendix G), and through toxicity testing (Subsection 4.2.3 and Appendix I).

Four vertebrate receptors are selected to illustrate potential exposures via the ingestion pathway, based on ecological relevance (e.g., trophic position; see Subsection 2.3); susceptibility to exposure (i.e., apparent distribution and relative abundance); availability of behavioral and physiological information upon which to base exposure assumptions (see previous subsection); and availability of relevant toxicological data for use in subsequent risk characterization. The last consideration effectively precludes selection of amphibians or reptiles, although representatives of both classes were observed in some parts of the study area and presumably play important roles in the trophic structure (e.g., frogs, turtles, water snakes). Aside from tests with amphibian embryos and larvae (tadpoles), there are very few well-documented toxicological data available for amphibians or reptiles. Amphibians and reptiles are anatomically and physiologically very different from each other, as well as from other vertebrate classes, so that extrapolation from other groups (e.g., fish for amphibians or birds for reptiles) is not advisable (Suter 1993).

Based on the discussion above, two birds (an omnivore and a carnivore) and two mammals (an herbivore and omnivore) are selected as having the greatest potential for exposure. Toxicological data are available for these groups but are of insufficient depth in detail to discern if any of those species identified as present or potentially present at the site (Subsection 2.1) are more sensitive than others associated with the site. Additionally, given the broad range of COECs identified no single toxic mechanism can be identified that would direct a selection of receptor species. Therefore, selection was made on the basis of representativeness of the group (bird, mammal, herbivore, omnivore, carnivore) in general sensitivity and susceptibility to a wide range of COECs. These representative species are discussed in the following profiles.

4.1.2.1 Green Heron (*Butorides virescens*)

The green heron is selected to represent carnivorous ("piscivorous") wading birds that may be particularly susceptible to dietary exposures to the COECs. *Butorides virescens* is one of two wading birds that were actually seen during formal and reconnaissance field activities; it is selected because: (1) individuals were seen more frequently than those of the great egret (*Casmerodius albus*); (2) it is the smallest of the ardeids likely to be present (hence the most vulnerable); and (3) it is a solitary nester, preferring areas similar to the off-base sections of East Soldier Creek, and therefore more likely to occur more often locally than a colonial nester (e.g., great egret).

Butorides virescens is one of the smallest North American herons. The lower extreme of the range of body weights reported by Terres (1991), 158 grams, is assumed for purposes of this EA (Table 4-1). These birds are known, at times, to exhibit territorial feeding behavior (Kushlan 1978; DeGraaf and Rudis 1987), although no published details on the size of territories were found. Green herons are not resident in central Oklahoma (nor are any other ardeids; Peterson 1980), but probably remain in the region throughout most of the warmer months. In estimating an area use factor, it is conservatively assumed that a territorial individual obtains all of its diet in each of the study sections with areas shallow enough to be waded by a green heron (EE03 through EE08, EW02 and EW03), but for only *half* the year. Thus an area use factor (F) of 50% is used.

Using the assumed body weight of 0.158 kg, a food ingestion rate (IR_{food}) of 0.028 kg/day is derived for the green heron from the nomograph developed for wading birds by Kushlan (1978). A water ingestion rate (IR_{water}) of 0.017 l/day is derived using the allometric relationship $WI = 0.059Wt^{0.67}$ (Equation 3-15 in USEPA 1993b). An example of the use of the allometric equations follows in three easy steps, using the 158 grams (0.158 kg) body weight of the green heron as listed in the previous paragraph:

Step 1: $WI = 0.059 \times (0.158)^{0.67}$ (where WI is water intake/water ingestion rate)
Step 2: $WI = 0.059 \times 0.2904693$
Step 3: $WI = 0.017$ l/day

This example may be used to explain the remaining allometric equations in Table 4-1. Since much of the diet of a green heron consists of substrate-associated aquatic invertebrates or ground-dwelling terrestrial animals, it is conservatively assumed that sediment is ingested at a rate of 5% of the food ingestion rate (0.001 kg/day).

The hypothetical diet of *Butorides virescens* in the Soldier Creek study area depicted in Table 4-2 is based on information from Kushlan (1978), DeGraaf and Rudis (1987), and Terres (1991), adjusted to reflect the site-specific community structure thus far observed. However, since fish would normally be a significant component in the diet, it is assumed that they contribute 25% (even though fish are actually scarce under prevailing conditions). Green herons are not, strictly speaking, "piscivorous", nor do they confine their foraging activities to aquatic or riparian habitats (Kushlan 1978). However, for purposes of this EA it is assumed that all of an hypothetical individual's diet (50% of the year) is obtained from a given study section along Soldier Creek.

4.1.2.2 Red-winged Blackbird (*Agelaius phoeniceus*)

The red-winged blackbird is selected to represent omnivorous birds. *Agelaius phoeniceus* is a small, basically-granivorous bird which prefers open fields, marshes, or marsh-like areas (Nero 1956; Terres 1991). During formal and reconnaissance field activities, red-winged blackbirds were noted to be very common and abundant in the marshy areas along the middle portion of East Soldier Creek (EE04-EE08) and the upper portion of West Soldier Creek (EW01). Numerous active nests were observed in June 1994 and June 1995. The species is resident in central Oklahoma (Peterson 1980), and individuals typically have very small (e.g., 0.2 acres) home ranges, so an area use factor of 100% is assumed for the red-winged blackbird (Table 4-1). Indeed, the risk characterization assumes that a given red-winged blackbird obtains its entire diet from only one of the designated study sections, which is extremely unlikely (except perhaps in EE04-08 and EW01).

A body weight of 0.05 kg is assumed based on information presented in Dunning (1993). Food is assumed to be ingested at a rate of 0.01 kg/day, based on the allometric relationship $FI = 0.0852Wt^{0.651}$ (Equation 3-3 in USEPA 1993b). Water intake is estimated as 0.008 l/day, using the allometric relationship $0.059Wt^{0.67}$ (Equation 3-15 in USEPA 1993b). Red-

winged blackbirds feed mainly by stripping seeds from plant stalks or plucking insects from plant branches/foliage (or in flight from the air), and they seldom feed on the ground except in plowed fields (Martin *et al.* 1951). Owing to this behavior, it is reasoned that no sediment is ingested, although small amounts of soil are probably ingested incidentally to grooming.

The diet of *Agelaius phoeniceus* (Table 4-2) is assumed to consist of 70% plant material and 30% terrestrial invertebrates (mainly insects), based on information summarized in Martin *et al.* (1951) and Terres (1991). For purposes of this EA it is conservatively assumed that all of the plant material ingested is derived from marshes where the vegetation grows with its roots in the pore water of contaminated sediments; it is also assumed that the "terrestrial" invertebrates consumed consist entirely of the emerged adult stages of insects whose larvae were members of the infaunal benthic communities of Soldier Creek. This, of course, cannot be true most of the time, but there is some evidence (Orians 1980; regarding a closely-related species) that during territorial marsh nesting (about 3-4 months in a year) it is essentially representative of the birds' behavior.

4.1.2.3 Muskrat (*Ondatra zibethicus*)

Ondatra zibethicus is selected to represent the most vulnerable herbivorous mammal, owing to its intimate association with aquatic vegetation and the tendency for individuals to have very small foraging areas (Davis 1960; USEPA 1993b). Muskrats or their "sign" were observed along the on-base portions of East Soldier Creek (see Subsection 2.1 and Appendix G). Within these sections (EE01-EE08) an area use factor of 100% is assumed (Table 4-1); conversely, since there is no habitat, it is assumed that muskrat do not receive exposures in other study sections.

A body weight of 730 grams (0.730 kg) is assumed, based on the lower extreme of the range of reported values (USEPA 1993b). Food ingestion is estimated as 0.070 kg/day based on the allometric relationship for herbivorous mammals, $FI = 0.577Wt^{0.727}$ (Equation 3-9 in USEPA 1993b); and water ingestion is estimated as 0.075 l/day based on the relationship $WI = 0.099Wt^{0.90}$ (Equation 3-17 in USEPA 1993b). Since muskrats feed mainly on aquatic and streambank vegetation, it is conservatively assumed that sediment is ingested at a rate equivalent to 3% of the food ingestion rate (0.002 kg/day).

The hypothetical diet of a muskrat along on-base portions of East Soldier Creek, depicted in Table 4-2, is based on information summarized in USEPA (1993b). Although primarily herbivorous, muskrats occasionally feed on crayfish, frogs, birds (e.g., eggs), and mammals (including their own young) (Davis 1960).

4.1.2.4 Raccoon (*Procyon lotor*)

The raccoon is selected to represent omnivorous and carnivorous mammals. Although feral dogs and cats appear to be prevalent in some parts of the study area, and coyotes may occasionally intrude on certain areas (e.g., part of West Soldier Creek), there is no evidence that any strictly-carnivorous nondomesticated mammals (e.g., fox, bobcat) occur regularly in the Operable Unit (or in the general vicinity). "Sign" of *Procyon lotor* was prevalent along much of the off-base portions of both East and West Soldier Creeks. Since raccoons are known to feed preferentially on crayfish when accessible (Lowery 1974; Kaufman 1982), it is possible that raccoons may occur in the study area more frequently and extensively during the warmer months when crayfish are more prevalent. Using the ratio of total area of the Operable Unit (18 acres) to the lower extreme raccoon home range size (99 acres; Kaufman 1982), an area use factor of 18% is conservatively assumed for this EA (Table 4-1).

A body weight of 4.2 kg is assumed, based on the smallest reported adult weight (USEPA 1993b). This hypothetical raccoon would ingest about 0.223 kg/day of food, based on the allometric relationship $FI = 0.0687Wt^{0.822}$ (Equation 3-7 in USEPA 1993), and would drink about 360 ml/day of Soldier Creek water, based on the allometric relationship $WI = 0.099Wt^{0.90}$ (Equation 3-17 in USEPA 1993). Sediment is assumed to be ingested at a rate equivalent to 9% of the food ingestion rate (0.02 kg/day), based on empirical measurements presented in Beyer *et al.* (1994).

Raccoons are very opportunistic feeders (Lowery 1974; Kaufman 1982), and the relative amount of plant *versus* animal matter in the diet varies seasonally (Martin *et al.* 1951; USEPA 1993b). It is well established that plants are generally more prominent in the diets of raccoons living in close proximity to agricultural and residential areas, whereas the reverse is the case for less-developed areas. The Operable Unit diet postulated for *Procyon lotor* in

Table 4-2 is based on the foregoing considerations and information summarized in USEPA (1993b).

4.1.3 Quantification (Estimation) of Exposure

The distribution of COECs in the Soldier Creek Sediment and Surface Water Operable Unit is highly variable (Subsection 2.2; see also Tables 4-3 through 4-7). To realistically characterize exposures it is necessary to account for the spatial variation in COEC concentrations as well as distributional attributes of the receptors. For example, if a red-winged blackbird confines its foraging activity to a given study section, then it is appropriate to assume that COEC levels in its diet reflect those in the physical and biological media of that section.

Exposures may occur directly or indirectly. Examples of direct exposures are fish and aquatic insects in direct contact with surface water and sediments. Indirect exposures occur by ingesting COECs in sediments or water, or via dietary items that have assimilated COECs into tissues. Meaningful inferences about the potential hazards of ingesting COECs require an understanding of the relationship between exposures, expressed as *doses* or rates (i.e., mass of COEC/unit of receptor body weight/unit of time), and *responses*. Doses are estimated using:

- the measured and/or predicted concentrations of each COEC in media known or assumed to be ingested (i.e., water, food, sediment); and
- estimates of the mass of each COEC consumed per day, obtained by multiplying the concentration (mg/kg or µg/l) in a medium by the amount of that medium (kg or l) assumed to be ingested by an individual in the population of the receptor species and expressed in terms of the mass (body weight) of the receptor.

In Section 5.1, potential risks are estimated on the basis of individual study sections within the Soldier Creek Sediment and Surface Water Operable Unit. Exposure point concentrations, both direct and indirect, are necessary for evaluating risk.

4.1.3.1 Direct-Exposure Concentrations

Direct-exposure concentrations are used to assess the risk to strictly-aquatic receptors. COEC concentrations in water and sediments were compiled for the October 1994 and June 1995 studies. The following approaches were taken for assessing direct-exposure concentrations:

- For algae, water-column invertebrates, and fish, surface-water concentrations are used as exposure point concentrations for both inorganic and organic COECs.

- For inorganic COEC exposures to vascular aquatic plants and benthic invertebrates, bulk-sediment concentrations are used as exposure point concentrations since reliable methods are not available for estimated concentrations of metals in the pore water of sediments.

- For organic COEC exposures to benthic invertebrates, sediment pore-water concentrations calculated using the equilibrium partitioning (EqP) approach were used as exposure point concentrations.

Exposure point concentrations are expressed as both the mean and maximum of the 1994 and 1995 data for each constituent at each sampling location. Analytical nondetects (NDs) are input as one-half the detection limit. Note that optimally the upper 95% confidence limit of the mean would be used in lieu of the maximum value; however, confidence limits cannot be effectively calculated with only two data points. Water-column concentrations of inorganic COECs are summarized in Table 4-3, and water-column concentrations for organic COECs are summarized in Table 4-4. Sediment concentrations for inorganic COECs are summarized in Table 4-5, and sediment concentrations for organic COECs are summarized in Table 4-6.

Sediment pore-water concentrations for organics were calculated using the relationship (EPA 1993a):

$$C_{\text{Pore water}} = C_{\text{sediment}} \div (K_{oc} \times f_{oc}) \qquad \text{[Eq. 4-1]}$$

where :

$C_{\text{Pore water}}$ = Contaminant concentration in pore water (ug/l)

C_{sediment} = Contaminant concentration in sediment (ug/kg)

K_{oc} = Organic carbon partitioning coefficient (l/kg organic carbon)

f_{oc} = fraction organic carbon (kg organic carbon/kg sediment)

Organic-carbon partitioning coefficients were obtained from the ASTER online database. Pore-water concentrations were calculated using both the mean and maximum concentrations of sediment organic constituents. For both the mean and maximum scenarios, the mean organic carbon concentration was used to calculate f_{oc}. Using aldrin as an example, the f_{oc} for Section EE03 equals 0.02215 from the following equation: mean TOC concentration (22,150 milligrams organic carbon per kilograms of sediment) divided by conversion factor of one-million milligrams sediment per kilogram sediment (22,150 mg/kg ÷ 1,000,000 mg/kg). Using Equation 4.1 above, where:

$C_{sediment}$ = Contaminant concentration in sediment (6 ug/kg)

K_{oc} = Organic carbon partitioning coefficient ($10^{4.1}$ l/kg organic carbon)

f_{oc} = fraction organic carbon (0.02215 kg organic carbon/kg sediment)

The resulting pore water concentration for aldrin at Section EE03 is 0.0215 ug/l (rounded to two significant digits 0.022) as listed in Table 4-7. The remaining calculated organic pore-water concentrations are also summarized in Table 4-7.

4.1.3.2 Indirect (Ingestion-Pathway) Exposure-Point Concentrations

Ingestion-pathway exposures to the four terrestrial or semiaquatic vertebrate receptors are estimated as *applied daily doses* using the approach outlined in USEPA (1993b) as follows:

$$ADD = [(IR_{food} * C_{food}) + (IR_{water} * C_{water}) + (IR_{sed} * C_{sed})] * F/BW \qquad \text{[Eq. 4-2]}$$

where:

ADD = Applied Daily Dose (mg/kg/day)

IR_{food} = Ingestion rate of food in kg/day

IR_{water} = Ingestion rate of water in l/day

IR_{sed} = Ingestion rate of sediment in kg/day

C_{food} = Concentration of contaminant in food (mg/kg)

C_{food} = Σ [(diet composition1$_{food}$[1] * C_{food1}) + (diet composition$_{food2}$) ..... food$_n$]/100

C_{water} = Concentration of contaminant in water (mg/l)2[2]

C_{sed} = Concentration of contaminant in sediment (mg/kg)

F = Area use factor (percent)

BW = Body weight (kg)

Measured site-specific COEC concentrations in media other than water, sediment and crayfish that are relevant to the ingestion pathway were not available -- specifically: plant material; aquatic and terrestrial invertebrates (e.g., insects); amphibians and reptiles; small mammals; and small birds. A series of approaches were taken to estimate concentrations in these dietary items:

- For aquatic insects and terrestrial insects (note that all terrestrial insects were assumed to be emergent aquatic invertebrates):
  - for organics, equilibrium partitioning was used to estimate a sediment pore-water concentration as discussed previously; (A bioconcentration factor [BCF] for the constituent was applied to the pore-water concentration to estimate a tissue concentration.)

    tissue concentration (µg/kg) = $C_{pore\ water}$ (ug/L) x (BCF) [Eq. 4-3]

  - for inorganics, the constituent BCF was applied directly to the surface-water concentration.

    tissue concentration (µg/kg) = $C_{surface\ water}$ (ug/L) x (BCF) [Eq. 4-4]

- For plants:
  - for organics, a model was developed after Trapp and McFarlane (1995) that estimates contaminant uptake into the transpiration system where contaminants are transported to various portions of the plant; (This is discussed in greater detail later in this section.)

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[1] **Diet composition is input as a percentage of the overall diet [the sum of all should equal 100].**

[2] **Water concentrations were input in units of µg/l in spreadsheets used to calculate ADDs in this assessment. These were subsequently corrected in the calculation by dividing by 1,000 to convert µg/l to mg/l.**

- for inorganics, the constituent BCF (a plant-specific BCF was used when available) was applied directly to the surface-water concentration to estimate the concentration in plants.

tissue concentration (μg/kg) = $C_{surface\ water}$ (ug/L) x (BCF) [Eq. 4-5]

- For small mammals, amphibians and reptiles, and birds:

  - for organics with a K_{ow} greater than 2.0, the food chain multiplier approach was used from the *Final Water Quality Guidance for the Great Lakes System, Final Rule* (USEPA 1995) using measured surface-water concentrations; (This is discussed in greater detail later in this section.)

  - for organics with a K_{ow} less than 2.0, all food chain multipliers (FCMs) were assumed to equal 1 (resulting simply in BCFs being applied directly to pore water (for organics) for all trophic levels);

  - for inorganics, the constituent BCF was applied to the surface-water concentration, and the FCM was assumed to equal 1, with the exception of mercury. (Organism-specific BCFs were used where available.)

As noted above for organic COECs, exposure-point concentrations were conservatively estimated using bioaccumulation and partitioning theory, with the approach from USEPA (1995). The general approach is shown in Figure 4-1.

Bioconcentration factors for organic COECs were derived from the relationship between octanol-water partition coefficients (log K_{ow}) and the lipid content of the biota in question, as well as trophic position, following the general guidance obtained from the *Final Water Quality Guidance for the Great Lakes System, Final Rule.* The following approach was used for calculating the COEC concentration in invertebrates and vertebrates:

$$BCF_{lipid} = 10^{\log Kow} \qquad \text{[Eq. 4-5]}$$

$$BCF = BCF_{lipid} * \%lipid/100 \qquad \text{[Eq. 4-6]}$$

Lipid contents used for specific organisms were based on information obtained from USEPA (1993b). The lipid content of birds is based on bobwhite quail. Body fat data for bobwhite quail were reported as % dry weight and average 11.15%. Assuming a moisture content of 80%, this converts to a lipid content of 2%. Small mammal lipid content is based on the meadow vole, which contained a total lipid content of 0.72 g. Assuming an average body weight of 37.25 g, this converts to a lipid concentration of about 2 %. For reptiles, lipid content for the box turtle averaged 0.059 g/g-BW. A value of 6 percent lipid content was used in calculating contaminant bioaccumulation. Lipid data for amphibians was from Ulene (1995) where 3% total fat was reported in frog legs. Ulene (1995) was also the source of estimated lipid concentrations for aquatic invertebrates (4%), emergent insects (3.5%), and forage fish (4%).

In accordance with USEPA (1995; see also Opresko *et al.* 1994), the approach for estimating tissue concentrations consists of multiplying the water concentrations by the BCF and a food chain multiplier (FCM) specific for the trophic level of interest to develop a trophic-level bioaccumulation factor (BAF):

$$BCF_{lipid} * FCM = BAF_{lipid} \qquad \text{[Eq. 4-7a]}$$

$$BAF = BAF_{lipid} * f_{lipid} \qquad \text{[Eq. 4-7b]}$$

where:

f_{lipid} = the lipid fraction of the organism

FCMs are selected based on the octanol-water partitioning coefficient of the constituent and the trophic level of interest, and were interpolated from the table of FCMs in USEPA (1995). These FCMs are summarized in Table 4-8. Trophic Level 2 consists of primary consumers such as zooplankton, certain benthic invertebrates and terrestrial herbivores. Trophic Level 2 FCMs were used to calculate tissue concentrations in small mammals and forage fish. Trophic Level 3 consists of secondary and tertiary consumers such as predaceous fish, insectivorous birds, carnivores, and omnivores. Trophic Level 3 FCMs were selected for amphibians, reptiles and birds. Spreadsheets summarizing output calculations are presented in Appendix I. Appendix I also contains the summary of all exposure point concentrations for vertebrates and invertebrates (and plants) subsequently used in risk estimation.

Plant tissue values were estimated based on a modeling approach modified from Trapp and McFarlane (1995) as follows:

$$k_{rw} = \text{root moisture (\%)}/100 + \text{root lipid(\%)} * 10^{(kow)\wedge 0.75} \quad \text{[Eq. 4-8a]}$$

$$TSCF = 0.784*\exp[-(\log K_{ow}-1.78)^{\wedge 2}/2.44)] \quad \text{[Eq. 4-8b]}$$

$$k_{cw} = \text{fruit moisture (\%)}/100 + \text{fruit lipid(\%)} * 10^{(kow)\wedge 0.75} \quad \text{[Eq. 4-8c]}$$

where:

k_{rw}	=	partition coefficient between root and water
TSCF	=	transpiration stream concentration factor
k_{cw}	=	partition coefficient between cuticle and water

The concentration in the transpiration stream (stem) is first calculated as:

$$\text{Transpiration stream concentration} = TSCF * \text{pore water concentration} \quad \text{[Eq. 4-8d]}$$

Based on the resulting transpiration stream concentration, the concentration in the fruit is then calculated as:

$$\text{Concentration in fruit} = k_{cw} * \text{Transpiration stream concentration} \quad \text{[Eq. 4-8e]}$$

Values of 5% lipids and 75% moisture were used in the above calculations (Trapp and MacFarlane 1995). Spreadsheets summarizing output of the plant calculations are presented in Appendix I. Appendix I also contains the summary of all exposure-point concentrations for plants subsequently used in risk estimation. Fruit concentrations were used as the exposure point concentrations employed for the risk estimation. Calculations of all plant tissue concentrations are presented in Appendix I. These calculations were necessary to estimate the fruit concentrations that were used as exposure point concentrations employed for the risk estimation.

No reliable method was identified for estimating concentrations of metals in the pore water of sediments. Thus for metals, plant-tissue concentrations were calculated as:

$$\text{tissue concentration (mg/kg)} = (C_{\text{surface water}}\ \text{(mg/L)} \times \text{BCF} \times \text{FCM}) \quad \text{[Eq. 4-9]}$$

Metals bioconcentration factors were compiled from the on-line database AQUIRE (1995). All values reported for the COECs were downloaded. BCF values based on durations less than 25 days for fish were not used; nor were short-term values for invertebrates or vascular plants (e.g., less than 14 days). Some short-term exposure algal BCFs were used (e.g., 4-day). As algal populations in the laboratory have very high population turn-over rates, such BCFs were deemed appropriate. After the data sets were censored of short-term exposure results, the geometric mean of the values was produced and used in the exposure point calculation(s). If no data were obtained from the AQUIRE database, USEPA (1979) was consulted for plant, fish, algal, and invertebrate BCF values. If neither AQUIRE nor USEPA (1979) contained a BCF for a specific forage group or COEC, values obtained from the OHM/TADS database were used.

The FCM for metals was assumed to be one, with the exception of mercury, the only metal among the COECs with clearly-defined propensity to biomagnify (Table 2-9). The *Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors - June 1994* (USEPA 1994) indicates that data from Watras and Bloom (1992) show an increase in mercury of a factor of about 2 from Trophic Level 1 to Trophic Level 2, and about a factor of 1.26 from Trophic Level 2 to Trophic Level 3. This represents a FCM of 2 for Trophic Level 2 and a FCM of 2.52 for Trophic Level 3. These values were used for estimating bioaccumulation factors for mercury.

4.2 TOXICITY ASSESSMENT

Screening benchmarks represent media-specific concentrations above which there is sufficient evidence for concern regarding a potential ecological impact that further, more refined evaluation, is warranted. These screening benchmarks may be based: (1) on a consideration of background concentrations, e.g., some of the Netherlands benchmarks or the State of Wisconsin approach; or (2) a statistical treatment of the available field database for

effects, e.g., for sediment; Ontario Ministry of the Environment, NSCI, NOAA, and some of the Netherlands benchmarks, and for surface water; Ambient Water Quality Standards (please refer to Section 2.2). The results of this screening and selection process (Subsection 2.2) culminated in the identification of 46 chemicals of potential ecological concern (some of the latter are treated as groups or classes; see below).

Once a concern is identified, i.e., the chemical becomes COEC, site specific receptors of concern were identified for evaluation of general assessment endpoints (GAE, Subsection 2.3.1). In order to address these general endpoints, toxicity reference values (TRVs) were selected and incorporated into the testable hypothesis stated in Subsections 2.3.2 and 2.3.3 in characterizing the potential ecological risks3. This subsection identifies the TRVs and presents the rationale for their selection. It should be noted that TRVs may be more site-specific than conservative screening ecotoxicity values. Also discussed are the results of the standardized bulk-sediment and surface-water toxicity tests on samples collected during the October 1994 and June 1995 field activities.

4.2.1 Grouping of Organic COECs

Once the screening and selection process for COECs was completed (Subsection 2.2), certain of the organic constituents were organized into groups in order to more effectively evaluate the associated potential risks ("mechanisms of toxicity") to ecological receptors. During this process of organizing the COECs, those materials for which no screening benchmarks were available were re-evaluated for inclusion within a group or class of materials that had been definitively selected as a COEC. Inclusion of these constituents was based on similarity in structure or whether the chemical at issue was an isomer of one of the selected COECs. These inclusions optimally would include similar toxic expression but as little or no information was available, it can only be inferred. This inference has been accepted as a practice given no chemical-specific data, i.e., the ASTER database and SMILES calculations. A group of chemicals exerting similar to identical mechanisms of toxicity, e.g., nonpolar narcosis or polar narcosis, can be used to develop predictive toxicity models (e.g., the SMILES model [USEPA 1995, within ASTER]). While derivation of such training sets and

3 Note that the COECs evaluated for the specific receptors vary, as discussed in Subsection 2.2.3.4 and Section 2.3 of the text, and in Tables 2-10 and 2-11.

regression analysis are beyond the scope of the present ecological risk assessment, it was decided (1) inclusion based on surrogate toxicity information is preferred over exclusion; and (2) there is sufficient evidence available that the use of surrogate values is appropriate. While this may add a degree of uncertainty to the evaluation due to use of surrogate information, omission from the following assessment would have produced a greater level of uncertainty.

The surrogate chemical selected to represent the class or group of chemicals for the risk estimation were selected from those values presented in Appendix H and are reported in Tables 4-9 through 4-12.

The polycyclic aromatic hydrocarbons present a special case. PAHs were grouped by molecular weight. The rationale (Subsection 2.2.3) is reiterated here. Excluding the carcinogenic effects attributed to some of the PAHs, their mode of toxicity is polar narcosis. Narcosis is generally considered a nonspecific toxicologically-induced, reversible, disruption of neural activity (i.e., anesthesia). There are presently two theories regarding how narcosis occurs within an organism. The "critical volume" theory (Abernethy and Mackay 1988) involves a swelling or volume change due to dissolved toxicant in nerve cells that results in changes in the structure of lipid bilayers within the cell membrane. The "protein binding" theory (Abernathy and Mackay 1988) involves the toxicant binding to specific receptor sites of specific dimensions within the nerve cells, resulting in narcosis. Chronic exposures can produce a myriad of effects depending on the organism and its physiology. The key here is that the *size of the PAH controls the effective concentration or dose related response* (Abernathy and Mackay 1988). Either theory supports this conclusion. The critical volume theory holds that the toxic mechanism is a swelling of the cell. To elicit the same magnitude of swelling, more of a lower molecular weight PAH would be required than that of a higher molecular weight PAH, as swelling is a function of size. The protein binding theory refers to binding to specific receptor sites, which is controlled by the size and structure of the toxicant. Here again the size of a PAH is implied to control the toxic response. Additionally, the available empirically-derived toxicological results (Appendix H) bear out the hierarchy, increased toxicity with increased molecular weight. Thus, the PAHs have been grouped in to three subgroups based on the mechanism of their toxicity as it relates to their structure: (1) low molecular weight PAHs (MW<200); (2) medium molecular weight PAHs (MW = 200 to <220); and (3) high molecular weight PAHs (MW>220).

The foregoing process resulted in establishment of the following organic COEC groups:

Chlorinated Aromatic Hydrocarbons (Chlorinated naphthalenes)

Naphthalene, 1,2,3,4-tetrachloro-
Naphthalene, 1,3,5,7-tetrachloro-
Naphthalene, 1,4,6,7-tetrachloro-
Naphthalene, 2,3,6-tetrachloro-
Naphthalene, heptachloro-

Phenol and substituted Phenols

Phenol
Phenol, 4-(2,2,3,3,-tetramethylbutyl)-
Phenol, 4-4'-(1,2-diethyl-1,2-^ethanediyl)bis-
Phenol, 4-dodecyl-

Nonylphenols

2-Nonylphenol
Nonylphenol

Total PCBs

Aroclor 1254
Aroclor 1260
1,1-Biphenyl, 2,2',3,4,5,5'-hexachloro-
1,1'-Biphenyl, 2,2',3',4,5,-^pentachloro-
1,1'-Biphenyl, 2,2',4,4',5-^pentachloro-
1,1'-Biphenyl, 2,2,4,4',6-pentachloro-

alpha & delta BHC

alpha BHC
delta BHC

Low Molecular Weight PAHs (molecular weight < 200)

Naphthalene
2-Methylnaphthalene
Naphthalene, decahydro-2-methyl-
Acenaphthalene
Fluorene
Carbazole
Dibenzofuran
Anthracene
Phenanthrene

Dibenzothiophene, 3-methyl-
4H-Cyclopenta[def]phenanthrene
Anthracene, 1-methyl-
Anthracene, 2-methyl-
Anthracene, 9-methyl-
Phenanthrene, 3-methyl

Medium Molecular Weight PAHs (molecular weight > 200 and < 220)

Fluoranthene
Pyrene
9,10-Dimethylanthracene
Phenanthrene, 2,5-dimethyl-
Phenanthrene, 3,6-dimethyl-
Phenanthrene, 9,10-dimethyl-
9,10-Anthracenedione
Naphtho[2,3-b]thiophene,4,9,-dimethyl-
11H-Benzo[b]fluorene
Pyrene, 2-methyl-
Pyrene, 4-methyl-
Benzo(a)carbazole

High Molecular Weight PAHs (molecular weight >220)

Phenanthrene, 2,3,5-trimethyl-
Benzo(a)anthracene
Benzo[c]phenanthrene
Chrysene
Triphenylene
Benzo[b]naptho[2,1-d]thiophene
Benzo[c]phenanthrene,3-methyl-
Triphenylene, 2-methyl-
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(e)pyrene
Benzo(k)fluoranthene
Perylene
Chrysin
Benzo(a,g,h,i)perylene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Dibenz(a,c)anthracene

Molecular weights were not identified for several PAH compounds. These were grouped with the High Molecular Weight PAHs and included:

2-Phenylnaphthalene
3,4-Dihydrocyclopenta(cd)pyrene (acepyrene)
3-Fluoranthenamine
2,8-Dimethyldibenzo(B,D)thiophene
Benz[j]aceanthrylene, 3-methyl-
Benzo(c)carbazole
Chrysene, 3-methyl
Dibenzo(B-def)carbazole
Dibenzothiophene
Indolo(3,2-c)cinnoline

The grouping process resulted in the ultimate recognition of 27 "organic COECs", including those addressed individually (acetone, carbon disulfide, chlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, alpha chlordane, methylene chloride, toluene, total xylene, DEHP, PCP, aldrin, dieldrin, endosulfan sulfate, heptachlor, heptachlor expoxide, methoxychlor, benzidine, TPS) for purposes of this EA.

4.2.2 Effects Levels

Several databases, in addition to the open literature, were consulted for compilation of the ecotoxicological effects presented below. These include the Assessment Tools for the Evaluation of Risk (ASTER); Aquatic toxicity Information Retrieval (AQUIRE); the Hazardous Substances DataBase (HSDB); the Integrated Risk Information System (IRIS); the Toxicity Network (TOXNET, which includes MEDTECS); the Registry of Toxic Effects of Chemicals (RTECS). U.S. Fish and Wildlife Service *Contaminant Hazard Series* synopses and available ATSDR *Toxicological Profiles* were also used to provide the information necessary for selecting toxicity reference values (TRVs) to perform the risk estimation in Section 5.1, and to more completely illustrate the nature of the potential toxicity associated with the chemicals of ecological concern.

4.2.2.1 Direct (Aquatic Toxicity)

The AQUIRE database, which contains all of the data used in the calculation of Federal Ambient Water Quality Criteria (FAWQC[4]), was used to compile toxicity values for each COEC and resultant toxicity values were subsequently sorted into values associated with fish, invertebrates, algae and aquatic plants. There were insufficient data obtainable from AQUIRE and the additional sources to evaluate direct exposure to amphibians or reptiles as a separate receptor group. If no data were available in AQUIRE, the following sources were used to obtain TRV information: Suter and Mabrey (1994); Federal Water Pollution Control Administration (1968; *Report to the Committee on Water Quality Criteria*); Sheedy *et al.* (1991); and Spehar *et al.* (1982). Data regarding inhibition of bacterial/fungal activity were obtained from Alexander (1993), Eckenfelder (1989), Eckenfelder and Musterman (1995), and Verschueren (1983) to use in assessing impacts to the microbial decomposer community. TRVs were selected in the following manner:

- Where literature values were identified for a receptor group, the lowest Lowest-Observed-Adverse-Effects Concentration (LOAEC) representing the most relevant response (survival, reproduction, development, and/or growth, in that order of preference) was selected. For the No-Observed-Adverse-Effect Concentration (NOAEC) scenario, the highest NOAEC that did not exceed the lowest LOAEC was selected.

- Where values were not identified for a receptor group, values from surrogate groups were selected and modified by applying an uncertainty factor. For example, if no fish data were available for a particular COEC, the lowest available invertebrate TRV was divided by 10 for use as the fish TRV (Suter 1993).

- If LOAEC and/or NOAEC data were not available, but lethal concentration data were reported (e.g., LC_{50}s), an uncertainty factor (division) of 10 was applied to the lethal concentration to derive a LOAEC, and an uncertainty factor of 10 to derive a NOAEC (USEPA 1994). Note that lethal concentration values were only used in the absence of reported NOAEC and LOAEC data.

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[4] **Federal AWQCs were used for screening, but were not used for direct toxicity comparisons. This was to provide resolution to the risk assessment. FAWQC, when applied as a Final Chronic Value (FCV) is derived based on a mixture of taxa such that differences between the sensitivities of ecological receptors is obscured.**

- Weight was given to the duration of exposure, as well as the toxicological endpoint. For example, if available, endpoints related to survival, reproduction, and/or growth (or chlorophyll production/inhibition for algae) were preferentially selected as being more ecologically-relevant.

Summaries of the direct-exposure TRVs for inorganic and organic COECs are presented in Table 4-9 and Table 4-10, respectively. These tables present the TRV selected from the relevant effects levels found and in the case of chemical grouping, that surrogate chemical selected to represent the group. All relevant effects levels located are listed in Appendix H. Since dozens of individual source documents were involved, the literature citations are presented in Appendix H.

4.2.2.2 Ingestion Pathway/Dose-Response Relationships

In accordance with specific assessment endpoints involving survival, reproduction, development, and/or growth for ingestion-pathway receptors (see Table 2-9), a literature search was conducted for appropriate dietary toxicological endpoints. These included the lethal dose, the Lowest-Observed-Adverse-Effect Level (LOAEL), and the No-Observed-Adverse-Effect Level (NOAEL). The lethal dose, expressed, for example as the $LD_{50,}$ is the dose lethal to 50% of the test organisms over a specific exposure period. Another example, the LD_{lo}, is a reported dose that is capable of producing lethality. The LOAEL is the lowest dose that results in a statistically significant effect compared to a control. The NOAEL is the highest dose where there is no statistically significant difference in the control response.

Lethal dose values generally represent acutely toxic endpoints, although this must be examined in the context of the exposure duration and the test animal. For example, a lethal dose based on a 1- to 5-day exposure might be considered an acutely toxic response, whereas a lethal dose reported for 50 or 100 days might be considered a chronic response. Emphasis was placed on selection of chronic endpoints (i.e., NOAELs and LOAELs) or lethal doses over extended periods. Greater weight was given to multi-day or multi-week studies rather than single-dose studies. Based on the compiled literature endpoints, a receptor-specific TRV (or surrogate) was selected for characterizing risk (i.e., as the denominator for use in the hazard calculation to be discussed in Section 5.0).

Data compiled from the literature search for each of the COECs are presented in detail in Appendix H. The general strategy for selecting (or deriving) a single LOAEL and NOAEL value as a TRV from among the many values reported in the literature was as follows:

- Where literature values were identified for the specific assessment receptor, the lowest LOAEL representing the assessment endpoint (survival, reproduction, development, and/or growth) was selected. For the NOAEL scenario, the highest NOAEL that did not exceed the lowest LOAEL was selected.

- Where values were not identified for a specific assessment receptor (which is characteristic of the vast majority of the literature values), values from surrogate receptors were used. For example, an attempt was made to use rodent data for the muskrat, or omnivore (or carnivore) data for the raccoon (e.g., pigs or dogs). If mammalian data were reported but bird data were unavailable, an uncertainty factor (division) of 10 was applied to the lowest TRV selected for the mammals.

- In cases where NOAELs were reported, but LOAELs were not identified, the lowest NOAEL value was used for deriving TRVs. In such an instance, a LOAEL was derived based on 10 times the NOAEL.

- If LOAEL and/or NOAEL data were not available, but lethal dose data were reported, an uncertainty factor (division) of 10 was applied to the lethal dose to derive a LOAEL, or an uncertainty factor of 100 to derive a NOAEL (USEPA 1994). LD_{lo}s (lethal dose-low) were selected preferably over LD_{50}s (lethal dose to 50% of the test subjects) as the former refers to the lowest observed lethal dose and the latter refers to that dose expected to produce 50% lethality in all exposed individuals. An uncertainty factor (division) of 10 was also applied to the LOAEL to derive a NOAEL. Note that lethal dose values were generally only used in the absence of LOAEL and NOAEL information.

- Weight was given to the duration of the study, as well as the toxicological endpoint.

- Measurement endpoints considered included survival, growth and reproduction. Endpoints specifically related to survival, reproduction, development, and/or growth such as fetotoxicity or infertility were also considered. Effects such as carcinogenesis, liver damage or kidney function, though reported in the toxicity compilation tables in Appendix H, were generally not considered appropriate measurement endpoints.

This process just described was not always possible. For many metals, a number of lethal dose values were lower than all of the reported NOAEL or LOAEL values. In several cases, a single value was selected as a TRV for both the NOAEL and LOAEL due to, for example, large discrepancies between reported values for similar endpoints.

The selection of TRVs for each of the COECs or groups of COECs is discussed below. Where assessment receptor-specific data are not specifically noted, mammal endpoints presented were used for muskrat and raccoon, and endpoints for birds were used for the green heron and red-winged blackbird. Summaries of TRVs are presented in Table 4-11 for inorganics and Table 4-12 for organics. These tables present the TRV selected from the relevant effects levels found and in the case of chemical grouping, that surrogate chemical selected to represent the group. All relevant effects levels located are listed in Appendix H. Since dozens of individual source documents were involved, the literature citations are presented in Appendix H.

INORGANICS

Antimony

A number of LOAELs were reported for antimony. An LOAEL of 1,338 mg/kg-BW/day was selected as a TRV based on an 80-day study assessing growth in rats. Note that sheep LOAELs were more sensitive, but were not selected because sheep are not rodents and are much larger animals that either mammal of interest in this EA. A corresponding NOAEL TRV of 134 mg/kg-BW/day was reported for the rat study. The values reported in the rat study were used for the muskrat and raccoon. There were other endpoints associated with reduced lifespan and maternal body weight, but these were not believed directly related to the assessment endpoints selected during problem formulation.

There were no values reported for birds. Therefore, the mammal TRVs were adjusted with uncertainty factors of 10, resulting in TRVs for the green heron and red-winged blackbird of 133.8 mg/kg-BW/day (LOAEL) and 13.4 mg/kg-BW/day (NOAEL).

Arsenic

The lowest LOAEL reported for arsenic in mammals was 0.8 mg/kg-BW/day. This was a 3-generation study in mice with the LOAEL representing reduced litter size. A NOAEL of 10.4 mg/kg-BW/day was also reported for mice, based on survival over a period of 96 hrs. Because of the greater length of the LOAEL study and a reproductive endpoint, the 0.8 mg/kg-BW/day was adjusted to an NOAEL of 0.08 mg/kg-BW/day using an uncertainty factor of 10. These TRVs were used for the muskrat.

A NOAEL of 0.9 mg/kg-BW/day was reported in a 90-day study in dogs where no adverse effects were reported. This was adjusted to an LOAEL TRV of 9.0 by multiplying by a factor of 10. These values were used for the raccoon.

A NOAEL of 4.7 mg/kg-BW/day was reported for the cowbird based on a 6-month study in which the reported effect was "clinical signs". The cowbird was selected as a representative surrogate for the red-winged blackbird (the two species are very closely-related). Lethal dose values of 14.2 mg/kg-BW/day were also reported. Because these values are less than 10 times the NOAEL, 4.7 mg/kg-BW/day was used as the TRV for both the LOAEL and NOAEL.

A number of NOAELs and lethal dose values were reported for birds other than the cowbird, but there was a notable lack of LOAELs. It is interesting to note that there was significant overlap between lethal dose and NOAEL values, making it difficult to select appropriate TRVs. For the green heron, the lowest LOAEL and highest NOAEL below the LOAEL was selected, which coincidentally were those reported for the cowbird. Therefore, the TRVs selected for the red-winged blackbird discussed previously were also selected for the green heron.

Cadmium

The lowest LOAEL for mammals reported for cadmium (and also representative of measurement endpoints selected for this EA) was 1.6 mg/kg-BW/day from a 9-day study in rats, where fetal death was the endpoint. There were no NOAELs reported for mammals, so

the value of 1.6 mg/kg-BW/day was divided by an uncertainty factor of 10 to derived a NOAEL TRV, resulting in a value of 0.16 mg/kg-BW/day.

The lowest LOAEL in birds for was 7.8 mg/kg-BW/day. This value was from a 6-wk study in Japanese quail, where testicular damage was a test endpoint, which is inferred to represent reproductive impairment. The only NOAEL was reported for survival and growth in mallards over a 90-day period at a dose of 11.1 mg/kg-BW/day, which is higher than the LOAEL discussed previously. A NOAEL TRV was derived by applying an uncertainty factor of 10 to the LOAEL, resulting in a value of 0.78 mg/kg-BW/day.

Chromium

A series of NOAELs were reported for chromium in mammals. There were no adverse effects in a 3-month study of rats at a dose of 18 mg/kg-BW/day of Cr^{VI}. No effects were observed with doses of trivalent chromium as high as 170 mg/kg-BW/day. Though no LOAELs were reported, a lethal dose (LD_{lo}) for hexavalent chromium was reported for rats at a dose of 82 mg/kg-BW/day. A value of 18 mg/kg-BW/day was used for both the LOAEL and NOAEL scenarios for the muskrat.

A NOAEL value of 0.3 mg/kg-BW/day was reported during a 4-year study in dogs in which no adverse effects were observed. An 3-month LD_{lo} was also reported for dogs at a dose of 3 mg/kg-BW/day, which was used as the LOAEL TRV. Therefore, 0.3 mg/kg-BW/day was used as a TRV for and NOAEL and 3 mg/kg-BW/day was used as the LOAEL.

A NOAEL of 2.8 mg/kg-BW/day for survival, growth and reproduction in adult black ducks was reported in 5-month study. However, a LOAEL of 2.7 mg/kg-BW/day was reported for young black ducks based on survival in a 10-week study. This suggests that the young black ducks are more sensitive than the adults (which is often, but not always the case). Therefore, an uncertainty factor of 10 was applied to the LOAEL study to derive a NOAEL TRV of 0.27 mg/kg-BW/day.

Cobalt

A NOAEL of 0.13 mg/kg-BW/day was reported for a 14-wk study in rats using survival as an endpoint. This was adjusted to a LOAEL of 1.3 mg/kg-BW/day by multiplying by a factor of 10. Note that one study reported a dose of 0.05 mg/kg-BW/day administered during gestation resulted in a LOAEL based on reduced birth weight. However, reduced birth weight was not considered a measurement of survival, reproduction, or growth.

In the only studies identified for birds, chickens dosed at 0.24 mg/kg-BW/day showed no adverse effects. A dose of 2.4 mg/kg-BW/day was reported as both an LD_{lo} and a LOAEL based on growth. TRVs selected for birds from these studies were 2.4 mg/kg-BW/day (LOAEL) and 0.24 mg/kg-BW/day (NOAEL).

Cyanide

The lowest LOAEL for mammals was in a 4-week study of growth in rats at a dose of 26.8 mg/kg-BW/day. No adverse effects were observed over a 2-year study in rats at a dose of 12 mg/kg-BW/day or in a 30-day study with dogs at a dose of 4.7 mg/kg-BW/day. However, lower values were reported as lethal (single) doses in rats (an LD_{50} of 3.6 mg/kg-BW/day) and rabbits (an LD_{50} of 2.5 mg/kg-BW/day). A single dose LD_{50} of 24.0 mg/kg-BW/day was also reported in dogs. Dogs were selected as a surrogate for the raccoon with 4.7 mg/kg-BW/day used as a TRV for both the LOAEL and NOAEL scenario. For the muskrat, TRVs were selected by applying uncertainty factors of 10 and 100 to the LD_{50} of 2.5 mg/kg-BW/day in rabbits, resulting in an LOAEL TRV of 0.25 mg/kg-BW/day and a NOAEL TRV of 0.025 mg/kg-BW/day.

A 20-day study of growth in chicks resulted in a LOAEL of 19.6 mg/kg-BW/day. No adverse effects were observed in chicks during an 8-week study at a dose of 14.9 mg/kg-BW/day. However, a number of lethal dose studies suggest that chickens may be less sensitive to cyanide than many other birds. The lowest LD_{50} value was 1.43 mg/kg-BW/day in mallard. Uncertainty factors of 10 (to estimate an LOAEL) and a factor of 100 (to estimate a NOAEL) were applied to the mallard data to develop TRVs for the green heron. Resulting values were 0.143 mg/kg-BW/day and 0.0143 mg/kg-BW/day respectively.

An LD_{50} value of 9.0 mg/kg-BW/day was also reported for starling. The starling was used as a surrogate for the red-winged blackbird. Uncertainty factors of 10 and 100 were applied to derive LOAEL and NOAEL TRVs of 0.9 mg/kg-BW/day and 0.09 mg/kg-BW/day, respectively.

Lead

In mammals (other than sheep) the lowest LOAEL for measurement endpoints for lead was 150 mg/kg-BW/day in mice with a measurement endpoint of effects on fertility. There were no comparable NOAEL values, so a NOAEL TRV was derived by dividing by an uncertainty factor of 10, resulting in a value of 15 mg/kg-BW/day. Note that lower values were reported for sheep, but mice were selected because they are more closely related taxonomically and functionally to the assessment receptors.

The lowest LOAEL reported for birds was for the bald eagle, which was 0.4 mg/kg-BW/day based on a single-dose study which included growth as an endpoint. This value was used for the green heron. An uncertainty factor of 10 was applied to attain a NOAEL of 0.04 mg/kg-BW/day. The next lowest measurement endpoint LOAEL for birds was an LOAEL of 48 mg/kg-BW/day for the rock dove based on a 10-day dose and growth as an endpoint. The highest NOAEL below the LOAEL was 16 mg/kg-BW/day for quail, in which no adverse effects were reported during a 12-week study. A LOAEL TRV of 48 mg/kg-BW/day and NOAEL TRV of 16 mg/kg-BW/day were used for the red-winged blackbird.

Mercury

LOAELs ranging from 0.1 mg/kg-BW/day to 0.25 mg/kg-BW/day during gestation were reported for fetotoxicity in dogs related to organic mercury. However, an LD_{100} of 0.07 mg/kg-BW/day was reported in mink. A LOAEL TRV of 0.07 mg/kg-BW/day was selected for raccoon, with an uncertainty factor of 10 applied to derive a NOAEL TRV of 0.007 mg/kg-BW/day.

A study reporting an LOAEL of 0.5 mg/kg-BW/day based on reduced fertility in rats was selected as a LOAEL TRV for the muskrat. An uncertainty factor 10 was applied to derive a NOAEL TRV of 0.05 mg/kg-BW/day.

In birds, the lowest LOAEL was 0.06 mg/kg-BW/day methylmercury in mallards measured during a 3-generation study based on reduced fertility (as well as behavioral effects). Several NOAELs were reported for survival ranging from 0.42 mg/kg-BW/day to 5.1 mg/kg-BW/day, all of which were above the mallard LOAEL. An uncertainty factor of 10 was applied to the mallard value to derive a NOAEL TRV of 0.006 mg/kg-BW/day. These values were used for the green heron.

For the red-winged blackbird, the grey pheasant was used as a surrogate to obtain a LOAEL of 0.64 mg/kg-BW/day, based on reproductive effects. A NOAEL of 0.42 mg/kg-BW/day (based on pheasant survival) was selected as a NOAEL TRV.

Molybdenum

With one exception, the lowest LOAEL measurement endpoint in mammals for molybdenum was 0.3 mg/kg-BW/day in a study of reduced offspring growth in mice. The study duration was not reported. The exception was a study in cattle, which reported a value of 0.1 mg/kg-BW/day causing fertility effects; however, the mouse value was selected based of mice being taxonomically closer to muskrats (and also because cattle are ruminants). The mouse value was also selected for raccoon. A NOAEL of 0.03 mg/kg-BW/day was estimated from the LOAEL using an uncertainty factor of 10.

No TRVs were identified for birds since molybdenum was not included in the assessment endpoints for the red-winged blackbird and green heron.

Nickel

The lowest LOAEL reported for nickel was 0.67 mg/kg-BW/day for increased mortality of newborns in a 3-generation study of rats. This dose is approximately one order of magnitude *below* NOAELs reported for growth in rats (5 mg/kg-BW/day) and nearly two orders of

magnitude below other reported LOAELs (35 to 50 mg/kg-BW/day). The LOAEL of 0.67 mg/kg-BW/day was selected for the muskrat and was used for both the NOAEL and LOAEL TRVs.

A LOAEL of 63 mg/kg-BW/day and a NOAEL of 25 mg/kg-BW/day were reported for growth in dogs in a 2-year study. Values from the dog studies were used for the raccoon: 25 mg/kg-BW/day (NOAEL) and 63 mg/kg-BW/day (LOAEL).
There were no reported toxicity values identified for birds. Therefore, an uncertainty factor of 10 was applied to 0.67 mg/kg-BW/day, resulting in a value of 0.067 mg/kg-BW/day.

Selenium

The lowest LOAEL for selenium and mammals was 0.35 mg/kg-BW/day for reproduction in rats over a 1-year period. A single NOAEL was reported for mammals at 0.17 mg/kg-BW/day for reproduction in mice. These values were used for the muskrat and raccoon TRVs.

The lowest LOAEL in birds was 0.34 mg/kg-BW/day, where reduced hatching was observed in chickens. A NOAEL of 0.28 mg/kg-BW/day was reported for growth and reproduction for mallards. The duration was not reported for either of the bird studies.

Silver

The lowest LOAEL reported for silver and mammals was 2.7 mg/kg-BW/day in an 11-month study of growth in rats. The highest NOAEL below the LOAEL was 0.67 mg/kg-BW/day for a lifetime study of mortality in rats. These values were used as TRVs for the raccoon and muskrat.

The lowest LOAEL reported for birds was 43.5 mg/kg-BW/day based on a 28-day study measuring survival and growth in chickens. A NOAEL of 4.8 mg/kg-BW/day was reported in a 3-week chicken study where no clinical signs were observed. These values were used as TRVs for the green heron and red-winged blackbird.

ORGANICS

Pentachlorophenol (PCP)

A relatively large amount of data was available for PCP compared to many of the other COECs. The lowest LOAEL identified was 5 mg/kg-BW/day in a 5-day study of fetotoxicity in hamsters. A value of 3 mg/kg-BW/day in rats was the highest NOAEL observed for reproduction and fetal development. PCP was not evaluated for birds (Subsection 2.3).

Total PCBs

Endpoints for total PCBs were based on literature values for Aroclor 1254 and, to a much lesser extent, Aroclor 1260. The lowest LOAEL reported for mammals was 0.4 mg/kg-BW/day in an 8-month study of mink, in which reproductive failure was the measured endpoint. The mink data were more than an order of magnitude lower than all other LOAELs, and nearly an order of magnitude lower than all NOAELs. Based on the mink data, an LOAEL TRV of 0.4 mg/kg-BW/day was selected for the raccoon. This was further adjusted to an NOAEL of 0.04 mg/kg-BW/day using an uncertainty factor of 10.

For the muskrat, a LOAEL for rabbits of 12.5 mg/kg-BW/day (fetotoxicity) was selected. With the exception of a LOAEL of 5 mg/kg-BW/day reported for survival in monkeys, the rabbit LOAEL was the next lowest LOAEL identified after those for mink. The associated NOAEL for reproduction in rabbits was 10 mg/kg-BW/day.

The lowest LOAEL for birds was 1.8 mg/kg-BW/day in chicken (reduced hatchability). Note that LOAELs for other birds (including turtle dove, mourning dove, American kestrel, and pheasants) ranged from about 7 to 12 mg/kg-BW/day. A LOAEL of 1.4 mg/kg-BW/day for a "long-term" study of reproductive effects in mallard lower than the lowest NOAEL reported. Therefore, a value of 1.8 mg/kg-BW/day was used as the LOAEL TRV and 1.4 mg/kg-BW/day was used as the NOAEL TRV.

alpha Chlordane

The lowest LOAEL reported for measurement endpoints in mammals was 3.9 mg/kg-BW/day measured in an 80-wk study of mice survival. The highest NOAEL below the LOAEL was 3.2 mg/kg-BW/day based on a 30-day study of mice survival. These values were used as TRVs for the muskrat and raccoon.

There were no LOAELs reported for birds. However, a NOAEL of 2.5 mg/kg-BW/day was reported for Japanese quail survival and weight gain. No adverse effects were reported in a study of bobwhite quail at a dose of 0.0145 mg/kg-BW/day. The lowest LD_{50} values reported were 24 mg/kg-BW/day for pheasants and 25.9 mg/kg-BW/day for bobwhite quail. A NOAEL TRV of 2.5 mg/kg-BW/day was selected based on the Japanese quail study. Because the LD_{50} results were about 10 times the NOAEL (*i.e.*, about the same dose as a LOAEL might be derived from the NOAEL), the NOAEL value was used as the LOAEL TRV as well.

Aldrin

The lowest LOAEL for aldrin was 0.24 mg/kg-BW/day assessing live birth index in dogs over a 44-wk period. This value was selected as the LOAEL endpoint for the raccoon. There were no comparable NOAEL data, so an uncertainty factor of 10 was applied to attain an NOAEL of 0.024 mg/kg-BW/day.

For the muskrat, an LOAEL of 4.1 mg/kg-BW/day was selected based on a 2-year survival study in rats. A NOAEL of 2.82 mg/kg-BW/day was selected based on 2-year study of survival and growth in rats.

A number of LD50 data were available for birds, the lowest of which was 6.59 mg/kg-BW/day (single dose in bobwhite quail). Uncertainty factors of 10 and 100 were applied to derive a LOAEL and NOAEL of 0.659 and 0.0659, respectively.

Dieldrin

An LOAEL of 0.101 mg/kg-BW/day was reported for reduced litter size and fertility in raccoons. There were no comparable NOAEL data for raccoons. Therefore, an uncertainty factor of 10 was applied to this assessment receptor-specific value, though it is substantially less than all other reported NOAELs. Examination of the LOAEL data suggest that the raccoon are relatively sensitive to dieldrin.

The second lowest LOAEL was 0.25 mg/kg-BW/day based on a 9-day exposure to mice, measuring fetotoxicity as an endpoint. This is lower than all NOAEL values examined for mice (including a 9-day exposure in mice measuring teratology -- 3 mg/kg-BW/day). Therefore, 0.25 mg/kg-BW/day was also used as the NOAEL scenario for the muskrat.

Several LD_{50} values were reported for birds. The lowest LD_{50} was 8.84 mg/kg-BW/day for gray partridge. Uncertainty factors of 10 and 100 were applied, resulting in TRVs of 0.88 mg/kg-BW/day (LOAEL) and 0.088 mg/kg-BW/day (NOAEL).

Heptachlor

The lowest LOAEL value for heptachlor was 1 mg/kg-BW/day during a 1-yr survival study in dogs. This value was used for the raccoon. It was adjusted to a NOAEL value using an uncertainty factor of 10 to derive a value of 0.1 mg/kg-BW/day.

There were no associated LOAEL toxicological endpoints for rats to use as a surrogate for the muskrat. However, a 90-week study with mice was reported where no effect was observed in survival at a dose of 3.1 mg/kg-BW/day. This was adjusted to a LOAEL value of 31 mg/kg-BW/day by multiplying by 10.

Four lethal-dose studies were reported for birds. The lowest LD50 (5-day) was 19.5 mg/kg-BW/day in bobwhite quail. This was converted to LOAEL and NOAEL doses of 1.95 mg/kg-BW/day and 0.195 mg/kg-BW/day, respectively.

Heptachlor epoxide

The lowest LOAEL toxicological endpoint was 0.175 mg/kg-BW/day in dog pups in a 2-generation study. The NOAEL value in this study was 0.125 mg/kg-BW/day based on reproduction. These values were used for the raccoon.

A 0.5 mg/kg-BW/day LOAEL based on survival was reported for rats in a 3-generation study. A NOAEL based on reproduction in rats of 0.25 mg/kg-BW/day was also reported. These values were used as TRVs for the muskrat.

There were no values reported for birds. Therefore, the raccoon TRVs were adjusted using uncertainty factors of 10 to derive values of 0.0175 mg/kg-BW/day (LOAEL) and 0.0125 (NOAEL) for the green heron and red-winged blackbird.

Endosulfan Sulfate

A single LOAEL measurement endpoint and a single NOAEL measurement endpoint were identified for endosulfan sulfate. The LOAEL was 5 mg/kg-BW/day from a 9-day study of fertility effects in rats. The NOAEL was from a 2-year study in rats at a reported dose of 2.4 mg/kg-BW/day.

Several lethal-dose studies were reported for birds, both in single dose and 5-day studies. The 5-day values were selected preferentially over the single dose studies due to the study duration. The lowest 5-day LD_{50} was 101 mg/kg-BW/day in ducks (comparatively, the lowest single-dose LD_{50} was 33 mg/kg-BW/day in ducks). The 5-day LD_{50} was converted to LOAEL and NOAEL TRVs of 10.1 mg/kg-BW/day and 1.01 mg/kg-BW/day, respectively, for the green heron and red-winged blackbird.

High Molecular Weight PAHs

Data for the high molecular weight PAHs were limited to rodents among mammals, with some information for ducks and pigeons. The lowest LOAEL for rodents was 2.4 mg/kg-BW/day in mice based on reduced fertility (a reproductive endpoint). A single NOAEL

associated with applicable assessment endpoints was above the lowest LOAEL. Therefore a factor of 10 was applied to the lowest LOAEL to calculate an associated NOAEL of 0.24 mg/kg-BW/day.
The lowest measurement endpoint in birds was an LOAEL for survival in ducks of 44 mg/kg-BW/day. An associated NOAEL of 4.4 mg/kg-BW/day was calculated using an uncertainty factor of 10.

Benzidine

A single NOAEL related to survival was identified for benzidine; there were no LOAELs identified related to survival, growth or reproduction. A dose of 16 mg/kg-BW/day was reported as a NOAEL for dogs in a 5-year study. This was converted to an LOAEL of 160 mg/kg-BW/day as a LOAEL. This is consistent with LD_{lo}s ranging from 200 mg/kg-BW/day to 75,000 mg/kg-BW/day reported for dogs, rabbits, rats and hamsters.

There were no endpoints identified for birds. Uncertainty factors of 10 were applied to the mammal endpoints, resulting in TRVs of 16 mg/kg-BW/day (LOAEL) and 1.6 mg/kg-BW/day (NOAEL).

4.2.3 Summary and Evaluation of Toxicity Test Results

Acute and chronic toxicity tests were performed in fall 1994, and summer 1995, using fathead minnows (*Pimephales promelas)*, water fleas (cladocerans; *Ceriodaphnia dubia*), scuds (amphipods; *Hyalella azteca*), and aquatic worms (*Lumbriculus variegatus*). Fifteen surface-water and sediment samples were tested and compared to results obtained using laboratory control water and sediment.

The relationship between an evaluation of surface water toxicity when adequately related to instream conditions can provide a valid indication of impact (Policy Statement, USEPA, 49CFR No. 48, March 9, 1984). The correlation between impacts and the standardized test procedures with *Ceriodaphnia dubia* and the fathead minnow has been reviewed by USEPA (1991) which concluded that the correlation between toxicity testing and environmental impact is valid. The use of surface water toxicity tests within the context of the

environmental assessment is to evaluate, not merely the presence of toxic contaminants but, the ability to elicit an environmental impact. Chemical analysis alone cannot assess whether there are issues with regards to bio-availability, synergism or antagonism between the contaminants present, or other potentiation/mitigation factors such as hardness (metal toxicity), pH (e.g., ammonia toxicity), or dissolved oxygen levels (e.g., sulfides), thus the incorporation of toxicity tests. The same may be said of bulk sediment toxicity tests (USEPA 1992).

The endpoints of toxicity tests are indices for toxicity, effects on survival, growth and/or reproduction. These values are to be used as site specific reality checks with regards to the ecotoxicity evaluations performed as part of the environmental assessment. Additional uses of the toxicity results when in combination with other assessment tools, e.g., chemical analysis, equilibrium partitioning, benthic biodiversity, etc., can provide information leading to site specific numerical criteria (USEPA 1993a; USEPA 1993b; USEPA 1992; and USEPA 1991).

The selection of specific toxicity tests is based on the media pathways as outlined in the site conceptual exposure design, sediments and surface waters. The use of standard toxicity test procedures and standard test organisms for the environmental assessment is cited as the most appropriate for the evaluation of hazardous waste sites (USEPA 1989a) and their use at Tinker AFB is warranted to assure that the Data Quality Objectives (DQOs) can be met. Non-standard methodologies, e.g., biomarkers, do not allow for strict control over the ability to discriminate between responses based on physical and physiological tolerances to site specific conditions, poor acclimation to testing conditions, a history of contaminant exposure, disease state and/or nutritional deficiency. These concerns are addressed through the use of standard test species under standard methodologies. The selected species for the assessment are suggested by USEPA (USEPA 1989a and USEPA 1989b). Additionally, the precision of non-standard tests is rarely established whereas standardized tests with standard test species have established precision, most often reported as coefficients of variation (CV). The precision of standard toxicity testing is very close to that of chemical analysis (USEPA 1991). Given this high precision and historical database, data quality not only can be assured but assessed more accurately.

Surface-water toxicity test methods and procedures were in accordance with EPA/600/4-90/027F, *Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms* (USEPA 1993c), and in accordance with EPA/600/4-89/001, *Short-Term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms* (USEPA 1989c).

Bulk-sediment toxicity test methods were in accordance with ASTM E-1383-92, *Standard guide for conducting sediment toxicity tests with freshwater invertebrates* (ASTM, 1994), ASTM *Draft, Proposed standard test methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates* (ASTM, 1994), and ASTM E-1391-90, *New standard guide for collection, storage, characterization, and manipulation of sediments for toxicological testing* (ASTM, 1994).

The acute-toxicity tests provide concentration-response information, with the endpoint expressed as the percent sample concentration that is lethal to 50% of the test organisms (LC_{50}) within 48-hours (surface water tests) or 96-hours (bulk-sediment tests). The LC_{50} was determined by either a point estimation technique (the Trimmed Spearman-Karber method) or by probit regression. A LC_{50} cannot be calculated unless at least one exposure concentration results in a mortality rate greater than 50%. For the evaluation presented below, if a LC_{50} could not be calculated, the percent mortality observed at the highest exposure concentration tested is presented in the associated tables and discussion.

The results of all chronic-toxicity tests (measurement endpoints of; survival, growth, reproduction) were assessed for independence and normality, and to see if the variances within each of the datasets were homogenous across all exposure concentrations and the control. If these assumptions were met, the results were analyzed using parametric procedures such as Dunnett's Procedure or Bonferroni's T-test. If the data did not meet these assumptions, a nonparametric procedure such as Steel's Many-One Rank Test or Wilcoxon's Rank Sum Test was used. The specific statistical method used for each test is reported within Appendix J. The endpoint used in evaluating the chronic toxicity tests was the No-Observed-Effect-Concentration (NOEC). The NOEC is the highest concentration to which the organisms were exposed that did not produce a statistically-significant effect on survival, growth, and/or reproduction of the test organisms.

4.2.3.1 Bulk-Sediment Toxicity

Results of the acute toxicity tests with bulk sediment are summarized in Table 4-13; details are presented in Appendix J. There were no statistically significant effects on survival in the 1994 acute *Lumbriculus variegatus* sediment toxicity tests. There were, in a majority of the samples for both years, indigenous worms that may have interfered with the assessment. In 1995, one sample produced an acute mortality rate of 22.5%, EE08 (Table 4-13). Given the problems associated with interferences due to an indigenous population of *Lumbriculus*, no chronic assessments were performed with worms.

In 1994, there was sufficient *Hyalella azteca* acute mortality in samples EE06, EE07, and EW02, to produce LC_{50} values of 77.1%, 78.9%, and 58%, respectively (Table 4-13). Four additional sediment samples in 1994 elicited significant acute lethality, albeit less than that required for calculation of LC_{50} values: EE02, EE09, EW01, and EW03. Mortality rates in these samples ranged from 42.5% to 25% (Table 4-13). Survival of the scuds in all other samples ranged between 80 and 100% (Table 4-13). In 1995, two sediment samples (EE02 and EE07) produced acute toxicity of sufficient magnitude to calculate LC_{50} values. The LC_{50}s were 75.6% and 71.9% respectively. Five of the remaining sediment samples collected from Soldier Creek in 1995 showed some acute toxicity to *H. azteca* (EE01, EE04, EE06, EE08, and EE09) which ranged from mortality rates of 46.7% to 33.3% (Table 4-13). Survival in the remaining sediment samples ranged from 77% to 100%.

All of the sediment samples collected in 1994 were highly toxic to *H. azteca* given chronic exposures (Table 4-14). The No-Observed-Effect-Concentration (NOEC) for eight out of the 13 sediment samples tested in 1994 was below the lowest test concentration employed. Of those eight, EE04, EE05, EE08, EE09, and EW01 employed exposure concentrations down to 6.25% of the sediment sample. In all of these samples, a statistically significant reduction in survival was observed at exposure concentrations as low as 6.25%. Three of the sediment samples were shown to be highly toxic given acute exposure and as such, lower exposure concentrations were prepared for the chronic test. This was done in the hopes of producing results such that a NOEC could be derived. Unfortunately, in all cases the lowest tested concentration produced a statistically-significant reduction in the survival of the exposed

scuds. For sediment samples EE06 and EE07 the lowest tested concentration was 5% and for EW02 the lowest exposure concentration was 4%. The least lethal of the sediment samples tested in 1994 were EE01 and EW03 which produced survival NOECs of 50% sample (Table 4-14). The remaining sediment samples: EE02, EE03, and EE10, produced survival NOECs of 25%, 12.5%, and 6.25%, respectively.

The 1994 *H. azteca* growth results are somewhat misleading (Table 4-14) in that there may be interferences due to differences in the quantity of food available to survivors compared to control organisms. Feeding regimes were NOT adjusted during the exposure period as survival/mortality rates were not observed until the termination of exposure. Thus those scuds surviving exposure in the test sediments had more food per individual animal available to them compared to the control animals. This can lead to greater growth in the test organisms and poor comparability to controls (due to a lack of experimental control over feeding). It should also be noted that the concentration-response relationship (specifically for lethality-1994 data) in many of the results for the sediment samples was flat. The response was very similar within each exposure concentration such there was little change in the magnitude of the response as the concentration of test sediment increased (please refer to Appendix J).

In 1995, the toxicity results are much different (Table 4-14). Survival of the scuds was affected in 7 to 9 of the sediment samples tested but the magnitude of these effects was far below that observed in 1994.

Three of the survival results are ambiguous, EE09, EW01 and EW03. The concentration-to-response relationship observed in the results obtained from the test with EE09 was not monotonic in nature. This means that the relationship between exposure concentration and the magnitude of the response (lethality) was not functional. It is not normal for lower concentrations to be more effective in eliciting a response than higher concentrations. While it is not normal, it is not as rare as might be expected. Typically this type of occurrence is due to an interaction between the toxicant and the dilution media. Water hardness is a good example, in that testing for toxicity in very hard water can result in no response yet, if that water is diluted with very soft water, there can occur a response at diluted concentrations. This occurs as the level of hardness and the protection it provides may be diluted to a point

where there is still sufficient toxicant that the effect is manifested. While this example is an over-simplification for sediments it may be operative. Nevertheless, the effect at 100% of sample is unambiguous as there is no interference or interaction with the dilution sediment and, as such, there is a significant effect on the survival of the scuds exposed to the sediment sample EE09 (a 33.3% mortality rate, Table 4-14). In the case of the responses observed in the tests with EW01 and EW03 there was some control mortality that resulted in a loss of statistical power for calculation of the No-Observed-Effect-Concentration (NOEC, please see Appendix J). Thus while the responses appear to be significant, mortality rates of 43.3% and 40% respectively (Table 4-14), they are not statistically significant.

Statistically-significant reduction of *H. azteca* survival was observed due to exposure to 1995 sediment samples EE04, EE05, EE06, EE07, and EE08. Survival was reduced at all of the exposure concentrations of EE07. In contrast to the 1994 results where nine of the sediment samples produced such a magnitude of effect, EE07 was the only sample in 1995 to produce survival effects at all tested concentrations. Sediment samples EE01, EE04, and EE08 produced survival NOECs of 50% sample, while EE06 and EE05 produced survival NOECs of 25% and 6.25% respectively (Table 4-14). As with the data produced in 1994, growth results are somewhat misleading as feeding regimes were not constant during exposure. As such the growth results are to be evaluated cautiously. Only two samples show any statistically- significant effect on the growth of the scuds in 1995, EE07 and EW02.
Additionally, the results obtained from the tests performed in 1995 (as with those collected in 1994) exhibit fairly flat concentration-to-response curves (please refer to Appendix J), such that large differences in the exposure concentration do not necessarily show similar magnitude differences in the response, again specifically the lethal response.

In 1994, the reference stream employed was Crooked Oak Creek. Chronic exposure to sample 1 from Crooked Oak Creek produced a mortality rate of 23.3% in the scuds and sample 2, a mortality rate of 73.3% (Table 4-14). Sample 2 from Crooked Oak Creek also produced a significant effect on the scud growth over the exposure period, a NOEC was determined to be less than 6.25%. While this effect also showed a "flat" concentration response curve, it was statistically significant. Exposure to sediment collected from Crutcho Creek in 1995 produced no statistically-significant effects on the survival or the growth of

scuds exposed over the 28-day period. Relative to those of Soldier Creek, the sediments collected from Crutcho Creek were not toxic.

In summary, the bulk sediment toxicity results reveal that there exist potentially toxic sediments within Soldier Creek. The magnitude of this toxicity, however, is highly variable considered the two sampling events. Additionally, there may be interactions occurring with the dilution sediments (artificially reconstituted sediment following ASTM recipes). The silt controls used in chronic testing did not reproduce such that reproduction could be used as a test endpoint. The test results are unable to distinguish a contaminated-related reduction in reproduction from the physical (grain-size) effect. USEPA (MED-Duluth) also reports this effect. The upper reaches of East Soldier Creek (EE01 through EE03) *appear* to be less toxic than the lower reaches (EE08 through EE10) and the most toxic sediments *appear* to be from the mid-reach area of the Creek (EE04 through EE07). The change in toxicity from 1994 to 1995 is dramatic. There was a highly significant reduction in the level of toxicity expressed by the test organisms exposed to samples collected from the same location but at different times. This *suggests* that either there are factors strongly effecting the availability of toxicants within the sediments over time, hereto unknown, or that there exists a complexity due to variations in the relative chemical/toxicant mixture within the sediments that has caused this shift in toxicity. Additional rationalizations for this shift are certainly possible but the shift itself is unequivocal.

4.2.3.2 Surface-Water Toxicity

The acute toxicity test results for both surface water test species and both years are presented in Table 4-15. Chronic toxicity test results are presented in Table 4-16. Detailed reports of these results are located in Appendix J.

In 1994, three surface water samples elicited sufficient acute toxicity in *Ceriodaphnia dubia* to calculate LC_{50}s (EE01, EE02, and EE03). The calculated LC_{50} values are 45.6%, 11.1%, and 34.9%, respectively. Only four other surface water samples showed any effect in *C. dubia*; EE04, EE05, EE06 and EW01. None of the effects, ranging from 5% to 15% mortality rates, were found to be statistically-significant when compared to controls. The remaining surface water samples showed no acute toxicity to *C. dubia*.

In 1995, only one surface water sample elicited sufficient toxicity to calculate an acute LC_{50} (EE08), which produced a LC_{50} value of 24.8%. Two other samples produced statistically significant effects on survival of the *C. dubia* but with insufficient magnitude for the calculation of LC_{50} values, EE09 and EW01. Survival of the ceriodaphnids was 65% and 70% in these samples, respectively. The surface water sample collected from EW03 showed a 5% mortality rate which is not considered different from control. No other sample elicited any effect on survival of *C. dubia*.

The patterns of acute toxicity produced with surface water samples collected from Soldier Creek are different when considering 1994 and 1995 test results with ceriodaphnids. Samples EE01, EE02, and EE03 were highly-acutely toxic in 1994 but not acutely toxic in 1995. EE08 and EE09 were not acutely toxic in 1994, but were in 1995. Toxicity elicited by exposure to water collected from EW01 was slightly toxic in both years (considering acute lethality).

In neither year was there observed sufficient acute toxicity expressed by fathead minnows exposed to any of the surface water samples to calculate LC_{50} values. In 1994 only two samples showed any effect, both of which cannot be identified (statistically) as different from control (EE03 and EE09) with 10% and 5% mortality rates, respectively. In 1995, seven water samples showed some mortality with only one being statistically-significant (EE08) with a mortality rate of 25% (Table 4-15). Acute lethality in fathead minnows was not well established in samples collected from either year and as such, little elaboration of the results is possible.

Due to the acute lethality observed in the 1994 *C. dubia* tests of EE01, EE02 and EE03, these samples were tested at lower concentrations in hopes of providing a concentration-response that included a NOEC for reproduction in the chronic test. The concentrations selected, unfortunately, were too low to show any significant effects on survival of *C. dubia*, but both EE01 and EE03 results do show significantly-reduced reproduction when compared to the controls (Table 4-16). The No-Observed-Effect-Concentration (NOEC) for *C. dubia* exposed to EE01 surface water considering reproduction was less than 3.6%, the lowest test concentration employed. The results from the test with EE02, however, showed no significant effects on reproduction at the highest test concentration employed, 10%. Thus,

the reproduction NOEC for EE02 is 10%. The results of the chronic exposure to EE03 showed significant effects on reproduction at all of the test concentrations and produced NOEC of less than 1.4%. No other samples collected in 1994 were able to elicit a significant chronic effect on ceriodaphnid survival or reproduction.

Chronic ceriodaphnid test results obtained in 1995 (Table 4-16) reveal four surface water samples capable of affecting lower survival over a chronic exposure; EE05, EE08, EE09, and EW01. The NOECs for ceriodaphnid survival were 6.25%, 50%, 50%, and 25%, respectively (Table 4-16). Ten surface-water samples affected reproduction: EE01 through EE05; EE08 through EE10; EW01; and EW03. Reproduction was reduced at all test concentrations of samples EE02, EE03, EE04, and EE05. The NOEC therefore is less than the lowest concentration tested (6.25%). In one case, those results obtained with EW01, the NOEC for survival was lower than the NOEC for reproduction. This is due to the fact that the animals were able to reproduce before mortality was expressed. Thus, reproduction was not as adversely affected.

Chronic toxicity results with fathead minnows obtained in 1994 (Table 4-16) reveal only one surface water sample affecting survival, EE08. The NOEC for survival of fathead minnows exposed to surface water from EE08 was 50% (Table 4-16). Effects on the growth of fathead minnows were observed in nine of the surface water samples collected from Soldier Creek (EE01, EE03, EE04, EE05, EE08, EE10, EW01, EW02, EW03). In four cases, EE05, EE10, EW02, and EW03, the effect on growth was exhibited at all of the concentrations tested. The NOEC for these samples is then the lowest test concentration, 6.25% (Table 4-16). In 1995, there are significantly different results, especially regarding the effects on growth. Only three surface-water samples elicited any effect on the growth of fathead minnows (EE01, EE02, and EE08). Test results with EE01 and the minnows show a NOEC of 50% while all of the test concentrations of EE02 showed an effect on growth resulting in a NOEC of less than 6.25%. The growth NOEC produced in the EE08 surface water exposure was 25%.

Compared to the 1994 minnow results, samples EE03, EE04, EE05, EE10, EW01, EW02, and EW03 all "lost" their toxicity in 1995. Only EE01 and EE08 retained their ability to elicit an effect in fathead minnows, whereas EE02 was effective only in 1995.

Crutcho Creek, the reference stream in 1995, had no significant toxicological effects in either species when compared to the laboratory control.

In summary, the surface-water toxicity tests results reveal that potential toxic surface waters exist within Soldier Creek. The pattern of surface water toxicity, represented by the results with ceriodaphnids and fathead minnows is not quite in keeping with the pattern suggested by the bulk sediment results (Section 4.2.3.1). There is a shift in the magnitude of toxicity within the surface water samples collected during 1994 compared to those collected in 1995 but the shift is towards a greater magnitude in 1995 compared to 1994 considering ceriodaphnids and a decrease in magnitude considering fathead minnows. Only water samples from the upper reaches (EE01 through EE03) of East Soldier Creek effected reproduction and survival of ceriodaphnids in 1994, while in 1995 survival and/or reproductive effects were identified in all but EE06 and EE07 in East Soldier Creek (Table 4-16). The magnitude of the effects within the upper reach surface water *appears* to be reduced in 1995 compared to 1994, but overall there *appears* to be no consistent pattern in the distribution of toxic surface water within Soldier Creek.

TABLE 4-1

INGESTION-PATHWAY EXPOSURE ASSUMPTIONS FOR SELECTED ECOLOGICAL RECEPTORS IN SOLDIER CREEK SEDIMENT AND SURFACE-WATER OPERABLE UNIT, OKLAHOMA

Receptor	Area Use Factor (%)[a]	Body Weight (kg)	Food Ingestion Rate (kg/day)	Water Ingestion Rate (l/day)	Sediment Ingestion Rate (kg/day)
Green Heron (*Butorides virescens*)	50[b]	0.158[c]	0.028[d]	0.017[e]	0.001[f]
Red-Winged Blackbird (*Agelaius phoeniceus*)	100[g]	0.050[h]	0.010[i]	0.008[e]	0[j]
Muskrat (*Ondatra zibethicus*)	100[k]	0.730[l]	0.070[m]	0.075[n]	0.002[o]
Raccoon (*Procyon lotor*)	18[p]	4.2[l]	0.223[q]	0.360[n]	0.020[r]

a Percent of diet obtained from the Operable Unit.
b Although probably territorial when present, this migratory species is assumed to be present only during warmer months (see text).
c Terres (1991).
d Estimated from allometric relationship graph developed by Kushlan (1978) specifically for wading birds (database includes green heron).
e Estimated from allometric relationship, $WI = 0.059Wt^{0.67}$ (Equation 3-15 in USEPA 1993b).
f 5% of diet; in absence of empirical measurements for the species or credible surrogate, based on professional judgement.
g Reported home range (0.2 acres; Nero 1956) is much smaller than area of available habitat in Operable Unit.
h Dunning (1993).
i Estimated from allometric relationship, $FI = 0.0582Wt^{0.651}$ (Equation 3-3 in USEPA 1993b).
j Based on feeding behavior, no sediment is assumed to be ingested (see text).
k Reported home range (a few square meters; USEPA 1993b) is much smaller than area of available habitat in Operable Unit.
l Smallest reported adult body weight (USEPA 1993b).
m Estimated from allometric relationship for herbivorous mammals, $FI = 0.577Wt^{0.727}$ (Equation 3-9 in USEPA 1993b).
n Estimated from allometric relationship for mammals, $WI = 0.099Wt^{0.90}$ (Equation 3-17 in USEPA 1993b).
o 3% of diet; in absence of empirical measurements for the species or credible surrogate, based on professional judgement.
p Study area (18 acres) divided by lower extreme of reported homes ranges (99 acres; Kaufman 1982).
q Estimated from allometric relationship, $FI = 0.0687Wt^{0.822}$ (Equation 3-7 in USEPA 1993b).
r 9% of diet; based on data from Beyer *et al.* (1994).

TABLE 4-2

ASSUMED DIETARY COMPOSITION OF SELECTED ECOLOGICAL RECEPTORS IN SOLDIER CREEK SEDIMENT AND SURFACE-WATER OPERABLE UNIT, OKLAHOMA

Receptor	Estimated Percentage of Diet by Weight[a]							
	Plants[b]	Crayfish	Other Aquatic Invertebrates	Fish	Terrestrial Invertebrates (mainly insects)[c]	Amphibians and Reptiles	Birds	Mammals
Green Heron (*Butorides virescens*)[d]		25	10	25	20	15		5
Red-Winged Blackbird (*Agelaius phoeniceus*)[e]	70				30			
Muskrat (*Ondatra zibethicus*)[f]	93	3				2	1	1
Raccoon (*Procyon lotor*)[g]	38	30		5	15	5	5	2

a Please refer to Subsection 4.1.1.1 of the text for a summary of the composition of the respective dietary component categories.
b It is conservatively assumed that all plant material consumed derives from vegetation growing with its roots in Soldier Creek sediments.
c Terrestrial invertebrates are conservatively assumed to consist entirely of animals (mainly emergent adult insects) that have bioaccumulated COECs from sediment pore water.
d Based on Kushlan (1978), DeGraaf and Rudis (1986), Terres (1991), and professional judgement (see text).
e Based on Martin *et al.* (1951) and Terres (1991).
f Based on data summarized in USEPA (1993b).
g Based on data summarized in USEPA (1993b) and professional judgement.

TABLE 4-3
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN WATER COLUMN USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE01		EE02		EE03		EE04		EE05		EE06	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (ug/L)												
Acetone	10.00	15.00	7.00	9.00	12.00	19.00	5.00	5.00	5.00	5.00	6.05	7.10
Carbon Disulfide	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Toluene	2.50	2.50	13.75	25.00	1.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Methylene Chloride	1.90	2.50	1.85	2.50	4.40	7.40	4.20	7.00	2.50	2.50	2.50	2.50
Total Xylenes	2.50	2.50	13.75	25.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Chlorobenzene	2.50	2.50	13.75	25.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
1,4-Dichlorobenzene	3.50	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Chlorinated Aromatic Hydrocarbons[1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4-Dimethylphenol	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Pentachlorophenol	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Phenol & Substituted Phenols	5.00	5.00	3.30	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Nonyl Phenols[1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phthalates	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Total PCBs	0.75	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Aldrin	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
alpha-Chlordane	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Dieldrin	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.05	0.05
Heptachlor	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Heptachlor epoxide	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
alpha & delta BHC	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Endosulfan Sulfate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Methoxychlor	0.14	0.25	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Benzidine	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Phosphine sulfide, triphenyl[1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Low MW PAHs	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	6.10	7.20	5.00	5.00
Middle MW PAHs	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	7.65	9.20	5.00	5.00
High MW PAHs	10.00	15.00	12.50	15.00	12.50	15.00	12.50	15.00	13.85	15.00	15.00	15.00

[1] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not iden

Values of 0.00 in the table indicate the constituent was not detected at that location.

TABLE 4-3
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN WATER COLUMN USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE07		EE08		EE09		EE10		EW01		EW02		EW03	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (ug/L)														
Acetone	7.55	7.70	7.85	11.00	8.50	12.00	5.00	5.00	5.00	5.00	5.00	5.00	4.65	5.00
Carbon Disulfide	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Toluene	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.40	2.50	2.50	2.50	2.50	2.50
Methylene Chloride	4.55	6.60	4.85	7.20	3.25	4.00	2.30	2.50	4.60	6.70	4.00	6.40	4.25	6.00
Total Xylenes	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Chlorobenzene	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
1,4-Dichlorobenzene	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Chlorinated Aromatic Hydrocarbons[1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2,4-Dimethylphenol	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Pentachlorophenol	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Phenol & Substituted Phenols	5.00	5.00	6.95	8.90	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Nonyl Phenols[1]	0.00	0.00	2.70	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phthalates	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	3.45	5.00	5.00	5.00	31.50	58.00
Total PCBs	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Aldrin	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
alpha-Chlordane	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Dieldrin	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.05	0.05
Heptachlor	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Heptachlor epoxide	0.03	0.03	0.08	0.14	0.06	0.10	0.04	0.06	0.03	0.03	0.03	0.03	0.03	0.03
alpha & delta BHC	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Endosulfan Sulfate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Methoxychlor	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Benzidine	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Phosphine sulfide, triphenyl[1]	0.00	0.00	13.60	18.00	12.00	17.00	9.30	12.00	0.00	0.00	0.00	0.00	0.00	0.00
Low MW PAHs	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Middle MW PAHs	5.00	5.00	5.00	5.00	5.00	5.00	7.55	10.10	5.95	6.90	5.00	5.00	34.00	63.00
High MW PAHs	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

[1] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not identified.

Values of 0.00 in the table indicate the constituent was not detected at that location.

TABLE 4-4
EXPOSURE POINT CONCENTRATIONS OF INORGANIC COECs IN WATER COLUMN USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE01		EE02		EE03		EE04		EE05		EE06	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
INORGANICS (ug/L)												
Aluminum	80.0	110.0	50.0	50.0	50.0	50.0	50.0	50.0	335.0	570.0	102.0	120.0
Antimony	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Arsenic	2.5	2.5	2.4	3.7	3.7	5.0	3.8	5.0	5.0	5.0	3.8	5.0
Barium	415.0	440.0	535.0	650.0	485.0	500.0	435.0	470.0	405.0	450.0	375.0	450.0
Cadmium	1.4	2.5	1.7	2.5	1.7	2.5	0.3	0.4	8.3	9.8	0.9	1.1
Chromium	5.0	5.0	10.3	12.0	6.8	8.6	5.7	6.3	13.5	22.0	5.0	5.0
Cobalt	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Copper	7.0	9.2	140.0	150.0	61.5	70.0	35.0	38.0	15.0	20.0	36.5	49.0
Cyanide	2.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Iron	125.0	200.0	155.0	200.0	78.5	85.0	68.5	87.0	340.0	570.0	140.0	180.0
Lead	1.9	2.7	13.0	24.0	2.2	3.5	1.5	2.0	3.7	6.8	16.4	30.0
Manganese	10.3	16.0	9.8	11.0	8.3	9.2	7.7	9.7	26.5	29.0	32.5	54.0
Mercury	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Molybdenum	14.0	18.0	472.0	850.0	215.0	250.0	103.0	170.0	10.0	10.0	73.0	110.0
Nickel	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Selenium	2.5	2.5	2.8	3.0	2.5	2.5	2.5	2.5	2.5	2.5	3.8	5.0
Silver	0.06	0.07	0.06	0.06	0.12	0.18	0.05	0.05	0.15	0.25	0.05	0.05
Vanadium	11.9	14.0	22.5	31.0	17.0	18.0	14.0	16.0	10.8	13.0	13.0	14.0
Zinc	17.0	20.0	63.5	85.0	25.0	26.0	24.5	26.0	40.0	41.0	25.0	25.0

TABLE 4-4
EXPOSURE POINT CONCENTRATIONS OF INORGANIC COECs IN WATER COLUMN USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE07		EE08		EE09		EE10		EW01		EW02		EW03	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
INORGANICS (ug/L)														
Aluminum	115.0	130.0	72.5	85.0	74.5	93.0	74.0	80.0	105.0	160.0	146.0	220.0	125.0	140.0
Antimony	30.0	30.0	30.0	30.0	37.5	45.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Arsenic	1.4	1.7	2.5	2.5	2.5	2.5	116.3	230.0	2.1	2.5	2.1	2.5	2.2	2.5
Barium	350.0	470.0	340.0	410.0	345.0	420.0	330.0	390.0	230.0	240.0	250.0	330.0	260.0	340.0
Cadmium	1.0	1.2	0.9	1.0	0.9	1.0	0.9	1.1	0.3	0.4	1.4	2.4	0.7	1.0
Chromium	5.6	6.1	31.5	42.0	22.5	33.0	13.5	16.0	5.0	5.0	5.8	6.6	5.0	5.0
Cobalt	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Copper	32.0	42.0	16.0	22.0	16.0	20.0	15.0	16.0	5.2	6.5	7.9	12.0	8.3	13.0
Cyanide	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Iron	160.0	170.0	190.0	210.0	180.0	190.0	180.0	220.0	970.0	1700.0	200.0	310.0	205.0	300.0
Lead	3.1	3.2	2.2	2.3	4.9	7.6	2.3	2.3	2.1	2.2	12.9	25.0	1.5	2.0
Manganese	30.0	47.0	135.0	150.0	125.0	140.0	140.0	180.0	268.5	500.0	61.5	76.0	77.5	100.0
Mercury	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Molybdenum	109.0	130.0	42.5	72.0	34.0	58.0	33.0	56.0	25.0	32.0	15.0	20.0	13.5	17.0
Nickel	14.8	20.0	15.0	20.0	17.0	20.0	20.0	20.0	69.0	99.0	16.5	20.0	16.0	20.0
Selenium	2.5	2.5	2.8	3.1	3.8	5.0	23.8	44.0	2.5	2.5	4.0	5.0	2.8	3.1
Silver	0.05	0.05	0.12	0.19	0.10	0.14	0.05	0.05	0.09	0.12	0.09	0.13	0.05	0.05
Vanadium	12.4	16.0	8.0	11.0	6.7	8.3	8.1	9.2	5.9	6.7	5.0	5.0	4.6	5.0
Zinc	28.5	29.0	22.5	25.0	23.0	24.0	24.0	26.0	26.5	28.0	15.0	16.0	16.5	20.0

TABLE 4-5
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN SEDIMENT USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE01		EE02		EE03		EE04		EE05		EE06	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (mg/kg wet wt)												
Acetone	0.005	0.006	0.003	0.005	0.004	0.005	0.014	0.022	0.006	0.009	0.036	0.044
Carbon Disulfide	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
Toluene	0.003	0.003	0.003	0.003	0.003	0.003	0.010	0.017	0.002	0.002	0.002	0.002
Methylene Chloride	0.004	0.006	0.003	0.004	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.005
Total Xylenes	0.003	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
Chlorobenzene	0.003	0.003	0.002	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.075	0.106
1,4-Dichlorobenzene	0.515	0.830	1.172	1.672	0.502	0.672	0.165	0.166	1.227	1.634	0.501	0.836
Chlorinated Aromatic Hydrocarbons[1]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	22.982	43.086	0.000	0.000
2,4-Dimethylphenol	0.515	0.830	1.172	1.672	0.502	0.672	0.165	0.166	1.227	1.634	0.501	0.836
Pentachlorophenol	2.513	4.026	5.586	7.980	2.392	3.192	0.794	0.800	6.035	8.170	2.380	3.960
Phenol & Substituted Phenols	0.915	1.000	1.172	1.672	0.502	0.672	0.165	0.166	1.227	1.634	0.501	0.836
Nonyl Phenols[1]	0.915	1.000	0.336	0.672	0.502	0.672	0.083	0.166	0.000	0.000	0.000	0.000
Phthalates	0.916	1.162	0.537	0.562	1.011	1.720	0.419	0.464	2.927	4.134	2.816	5.280
Total PCBs	5.815	10.790	24.237	26.737	0.582	0.813	0.531	0.540	32.720	32.760	0.727	0.920
Aldrin	0.046	0.087	0.084	0.084	0.005	0.009	0.004	0.004	0.859	0.860	0.021	0.021
alpha-Chlordane	0.046	0.087	0.084	0.084	0.005	0.009	0.004	0.004	4.096	7.332	0.004	0.004
Dieldrin	0.088	0.166	0.166	0.167	0.010	0.017	0.008	0.008	16.280	17.940	0.008	0.008
Heptachlor	0.046	0.087	0.084	0.084	0.005	0.009	0.004	0.004	2.964	3.354	0.021	0.037
Heptachlor epoxide	0.046	0.087	0.084	0.084	0.005	0.009	0.004	0.004	0.859	0.860	0.004	0.004
alpha & delta BHC	0.046	0.087	0.084	0.084	0.005	0.009	0.006	0.008	0.859	0.860	0.004	0.004
Endosulfan Sulfate	0.088	0.166	0.166	0.167	0.011	0.017	0.008	0.008	2.126	2.614	0.008	0.008
Methoxychlor	0.461	0.872	0.838	0.840	0.051	0.086	0.043	0.044	8.590	8.600	0.042	0.042
Benzidine	3.888	6.225	6.404	12.540	3.767	5.040	1.243	1.245	9.355	12.470	3.703	6.160
Phosphine sulfide, triphenyl[1]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Low MW PAHs	2.793	5.329	20.523	35.644	20.282	34.558	5.711	9.364	16.150	19.875	2.375	4.356
Middle MW PAHs	8.962	15.023	43.302	76.608	25.679	39.404	10.305	17.008	22.458	31.734	3.537	5.852
High MW PAHs	12.868	22.817	92.352	163.704	31.242	44.780	16.517	26.792	27.483	36.051	4.123	6.895

[1] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not identified.
Values of 0.000 in the table indicate the constituent was not detected at that location.

TABLE 4-5
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN SEDIMENT USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE07		EE08		EE09		EE10		EW01		EW02		EW03	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (mg/kg wet wt)														
Acetone	0.010	0.015	0.010	0.012	0.009	0.012	0.005	0.005	0.037	0.055	0.004	0.006	0.005	0.005
Carbon Disulfide	0.003	0.003	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.004	0.005	0.003	0.003
Toluene	0.003	0.003	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.003	0.003	0.003	0.003	0.003
Methylene Chloride	0.003	0.003	0.002	0.003	0.004	0.005	0.005	0.007	0.002	0.003	0.003	0.003	0.002	0.003
Total Xylenes	0.003	0.003	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Chlorobenzene	0.005	0.007	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1,4-Dichlorobenzene	0.166	0.167	0.162	0.166	0.165	0.166	0.164	0.164	0.334	0.336	0.165	0.165	0.166	0.167
Chlorinated Aromatic Hydrocarbons[1]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2,4-Dimethylphenol	0.166	0.167	1.699	3.071	0.165	0.168	0.164	0.164	0.334	0.336	0.165	0.165	0.166	0.167
Pentachlorophenol	0.803	0.817	1.216	1.622	0.815	0.820	0.789	0.798	1.598	1.600	0.783	0.788	0.806	0.820
Phenol & Substituted Phenols	0.404	0.643	2.608	4.678	4.343	8.055	1.038	1.576	0.334	0.336	0.165	0.165	0.166	0.167
Nonyl Phenols[1]	0.391	0.781	9.114	14.421	5.838	10.692	0.989	1.466	0.000	0.000	0.000	0.000	0.000	0.000
Phthalates	0.744	1.420	0.442	0.470	0.543	0.972	0.740	1.170	3.500	5.880	0.294	0.458	0.194	0.273
Total PCBs	0.168	0.261	0.114	0.195	0.153	0.260	0.265	0.345	9.336	14.259	0.684	0.900	0.445	0.497
Aldrin	0.005	0.009	0.016	0.028	0.004	0.008	0.002	0.002	0.052	0.086	0.006	0.009	0.004	0.004
alpha-Chlordane	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.052	0.086	0.006	0.009	0.004	0.004
Dieldrin	0.002	0.003	0.017	0.033	0.002	0.003	0.003	0.003	0.100	0.166	0.012	0.017	0.008	0.008
Heptachlor	0.006	0.012	0.021	0.042	0.003	0.003	0.026	0.036	0.052	0.086	0.006	0.009	0.004	0.004
Heptachlor epoxide	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.052	0.086	0.006	0.009	0.004	0.004
alpha & delta BHC	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.052	0.086	0.006	0.009	0.004	0.004
Endosulfan Sulfate	0.002	0.003	0.002	0.002	0.002	0.003	0.003	0.003	0.100	0.166	0.012	0.017	0.008	0.008
Methoxychlor	0.013	0.017	0.009	0.009	0.013	0.017	0.017	0.017	0.517	0.861	0.064	0.086	0.042	0.043
Benzidine	1.244	1.245	2.495	2.519	1.263	1.271	1.254	1.260	2.520	2.520	1.234	1.238	1.274	1.276
Phosphine sulfide, triphenyl[1]	0.000	0.000	0.746	0.828	1.095	2.025	0.429	0.858	0.000	0.000	0.000	0.000	0.000	0.000
Low MW PAHs	0.772	1.379	0.531	0.627	0.307	0.392	0.203	0.242	0.763	1.072	0.425	0.540	1.182	2.200
Middle MW PAHs	1.275	2.343	1.304	1.587	0.613	1.029	0.694	1.186	2.720	3.360	1.099	1.410	1.503	2.842
High MW PAHs	1.426	2.266	1.527	1.597	0.920	1.057	0.812	0.920	4.291	4.872	1.395	1.455	1.132	2.100

[1] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not identified.
Values of 0.000 in the table indicate the constituent was not detected at that location.

TABLE 4-6
EXPOSURE POINT CONCENTRATIONS OF INORGANIC COECs IN SEDIMENT USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE01		EE02		EE03		EE04		EE05		EE06		EE07	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
INORGANICS (mg/kg wet wt)														
Aluminum	3626.05	4040.00	963.94	1132.40	1201.70	1276.80	1533.25	1618.50	23795.90	43524.00	6688.50	6909.00	781.35	1214.10
Antimony	4.86	6.02	10.48	14.91	4.49	5.96	2.99	3.00	3.85	5.69	3.01	3.01	3.02	3.03
Arsenic	1.58	2.00	3.77	6.61	1.10	1.26	1.10	1.33	2.56	3.01	2.45	2.68	0.48	0.68
Barium	197.35	201.69	838.30	1109.60	1066.28	1978.00	205.22	222.44	557.37	593.58	353.96	412.28	77.76	126.38
Cadmium	1.72	1.74	0.88	1.26	3.39	4.62	2.69	2.88	124.63	160.68	45.10	69.52	4.04	5.75
Chromium	12.07	16.50	42.60	64.37	25.58	25.70	58.51	86.40	537.64	584.22	345.05	563.20	52.20	89.46
Cobalt	2.75	4.50	2.68	2.89	1.32	1.63	1.75	1.84	6.45	6.63	7.36	8.80	3.34	5.61
Copper	144.32	284.00	160.89	252.32	17.60	24.02	26.60	29.12	957.07	1872.00	183.97	194.58	18.28	31.67
Cyanide	0.13	0.25	0.25	0.25	0.25	0.25	0.25	0.25	2.85	4.84	0.25	0.26	0.25	0.25
Iron	5116.25	5602.50	4570.80	6132.00	3539.40	3570.00	2965.25	3610.50	7099.50	7878.00	9503.00	10076.00	1840.40	2776.10
Lead	19.86	25.20	15.07	17.71	12.04	21.59	112.48	196.00	94.79	106.08	72.10	91.08	7.31	10.79
Manganese	400.30	408.00	125.11	180.60	275.44	413.28	101.73	124.50	706.53	737.10	155.36	178.64	87.08	133.48
Mercury	0.11	0.17	0.41	0.71	0.12	0.15	0.05	0.05	0.27	0.39	0.22	0.23	0.05	0.05
Molybdenum	1.62	1.99	3.85	4.96	1.21	1.43	2.02	3.04	0.88	0.99	5.52	6.29	1.00	1.00
Nickel	6.86	8.00	47.93	48.22	13.81	17.37	21.81	25.15	200.47	258.18	135.03	228.80	19.94	36.64
Selenium	0.87	1.25	0.63	1.01	0.51	0.52	0.37	0.50	0.25	0.25	0.34	0.48	0.38	0.50
Silver	6.35	11.70	1.73	2.48	0.76	1.01	0.49	0.50	8.97	9.59	6.36	10.65	0.85	1.21
Vanadium	13.11	14.53	4.85	6.08	5.91	5.96	7.99	10.29	15.63	19.73	23.23	24.33	4.47	6.04
Zinc	78.10	91.80	144.20	148.96	182.07	292.40	65.08	74.96	262.25	378.30	186.85	195.05	31.28	47.78

TABLE 4-6
EXPOSURE POINT CONCENTRATIONS OF INORGANIC COECs IN SEDIMENT USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE08		EE09		EE10		EW01		EW02		EW03	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
INORGANICS (mg/kg wet wt)												
Aluminum	1819.05	1968.30	2264.60	3094.20	3104.70	3502.80	6034.00	7812.00	2107.15	2992.50	2024.60	2983.20
Antimony	3.00	3.00	3.00	3.00	3.01	3.02	3.00	3.00	3.00	3.00	2.99	2.99
Arsenic	1.23	1.30	0.66	0.89	2.02	2.18	1.46	1.72	1.49	1.50	2.91	5.10
Barium	123.23	133.86	902.17	1566.20	712.20	1193.40	206.76	317.52	333.22	380.25	421.14	1344.80
Cadmium	13.58	18.47	22.33	22.80	11.13	20.67	15.84	27.85	2.95	3.20	1.05	1.85
Chromium	88.59	146.61	186.95	238.62	109.25	202.80	158.21	272.58	54.10	70.73	29.49	33.29
Cobalt	3.42	3.52	3.95	4.10	3.95	4.45	35.86	56.28	3.35	3.75	4.27	6.07
Copper	8.35	11.18	20.05	27.63	16.57	27.92	192.67	313.74	8.78	12.98	4.37	7.83
Cyanide	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Iron	4375.35	4900.50	7442.15	9676.00	8502.60	10218.00	11495.00	15582.00	5094.80	5655.00	8977.70	13552.00
Lead	13.22	17.82	56.69	63.96	16.28	23.40	73.37	119.70	34.70	51.45	10.82	15.49
Manganese	453.66	614.10	600.09	975.80	582.12	873.60	132.63	169.26	288.56	346.86	572.08	665.28
Mercury	0.06	0.08	0.05	0.05	0.09	0.13	0.23	0.40	0.05	0.05	0.05	0.05
Molybdenum	0.85	1.01	1.55	2.11	1.01	1.01	23.05	40.74	2.02	2.40	0.62	0.98
Nickel	21.02	32.32	65.66	107.42	41.70	75.43	1002.10	1751.40	51.68	78.75	12.55	20.59
Selenium	0.50	0.52	0.37	0.49	0.17	0.23	0.53	0.80	0.26	0.26	0.37	0.49
Silver	0.83	1.13	4.49	5.82	2.51	4.52	8.32	15.12	2.70	4.43	0.77	1.06
Vanadium	8.81	9.88	11.45	12.07	12.27	13.78	25.33	37.55	11.05	11.78	16.88	23.58
Zinc	22.12	31.27	50.67	54.12	46.34	47.29	390.60	579.60	65.02	91.50	20.51	20.59

TABLE 4-7
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN SEDIMENT PORE WATER USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE01				EE02				EE03			
	NOAEL		LOAEL		NOAEL		LOAEL		NOAEL		LOAEL	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (ug/L)												
Acetone	15.1	15.1	15.1	15.1	8.7	13.1	8.7	13.1	14.9	17.5	14.9	17.5
Carbon Disulfide	0.8	0.8	0.8	0.8	0.5	0.7	0.5	0.7	0.9	0.9	0.9	0.9
Toluene	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Methylene Chloride	1.6	2.1	1.6	2.1	1.3	1.7	1.3	1.7	1.3	1.3	1.3	1.3
Total Xylenes	2.1	2.1	2.1	2.1	1.8	1.9	1.8	1.9	2.3	2.3	2.3	2.3
Chlorobenzene	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
1,4-Dichlorobenzene	12.3	20.5	12.3	20.5	26.6	39.0	26.6	39.0	14.0	19.0	14.0	19.0
Chlorinated Aromatic Hydrocarbons[2]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2,4-Dimethylphenol	33.1	55.2	33.1	55.2	71.6	105.0	71.6	105.0	37.8	51.0	37.8	51.0
Pentachlorophenol	9.3	15.4	9.3	15.4	19.6	28.8	19.6	28.8	10.4	13.9	10.4	13.9
Phenol & Substituted Phenols	0.6	0.6	0.6	0.6	0.8	1.2	0.8	1.2	0.4	0.6	0.4	0.6
Nonyl Phenols[2]	2.4	2.4	2.4	2.4	0.8	1.6	0.8	1.6	1.6	2.2	1.6	2.2
Phthalates[1]	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Total PCBs[1]	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	0.7	1.0	0.7	1.0
Aldrin	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.022	0.036	0.022	0.036
alpha-Chlordane[1]	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.012	0.020	0.012	0.020
Dieldrin[1]	4.9	9.4	4.9	9.4	8.4	8.9	8.4	8.9	0.6	1.1	0.6	1.1
Heptachlor[1]	0.3	0.6	0.3	0.6	0.5	0.5	0.5	0.5	0.0	0.1	0.0	0.1
Heptachlor epoxide	0.3	0.6	0.3	0.6	0.5	0.5	0.5	0.5	0.039	0.1	0.039	0.1
alpha & delta BHC	0.9	1.7	0.9	1.7	1.5	1.5	1.5	1.5	0.1	0.2	0.1	0.2
Endosulfan Sulfate[1]	1.7	3.3	1.7	3.3	2.9	3.1	2.9	3.1	0.2	0.4	0.2	0.4
Methoxychlor[1]	1.3	2.4	1.3	2.4	2.1	2.2	2.1	2.2	0.2	0.3	0.2	0.3
Benzidine	1280.5	2122.4	1280.5	2122.4	2058.3	4038.2	2058.3	4038.2	1455.4	1962.4	1455.4	1962.4
Phosphine sulfide, triphenyl	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Low MW PAHs	21.6	41.6	21.6	41.6	149.5	263.0	149.5	263.0	180.3	308.2	180.3	308.2
Medium MW PAHs[1]	27.1	46.7	27.1	46.7	125.8	225.0	125.8	225.0	90.7	139.9	90.7	139.9
High MW PAHs[1]	14.9	27.0	14.9	27.0	62.0	62.0	62.0	62.0	41.9	60.5	41.9	60.5

[1] Pore water concentrations were adjusted not to exceed solubility of the constituent.

[2] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not identified.
Values of 0.000 in the table indicate the constituent was not detected at that location.

DG - Data Gap: the pore water concentration cannot be calculated in the absence of a K_{ow} for the constituent.

TABLE 4-7
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN SEDIMENT PORE WATER USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE04				EE05				EE06			
	NOAEL		LOAEL		NOAEL		LOAEL		NOAEL		LOAEL	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (ug/L)												
Acetone	98.8	161.7	98.8	161.7	84.2	113.8	84.2	113.8	164.2	205.3	164.2	205.3
Carbon Disulfide	2.0	2.0	2.0	2.0	3.7	3.9	3.7	3.9	1.2	1.2	1.2	1.2
Toluene	1.5	2.6	1.5	2.6	0.6	0.8	0.6	0.8	0.2	0.2	0.2	0.2
Methylene Chloride	2.3	2.7	2.3	2.7	5.6	5.7	5.6	5.7	2.3	3.0	2.3	3.0
Total Xylenes	4.9	5.0	4.9	5.0	9.3	9.8	9.3	9.8	3.0	3.0	3.0	3.0
Chlorobenzene	0.4	0.4	0.4	0.4	0.7	0.7	0.7	0.7	6.8	9.8	6.8	9.8
1,4-Dichlorobenzene	9.9	10.0	9.9	10.0	136.4	175.7	136.4	175.7	18.8	31.7	18.8	31.7
Chlorinated Aromatic Hydrocarbons[2]	0.000	0.000	0.000	0.000	96.762	180.249	96.762	180.249	0.000	0.000	0.000	0.000
2,4-Dimethylphenol	26.5	26.9	26.5	26.9	367.1	472.9	367.1	472.9	50.6	85.3	50.6	85.3
Pentachlorophenol	7.4	7.5	7.4	7.5	103.8	136.1	103.8	136.1	13.8	23.3	13.8	23.3
Phenol & Substituted Phenols	0.3	0.3	0.3	0.3	4.2	5.4	4.2	5.4	0.6	1.0	0.6	1.0
Nonyl Phenols[2]	0.6	1.1	0.6	1.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Phthalates[1]	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Total PCBs[1]	1.4	1.5	1.4	1.5	5.7	5.7	5.7	5.7	1.2	1.6	1.2	1.6
Aldrin	0.039	0.041	0.039	0.041	14.7	15.4	14.7	15.4	0.1	0.1	0.1	0.1
alpha-Chlordane[1]	0.022	0.023	0.022	0.023	40.9	56.0	40.9	56.0	0.013	0.013	0.013	0.013
Dieldrin[1]	1.1	1.2	1.1	1.2	186.0	186.0	186.0	186.0	0.7	0.7	0.7	0.7
Heptachlor[1]	0.1	0.1	0.1	0.1	56.0	56.0	56.0	56.0	0.2	0.4	0.2	0.4
Heptachlor epoxide	0.1	0.1	0.1	0.1	26.7	28.0	26.7	28.0	0.043	0.044	0.043	0.044
alpha & delta BHC	0.3	0.4	0.3	0.4	77.1	80.8	77.1	80.8	0.1	0.1	0.1	0.1
Endosulfan Sulfate[1]	0.4	0.4	0.4	0.4	188.8	220.0	188.8	220.0	0.2	0.3	0.2	0.3
Methoxychlor[1]	0.3	0.3	0.3	0.3	100.0	100.0	100.0	100.0	0.2	0.2	0.2	0.2
Benzidine	1024.8	1041.6	1024.8	1041.6	14361.1	18509.8	14361.1	18509.8	1917.6	3224.8	1917.6	3224.8
Phosphine sulfide, triphenyl	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Low MW PAHs	109.2	180.2	109.2	180.2	570.8	675.8	570.8	675.8	28.3	52.2	28.3	52.2
Medium MW PAHs[1]	78.4	130.3	78.4	130.3	260.0	260.0	260.0	260.0	16.7	27.9	16.7	27.9
High MW PAHs[1]	47.8	78.0	47.8	78.0	62.0	62.0	62.0	62.0	7.4	12.5	7.4	12.5

[1] Pore water concentrations were adjusted not to exceed solubility of the constituent.

[2] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not identified.

Values of 0.000 in the table indicate the constituent was not detected at that location.

DG - Data Gap: the pore water concentration cannot be calculated in the absence of a K_{ow} for the constituent.

TABLE 4-7
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN SEDIMENT PORE WATER USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EE07				EE08				EE09				EE10			
	NOAEL		LOAEL		NOAEL		LOAEL		NOAEL		LOAEL		NOAEL		LOAEL	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (ug/L)																
Acetone	165.1	256.8	165.1	256.8	158.2	203.4	158.2	203.4	23.3	33.3	23.3	33.3	13.9	14.4	13.9	14.4
Carbon Disulfide	4.3	4.7	4.3	4.7	4.1	4.4	4.1	4.4	0.7	0.7	0.7	0.7	0.6	0.8	0.6	0.8
Toluene	0.9	0.9	0.9	0.9	0.5	0.7	0.5	0.7	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2
Methylene Chloride	6.0	7.4	6.0	7.4	5.4	8.2	5.4	8.2	1.6	2.2	1.6	2.2	1.9	2.8	1.9	2.8
Total Xylenes	10.9	11.7	10.9	11.7	10.2	11.1	10.2	11.1	1.8	1.9	1.8	1.9	1.9	1.9	1.9	1.9
Chlorobenzene	1.5	2.2	1.5	2.2	0.8	0.8	0.8	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1,4-Dichlorobenzene	21.6	23.4	21.6	23.4	20.0	22.0	20.0	22.0	3.7	3.7	3.7	3.7	3.7	3.8	3.7	3.8
Chlorinated Aromatic Hydrocarbons[2]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2,4-Dimethylphenol	58.2	62.9	58.2	62.9	600.0	1099.9	600.0	1099.9	9.8	9.9	9.8	9.9	9.8	10.2	9.8	10.2
Pentachlorophenol	16.2	17.7	16.2	17.7	23.8	33.4	23.8	33.4	2.8	2.8	2.8	2.8	2.7	2.8	2.7	2.8
Phenol & Substituted Phenols	1.7	2.8	1.7	2.8	10.6	19.2	10.6	19.2	3.0	5.5	3.0	5.5	0.7	1.1	0.7	1.1
Nonyl Phenols[2]	6.3	12.6	6.3	12.6	21.0	21.0	21.0	21.0	14.9	21.0	14.9	21.0	2.6	3.9	2.6	3.9
Phthalates[1]	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Total PCBs[1]	1.0	1.6	1.0	1.6	0.6	1.0	0.6	1.0	0.2	0.3	0.2	0.3	0.3	0.4	0.3	0.4
Aldrin	0.1	0.2	0.1	0.2	0.3	0.5	0.3	0.5	0.015	0.027	0.015	0.027	0.006	0.006	0.006	0.006
alpha-Chlordane[1]	0.015	0.020	0.015	0.020	0.009	0.010	0.009	0.010	0.002	0.003	0.002	0.003	0.003	0.003	0.003	0.003
Dieldrin[1]	0.8	1.1	0.8	1.1	5.3	10.1	5.3	10.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Heptachlor[1]	0.2	0.5	0.2	0.5	0.7	1.3	0.7	1.3	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2
Heptachlor epoxide	0.047	0.1	0.047	0.1	0.029	0.032	0.029	0.032	0.008	0.010	0.008	0.010	0.011	0.011	0.011	0.011
alpha & delta BHC	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Endosulfan Sulfate[1]	0.3	0.4	0.3	0.4	0.2	0.2	0.2	0.2	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1
Methoxychlor[1]	0.2	0.3	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzidine	2229.6	2401.1	2229.6	2401.1	4246.5	4626.8	4246.5	4626.8	385.7	385.7	385.7	385.7	385.7	398.1	385.7	398.1
Phosphine sulfide, triphenyl	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Low MW PAHs	33.7	61.0	33.7	61.0	20.4	22.5	20.4	22.5	2.2	2.8	2.2	2.8	1.4	1.8	1.4	1.8
Medium MW PAHs[1]	22.2	41.3	22.2	41.3	20.6	26.6	20.6	26.6	1.7	2.9	1.7	2.9	2.0	3.4	2.0	3.4
High MW PAHs[1]	9.3	15.2	9.3	15.2	9.0	9.3	9.0	9.3	1.0	1.1	1.0	1.1	0.9	1.0	0.9	1.0

[1] Pore water concentrations were adjusted not to exceed solubility of the constituent.

[2] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not identified.

Values of 0.000 in the table indicate the constituent was not detected at that location.

DG - Data Gap: the pore water concentration cannot be calculated in the absence of a K_{ow} for the constituent.

TABLE 4-7
EXPOSURE POINT CONCENTRATIONS OF ORGANIC COECs IN SEDIMENT PORE WATER USED IN HAZARD QUOTIENT CALCULATIONS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	EW01				EW02				EW03			
	NOAEL		LOAEL		NOAEL		LOAEL		NOAEL		LOAEL	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
ORGANICS (ug/L)												
Acetone	99.2	166.4	99.2	166.4	58.3	85.0	58.3	85.0	185.6	193.7	185.63	193.70
Carbon Disulfide	0.4	0.4	0.4	0.4	5.9	7.8	5.9	7.8	10.7	11.6	10.72	11.59
Toluene	0.1	0.2	0.1	0.2	0.8	0.9	0.8	0.9	2.0	2.1	2.04	2.11
Methylene Chloride	0.8	1.0	0.8	1.0	6.0	6.5	6.0	6.5	10.6	13.6	10.62	13.61
Total Xylenes	1.6	2.1	1.6	2.1	10.5	11.0	10.5	11.0	25.6	26.5	25.63	26.50
Chlorobenzene	0.1	0.2	0.1	0.2	0.8	0.8	0.8	0.8	1.9	2.0	1.90	1.96
1,4-Dichlorobenzene	6.3	8.3	6.3	8.3	20.7	21.7	20.7	21.7	51.2	52.5	51.17	52.48
Chlorinated Aromatic Hydrocarbons[2]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2,4-Dimethylphenol	17.0	22.4	17.0	22.4	55.8	58.5	55.8	58.5	137.7	141.3	137.72	141.25
Pentachlorophenol	4.7	6.1	4.7	6.1	15.3	16.1	15.3	16.1	38.6	40.6	38.61	40.64
Phenol & Substituted Phenols	0.2	0.3	0.2	0.3	0.6	0.7	0.6	0.7	1.6	1.6	1.58	1.62
Nonyl Phenols[2]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
Phthalates[1]	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Total PCBs[1]	5.7	5.7	5.7	5.7	3.9	5.3	3.9	5.3	5.7	5.7	5.70	5.70
Aldrin	0.2	0.3	0.2	0.3	0.1	0.2	0.1	0.2	0.2	0.2	0.20	0.20
alpha-Chlordane[1]	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.11
Dieldrin[1]	5.2	9.4	5.2	9.4	3.6	5.0	3.6	5.0	5.9	6.0	5.86	6.01
Heptachlor[1]	0.3	0.6	0.3	0.6	0.2	0.3	0.2	0.3	0.4	0.4	0.36	0.36
Heptachlor epoxide	0.3	0.6	0.3	0.6	0.2	0.3	0.2	0.3	0.4	0.4	0.36	0.36
alpha & delta BHC	0.9	1.7	0.9	1.7	0.6	0.9	0.6	0.9	1.0	1.0	1.03	1.04
Endosulfan Sulfate[1]	1.8	3.3	1.8	3.3	1.3	1.7	1.3	1.7	2.0	2.1	2.03	2.08
Methoxychlor[1]	1.3	2.4	1.3	2.4	0.9	1.3	0.9	1.3	1.5	1.5	1.45	1.47
Benzidine	656.9	861.6	656.9	861.6	2146.7	2249.0	2146.7	2249.0	5433.3	5614.4	5433.27	5614.38
Phosphine sulfide, triphenyl	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Low MW PAHs	4.0	4.4	4.0	4.4	16.8	20.5	16.8	20.5	112.0	207.4	112.02	207.45
Medium MW PAHs[1]	6.9	10.5	6.9	10.5	17.7	23.4	17.7	23.4	56.7	106.7	56.65	106.70
High MW PAHs[1]	4.0	5.8	4.0	5.8	8.4	8.4	8.4	8.4	16.2	30.0	16.24	29.97

[1] Pore water concentrations were adjusted not to exceed solubility of the constituent.

[2] These constituents were tentatively identified in sediment or water. Detection limits were not reported where not identified.

Values of 0.000 in the table indicate the constituent was not detected at that location.

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TABLE 4-8
FOOD CHAIN MULTIPLIERS FOR TROPHIC LEVELS FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

$LogK_{ow}$	TROPHIC LEVEL			$LogK_{ow}$	TROPHIC LEVEL		
	2	3	4		2	3	4
	Food Chain Multipliers				Food Chain Multipliers		
2.0	1	1.005	1	6.0	1	10.556	15.996
2.1	1	1.005	1	6.1	1	11.337	17.783
2.2	1	1.005	1	6.2	1	12.064	19.907
2.3	1	1.005	1	6.3	1	12.691	21.677
2.4	1	1.005	1	6.4	1	13.228	23.281
2.5	1	1.010	1.002	6.5	1	13.662	24.604
2.6	1	1.010	1.002	6.6	1	13.98	25.645
2.7	1	1.010	1.002	6.7	1	14.223	26.363
2.8	1	1.010	1.002	6.8	1	14.355	26.669
2.9	1	1.010	1.002	6.9	1	14.388	26.669
3.0	1	1.028	1.007	7.0	1	14.305	26.242
3.1	1	1.034	1.007	7.1	1	14.142	25.468
3.2	1	1.042	1.009	7.2	1	13.852	24.322
3.3	1	1.053	1.012	7.3	1	13.474	22.856
3.4	1	1.067	1.014	7.4	1	12.987	21.038
3.5	1	1.083	1.019	7.5	1	12.517	18.967
3.6	1	1.103	1.023	7.6	1	11.708	16.749
3.7	1	1.128	1.033	7.7	1	10.914	14.388
3.8	1	1.161	1.042	7.8	1	10.069	12.05
3.9	1	1.202	1.054	7.9	1	9.162	9.84
4.0	1	1.253	1.072	8.0	1	8.222	7.798
4.1	1	1.315	1.096	8.1	1	7.278	6.012
4.2	1	1.38	1.13	8.2	1	6.361	4.519
4.3	1	1.491	1.178	8.3	1	5.489	3.311
4.4	1	1.614	1.242	8.4	1	4.683	2.371
4.5	1	1.766	1.334	8.5	1	3.949	1.663
4.6	1	1.95	1.459	8.6	1	3.296	1.146
4.7	1	2.175	1.633	8.7	1	2.732	0.778
4.8	1	2.452	1.871	8.8	1	2.246	0.521
4.9	1	2.78	2.193	8.9	1	1.837	0.345
5.0	1	3.181	2.612	9.0	1	1.493	0.226
5.1	1	3.643	3.162				
5.2	1	4.188	3.873				
5.3	1	4.803	4.742				
5.4	1	5.502	5.821				
5.5	1	6.266	7.079				
5.6	1	7.096	8.551				
5.7	1	7.962	10.209				
5.8	1	8.841	12.05				
5.9	1	9.716	13.964				

Note: All values were taken from USEPA (1995).

TABLE 4-9
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS AQUATIC EXPOSURES FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA[1]

		LITERATURE ENDPOINT*			UNCERTAINTY FACTORS			FINAL ENDPOINTS	
COPEC	ASSESSMENT RECEPTOR	Measurement	Effect	Concentration (ug/L)	Not a NOAEC	Not a LOAEC	Correction across major taxonomic groups	LOAEC	NOAEC
Aluminum	Algae	LOAEC	not reported	460	/10			460	46
	Vascular Plants	LOAEC	growth	20000				20000	
	Vascular Plants	NOAEC	growth	10000					10000
	Invertebrates	LOAEC	reproduction	1500				1500	
	Invertebrates	NOAEC	reproduction	700					700
	Fish	LOAEC	mortality	1190	/10			1190	119
Antimony	Algae	LOAEC	not reported	610				610	
	Algae	NOAEC	chlorophyl	200					200
	Invertebrates	LOAEC	reproduction	7050	/10			7050	705
	Fish	LOAEC	growth	2310				2310	
	Fish	NOAEC	growth	1130					1130
Arsenic	Algae	LOAEL	not reported	48	/10			48	4.8
	Vascular Plants	LOAEC	growth	10000				10000	1000
	Vascular Plants	NOAEC	growth	1000					1000
	Invertebrates	LOAEC	not reported	450	/10			450	45
	Fish	LOAEC	not reported	891.6	/10			891.6	89.16
Barium	Algae[2]	EC_{50}	growth	25000	/10			2500	250
	Vascular Plants	EC_{50}	growth	25000	/10			2500	250
	Invertebrates	LOAEC	not reported	5800	/10			5800	580
	Fish[3]	LOAEC	NA	5800	/10		/10	580	58
Cadmium	Algae	LOAEC	not reported	2	/10			2	0.2
	Vascular Plants	LOAEC	growth	17.9				17.9	
	Vascular Plants	NOAEC	growth	8.96					8.96
	Invertebrates	LOAEC	reproduction	0.2	/10			0.2	0.02
	Fish	LOAEC	mortality	1.74				1.74	
	Fish	NOAEC	mortality	0.7					0.7

TABLE 4-9
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS AQUATIC EXPOSURES FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA[1]

		LITERATURE ENDPOINT*			UNCERTAINTY FACTORS			FINAL ENDPOINTS	
COPEC	ASSESSMENT RECEPTOR	Measurement	Effect	Concentration (ug/L)	Not a NOAEC	Not a LOAEC	Correction across major taxonomic groups	LOAEC	NOAEC
Chromium	Algae	LOAEC	not reported	2	/10			2	0.2
	Vascular Plants	LOAEC	growth	20000				20000	
	Vascular Plants	NOAEC	growth	5000					5000
	Invertebrates	LOAEC	not reported	6.132	/10			6.132	0.6132
	Fish	LOAEC	not reported	73.18	/10			73.18	7.318
Cobalt	Vascular Plants	LOAEC	growth	10000				10000	
	Vascular Plants	NOAEC	growth	200					200
	Invertebrates	LOAEC	reproduction	9.3				9.3	
	Invertebrates	NOAEC	reproduction	2.8					2.8
	Fish	LOAEC	growth	390				390	
	Fish	NOAEC	growth	210					210
Copper	Algae	LOAEC	not reported	1	/10			1	0.1
	Vascular Plants	LOAEC	growth	5000				5000	
	Vascular Plants	NOAEC	growth	200					200
	Invertebrates	LOAEC	reproduction	30				30	
	Invertebrates	NOAEC	reproduction	20					20
	Fish	LC_{50}	mortality	7	/10	/10		0.7	0.07
Cyanide	Algae	LOAEC	not reported	30	/10			30	3
	Vascular Plants[4]	LOAEC	NA	30	/10			30	3
	Invertebrates	LOAEC	growth	4	/10			4	0.4
	Fish	LOAEC	not reported	7.8	/10			7.8	0.78
Iron	Algae	NOAEC	chlorophyl	1000		*10		10000	1000
	Vascular Plants[4]	NOAEC	NA	1000		*10		10000	1000
Lead	Algae	LOAEC	not reported	500	/10			500	50
	Vascular Plants	LOAEC	growth	20000				20000	
	Vascular Plants	NOAEC	growth	5000					5000
	Invertebrates	LC_{50}	mortality	60	/10	/10		0.6	0.06
	Fish	LOAEC	not reported	18.88	/10			18.88	1.888

TABLE 4-9
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS AQUATIC EXPOSURES FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA[1]

		LITERATURE ENDPOINT*			UNCERTAINTY FACTORS			FINAL ENDPOINTS	
COPEC	ASSESSMENT RECEPTOR	Measurement	Effect	Concentration (ug/L)	Not a NOAEC	Not a LOAEC	Correction across major taxonomic groups	LOAEC	NOAEC
Manganese	Algae[2]	LOAEC	NA	20000				20000	
	Algae[2]	NOAEC	NA	2000					2000
	Vascular Plants	LOAEC	growth	20000				20000	
	Vascular Plants	NOAEC	growth	2000					2000
	Invertebrates	LOAEC	growth	60	/10			60	6
Mercury	Algae	LOAEC	not reported	0.8	/10			0.8	0.08
	Vascular Plants[4]	LOAEC	NA	0.8	/10			0.8	0.08
	Invertebrates	EC_{50}	immobilization	5.2	/10	/10		0.52	0.052
	Fish	LC_{50}	mortality	12.4	/10	/10		1.24	0.124
Molybdenum	Vascular Plants	LOAEC	growth	500				500	
	Vascular Plants	NOAEC	growth	50					50
	Invertebrates	LOAEC	reproduction	1150				1150	
	Invertebrates	NOAEC	reproduction	670					670
	Fish	DG							
Nickel	Algae	LOAEC	growth	8000				8000	
	Algae	NOAEC	growth	4000					4000
	Vascular Plants	LOAEC	growth	2000				2000	
	Vascular Plants	NOAEC	growth	500					500
	Invertebrates	NOAEC	mortality	124		*10		1240	124
	Fish	LOAEC	not reported	35	/10			35	3.5
Selenium	Algae	LOAEC	not reported	100	/10			100	10
	Vascular Plants	LOAEC	growth	50	/10			50	5
	Invertebrates	EC_{50}	immobilization	1790	/10	/10		179	17.9
	Fish	LOAEC	not reported	88.32	/10			88.32	8.832
Silver	Algae	LOAEC	not reported	30	/10			30	3
	Invertebrates	LOAEC	not reported	2.6	/10			2.6	0.26
	Fish	LC_{50}	mortality	600	/10	/10		60	6

TABLE 4-9
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS AQUATIC EXPOSURES FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA[1]

		LITERATURE ENDPOINT*			UNCERTAINTY FACTORS			FINAL ENDPOINTS	
COPEC	ASSESSMENT RECEPTOR	Measurement	Effect	Concentration (ug/L)	Not a NOAEC	Not a LOAEC	Correction across major taxonomic groups	LOAEC	NOAEC
Zinc	Algae	LOAEC	not reported	30	/10			30	3
	Invertebrates	LOAEC	not reported	46.73	/10			46.73	4.673
	Fish	LC_{50}	mortality	410	/10	/10		41	4.1
Vanadium	Vascular Plants	LOAEC	growth	10000	/10			10000	1000
	Invertebrates	LOAEC	not reported	940	/10			940	94
	Fish	LOAEC	not reported	80	/10			80	8

[1] No surrogates were used for the inorganic TRVs.

[2] Data not available for algae. Vascular plants data were used

[3] Data not available for fish. Invertebrate data were used.

[4] Data not available for vascular plants. Algae data were used

NA = Not applicable

*See Appendix I for compilation of all measurement endpoints. Data are summarized in tables by COPEC. The literature enpoint values were taken from the following sources: AQUIRE (1995); Suter and Mabry (1994); Federal Water Pollution Control Administration (1968); Sheedy et al. (1991); and Spehar et al. (1982).

TABLE 4-10
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR ORGANICS AQUATIC EXPOSURES FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

		LITERATURE ENDPOINT*				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
COPEC	ASSESSMENT RECEPTOR	Measurement	Effect	Concentration (ug/L)	Chemical used as Surrogate[1]	Not a NOAEC	Not a LOAEC	Correction across major taxonomic groups	LOAEC	NOAEC
Acetone	Algae	LC_{50}	mortality	11493	No Surrogate	/10	/10		1149.3	114.9
Carbon Disulfide	Algae	LOAEC	growth	8000	No Surrogate				8000	
	Algae	NOAEC	growth	4000	"					4000
	Invertebrates	LOAEC	reproduction	7700	"				7700	
	Invertebrates	NOAEC	reproduction	1100	"					1100
	Fish	LOAEC	growth	2480	"				2480	
	Fish	NOAEC	growth	1270	"					1270
Toluene	Algae	EC_{50}	growth	9400	No Surrogate	/10	/10		940	94
	Invertebrates	EC_{50}	immobilization	6000	"				6000	
	Invertebrates	NOAEC	reproduction	1000	"					1000
	Fish	LOAEC	growth	6000	"				6000	
	Fish	NOAEC	growth; mortality	5440	"					5440
Methylene Chloride	Invertebrates	LC_{50}	mortality	220000	No Surrogate	/10	/10		22000	2200
	Fish	EC_{50}	immobilization	99000	"	/10	/10		9900	990
Total Xylenes	Invertebrates	LC_{50}	mortality	5300	o-xylene	/10	/10		530	53
	Fish	LC_{50}	mortality	8200	o-xylene	/10	/10		820	82
Chlorobenzene	Fish	LC50	mortality	50	No Surrogate	/10	/10		5	0.5
1,4-Dichlorobenzene	Algae	EC_{50}	growth	1600	No Surrogate	/10	/10		160	16
	Invertebrates	EC_{50}	reproduction	930	"				930	
	Invertebrates	NOAEC	reproduction	300	"					300
	Fish	LOAEC	mortality	263	"	/10			263	26.3
Chlorinated Aromatic	Invertebrates	LC_{50}	mortality	1600	Chloronaphthalene	/10	/10		160	16
Hydrocarbons	Fish	LC_{50}	mortality	2300	Chloronaphthalene	/10	/10		230	23
2,4-Dimethylphenol	Vascular Plants	LC_{50}	mortality	290000	No Surrogate	/10	/10		29000	2900
	Invertebrates	NOAEC	reproduction	2000	"		*10		20000	2000
	Fish	LC_{50}	mortality	7800	"	/10	/10		780	78
Pentachlorophenol	Algae	EC_{50}	growth	80	No Surrogate	/10	/10		8	0.8
	Vascular Plants	LC_{50}	mortality	190	"	/10	/10		19	1.9
	Invertebrates	EC_{50}	reproduction	130	"	/10	/10		13	1.3
	Fish	LC_{50}	mortality	18	"	/10	/10		1.8	0.18
Phenol & Substituted	Invertebrates	LC_{50}	mortality	45	Phenol	/10	/10		4.5	0.45
Phenols	Fish	LC_{50}	mortality	70	Phenol	/10	/10		7	0.7
Nonyl Phenols	Invertebrates	LC_{50}	mortality	100	Nonyl Phenol	/10	/10		10	1
	Fish	LC_{50}	mortality	135	Nonyl Phenol	/10	/10		13.5	1.35
Bis(2-ethylhexyl)phthalate	Algae	EC_{50}	growth	320	No Surrogate	/10	/10		32	3.2
	Invertebrates	EC_{50}	immobilization	133	"	/10	/10		13.3	1.33
	Fish	NOAEC	mortality; growth; development	320	"		*10		320	3200
Total PCBs	Algae	LOAEC	not reported	0.1	Arochlor 1254	/10			0.1	0.01
	Invertebrates	LC_{50}	mortality	0.45	Arochlor 1254	/10	/10		0.045	0.0045
	Fish	LC_{50}	mortality	0.32	Arochlor 1254	/10	/10		0.032	0.0032

TABLE 4-10
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR ORGANICS AQUATIC EXPOSURES FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

		LITERATURE ENDPOINT*				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
COPEC	ASSESSMENT RECEPTOR	Measurement	Effect	Concentration (ug/L)	Chemical used as Surrogate[1]	Not a NOAEC	Not a LOAEC	Correction across major taxonomic groups	LOAEC	NOAEC
Aldrin	Invertebrates	LC_{50}	mortality	0.097	No Surrogate	/10	/10		0.0097	0.00097
	Fish	LC_{50}	mortality	0.9	"	/10	/10		0.09	0.009
alpha-Chlordane	Invertebrates	LC_{50}	mortality	2.5	Chlordane	/10	/10		0.25	0.025
	Fish	LC_{50}	mortality	2.9	"	/10	/10		0.29	0.029
Dieldrin	Algae	EC_{50}	growth	100	No Surrogate	/10	/10		10	1
	Invertebrates	LC_{50}	mortality	0.2	"	/10	/10		0.02	0.002
	Fish	LC_{50}	mortality	0.26	"	/10	/10		0.026	0.0026
Heptachlor	Invertebrates	LC_{50}	mortality	0.5	No Surrogate	/10	/10		0.05	0.005
	Fish	LC_{50}	mortality	0.7	"	/10	/10		0.07	0.007
Heptachlor epoxide	Invertebrates	LC_{50}	mortality	120	No Surrogate	/10	/10		12	1.2
	Fish	LC_{50}	mortality	5.3	"	/10	/10		0.53	0.053
alpha and delta BHC	Invertebrates	EC_{50}	reproduction	65	alpha BHC	/10	/10		6.5	0.65
	Fish	EC_{50}	immobilization	800	alpha BHC	/10	/10		80	8
Endosulfan Sulfate	Invertebrates[2]	LC_{50}	NA	0.16	alpha Endosulfan	/10	/10	/10	0.0016	0.00016
	Fish	LC_{50}	mortality	0.16	alpha Endosulfan	/10	/10		0.016	0.0016
Methoxychlor	Invertebrates	LC_{50}	mortality	0.2	No Surrogate	/10	/10		0.02	0.002
	Fish	LC_{50}	mortality	1.7	"	/10	/10		0.17	0.017
Benzidine	Invertebrates	EC_{50}	immobilization	600	No Surrogate	/10	/10		60	6
	Fish	LC_{50}	mortality	10500	"	/10	/10		1050	105
Phosphine sulfide,triphenyl	Fish	LC_{50}	mortality	53700	No Surrogate	/10	/10		5370	537
Low Molecular Weight	Algae	EC_{50}	development	3.3	Anthracene	/10	/10		0.33	0.033
PAHs	Invertebrates	LC_{50}	mortality	6.4	9-Methylanthracene	/10	/10		0.64	0.064
	Fish	LC_{50}	mortality	1.27	Anthracene	/10	/10		0.127	0.0127
Medium Molecular Weight	Algae	EC_{50}	chlorophyl	4140	Flouranthene	/10	/10		414	41.4
PAHs	Invertebrates	LC_{50}	mortality	4	Pyrene	/10	/10		0.4	0.04
	Fish	LC_{50}	mortality	7.1	Flouranthene	/10	/10		0.71	0.071
High Molecular Weight	Algae	EC_{50}	growth	5	Benzo(a)pyrene	/10	/10		0.5	0.05
PAHs	Invertebrates	LC_{50}	mortality	5	Benzo(a)anthracene	/10	/10		0.5	0.05
	Fish	LOAEC	development	1	Benzo(a)pyrene	/10			1	0.1

[1] Chemical used as Surrogate refers to that chemical selected to represent the toxicity of a chemical group or class in the respective ecological receptors

2 Data not available for invertebrates. Fish data were used.

DG = Data Gap

EC50[a] = The EC50 was used as an LOAEC when the NOAEC was greater than the EC50 divided by 10.

*See Appendix I for compilation of all measurement endpoints. Data are summarized in tables by COPEC. The literature enpoint values were taken from the following sources: AQUIRE (1995); Suter and Mabry (1994); Federal Water Pollution Control Administration (1968); Sheedy et al. (1991); and Spehar et al. (1982).

TABLE 4-11
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS
INGESTION PATHWAY EXPOSURES FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
Antimony	Green Heron	LOAEL	Growth (rat)	1338	No Surrogate			/10	133.8	
	Green Heron	NOAEL	Growth (rat)	134	"			/10		13.4
	Muskrat	LOAEL	Growth (rat)	1338	"				1338	
	Muskrat	NOAEL	Growth (rat)	134	"					134
	Raccoon	LOAEL	Growth (rat)	1338	"				1338	
	Raccoon	NOAEL	Growth (rat)	134	"					134
Arsenic	Green Heron	LOAEL	Toxicity (cowbird)	4.7	Copper		see text		4.7	
	Green Heron	NOAEL	Toxicity (cowbird)	4.7	Acetoarsenite					4.7
	Red-winged Blackbird	NOAEL	Toxicity (cowbird)	4.7	"		see text		4.7	
	Red-winged Blackbird	NOAEL	Toxicity (cowbird)	4.7	"					4.7
	Muskrat	LOAEL	Reduced litter size (mice)	0.8	Sodium				0.8	
	Muskrat	LOAEL	Reduced litter size (mice)	0.8	Arsenate	/10				0.08
	Raccoon	NOAEL	Toxicity (dog)	0.9	Methanearonic		X10		9	
	Raccoon	NOAEL	Toxicity (dog)	0.9	Acid					0.9
Cadmium	Green Heron	LOAEL	Reproductive impairment (quail)	7.8	No Surrogate				7.8	
	Green Heron	LOAEL	Reproductive impairment (quail)	7.8	"	/10				0.78
	Red-winged Blackbird	LOAEL	Reproductive impairment (quail)	7.8	"				7.8	
	Red-winged Blackbird	LOAEL	Reproductive impairment (quail)	7.8	"	/10				0.78
	Muskrat	LOAEL	Fetal death (rat)	1.6	"				1.6	
	Muskrat	LOAEL	Fetal death (rat)	1.6	"	/10				0.16
	Raccoon	LOAEL	Fetal death (rat)	1.6	"				1.6	
	Raccoon	LOAEL	Fetal death (rat)	1.6	"	/10				0.16

TABLE 4-11
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS
INGESTION PATHWAY EXPOSURES FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
Chromium	Green Heron	LOAEL	Survival (duck)	2.7	Chromium III				2.7	
	Green Heron	LOAEL	Survival (duck)	2.7	"	/10				0.27
	Red-winged Blackbird	LOAEL	Survival (duck)	2.7	"				2.7	
	Red-winged Blackbird	LOAEL	Survival (duck)	2.7	"	/10				0.27
	Muskrat	NOAEL	Toxicity (rat)	18	Chromium IV		see text		18	
	Muskrat	NOAEL	Toxicity (rat)	18	"					18
	Raccoon	LD_{lo}	Mortality (dog)	3	"		see text		3	
	Raccoon	NOAEL	Toxicity (dog)	0.3	"					0.3
Cobalt	Green Heron	LOAEL	Growth (chicken)	2.4	No Surrogate				2.4	
	Green Heron	NOAEL	Adverse effect (chicken)	0.24	"					0.24
	Red-winged Blackbird	LOAEL	Growth (chicken)	2.4	"				2.4	
	Red-winged Blackbird	NOAEL	Adverse effect (chicken)	0.24	"					0.24
	Muskrat	NOAEL	Survival (rat)	0.13	"		X10		1.3	
	Muskrat	NOAEL	Survival (rat)	0.13	"					0.13
	Raccoon	NOAEL	Survival (rat)	0.13	"		X10		1.3	
	Raccoon	NOAEL	Survival (rat)	0.13	"					0.13
Cyanide	Green Heron	LD_{50}	Mortality (mallard)	1.43	No Surrogate		/10		0.143	
	Green Heron	LD_{50}	Mortality (mallard)	1.43	"	/10	/10			0.0143
	Red-winged Blackbird	LD_{50}	Mortality (starling)	9	"		/10		0.9	
	Red-winged Blackbird	LD_{50}	Mortality (starling)	9	"	/10	/10			0.09
	Muskrat	LD_{50}	Mortality (rabbit)	2.5	"	/10			0.25	
	Muskrat	LD_{50}	Mortality (rabbit)	2.5	"	/10	/10			0.025
	Raccoon	NOAEL	Adverse effect (dog)	4.7	"		see text		4.7	
	Raccoon	NOAEL	Adverse effect (dog)	4.7	"					4.7

TABLE 4-11
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS
INGESTION PATHWAY EXPOSURES FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
Lead	Green Heron	LOAEL	Growth (bald eagle)	0.4	No Surrogate				0.4	
	Green Heron	LOAEL	Growth (bald eagle)	0.4	"	/10				0.04
	Red-winged Blackbird	NOAEL	Growth (rock dove)	48	"				48	
	Red-winged Blackbird	LOAEL	Growth (quail)	16	"					16
	Muskrat	LOAEL	Fertility (mice)	150	"				150	
	Muskrat	LOAEL	Fertility (mice)	150	"	/10				15
	Raccoon	LOAEL	Fertility (mice)	150	"				150	
	Raccoon	LOAEL	Fertility (mice)	150	"	/10				15
Mercury	Green Heron	LOAEL	Reduced fertility (mallard)	0.06	Methylmercury				0.06	
	Green Heron	NOAEL	Reduced fertility (mallard)	0.06	"	/10				0.006
	Red-winged Blackbird	LOAEL	Reduced fertility (mallard)	0.64	"				0.64	
	Red-winged Blackbird	NOAEL	Reduced fertility (mallard)	0.42	"					0.42
	Muskrat	LOAEL	Reduced fertility (rat)	0.5	Organomercury				0.5	
	Muskrat	LOAEL	Reduced fertility (rat)	0.5	"	/10				0.05
	Raccoon	LOAEL	Mortality (mink)	0.07	"				0.07	
	Raccoon	NOAEL	Mortality (mink)	0.007	"	/10				0.007
Molybdenum	Muskrat	LOAEL	Reduced offspring growth (mice)	0.3	No Surrogate				0.3	
	Muskrat	LOAEL	Reduced offspring growth (mice)	0.3	"	/10				0.03
	Raccoon	LOAEL	Reduced offspring growth (mice)	0.3	"				0.3	
	Raccoon	LOAEL	Reduced offspring growth (mice)	0.3	"	/10				0.03

TABLE 4-11
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS
INGESTION PATHWAY EXPOSURES FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
Nickel	Green Heron	LOAEL	Mortality of newborns (rat)	0.67	No Surrogate				0.67	
	Green Heron	LOAEL	Mortality of newborns (rat)	0.67	"			/10		0.067
	Red-winged Blackbird	LOAEL	Mortality of newborns (rat)	0.67	"				0.67	
	Red-winged Blackbird	LOAEL	Mortality of newborns (rat)	0.67	"			/10		0.067
	Muskrat	LOAEL	Mortality of newborns (rat)	0.67	"		see text			0.67
	Muskrat	LOAEL	Mortality of newborns (rat)	0.67	"				0.67	
	Raccoon	LOAEL	Growth (dog)	63	"				63	
	Raccoon	NOAEL	Growth (dog)	25	"					25
Selenium	Green Heron	LOAEL	Reduced hatching (chicken)	0.34	Not Specified				0.34	
	Green Heron	NOAEL	Growth & reproduction (mallard)	0.28	Organo-Se					0.28
	Red-winged Blackbird	LOAEL	Reduced hatching (chicken)	0.34	Not Specified				0.34	
	Red-winged Blackbird	NOAEL	Growth & reproduction (mallard)	0.28	Organo-Se					0.28
	Muskrat	LOAEL	Reproduction (rat)	0.35	Selenate/Selenite				0.35	
	Muskrat	NOAEL	Reproduction (mice)	0.17	"					0.17
	Raccoon	LOAEL	Reproduction (rat)	0.35	"				0.35	
	Raccoon	NOAEL	Reproduction (mice)	0.17	"					0.17

TABLE 4-11
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR INORGANICS
INGESTION PATHWAY EXPOSURES FOR SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
Silver	Green Heron	LOAEL	Survival & growth (chicken)	43.5	Silver Nitrate				43.5	
	Green Heron	LOAEL	Survival & growth (chicken)	4.8	"					4.8
	Red-winged Blackbird	LOAEL	Survival & growth (chicken)	43.5	"				43.5	
	Red-winged Blackbird	LOAEL	Survival & growth (chicken)	4.8	"					4.8
	Muskrat	LOAEL	Growth (rat)	2.7	"				2.7	
	Muskrat	NOAEL	Mortality (rat)	0.67	"					0.67
	Raccoon	LOAEL	Growth (rat)	2.7	"				2.7	
	Raccoon	NOAEL	Mortality (rat)	0.67	"					0.67

[1] See Appendix I for compilation of all measurement endpoints. Data are summarized in Tables by COEC.

TABLE 4-12
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR ORGANICS INGESTION PATHWAY EXPOSURES SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as a Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
Pentachlorophenol	Muskrat	LOAEL	Fetotoxicity (hamsters)	5	No Surrogate				5	
	Muskrat	NOAEL	Reproduction & Fetal Development (hamsters)	3	"					3
	Raccoon	LOAEL	Fetotoxicity (hamsters)	5	"				5	
	Raccoon	NOAEL	Reproduction & Fetal Development (hamsters)	3	"					3
Total PCBs	Green Heron	LOAEL	Reduced hatchability (chicken)	1.8	Aroclor 1254				1.8	
	Green Heron	NOAEL	Reproductive effects (mallard)	1.4	"					1.4
	Red-winged Blackbird	LOAEL	Reduced hatchability (chicken)	1.8	"				1.8	
	Red-winged Blackbird	NOAEL	Reproductive effects (mallard)	1.4	"					1.4
	Muskrat	LOAEL	Fetotoxicity (rabbit)	12.5	"				12.5	
	Muskrat	NOAEL	Reproduction (rabbit)	10	"					10
	Raccoon	NOAEL	Reproduction failure (mink)	0.4	"				0.4	
	Raccoon	NOAEL	Reproduction failure (mink)	0.4	"	/10				0.04
Aldrin	Green Heron	LD_{50}	Mortality (quail)	6.59	No Surrogate	/10			0.659	
	Green Heron	LD_{50}	Mortality (quail)	6.59	"	/10	/10			0.0659
	Red-winged Blackbird	LD_{50}	Mortality (quail)	6.59	"	/10			0.659	
	Red-winged Blackbird	LD_{50}	Mortality (quail)	6.59	"	/10	/10			0.0659
	Muskrat	LOAEL	Survival (rat)	4.1	"				4.1	
	Muskrat	NOAEL	Survival and growth (rat)	2	"					2
	Raccoon	LOAEL	Live birth index (dog)	0.24	"				0.24	
	Raccoon	LOAEL	Live birth index (dog)	0.24	"	/10				0.024

TABLE 4-12
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR ORGANICS INGESTION PATHWAY EXPOSURES SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as a Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
alpha-Chlordane	Green Heron	LOAEL	Survival & weight gain (quail)	2.5	No Surrogate				2.5	
	Green Heron	NOAEL	Survival & weight gain (quail)	2.5	"					2.5
	Red-winged Blackbird	LOAEL	Survival & weight gain (quail)	2.5	"				2.5	
	Red-winged Blackbird	NOAEL	Survival & weight gain (quail)	2.5	"					2.5
	Muskrat	LOAEL	Survival (mice)	3.9	"				3.9	
	Muskrat	NOAEL	Survival (mice)	3.2	"					3.2
	Raccoon	LOAEL	Survival (mice)	3.9	"				3.9	
	Raccoon	NOAEL	Survival (mice)	3.2	"					3.2
Dieldrin	Green Heron	LD_{50}	Mortality (gray partridge)	8.84	No Surrogate	/10			0.884	
	Green Heron	LD_{50}	Mortality (gray partridge)	8.84	"	/10	/10			0.0884
	Red-winged Blackbird	LD_{50}	Mortality (gray partridge)	8.84	"	/10			0.884	
	Red-winged Blackbird	LD_{50}	Mortality (gray partridge)	8.84	"	/10	/10			0.0884
	Muskrat	LOAEL	Fetotoxicity (mice)	0.25	"	see text			0.25	0.25
	Raccoon	LOAEL	Reduced litter size & Fertility (raccoon)	0.101	"				0.101	
	Raccoon	LOAEL	Reduced litter size & Fertility (raccoon)	0.101	"	/10				0.0101
Heptachlor	Green Heron	LD_{50}	Mortality (quail)	19.5	No Surrogate	/10			1.95	
	Green Heron	LD_{50}	Mortality (quail)	19.5	"	/10	/10			0.195
	Red-winged Blackbird	LD_{50}	Mortality (quail)	19.5	"	/10			1.95	
	Red-winged Blackbird	LD_{50}	Mortality (quail)	19.5	"	/10	/10			0.195
	Muskrat	NOAEL	Survival (mice)	3.1	"		X10		31	
	Muskrat	NOAEL	Survival (mice)	3.1	"					3.1
	Raccoon	LOAEL	Survival (dog)	1	"				1	
	Raccoon	LOAEL	Survival (dog)	1	"	/10				0.1

TABLE 4-12
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR ORGANICS INGESTION PATHWAY EXPOSURES SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as a Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
Heptachlor epoxide	Green Heron	LOAEL	Reproduction (dog pups)	0.175	No Surrogate			/10	0.0175	
	Green Heron	NOAEL	Reproduction (dog pups)	0.125	"			/10		0.0125
	Red-winged Blackbird	LOAEL	Reproduction (dog pups)	0.175	"			/10	0.0175	
	Red-winged Blackbird	NOAEL	Reproduction (dog pups)	0.125	"			/10		0.0125
	Muskrat	LOAEL	Survival (rat)	0.5	"				0.5	
	Muskrat	NOAEL	Reproduction (rat)	0.25	"					0.25
	Raccoon	LOAEL	Reproduction (dog pups)	0.175	"				0.175	
	Raccoon	NOAEL	Reproduction (dog pups)	0.125	"					0.125
Endosulfan Sulfate	Green Heron	LD_{50}	Mortality (duck)	101	Endosulfan	/10			10.1	
	Green Heron	LD_{50}	Mortality (duck)	101	"	/10	/10			1.01
	Red-winged Blackbird	LD_{50}	Mortality (duck)	101	"	/10			10.1	
	Red-winged Blackbird	LD_{50}	Mortality (duck)	101	"	/10	/10			1.01
	Muskrat	LOAEL	Fertility (rat)	5	"				5	
	Muskrat	NOAEL	Fertility (rat)	2.4	"					2.4
	Raccoon	LOAEL	Fertility (rat)	5	"				5	
	Raccoon	NOAEL	Fertility (rat)	2.4	"					2.4
Benzidine	Red-winged Blackbird	NOAEL	Survival (dog)	16	No Surrogate		X10	/10	16	
	Red-winged Blackbird	NOAEL	Survival (dog)	16	"			/10		1.6
	Muskrat	NOAEL	Survival (dog)	16	"		X10		160	
	Muskrat	NOAEL	Survival (dog)	16	"					16
	Raccoon	NOAEL	Survival (dog)	16	"		X10		160	
	Raccoon	NOAEL	Survival (dog)	16	"					16

TABLE 4-12
SUMMARY OF MEASUREMENT ENDPOINTS AND TRV DERIVATION FOR ORGANICS INGESTION PATHWAY EXPOSURES SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

COEC	ASSESSMENT RECEPTOR	LITERATURE ENDPOINT[1]				UNCERTAINTY FACTORS			FINAL ENDPOINTS	
		Measurement	Effect	Dose (mg/kg-BW/day)	Chemical used as a Surrogate	Not a NOAEL	Not a LOAEL	Correction across major taxonomic groups	LOAEL	NOAEL
High Molecular	Green Heron	LOAEL	Survival (duck)	44	Benzo (a)				44	
Weight PAHs	Green Heron	LOAEL	Survival (duck)	44	pyrene	/10				4.4
	Red-winged Blackbird	LOAEL	Survival (duck)	44	"				44	
	Red-winged Blackbird	LOAEL	Survival (duck)	44	"	/10				4.4
	Muskrat	LOAEL	Reduced fertility (rodents)	2.4	"				2.4	
	Muskrat	LOAEL	Reduced fertility (rodents)	2.4	"	/10				0.24
	Raccoon	LOAEL	Reduced fertility (rodents)	2.4	"				2.4	
	Raccoon	LOAEL	Reduced fertility (rodents)	2.4	"	/10				0.24

[1] See Appendix I for compilation of all measurement endpoints. Data are summarized in Tables by COEC.

TABLE 4-13
1994-1995 SEDIMENT ACUTE TOXICITY SUMMARY

Sample	1994 Tinker LC_{50}'s Acute Toxicity Tests		1994 Tinker Survival at 100% Sample		Sample	1995 Tinker LC_{50}'s Acute Toxicity Tests		1995 Tinker Survival at 100% Sample	
	L. variegatus (%)	*H. azteca* (%)	*L. variegatus* (%)	*H. azteca* (%)		*L. variegatus* (%)	*H. azteca* (%)	*L. variegatus* (%)	*H. azteca* (%)
EE01	>100	>100	100	80	EE01	>100	>100	100	60
EE02	>100	>100	100	65	EE02	>100	75.6	100	20
EE03	>100	>100	97.5	90	EE03	>100	>100	97.5	83.3
EE04	>100	>100	100	95	EE04	>100	>100	100	53.3
EE05	>100	>100	100	95	EE05	>100	>100	100	76.7
EE06	>100	77.1	100	42.5	EE06	>100	>100	100	63.3
EE07	>100	78.85	95	30	EE07	>100	71.9	92.5	40
EE08	>100	>100	100	80	EE08	>100	>100	77.5	66.7
EE09	>100	>100	100	57.5	EE09	>100	>100	90	56.7
EE10	>100	>100	100	97.5	EE10	>100	>100	100	83.3
EW01	>100	>100	100	60	EW01	>100	>100	100	83.3
EW02	>100	58.02	100	5	EW02	>100	>100	100	80
EW03	>100	>100	100	75	EW03	>100	>100	97.5	76.7
Crooked Oak Creek #1	>100	>100	100	100	Crooked Oak Creek #1	N/A	N/A	N/A	N/A
Crooked Oak Creek #2	>100	>100	97.5	95	Crooked Oak Creek #2	N/A	N/A	N/A	N/A
Crutcho Creek #1	N/A	N/A	N/A	N/A	Crutcho Creek #1	>100	>100	92.5	86.7
Crutcho Creek #2	N/A	N/A	N/A	N/A	Crutcho Creek #2	>100	>100	97.5	76.7

N/A = Not Applicable

TABLE 4-14
HYALLELA AZTECA SEDIMENT TOXICITY TEST RESULTS

1994 Chronic Toxicity Tests				1995 Chronic Toxicity Tests			
Sample	% Survival at 100% Sample	NOEC Survival (%)	NOEC Weight (%)	Sample	% Survival at 100% Sample	NOEC Survival (%)	NOEC Weight (%)
EE01	30	50	100	EE01	50	50	100
EE02	36.7	25	100	EE02	80	100	100
EE03	46.7	12.5	100	EE03	80	100	100
EE04	0	<6.25	<6.25	EE04	40	50	100
EE05	0	<6.25	12.5	EE05	40	6.25	100
EE06	13.3	<5.0	80	EE06	20	25	100
EE07	6.7	<5.0	20	EE07	3.3	<6.25	50
EE08	10	<6.25	100	EE08	43.3	50	100
EE09	0	<6.25	50	EE09	66.7	N.C.	100
EE10	50	6.25	100	EE10	86.7	100	100
EW01	0	<6.25	12.5	EW01	56.7	100	100
EW02	0	<4.0	32	EW02	80	100	50
EW03	20	50	25	EW03	60	100	100
Crooked Oak Creek #1	76.7	100	100	Crooked Oak Creek #1	N/A	N/A	N/A
Crooked Oak Creek #2	26.7	<6.25	100	Crooked Oak Creek #2	N/A	N/A	N/A
Crutcho Creek #1	N/A	N/A	N/A	Crutcho Creek #1	83.3	100	100
Crutcho Creek #2	N/A	N/A	N/A	Crutcho Creek #2	103	100	100

N/A = Not Applicable
N.C. = Not Calculable; non-monotonic response curve

TABLE 4-15
1994-1995 SURFACE WATER ACUTE TOXICITY SUMMARY

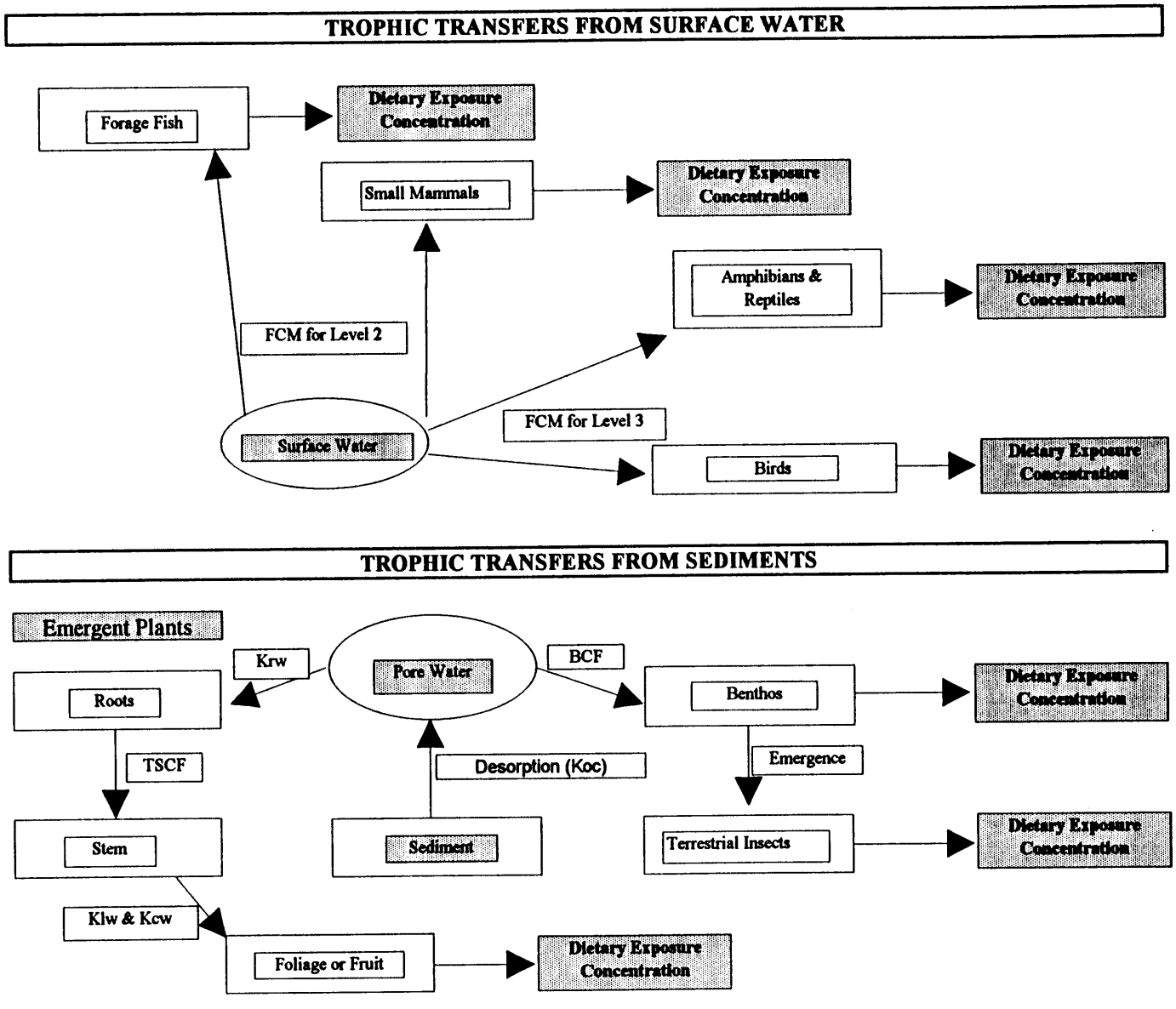
Sample	1994 Tinker LC_{50}'s Acute Toxicity Tests		1994 Tinker Survival at 100% Sample		Sample	1995 Tinker LC_{50}'s Acute Toxicity Tests		1995 Tinker Survival at 100% Sample	
	P. promelas (%)	*C. dubia* (%)	*P. promelas* (%)	*C. dubia* (%)		*P. promelas* (%)	*C. dubia* (%)	*P. promelas* (%)	*C. dubia* (%)
EE01	>100	45.6	100	10	EE01	>100	>100	100	100
EE02	>100	11.1	100	0	EE02	>100	>100	95	100
EE03	>100	34.9	90	0	EE03	>100	>100	100	100
EE04	>100	>100	100	85	EE04	>100	>100	100	100
EE05	>100	>100	100	90	EE05	>100	>100	85	100
EE06	>100	>100	100	95	EE06	>100	>100	90	100
EE07	>100	>100	100	100	EE07	>100	>100	85	100
EE08	>100	>100	100	100	EE08	>100	24.79	75	30
EE09	>100	>100	95	100	EE09	>100	>100	90	65
EE10	>100	>100	100	100	EE10	>100	>100	80	100
EW01	>100	>100	100	85	EW01	>100	>100	100	70
EW02	>100	>100	100	100	EW02	>100	>100	100	100
EW03	>100	>100	100	100	EW03	>100	>100	100	95
Crooked Oak Creek #1	>100	>100	100	100	Crooked Oak Creek #1	N/A	N/A	N/A	N/A
Crooked Oak Creek #2	>100	>100	100	100	Crooked Oak Creek #2	N/A	N/A	N/A	N/A
Crutcho Creek #1	N/A	N/A	N/A	N/A	Crutcho Creek #1	>100	100	100	100
Crutcho Creek #2	N/A	N/A	N/A	N/A	Crutcho Creek #2	>100	100	95	100

N/A = Not Applicable

TABLE 4-16
1994-1995 SURFACE WATER CHRONIC TOXICITY SUMMARY

Sample	1994 Tinker NOEC Chronic Toxicity Tests				Sample	1995 Tinker NOEC Chronic Toxicity Tests			
	Survival *P. promelas* (%)	Growth *P. promelas* (%)	Survival *C. dubia* (%)	Reproduction *C. dubia* (%)		Survival *P. promelas* (%)	Growth *P. promelas* (%)	Survival *C. dubia* (%)	Reproduction *C. dubia* (%)
EE01	100	50	50	<3.6	EE01	100	50	100	12.5
EE02	100	100	>10	>10	EE02	100	<6.25	100	<6.25
EE03	100	25	>30	<1.4	EE03	100	100	100	<6.25
EE04	100	50	<1.4	100	EE04	100	100	100	<6.25
EE05	100	<6.25	100	100	EE05	100	100	6.25	<6.25
EE06	100	100	100	100	EE06	100	100	100	100
EE07	100	100	100	100	EE07	100	100	100	100
EE08	50	50	100	100	EE08	25	25	50	50
EE09	100	100	100	100	EE09	100	100	50	12.5
EE10	100	<6.25	100	100	EE10	50	100	100	50
EW01	100	50	100	100	EW01	100	100	25	50
EW02	100	<6.25	100	100	EW02	100	100	100	100
EW03	100	<6.25	100	100	EW03	100	100	100	50
Crooked Oak Creek #1	100	100	100	100	Crooked Oak Creek #1	N/A	N/A	N/A	N/A
Crooked Oak Creek #2	100	50	100	100	Crooked Oak Creek #2	N/A	N/A	N/A	N/A
Crutcho Creek #1	N/A	N/A	N/A	N/A	Crutcho Creek #1	100	100	100	100
Crutcho Creek #2	N/A	N/A	N/A	N/A	Crutcho Creek #2	100	100	100	100

FIGURE 4-1



FCM = Food-Chain-Multiplier

Koc = Partition Coefficient; organic carbon vs water

BCF = Bioconcentration Factor

Krw = Partition Coefficient; plant root vs (pore) water

TSCF = Transpiration stream concentration factor

Klw = Partition Coefficient; plant leaves vs water (*i.e.*,. transpiration stream)

Kcw = Partition Coefficient; fruit cuticles vs water (*i.e.*, transpiration stream)

5.0
RISK CHARACTERIZATION

Risk characterization involves two major processes, risk estimation and risk description (USEPA 1992). The risk estimation consists of comparing relevant information about exposures and toxicity (Section 4.0), as well as evaluating and summarizing the associated uncertainties and assumptions, in order to characterize the current and potential adverse ecological effects posed by the site-related COECs. The potential impacts from all complete exposure pathways and all appropriate media are addressed in risk estimation. The risk description consists of a summary of the results of risk estimation and uncertainty evaluation, and an assessment of the confidence in the risk estimates through discussion of the weight of evidence developed.

5.1 RISK ESTIMATION

In the following subsections, exposures are evaluated both qualitatively and semi-quantitatively. The latter evaluations are based on the quotient method, wherein particular exposure scenarios (medium/pathway/receptor/COEC) are compared to appropriate TRVs to generate ratios known as Hazard Quotients (HQs). The HQ is calculated as the COEC concentration divided by the TRV. Interpretation of HQs is discussed at length by Barnthouse *et al.* (1986) and Suter (1993). According to these and other authors, if a calculated HQ based on a LOAEC or LOAEL is less than or equal to 1, there is a "low probability" that an adverse effect (of the type reflected by the TRV) will occur.[1] HQs ranging from 1 to 10 signify that there is a possibility of effects, and values greater than 10 indicate that it is "probable" that some individual receptors are being affected. USEPA (1992) cites Barnthouse *et al.* (1986) but states that if a HQ "is one or more, an adverse effect is considered likely to occur." To provide a range of potential effects, HQs in this report are calculated for the following scenarios:

[1]**It is sometimes stated that when a HQ is calculated based on a NOAEC/LOAEL a resulting ratio less than one strongly suggests that no risk is associated with the exposure scenario in question. This is only true when the no-effect level has been developed using reliable experimental toxicity-testing methods.**

- Direct exposure to surface water (fish, algae, water-column invertebrates, microbial decomposers):

  - mean and maximum surface-water COEC concentration divided by the lowest appropriate NOAECs and LOAECs.

- Direct exposure to sediments (aquatic vascular plants, benthic invertebrates):

  - for organics, the mean and maximum estimated (by EqP) COEC concentration in pore water divided by the lowest appropriate NOAECs and LOAECs; and

  - for inorganics, the mean and maximum bulk-sediment COEC concentration divided by the lowest available adverse effects threshold (AET, usually from MOE and/or NSCSI)[2].

- Ingestion-pathway (indirect) exposures:

  - mean and maximum applied daily dose (ADD) divided by the lowest appropriate dietary NOAELs and LOAELs.

The HQ should not be viewed as a statistical (i.e., probabilistic) index of risk. For example, an HQ of 0.01 does not mean that there is a one-in-one hundred probability of the adverse effect occurring; rather, it indicates simply that the exposure is one hundred times less than the selected TRV for the COEC. Additionally, the exposure/TRV ratio does not imply a linear relationship; i.e., the hazard posed by exposure to the COEC does not increase linearly as the HQ increases linearly. This is true for numerous reasons, including the facts that TRVs:

1) are not accurate descriptors of hazards, because they are generally developed by use of multiple/additive uncertainty factors, usually based on surrogate receptors exposed to relatively pure and more bioavailable forms of the chemical in question (Barnthouse *et al.* 1986: USEPA 1992; Suter 1993)

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[2]**AETs were used as screening benchmarks in selection of COECs; however, the lowest available sediment benchmarks were seldom based on AETs. The procedure adopted resulted in the use of the same TRV for evaluation of the endpoint for vascular aquatic plants and benthic invertebrates, relative to inorganic COECs.**

2) dose/response "curves" are typically sigmoid (or at least curvilinear) in shape (Rand *et al.* 1995)

3) the severity of potential effects varies, because dose-response relationships differ substantially even under standardized testing scenarios (Rand *et al.* 1995; see also several of the ecotoxicological profiles in Subsection 4.2.1)

The latter is particularly relevant when one considers that in ecological risk assessment the salient endpoints are supposed to be at higher organizational levels than organismal (i.e., at least population [USEPA 1992]).

To address the fact that the receptors are exposed to multiple COECs, Hazard Quotients associated with a specific endpoint are summed to derive a Hazard Index (HI) for a given receptor (ingestion-pathway) or class of receptors (direct exposures to aquatic organisms) in each designated stream section. This approach simplistically assumes that all of the effects of the various contaminants are additive. As such, it introduces substantial uncertainty because some combinations of chemical stressors are known or suspected to be not only additive but synergistic (e.g., some combinations of pesticides and metals), while on the other hand there are some combinations which are known to be antagonistic (e.g., several metal combinations such as mercury and selenium). Thus a HI can either underestimate or overestimate the potential hazards associated with multiple COECs.

It must be stressed that the quotient method addresses potential adverse effects only at the organismal level. That is, it provides a crude basis for evaluating the risk to a hypothetical individual, requiring the assessor to exercise considerable judgement in interpreting the results in the context of populations. In this EA, additional measurement endpoints were considered to augment this interpretation -- namely, biological surveys (Subsection 2.1; Appendix G) and standardized toxicity testing (Subsection 4.2.3; see also Appendix J).

5.1.1 Strictly-Aquatic Receptors

This subsection summarizes and interprets the hazard quotients derived to illustrate the potential hazards of site-related COECs to algal communities (periphyton and phytoplankton), benthic invertebrates, water-column invertebrates, and fish. It will be noted

in the tables that many of the HQs (particularly for metals and certain organic compounds) are identical in most or all study sections. This is because, as explained in Sections 2.0 and 4.0, once selected as COECs, these constituents were conservatively considered to be present (and bioavailable) in aquatic media *regardless of whether they were actually measured in samples*. Half of the applicable analytical quantitation (detection) limit was used to represent an exposure-point concentration for each COEC that was "ND" in a particular location. Since the detection limits were often (but not always) the same, and the TRV was a constant, the same ratio resulted in all cases of nondetections for a particular COEC. In the following discussions, most such artifactual HQs (although reported in the tables) are mentioned but not discussed at length because they are of little relevance. These results are deemed to be highly conservative since: (1) there are no hinderances recognized for exposure; (2) all COECs are considered to be 100% bioavailable; and (3) predicted bioaccumulation is such that the resultant HQs are concentration-based with COEC mass assumed to be unlimited. There is the potential for chemicals not detected to result in the underestimation of risk (see Subsection 5.2.1.3) but for the selected COECs one-half of the detection limit in the evaluation present is a conservative approach with little chance for underestimation given the exposure assumptions made. Emphasis is placed on LOAEC-based HQs, because these generally represent empirically-derived TRVs (albeit in many cases involving surrogate receptors) that are associated with a tangible exposure/response relationship. NOAECs and NOAELs are often extrapolated values whose derivation incorporated reduction by an order of magnitude from a measured value. Even when experimentally derived, NOAECs/NOAELs are heavily dependent upon the robustness of the design of the tests; the same is true of LOAECs/LOAELs, but at least these are values associated with a clearly-defined response. The NOAECs/NOAELs are incorporated in this EA mainly to provide an indication of the higher end of the spectrum of conceivable risks. As noted above, NOAEC-based HQs are generally not addressed in the summary discussions (for the reasons stated above); however, these values (for both maximum and mean exposure-point concentrations) are included in the tables and are addressed to some degree in later discussions of preliminary remedial goals (Appendix L).

5.1.1.1 Algae

Direct exposures of periphyton and phytoplankton to surface water concentrations of the site-related inorganic COECs are compared to algal TRVs in Table 5-1. The resulting HQs suggest that aluminum, cadmium, chromium, copper, molybdenum, and zinc may be adversely affecting algal communities in the upper portions of East Soldier Creek (especially EE01 and EE02). Arsenic appears to be a significant source of risk in EE10. Copper and chromium are clearly the main potential threat to algae throughout East and West Soldier Creeks.

Algal HQs for surface-water concentrations of site-related organic COECs are summarized in Table 5-2. Whereas LOAEC-based algal HQs for PCP, total PCBs, low molecular weight PAHs, and high molecular weight PAHs suggest potential risks, the ratios are primarily artifacts of using half of the analytical quantitation limit -- inasmuch as the COECs themselves were rarely, if ever, actually measured in surface-water samples.

5.1.1.2 Aquatic Vascular Plants

Aquatic macrophyte HQs for exposures to predicted sediment pore-water concentrations of site-related organic COECs are presented in Table 5-3. The NOAEC-based HQs for PCP, total PCBs, dieldrin, heptachlor, heptachlor epoxide, and two PAH groups generally suggest that these compounds pose a risk to aquatic vascular plants. Note, however, that the plant NOAECs were mainly derived by application of a factor of 10, while the conservatism built into the EqP-based prediction of the pore-water concentrations probably significantly inflated the numerator (relative to its true value) in the HQ calculation. Notwithstanding the relative sensitivity noted in Table 2-9, vascular plants in general tend to be resistant to organic compounds (with the exception of herbicides). This phenomena is due to a lack of the toxicity targets generally associated with the aforementioned compounds. Inasmuch that both dieldrin and heptachlor were/are used as pesticides on crop species (Epstein and Legator 1971), their development in part, was to insure that such vascular plants were resistant. PCP was developed in part to serve as a herbicide (Epstein and Legator 1971) and may actually pose a hazard to vascular plants. Plants, given their physiology, are not as susceptible to PCB than the other receptors listed, as the mechanism most associated with PCB toxicity is a

distribution of liver function(s) which plants lack. Thus, the only organic COECs that might actually pose a hazard to aquatic vascular plants are PCP and the higher molecular weight PAHs, because there are gaps in our understanding of the toxicology associated with these materials and it is therefore impossible to rule out potential effects.

Owing to the lack of a reliable method for predicting sediment pore-water concentrations of the inorganic COECs, a crude comparison is provided to the lowest AET-based sediment benchmark (normally a screening value) as summarized in Table 5-4. Here the "HQs" implicate cadmium, chromium, copper, cyanide, mercury, nickel, selenium, silver, vanadium, and zinc in bulk sediments as potential hazards to vascular plants (and benthic invertebrates, see below). Among those COECs, cadmium, chromium, copper, nickel, silver, and vanadium appear to be widespread, whereas the potential risks of cyanide, selenium, mercury, and zinc are more localized.

5.1.1.3 Benthic Invertebrates

The values in Table 5-4 are also used to represent "HQs" for benthic invertebrates exposed to bulk-sediment concentrations of site-related inorganic COECs. Contrary to the situation with vascular plants, cadmium, chromium, copper, cyanide, lead, nickel, silver, vanadium, and zinc are all known to be serious to very serious toxicants to aquatic invertebrates. The aqueous-toxicity-based TRVs for most of these COECs (cadmium, chromium, copper, nickel, silver, and zinc) indicate that *if* the sediment pore-water concentrations actually approach those of the AET-based sediment benchmarks there are likely to be significant adverse effects on benthic invertebrates.

Benthic-invertebrate HQs for exposures to site-related organic COECs in sediment pore water are presented in Table 5-5. The ratios suggest that all PAHs (especially low and medium molecular weight compounds), PCBs, and benzidine pose substantial potential hazards to infaunal animals throughout both East and West Soldier Creek -- because in most cases the LOAEC-based TRVs were well below the predicted pore-water concentrations. HQs for several of the organochlorine pesticides and PCP indicate significant potential risks associated with EE05 (Outfall F). HQs for phenols and nonylphenols suggest that sediments

in the sections of East Soldier Creek below the IWTP (especially EE08) pose potential risks to benthic invertebrates.

5.1.1.4 Water-Column Invertebrates

Water-column invertebrate HQs for site-related inorganic COECs in surface water are presented in Table 5-6. The LOAEC-based HQs for cadmium and lead indicate a potential for adverse effects on these invertebrates throughout most sections in both East and West Soldier Creeks. Considering LOAEC-based HQs only, it appears that two additional metals (copper and silver) are limiting the occurrence of sensitive invertebrates in the uppermost section of East Soldier Creek (EE01). The contributions of barium, cobalt, manganese, manganese, molybdenum, and zinc exacerbate the problem in EE01 and collectively result in HIs exceeding unity in the other sections above Bradley Street (EE02 and EE03). The inorganic COECs alone probably explain the paucity and low diversity of benthic and water-column invertebrates in the uppermost reaches of East Soldier Creek (see Subsection 2.1.3 and Appendix G).

The potential risks to water-column invertebrates from surface-water concentrations of site-related organic COECs are estimated in Table 5-7. Virtually all of the high HQs for organics (i.e., those seldom, if ever, actually measured in surface-water) are artifacts of the conservative use of half the analytical quantitation limit, but it appears that at least the PAHs pose a potential hazard to water-column invertebrates in localized areas.

5.1.1.5 Fish

Fish HQs for site-related inorganic COECs are presented in Table 5-8. Considering LOAEC-based HQs only, its appears that copper is the only COEC potentially affecting the entire operable unit. Barium, cadmium, and lead pose substantial risks to fish in upper sections of East Soldier Creek and one or both lower sections in West Soldier Creek. Manganese and nickel probably add significantly to potential risks to fish in West Soldier Creek. Manganese and copper also appear to be the only inorganic COECs presenting a potential hazard to fish in East Soldier Creek below the ponded portion (EE08-EE10).

The organic HQs for fish (Table 5-9) appear, for the most part, to be artifacts of the conservative use of half the analytical quantitation limits in estimating surface-water concentrations.

5.1.2 Terrestrial/Semiaquatic Receptors

5.1.2.1 Muskrat (Herbivorous Mammal)

Tables 5-10 and 5-11 summarize the HQs for ingestion-pathway exposures of muskrats to site-related COECs. Molybdenum and high molecular weight PAHs appear to pose substantial potential risks to muskrats in many sections of East and West Soldier Creek. Nickel may be a problem in EW01, as well as in EE05 and EE06. Selenium LOAEL-based HQs exceed unity in EE06, EE09, EE10, and EW02. Arsenic is potentially a problem in EE10. In interpreting these HQs, however, it should be kept in mind that the bulk of the estimated exposure (ADD) is derived from consumption of aquatic vascular plants, which are scarce or absent in the off-base sections of East Soldier Creek (EE09 and EE10).

5.1.2.2 Red-Winged Blackbird (Omnivorous Bird)

Ingestion-pathway HQs for estimated exposures of red-winged blackbirds to site-related COECs are summarized in Tables 5-12 and 5-13. Chromium, selenium, total PCBs, heptachlor epoxide, and high molecular weight PAHs appear to present substantial potential risks to omnivorous birds throughout much of the on-base portion of East Soldier Creek and in the study sections in West Soldier Creek. The high HQs for mercury are artifacts of using half of the detection limit in water to predict (via FCMs) exposure concentrations. Several pesticides are responsible for LOAEL-based HQs greater than 1 in EE05 (Outfall F), and nickel appears to be a problem in EW01. Arsenic, chromium, and selenium HQs exceeding unity are also associated with off-base sections including, in the case of selenium, West Soldier Creek. It should be kept in mind that the off-base study sections (except upper portions of EE09) are generally not attractive habitat for the red-winged blackbird.

5.1.2.3 Raccoon (Omnivorous Mammal)

Tables 5-14 and 5-15 present the HQs for ingestion-pathway exposures of raccoons to site-related COECs. Total PCBs and high molecular weight PAHs appear to pose a hazard to omnivorous mammals throughout the Operable Unit. LOAEL-based HQs for molybdenum exceeded unity in EE02.

5.1.2.4 Green Heron (Carnivorous Bird)

Ingestion-pathway HQs for estimated exposures of green heron to site-related COECs are presented in Tables 5-16 and 5-17. As in the case of omnivorous birds and mammals, total PCBs and high molecular weight PAHs appear to be a substantial potential threat to carnivorous birds throughout much of the Operable Unit. The high HQs for mercury are artifacts of using half of the detection limit in water to predict (via FCMs) exposure concentrations. HQs for chromium, lead, and nickel exceeded unity in more localized areas. The green heron also appears to be at potential risk from ingestion of aldrin, alpha-chlordane, heptachlor, and heptachlor epoxide in any prey obtained from the vicinity of EE05 (Outfall F). However, this section is very small (with only a few square meters of rooted aquatic plants) and in a location that is unlikely to be visited very frequently by wading birds..

5.1.3 Microbial Decomposers

Relatively few TRVs, all for inorganic COECs, were available for bacteria and fungi. HQs for microbial decomposers in surface water are summarized in Table 5-18, indicating that nickel might pose a threat to these receptors in several areas. Although no LOAEL-based HQs exceeded unity, the HI for EW01 was 1.08, and nickel contributed significantly to that value.

5.2 EVALUATION OF UNCERTAINTY

It is essential that the EA fully characterize, at least qualitatively, the sources of uncertainty at every stage in the process and summarize them again at this point (USEPA 1992). In an

ecological risk assessment, uncertainty can be contributed by four basic factors (USEPA 1992):

- stochasticity (natural variation)
- lack of information ("data gaps")
- flawed model assumptions
- human error

Natural variability is an inherent characteristic of ecological systems and the factors that influence the systems (e.g., weather). Of all the contributions to uncertainty, stochasticity is the only one that can be acknowledged and described but not reduced (Suter 1990; 1993). For example, and as noted in Section 2.1, target sample quotas for crayfish were not met during the 1994 assessment. Inasmuch as densities of *Orconectes* clearly declined between the June 1994 reconnaissance and October 1994 it is evident that at least part of the decline is attributable to natural changes in the crayfish population. As one of the most important aquatic prey organisms in each area, *Orconectes* presumably underwent substantial attrition over the intervening months. Moreover, these animals tend to retire to burrows during autumn and winter (Hobbs 1972). Results of the June 1995 sampling corroborate the foregoing discussion.

Lack of empirical measurements of COEC concentrations in most of the forage items (e.g., plant tissues) are examples of "data gaps" that introduce uncertainty in this EA.

An example of potentially-flawed model assumptions in the EA would be the selection of certain receptors to represent exposure pathways. Several species of wading birds are likely to occur, at least occasionally, in the Operable Unit, which raises the issue of whether the green heron is the most appropriate representative of the category. However, the selection is considered appropriate (see the rationale presented in Subsection 4.1.2.1) -- and, in any case conservative because the plausible alternatives are larger birds.

Another example may be the use of equilibrium partitioning modeling (EqP) to assess chemicals in aquatic sediment. There are a number of inherent assumptions required for the application of EqP modeling that are not met and can never be met, therefore, leading to significant uncertainty. However, the EqP approach does show promise regarding sediment

risk assessment in that while it may over estimate potential toxicity and perhaps bioconcentration, it can be an effective risk screening mechanism.

Human error is always possible, although most if not all simple mistakes of transcription and calculation are generally eliminated through meticulous technical review. Ecological risk assessment necessarily relies heavily on professional judgement (USEPA 1989a, 1992; Suter 1993), which, to the extent that it may be erroneous, can also contribute to uncertainty. The only way to eliminate or at least minimize this contribution is to ensure that qualified ecologists and ecotoxicologists are involved in the planning and implementation of the assessment.

5.2.1 Sampling and Analyses

The types and numbers of samples/observations, sampling procedures, and analytical procedures all contain elements that contribute to uncertainties in the EA. The following discussion addresses the major elements of study design and implementation that contribute uncertainty.

5.2.1.1 Spatiotemporal Distribution of Sampling

Sampling locations were intended to address two basic objectives: (1) verification that concentrations of COECs are in fact elevated in the Soldier Creek Sediment and Surface Water Operable Unit relative to off-site areas; and (2) characterization of variation in COEC levels in various media among sections within the Operable Unit. For all physical media the specified numbers of samples/measurements were obtained in both areas. With only two measurements of bulk COEC concentrations in physical media from a given section an inevitable question remains about the representativeness of the mean and maximum values used as exposure point concentrations, especially for sediments. In many sections, however, there were logistical problems in obtaining adequate volumes of sediment for even the few samples obtained (due to predominantly erosional conditions). The issue of further sampling to address uncertainty is addressed in Appendix L. The Workplan (WCFS 1994) design was not fulfilled for crayfish (neither area) during 1994, apparently due in large part to sampling

at a time when the animals were few in number and aestivating. This problem was resolved by the second field sampling event (June 1995).[3]

The sampling design for the EA *per se* did not address temporal variation in COEC concentrations in physical media beyond the establishment of two sampling events. This is partially mitigated by consideration of Quarterly Monitoring results, insofar as available. Note, however, that quarterly data were not used in estimating exposure point concentrations because in most cases the samples were not precisely collocated with points where ecological samples were obtained.

An element of uncertainty also persists regarding temporal variation in COEC concentrations in biotic media. For example, in at least crayfish (and presumably most other forage organisms) there is a relationship between whole-body COEC levels and lipid content, which varies seasonally in most organisms. Another important consideration is that for some of the smaller organisms with relatively short life spans and relatively high metabolic rates (e.g., crayfish, many insects, rodents) seasonal variation in "average" or representative COEC concentrations are expected merely because different cohorts (age-classes) would be represented in samples. COEC levels in crayfish are significantly affected by the molting process (Kleinow and Goodrich 1994). It thus matters considerably *when* samples of biological tissues are collected. This was dramatically illustrated by the differences in the whole-body crayfish concentrations of volatile organic COECs between the two sampling events.

5.2.1.2 Sampling Process

The sampling process itself can contribute to uncertainties in the data due to numerous factors, such as: sampling contamination (e.g., cross-contamination from other locations); inappropriate sample storage (e.g., failure to maintain proper temperatures); and sample loss or breakage. Aside from certain external factors influencing actual acquisition of targeted increments of media (e.g., sampling crayfish in the "wrong" season), there were no

[3]**The implications of these observations relative to assuming that crayfish consistently contribute a particular proportion to the diet of consumer species should also be noted.**

significant deviations from the procedures outlined in Appendix A, so uncertainties due to the sampling process *per se* are considered inconsequential in this EA.

5.2.1.3 Analytical Factors

Analytical methodologies and sensitivities were all intended to be state-of-the-art or even more rigorous (see Section 3.0, as well as Appendix A). Most of the *a priori* requirements were met; Appendix E provides a detailed discussion of any required "qualifications" of analytical results (and these qualifiers are incorporated in the presentations of the data in Appendices C and D). Although the *nominal* method quantitation limits for most of the COECs (except PCBs) were generally adequate, matrix effects and other factors resulted in many actual detection limits (especially for certain organics) for specific samples being too high to support subsequent interpretation. As noted in Subsection 2.2, many obscure organic constituents in the bulk-sediment matrix could not be conclusively selected or eliminated as COECs due to a few individual analyses where the quantitation limits were unavoidably too high. Table 5-19 summarizes the chemicals listed as uncertainties for this EA. As discussed in Section 2.2.2, the potential for some constituents other than or in addition to those definitely selected as COECs to contribute to the overall risk is a source of uncertainty. And, as noted earlier in this section, a number of exposure concentration estimations had to default to half the detection limit, which in turn resulted in extremely high HQs (again mainly for organics). On balance, it appears that analytical sensitivity is a very significant source of uncertainty in this EA. While certain detection limits led to uncertainty regarding the selection of COECs, of those chemicals selected as COECs, the use of one-half of the detection limit in the calculation of ADDs from locations where the COEC was not detected essentially ensures that the ADD was not underestimated.

5.2.2 Exposure Assumptions

Point values for exposure factors and exposure-point concentrations are used in this EA, rather than a range of values that would describe the distribution of exposures. With respect to the exposure factors in particular, however, deliberate efforts were made to ensure that the values are realistically conservative as discussed at some length in previous subsections.

This reduces uncertainty in the sense that underestimates of *exposure* are essentially precluded.

5.2.2.1 Area Use Factor

When a range of reported "home ranges" or foraging areas was available, the lowest credible extreme was consistently selected and then divided by the largest conceivable acreage of usable habitat in the Operable Unit to derive the percent of that receptor's diet assumed to come from the study area (Table 4-1). Thus any uncertainty attributable to area use factors for most of the receptors relates to the degree to which the exposure is overestimated.

5.2.2.2 Body Weight

As in the case of all the other exposure factors, use of a single point value for body weight (especially an extreme as used herein; i.e., the low-point of reported ranges) introduces uncertainty. But uncertainty attributable to BW assumptions is probably inconsequential because in evaluating ingestion-pathways the exposures are ultimately normalized to body weight via calculation of the doses. It is acknowledged, however, that assumed ingestion rates (for all media), when derived from allometric relationships (cf. USEPA 1993b), depend in part on body weights.

5.2.2.3 Food Ingestion Rate

Food ingestion rates for most wildlife are either unknown or highly variable and very site-specific (USEPA 1993b). It thus must be acknowledged that the IR_{food} may be a significant contributor of uncertainty in applied dietary doses (ADDs) in this EA. However, as discussed at length above, derivation of the IR_{food}s/ADDs is done in a way that tends to preclude underestimation. It follows that dietary exposures to all designated receptors are probably overestimated to some degree.

5.2.2.4 Water Ingestion Rate

As in the case of food ingestion rates, the assumed water ingestion rates include a substantial element of uncertainty (for the same reasons). And, unlike IR_{food}s, there was no technically-credible way to derive IR_{water}s that would *guarantee* overestimation. Even so, the uncertainty attributable to IR_{water} assumptions is inconsequential because the incremental contribution to ingestion pathway exposures is extremely small.

5.2.2.5 Sediment Ingestion Rate

Sediment ingestion rates are extremely variable among vertebrates in general and poorly, if at all, documented in the designated receptors for this EA (USEPA 1993b; Beyer *et al.* 1994). At the same time, the discussion in Appendix L shows that this factor essentially "drives" the ADDs (hence HQs/HIs) for some COECs in receptors like the green heron and raccoon. The sediment ingestion rates assumed are sufficiently conservative to ensure that related doses are unlikely to be underestimated. With this in mind it should be pointed out that these rates may be the most significant sources of uncertainty among all those related to ingestion-pathway exposure assumptions.

5.2.2.6 Composition of Diet

As discussed in Subsection 4.1.1, there is considerable uncertainty associated with predicted diets for the designated receptors. The diets assumed for this EA are based on careful consideration of published information on populations considered most relevant to environments like the Soldier Creek Sediment and Surface Water Operable Unit, but professional judgement necessarily played a role. The intent was to predict as realistic a diet as possible with the information at hand. Fortunately, for most receptors there are several published diets for highly-relevant populations. Unfortunately, the uncertainty in this factor cannot be absolutely guaranteed to consistently overestimate exposures. But neither is it likely to significantly underestimate exposures, for the simple reason that the diets are realistic when compared to a relatively large literature[4].

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[4]**Indeed, contrary to the general perception that assuming simplified diets (e.g., 100% fish when fish are perceived to be particularly contaminated, relative to, say invertebrates) will guarantee maximal**

5.2.2.7 Other Physiological and Behavioral Considerations

A very significant source of uncertainty in dietary exposure estimation is the assumption of 100% assimilation efficiency. This factor was ignored because it is dependent upon numerous complex and interrelated conditions, and therefore virtually impossible to predict with certainty. It must be stated, however, that assimilation cannot (*per* thermodynamic laws) be complete. Assimilation efficiencies have been empirically measured in numerous domesticated (or at least captive) animals. In general, herbivores assimilate from 60-75% of the energy value in their food, carnivores assimilate from about 85-93%, and omnivores are intermediate (Teubner and Barrett 1983). For example, assimilation efficiencies of 87-89% have been measured for subadult raccoons (Teubner and Barret 1983), which the authors cited as evidence for a predominance of carnivory in the species.

Note, moreover, that one of the more important factors affecting assimilation rates, relative to COECs, is that binding efficiencies vary among the matrices ingested (Kleinow and Goodrich 1994). The raccoon, for example, assimilates materials from animal prey much more effectively than from vegetable material. The disparity in binding efficiencies among food matrices is particularly important. When ingesting relatively inert materials like soil, sediment, crustacean carapaces, feathers, or hair, most animals (higher vertebrates in particular) will actually assimilate very little of any contained nutrients or contaminants.

Another physiological axiom that has relevance to the issue of "preferential" feeding is the fact that ration size strongly influences assimilation efficiency (Kleinow and Goodrich 1994). Many animals, especially predators (e.g., green herons) are "binge" feeders (Allee *et al.* 1951). But any physiology textbook will confirm that, *the larger the ration, the higher the ejestion rate and the lower the assimilation rate* (Kleinow and Goodrich 1994). So, even though there may be preferential feeding upon, say, crayfish in late spring and early summer, the actual dose incurred from crayfish may not be equivalent to that derived from a more steady diet of staple components.

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estimated ingestion-pathway exposures, assuming more realistic (complex) diets will in fact inflate dose estimates. This is because prey items from higher trophic levels (e.g., amphibians, reptiles, small birds and mammals) will typically have much higher body burdens (than fish) of most COECs.

In summary, all of the immediately-foregoing factors that relate to conservative assumptions of thermodynamic steady-state conditions, first-order kinetics, and 100% assimilation efficiencies (none of which actually obtain in nature) work together to ensure overestimation of actual doses via the ingestion pathway.

5.2.2.8 Exposure Point Concentrations

There is always uncertainty associated with the use of single-point values, particularly when they are actual single measurements or summary statistics from small arrays of measurements (see discussion at 5.2.1.1). Use of a solitary measurement or estimate may either underestimate or overestimate the actual exposure. The only mitigation for the problem in this EA is the availability of four sets of quarterly-monitoring data, which generally corroborate the patterns and concentrations of COECs indicated by sediment and surface-water sampling during the ecological field activities. It is noteworthy, however, that there were some apparent inconsistencies between the two sets of data that may or may not be attributable to the facts that they were not contemporaneous or collocated. For example, several of the pesticides were detected more frequently and in higher concentrations during quarterly monitoring than during the two ecological sampling events[5].

5.2.3 Effects Levels (Ecotoxicological Reference Values [TRVs])

The direct-exposure toxicity reference values (TRVs) used in this EA for the strictly-aquatic receptors are (or are derived from) essentially the lowest available LOAELs. As such, these TRVs are unlikely to underestimate the hazards, since the tests upon which they are based involved high doses of COECs administered in forms that assured maximal availability. Therefore, the principal uncertainty associated with the aquatic-receptor TRVs is the degree to which the HQs/HIs overstate the potential hazard.

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[5]**The unusual "hits" for some pesticides were from deeper layers, presumably representing historic releases that were subsequently covered by deposition.**

The dietary TRVs used in the this EA are (or are derived from), for the most part, LOAELs and NOAELs based on measured dose/response relationships in species that are only surrogates for the designated receptors in the Operable Unit. As such, there is greater uncertainty associated with the dietary TRVs than with the aquatic TRVs. For certain COEC/receptor combinations, the possibility that hazards to individuals may be underestimated (or overestimated) cannot be ruled out. For example, the lack of relevant dietary toxicological data for amphibians and reptiles leads to the issue that potential risks to these animals remains one of the most significant uncertainties in this EA. The endpoints of the tests used to derive most of these TRVs, however, are sufficiently sensitive that adverse effects at the population level are unlikely to be significant. Moreover, as in the case of the aquatic TRVs, the tests used to derive the dietary TRVs involved administration of essentially pure forms of the COECs, which would tend to enhance uptake compared to the forms likely to be encountered in nature. It should also be noted that scaling factors (such as proposed by Opresko *et al.* 1994) were not applied in extrapolating TRVs from experimental data involving surrogate receptors.

Further considerations of uncertainty include the fact that the EA's approach addresses dietary hazards to adult animals, whereas immature individuals may be more sensitive. Additionally, the evaluation of hazards for individual site-related COECs may understate the cumulative risk by not considering additive or synergistic effects. Derivation of HIs is an attempt to at least partially mitigate this problem. It is also known that certain combinations of COECs counteract each other's toxicity, resulting in an antagonistic effect (Suter 1993).

5.3 RISK DESCRIPTION

Risk description has two main elements: (1) an ecological risk summary (i.e., of the foregoing subsection, as well as results of previous investigations); and (2) interpretation of ecological significance.

5.3.1 Ecological Risk Summary

Based on the results summarized above, the EA indicates that exposures via all pathways pose some risk of both acute and chronic, sublethal effects to certain individual receptors or

individuals of receptor classes. In many cases, the HQs and HIs appear to be somewhat inflated by additive conservative assumptions, but the weight of evidence suggests definite patterns which are generally corroborated by other measurement endpoints. The quotient-method estimates, toxicity-test results, and benthic invertebrate studies, all show that the magnitude of actual or potential effects is very COEC- and location-dependent. In general, the on-base sections of both East and West Soldier Creeks appear to pose hazards to both aquatic animals and some of the terrestrial wildlife that may feed in the vicinity. Both "measured" (i.e., toxicity testing) and estimated risks for many COECs seem to exhibit gradients in West Soldier Creek in general and within the major hydrographic subdivisions of East Soldier Creek. PCBs and PAHs and their estimated effects are fairly pervasive on-base in both streams, while most of the metals and their apparent and estimated effects are concentrated in the upper reaches of both streams. Many of the other organics (e.g., some pesticides and the chloronaphthalenes) are localized in the ponded area of East Soldier Creek. There also appear to be some COECs with apparent and estimated risks that are related to the IWTP (nonylphenols, some pesticides, TPS).

In this EA it appears that, on balance, most of the uncertainty is associated with the degree to which exposures and toxicities are overestimated. This is consistent with ERAGS (USEPA 1994), and is appropriate for this modified "desktop" assessment. There remains a slight potential for "false negative" inferences (i.e., underestimation of risk) due to lack of absolute certainty in the predicted dietary composition, as well as the use of TRVs derived from tests with surrogate receptors (and, in a few cases, surrogate chemicals). Nevertheless, the weight of evidence presented herein provides a reasonable degree of confidence in the potential risk estimates, at least in a *relative sense*. Better understanding of the ingestion-pathway exposures (as opposed to estimating dietary constituent concentrations of COECs) may require additional sampling. For example, sampling/analyses of plant tissues (particularly fruits), amphibians, and/or small mammals would provide a better understanding of the dietary exposures to higher-level consumers as well as more insights into the actual availability for direct uptake of the COECs.

Another uncertainty which may be of greater significance is the degree to which the concentrations of COECs, in physical media and biota, extend beyond the study area boundaries as herein defined. As noted above, measurements of many of the constituents in

sediment and surface water indicated clear upstream-to-downstream concentration gradients. The distributions of HQs, however, did not always reflect these gradients, and when they did the rate of decrease was typically lower than that of the change in bulk media concentrations. This is explained primarily by the relative bioavailability or propensity for desorption, which is heavily influenced by sediment texture, organic carbon content, and other aspects of sediment chemistry. Nevertheless, the salient point is that, for some COECs (e.g., chromium, copper, PCBs, PAHs) neither the bulk concentrations in physical media nor the associated estimated risk (HQ) had diminished to negligible levels on the south side of I-40. At some point it may be advisable to consider sampling selected media farther downstream to more accurately characterize the extent of contamination and associated potential hazards to ecological receptors.

5.3.2 Interpretation of Ecological Significance

The apparent and estimated adverse effects of several of the COECs, based on the results of this limited study, suggest impacts of potential ecological significance (i.e., at the population and community level, primarily to strictly-aquatic receptors and small terrestrial vertebrates). These effects seem largely-confined to the on-base portions of the Soldier Creek Sediment and Surface Water Operable Unit, (but see the discussion at the end of the immediately-preceding subsection). Moreover, as noted in earlier sections of this report, interpretation of significance is confounded by the overt presence of other stresses -- especially the extensive physical modifications of habitats in both creeks and the presence of NPDES outfalls which dominate flows in East Soldier Creek.

The ecological significance of the apparent and estimated potential hazards must finally be addressed in the context of the assessment endpoints (Subsection 2.3). Table 5-19 (a modified version of Table 2-10) summarizes the resolution of the measurement endpoints. Virtually every null hypothesis ("No effect or potential effect?") implied by the consolidated measurement endpoints is rejected, at least to some degree. This would suggest, on balance, that ecological receptors have been (and are being) adversely affected by the presence of at least some of the site-related COECs. Considering the relative quality and quantity of the habitats and their inhabitants (see Subsection 2.1), however, these actual or potential effects are clearly limited to a localized scale. This is why the most ecologically-relevant actual or

potential effects are those on strictly-aquatic communities (i.e., algae, benthic and water-column invertebrates, fish) and small terrestrial/semiaquatic animals. Aside from an occasional individual in certain on-base portions of the Operable Unit, it appears unlikely that larger terrestrial vertebrates ("wildlife") are at much risk from site-related COECs.

TABLE 5-1
HAZARD QUOTIENTS FOR ALGAE DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Aluminum	NOAEL	Mean	46	460	1.739	1.087	1.087	1.087	7.283	2.217	2.500	1.576	1.620	1.609	2.283	3.174	2.717
	NOAEL	Max			2.391	1.087	1.087	1.087	12.391	2.609	2.826	1.848	2.022	1.739	3.478	4.783	3.043
	LOAEL	Mean			0.174	0.109	0.109	0.109	0.728	0.222	0.250	0.158	0.162	0.161	0.228	0.317	0.272
	LOAEL	Max			0.239	0.109	0.109	0.109	1.239	0.261	0.283	0.185	0.202	0.174	0.348	0.478	0.304
Antimony	NOAEL	Mean	200	610	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.188	0.150	0.150	0.150	0.150
	NOAEL	Max			0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.225	0.150	0.150	0.150	0.150
	LOAEL	Mean			0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.061	0.049	0.049	0.049	0.049
	LOAEL	Max			0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.074	0.049	0.049	0.049	0.049
Arsenic	NOAEL	Mean	4.8	48	0.521	0.500	0.760	0.781	1.042	0.781	0.281	0.521	0.521	24.219	0.427	0.427	0.448
	NOAEL	Max			0.521	0.771	1.042	1.042	1.042	1.042	0.354	0.521	0.521	47.917	0.521	0.521	0.521
	LOAEL	Mean			0.052	0.050	0.076	0.078	0.104	0.078	0.028	0.052	0.052	2.422	0.043	0.043	0.045
	LOAEL	Max			0.052	0.077	0.104	0.104	0.104	0.104	0.035	0.052	0.052	4.792	0.052	0.052	0.052
Barium	NOAEL	Mean	250	2500	1.660	2.140	1.940	1.740	1.620	1.500	1.400	1.360	1.380	1.320	0.920	1.000	1.040
	NOAEL	Max			1.760	2.600	2.000	1.880	1.800	1.800	1.880	1.640	1.680	1.560	0.960	1.320	1.360
	LOAEL	Mean			0.166	0.214	0.194	0.174	0.162	0.150	0.140	0.136	0.138	0.132	0.092	0.100	0.104
	LOAEL	Max			0.176	0.260	0.200	0.188	0.180	0.180	0.188	0.164	0.168	0.156	0.096	0.132	0.136
Cadmium	NOAEL	Mean	0.2	2	6.950	8.275	8.325	1.650	41.500	4.400	4.750	4.275	4.400	4.575	1.575	6.900	3.275
	NOAEL	Max			12.500	12.500	12.500	1.800	49.000	5.500	6.000	5.000	5.000	5.500	1.800	12.000	5.000
	LOAEL	Mean			0.695	0.828	0.833	0.165	4.150	0.440	0.475	0.428	0.440	0.458	0.158	0.690	0.328
	LOAEL	Max			1.250	1.250	1.250	0.180	4.900	0.550	0.600	0.500	0.500	0.550	0.180	1.200	0.500
Chromium	NOAEL	Mean	0.2	2	25.00	51.25	34.00	28.25	67.50	25.00	27.75	157.50	112.50	67.50	25.00	29.00	25.00
	NOAEL	Max			25.00	60.00	43.00	31.50	110.00	25.00	30.50	210.00	165.00	80.00	25.00	33.00	25.00
	LOAEL	Mean			2.50	5.13	3.40	2.83	6.75	2.50	2.78	15.75	11.25	6.75	2.50	2.90	2.50
	LOAEL	Max			2.50	6.00	4.30	3.15	11.00	2.50	3.05	21.00	16.50	8.00	2.50	3.30	2.50

TABLE 5-1
HAZARD QUOTIENTS FOR ALGAE DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Copper	NOAEL	Mean	0.1	1	70.0	1400.0	615.0	350.0	150.0	365.0	320.0	159.5	160.0	150.0	51.5	79.0	83.0
	NOAEL	Max			92.0	1500.0	700.0	380.0	200.0	490.0	420.0	220.0	200.0	160.0	65.0	120.0	130.0
	LOAEL	Mean			7.0	140.0	61.5	35.0	15.0	36.5	32.0	16.0	16.0	15.0	5.2	7.9	8.3
	LOAEL	Max			9.2	150.0	70.0	38.0	20.0	49.0	42.0	22.0	20.0	16.0	6.5	12.0	13.0
Cyanide	NOAEL	Mean	3	30	0.834	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667
	NOAEL	Max			1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667
	LOAEL	Mean			0.083	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
	LOAEL	Max			0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167
Iron	NOAEL	Mean	1000	10000	0.125	0.155	0.079	0.069	0.340	0.140	0.160	0.190	0.180	0.180	0.970	0.200	0.205
	NOAEL	Max			0.200	0.200	0.085	0.087	0.570	0.180	0.170	0.210	0.190	0.220	1.700	0.310	0.300
	LOAEL	Mean			0.013	0.016	0.008	0.007	0.034	0.014	0.016	0.019	0.018	0.018	0.097	0.020	0.021
	LOAEL	Max			0.020	0.020	0.009	0.009	0.057	0.018	0.017	0.021	0.019	0.022	0.170	0.031	0.030
Lead	NOAEL	Mean	50	500	0.038	0.260	0.044	0.029	0.073	0.327	0.061	0.044	0.097	0.045	0.042	0.258	0.030
	NOAEL	Max			0.054	0.480	0.070	0.040	0.136	0.600	0.064	0.046	0.152	0.046	0.044	0.500	0.040
	LOAEL	Mean			0.004	0.026	0.004	0.003	0.007	0.033	0.006	0.004	0.010	0.005	0.004	0.026	0.003
	LOAEL	Max			0.005	0.048	0.007	0.004	0.014	0.060	0.006	0.005	0.015	0.005	0.004	0.050	0.004
Manganese	NOAEL	Mean	2000	20000	0.005	0.005	0.004	0.004	0.013	0.016	0.015	0.068	0.063	0.070	0.134	0.031	0.039
	NOAEL	Max			0.008	0.006	0.005	0.005	0.015	0.027	0.024	0.075	0.070	0.090	0.250	0.038	0.050
	LOAEL	Mean			0.001	0.000	0.000	0.000	0.001	0.002	0.002	0.007	0.006	0.007	0.013	0.003	0.004
	LOAEL	Max			0.001	0.001	0.000	0.000	0.001	0.003	0.002	0.008	0.007	0.009	0.025	0.004	0.005
Mercury	NOAEL	Mean	0.08	0.8	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
	NOAEL	Max			1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
	LOAEL	Mean			0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
	LOAEL	Max			0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Nickel	NOAEL	Mean	4000	8000	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.005	0.017	0.004	0.004
	NOAEL	Max			0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.025	0.005	0.005
	LOAEL	Mean			0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.009	0.002	0.002
	LOAEL	Max			0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.012	0.003	0.003

TABLE 5-1
HAZARD QUOTIENTS FOR ALGAE DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Silver	NOAEL	Mean	3	30	0.020	0.018	0.038	0.017	0.050	0.017	0.017	0.040	0.032	0.017	0.028	0.030	0.017
	NOAEL	Max			0.023	0.020	0.060	0.017	0.083	0.017	0.017	0.063	0.047	0.017	0.040	0.043	0.017
	LOAEL	Mean			0.002	0.002	0.004	0.002	0.005	0.002	0.002	0.004	0.003	0.002	0.003	0.003	0.002
	LOAEL	Max			0.002	0.002	0.006	0.002	0.008	0.002	0.002	0.006	0.005	0.002	0.004	0.004	0.002
Zinc	NOAEL	Mean	3	30	5.667	21.167	8.333	8.167	13.333	8.333	9.500	7.500	7.667	8.000	8.833	5.000	5.500
	NOAEL	Max			6.667	28.333	8.667	8.667	13.667	8.333	9.667	8.333	8.000	8.667	9.333	5.333	6.667
	LOAEL	Mean			0.567	2.117	0.833	0.817	1.333	0.833	0.950	0.750	0.767	0.800	0.883	0.500	0.550
	LOAEL	Max			0.667	2.833	0.867	0.867	1.367	0.833	0.967	0.833	0.800	0.867	0.933	0.533	0.667
Hazard Indices	NOAEL	Mean			114	1488	673	395	286	411	370	336	292	261	95	128	124
	NOAEL	Max			144	1609	772	429	392	538	475	451	386	309	111	181	175
	LOAEL	Mean			11	149	67	40	29	41	37	34	29	26	10	13	12
	LOAEL	Max			14	161	77	43	39	54	47	45	39	31	11	18	18

Note: Values of 0.000 should be interpreted as the hazard quotient being less than 0.001, rather than an indication of zero risk.

TABLE 5-2
HAZARD QUOTIENTS FOR ALGAE DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/l)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Acetone	NOAEL	Mean	114.9	1149.3	0.0870	0.0609	0.1044	0.0435	0.0435	0.0527	0.0657	0.0683	0.0740	0.0435	0.0435	0.0435	0.0405
	NOAEL	Max			0.1305	0.0783	0.1654	0.0435	0.0435	0.0618	0.0670	0.0957	0.1044	0.0435	0.0435	0.0435	0.0435
	LOAEL	Mean			0.0087	0.0061	0.0104	0.0044	0.0044	0.0053	0.0066	0.0068	0.0074	0.0044	0.0044	0.0044	0.0040
	LOAEL	Max			0.0131	0.0078	0.0165	0.0044	0.0044	0.0062	0.0067	0.0096	0.0104	0.0044	0.0044	0.0044	0.0044
Carbon Disulfide	NOAEL	Mean	4000	8000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	NOAEL	Max			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	LOAEL	Mean			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LOAEL	Max			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Toluene	NOAEL	Mean	94	940	0.0266	0.1463	0.0160	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0255	0.0266	0.0266
	NOAEL	Max			0.0266	0.2660	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266	0.0266
	LOAEL	Mean			0.0027	0.0146	0.0016	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0026	0.0027	0.0027
	LOAEL	Max			0.0027	0.0266	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027
1,4-Dichlorobenzene	NOAEL	Mean	16	160	0.2188	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125
	NOAEL	Max			0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125
	LOAEL	Mean			0.0219	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313
	LOAEL	Max			0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313

TABLE 5-2
HAZARD QUOTIENTS FOR ALGAE DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/l)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Pentachlorophenol	NOAEL	Mean	0.8	8	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3
	NOAEL	Max			31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3
	LOAEL	Mean			3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	LOAEL	Max			3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Phthalates	NOAEL	Mean	3.2	32	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.0781	1.5625	9.8438
	NOAEL	Max			1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	1.5625	18.1250
	LOAEL	Mean			0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1078	0.1563	0.9844
	LOAEL	Max			0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	1.8125
Total PCBs	NOAEL	Mean	0.01	0.1	75.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
	NOAEL	Max			100.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
	LOAEL	Mean			7.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	LOAEL	Max			10.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Dieldrin	NOAEL	Mean	1	10	0.0500	0.0500	0.0500	0.0500	0.0610	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0610	0.0500
	NOAEL	Max			0.0500	0.0500	0.0500	0.0500	0.0720	0.0500	0.0500	0.0500	0.0500	0.0500	0.0500	0.0720	0.0500
	LOAEL	Mean			0.0050	0.0050	0.0050	0.0050	0.0061	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0061	0.0050
	LOAEL	Max			0.0050	0.0050	0.0050	0.0050	0.0072	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0072	0.0050
Low MW PAHs	NOAEL	Mean	0.033	0.33	151.5	151.5	151.5	151.5	184.8	151.5	151.5	151.5	151.5	151.5	151.5	151.5	151.5
	NOAEL	Max			151.5	151.5	151.5	151.5	218.2	151.5	151.5	151.5	151.5	151.5	151.5	151.5	151.5
	LOAEL	Mean			15.2	15.2	15.2	15.2	18.5	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
	LOAEL	Max			15.2	15.2	15.2	15.2	21.8	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
Middle MW PAHs	NOAEL	Mean	41.4	414	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.8
	NOAEL	Max			0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.1	1.5
	LOAEL	Mean			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	LOAEL	Max			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
High MW PAHs	NOAEL	Mean	0.05	0.5	200.0	250.0	250.0	250.0	277.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
	NOAEL	Max			300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
	LOAEL	Mean			20.0	25.0	25.0	25.0	27.7	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	LOAEL	Max			30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Hazard Indices	NOAEL	Mean			460	485	485	485	545	535	535	535	535	535	534	535	544
	NOAEL	Max			585	535	535	535	602	535	535	535	535	535	535	535	553
	LOAEL	Mean			46	49	48	48	55	53	53	53	53	53	53	53	54
	LOAEL	Max			58	54	54	53	60	53	53	53	53	54	53	53	55

Values reported as 0.0000 should be interpreted as a hazard quotient less than 0.0001, rather than an indication of zero risk.

TABLE 5-3

HAZARD QUOTIENT FOR VASCULAR PLANTS DIRECTLY EXPOSED TO ORGANIC COECs IN SEDIMENT PORE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek					
CONSTITUENT	ENDPOINTS	VALUE	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06
2,4-Dimethylphenol	NOAEL	Mean	2900.0	29000.0	0.0114	0.0247	0.0130	0.0091	0.1266	0.0175
	NOAEL	Max			0.0190	0.0362	0.0176	0.0093	0.1631	0.0294
	LOAEL	Mean			0.0011	0.0025	0.0013	0.0009	0.0127	0.0017
	LOAEL	Max			0.0019	0.0036	0.0018	0.0009	0.0163	0.0029
Pentachlorophenol	NOAEL	Mean	1.9	19.0	4.8880	10.3338	5.4562	3.8693	54.6536	7.2775
	NOAEL	Max			8.1049	15.1755	7.3393	3.9685	71.6150	12.2424
	LOAEL	Mean			0.4888	1.0334	0.5456	0.3869	5.4654	0.7277
	LOAEL	Max			0.8105	1.5176	0.7339	0.3969	7.1615	1.2242
Hazard Indices	NOAEL	Mean			5	10	5	4	55	7
	NOAEL	Max			8	15	7	4	72	12
	LOAEL	Mean			1	2	1	0	7	1
	LOAEL	Max			1	2	1	0	7	1

TABLE 5-3

HAZARD QUOTIENT FOR VASCULAR PLANTS DIRECTLY EXPOSED TO ORGANIC COECs IN SEDIMENT PORE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINTS	VALUE	TRVs (ug/l)		Soldier Creek						
			NOAEL	LOAEL	EE07	EE08	EE09	EE10	EW01	EW02	EW03
2,4-Dimethylphenol	NOAEL	Mean	2900.0	29000.0	0.0201	0.2069	0.0034	0.0034	0.0059	0.0192	0.0475
	NOAEL	Max			0.0217	0.3793	0.0034	0.0035	0.0077	0.0202	0.0487
	LOAEL	Mean			0.0022	0.0207	0.0003	0.0003	0.0006	0.0019	0.0047
	LOAEL	Max			0.0022	0.0379	0.0003	0.0004	0.0008	0.0020	0.0049
Pentachlorophenol	NOAEL	Mean	1.9	19.0	8.5075	12.5385	1.4694	1.4326	2.4591	8.0490	20.3208
	NOAEL	Max			9.3177	17.5913	1.4694	1.4694	3.2223	8.4515	21.3903
	LOAEL	Mean			0.9318	1.2538	0.1469	0.1433	0.2459	0.8049	2.0321
	LOAEL	Max			0.9318	1.7591	0.1469	0.1469	0.3222	0.8451	2.1390
Hazard Indices	NOAEL	Mean			9	13	1	1	2	8	20
	NOAEL	Max			9	18	1	1	3	8	21
	LOAEL	Mean			1	2	0	0	0	1	2
	LOAEL	Max			1	2	0	0	0	1	2

TABLE 5-4

HAZARD QUOTIENTS FOR VASCULAR PLANTS AND BENTHIC INVERTEBRATES DIRECTLY EXPOSED TO INORGANIC COECs IN BULK SEDIMENT FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	TRVs	EE01		EE02		EE03		EE04		EE05		EE06		EE07		EE08		EE09		EE10		EW01		EW02		EW03	
	Bench mark	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
Aluminum	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Arsenic	6	0.3	0.3	0.8	1.5	0.2	0.3	0.2	0.3	0.5	0.6	0.9	1.0	0.1	0.2	0.3	0.3	0.1	0.2	0.4	0.5	0.5	0.7	0.3	0.3	0.5	1.0
Cadmium	0.6	3.2	3.5	1.8	2.5	6.7	9.2	5.5	6.0	258	343	168	263	9.1	13.5	29.5	38.0	45.7	46.3	23.7	44.2	59.3	110.5	6.3	6.5	2.0	3.5
Chromium	26	0.5	0.6	2.1	3.3	1.2	1.2	2.8	4.2	25.4	28.8	29.8	49.2	2.8	4.8	4.3	7.0	8.8	11.2	5.4	10.0	13.5	25.0	2.7	3.6	1.3	1.6
Cobalt	50	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.4	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	1.5	2.7	0.1	0.1	0.1	0.1
Copper	16	9.1	17.8	13.0	20.8	1.3	1.8	2.0	2.3	76.5	150.0	25.3	25.9	1.6	2.8	0.7	0.9	1.5	2.1	1.3	2.2	26.1	46.7	0.7	1.1	0.3	0.6
Lead	31	0.7	0.8	0.6	0.8	0.5	0.8	4.5	7.9	3.8	4.4	5.2	6.7	0.3	0.5	0.6	0.7	2.2	2.5	0.7	1.0	5.1	9.2	1.5	2.2	0.4	0.6
Manganese	460	1.0	1.0	0.3	0.5	0.7	1.1	0.3	0.3	1.9	2.1	0.7	0.9	0.3	0.4	1.4	1.9	1.6	2.6	1.6	2.4	0.6	0.9	0.8	0.9	1.5	1.6
Mercury	0.2	0.6	0.9	2.5	4.3	0.7	0.9	0.3	0.3	1.6	2.3	2.5	2.5	0.3	0.4	0.4	0.6	0.3	0.3	0.6	0.9	2.5	4.8	0.3	0.3	0.3	0.3
Molybdenum	10	0.2	0.2	0.5	0.6	0.1	0.2	0.3	0.4	0.1	0.1	1.2	1.4	0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.1	5.2	9.7	0.3	0.3	0.1	0.1
Nickel	16	0.5	0.5	3.8	3.9	1.0	1.3	1.7	1.9	15.5	20.7	19.0	32.5	1.7	3.2	1.7	2.5	5.0	8.2	3.3	6.0	140.2	260.6	4.2	6.6	0.9	1.5
Selenium	1.6	0.6	0.8	0.5	0.8	0.4	0.4	0.3	0.4	0.2	0.2	0.5	0.7	0.3	0.4	0.4	0.5	0.3	0.4	0.1	0.2	0.7	1.2	0.2	0.2	0.3	0.4
Vanadium	2.2	6.6	8.0	2.8	3.6	3.2	3.2	4.4	5.6	8.8	11.5	23.3	25.1	2.7	3.9	5.3	5.5	6.4	6.8	6.9	7.5	24.0	40.6	6.4	7.1	8.9	12.2
Hazard Index		23	34	29	42	16	20	22	30	392	564	277	410	19	30	45	58	72	81	44	75	279	512	24	29	17	23

DG - Data Gap

Note: A value of 0.0 should be interpreted as representing a hazard quotient less than 0.1, rather than an indication of zero risk.

TABLE 5-5
HAZARD QUOTIENT FOR BENTHIC INVERTEBRATES DIRECTLY EXPOSED TO ORGANIC COECs IN SEDIMENT PORE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINTS	VALUE	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Acetone	NOAEL	Mean	100	1000	0.1513	0.0873	0.1487	0.9882	0.8419	1.6424	1.6508	1.5817	0.2328	0.1386	0.9918	0.5831	1.8563
	NOAEL	Max			0.1513	0.1309	0.1749	1.6171	1.1377	2.0530	2.5679	2.0336	0.3326	0.1441	1.6637	0.8503	1.9370
	LOAEL	Mean			0.0151	0.0087	0.0149	0.0988	0.0842	0.1642	0.2568	0.1582	0.0233	0.0139	0.0992	0.0583	0.1856
	LOAEL	Max			0.0151	0.0131	0.0175	0.1617	0.1138	0.2053	0.2568	0.2034	0.0333	0.0144	0.1664	0.0850	0.1937
Carbon Disulfide	NOAEL	Mean	1100	7700	0.0007	0.0005	0.0008	0.0018	0.0034	0.0011	0.0039	0.0037	0.0007	0.0005	0.0004	0.0054	0.0097
	NOAEL	Max			0.0007	0.0006	0.0008	0.0018	0.0035	0.0011	0.0042	0.0040	0.0007	0.0007	0.0004	0.0071	0.0105
	LOAEL	Mean			0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0006	0.0005	0.0001	0.0001	0.0001	0.0008	0.0014
	LOAEL	Max			0.0001	0.0001	0.0001	0.0003	0.0005	0.0002	0.0006	0.0006	0.0001	0.0001	0.0001	0.0010	0.0015
Toluene	NOAEL	Mean	1000	6000	0.0002	0.0002	0.0002	0.0015	0.0006	0.0002	0.0009	0.0005	0.0001	0.0001	0.0001	0.0008	0.0020
	NOAEL	Max			0.0002	0.0002	0.0002	0.0026	0.0008	0.0002	0.0009	0.0007	0.0001	0.0002	0.0002	0.0009	0.0021
	LOAEL	Mean			0.0000	0.0000	0.0000	0.0002	0.0001	0.0000	0.0002	0.0001	0.0000	0.0000	0.0000	0.0001	0.0003
	LOAEL	Max			0.0000	0.0000	0.0000	0.0004	0.0001	0.0000	0.0002	0.0001	0.0000	0.0000	0.0000	0.0001	0.0004
Methylene Chloride	NOAEL	Mean	2200	22000	0.0007	0.0006	0.0006	0.0010	0.0025	0.0011	0.0027	0.0025	0.0007	0.0009	0.0004	0.0027	0.0048
	NOAEL	Max			0.0009	0.0008	0.0006	0.0012	0.0026	0.0014	0.0034	0.0037	0.0010	0.0013	0.0005	0.0029	0.0062
	LOAEL	Mean			0.0001	0.0001	0.0001	0.0001	0.0003	0.0001	0.0003	0.0002	0.0001	0.0001	0.0000	0.0003	0.0005
	LOAEL	Max			0.0001	0.0001	0.0001	0.0001	0.0003	0.0001	0.0003	0.0004	0.0001	0.0001	0.0000	0.0003	0.0006
Total Xylenes	NOAEL	Mean	53	530	0.0391	0.0346	0.0433	0.0928	0.1762	0.0573	0.2049	0.1922	0.0346	0.0349	0.0297	0.1974	0.4836
	NOAEL	Max			0.0391	0.0366	0.0437	0.0943	0.1849	0.0573	0.2205	0.2094	0.0349	0.0360	0.0390	0.2067	0.5000
	LOAEL	Mean			0.0039	0.0035	0.0043	0.0093	0.0176	0.0057	0.0220	0.0192	0.0035	0.0035	0.0030	0.0197	0.0484
	LOAEL	Max			0.0039	0.0037	0.0044	0.0094	0.0185	0.0057	0.0220	0.0209	0.0035	0.0036	0.0039	0.0207	0.0500
1,4-Dichlorobenzene	NOAEL	Mean	300	930	0.0410	0.0886	0.0468	0.0329	0.4547	0.0627	0.0721	0.0666	0.0122	0.0122	0.0211	0.0691	0.1706
	NOAEL	Max			0.0683	0.1300	0.0632	0.0333	0.5857	0.1057	0.0779	0.0735	0.0123	0.0126	0.0277	0.0724	0.1749
	LOAEL	Mean			0.0132	0.0286	0.0151	0.0106	0.1467	0.0202	0.0251	0.0215	0.0039	0.0039	0.0068	0.0223	0.0550
	LOAEL	Max			0.0220	0.0419	0.0204	0.0107	0.1889	0.0341	0.0251	0.0237	0.0040	0.0041	0.0089	0.0234	0.0564
Chlorinated Aromatic	NOAEL	Mean	16	160	0.0000	0.0000	0.0000	0.0000	6.0476	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hydrocarbons	NOAEL	Max			0.0000	0.0000	0.0000	0.0000	11.2655	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Mean			0.0000	0.0000	0.0000	0.0000	0.6048	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Max			0.0000	0.0000	0.0000	0.0000	1.1266	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2,4-Dimethylphenol	NOAEL	Mean	2000	20000	0.0166	0.0358	0.0189	0.0133	0.1836	0.0253	0.0291	0.3000	0.0049	0.0049	0.0085	0.0279	0.0689
	NOAEL	Max			0.0276	0.0525	0.0255	0.0134	0.2365	0.0427	0.0314	0.5499	0.0050	0.0051	0.0112	0.0292	0.0706
	LOAEL	Mean			0.0017	0.0036	0.0019	0.0013	0.0184	0.0025	0.0031	0.0300	0.0005	0.0005	0.0009	0.0028	0.0069
	LOAEL	Max			0.0028	0.0052	0.0026	0.0013	0.0236	0.0043	0.0031	0.0550	0.0005	0.0005	0.0011	0.0029	0.0071
Pentachlorophenol	NOAEL	Mean	1.30	13.00	7.1440	15.1033	7.9745	5.6551	79.8783	10.6363	12.4340	18.3255	2.1475	2.0938	3.5941	11.7640	29.6996
	NOAEL	Max			11.8456	22.1796	10.7267	5.8001	104.6681	17.8928	13.6182	25.7104	2.1475	2.1475	4.7095	12.3522	31.2627
	LOAEL	Mean			0.7144	1.5103	0.7974	0.5655	7.9878	1.0636	1.3618	1.8325	0.2148	0.2094	0.3594	1.1764	2.9700
	LOAEL	Max			1.1846	2.2180	1.0727	0.5800	10.4668	1.7893	1.3618	2.5710	0.2148	0.2148	0.4710	1.2352	3.1263
Phenol & Substituted	NOAEL	Mean	0.45	4.50	5.2306	1.8095	3.5818	1.2421	0.0000	0.0000	13.9481	46.6667	33.1134	5.7259	0.0000	0.0000	0.0000
Phenols	NOAEL	Max			5.2306	3.6190	4.8362	2.4843	0.0000	0.0000	27.8963	46.6667	46.6667	8.6463	0.0000	0.0000	0.0000
	LOAEL	Mean			0.5231	0.1809	0.3582	0.1242	0.0000	0.0000	2.7896	4.6667	3.3113	0.5726	0.0000	0.0000	0.0000
	LOAEL	Max			0.5231	0.3619	0.4836	0.2484	0.0000	0.0000	2.7896	4.6667	4.6667	0.8646	0.0000	0.0000	0.0000
Nonyl Phenols*	NOAEL	Mean	1	10	2.3537	0.8143	1.6118	0.5590	0.0000	0.0000	6.2767	21.0000	14.9010	2.5766	0.0000	0.0000	0.0000
	NOAEL	Max			2.3537	1.6285	2.1763	1.1179	0.0000	0.0000	12.5533	21.0000	21.0000	3.8908	0.0000	0.0000	0.0000
	LOAEL	Mean			0.2354	0.0814	0.1612	0.0559	0.0000	0.0000	1.2553	2.1000	1.4901	0.2577	0.0000	0.0000	0.0000
	LOAEL	Max			0.2354	0.1629	0.2176	0.1118	0.0000	0.0000	1.2553	2.1000	2.1000	0.3891	0.0000	0.0000	0.0000

TABLE 5-5

HAZARD QUOTIENT FOR BENTHIC INVERTEBRATES DIRECTLY EXPOSED TO ORGANIC COECs IN SEDIMENT PORE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINTS	VALUE	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Phthalates*	NOAEL	Mean	32	320	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
	NOAEL	Max			0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
	LOAEL	Mean			0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
	LOAEL	Max			0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
Total PCBs*	NOAEL	Mean	0.005	0.045	1266.7	1266.7	160.4	315.3	1266.7	267.1	225.9	131.5	33.6	59.2	1266.7	867.4	1266.7
	NOAEL	Max			1266.7	1266.7	222.3	326.2	1266.7	346.2	362.1	219.2	57.4	79.2	1266.7	1176.2	1266.7
	LOAEL	Mean			126.7	126.7	16.0	31.5	126.7	26.7	36.2	13.1	3.4	5.9	126.7	86.7	126.7
	LOAEL	Max			126.7	126.7	22.2	32.6	126.7	34.6	36.2	21.9	5.7	7.9	126.7	117.6	126.7
Aldrin	NOAEL	Mean	0.001	0.010	175.9	290.5	22.2	39.9	15151.4	119.8	109.3	286.6	15.4	6.0	183.8	127.1	201.7
	NOAEL	Max			335.9	304.3	37.0	41.8	15872.9	122.4	201.6	487.2	27.8	6.2	332.8	177.2	204.7
	LOAEL	Mean			17.6	29.0	2.2	4.0	1515.1	12.0	20.2	28.7	1.5	0.6	18.4	12.7	20.2
	LOAEL	Max			33.6	30.4	3.7	4.2	1587.3	12.2	20.2	48.7	2.8	0.6	33.3	17.7	20.5
alpha-Chlordane*	NOAEL	Mean	0.025	0.250	3.839	6.338	0.484	0.870	1637.184	0.526	0.584	0.360	0.097	0.130	4.011	2.773	4.400
	NOAEL	Max			7.328	6.640	0.807	0.912	2240.000	0.540	0.812	0.391	0.129	0.135	7.260	3.866	4.467
	LOAEL	Mean			0.384	0.634	0.048	0.087	163.718	0.053	0.081	0.036	0.010	0.013	0.401	0.277	0.440
	LOAEL	Max			0.733	0.664	0.081	0.091	224.000	0.054	0.081	0.039	0.013	0.014	0.726	0.387	0.447
Dieldrin*	NOAEL	Mean	0.002	0.020	2465.6	4214.0	317.5	571.6	93000.0	348.8	381.4	2632.3	63.0	84.7	2600.5	1809.6	2930.5
	NOAEL	Max			4696.3	4467.9	529.2	585.5	93000.0	363.2	535.1	5048.9	84.7	87.7	4706.6	2488.2	3005.7
	LOAEL	Mean			246.6	421.4	31.8	57.2	9300.0	34.9	53.5	263.2	6.3	8.5	260.1	181.0	293.1
	LOAEL	Max			469.6	446.8	52.9	58.6	9300.0	36.3	53.5	504.9	8.5	8.8	470.7	248.8	300.6
Heptachlor*	NOAEL	Mean	0.005	0.050	62.1	102.5	7.8	14.1	11200.0	43.2	49.4	134.7	3.1	32.3	64.9	44.9	71.2
	NOAEL	Max			118.6	107.4	13.1	14.7	11200.0	78.1	93.1	263.0	4.1	45.7	117.5	62.5	72.3
	LOAEL	Mean			6.2	10.3	0.8	1.4	1120.0	4.3	9.3	13.5	0.3	3.2	6.5	4.5	7.1
	LOAEL	Max			11.9	10.7	1.3	1.5	1120.0	7.8	9.3	26.3	0.4	4.6	11.7	6.3	7.2
Heptachlor epoxide	NOAEL	Mean	1.20	12	0.259	0.427	0.033	0.059	22.287	0.035	0.039	0.024	0.007	0.009	0.270	0.187	0.297
	NOAEL	Max			0.494	0.448	0.054	0.061	23.348	0.036	0.055	0.026	0.009	0.009	0.489	0.261	0.301
	LOAEL	Mean			0.026	0.043	0.003	0.006	2.229	0.004	0.005	0.002	0.001	0.001	0.027	0.019	0.030
	LOAEL	Max			0.049	0.045	0.005	0.006	2.335	0.004	0.005	0.003	0.001	0.001	0.049	0.026	0.030
alpha & delta BHC	NOAEL	Mean	0.65	6.50	1.378	2.275	0.174	0.461	118.662	0.189	0.210	0.129	0.035	0.047	1.440	0.995	1.579
	NOAEL	Max			2.630	2.383	0.290	0.595	124.312	0.194	0.292	0.140	0.046	0.048	2.606	1.388	1.603
	LOAEL	Mean			0.138	0.228	0.017	0.046	11.866	0.019	0.029	0.013	0.003	0.005	0.144	0.100	0.158
	LOAEL	Max			0.263	0.238	0.029	0.059	12.431	0.019	0.029	0.014	0.005	0.005	0.261	0.139	0.160
Endosulfan Sulfate*	NOAEL	Mean	0.0002	0.0016	10686.3	18264.4	1513.9	2477.3	1179905.6	1511.9	1653.1	1014.4	272.9	366.9	11271.3	7843.3	12701.5
	NOAEL	Max			20355.0	19364.7	2293.7	2537.8	1375000.0	1574.0	2319.2	1094.1	366.9	380.3	20399.3	10784.5	13027.2
	LOAEL	Mean			1068.6	1826.4	151.4	247.7	117990.6	151.2	231.9	101.4	27.3	36.7	1127.1	784.3	1270.1
	LOAEL	Max			2035.5	1936.5	229.4	253.8	137500.0	157.4	231.9	109.4	36.7	38.0	2039.9	1078.4	1302.7
Methoxychlor	NOAEL	Mean	0.002	0.020	632.5	1044.4	79.8	143.4	50000.0	86.6	96.2	59.2	15.9	21.5	660.9	457.0	725.0
	NOAEL	Max			1207.6	1094.1	132.9	150.2	50000.0	88.9	133.8	64.4	21.2	22.2	1196.4	637.0	736.1
	LOAEL	Mean			63.3	104.4	8.0	14.3	5000.0	8.7	13.4	5.9	1.6	2.1	66.1	45.7	72.5
	LOAEL	Max			120.8	109.4	13.3	15.0	5000.0	8.9	13.4	6.4	2.1	2.2	119.6	63.7	73.6
Benzidine	NOAEL	Mean	6.00	60.00	213.4	343.0	242.6	170.8	2393.5	319.6	371.6	707.7	64.3	64.3	109.5	357.8	905.5
	NOAEL	Max			353.7	673.0	327.1	173.6	3085.0	537.5	400.2	771.1	64.3	66.4	143.6	374.8	935.7
	LOAEL	Mean			21.3	34.3	24.3	17.1	239.4	32.0	40.0	70.8	6.4	6.4	10.9	35.8	90.6
	LOAEL	Max			35.4	67.3	32.7	17.4	308.5	53.7	40.0	77.1	6.4	6.6	14.4	37.5	93.6

TABLE 5-5

HAZARD QUOTIENT FOR BENTHIC INVERTEBRATES DIRECTLY EXPOSED TO ORGANIC COECs IN SEDIMENT PORE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINTS	VALUE	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Low MW PAHs	NOAEL	Mean	0.06	0.64	338.2	2336.0	2817.0	1706.1	8919.4	442.8	526.0	318.5	33.6	22.5	62.2	261.7	1750.3
	NOAEL	Max			650.3	4108.7	4816.3	2815.6	10559.8	816.3	953.8	351.2	43.1	27.6	68.9	321 0	3241.4
	LOAEL	Mean			33.8	233.6	281.7	170.6	891.9	44.3	95.4	31.9	3.4	2.2	6.2	26.2	175.0
	LOAEL	Max			65.0	410.9	481.6	281.6	1056.0	81.6	95.4	35.1	4.3	2.8	6.9	32.1	324.1
Middle MW PAHs*	NOAEL	Mean	0.04	0.40	677.5	3144.4	2267.3	1961.2	6500.0	417.5	555.3	514.5	42.8	50.0	173.5	441.3	1416.4
	NOAEL	Max			1167.8	5624.8	3498.1	3257.5	6500.0	698.5	1032.3	664.7	72.0	86.2	261.9	584.2	2667.5
	LOAEL	Mean			67.7	314.4	226.7	196.1	650.0	41.8	103.2	51.4	4.3	5.0	17.4	44.1	141.6
	LOAEL	Max			116.8	562.5	349.8	325.8	650.0	69.9	103.2	66.5	7.2	8 6	26.2	58.4	266.8
Hazard Indices	NOAEL	Mean			16539	31033	7443	7410	1370202	3570	4004	5888	595	718	16404	12227	22007
	NOAEL	Max			30182	37049	11889	9916	1568990	4646	6089	9061	812	817	28510	16625	25198
	LOAEL	Mean			1654	3103	744	741	137020	357	609	589	60	72	1640	1223	2201
	LOAEL	Max			3018	3705	1189	992	156899	465	609	906	81	82	2851	1662	2520

DG - Data gap: the pore water concentration cannot be calculated in the absence of the constituent K_{ow}.

Pore water concentrations were adjusted to remain at or below the solubility of the constituent.

Note: A value of 0.0000 should be interpreted as representing a hazard quotient less than 0.0001, rather than an indication of zero risk.

TABLE 5-6

HAZARD QUOTIENT CALCULATIONS FOR WATER COLUMN INVERTEBRATES DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Aluminum	NOAEL	Mean	700	1500	0.114	0.071	0.071	0.071	0.479	0.146	0.164	0.104	0.106	0.106	0.150	0.209	0.179
	NOAEL	Max			0.157	0.071	0.071	0.071	0.814	0.171	0.186	0.121	0.133	0.114	0.229	0.314	0.200
	LOAEL	Mean			0.053	0.033	0.033	0.033	0.223	0.068	0.077	0.048	0.050	0.049	0.070	0.097	0.083
	LOAEL	Max			0.073	0.033	0.033	0.033	0.380	0.080	0.087	0.057	0.062	0.053	0.107	0.147	0.093
Antimony	NOAEL	Mean	705	7050	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.053	0.043	0.043	0.043	0.043
	NOAEL	Max			0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.064	0.043	0.043	0.043	0.043
	LOAEL	Mean			0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.004	0.004	0.004	0.004
	LOAEL	Max			0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.006	0.004	0.004	0.004	0.004
Arsenic	NOAEL	Mean	45	450	0.056	0.053	0.081	0.083	0.111	0.083	0.030	0.056	0.056	2.583	0.046	0.046	0.048
	NOAEL	Max			0.056	0.082	0.111	0.111	0.111	0.111	0.038	0.056	0.056	5.111	0.056	0.056	0.056
	LOAEL	Mean			0.006	0.005	0.008	0.008	0.011	0.008	0.003	0.006	0.006	0.258	0.005	0.005	0.005
	LOAEL	Max			0.006	0.008	0.011	0.011	0.011	0.011	0.004	0.006	0.006	0.511	0.006	0.006	0.006
Barium	NOAEL	Mean	580	5800	0.716	0.922	0.836	0.750	0.698	0.647	0.603	0.586	0.595	0.569	0.397	0.431	0.448
	NOAEL	Max			0.759	1.121	0.862	0.810	0.776	0.776	0.810	0.707	0.724	0.672	0.414	0.569	0.586
	LOAEL	Mean			0.072	0.092	0.084	0.075	0.070	0.065	0.060	0.059	0.059	0.057	0.040	0.043	0.045
	LOAEL	Max			0.076	0.112	0.086	0.081	0.078	0.078	0.081	0.071	0.072	0.067	0.041	0.057	0.059
Cadmium	NOAEL	Mean	0.02	0.2	69.5	82.8	83.3	16.5	415.0	44.0	47.5	42.8	44.0	45.8	15.8	69.0	32.8
	NOAEL	Max			125.0	125.0	125.0	18.0	490.0	55.0	60.0	50.0	50.0	55.0	18.0	120.0	50.0
	LOAEL	Mean			7.0	8.3	8.3	1.7	41.5	4.4	4.8	4.3	4.4	4.6	1.6	6.9	3.3
	LOAEL	Max			12.5	12.5	12.5	1.8	49.0	5.5	6.0	5.0	5.0	5.5	1.8	12.0	5.0
Chromium	NOAEL	Mean	0.6132	6.132	8.15	16.72	11.09	9.21	22.02	8.15	9.05	51.37	36.69	22.02	8.15	9.46	8.15
	NOAEL	Max			8.15	19.57	14.02	10.27	35.88	8.15	9.95	68.49	53.82	26.09	8.15	10.76	8.15
	LOAEL	Mean			0.82	1.67	1.11	0.92	2.20	0.82	0.91	5.14	3.67	2.20	0.82	0.95	0.82
	LOAEL	Max			0.82	1.96	1.40	1.03	3.59	0.82	0.99	6.85	5.38	2.61	0.82	1.08	0.82
Cobalt	NOAEL	Mean	2.8	9.3	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786
	NOAEL	Max			1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786	1.786
	LOAEL	Mean			0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538
	LOAEL	Max			0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538
Copper	NOAEL	Mean	20	30	0.350	7.000	3.075	1.750	0.750	1.825	1.600	0.798	0.800	0.750	0.258	0.395	0.415
	NOAEL	Max			0.460	7.500	3.500	1.900	1.000	2.450	2.100	1.100	1.000	0.800	0.325	0.600	0.650
	LOAEL	Mean			0.233	4.667	2.050	1.167	0.500	1.217	1.067	0.532	0.533	0.500	0.172	0.263	0.277
	LOAEL	Max			0.307	5.000	2.333	1.267	0.667	1.633	1.400	0.733	0.667	0.533	0.217	0.400	0.433

TABLE 5-6

HAZARD QUOTIENT CALCULATIONS FOR WATER COLUMN INVERTEBRATES DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Cyanide	NOAEL	Mean	0.4	4	6.256	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500
	NOAEL	Max			12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500	12.500
	LOAEL	Mean			0.626	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
	LOAEL	Max			1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
Lead	NOAEL	Mean	0.06	0.6	31.667	216.667	36.583	24.167	60.833	272.500	50.833	36.667	80.833	37.500	35.000	214.833	24.583
	NOAEL	Max			45.000	400.000	58.333	33.333	113.333	500.000	53.333	38.333	126.667	38.333	36.667	416.667	33.333
	LOAEL	Mean			3.167	21.667	3.658	2.417	6.083	27.250	5.083	3.667	8.083	3.750	3.500	21.483	2.458
	LOAEL	Max			4.500	40.000	5.833	3.333	11.333	50.000	5.333	3.833	12.667	3.833	3.667	41.667	3.333
Manganese	NOAEL	Mean	6	60	1.717	1.625	1.383	1.275	4.417	5.417	5.000	22.500	20.833	23.333	44.750	10.250	12.917
	NOAEL	Max			2.667	1.833	1.533	1.617	4.833	9.000	7.833	25.000	23.333	30.000	83.333	12.667	16.667
	LOAEL	Mean			0.172	0.163	0.138	0.128	0.442	0.542	0.500	2.250	2.083	2.333	4.475	1.025	1.292
	LOAEL	Max			0.267	0.183	0.153	0.162	0.483	0.900	0.783	2.500	2.333	3.000	8.333	1.267	1.667
Mercury	NOAEL	Mean	0.052	0.52	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923
	NOAEL	Max			1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923	1.923
	LOAEL	Mean			0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192
	LOAEL	Max			0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192
Molybdenum	NOAEL	Mean	670	1150	0.021	0.704	0.321	0.154	0.015	0.109	0.163	0.063	0.051	0.049	0.037	0.022	0.020
	NOAEL	Max			0.027	1.269	0.373	0.254	0.015	0.164	0.194	0.107	0.087	0.084	0.048	0.030	0.025
	LOAEL	Mean			0.012	0.410	0.187	0.090	0.009	0.063	0.095	0.037	0.030	0.029	0.022	0.013	0.012
	LOAEL	Max			0.016	0.739	0.217	0.148	0.009	0.096	0.113	0.063	0.050	0.049	0.028	0.017	0.015
Nickel	NOAEL	Mean	124	1240	0.161	0.161	0.161	0.161	0.161	0.161	0.119	0.121	0.137	0.161	0.556	0.133	0.129
	NOAEL	Max			0.161	0.161	0.161	0.161	0.161	0.161	0.161	0.161	0.161	0.161	0.798	0.161	0.161
	LOAEL	Mean			0.016	0.016	0.016	0.016	0.016	0.016	0.012	0.012	0.014	0.016	0.056	0.013	0.013
	LOAEL	Max			0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.080	0.016	0.016
Selenium	NOAEL	Mean	17.9	179	0.140	0.154	0.140	0.140	0.140	0.209	0.137	0.156	0.209	1.327	0.140	0.221	0.156
	NOAEL	Max			0.140	0.168	0.140	0.140	0.140	0.279	0.140	0.173	0.279	2.458	0.140	0.279	0.173
	LOAEL	Mean			0.014	0.015	0.014	0.014	0.014	0.021	0.014	0.016	0.021	0.133	0.014	0.022	0.016
	LOAEL	Max			0.014	0.017	0.014	0.014	0.014	0.028	0.014	0.017	0.028	0.246	0.014	0.028	0.017

TABLE 5-6

HAZARD QUOTIENT CALCULATIONS FOR WATER COLUMN INVERTEBRATES DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Silver	NOAEL	Mean	0.26	2.6	0.231	0.212	0.442	0.192	0.577	0.192	0.192	0.462	0.365	0.192	0.327	0.346	0.192
	NOAEL	Max			0.269	0.231	0.692	0.192	0.962	0.192	0.192	0.731	0.538	0.192	0.462	0.500	0.192
	LOAEL	Mean			0.023	0.021	0.044	0.019	0.058	0.019	0.019	0.046	0.037	0.019	0.033	0.035	0.019
	LOAEL	Max			0.027	0.023	0.069	0.019	0.096	0.019	0.019	0.073	0.054	0.019	0.046	0.050	0.019
Vanadium	NOAEL	Mean	94	940	0.126	0.239	0.181	0.149	0.115	0.138	0.131	0.085	0.071	0.086	0.062	0.053	0.049
	NOAEL	Max			0.149	0.330	0.191	0.170	0.138	0.149	0.170	0.117	0.088	0.098	0.071	0.053	0.053
	LOAEL	Mean			0.013	0.024	0.018	0.015	0.011	0.014	0.013	0.009	0.007	0.009	0.006	0.005	0.005
	LOAEL	Max			0.015	0.033	0.019	0.017	0.014	0.015	0.017	0.012	0.009	0.010	0.007	0.005	0.005
Zinc	NOAEL	Mean	4.673	46.73	3.638	13.589	5.350	5.243	8.560	5.350	6.099	4.815	4.922	5.136	5.671	3.210	3.531
	NOAEL	Max			4.280	18.190	5.564	5.564	8.774	5.350	6.206	5.350	5.136	5.564	5.992	3.424	4.280
	LOAEL	Mean			0.364	1.359	0.535	0.524	0.856	0.535	0.610	0.481	0.492	0.514	0.567	0.321	0.353
	LOAEL	Max			0.428	1.819	0.556	0.556	0.877	0.535	0.621	0.535	0.514	0.556	0.599	0.342	0.428
Hazard Indices	NOAEL	Mean			127	357	159	76	530	355	138	177	206	156	128	325	100
	NOAEL	Max			204	592	227	89	673	598	158	207	278	181	171	582	131
	LOAEL	Mean			13	40	18	9	54	37	15	19	21	16	13	33	11
	LOAEL	Max			21	64	25	10	69	62	17	22	29	19	18	59	14

TABLE 5-7

HAZARD QUOTIENTS FOR WATER COLUMN INVERTEBRATES DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/L)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Acetone	NOAEL	Mean	100	1000	0.1000	0.0700	0.1200	0.0500	0.0500	0.0605	0.0755	0.0785	0.0850	0.0500	0.0500	0.0500	0.0465
	NOAEL	Max			0.1500	0.0900	0.1900	0.0500	0.0500	0.0710	0.0770	0.1100	0.1200	0.0500	0.0500	0.0500	0.0500
	LOAEL	Mean			0.0100	0.0070	0.0120	0.0050	0.0050	0.0061	0.0076	0.0079	0.0085	0.0050	0.0050	0.0050	0.0047
	LOAEL	Max			0.0150	0.0090	0.0190	0.0050	0.0050	0.0071	0.0077	0.0110	0.0120	0.0050	0.0050	0.0050	0.0050
Carbon Disulfide	NOAEL	Mean	1100	7700	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
	NOAEL	Max			0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023
	LOAEL	Mean			0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
	LOAEL	Max			0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Toluene	NOAEL	Mean	1000	6000	0.0025	0.0138	0.0015	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0024	0.0025	0.0025
	NOAEL	Max			0.0025	0.0250	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
	LOAEL	Mean			0.0004	0.0023	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
	LOAEL	Max			0.0004	0.0042	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Methylene Chloride	NOAEL	Mean	2200	22000	0.0009	0.0008	0.0020	0.0019	0.0011	0.0011	0.0021	0.0022	0.0015	0.0010	0.0021	0.0018	0.0019
	NOAEL	Max			0.0011	0.0011	0.0034	0.0032	0.0011	0.0011	0.0030	0.0033	0.0018	0.0011	0.0030	0.0029	0.0027
	LOAEL	Mean			0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001	0.0002	0.0002	0.0002
	LOAEL	Max			0.0001	0.0001	0.0003	0.0003	0.0001	0.0001	0.0003	0.0003	0.0002	0.0001	0.0003	0.0003	0.0003
Total Xylenes	NOAEL	Mean	53	530	0.0472	0.2594	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472
	NOAEL	Max			0.0472	0.4717	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472
	LOAEL	Mean			0.0047	0.0259	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047
	LOAEL	Max			0.0047	0.0472	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047
1,4-Dichlorobenzene	NOAEL	Mean	300	930	0.0117	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167
	NOAEL	Max			0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167
	LOAEL	Mean			0.0038	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054
	LOAEL	Max			0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054
Chlorinated Aromatic	NOAEL	Mean	16	160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hydrocarbons	NOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Mean			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 5-7
HAZARD QUOTIENTS FOR WATER COLUMN INVERTEBRATES DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/L)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
2,4-Dimethylphenol	NOAEL	Mean	2000	20000	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
	NOAEL	Max			0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
	LOAEL	Mean			0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
	LOAEL	Max			0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Pentachlorophenol	NOAEL	Mean	1.3	13	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308
	NOAEL	Max			19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308
	LOAEL	Mean			1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231
	LOAEL	Max			1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231
Phenol & Substituted	NOAEL	Mean	0.45	4.5	11.1	7.3	11.1	11.1	11.1	11.1	11.1	15.4	11.1	11.1	11.1	11.1	11.1
Phenols	NOAEL	Max			11.1	11.1	11.1	11.1	11.1	11.1	11.1	19.8	11.1	11.1	11.1	11.1	11.1
	LOAEL	Mean			1.1	0.7	1.1	1.1	1.1	1.1	1.1	1.5	1.1	1.1	1.1	1.1	1.1
	LOAEL	Max			1.1	1.1	1.1	1.1	1.1	1.1	1.1	2.0	1.1	1.1	1.1	1.1	1.1
Nonyl Phenols	NOAEL	Mean	1	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.7000	0.0000	0.0000	0.0000	0.0000	0.0000
	NOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	5.4000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Mean			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2700	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5400	0.0000	0.0000	0.0000	0.0000	0.0000
Phthalates	NOAEL	Mean	1.33	13.33	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	2.5940	3.7594	23.6842
	NOAEL	Max			3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	3.7594	43.6090
	LOAEL	Mean			0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.2588	0.3751	2.3631
	LOAEL	Max			0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	0.3751	4.3511
Total PCBs	NOAEL	Mean	0.0045	0.045	166.7	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1
	NOAEL	Max			222.2	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1
	LOAEL	Mean			16.7	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1
	LOAEL	Max			22.2	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1
Aldrin	NOAEL	Mean	0.00097	0.0097	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8
	NOAEL	Max			25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8
	LOAEL	Mean			2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	LOAEL	Max			2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
alpha-Chlordane	NOAEL	Mean	0.025	0.25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	NOAEL	Max			1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	LOAEL	Mean			0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
	LOAEL	Max			0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
Dieldrin	NOAEL	Mean	0.002	0.02	25.0	25.0	25.0	25.0	30.5	25.0	25.0	25.0	25.0	25.0	25.0	30.5	25.0
	NOAEL	Max			25.0	25.0	25.0	25.0	36.0	25.0	25.0	25.0	25.0	25.0	25.0	36.0	25.0
	LOAEL	Mean			2.5	2.5	2.5	2.5	3.1	2.5	2.5	2.5	2.5	2.5	2.5	3.1	2.5
	LOAEL	Max			2.5	2.5	2.5	2.5	3.6	2.5	2.5	2.5	2.5	2.5	2.5	3.6	2.5

TABLE 5-7

HAZARD QUOTIENTS FOR WATER COLUMN INVERTEBRATES DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/L)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Heptachlor	NOAEL	Mean	0.005	0.05	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	NOAEL	Max			5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	LOAEL	Mean			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	LOAEL	Max			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Heptachlor epoxide	NOAEL	Mean	1.2	12	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0688	0.0513	0.0354	0.0208	0.0208	0.0208
	NOAEL	Max			0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.0208	0.1167	0.0817	0.0500	0.0208	0.0208	0.0208
	LOAEL	Mean			0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0069	0.0051	0.0035	0.0021	0.0021	0.0021
	LOAEL	Max			0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0117	0.0082	0.0050	0.0021	0.0021	0.0021
alpha & delta BHC	NOAEL	Mean	0.65	6.5	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385
	NOAEL	Max			0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385	0.0385
	LOAEL	Mean			0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038
	LOAEL	Max			0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038
Endosulfan Sulfate	NOAEL	Mean	0.00016	0.0016	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5
	NOAEL	Max			312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5	312.5
	LOAEL	Mean			31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3
	LOAEL	Max			31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3
Methoxychlor	NOAEL	Mean	0.002	0.02	68.8	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
	NOAEL	Max			125.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
	LOAEL	Mean			6.9	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
	LOAEL	Max			12.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Benzidine	NOAEL	Mean	6	60	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167
	NOAEL	Max			4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167	4.167
	LOAEL	Mean			0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
	LOAEL	Max			0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
Low MW PAHs	NOAEL	Mean	0.064	0.64	78.1	78.1	78.1	78.1	95.3	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1
	NOAEL	Max			78.1	78.1	78.1	78.1	112.5	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1
	LOAEL	Mean			7.8	7.8	7.8	7.8	9.5	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	LOAEL	Max			7.8	7.8	7.8	7.8	11.3	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
Middle MW PAHs	NOAEL	Mean	0.04	0.4	125.0	125.0	125.0	125.0	191.3	125.0	125.0	125.0	125.0	188.8	148.8	125.0	850.0
	NOAEL	Max			125.0	125.0	125.0	125.0	230.0	125.0	125.0	125.0	125.0	252.5	172.5	125.0	1575.0
	LOAEL	Mean			12.5	12.5	12.5	12.5	19.1	12.5	12.5	12.5	12.5	18.9	14.9	12.5	85.0
	LOAEL	Max			12.5	12.5	12.5	12.5	23.0	12.5	12.5	12.5	12.5	25.3	17.3	12.5	157.5
Hazard Indices	NOAEL	Mean			846	731	735	734	823	734	734	742	735	798	757	740	1479
	NOAEL	Max			958	735	735	734	885	734	734	749	735	862	782	745	2224
	LOAEL	Mean			85	73	73	73	82	73	73	74	73	80	76	74	148
	LOAEL	Max			96	73	73	73	88	73	73	75	73	86	78	75	222

Note: A value of 0.0000 should be interpreted as a hazard quotient less than 0.0001, rather than an indication of zero risk.

TABLE 5-8
HAZARD QUOTIENTS FOR FISH DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Aluminum	NOAEL	Mean	119	1190	0.672	0.420	0.420	0.420	2.815	0.857	0.966	0.609	0.626	0.622	0.882	1.227	1.050
	NOAEL	Max			0.924	0.420	0.420	0.420	4.790	1.008	1.092	0.714	0.782	0.672	1.345	1.849	1.176
	LOAEL	Mean			0.067	0.042	0.042	0.042	0.282	0.086	0.097	0.061	0.063	0.062	0.088	0.123	0.105
	LOAEL	Max			0.092	0.042	0.042	0.042	0.479	0.101	0.109	0.071	0.078	0.067	0.134	0.185	0.118
Antimony	NOAEL	Mean	1130	2310	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.033	0.027	0.027	0.027	0.027
	NOAEL	Max			0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.040	0.027	0.027	0.027	0.027
	LOAEL	Mean			0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.016	0.013	0.013	0.013	0.013
	LOAEL	Max			0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.019	0.013	0.013	0.013	0.013
Arsenic	NOAEL	Mean	89.16	891.6	0.028	0.027	0.041	0.042	0.056	0.042	0.015	0.028	0.028	1.304	0.023	0.023	0.024
	NOAEL	Max			0.028	0.041	0.056	0.056	0.056	0.056	0.019	0.028	0.028	2.580	0.028	0.028	0.028
	LOAEL	Mean			0.003	0.003	0.004	0.004	0.006	0.004	0.002	0.003	0.003	0.130	0.002	0.002	0.002
	LOAEL	Max			0.003	0.004	0.006	0.006	0.006	0.006	0.002	0.003	0.003	0.258	0.003	0.003	0.003
Cadmium	NOAEL	Mean	0.7	1.74	1.986	2.364	2.379	0.471	11.857	1.257	1.357	1.221	1.257	1.307	0.450	1.971	0.936
	NOAEL	Max			3.571	3.571	3.571	0.514	14.000	1.571	1.714	1.429	1.429	1.571	0.514	3.429	1.429
	LOAEL	Mean			0.799	0.951	0.957	0.190	4.770	0.506	0.546	0.491	0.506	0.526	0.181	0.793	0.376
	LOAEL	Max			1.437	1.437	1.437	0.207	5.632	0.632	0.690	0.575	0.575	0.632	0.207	1.379	0.575
Chromium	NOAEL	Mean	7.318	73.18	0.683	1.401	0.929	0.772	1.845	0.683	0.758	4.304	3.075	1.845	0.683	0.793	0.683
	NOAEL	Max			0.683	1.640	1.175	0.861	3.006	0.683	0.834	5.739	4.509	2.186	0.683	0.902	0.683
	LOAEL	Mean			0.068	0.140	0.093	0.077	0.184	0.068	0.076	0.430	0.307	0.184	0.068	0.079	0.068
	LOAEL	Max			0.068	0.164	0.118	0.086	0.301	0.068	0.083	0.574	0.451	0.219	0.068	0.090	0.068
Cobalt	NOAEL	Mean	210	390	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	NOAEL	Max			0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	LOAEL	Mean			0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
	LOAEL	Max			0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Copper	NOAEL	Mean	0.07	0.7	100.0	2000.0	878.6	500.0	214.3	521.4	457.1	227.9	228.6	214.3	73.6	112.9	118.6
	NOAEL	Max			131.4	2142.9	1000.0	542.9	285.7	700.0	600.0	314.3	285.7	228.6	92.9	171.4	185.7
	LOAEL	Mean			10.0	200.0	87.9	50.0	21.4	52.1	45.7	22.8	22.9	21.4	7.4	11.3	11.9
	LOAEL	Max			13.1	214.3	100.0	54.3	28.6	70.0	60.0	31.4	28.6	22.9	9.3	17.1	18.6

TABLE 5-8

HAZARD QUOTIENTS FOR FISH DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Cyanide	NOAEL	Mean	0.78	7.8	3.208	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410
	NOAEL	Max			6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410	6.410
	LOAEL	Mean			0.321	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641
	LOAEL	Max			0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641	0.641
Lead	NOAEL	Mean	1.888	18.88	1.006	6.886	1.163	0.768	1.933	8.660	1.615	1.165	2.569	1.192	1.112	6.827	0.781
	NOAEL	Max			1.430	12.712	1.854	1.059	3.602	15.890	1.695	1.218	4.025	1.218	1.165	13.242	1.059
	LOAEL	Mean			0.101	0.689	0.116	0.077	0.193	0.866	0.162	0.117	0.257	0.119	0.111	0.683	0.078
	LOAEL	Max			0.143	1.271	0.185	0.106	0.360	1.589	0.169	0.122	0.403	0.122	0.117	1.324	0.106
Mercury	NOAEL	Mean	0.124	1.24	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806
	NOAEL	Max			0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806	0.806
	LOAEL	Mean			0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
	LOAEL	Max			0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081
Molybdenum	NOAEL	Mean	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
	NOAEL	Max			DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
	LOAEL	Mean			DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
	LOAEL	Max			DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Nickel	NOAEL	Mean	3.5	35	5.714	5.714	5.714	5.714	5.714	5.714	4.214	4.286	4.857	5.714	19.714	4.714	4.571
	NOAEL	Max			5.714	5.714	5.714	5.714	5.714	5.714	5.714	5.714	5.714	5.714	28.286	5.714	5.714
	LOAEL	Mean			0.571	0.571	0.571	0.571	0.571	0.571	0.421	0.429	0.486	0.571	1.971	0.471	0.457
	LOAEL	Max			0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571	2.829	0.571	0.571
Selenium	NOAEL	Mean	8.832	88.32	0.283	0.311	0.283	0.283	0.283	0.425	0.277	0.317	0.425	2.689	0.283	0.447	0.317
	NOAEL	Max			0.283	0.340	0.283	0.283	0.283	0.566	0.283	0.351	0.566	4.982	0.283	0.566	0.351
	LOAEL	Mean			0.028	0.031	0.028	0.028	0.028	0.042	0.028	0.032	0.042	0.269	0.028	0.045	0.032
	LOAEL	Max			0.028	0.034	0.028	0.028	0.028	0.057	0.028	0.035	0.057	0.498	0.028	0.057	0.035

TABLE 5-8
HAZARD QUOTIENTS FOR FISH DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

			TRVs (ug/l)		Soldier Creek												
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Silver	NOAEL	Mean	6	60	0.010	0.009	0.019	0.008	0.025	0.008	0.008	0.020	0.016	0.008	0.014	0.015	0.008
	NOAEL	Max			0.012	0.010	0.030	0.008	0.042	0.008	0.008	0.032	0.023	0.008	0.020	0.022	0.008
	LOAEL	Mean			0.001	0.001	0.002	0.001	0.003	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.001
	LOAEL	Max			0.001	0.001	0.003	0.001	0.004	0.001	0.001	0.003	0.002	0.001	0.002	0.002	0.001
Vanadium	NOAEL	Mean	8	80	1.481	2.813	2.125	1.750	1.350	1.625	1.544	1.000	0.831	1.013	0.731	0.619	0.575
	NOAEL	Max			1.750	3.875	2.250	2.000	1.625	1.750	2.000	1.375	1.038	1.150	0.838	0.625	0.625
	LOAEL	Mean			0.148	0.281	0.213	0.175	0.135	0.163	0.154	0.100	0.083	0.101	0.073	0.062	0.058
	LOAEL	Max			0.175	0.388	0.225	0.200	0.163	0.175	0.200	0.138	0.104	0.115	0.084	0.063	0.063
Zinc	NOAEL	Mean	4.1	41	4.146	15.488	6.098	5.976	9.756	6.098	6.951	5.488	5.610	5.854	6.463	3.659	4.024
	NOAEL	Max			4.878	20.732	6.341	6.341	10.000	6.098	7.073	6.098	5.854	6.341	6.829	3.902	4.878
	LOAEL	Mean			0.415	1.549	0.610	0.598	0.976	0.610	0.695	0.549	0.561	0.585	0.646	0.366	0.402
	LOAEL	Max			0.488	2.073	0.634	0.634	1.000	0.610	0.707	0.610	0.585	0.634	0.683	0.390	0.488
Hazard Indices	NOAEL	Mean			120	2043	905	523	257	554	482	254	255	243	111	140	139
	NOAEL	Max			158	2199	1029	567	336	741	628	344	317	262	140	209	209
	LOAEL	Mean			13	205	91	53	29	56	49	26	26	25	11	15	14
	LOAEL	Max			17	221	104	57	38	75	63	35	32	27	14	22	21

DG - Data Gap

TABLE 5-9
HAZARD QUOTIENTS FOR FISH DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/L)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Carbon Disulfide	NOAEL	Mean	1270	2480	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
	NOAEL	Max			0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
	LOAEL	Mean			0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
	LOAEL	Max			0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Toluene	NOAEL	Mean	5440	6000	0.0005	0.0025	0.0003	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0005	0.0005
	NOAEL	Max			0.0005	0.0046	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	LOAEL	Mean			0.0004	0.0023	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
	LOAEL	Max			0.0004	0.0042	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Methylene Chloride	NOAEL	Mean	990	9900	0.0019	0.0019	0.0044	0.0042	0.0025	0.0025	0.0046	0.0049	0.0033	0.0023	0.0046	0.0040	0.0043
	NOAEL	Max			0.0025	0.0025	0.0075	0.0071	0.0025	0.0025	0.0067	0.0073	0.0040	0.0025	0.0068	0.0065	0.0061
	LOAEL	Mean			0.0002	0.0002	0.0004	0.0004	0.0003	0.0003	0.0005	0.0005	0.0003	0.0002	0.0005	0.0004	0.0004
	LOAEL	Max			0.0003	0.0003	0.0007	0.0007	0.0003	0.0003	0.0007	0.0007	0.0004	0.0003	0.0007	0.0006	0.0006
Total Xylenes	NOAEL	Mean	82	820	0.0305	0.1677	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305
	NOAEL	Max			0.0305	0.3049	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305	0.0305
	LOAEL	Mean			0.0030	0.0168	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
	LOAEL	Max			0.0030	0.0305	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
Chlorobenzene	NOAEL	Mean	0.5	5	5.0000	27.5000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
	NOAEL	Max			5.0000	50.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
	LOAEL	Mean			0.5000	2.7500	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
	LOAEL	Max			0.5000	5.0000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
1,4-Dichlorobenzene	NOAEL	Mean	26.3	263	0.1331	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901
	NOAEL	Max			0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901	0.1901
	LOAEL	Mean			0.0133	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190
	LOAEL	Max			0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190	0.0190
Chlorinated Aromatic	NOAEL	Mean	23	230	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hydrocarbons	NOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Mean			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 5-9
HAZARD QUOTIENTS FOR FISH DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/L)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
2,4-Dimethylphenol	NOAEL	Mean	78	780	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641
	NOAEL	Max			0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641	0.0641
	LOAEL	Mean			0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064
	LOAEL	Max			0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064
Pentachlorophenol	NOAEL	Mean	0.18	1.8	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9
	NOAEL	Max			138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9	138.9
	LOAEL	Mean			13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
	LOAEL	Max			13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
Phenol & Substituted	NOAEL	Mean	0.7	7	7.1429	4.7143	7.1429	7.1429	7.1429	7.1429	7.1429	9.9286	7.1429	7.1429	7.1429	7.1429	7.1429
Phenols	NOAEL	Max			7.1429	7.1429	7.1429	7.1429	7.1429	7.1429	7.1429	12.7143	7.1429	7.1429	7.1429	7.1429	7.1429
	LOAEL	Mean			0.7143	0.4714	0.7143	0.7143	0.7143	0.7143	0.7143	0.9929	0.7143	0.7143	0.7143	0.7143	0.7143
	LOAEL	Max			0.7143	0.7143	0.7143	0.7143	0.7143	0.7143	0.7143	1.2714	0.7143	0.7143	0.7143	0.7143	0.7143
Nonyl Phenols	NOAEL	Mean	1.35	13.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	NOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	4.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Mean			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000
	LOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4000	0.0000	0.0000	0.0000	0.0000	0.0000
Phthalates	NOAEL	Mean	320	3200	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0108	0.0156	0.0984
	NOAEL	Max			0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156	0.1813
	LOAEL	Mean			0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0011	0.0016	0.0098
	LOAEL	Max			0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0181
Total PCBs	NOAEL	Mean	0.0032	0.032	234.4	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3
	NOAEL	Max			312.5	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3	156.3
	LOAEL	Mean			23.4	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
	LOAEL	Max			31.3	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Aldrin	NOAEL	Mean	0.009	0.09	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778
	NOAEL	Max			2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778	2.7778
	LOAEL	Mean			0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778
	LOAEL	Max			0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778
alpha-Chlordane	NOAEL	Mean	0.029	0.29	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621
	NOAEL	Max			0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621	0.8621
	LOAEL	Mean			0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862
	LOAEL	Max			0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862	0.0862
Dieldrin	NOAEL	Mean	0.0026	0.026	19.2308	19.2308	19.2308	19.2308	23.4615	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	23.4615	19.2308
	NOAEL	Max			19.2308	19.2308	19.2308	19.2308	27.6923	19.2308	19.2308	19.2308	19.2308	19.2308	19.2308	27.6923	19.2308
	LOAEL	Mean			1.9231	1.9231	1.9231	1.9231	2.3462	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	2.3462	1.9231
	LOAEL	Max			1.9231	1.9231	1.9231	1.9231	2.7692	1.9231	1.9231	1.9231	1.9231	1.9231	1.9231	2.7692	1.9231

TABLE 5-9
HAZARD QUOTIENTS FOR FISH DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/L)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Heptachlor	NOAEL	Mean	0.007	0.07	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714
	NOAEL	Max			3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714	3.5714
	LOAEL	Mean			0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571
	LOAEL	Max			0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571	0.3571
Heptachlor epoxide	NOAEL	Mean	0.053	0.53	0.4717	0.4717	0.4717	0.4717	0.4717	0.4717	0.4717	1.5566	1.1604	0.8019	0.4717	0.4717	0.4717
	NOAEL	Max			0.4717	0.4717	0.4717	0.4717	0.4717	0.4717	0.4717	2.6415	1.8491	1.1321	0.4717	0.4717	0.4717
	LOAEL	Mean			0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.1557	0.1160	0.0802	0.0472	0.0472	0.0472
	LOAEL	Max			0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.0472	0.2642	0.1849	0.1132	0.0472	0.0472	0.0472
alpha & delta BHC	NOAEL	Mean	8	80	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
	NOAEL	Max			0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
	LOAEL	Mean			0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
	LOAEL	Max			0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Endosulfan Sulfate	NOAEL	Mean	0.0016	0.016	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250
	NOAEL	Max			31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250	31.250
	LOAEL	Mean			3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125
	LOAEL	Max			3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125	3.125
Methoxychlor	NOAEL	Mean	0.017	0.17	8.088	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471
	NOAEL	Max			14.706	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471	1.471
	LOAEL	Mean			0.809	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
	LOAEL	Max			1.471	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147	0.147
Benzidine	NOAEL	Mean	105	1050	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381
	NOAEL	Max			0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381	0.2381
	LOAEL	Mean			0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238
	LOAEL	Max			0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238
Phosphine sulfide,	NOAEL	Mean	537	5370	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0253	0.0223	0.0173	0.0000	0.0000	0.0000
triphenyl	NOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0335	0.0317	0.0223	0.0000	0.0000	0.0000
	LOAEL	Mean			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0025	0.0022	0.0017	0.0000	0.0000	0.0000
	LOAEL	Max			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0034	0.0032	0.0022	0.0000	0.0000	0.0000
Low MW PAHs	NOAEL	Mean	0.0127	0.127	393.7	393.7	393.7	393.7	480.3	393.7	393.7	393.7	393.7	393.7	393.7	393.7	393.7
	NOAEL	Max			393.7	393.7	393.7	393.7	566.9	393.7	393.7	393.7	393.7	393.7	393.7	393.7	393.7
	LOAEL	Mean			39.4	39.4	39.4	39.4	48.0	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4
	LOAEL	Max			39.4	39.4	39.4	39.4	56.7	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4
Middle MW PAHs	NOAEL	Mean	0.071	0.71	70.4	70.4	70.4	70.4	107.7	70.4	70.4	70.4	70.4	106.3	83.8	70.4	478.9
	NOAEL	Max			70.4	70.4	70.4	70.4	129.6	70.4	70.4	70.4	70.4	142.3	97.2	70.4	887.3
	LOAEL	Mean			7.0	7.0	7.0	7.0	10.8	7.0	7.0	7.0	7.0	10.6	8.4	7.0	47.9
	LOAEL	Max			7.0	7.0	7.0	7.0	13.0	7.0	7.0	7.0	7.0	14.2	9.7	7.0	88.7

TABLE 5-9
HAZARD QUOTIENTS FOR FISH DIRECTLY EXPOSED TO ORGANIC COECs IN SURFACE WATER FROM SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

CONSTITUENT	ENDPOINT	VALUES	TRVs (ug/L)		Soldier Creek												
			NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Hazard Indices	NOAEL	Mean			916	852	832	832	960	832	832	837	832	868	845	836	1240
	NOAEL	Max			1001	877	832	832	1072	832	832	843	833	904	858	840	1649
	LOAEL	Mean			92	85	83	83	96	83	83	84	83	87	84	84	124
	LOAEL	Max			100	88	83	83	107	83	83	84	83	90	86	84	165

Note: A value of 0.0000 should be interpretted as a hazard quotient of less than 0.0001, rather than an indication of zero risk.

TABLE 5-10
HAZARD QUOTIENTS FOR
MUSKRATS INDIRECTLY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Antimony	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arsenic	NOAEL	Mean	1.0	1.0	1.4	1.5	2.0	1.5	0.5	1.0	1.0	43.4	0.8	0.8	0.9
	NOAEL	Max	1.0	1.6	1.9	1.9	2.0	2.0	0.7	1.0	1.0	85.6	1.0	1.0	1.0
	LOAEL	Mean	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	4.3	0.1	0.1	0.1
	LOAEL	Max	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	8.6	0.1	0.1	0.1
Cadmium	NOAEL	Mean	0.7	0.8	0.9	0.3	6.2	1.3	0.5	0.7	0.9	0.7	0.5	0.7	0.4
	NOAEL	Max	1.3	1.3	1.3	0.4	7.5	1.9	0.7	0.8	0.9	1.0	0.7	1.2	0.6
	LOAEL	Mean	0.1	0.1	0.1	0.0	0.6	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0
	LOAEL	Max	0.1	0.1	0.1	0.0	0.8	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Chromium	NOAEL	Mean	0.1	0.2	0.1	0.1	0.4	0.2	0.1	0.6	0.5	0.3	0.1	0.1	0.1
	NOAEL	Max	0.1	0.2	0.2	0.1	0.5	0.2	0.1	0.9	0.7	0.3	0.1	0.1	0.1
	LOAEL	Mean	0.1	0.2	0.1	0.1	0.4	0.2	0.1	0.6	0.5	0.3	0.1	0.1	0.1
	LOAEL	Max	0.1	0.2	0.2	0.1	0.5	0.2	0.1	0.9	0.7	0.3	0.1	0.1	0.1
Cobalt	NOAEL	Mean	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	1.0	0.3	0.3
	NOAEL	Max	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	1.4	0.3	0.4
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Cyanide	NOAEL	Mean	0.1	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	NOAEL	Max	0.1	0.1	0.1	0.1	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead	NOAEL	Mean	0.0	0.2	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.2	0.0
	NOAEL	Max	0.0	0.3	0.0	0.1	0.1	0.4	0.0	0.0	0.1	0.0	0.1	0.3	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mercury	NOAEL	Mean	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	NOAEL	Max	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 5-10
HAZARD QUOTIENTS FOR
MUSKRATS INDIRECTLY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Molybdenum	NOAEL	Mean	4.6	148.4	67.6	32.6	3.3	23.5	34.4	13.5	10.9	10.5	10.0	5.0	4.4
	NOAEL	Max	5.9	267.0	78.6	53.7	3.3	35.2	40.9	22.8	18.5	17.7	13.8	6.6	5.5
	LOAEL	Mean	0.5	14.8	6.8	3.3	0.3	2.3	3.4	1.3	1.1	1.1	1.0	0.5	0.4
	LOAEL	Max	0.6	26.7	7.9	5.4	0.3	3.5	4.1	2.3	1.8	1.8	1.4	0.7	0.6
Nickel	NOAEL	Mean	0.3	0.5	0.3	0.4	1.1	0.8	0.3	0.3	0.5	0.4	5.0	0.4	0.3
	NOAEL	Max	0.3	0.5	0.3	0.4	1.3	1.2	0.4	0.4	0.7	0.6	8.5	0.6	0.4
	LOAEL	Mean	0.3	0.5	0.3	0.4	1.1	0.8	0.3	0.3	0.5	0.4	5.0	0.4	0.3
	LOAEL	Max	0.3	0.5	0.3	0.4	1.3	1.2	0.4	0.4	0.7	0.6	8.5	0.6	0.4
Selenium	NOAEL	Mean	1.1	1.2	1.1	1.1	1.1	1.6	1.0	1.2	1.6	10.0	1.1	1.7	1.2
	NOAEL	Max	1.1	1.3	1.1	1.1	1.1	2.1	1.1	1.3	2.1	18.5	1.1	2.1	1.3
	LOAEL	Mean	0.5	0.6	0.5	0.5	0.5	0.8	0.5	0.6	0.8	4.9	0.5	0.8	0.6
	LOAEL	Max	0.5	0.6	0.5	0.5	0.5	1.0	0.5	0.6	1.0	9.0	0.5	1.0	0.6
Silver	NOAEL	Mean	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAZARD INDEX	NOAEL	Mean	8.5	152.9	72.0	36.5	15.0	29.8	37.5	18.0	16.0	66.0	18.9	9.6	7.9
	NOAEL	Max	10.6	272.8	84.1	58.2	17.1	43.7	44.6	27.9	24.7	124.5	27.1	12.6	9.6
	LOAEL	Mean	1.7	16.4	8.0	4.5	3.2	4.5	4.5	3.1	3.1	11.1	7.0	2.1	1.6
	LOAEL	Max	1.9	28.4	9.3	6.7	3.8	6.5	5.4	4.4	4.6	20.4	10.9	2.8	1.9

Note: A value of 0.0 should be interpretted as a hazard quotient of less than 0.1 rather than an indication of zero risk.

TABLE 5-11
HAZARD QUOTIENTS FOR MUSKRATS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Pentachlorophenol	NOAEL	Mean	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	NOAEL	Max	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	LOAEL	Mean	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LOAEL	Max	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total PCBs	NOAEL	Mean	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	NOAEL	Max	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Max	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Aldrin	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alpha-Chlordane	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dieldrin	NOAEL	Mean	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptachlor	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptachlor epoxide	NOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 5-11
HAZARD QUOTIENTS FOR MUSKRATS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Endosulfan Sulfate	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzidine	NOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
High MW PAHs	NOAEL	Mean	31.6	40.3	39.6	39.5	43.9	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2
	NOAEL	Max	47.4	49.0	47.6	47.5	47.6	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2
	LOAEL	Mean	3.2	4.0	4.0	4.0	4.4	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	LOAEL	Max	4.7	4.9	4.8	4.7	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
HAZARD INDEX	NOAEL	Mean	32.0	40.8	40.0	39.9	44.9	47.6	47.6	47.6	47.5	47.6	47.6	47.6	47.6
	NOAEL	Max	47.9	49.4	48.0	47.9	48.7	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6
	LOAEL	Mean	3.5	4.3	4.2	4.2	5.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	LOAEL	Max	5.1	5.2	5.0	5.0	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

Note: A value of 0.0 should be interpretted as a hazard quotient less than 0.1 rather than an indication of zero risk.

TABLE 5-12
HAZARD QUOTIENTS FOR
RED-WINGED BLACKBIRDS INDIRECLTY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Antimony	NOAEL	Mean	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.8	2.2	2.2	2.2	2.2
	NOAEL	Max	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	3.4	2.2	2.2	2.2	2.2
	LOAEL	Mean	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2
	LOAEL	Max	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2
Arsenic	NOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	2.4	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	2.4	0.0	0.0	0.0
Cadmium	NOAEL	Mean	0.3	0.4	0.4	0.1	1.9	0.2	0.2	0.2	0.2	0.2	0.1	0.3	0.1
	NOAEL	Max	0.6	0.6	0.6	0.1	2.2	0.2	0.3	0.2	0.2	0.2	0.1	0.5	0.2
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.1	0.1	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Chromium	NOAEL	Mean	12.6	25.8	17.1	14.2	34.0	12.6	14.0	79.4	56.7	34.0	12.6	14.6	12.6
	NOAEL	Max	12.6	30.2	21.7	15.9	55.4	12.6	15.4	105.8	83.1	40.3	12.6	16.6	12.6
	LOAEL	Mean	1.3	2.6	1.7	1.4	3.4	1.3	1.4	7.9	5.7	3.4	1.3	1.5	1.3
	LOAEL	Max	1.3	3.0	2.2	1.6	5.5	1.3	1.5	10.6	8.3	4.0	1.3	1.7	1.3
Cobalt	NOAEL	Mean	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	NOAEL	Max	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	LOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Max	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cyanide	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead	NOAEL	Mean	0.0	0.3	0.1	0.0	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.3	0.0
	NOAEL	Max	0.1	0.6	0.1	0.0	0.2	0.7	0.1	0.1	0.2	0.1	0.1	0.6	0.0
	LOAEL	Mean	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
	LOAEL	Max	0.0	0.2	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.2	0.0
Mercury	NOAEL	Mean	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	NOAEL	Max	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	LOAEL	Mean	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	LOAEL	Max	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

TABLE 5-12
HAZARD QUOTIENTS FOR
RED-WINGED BLACKBIRDS INDIRECLTY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Nickel	NOAEL	Mean	6.0	6.0	6.0	6.0	6.0	6.0	4.4	4.5	5.1	6.0	20.8	5.0	4.8
	NOAEL	Max	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	29.8	6.0	6.0
	LOAEL	Mean	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.5	0.5	0.6	2.1	0.5	0.5
	LOAEL	Max	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	3.0	0.6	0.6
Selenium	NOAEL	Mean	1.1	1.2	1.1	1.1	1.1	1.6	1.1	1.2	1.6	10.2	1.1	1.7	1.2
	NOAEL	Max	1.1	1.3	1.1	1.1	1.1	2.1	1.1	1.3	2.1	18.9	1.1	2.1	1.3
	LOAEL	Mean	0.9	1.0	0.9	0.9	0.9	1.3	0.9	1.0	1.3	8.4	0.9	1.4	1.0
	LOAEL	Max	0.9	1.1	0.9	0.9	0.9	1.8	0.9	1.1	1.8	15.6	0.9	1.8	1.1
Silver	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAZARD INDEX	NOAEL	Mean	25.2	38.9	29.8	26.6	48.3	26.0	24.9	90.5	69.5	56.9	39.7	27.1	24.0
	NOAEL	Max	25.5	43.9	34.6	28.3	70.1	26.9	28.0	118.6	98.0	73.1	48.8	31.1	25.4
	LOAEL	Mean	4.1	5.7	4.6	4.3	6.5	4.7	4.1	10.8	9.0	15.0	5.6	4.8	4.1
	LOAEL	Max	4.2	6.3	5.1	4.5	8.7	5.3	4.4	13.7	12.2	24.0	6.5	5.6	4.4

Note: A value of 0.0 should be interpretted as a hazard quotient of less than 0.1 rather than an indication of zero risk.

TABLE 5-13
HAZARD QUOTIENTS FOR RED-WINGED BLACKBIRDS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Total PCBs	NOAEL	Mean	17.1	17.1	2.2	4.2	17.1	3.6	3.0	1.8	0.5	7.6	17.1	11.7	17.1
	NOAEL	Max	17.1	17.1	3.0	4.4	17.1	4.7	4.9	3.0	0.8	10.2	17.1	15.8	17.1
	LOAEL	Mean	13.3	13.3	1.7	3.3	13.3	2.8	2.4	1.4	0.4	5.9	13.3	9.1	13.3
	LOAEL	Max	13.3	13.3	2.3	3.4	13.3	3.6	3.8	2.3	0.6	7.9	13.3	12.3	13.3
Aldrin	NOAEL	Mean	0.7	1.1	0.1	0.2	57.7	0.5	0.4	1.1	0.1	0.2	0.7	0.5	0.8
	NOAEL	Max	1.3	1.2	0.1	0.2	60.5	0.5	0.8	1.9	0.1	0.2	1.3	0.7	0.8
	LOAEL	Mean	0.1	0.1	0.0	0.0	5.8	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
	LOAEL	Max	0.1	0.1	0.0	0.0	6.0	0.0	0.1	0.2	0.0	0.0	0.1	0.1	0.1
alpha-Chlordane	NOAEL	Mean	0.0	0.0	0.0	0.0	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.1	0.0	0.0	0.0	16.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.1	0.0	0.0	0.0	16.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Dieldrin	NOAEL	Mean	0.1	0.2	0.0	0.0	4.8	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.2
	NOAEL	Max	0.2	0.2	0.0	0.0	4.8	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.2
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptachlor	NOAEL	Mean	0.1	0.2	0.0	0.0	24.7	0.1	0.1	0.3	0.0	0.7	0.1	0.1	0.2
	NOAEL	Max	0.3	0.2	0.0	0.0	24.7	0.2	0.2	0.6	0.0	1.0	0.3	0.1	0.2
	LOAEL	Mean	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Heptachlor epoxide	NOAEL	Mean	2.1	3.5	0.3	0.5	184.3	0.3	0.3	0.2	0.1	0.7	2.2	1.5	2.5
	NOAEL	Max	4.1	3.7	0.5	0.5	193.1	0.3	0.5	0.2	0.1	0.7	4.0	2.2	2.5
	LOAEL	Mean	1.5	2.5	0.2	0.3	131.6	0.2	0.2	0.1	0.0	0.5	1.6	1.1	1.8
	LOAEL	Max	2.9	2.6	0.3	0.4	137.9	0.2	0.3	0.2	0.1	0.5	2.9	1.5	1.8
Endosulfan Sulfate	NOAEL	Mean	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzidine	NOAEL	Mean	0.5	0.7	0.5	0.4	5.1	0.7	0.8	1.5	0.1	1.3	0.2	0.8	1.9
	NOAEL	Max	0.8	1.4	0.6	0.4	5.5	0.8	0.8	1.5	0.1	1.3	0.3	0.8	1.9
	LOAEL	Mean	0.0	0.1	0.1	0.0	0.5	0.1	0.1	0.2	0.0	0.1	0.0	0.1	0.2
	LOAEL	Max	0.1	0.1	0.1	0.0	0.5	0.1	0.1	0.2	0.0	0.1	0.0	0.1	0.2

TABLE 5-13
HAZARD QUOTIENTS FOR RED-WINGED BLACKBIRDS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
High MW PAHs	NOAEL	Mean	7.0	28.9	19.5	22.3	28.9	3.5	4.3	4.2	0.5	3.9	1.9	3.9	7.6
	NOAEL	Max	12.6	28.9	28.2	28.9	28.9	5.8	7.1	4.3	0.5	4.5	2.7	3.9	14.0
	LOAEL	Mean	0.7	2.9	2.0	2.2	2.9	0.3	0.4	0.4	0.0	0.4	0.2	0.4	0.8
	LOAEL	Max	1.3	2.9	2.8	2.9	2.9	0.6	0.7	0.4	0.1	0.5	0.3	0.4	1.4
HAZARD INDEX	NOAEL	Mean	27.6	51.9	22.6	27.6	336.9	8.6	9.0	9.2	1.2	14.4	22.4	18.6	30.2
	NOAEL	Max	36.4	52.8	32.4	34.4	353.6	12.3	14.2	11.7	1.6	18.0	25.9	23.7	36.6
	LOAEL	Mean	15.7	19.0	3.9	5.9	169.2	3.5	3.2	2.2	0.5	7.0	15.2	10.7	16.1
	LOAEL	Max	17.8	19.2	5.6	6.7	180.2	4.6	5.0	3.3	0.7	9.1	16.7	14.5	16.8

Note: A value of 0.0 should be interpretted as a hazard quotient less than 0.1 rather than an indication of zero risk.

TABLE 5-14
HAZARD QUOTIENTS FOR RACCOONS INDIRECTELY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Antimony	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arsenic	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	NOAEL	Mean	0.1	0.1	0.1	0.1	1.0	0.4	0.1	0.2	0.2	0.2	0.1	0.1	0.1
	NOAEL	Max	0.1	0.1	0.1	0.2	1.3	0.5	0.1	0.2	0.2	0.2	0.2	0.1	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromium	NOAEL	Mean	0.4	0.8	0.5	0.5	2.4	1.3	0.5	2.2	1.9	1.1	0.8	0.5	0.4
	NOAEL	Max	0.4	0.9	0.6	0.7	3.0	1.9	0.7	2.9	2.7	1.6	1.1	0.6	0.4
	LOAEL	Mean	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.0
	LOAEL	Max	0.0	0.1	0.1	0.1	0.3	0.2	0.1	0.3	0.3	0.2	0.1	0.1	0.0
Cobalt	NOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1
	NOAEL	Max	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.1	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyanide	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mercury	NOAEL	Mean	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	NOAEL	Max	2.2	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	LOAEL	Mean	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LOAEL	Max	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

TABLE 5-14
HAZARD QUOTIENTS FOR RACCOONS INDIRECTELY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Molybdenum	NOAEL	Mean	0.5	11.0	5.0	2.5	0.3	1.9	2.6	1.1	0.9	0.9	1.3	0.5	0.4
	NOAEL	Max	0.6	19.6	5.8	4.1	0.4	2.8	3.1	1.8	1.5	1.4	2.0	0.6	0.5
	LOAEL	Mean	0.0	1.1	0.5	0.3	0.0	0.2	0.3	0.1	0.1	0.1	0.1	0.0	0.0
	LOAEL	Max	0.1	2.0	0.6	0.4	0.0	0.3	0.3	0.2	0.1	0.1	0.2	0.1	0.1
Nickel	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selenium	NOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.1	0.1	0.1
	NOAEL	Max	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.8	0.1	0.1	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.4	0.0	0.1	0.0
Silver	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAZARD INDEX	NOAEL	Mean	3.3	14.3	8.0	5.5	6.2	6.1	5.6	5.8	5.4	5.1	4.9	3.5	3.3
	NOAEL	Max	3.5	23.2	9.0	7.3	7.1	7.8	6.2	7.3	6.8	6.7	6.2	3.8	3.4
	LOAEL	Mean	0.4	1.5	0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.5	0.4	0.4
	LOAEL	Max	0.4	2.4	0.9	0.8	0.7	0.8	0.6	0.8	0.7	1.0	0.7	0.4	0.4

Note: A value of 0.0 should be interpretted as a hazard quotient less than 0.1, rather than an indication of zero risk.

TABLE 5-15
HAZARD QUOTIENTS FOR RACCOONS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Pentachlorophenol	NOAEL	Mean	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2
	NOAEL	Max	0.1	0.2	0.1	0.1	0.4	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.2
	LOAEL	Mean	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Max	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total PCBs	NOAEL	Mean	27.2	23.4	10.4	12.2	23.6	11.7	11.0	10.1	8.9	14.9	23.1	18.5	22.9
	NOAEL	Max	31.7	23.5	11.2	12.4	23.7	12.7	12.6	11.1	9.2	17.0	23.3	22.0	22.9
	LOAEL	Mean	2.7	2.3	1.0	1.2	2.4	1.2	1.1	1.0	0.9	1.5	2.3	1.8	2.3
	LOAEL	Max	3.2	2.4	1.1	1.2	2.4	1.3	1.3	1.1	0.9	1.7	2.3	2.2	2.3
Aldrin	NOAEL	Mean	0.1	0.1	0.0	0.0	3.8	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
	NOAEL	Max	0.1	0.1	0.0	0.0	4.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alpha-Chlordane	NOAEL	Mean	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dieldrin	NOAEL	Mean	0.0	0.1	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.1	0.1	0.0	0.0	2.6	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptachlor	NOAEL	Mean	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptachlor epoxide	NOAEL	Mean	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 5-15
HAZARD QUOTIENTS FOR RACCOONS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Endosulfan Sulfate	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Benzidine	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
High MW PAHs	NOAEL	Mean	13.6	26.1	21.8	23.0	27.3	17.3	17.7	17.6	16.0	17.5	16.6	17.5	19.1
	NOAEL	Max	21.3	29.0	28.2	28.5	28.6	18.3	18.9	17.7	16.0	17.8	17.0	17.5	21.9
	LOAEL	Mean	1.4	2.6	2.2	2.3	2.7	1.7	1.8	1.8	1.6	1.7	1.7	1.7	1.9
	LOAEL	Max	2.1	2.9	2.8	2.9	2.9	1.8	1.9	1.8	1.6	1.8	1.7	1.7	2.2
HAZARD INDEX	NOAEL	Mean	41.0	49.8	32.3	35.3	59.4	29.2	28.9	28.0	25.0	32.6	40.0	36.2	42.3
	NOAEL	Max	53.3	52.9	39.6	41.1	61.2	31.2	31.7	29.1	25.3	35.1	40.6	39.7	45.1
	LOAEL	Mean	4.2	5.1	3.3	3.6	6.5	3.0	3.0	2.9	2.6	3.3	4.1	3.7	4.3
	LOAEL	Max	5.4	5.4	4.0	4.2	6.8	3.2	3.2	3.0	2.6	3.6	4.1	4.0	4.6

Note: A value of 0.0 should be interpretted as a hazard quotient less than 0.1 rather than an indication of zero risk.

TABLE 5-16
HAZARD QUOTIENTS FOR
GREEN HERONS INDIRECTLY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Antimony	NOAEL	Mean	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.0	1.0	1.0	1.0
	NOAEL	Max	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.4	1.0	1.0	1.0	1.0
	LOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Max	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Arsenic	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cadmium	NOAEL	Mean	0.1	0.1	0.1	0.2	1.0	0.4	0.1	0.2	0.3	0.2	0.1	0.1	0.1
	NOAEL	Max	0.2	0.2	0.2	0.3	1.2	0.5	0.1	0.2	0.3	0.3	0.2	0.2	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chromium	NOAEL	Mean	1.5	3.0	2.1	2.2	9.6	5.4	2.2	8.6	7.6	4.6	3.1	2.1	1.6
	NOAEL	Max	1.6	3.7	2.5	2.7	12.1	8.0	2.8	11.6	10.6	6.3	4.5	2.5	1.7
	LOAEL	Mean	0.1	0.3	0.2	0.2	1.0	0.5	0.2	0.9	0.8	0.5	0.3	0.2	0.2
	LOAEL	Max	0.2	0.4	0.3	0.3	1.2	0.8	0.3	1.2	1.1	0.6	0.5	0.3	0.2
Cobalt	NOAEL	Mean	0.7	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.7	1.1	0.7	0.7
	NOAEL	Max	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.7	1.4	0.7	0.7
	LOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Max	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cyanide	NOAEL	Mean	0.4	0.5	0.5	0.5	1.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	NOAEL	Max	0.5	0.5	0.5	0.5	1.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	LOAEL	Mean	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	LOAEL	Max	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lead	NOAEL	Mean	4.2	13.9	3.8	12.4	13.0	22.7	4.3	4.3	9.8	4.2	8.2	14.9	2.8
	NOAEL	Max	5.6	24.3	6.0	20.4	17.6	37.4	5.1	4.8	13.0	5.0	12.0	27.2	3.9
	LOAEL	Mean	0.4	1.4	0.4	1.2	1.3	2.3	0.4	0.4	1.0	0.4	0.8	1.5	0.3
	LOAEL	Max	0.6	2.4	0.6	2.0	1.8	3.7	0.5	0.5	1.3	0.5	1.2	2.7	0.4
Mercury	NOAEL	Mean	45.6	45.8	45.6	45.6	45.7	45.7	45.6	45.6	45.6	45.6	45.7	45.6	45.6
	NOAEL	Max	45.7	45.9	45.6	45.6	45.8	45.7	45.6	45.6	45.6	45.6	45.8	45.6	45.6
	LOAEL	Mean	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
	LOAEL	Max	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6

TABLE 5-16
HAZARD QUOTIENTS FOR
GREEN HERONS INDIRECTLY EXPOSED TO INORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Nickel	NOAEL	Mean	1.6	3.5	1.9	2.4	10.8	7.7	2.1	2.2	4.3	3.3	50.5	3.5	1.9
	NOAEL	Max	1.6	3.5	2.1	2.7	13.7	12.3	3.3	3.0	6.6	5.1	87.2	4.9	2.4
	LOAEL	Mean	0.2	0.3	0.2	0.2	1.1	0.8	0.2	0.2	0.4	0.3	5.1	0.3	0.2
	LOAEL	Max	0.2	0.4	0.2	0.3	1.4	1.2	0.3	0.3	0.7	0.5	8.7	0.5	0.2
Selenium	NOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.1	0.1	0.1
	NOAEL	Max	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.7	0.1	0.2	0.1
	LOAEL	Mean	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1
	LOAEL	Max	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.6	0.1	0.1	0.1
Silver	NOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAZARD INDEX	NOAEL	Mean	55.3	68.6	55.9	65.1	83.0	84.3	56.5	63.2	70.1	60.6	110.4	68.4	54.3
	NOAEL	Max	57.0	80.0	58.8	74.1	93.9	106.5	59.2	67.5	78.9	65.3	152.7	82.7	56.1
	LOAEL	Mean	5.6	7.0	5.7	6.6	8.4	8.5	5.7	6.4	7.1	6.4	11.1	6.9	5.5
	LOAEL	Max	5.8	8.1	6.0	7.5	9.5	10.8	6.0	6.8	8.0	7.1	15.4	8.4	5.7

Note: A value of 0.0 should be interpretted as a hazard quotient of less than 0.1 rather than an indication of zero risk.

TABLE 5-17
HAZARD QUOTIENTS FOR GREEN HERONS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Total PCBs	NOAEL	Mean	14.6	12.5	5.5	6.5	12.5	6.2	5.9	5.3	4.7	8.0	12.4	9.9	12.4
	NOAEL	Max	16.9	12.5	5.9	6.6	12.5	6.7	6.7	5.9	4.8	9.2	12.5	11.9	12.4
	LOAEL	Mean	11.4	9.7	4.3	5.0	9.7	4.8	4.6	4.1	3.6	6.2	9.7	7.7	9.6
	LOAEL	Max	13.1	9.7	4.6	5.1	9.7	5.2	5.2	4.6	3.8	7.2	9.7	9.2	9.7
Aldrin	NOAEL	Mean	0.4	0.6	0.1	0.2	26.9	0.3	0.3	0.6	0.1	0.2	0.4	0.3	0.5
	NOAEL	Max	0.7	0.6	0.2	0.2	28.2	0.3	0.5	1.0	0.2	0.2	0.7	0.4	0.5
	LOAEL	Mean	0.0	0.1	0.0	0.0	2.7	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.1	0.1	0.0	0.0	2.8	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
alpha-Chlordane	NOAEL	Mean	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dieldrin	NOAEL	Mean	0.1	0.1	0.0	0.0	2.3	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
	NOAEL	Max	0.1	0.1	0.0	0.0	2.4	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptachlor	NOAEL	Mean	0.1	0.1	0.0	0.0	11.5	0.1	0.1	0.2	0.0	0.3	0.1	0.1	0.1
	NOAEL	Max	0.1	0.1	0.0	0.0	11.5	0.1	0.1	0.3	0.0	0.5	0.1	0.1	0.1
	LOAEL	Mean	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heptachlor epoxide	NOAEL	Mean	1.2	1.8	0.3	0.4	85.3	0.3	0.3	0.6	0.4	0.6	1.2	0.9	1.3
	NOAEL	Max	2.1	1.9	0.4	0.4	89.4	0.3	0.4	1.0	0.6	0.7	2.1	1.2	1.3
	LOAEL	Mean	0.8	1.3	0.2	0.3	60.9	0.2	0.2	0.4	0.3	0.4	0.9	0.6	0.9
	LOAEL	Max	1.5	1.4	0.3	0.3	63.8	0.2	0.3	0.7	0.5	0.5	1.5	0.8	0.9
Endosulfan Sulfate	NOAEL	Mean	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NOAEL	Max	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Mean	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LOAEL	Max	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 5-17
HAZARD QUOTIENTS FOR GREEN HERONS INDIRECTLY EXPOSED TO ORGANIC COECs IN INGESTED MEDIA

COEC	Endpoint	Value	EE01	EE02	EE03	EE04	EE05	EE06	EE07	EE08	EE09	EE10	EW01	EW02	EW03
High MW PAHs	NOAEL	Mean	14.1	27.0	22.7	23.9	28.5	17.9	18.3	18.2	16.5	18.1	17.2	18.1	19.8
	NOAEL	Max	22.1	29.8	29.4	29.7	29.7	19.0	19.6	18.3	16.5	18.4	17.5	18.1	22.8
	LOAEL	Mean	1.4	2.7	2.3	2.4	2.8	1.8	1.8	1.8	1.7	1.8	1.7	1.8	2.0
	LOAEL	Max	2.2	3.0	2.9	3.0	3.0	1.9	2.0	1.8	1.7	1.8	1.8	1.8	2.3
HAZARD INDEX	NOAEL	Mean	30.5	42.2	28.6	31.0	173.5	24.8	24.9	25.0	21.8	27.3	31.5	29.4	34.2
	NOAEL	Max	42.1	45.1	35.9	36.9	182.4	26.4	27.3	26.5	22.2	29.0	33.1	31.7	37.2
	LOAEL	Mean	13.7	13.8	6.8	7.7	83.2	6.8	6.7	6.5	5.6	8.5	12.4	10.2	12.7
	LOAEL	Max	17.0	14.2	7.8	8.4	88.5	7.4	7.5	7.2	5.9	9.6	13.1	12.0	13.0

Note: A value of 0.0 should be interpretted as a hazard quotient less than 0.1 rather than an indication of zero risk.

TABLE 5-18
HAZARD QUOTIENTS FOR MICROBIAL DECOMPOSERS (BACTERIA/FUNGI) DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER

			TRVs (ug/l)		Soldier Creek					
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE01	EE02	EE03	EE04	EE05	EE06
Chromium	NOAEL	Mean	500	5000	0.010	0.021	0.014	0.011	0.027	0.010
	NOAEL	Max			0.010	0.024	0.017	0.013	0.044	0.010
	LOAEL	Mean			0.001	0.002	0.001	0.001	0.003	0.001
	LOAEL	Max			0.001	0.002	0.002	0.001	0.004	0.001
Copper	NOAEL	Mean	100	1000	0.070	1.400	0.615	0.350	0.150	0.365
	NOAEL	Max			0.092	1.500	0.700	0.380	0.200	0.490
	LOAEL	Mean			0.007	0.140	0.062	0.035	0.015	0.037
	LOAEL	Max			0.009	0.150	0.070	0.038	0.020	0.049
Lead	NOAEL	Mean	10	100	0.190	1.300	0.220	0.145	0.365	1.635
	NOAEL	Max			0.270	2.400	0.350	0.200	0.680	3.000
	LOAEL	Mean			0.019	0.130	0.022	0.015	0.037	0.164
	LOAEL	Max			0.027	0.240	0.035	0.020	0.068	0.300
Nickel	NOAEL	Mean	10	100	2.000	2.000	2.000	2.000	2.000	2.000
	NOAEL	Max			2.000	2.000	2.000	2.000	2.000	2.000
	LOAEL	Mean			0.200	0.200	0.200	0.200	0.200	0.200
	LOAEL	Max			0.200	0.200	0.200	0.200	0.200	0.200
Silver	NOAEL	Mean	3	30	0.020	0.018	0.038	0.017	0.050	0.017
	NOAEL	Max			0.023	0.020	0.060	0.017	0.083	0.017
	LOAEL	Mean			0.002	0.002	0.004	0.002	0.005	0.002
	LOAEL	Max			0.002	0.002	0.006	0.002	0.008	0.002
Zinc	NOAEL	Mean	500	5000	0.034	0.127	0.050	0.049	0.080	0.050
	NOAEL	Max			0.040	0.170	0.052	0.052	0.082	0.050
	LOAEL	Mean			0.003	0.013	0.005	0.005	0.008	0.005
	LOAEL	Max			0.004	0.017	0.005	0.005	0.008	0.005
Hazard Indices	NOAEL	Mean			2.32	4.87	2.94	2.57	2.67	4.08
	NOAEL	Max			2.44	6.11	3.18	2.66	3.09	5.57
	LOAEL	Mean			0.23	0.49	0.29	0.26	0.27	0.41
	LOAEL	Max			0.24	0.61	0.32	0.27	0.31	0.56

TABLE 5-18
HAZARD QUOTIENTS FOR MICROBIAL DECOMPOSERS (BACTERIA/FUNGI) DIRECTLY EXPOSED TO INORGANIC COECs IN SURFACE WATER

			TRVs (ug/l)		Soldier Creek						
CONSTITUENT	ENDPOINT	VALUES	NOAEL	LOAEL	EE07	EE08	EE09	EE10	EW01	EW02	EW03
Chromium	NOAEL	Mean	500	5000	0.011	0.063	0.045	0.027	0.010	0.012	0.010
	NOAEL	Max			0.012	0.084	0.066	0.032	0.010	0.013	0.010
	LOAEL	Mean			0.001	0.006	0.005	0.003	0.001	0.001	0.001
	LOAEL	Max			0.001	0.008	0.007	0.003	0.001	0.001	0.001
Copper	NOAEL	Mean	100	1000	0.320	0.160	0.160	0.150	0.052	0.079	0.083
	NOAEL	Max			0.420	0.220	0.200	0.160	0.065	0.120	0.130
	LOAEL	Mean			0.032	0.016	0.016	0.015	0.005	0.008	0.008
	LOAEL	Max			0.042	0.022	0.020	0.016	0.007	0.012	0.013
Lead	NOAEL	Mean	10	100	0.305	0.220	0.485	0.225	0.210	1.289	0.148
	NOAEL	Max			0.320	0.230	0.760	0.230	0.220	2.500	0.200
	LOAEL	Mean			0.031	0.022	0.049	0.023	0.021	0.129	0.015
	LOAEL	Max			0.032	0.023	0.076	0.023	0.022	0.250	0.020
Nickel	NOAEL	Mean	10	100	1.475	1.500	1.700	2.000	6.900	1.650	1.600
	NOAEL	Max			2.000	2.000	2.000	2.000	9.900	2.000	2.000
	LOAEL	Mean			0.148	0.150	0.170	0.200	0.690	0.165	0.160
	LOAEL	Max			0.200	0.200	0.200	0.200	0.990	0.200	0.200
Silver	NOAEL	Mean	3	30	0.017	0.040	0.032	0.017	0.028	0.030	0.017
	NOAEL	Max			0.017	0.063	0.047	0.017	0.040	0.043	0.017
	LOAEL	Mean			0.002	0.004	0.003	0.002	0.003	0.003	0.002
	LOAEL	Max			0.002	0.006	0.005	0.002	0.004	0.004	0.002
Zinc	NOAEL	Mean	500	5000	0.057	0.045	0.046	0.048	0.053	0.030	0.033
	NOAEL	Max			0.058	0.050	0.048	0.052	0.056	0.032	0.040
	LOAEL	Mean			0.006	0.005	0.005	0.005	0.005	0.003	0.003
	LOAEL	Max			0.006	0.005	0.005	0.005	0.006	0.003	0.004
Hazard Indices	NOAEL	Mean			2.18	2.03	2.47	2.47	7.25	3.09	1.89
	NOAEL	Max			2.83	2.65	3.12	2.49	10.29	4.71	2.40
	LOAEL	Mean			0.22	0.20	0.25	0.25	0.73	0.31	0.19
	LOAEL	Max			0.28	0.26	0.31	0.25	1.03	0.47	0.24

TABLE 5-19
SUMMARY OF CONSTITUENTS CONSIDERED UNCERTAINTIES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	Matrix	Reason	Notes
1,1,1-Trichloroethane	S	D	
1,1-Dichloroethane	S	D	
1,1-Dichloroethene	S	D	
1-Naphthylamine	S	D	
2,3,4,6-Tetrachlorophenol	S	D	
2,4,5-Trichlorophenol	S	D	
2,4-Dinitrophenol	S	D	
2,4-Dinitrotoluene	S	D	
2,6-Dinitrotoluene	B	B	
2,6-Dinitrotoluene	S	B	
2-Methylphenol	S	D	
3,3'-Dichlorobenzidine	S	D	
3-Methylcholanthrene	B	B	
3-Methylcholanthrene	S	B	
3/4-Methylphenol	W	B	
4,4'-DDD	S	D	
4,4'-DDE	S	D	
4,4'-DDT	B	D	
4,4'-DDT	S	D	
4,6-Dinitro-^2-methylphenol	S	D	
4-Aminobiphenyl	S	D	
4-Bromophenyl^phenyl ether	S	D	
4-Chloro-3-methylphenol	S	D	
4-Chloroaniline	S	D	
4-Methyl-2-pentanone ^(MIBK)	S	B	
4-Nitroaniline	S	D	
4-Nitrophenol	B	B,D	Benchmark not available for water
4-Nitrophenol	S	D	
7,12-Dimethylbenz(a)-^anthracene	B	B	
7,12-Dimethylbenz(a)-^anthracene	S	B	
Acenaphthylene	S	B	
Acrolein	W	B	
alpha-Chlordane	W	B	
Aluminum	S	B	
Aniline	S	B	
Anthracene	W	D	
Aroclor 1016	W	B	
Aroclor 1248	W	D	
Aroclor 1254	W	D	
Aroclor 1260	W	D	
Azobenzene	S	D	
Benzo(b)fluoranthene	W	B	
Benzo(g,h,i)perylene	W	B	
Benzo(k)fluoranthene	W	B	
Benzyl alcohol	B	B, D	Benchmark not available for water
Benzyl alcohol	S	D	
beta-BHC	S	D	
bis(2-Chloroethoxy)^methane	B	B	
bis(2-Chloroethoxy)^methane	S	B	
bis(2-Chloroethyl)ether	S	B	
Bromodichloromethane	S	D	
cis-1,3-Dichloropropene	S	B	

TABLE 5-19
SUMMARY OF CONSTITUENTS CONSIDERED UNCERTAINTIES IN SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

Constituent or Group	Matrix	Reason	Notes
Dibenz(a,h)anthracene	W	B	
Dibenz(a,j)acridine	W	B	
Dibromochloromethane	S	D	
Diethyl phthalate	S	D	
Endosulfan I	S	D	
Endosulfan II	B	D	
Endosulfan II	S	D	
Endosulfan sulfate	W	B	
Endrin	W	D	
Endrin aldehyde	B	B	
Endrin aldehyde	S	B	
Ethyl methanesulfonate	B	B	
Ethyl methanesulfonate	S	B	
gamma-BHC (Lindane)	S	D	
gamma-Chlordane	B	B	
gamma-Chlordane	S	B	
Heptachlor	W	D	
Hexachlorobenzene	B	D	
Hexachlorobenzene	S	D	
Hexachlorobutadiene	S	D	
Hexachlorocyclopentadiene	B	D	
Hexachlorocyclopentadiene	S	D	
Hexachloroethane	S	D	
Indeno(1,2,3-cd)pyrene	W	B	
Methoxychlor	W	D	
Methyl methanesulfonate	B	B	
Methyl methanesulfonate	S	B	
N-Nitroso-di-^n-butylamine	B	B	
N-Nitroso-di-^n-propylamine	B	B	
N-Nitroso-di-^n-propylamine	S	B	
N-Nitroso-di-n-butylamine	W	B	
N-Nitrosodiphenylamine	S	B	
Pentachlorobenzene	S	D	
Pentachloronitrobenzene (PCNB)	S	D	
Pentachlorophenol [PCP]	W	D	
Thallium	W	B	
Toxaphene	B	D	
Toxaphene	S	D	
trans-1,4-Dichloro-2-butene	B	B	
trans-1,4-Dichloro-2-butene	S	B	
Vinyl chloride	W	B	

Notes:

Under matrix: s = sediment; w = water; B = both matrices.

Under reason: D = benchmark is lower than at least one detection limit; B = no benchmark available

n = 33 (no benchmark available)

n = 45 (benchmark lower than at least one detection limit)

TABLE 5-20

SUMMARY OF RESOLUTION OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Resolution
GAE 1. Protection of primary producers	SAE 1.1 Protection of periphyton and phytoplankton communities	M1.1.1 Reduced survival of sensitive algae due to direct toxicity of COECs in surface water?	Yes; primarily in uppermost portions of East Soldier Creek due to aluminum, cadmium, chromium, copper, molybdenum, and zinc.
	SAE 1.2 Protection of aquatic vascular plant communities	M1.2.1 Reduced survival of aquatic vascular plants due to direct toxicity of organic COECs in sediment pore water?	Yes; possibility of limitations on production due to PCP and high molecular weight PAHs cannot be ruled out because of uncertainty.
		M1.2.2 Reduced survival of aquatic vascular plants due to direct toxicity of inorganic COECs in bulk sediments?	Yes; production is probably limited in some areas due to elevated concentrations of cadmium, chromium, copper, nickel, silver, and vanadium.
GAE 2. Protection of aquatic primary consumers	SAE 2.1 Protection of benthic invertebrate community	M2.1.1 Reduced survival, reproduction, development, and/or growth of sensitive benthic invertebrates due to direct toxicity of organic COECs in sediment pore water?	Yes; survival is probably limited in much of Operable Unit due to elevated concentrations of PAHs, PCBs, and benzidine; additional localized effects are probable due to some pesticides, phenolics, and PCP.
GAE 2. (Continued)	SAE 2.1 (Continued)	M2.1.2 Reduced survival,	Yes; survival is probably limited in

TABLE 5-20

SUMMARY OF RESOLUTION OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Resolution
		reproduction, development, and/or growth of sensitive benthic invertebrates due to direct toxicity of inorganic COECs in bulk sediments?	much of Operable Unit due to elevated concentrations of several metals (e.g., cadmium, chromium, copper, nickel, silver, and zinc).
		M2.1.3 Reduced survival, reproduction, and/or growth of sensitive benthic invertebrates due to direct exposure to bulk sediments?	Yes; chronic effects were pervasive in both sets of tests (see Subsection 4.2.2).
		M2.1.4 Reduced survival, reproduction, and/or growth of benthic invertebrates due to effects of COECs on other ecological components?	Yes; effects on algae, vascular plants, and microbial decomposers probably limit food supply and/or cover.
		M2.1.5 Reduced diversity of benthic invertebrate communities?	Yes; benthic diversity in general is lower than in reference stream.
GAE 2. (Continued)	SAE 2.2 Protection of water-column invertebrate community	M2.2.1 Reduced survival, reproduction, development, and/or growth of sensitive	Yes; survival is probably limited in much of Operable Unit due to elevated concentrations of several

TABLE 5-20

SUMMARY OF RESOLUTION OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Resolution
		water-column invertebrates due to direct toxicity of COECs in surface water?	metals.
		M2.2.2 Reduced survival, reproduction, and/or growth of sensitive water-column invertebrates due to direct exposure to surface water?	Yes; surface-water exposures to cladocerans were acutely and/or chronically toxic at 9 of 13 locations.
		M2.2.3 Reduced survival, reproduction, and/or growth of water-column invertebrates due to effects of COECs on other ecological components?	Yes; effects on algae, vascular plants, and microbial decomposers probably limit food supply and/or cover.
		M2.2.4 Reduced diversity of water-column invertebrate communities?	Yes; aquatic invertebrate diversity in general is lower than in reference stream.
GAE 3. Protection of aquatic secondary consumers	SAE 3.1 Protection of fish community	M3.1.1 Reduced survival, reproduction, development, and/or growth of sensitive fishes due to direct toxicity of COECs in surface	Yes; survival, etc., are probably limited, at least in some portions of the Operable Unit due to elevated concentrations of barium, cadmium, copper, lead, and other metals.

TABLE 5-20

SUMMARY OF RESOLUTION OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Resolution
		water?	
GAE 3. (Continued)	SAE 3.1 (Continued)	M3.1.2 Reduced survival, reproduction, and/or growth of sensitive fish due to direct exposure to surface water?	Yes; 10 of 13 surface-water samples were chronically toxic to fathead minnows in 1994 (effects were less severe in 1995).
		M3.1.3 Reduced survival, reproduction, and/or growth of fishes due to effects of COECs on other ecological components?	Yes; effects on algae, vascular plants, and aquatic invertebrates probably limit food supply and/or cover.
		M3.1.4 Reduced diversity in fish community?	Yes; fish community is much less diverse than that of Crutcho Creek.
GAE 4. Protection of terrestrial primary consumers	SAE 4.1 Protection of herbivorous mammals	M4.1.1 Reduced survival, reproduction, development, and/or growth of muskrat due to ingestion of contaminated media?	Yes; reproduction, development, and or/growth are probably limited due to elevated concentrations of some metals, PCBs, dieldrin, and PAHs.
		M4.1.2 Reduced survival, reproduction, and/or growth of muskrat due to effects of COECs on other	Yes; effects of COECs on vascular plants probably limit the forage base and habitat for muskrat and other herbivorous mammals.

TABLE 5-20

SUMMARY OF RESOLUTION OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Resolution
		ecological components?	
GAE 5. Protection of terrestrial secondary consumers	SAE 5.1 Protection of omnivorous birds	M5.1.1 Reduced survival, reproduction, development, and/or growth of red-winged blackbird due to ingestion of contaminated media?	Yes; survival, etc., are probably limited due to elevated concentrations of chromium, selenium, PCBs, heptachlor epoxide, and PAHs.
		M5.1.2 Reduced survival, reproduction, and/or growth of red-winged blackbird due to effects of COECs on other ecological components?	Yes; effects of COECs on vascular plants and aquatic invertebrates probably limit the forage base and habitat for blackbird and other omnivorous birds.
	SAE 5.2 Protection of omnivorous mammals	M5.2.1 Reduced survival, reproduction, development, and/or growth of raccoon due to ingestion of contaminated media?	Yes; reproduction, development, and/or growth are probably limited due to elevated concentrations of PCBs, PAHs, chromium, and molybdenum.
		M5.2.2 Reduced survival, reproduction, and/or growth of raccoon due to effects of COECs on other ecological components?	Yes; effects of COECs on vascular plants, aquatic invertebrates, and fish probably limit the forage base for raccoons and other omnivorous mammals.

TABLE 5-20

SUMMARY OF RESOLUTION OF ENDPOINTS FOR ECOLOGICAL ASSESSMENT OF SOLDIER CREEK SEDIMENT AND SURFACE WATER OPERABLE UNIT, OKLAHOMA

General Assessment Endpoint	Specific Assessment Endpoint	Measurement Endpoint	Resolution
GAE 6. Protection of terrestrial tertiary/quaternary consumers	SAE 6.1 Protection of carnivorous birds	M6.1.1 Reduced survival, reproduction, development, and/or growth of green heron due to ingestion of contaminated media?	Yes; reproduction, development, and/or growth are probably limited due to elevated concentrations of PCBs, PAHs, some pesticides, and a few metals.
GAE 6. (Continued)	SAE 6.1 (Continued)	M6.1.2 Reduced survival, reproduction, and/or growth of green heron due to effects of COECs on other ecological components?	Yes; effects of COECs on aquatic invertebrates and fish probably limit the forage base for green herons and other carnivorous birds.
GAE 7. Protection of aquatic microbial decomposers	SAE 7.1 Protection of aquatic microbial decomposers	M7.1.1 Reduced survival of sensitive bacteria and fungi due to direct toxicity of COECs in surface water?	Yes; elevated surface-water concentrations of nickel, copper, lead, and silver.

6.0
CONCLUSIONS

The limited biological surveys performed in conjunction with this EA indicate that viable populations of plants and animals exist within the Soldier Creek Sediment and Surface Water Operable Unit. However, the diversity of most communities (particularly of strictly-aquatic forms) is extremely low compared to that which would be expected in and along similar streams outside the urban/industrial setting of Tinker. Physical modifications (e.g., dams, weirs, landscaping); constant intrusive human activities (e.g., vehicle, aircraft, and pedestrian traffic); and NPDES and storm water discharges are clearly significant factors influencing the composition of both aquatic and riparian terrestrial biological communities throughout East and West Soldier Creeks.

Forty-six chemical contaminants (or groups of similar contaminants) were identified as COECs in either sediment, surface water, or both media in the Operable Unit. At the concentrations estimated for direct exposures to strictly-aquatic organisms and/or the doses estimated for indirect (ingestion-pathway) to terrestrial/semiaquatic birds and mammals, about 16 of the COECs may pose a potential threat to ecological components. In general, the potential risks to strictly-aquatic organisms (algae, benthic and water-column invertebrates, and fish) are somewhat greater than the potential hazards to terrestrial animals. The potential risks associated with both direct (aqueous) and dietary exposures are largely, but not entirely, confined to the on-base portions of East and West Soldier Creek.

The most significant COECs in sediments appear to be cadmium, chromium, copper, nickel, silver, zinc, total PCBs, PAHs, certain organochlorine pesticides, and certain phenolic compounds. Among these, cadmium, chromium, copper, nickel, PCBs, and PAHs are the most ubiquitous, and their potential effects may extend downstream (northward) beyond the EA study area boundaries at I-40. In most cases, however, the potential hazards beyond I-40 are unlikely to be of major ecological significance, particularly at higher levels of biological organization (i.e., populations, communities, ecosystems).

The most significant COECs in surface water appear to be barium, cadmium, chromium, copper, lead, molybdenum, and zinc. All of these surface-water COECs except molybdenum are ubiquitous, and their effects probably extend downstream beyond I-40 to some extent. Copper and chromium are of particular concern because their phytotoxicity is probably limiting aquatic primary production (i.e., of periphyton) and thereby indirectly affecting higher trophic levels. These two metals, together with cadmium and zinc (and perhaps barium), are probably also directly affecting invertebrate and fish communities.

PCBs, high-molecular-weight PAHs, and chromium appear to be the most significant COECs in the ingestion-pathway to terrestrial/semiaquatic receptors. Birds appear to be at substantially greater risk than mammals although, as noted above, effects are probably limited to certain on-base stream sections and are probably not significant in the context of higher levels of ecological organization. Note, however, that lack of relevant dietary toxicological data prevented detailed quantitative estimation of dietary risks to amphibians and reptiles. It was postulated during problem formulation that amphibians and semiaquatic reptiles (e.g., certain turtles and water snakes) may be the most vulnerable "wildlife" receptors in the Operable Unit. The issue of potential risks to amphibians and reptiles remains one of the most significant uncertainties in this EA.

Toxicity tests with both bulk sediments and surface water generally corroborated the risk estimates based on the quotient method (HQs/HIs). That is, acute and (especially) chronic effects were measured on animals exposed to both media under controlled (laboratory) conditions, and these effects were not manifested in media collected from Crutcho Creek. Although there was general corroboration with the "desktop" estimates of potential risks, the toxicity tests indicate that conditions in lower (off-base) portions of West Soldier Creek are not as hazardous to aquatic receptors as suggested by the HQs/HIs.

The biological surveys (particularly of benthic invertebrate and fish communities) also generally support the conclusions of the quotient approach. Substantial agreement was also apparent between the aquatic biological surveys and the toxicity-testing results.

The toxicity tests and the biological surveys help mitigate the substantial uncertainty associated with the risk estimates derived via the quotient approach, at least in terms of

strictly-aquatic components of the ecosystem. Considerable uncertainty remains regarding the potential risks to terrestrial/semiaquatic receptors. However, most of the uncertainty is associated with the degree to which the potential hazards are overstated. The more important elements of uncertainty relate to:

- exposure point concentrations (due to inadequate analytical sensitivity, lack of replication of sediment and water samples within sections, lack of sampling/analyses of certain forage or prey, dietary composition assumptions, inadequate information on bioavailability of COECs); and

- toxicological information (i.e., for amphibians and reptiles in general, and for some of the more obscure COECs for other receptors).

These uncertainties are addressed in conjunction with the discussion of risk-management considerations in Appendix L.

Appendix L also discusses levels of COECs in sediment and surface water of Soldier Creek which are likely to be protective of ecological receptors. These levels are presented as initial chemical-specific, numerical, concentrations called preliminary remedial goal options (RGOs). The RGOs are not proposed clean-up levels, which must be developed outside the scope of this EA by incorporating numerous additional considerations. Any ultimate remedial action will satisfy Applicable or Relevant and Appropriate Requirements (ARARs), e.g., Federal Ambient Water Quality Criteria.

7.0
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