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Damage Assessment Plan for Jasper and Newton Counties, Missouri

Final June 2009

prepared for:

State of Missouri

Missouri Department of Natural Resources

U.S. Department of the Interior

U.S. Fish and Wildlife Service

prepared by:

Alix van Geel, Tina Bosch, Heidi Clark, and Mike Donlan

Industrial Economics, Incorporated

2067 Massachusetts Avenue

Cambridge, MA 02140

INDUSTRIAL ECONOMICS, INCORPORATED

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The following individuals contributed to the preparation of this document:

Jim Dwyer, U.S. Fish and Wildlife Service

Frances Klahr, Missouri Department of Natural Resources

Dave Mosby, U.S. Fish and Wildlife Service

Mary Lynn Taylor, U.S. Department of the Interior

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EXECUTIVE SUMMARY

Parts of Jasper and Newton Counties in Missouri fall within the Tri-State Mining District (TSMD), an area that was mined extensively for lead and zinc for more than a century. As a result of this mining and related activities, large amounts of metals including cadmium, lead, zinc, and nickel were released into Missouri's environment. Cadmium, lead, zinc, and other metals associated with mining are hazardous substances because they are potentially toxic to a wide variety of plants and animals.

Under relevant Federal and state laws, the Director of the Department of Natural Resources (MDNR) who is the designated Trustee for the State of Missouri and the Secretary of the U.S. Department of the Interior (DOI) are the Trustees for the natural resources in Jasper and Newton Counties. Natural resources include surface waters (rivers, lakes, streams, etc.), ground water, soils, air, plants, and animals. As Trustees, the State of Missouri and DOI serve as stewards for these resources within Jasper and Newton Counties and have the authority to assess potential contaminant-related injuries to them. Injuries to natural resources can occur if the resources are exposed to concentrations of hazardous substances that are high enough to cause specific adverse effects. For instance, injuries can occur if concentrations in surface waters are so high that relevant water quality criteria are exceeded, or that plants and animals become injured (for example, plants and animals die, or cannot reproduce normally, or become sick or are otherwise negatively affected as defined under relevant laws).

If the Trustees determine that releases of hazardous substances have injured natural resources, the Trustees may pursue compensation to restore, replace, or acquire the equivalent of the injured natural resources and their services. The Trustees collect compensation from the party or parties determined to be legally responsible for the releases.

The process through which the Trustees evaluate injuries associated with the release of hazardous substances and determine appropriate compensation for those injuries is called natural resource damage assessment (NRDA). DOI promulgated and published NRDA regulations in the Federal Register (43 CFR §11.10 et. seq.). These regulations provide procedures by which trustees can identify natural resource injuries, quantify those injuries, and determine appropriate compensation (damages) for the injured resources and the services they provide. The NRDA process includes a number of different steps, specifically:

- Preassessment,
- Assessment planning,

- Injury determination and quantification,
- Pathway determination, and
- Damage determination and restoration.

DOI and the State of Missouri have begun a NRDA for the Missouri portion of the TSMD. To date, the Trustees have completed the preassessment phase for the Jasper and Newton County sites, each of which culminated with the release of Preassessment Screens (MDNR and DOI 2002, 2008). In the Preassessment Screens, the Trustees concluded that:

(a) Releases of hazardous substances (cadmium, lead, and zinc) have occurred;

(b) Natural resources for which the Trustees can assert Trusteeship are, and/or likely have been, adversely impacted as a consequence of the releases;

(c) The quantity and concentration of the released substances are sufficient to potentially cause injury to natural resources;

(d) The data necessary to pursue a NRDA are readily available or can be obtained at a reasonable cost; and,

(e) Currently completed or planned response actions are insufficient to completely compensate the public for past and ongoing injuries to natural resources.

Having completed the preassessment phase, the Trustees have moved on to the assessment planning phase and have produced this Damage Assessment Plan (Plan). This Plan describes activities that the Trustees currently intend to pursue as part of the injury determination and quantification phase and the pathway determination phase of the Missouri Tri-State Mining District[1] NRDA (Exhibit ES-1).

The Trustees are pursuing compensation for injuries to natural resources on behalf of the public, and as such, public input is very important. During the NRDA process, the Trustees create a number of key documents, such as this Plan, which are released to the public, and the public is asked to provide comments. Comments may be submitted in writing to the address below.

Ms. Frances Hayes Klahr
Missouri Department of Natural Resources
Division of Environmental Quality
P.O. Box 176
Jefferson City, MO 65102-0176

[1] The Tri-State Mining District in Missouri includes a number of counties. For purpose of this Assessment Plan, however, the phrase "Missouri Tri-State Mining District" is considered to include only the area that falls within Jasper and Newton Counties.

The public can learn more about the Missouri Tri-State Mining District NRDA by visiting the website:

http://www.dnr.mo.gov/env/hwp/sfund/nrda.htm

EXHIBIT ES-1 CURRENTLY PLANNED AND IN PROCESS MISSOURI TRI-STATE MINING DISTRICT NRDA STUDIES

NATURAL RESOURCE(S)	STUDY	STATUS*
INJURY DETERMINATION AND QUANTIFICATION		
Surface Water	Exceedances of Regulatory Standards	Substantial progress
Surface Water Sediments	Exceedances of Regulatory Standards and Toxicity Thresholds	Some progress
Aquatic Biota	Fish, Shellfish, and other Aquatic Macroinvertebrates	Some progress
Aquatic Biota	Waterfowl	Planned
Terrestrial Biota	Small Mammals	Planned
Terrestrial Biota	Other Terrestrial Fauna, Including Birds	Planned
Terrestrial Biota	Vegetative Communities, Impacts at Current and Former Mine Waste Pile Locations	Some progress
Ground Water	Exceedances of Regulatory Standards	Some progress
Geologic Resources	Exceedances of Literature-Based Impact Thresholds	Some progress
Multiple	Injuries from Cleanup Activities	Planned
PATHWAY DETERMINATION		
All	Fate and Transport	Substantial progress
DAMAGE DETERMINATION		
Aquatic and Terrestrial Habitats	Habitat Equivalency Analysis/Primary Restoration	Some progress
Ground Water	Replacement Cost Estimation	Some progress

* Due to outside events including the Asarco bankruptcy filing (In re: Asarco LLC, et al. No. 05-21207, S.D. Texas Bkcy.), the Trustees were required to expedite certain assessment-related activities in advance of finalization of this DAP.

CHAPTER 1 | INTRODUCTION

Jasper and Newton Counties are located in southwestern Missouri. Portions of both these counties together with parts of neighboring counties in Kansas and Oklahoma are collectively known as the Tri-State Mining District (TSMD) and were mined extensively for lead and zinc for more than a century. During this time period, vast quantities of lead, cadmium and zinc were produced, and large quantities of metal-containing wastes were generated. This Assessment Plan describes proposed damage assessment activities within the 270 square mile portion of the TSMD that falls within Jasper and Newton Counties (EPA 1998).

1.1 MISSOURI TRI-STATE MINING DISTRICT SUPERFUND SITE HISTORY

Beginning over two decades ago, the U.S. Environmental Protection Agency (EPA) began to evaluate threats posed to human health and the environment by mining-related releases of hazardous substances, particularly metals, in the Tri-State Mining District. Based on this evaluation, the EPA placed each state's portion of the Tri-State Mining District on its National Priorities List (NPL).[2] The resulting Superfund sites are known as: the Oronogo/Duenweg Mining Belt Superfund Site (Jasper and Newton Counties, MO), the Newton County Mine Tailings Site (Newton County, MO), the Cherokee County Superfund Site (Cherokee County, KS), and the Tar Creek Superfund Site (Ottawa County, OK). The Oronogo/Duenweg Mining Belt Site was added to the NPL in 1990, and the Newton County Mine Tailings Site (also called the Granby site) was added in 2003. This document refers to the Missouri sites as the Missouri Tri-State Mining District.

EPA has divided the Oronogo/Duenweg and Newton County sites into a number of distinct operable units (OUs), designated areas (DAs) or subdistricts.[3] The operable units for the Oronogo/Duenweg Site are: mining and mill waste piles; lead-contaminated residential yard soils in smelter areas; lead-contaminated residential yard soils in mining waste areas; contaminated ground water, and the Spring River watershed (EPA 2004). The Newton County Site's OUs include: Diamond/Spring City/Granby; and remainder of

[2] The NPL is a list of the worst hazardous waste sites that have been identified by EPA. The list is primarily an information resource that identifies sites that may warrant cleanup. The NPL is operated under the auspices of EPA's Superfund Program, the Federal government's CERCLA-authorized program to clean up the nation's uncontrolled hazardous waste sites.

[3] A designated area is a geographically distinct portion of a Superfund site. One of the designated areas in the Oronogo/Duenweg Mining Belt Site shares the name Oronogo/Duenweg, but the entire Mining Belt Site includes all eleven DAs. An operable unit is a term for each of a number of separate activities undertaken as part of a Superfund site cleanup.

Newton County.[4] These divisions facilitate the identification, selection, and implementation of remedial activities at the sites. EPA has conducted cleanups at some of the identified OUs, while cleanup actions for others are in progress.

Exhibits 1 and 2 show the approximate locations and sizes of the Oronogo/Duenweg designated areas and the Newton County mining subdistricts. The designated areas for the Oronogo/Duenweg Site are:

- Neck/Alba
- Snap
- Oronogo/Duenweg
- Joplin
- Thoms
- Carl Junction
- Waco (this DA stretches into Kansas, where it is considered a subsite in the Cherokee County Superfund Site)
- Klondike
- Belleville/Chemical Plant
- Iron Gates, and
- Iron Gates Extension. The Iron Gates DA 4 Extension lies partially in Newton County but is a part of the Oronogo/Duenweg Superfund Site (CDM 1995).

The Newton County Site has two OUs: Diamond/Spring City/Granby (OU1) and Remainder of Newton County (OU2). This site is also divided geographically into a number of mining subdistricts, specifically:

- Granby
- Diamond
- Spring City-Spurgeon
- Stark City, and
- Wentworth.

[4] See USEPA, CERCLIS database, http://cfpub.epa.gov/supercpad/cursites/copinfo.cfm?id=0701651 accessed 01/23/06.

EXHIBIT 1 JASPER COUNTY MINING/MILLING WASTES

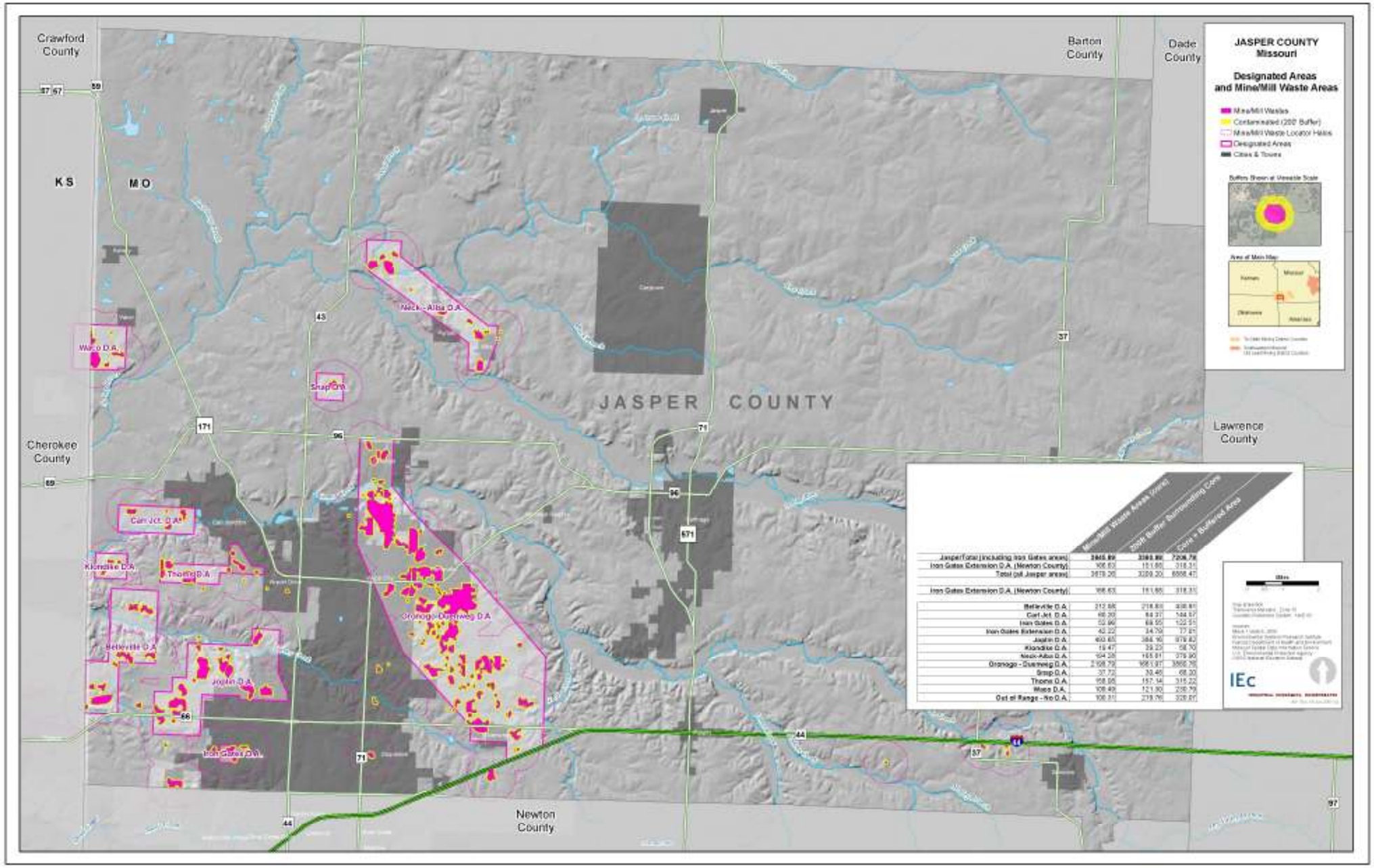
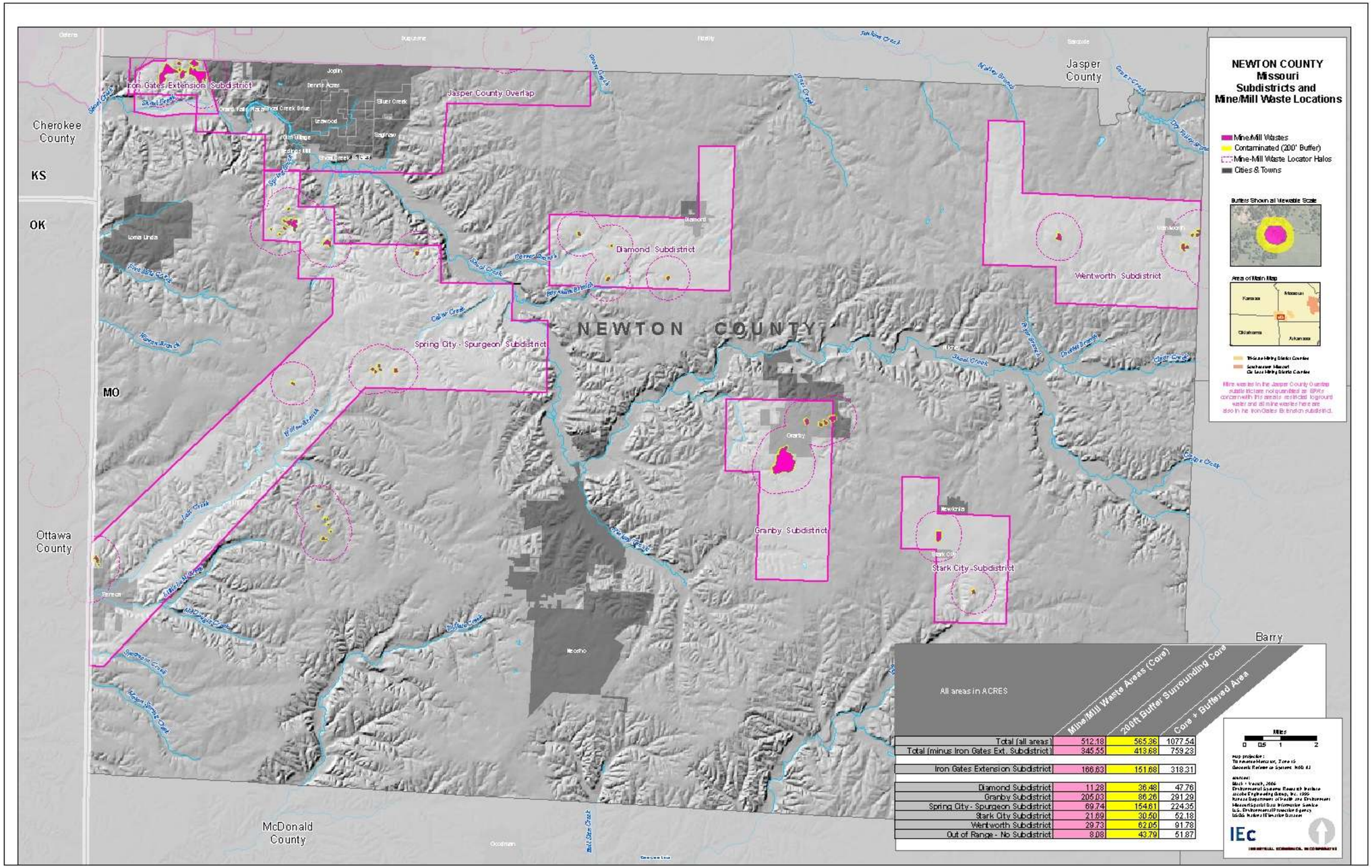


EXHIBIT 2 NEWTON COUNTY MINING/MILLING WASTES


NEWTON COUNTY
Missouri
Subdistricts and
Mine/Mill Waste Locations
Mine/Mill Wastes
Contaminated (200' Buffer)
Mine-Mill Waste Locator Halos
Cities & Towns
Buffers Shown at Viewable Scale
Area of Main Map
Kansas
Missouri
Oklahoma
Arkansas
Mine wastes in the Jasper County Overlap subdistrict are not quantified as EPA's concern with this area is restricted to ground water and all mine wastes here are also in the Iron Gates Extension subdistrict.
Miles
0 0.5 1 2
Map projection:
Universal Transverse Mercator, Zone 15
Geodetic Reference System NAD 83
sources:
Black + Veatch, 2006
Environmental Systems Research Institute
Jacobs Engineering Group, Inc. 1996
Kansas Department of Health and Environment
Missouri Spatial Data Information Service
U.S. Environmental Protection Agency
USGS Topo Map Viewer Dataset
IEc
INDUSTRIAL ECONOMICS, INCORPORATED
Cherokee County
KS
OK
MO
Ottawa County
McDonald County
Barry
Jasper County
Iron Gates Extension Subdistrict
Jasper County Overlap
Diamond Subdistrict
Spring City - Spurgeon Subdistrict
Granby Subdistrict
Stark City - Subdistrict
Wentworth Subdistrict
Joplin
Neosho
Newton
Granby
Stark City
Diamond
Wentworth
Lowell
Seneca
Lamar
Carthage
Webb City
Oronogo
Duenweg
Alba
Sarcoxie
Goodman
Lone Elm
Shoal Creek
Spring River
Elm Spring Creek
Willow Branch
Cow Creek
Dry Fork Creek
Buffalo Creek
Big Sugar Creek
Little Sugar Creek
Indian Creek
Turkey Creek
Dry Fork Creek
Clear Creek
Cave Spring Branch
Dry Fork Creek
Jackson Creek
Big Creek
Little Creek
Dry Fork Creek
Spring Creek
Shoal Creek
Shoal Creek
Shoal

1.2 NATURAL RESOURCE DAMAGE ASSESSMENT

In addition to being the legal authority for EPA's Superfund program, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended (42 U.S.C. 9601 *et. seq.*) gives natural resource Trustees the authority to pursue compensation from potentially responsible parties in order to restore or replace injured natural resources. This complements EPA Superfund actions by providing a means to restore injured public resources to the condition they would have been in if the unpermitted contaminant releases had not occurred, and to compensate the public for any interim lost services provided by those resources. In the case of the Missouri Tri-State Mining District, the natural resource Trustees are the U.S. Department of the Interior (DOI), as represented by the U.S. Fish and Wildlife Service (USFWS), and the Director of the Missouri Department of Natural Resources (MDNR). The process by which the Trustees evaluate these issues is known as natural resource damage assessment (NRDA).

Regulations for performing a NRDA, as prescribed by the DOI, are set forth in the Code of Federal Regulations at Title 43 Part 11. As described in more detail in Chapter 3, the major steps in a NRDA include:

- Preassessment,
- Assessment planning,
- Injury determination and quantification,
- Pathway determination,[5] and
- Damage determination and restoration.

The Jasper and Newton County Trustees (hereinafter referred to as the Trustees) have completed the preassessment phase for the Missouri TSMD. The main products of the preassessment phase are Preassessment Screens (PAS), which were issued in 2002 and 2008, respectively.[6] These documents confirmed the following:

(a) Heavy metals have been and are being released into the environment;

(b) Natural resources have been adversely affected by these releases;

(c) Contaminant concentrations are sufficient to injure natural resources;

(d) The data needed to conduct NRDA are available or can be obtained at a reasonable cost; and

(e) Completed or planned response actions would neither completely restore the injuries to natural resources nor compensate for the public's lost use.

Based on these results, the Trustees have decided to pursue additional NRDA activities. To that end, the Trustees have begun the assessment planning phase and have developed this Damage Assessment Plan (Plan). This Plan describes activities that will gather and

[5] DOI's NRDA regulations include pathway determination within the injury determination and quantification phase; for purposes of clarity, this document describes pathway determination as a separate phase.

[6] These documents are available at: http://www.dnr.mo.gov/env/hwp/news/final-jasper-county-pas-tds-02-06-18.pdf and http://www.dnr.mo.gov/env/hwp/docs/newton-county-mine-tailingspas2008.pdf (accessed 4/1/08).

collect information for determining the nature and extent of natural resources injuries and contaminant pathways. The Plan is a living document. It will continually be developed and refined as the NRDA progresses and additional information becomes available.[7] Potential changes to this Plan may include the addition of new studies and/or the modification of the planned studies identified in this document.

This Plan focuses on the Missouri TSMD. It does not address assessing the potential for injuries to natural resources beyond the State of Missouri. For natural resource injuries in Oklahoma and Kansas, equivalent documentation has been, or is being developed by the relevant Trustees for those states.

The remainder of this Plan is organized in the following manner:

- **Chapter 2 (Background)** discusses the Missouri TSMD's natural resources; it also identifies the primary contaminants of concern and describes the processes that resulted in the releases of these contaminants to the area;
- **Chapter 3 (Role of Trustees)** provides more information about the Trustees, their jurisdiction, and the natural resource damage assessment process that the Trustees plan to follow;
- **Chapter 4 (The Missouri Tri-State Mining District NRDA)** provides an overview of studies that the Trustees are currently proposing; and
- **Chapter 5 (Quality Assurance Management)** establishes the general procedures to be used in developing project-specific quality assurance plans.

[7] The DOI regulations allow an Assessment Plan to "be modified at any stage of the assessment as new information becomes available" 43 CFR §11.32(e). Any significant modifications "shall be made available for review by any identified potentially responsible party, any other affected natural resource trustees, other affected Federal or State agencies or Indian tribes, and any other interested member of the public for at least 30 calendar days, with reasonable extensions granted as appropriate, before tasks called for in the modified plan are begun" (43 CFR §11.32(e)(2)(i)).

CHAPTER 2 | BACKGROUND

2.1 NATURAL RESOURCES IN THE MISSOURI TRI-STATE MINING DISTRICT

The Missouri Tri-State Mining District lies on the northwest side of the Ozark uplift on parts of the Central Lowlands and Ozark Plateau physiographic provinces[8] (Davis and Schumacher 1992). The area supports a variety of natural resources potentially affected by mining-related contamination, including rivers and lakes, ground water, and geologic/terrestrial resources. These habitats support a wide variety of fish, birds, and other wildlife. A number of species present in the area are included on state or Federal threatened and endangered (T&E) species lists or are otherwise of special concern (see Appendix A). The following paragraphs briefly summarize key features of the area's natural resources, including information about what makes the area unique, and also available information about the threat posed to these resources by mining-related and other contamination.

2.1.1 SURFACE WATER RESOURCES: RIVERS, LAKES, STREAMS

Surface water resources are defined as "the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline" (43 CFR §11.14(pp)). Surface water resources in the Missouri TSMD include the Spring River and its tributaries, with the North Fork, Center, Turkey, Short, and Shoal Creeks most important among them. All of the Jasper County DAs, and the Newton County site, are part of the Spring River watershed. Exhibits 3 through 8 and the following paragraphs summarize key information about the area's surface water resources, including a brief description of each river or creek, plus available information about biota supported by each waterway, and contamination in the waterways.

[8] A physiographic province is a region of the landscape with distinctive geographical features resulting from a shared geologic history.

EXHIBIT 3 TRI-STATE MINING DISTRICT: SEDIMENT ZINC CONCENTRATIONS (PPM) AND MUSSEL SPECIES DIVERSITY

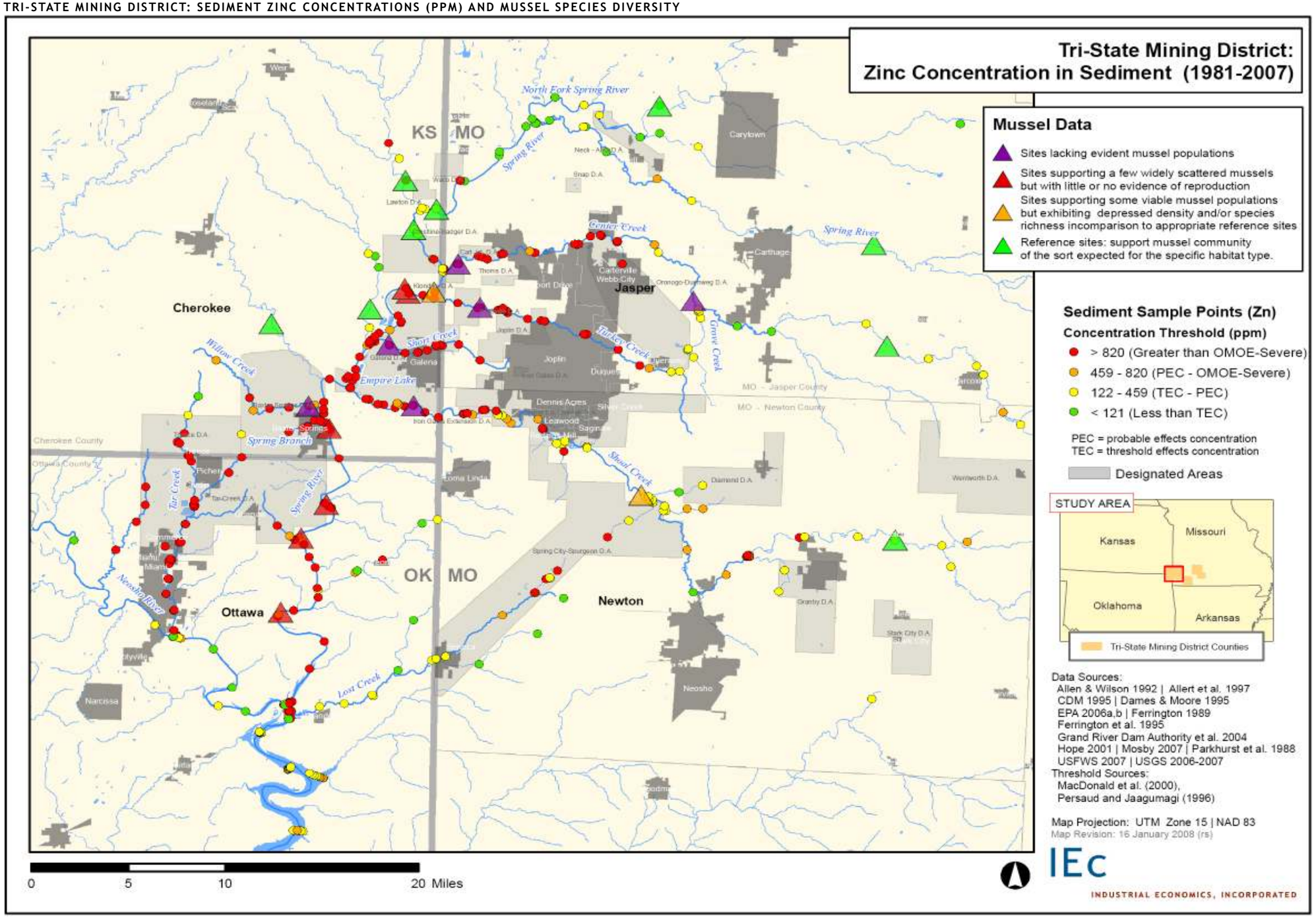
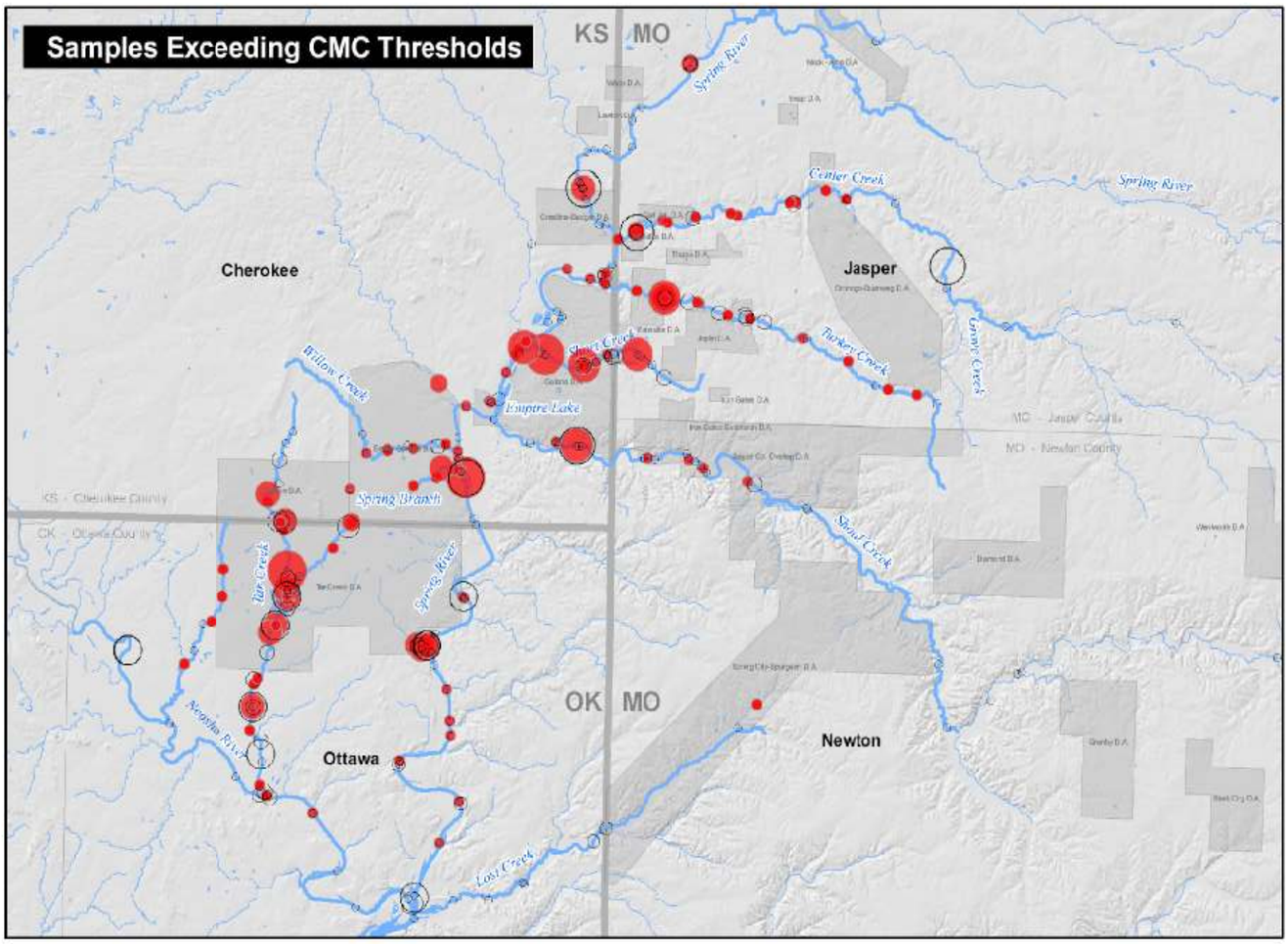
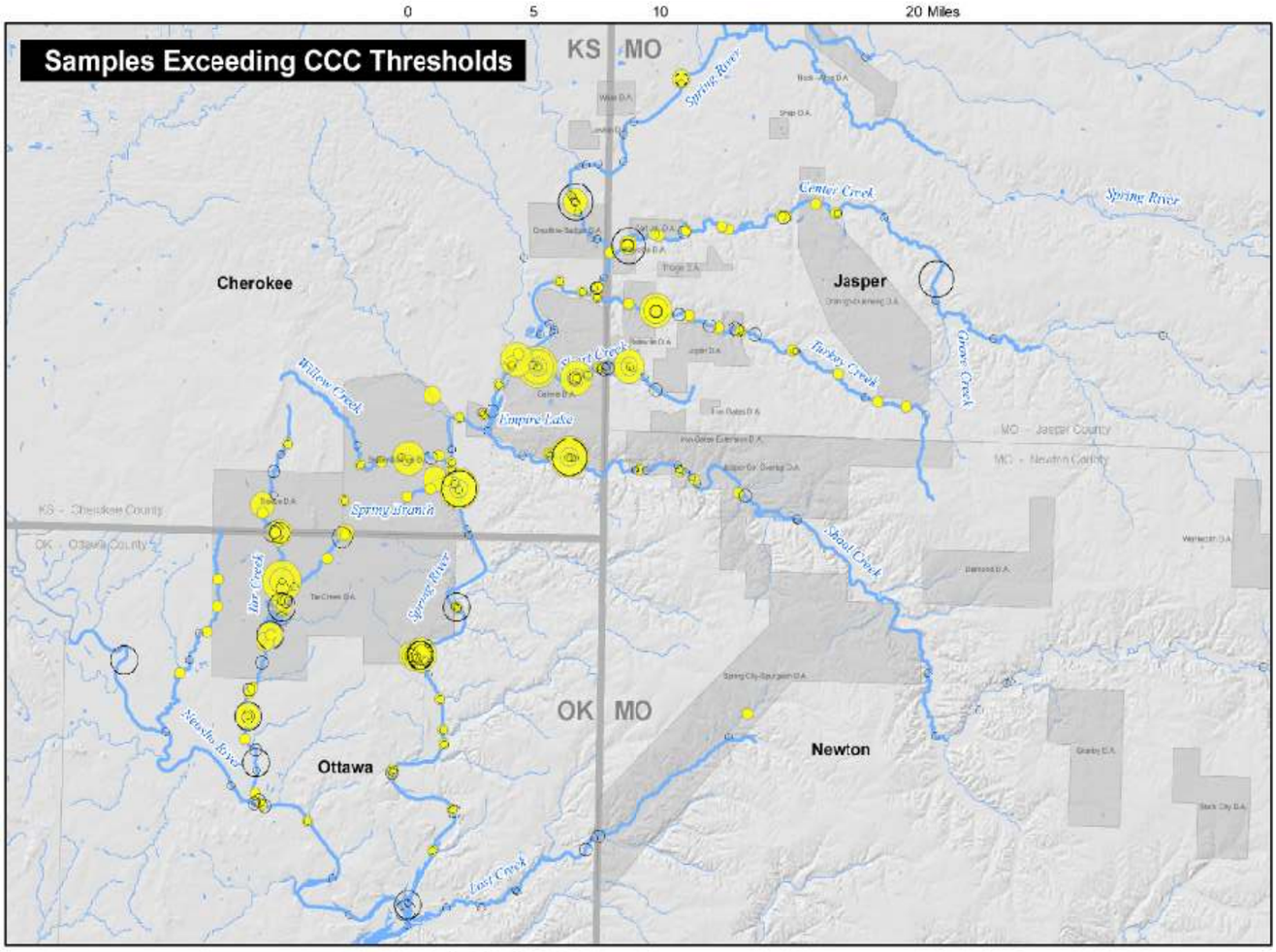


EXHIBIT 4 TRI-STATE MINING DISTRICT: ZINC WATER QUALITY EXCEEDANCES (1981-2006)



0 5 10 20 Miles



Zinc in Surface Water (Dissolved and Total)

Tri-State Mining District: Zinc Concentration in Dissolved and Total Surface Water with Sample Counts

1981 - 2006

Notes:
1. Symbol sizes in legend represent approximate sample counts at map locations; largest actual count at unique location shown in largest symbol at bottom
2. Non-detect data points are not depicted on the above maps

Number of Samples:

	Exceeding CMC Threshold	Exceeding CCC Threshold	Beneath CCC Threshold
1			
2 - 5			
6 - 10			
11 - 25			
26 - 80	55	63	80

Designated Areas

Tri-State Mining District Counties
Southeastern Missouri Lead Mining District Counties

Data Sources:
Allert et al. 1997, Dames & Moore 1993
Dames & Moore 1995, CDM 1995
EPA 2006a,b, Ferrington et al. 1995
Ferrington et al. 2000, Ferrington 2002, KDHE 2006
Parkhurst 1987, Schmitt et al. 1997
USGS 2006-7, Yoo and Janz 2003

Map Projection: UTM NAD83, Zone 15

Map Revision: 17 January 2008 (ns)

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EXHIBIT 5 AQUATIC NATURAL RESOURCES IN JASPER AND NEWTON COUNTIES, MISSOURI

WATERWAY	303(D) IMPAIRMENT STATUS	POLLUTANTS AND POTENTIAL SOURCES (also see Exhibits 5 to 7)	EVIDENCE OF BIOTIC IMPACTS	KNOWN THREATENED, ENDANGERED, AND SPECIES OF SPECIAL CONCERN	OTHER FEATURES
Spring River	In Missouri: Bacteria[6] In Kansas: Metals, Biological[17]	METALS: Waco DA; input from tributaries listed below. OTHERS: Urban and rural point and non-point sources.[6]	Below Center Creek confluence, Neosho madtom presence limited in part by metals.[14] In KS, substantially reduced mussel species diversity and density in mining-impacted reaches relative to reference locations, including upstream.[1,15,18] Below Center Creek confluence, fish may be indirectly limited by metals concentrations in invertebrate food sources.[15]	FISH: Neosho madtom, Arkansas darter[4] MUSSELS: Neosho mucket, rabbitsfoot, western fanshell[7]	Habitat is typical of higher-order Ozark streams. Outstandingly remarkable stream for scenic, recreational, fishing, and wildlife attributes.[2] Diverse mussel community upstream of Joplin.[3]
North Fork Spring River	Sediment[5] None in Jasper County[6]	METALS: Neck/Alba DA. OTHERS: Agricultural non-point sources.[16]	Biologically impaired based on assessments of macroinvertebrates, water and habitat quality.[16]		Plains stream
Center Creek	In Missouri: Zinc[5] Lead, Cadmium[6] In Kansas: Metals, Biologicall[17]	METALS: O/D DA, miner's ditches and tributaries, groundwater input.[8,11]	Tributary water toxic to water fleas and fathead minnows[13] Fish more diverse and abundant upstream of O/D DA than downstream.[7] Absent mussel community at mining-affected sites.[18] More robust and diverse mussel community in Spring River above Center Creek than below.[17] Reduced macroinvertebrate diversity compared with high quality habitat.[7] Historically present Quadrula cylindrica and Cyprogenia aberti mussels no longer present.[15]		Ozarkian stream

WATERWAY	303(D) IMPAIRMENT STATUS	POLLUTANTS AND POTENTIAL SOURCES (also see Exhibits 5 to 7)	EVIDENCE OF BIOTIC IMPACTS	KNOWN THREATENED, ENDANGERED, AND SPECIES OF SPECIAL CONCERN	OTHER FEATURES
Turkey Creek	In Missouri: Zinc[5] Cadmium[6] In Kansas: Metals, Biological[17]	**METALS**: Abandoned mine lands including Duenweg[6,10]	Absent mussel community at mining-affected sites. Less diverse mussel community in Spring River below the confluence with Turkey Creek than above.[18] Fish have elevated metals levels.[7] Benthic communities altered.[7]		Ozarkian stream
Short Creek	In Missouri: None In Kansas: Metals, Biological[17]	**METALS**: Iron Gates DA, Joplin DA, Belleville/Chem Plant DA. Phospho-gypsum waste pile.[7]	Waters acutely toxic to water fleas and fathead minnows.[7] Reduced macroinvertebrate diversity compared with high quality habitat.[7]		Intermittent stream; most of flow from urban and agricultural runoff.[8]
Shoal Creek	In Missouri: Fecal coliform[5] None[6] In Kansas: Metals, Biological[17]	**METALS**: Mining subdistricts: Granby, Diamond, Spring City - Spurgeon, Iron Gates 4X. **OTHERS**: Unknown agricultural sources.[5]	Abundance and diversity of mussels have declined as compared to the North Fork and Upper Spring River, and compared to more upstream reaches of Shoal Creek.[15,18] Absent mussel community downstream of Joplin.[18]	**FISH**: Arkansas darter	Outstandingly remarkable stream for scenic, recreational, fishing, and wildlife attributes[2]

Sources:

1. Cope 1985
2. NPS 1982
3. Obermeyer *et al.* 1995
4. USFWS 2005
5. MDNR 2004
6. MDNR 2007a
7. Dames & Moore 1995
8. Kiner *et al.* 1997
9. Davis and Schumacher 1992
10. MDNR 2005
11. MDNR 2006b
12. CDM 1995
13. Crawford 1993
14. Wildhaber et al. 2000
15. Clarke and Obermeyer 1996
16. MDNR 2006a
17. KDHE 2005
18. Angelo et al. 2007

EXHIBIT 6 AVERAGE CONCENTRATIONS OF METALS IN SEDIMENTS, 1981-2007

WATERWAY	CADMIUM		LEAD		ZINC	
	AVERAGE CONC. (PPM)[1]	N[1]	AVERAGE CONC. (PPM)	N	AVERAGE CONC. (PPM)	N
North Fork Spring River (MO)	0.4	6	8	6	96.9	6
Spring River, Upper[2] (MO)	1.1	15	28	15	189	15
Spring River, Upper[2] (KS)	3.6	7	31	9	537	9
Spring River, Lower[2] (KS)	17.1	34	229	34	2,448	34
Center Creek (MO)	21.7	31	279	31	2,881	34
Turkey Creek (MO)	18.8	19	289	19	4,795	27
Short Creek (MO)	15.7	12	157	12	2,923	12
Shoal Creek (MO)	3.3	34	70	34	1,698	43

Notes:

1. Concentration values are averages, in units of ppm (parts per million) dry weight. N refers to the number of samples.
2. For purposes of this table, the Upper Spring River is defined as the reach upstream of the river's confluence with Center Creek, while the Lower Spring River is downstream of this confluence.
3. Includes North Fork Spring River samples as well as those identified as background samples by the authors of the data source.

Data sources: Allen & Wilson (1992), Allert et al. (1997), CDM (1995), Dames and Moore (1995), EPA STORET (2006a), EPA (2006b), Mosby (2007), and USGS (2006-2007).

EXHIBIT 7 SEDIMENT EXCEEDANCES OF LITERATURE-BASED EFFECTS THRESHOLDS, 1981-2007

WATERWAY	N[1]	PERCENT EXCEEDING TEC[2]	PERCENT EXCEEDING PEC[2]	PERCENT EXCEEDING OMOE[2]
CADMIUM				
North Fork Spring River	6	0%	0%	0%
Spring River, Upper	14	36%	0%	0%
Center Creek	30	80%	60%	50%
Shoal Creek	34	85%	15%	9%
Short Creek	12	100%	92%	67%
Turkey Creek	18	100%	78%	44%
LEAD				
North Fork Spring River	6	0%	0%	0%
Spring River, Upper	14	7%	7%	0%
Center Creek	30	70%	53%	27%
Shoal Creek	34	59%	15%	3%
Short Creek	12	100%	58%	17%
Turkey Creek	18	100%	72%	39%
ZINC				
North Fork Spring River	6	33%	0%	0%
Spring River, Upper	14	36%	0%	0%
Center Creek	33	94%	73%	64%
Shoal Creek	43	98%	60%	35%
Short Creek	12	100%	100%	92%
Turkey Creek	26	100%	96%	85%

Notes:

1. N = number of samples. All samples in this table were taken from Missouri portions of the waterway.
2. The data sources for the percent exceedance calculations include: Allen & Wilson (1992), Allert et al. (1997), CDM (1995), Dames and Moore (1995), EPA (2006 a,b), Mosby (2007), Schmitt et al. (1997), and USGS (2006-2007). Percentage of samples exceeding sediment quality guidelines was calculated by compiling available sampling data from 1981 to 2007 and comparing it with three sediment quality guidelines: the Threshold Effects Concentration (TEC); The Probable Effects Concentration (PEC) as defined by MacDonald et al. (2000); and the Ontario Ministry of the Environment – Severe threshold (OMOE-Severe) as defined by Persaud and Jaagumagi (1996).

EXHIBIT 8 EXCEEDANCES OF WATER QUALITY STANDARDS, 1981-2006[1]

WATERWAY	N[2]	PERCENT NON-DETECT SAMPLES	PERCENT OF DETECTS EXCEEDING CCC[3,4]	PERCENT OF DETECTS EXCEEDING CMC[3,4]
CADMIUM				
North Fork Spring River	11	100%	N/A	N/A
Spring River Upper	50	84%	13%	0%
Center Creek	165	85%	44%	4%
Shoal Creek	67	94%	100%	100%
Short Creek	18	67%	17%	17%
Turkey Creek	97	46%	69%	10%
LEAD				
North Fork Spring River	11	100%	N/A	N/A
Spring River Upper	50	80%	40%	0%
Center Creek	170	76%	29%	0%
Shoal Creek	67	99%	100%	0%
Short Creek	18	78%	0%	0%
Turkey Creek	94	52%	22%	0%
ZINC				
North Fork Spring River	11	91%	0%	0%
Spring River Upper	54	61%	29%	10%
Center Creek	173	16%	21%	21%
Shoal Creek	67	61%	19%	19%
Short Creek	18	11%	63%	56%
Turkey Creek	98	3%	68%	68%

Notes:

1. Calculated figures reflect both dissolved metals and total extractable metals.
2. N = number of samples
3. The CCC and CMC are the U.S. Environmental Protection Agency's Criterion Chronic Concentration and Criterion Maximum Concentration. These values have changed over the years and typically are standards that are calculated base on measured water hardness of the particular sample. In calculating exceedances, contaminant concentrations are compared to the CCC and/or CMC in effect at the time of the sampling, and for the relevant total or dissolved value.
4. The percent exceedances are calculated only for samples for which contaminants were detected at concentrations above the stated detection limit. Determining whether or not a non-detect sample exceeded a water quality standard can be difficult: particularly for cadmium and lead, the detection limit was frequently higher than the applicable water quality standard. Consequently, it is possible that non-detect samples contained metals in excess of the relevant standard.
5. The data sources for the percent exceedance calculations include: Allert et al. (1997), Dames & Moore (1993b), Dames & Moore (1995), CDM (1995), EPA (2006a,b), Ferrington et al. (1995), Ferrington et al. (2000), Ferrington (2002), KDHE (2006), Parkhurst (1987), Schmitt et al. (1997), USGS (2006-7), Yoo and Janz (2003).

Spring River

The Spring River flows northwest to its confluence with the Spring River North Fork west of the Neck/Alba DA, then turns southwest, exiting Missouri into Kansas, just south of Waco, and the Waco DA. The Spring River's base flow is sustained from springs originating in the upper aquifer, and its drainage basin includes approximately 2,090 square miles in southwestern Missouri (Davis and Schumacher 1992), encompassing all of the Oronogo/Duenweg Mining Belt Superfund Site as well as much of the Newton County Mine Tailings Site. The Spring River and its tributaries therefore flow through, near, or adjacent to areas heavily impacted by mining.

The Spring River is typical of higher-order Ozark streams, with gravel substrate, a relatively uniform flow and lower velocity. As shown in Exhibit 9, some reaches support high-quality riparian corridor habitat.[9]

EXHIBIT 9 SPRING RIVER RIPARIAN CORRIDOR AT CONFLUENCE WITH CENTER CREEK (MISSOURI/KANSAS BORDER)

[9] Riparian corridors are low-lying natural lands within a certain distance of rivers or streams. Healthy riparian corridors are extremely important to the health of the surface waters they surround. They help reduce both erosion and nutrient pollution (for example, from fertilizer runoff), provide habitat for aquatic-associated animals (for example, nesting locations for birds and den locations for mink) and also provide continuous corridors of habitat that allow fauna to travel from one location to another. High-quality riparian corridors often support many different species of plants.

The Missouri Department of Conservation Natural Heritage Program recognizes the importance of the Spring River as a natural resource, identifying four unique habitat categories supported in its basin: prairie, forest, primary,[10] and wetland. Additionally, the Missouri Natural Areas Committee has designated two natural areas associated with the river in Newton County and one area in Jasper County for permanent protection (Kiner *et al.* 1997). The National Park Service classifies the river as an outstandingly remarkable stream for scenic, recreational, fishing, and wildlife attributes (NPS 1982). In Missouri, the river supports the federally threatened Neosho madtom (*Noturus placidus*) and the federal candidate Arkansas darter (*Etheostoma cragini*) (USFWS 2005). Twelve other fish and mussel species occurring in Jasper and Newton Counties are designated by Missouri as species of conservation concern (Appendix A).

The Spring River, especially in its more downstream reaches, has elevated metals levels (Dames & Moore 1995). Missouri DNR's 2002 303(d) list does not include the Spring River itself, but the list does indicate that two tributaries–Center and Turkey Creeks–are impaired by metals.[11] The influence of these tributaries on water quality in the Spring River is evident by spatial distribution of contamination in sediment samples taken above and below the river's confluence with Center Creek (Exhibit 6).

Elevated metals concentrations appear to be impacting the river's aquatic life in Kansas. Wildhaber *et al.* (2000) investigated fish populations in the Spring River and concluded that these fish, especially Neosho madtoms, are limited in part by the presence of metals in the water. Apart from one small population upstream of Baxter Springs, Kansas, Neosho madtoms have only been collected in the Spring River upstream of the major mining pollution sources (Wildhaber *et al.* 2000). Mussel populations also appear to have been impacted: Clarke and Obermeyer (1996) reported that zinc pollution in Center Creek may prevent resurgence of mussels within the stream. Cope (1985) found that "[d]rainage from mines and mine tailings along Center, Turkey, and Short creeks… probably contribute pollutants that are toxic to naiads [mussels]." Angelo et al. (2007) found substantially decreased mussel species diversity and abundance below the river's confluence with Center Creek and further declines below the confluence with Turkey Creek (Exhibit 3).

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[10] The habitat designation of "primary" is one of six categories used by the state to describe its natural resources based on topography, size, distribution, and associated plants. The primary category is a glade community (Kiner *et al.* 1997), characterized by rocky, barren openings on moderate to steep slopes with shallow soils, and dominated by grasses and flowering plants, with sparse woody vegetation (MDC, http://www.mdc.mo.gov/areas/natareas/p91-1l.htm, accessed 9/19/05).

[11] Section 303(d) of the Federal Clean Water Act requires states to periodically prepare a list (referred to as a 303(d) list) of all surface waters in the state with pollutant concentrations that exceed water quality standards. These waters are considered to be impaired with respect to specific beneficial uses associated with the water quality standards, such as drinking, recreation, aquatic habitat, and/or industrial use. Missouri's 2002 303(d) list is available at http://www.dnr.mo.gov/wpscd/wpcp/waterquality/303d/swro-303d.htm (accessed 9/19/05).

Spring River Tributaries

Key tributaries of the Spring River in Missouri, ordered from north to south are: North Fork of the Spring River, Center Creek, Turkey Creek, Short Creek, and Shoal Creek. Each of these tributaries flows in an east-to-west direction. Similar to the Spring River, some of these tributaries provide habitat to valued aquatic animals including threatened and endangered species and species of concern (Exhibit 5 and Appendix A). The following paragraphs briefly describe key characteristics of each.

North Fork is the primary northern tributary, entering the Spring River in Jasper County from Barton County. It is the only plains-type key tributary to the Spring River in Missouri. The North Fork drains 640 square miles and flows through the Neck/Alba DA before joining the Spring River (Kiner *et al.* 1997). The North Fork was listed as impaired from sediment due to non-point source pollutants (Missouri 303(d) 2002). Biological assessments in 2003-2004 measuring habitat, water quality, and macroinvertebrate communities indicated that the North Fork is biologically impaired (TMDL, EPA 2006), although the mussel community is diverse and sediment zinc levels are relatively low (Exhibits 3, 6, 7). Of the available water quality data, metals concentrations were rarely above detection limits (Exhibit 8).

Center Creek (Exhibit 10) is an Ozarkian stream that joins the Spring River near the Kansas/Missouri border. The creek's base flow is sustained from springs originating in the upper aquifer (Davis and Schumacher 1992); it also drains approximately 70 percent of the mine-affected land in Missouri (Barks 1977). Center Creek is a significant contributor of metals to the Spring River (Davis and Schumacher 1992; Dames & Moore 1995, Wildhaber et al. 2000); indeed, Center Creek receives loadings from its tributaries as well as miner's ditches, such as Ben's Branch (Exhibit 11). Drainage canals were dug to divert rain and mine waters away from heavy-use mine shafts, and heavy precipitation still flows through these man-made Center Creek tributaries (McFarland 1989). The Oronogo/Duenweg DA contributes contamination via "[a]rtesian flow from shafts and subsurface seepage…during low-flow. Seepage and runoff from tailing piles [in the Oronogo/Duenweg DA] are the principle sources of contamination in the stream during high flow" (Kiner *et al.* 1997).

Cadmium and zinc levels in Center Creek sediments are high (Exhibit 6). Concentrations of metals from the majority of sediment samples frequently exceeded the TEC, PEC, and OMOE-Severe values (Exhibits 3 and 7). As shown in Exhibit 8, surface water samples also show regular exceedences of water quality criteria.

Metals levels and other contamination in the watershed (*e.g.,* from fertilizer and explosives manufacturing in the watershed) have impacted—and continue to impact—Center Creek's aquatic biota. Davis and Schumacher (1992) describe surveys between the 1960s and 1980s that found "the chemical quality and the benthic invertebrate population [*to*] deteriorate rapidly downstream from Grove Creek [*a tributary to Center Creek*]." Water quality standards for fecal coliform, fluoride, ammonia, and zinc were "frequently exceeded," and zinc exceedances were the "likely reason for the almost total lack of a benthic invertebrate population in Center and Turkey Creeks" (*ibid.*). Dames

and Moore (1995) similarly found macroinvertebrate community structure upstream of the Oronogo/Duenweg DA to differ significantly from that downstream of the Carl Junction DA. Furthermore, concentrations of lead, zinc, and cadmium in invertebrates at the mouth of Center Creek were found to exceed levels identified as being detrimental to fish (Wildhaber et al. 2000, comparing findings with Farag *et al*. 1994, and Woodward *et al*. 1994).

Dames & Moore (1995) also suggest that fish communities in the creek have been impacted by elevated metal concentrations, as fish are both more diverse and more abundant upstream of the Oronogo/Duenweg DA relative to downstream. Waters of No Name Creek in the Center Creek basin were found to be acutely toxic to water fleas (*Ceriodaphnia dubia*) and fathead minnows (*Pimephalesi*); investigating the source of the toxicity "pointed towards metal contamination as the most probable cause" (Crawford 1993). In a recent mussel survey, Angelo et al. (2007) found no mussels in the lower reaches of Center Creek (Exhibit 3).

EXHIBIT 10 CENTER CREEK WITH MINE WASTE BARS

EXHIBIT 11 BEN'S BRANCH FLOWING THROUGH MINE WASTE PILES NEAR WEBB CITY, MISSOURI

Turkey Creek drains about 18 percent of the zinc-lead mined areas before joining the Spring River south of Center Creek, just west of the border in Kansas (Barks 1977). An Ozarkian stream, Turkey Creek flows through Joplin, Missouri and receives discharges from several industries and several sewage treatment plants, as well as runoff from historically mine-related areas (Dames & Moore 1995). Some parts of the creek contain visible mine waste bars (Exhibit 12).

EXHIBIT 12 TURKEY CREEK WITH MINE WASTE BARS

Exceedances of lead, cadmium, and particularly zinc water quality criteria have occurred in Turkey Creek (Exhibits 4 and 8); indeed, Dames & Moore (1995) state that runoff from the Oronogo/Duenweg DA in particular appears to cause Turkey Creek to exceed the chronic ambient life criterion for zinc. MDNR (2005) notes that Turkey Creek zinc levels frequently exceed state water quality standards during low flow, and MDNR's 2002 303(d) list states Turkey Creek is impaired by zinc.

Sediment samples from Turkey Creek indicate high levels of metals contamination (see Exhibit 6). Concentrations of cadmium, lead, and particularly zinc have frequently exceeded the TEC, PEC, and OMOE-Severe values (see Exhibits 3 and 7).

Benthic community surveys between the 1950s and 1970s found a "small density and nondiverse benthic community consist[ing] almost entirely of pollution-tolerant varieties" (Davis and Schumacher 1992). The exceedance of zinc water quality criteria was "the likely reason" for this observation, although wastewater treatment plant effluence

"probably" also contributed (*ibid.*). More recent analyses have similarly found that tissues from Turkey Creek fish had elevated levels of metals, and parts of the creek have altered benthic communities, indicating that these communities "may have been altered possibly by physical or chemical conditions" (Dames & Moore 1995). Concentrations of cadmium, lead and zinc in invertebrates at the mouth of Turkey Creek have exceeded levels identified as being detrimental to fish (Wildhaber *et al.* 2000). Angelo et al. (2007) failed to find live mussels in the creek.

Short Creek (Exhibit 13) originates in the city of Joplin and in the Iron Gates DA, passes through Missouri and into the Galena subsite in Kansas before joining the Spring River. It is an intermittent stream, draining eight square miles in Jasper County, or about five percent of the lead-zinc mined area in Missouri (Barks 1977). Most of its flow is contributed by urban and agricultural runoff (Dames & Moore 1995).

EXHIBIT 13 SHORT CREEK

The creek is highly contaminated with metals (*e.g.,* Ferrington *et al.* 1989). Although not included in Missouri's 2002 303(d) list, Kansas's 2004 303(d) list states that water quality impairments in Short Creek include contamination by cadmium, copper, lead, and zinc. Zinc appears to be the primary constituent causing Short Creek waters to be acutely toxic to water fleas (*Ceriodaphnia dubia*), and acutely toxic to fathead minnows under high flow conditions (Dames & Moore 1995).

Zinc loading in Short Creek is elevated during high flow and may be attributable to mine-related runoff from the Belleville DA (Dames & Moore 1995). Water quality problems in the creek also arise from mine-water seepage, runoff from a former smelter, and seepage from a phosphor-gypsum pile; indeed, Short Creek "is the largest single source of total phosphorous and dissolved zinc loads in the Spring River basin" (Davis and Schumacher 1992). Zinc levels in surface water have exceeded the CCC and CMC (Exhibits 4 and 8). Short Creek's sediments are also contaminated with frequent exceedances of the TEC, PEC, and OMOE-Severe, particularly (but not only) by zinc (Exhibits 3 and 7).

Dames & Moore (1995) sampled macroinvertebrates from Short, Turkey and Center Creeks and the Spring River. Generally, Short Creek macroinvertebrates exhibited the lowest species richness of all the streams investigated. Dissimilarity between macroinvertebrate communities upstream and downstream of the Joplin DA on Short Creek indicates that industrial and mining activities may have altered the structure and function of these communities (Dames & Moore 1995). Angelo et al. (2007) failed to find live mussels in the sampled portion of the creek (in Kansas).

Shoal Creek's base flow is sustained from springs originating in the upper aquifer (Davis and Schumacher 1992). As it flows through the region, it forms the southern border of the Iron Gates Extension DA and drains 472 square miles (Kiner *et al.*1997), joining the Spring River in Kansas. The creek is considered to be an Ozarkian stream where it crosses the Iron Gates Extension DA in Newton County, and it has exceptionally clear water and a rocky bottom (Exhibit 14). Wildlife, fish, scenery, and opportunities for recreation make Shoal Creek an "outstandingly remarkable" stream according to the National Park Service (1982).

EXHIBIT 14 SHOAL CREEK

The Newton County Mine Tailings Superfund Site falls within the Shoal Creek drainage, and parts of Shoal Creek have been subject to metals contamination. CDM (1995) states that runoff and seepage from mill wastes contribute cadmium, lead, and zinc to the creek. In particular, perennial Dry Branch creek contributes contaminants from the Prairie Run tailings area in Granby. The intermittent streams, Gum Spring Branch, and Wolf Creek also drain Newton County tailings piles to the creek (Jacobs Engineering Group 1995). Discharges of groundwater from mine structures including shafts and subsidence pits also affect water quality, and in Newton County, the contaminated shallow aquifer flows toward Shoal Creek (see groundwater section below) (EPA 2003b).

Sediments in Shoal Creek have elevated metals concentrations. As indicated in Exhibit 7, most samples exceed TEC for all three metals of concern, and there were frequent PEC and OMOE-Exceedances particularly from zinc. Some exceedances of water quality standards have also occurred (Exhibits 4 and 8).

Although some biological surveys in the 1950s through 1970s found a healthy invertebrate population (Davis and Schumacher 1992), recent data on unionid mussel communities in Shoal Creek suggest that the creek undergoes a radical transformation in character downstream of Joplin, Missouri. Although the unionid mussel community is readily apparent upstream of the city, it is essentially absent in downstream reaches (Angelo et al. 2007). Obermeyer *et al.* (1997) found the Neosho mucket (*Lamsilis rafinesqueana)* to be present in the more upstream reaches of Shoal Creek in Missouri, but in the Kansas stations closest to the creek's confluence with the Spring River, found either no evidence of the species or only weathered/relic mussel shells. Clarke and Obermeyer (1996) found fewer live specimens of mussel species per hour in Shoal Creek than in either the North Fork Spring River, or Spring River.

2.1.2 GEOLOGIC RESOURCES

In the context of a natural resource damage assessment, geologic resources are defined as "those elements of the Earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of ground [water] and surface water resources" (43 CFR §11.14(s)).

In its natural state, the area's soils support diverse ecosystems, such as tallgrass prairie and deciduous woodland. However, many of the geologic resources within the Missouri TSMD are either currently covered by mine waste piles or fall within the footprints of former piles. Exhibits 1 and 2 show the locations of mine wastes in Jasper and Newton Counties. Exhibit 15 presents the areal extent of these locations and also presents an estimate of mine-associated contaminated lands. Contaminated lands are considered to be those formerly occupied by mine wastes as well as "transition zone" soils (i.e., those within 200 feet of current mine and mill waste piles).

EXHIBIT 15 MINE WASTE AND CONTAMINATED LAND AREAS

SITE	EXTENT OF MINE WASTES (ACRES)	EXTENT OF SURROUNDING CONTAMINATED LAND (ACRES)[1]	TOTAL (ACRES)
Oronogo-Duenweg Superfund Site (including the Iron Gates Extension Area)	3,846	3,361	7,207
Newton County Superfund Site	365	473	838

Notes:

1. These are lands within a 200-foot transition zone of mine wastes, a width that is based on findings from the Jasper County Remedial Investigation (Dames & Moore 1995).
2. Location information for mine wastes and contaminated areas comes from several sources. In 2007, EPA contractor Black & Veatch provided IEc with GIS files containing mine waste location information. We understand these locations represent current locations of mine waste. For Newton County, we supplemented the Black & Veatch information with data from USGS 1:24,000 scale topographic sheets and information from the Newton County site inspection report (Jacob Engineering 1995).

The areal extent of mine wastes was even larger in the past: Dames & Moore (1995) and CDM (1995) have estimated that 7,744 terrestrial acres in the Oronogo/Duenweg (Jasper County) Site contain mine wastes or contaminated soils, with approximately 158 of those in the Iron Gates Extension DA.

The 200-foot zone is based on findings of Dames & Moore (1995), who investigated metals levels in DA soils. Dames & Moore (1995) found transition zone soils within 200 feet of mine and mill wastes to have three- to five-fold higher cadmium, lead, and zinc concentrations than did the DA soils (i.e., soils within the DA boundaries but at least 200 feet away from mine and mill wastes). Even DA soils had mean concentrations of lead, cadmium, copper, manganese, selenium, and zinc higher than in off-site reference soils. Chat, and the surficial soils underlying chat piles, also had cadmium, lead, and zinc metal concentrations in excess of those found in DA soils (*ibid.*).

Other studies have reached similar conclusions with respect to soil contamination (Angle 1999, CDM 1995), altogether suggesting that past mining activities have contaminated geologic resources underneath, and adjacent to, current and former mine waste piles.

Residual mine waste piles and contaminated soils may serve as a pathway through which contaminants reach ground water or surface water. To the extent that these terrestrial

areas contaminate and injure other natural resources such as ground and surface water, terrestrial areas are also injured.[12]

Site work to date suggests that mine wastes have contributed contamination to other natural resources including surface waters. In some cases, visual inspection alone suggests the connection between terrestrial wastes and surface waters (Exhibit 11).

Site investigations have also supported the existence of the terrestrial - surface water pathway. Investigations in the Iron Gates Extension DA have revealed that heavy precipitation falling on chat piles has resulted in erosion and the deposition of eroded materials in streams to a depth of 24 inches (CDM 1995). In Newton County, a number of current and former mine waste pile areas are located adjacent to surface waters, and the Final Site Inspection Report for the Newton County Mine Tailings Site notes specific observations of drainage pathways and/or runoff from the piles into waterways (Jacob Engineering Group 1995). The Final Remedial Investigation for the Oronogo-Duenweg Superfund Site found mine-related runoff and seepage contribute to the zinc loading of site streams. In particular, during high flow periods Dames & Moore (1995) estimated that mine-related runoff and seepage contribute 14 percent of loadings to Center Creek and 22 percent of loadings to Turkey Creek. (Low flow contribution estimates were lower.)

Current levels of soil contamination may also be responsible for toxic impacts to certain biota. To the extent that soil contamination has resulted in injury to plants or animals, the contaminated lands are considered to be injured, according to DOI's NRDA regulations (43 CFR 11.62(e)(11)). Section 2.1.4 addresses available information on biotic impacts.

2.1.3 GROUND WATER

Two major aquifers, the "shallow aquifer" and the "deep aquifer" underlie the Jasper and Newton County sites. The two aquifers are separated by low-permeability shale (Spruill 1987, Dames and Moore 1995, Imes and Emmett 1994). In Newton County, the aquifers are separated by a confining layer of up to 45 feet in thickness that largely prevents flow between them (although this confining layer is absent in the northwest portion of Newton County, and is present only sporadically in parts of Newton County, where it is composed of shale (EPA 2003b). The shallow aquifer flows west/northwest except in the Iron Gates Extension DA (in Newton County), where flow trends south toward Shoal Creek (CDM 1995). Recharge to the shallow aquifer occurs primarily by infiltration of local precipitation (Feder *et al.* 1969). The shallow aquifer is 300 feet deep on average, and consists primarily of limestone and chert with brecciated zones coincident with metal ore deposits, which were the target of mining operations.[13]

The shallow aquifer discharges into the perennial and intermittent streams in the area, providing base flow levels to these surface waters (Feder *et al*. 1969). For example, the

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[12] DOI's NRDA regulations state that injury has occurred to the geological resource if: "Concentrations of substances [are] sufficient to have caused injury as defined in paragraphs (b), (c), (d), or (f), of this section to surface water, ground water, air, or biological resources when exposed to the substances" (43 CFR 11.62(e)(11)).

[13] Brecciated zones are areas of rock that have fractures and are very porous, allowing for higher transmissivity of water.

shallow aquifer is hydraulically connected to Center and Turkey Creeks (Barks 1977). In the Granby area, the shallow aquifer is thought to flow towards Shoal Creek (Jacobs Engineering Group 1995). The shallow aquifer also discharges into "shallow wells, flowing mine openings, and collapse structures" (Dames & Moore 1995). During heavy precipitation, mine water levels peak rapidly (Feder 1969, Dames & Moore 1995). Shallow wells in the site exhibit higher average metal ion concentrations, including zinc, and lead, than in baseline wells, due to their contact with mine waste and acid rock drainage generated by mine waste leachates (Dames & Moore 1995).[14]

The shallow aquifer was once routinely used as a source of drinking water by the residents of Jasper and northern Newton Counties. It is still used in western Jasper County for watering livestock and gardens, and for industrial purposes (EPA 1998). EPA determined that metal contamination of the aquifer (from cadmium, lead, zinc, and manganese) was significant enough to render the water in some parts of the aquifer unsafe to drink[15] and in 1998 provided an alternate water supply as part of its selected remedial action for the Oronogo/Duenweg (Jasper County) Ground Water OU (EPA 1998). The selected remedy included the provision of water from the deep aquifer via public water supply to area residents.

Mining activities created vast networks of open space in the shallow aquifer that allow for the convection of water vertically and laterally at high rates, greatly increasing flow rates through, and storage capacity of, the water-bearing rock. Mining activities were also primarily responsible for the widespread contamination of the shallow aquifer. An estimated 132,000 acre feet of groundwater is present within underground mine workings in the TSMD (including Missouri, Kansas, and Oklahoma) (Spruill 1987). Yields from wells in the shallow aquifer are generally low, but in brecciated and mine-impacted areas can be in excess of 1000 gallons per minute. Annual recharge from precipitation only to the shallow aquifer (net of water that: evaporates, is transpired by plants, flows overland to rivers and streams, flows below ground to provide base flow for streams, flows to natural springs, and percolates to the deeper aquifer) is one percent of total precipitation (Imes and Emmett 1994). Given an annual precipitation rate of approximately 40 inches for the region, net recharge to the shallow aquifer is estimated to be 0.4 inches per year.

In the Newton County Mine Tailings Site, approximately 1,800 homes have private water wells that tap the shallow aquifer. According to 2000 (EPA 2003b) sampling information, a plume of groundwater contamination extends across a 160 square mile area in the site, and 400 wells are lead-contaminated. Bottled water has been provided to homes with wells containing lead concentrations above the action level as a first step in the selected remedy for the site (EPA 2003a). The Missouri Well Construction Rules define Jasper and Newton Counties as "Special Area 2" in response to the widespread metal

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[14]Acid rock/mine drainage results from exposure of sulfide minerals to air and water, creating sulfuric acid that then dissolves metals such as zinc, lead, cadmium, and copper into surface and ground water. Acid mine drainage is harmful to many aquatic species.

[15] Parts of the shallow aquifer are still used for residential purposes in Jasper and Newton Counties (D. Mosby, FWS, personal communication 2-28-08).

contamination of the shallow aquifer. The rules prohibit construction of additional wells drilled into the shallow aquifer, limit deepening of existing shallow aquifer wells, and require more stringent well construction standards for wells drilled into the deep aquifer (MDNR 2007b).

The deep aquifer is comprised of Ordovician and Cambrian dolomites and sandstones, and is bounded underneath by granites. Its ground water flow is east-to-west and southwest. Recharge occurs through precipitation falling on rock outcroppings in the Ozark region southeast of the site (CDM 1995, 3-8). Net recharge to the deeper aquifer is greater than net recharge to the shallow aquifer from precipitation (Imes and Emmett 1994).

The deep aquifer is estimated to contain approximately 43 million acre-feet of water. General flow is in the westerly direction. The deep aquifer does not currently appear to be contaminated, though wells passing through the shallow aquifer have been shown to yield contaminated water (Spruill 1987). Some authors have suggested the existence of downward leakage from the shallow aquifer through areas where confining layers are absent, and deteriorating wells, exploratory drill holes and shafts are present (Schloss 1986, Feder *et al.* 1969, Stramel 1957, Reed *et al.* 1955, all as cited in Dames & Moore 1995), although a U.S. Geological Survey study of the aquifers in northern Oklahoma concluded that all contamination of the deep aquifer is attributable to faulty well seals, and leaky casings (USGS 1990, as cited in Dames & Moore 1995). No surface discharge from the deep aquifer is known to occur in the area, except through pumped wells (CDM 1995). Today, the deep aquifer is the principal source of drinking water in Jasper and northern Newton Counties. The deep aquifer also supplies water for agricultural and industrial uses (Dames & Moore 1995).

A recent study of water supplies in Missouri's Jasper and Newton Counties noted that "groundwater withdrawals from the [deep] aquifer are increasing rapidly" and that this poses a future risk of contamination of the lower aquifer by the upper (Springfield Plateau) aquifer in Missouri (Wittman *et al.* 2003). Future water demands are expected to increase further; this, "combined with the limited capacity of the aquifer, make it likely that [resource] conflicts will occur" (Wittman *et al.* 2003). Groundwater in the Iron Gates Extension DA had concentrations exceeding the associated appropriate regulatory value for the metals cadmium, lead, zinc, iron, manganese, selenium, and aluminum (CDM 1995).

The condition of the area's ground water is of concern not only because of past and ongoing use by humans but also because, as discussed in section 2.1.4 under "Aquatic and Amphibious Species", the contamination may impact the Missouri endangered and federally threatened Ozark cavefish (*Amblyopsis rosae*).

2.1.4 BIOTIC RESOURCES

Vegetation

In Jasper County, croplands, grasslands, and woodlands are interspersed with mine-impacted spaces (Dames & Moore 1995). In Newton County, grasslands and woodlands

are interspersed with "intermediate areas" (CDM 1995). This variety of habitat types allows many kinds of plant to grow.

Open areas such as cropland, pasture, meadows, and overgrown areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The remaining areas of native prairie (e.g., Exhibit 16) including native prairie hay meadows are highly valued because less than four percent of the original habitat remains, making it among the most endangered ecosystems in the world. Native tallgrass prairies support native plants and support exceptionally high numbers of plant species. In particular, they can support hundreds of forb[16] species (Exhibit 17) and their seed banks[17] are exceptionally rich, even in areas used as hay meadows. Native prairie areas may also support important native rangeland grass species, such as the big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*) and little bluestem (*Schizachyrium scoparius*). Big bluestem and little bluestem are the dominant grasses in the limited remaining prairie portions of the Iron Gates Extension DA (CDM 1995).

EXHIBIT 16 DIAMOND GROVE PRAIRIE, NEWTON COUNTY

[16] Forbs are herbaceous, non-grass species.

[17] Seed banks are reserves of viable seeds present naturally on the surface and in the soil.

EXHIBIT 17 BLACK-EYED SUSAN (*RUDBECKIA HIRTA*, A FORB) IN A NATIVE PRAIRIE

About 18 percent of the Spring River basin is forested (Dames & Moore 1995). These woodlands tend to occur as irregular areas or strips, and as riparian corridors (Dames & Moore 1995). Woodlands also occur as strips on upland drainageways and on steep upland slopes (CDM 1995). Native forests are characterized by a variety of oak species (*Quercus* spp.), black walnut (*Juglans nigra*), pecan and other hickory species (*Carya* spp.), and associated shrubs, grasses, legumes, and wild herbaceous plants. Special-status terrestrial plants occurring in Jasper and Newton Counties include: pale gerardia (*Agalinis skinneriana*), auriculate false foxglove (*Agalinis auriculata*), Oklahoma sedge (*Carex oklahomensis*), Ozark chinquapin (*Castanea pumila*), and others (Appendix A).

As noted in the Geologic Resources section above, the aerial extent of mine wastes and associated contaminated lands in Jasper and Newton Counties is large. Chat piles in the Missouri TSMD do not support normal stands of terrestrial vegetation (for example, see Exhibits 19 and 21). Unremediated mine waste piles tend to be barren or sparsely vegetated. Acreages of barren and vegetated mine waste piles have been identified and measured as part of Superfund site investigation activities (e.g., Dames & Moore 1995, CDM 1995), and many are readily apparent in aerial photographs.

The loss of vegetation associated with phytotoxicity is an injury under DOI's NRDA regulations. Available evidence suggests that contamination in some areas affected by mine wastes is sufficiently toxic to cause decreases in plant productivity, changes in species diversity, and/or changes in species composition. In particular:

1. **Impacts are seen not only on mine wastes themselves but also on plant communities growing in soil adjacent to mine waste piles, and more severe impacts are seen closer to the piles.** Even after excluding barren mine wastes from the analysis, Dames & Moore (1995) found "a marked reduction in mean percent ground cover and current annual production between distant, near, and mine-affected sites (mean cover for distant, near, and mine-affected sites is 78, 73, and 59 percent, respectively, while mean production estimates are 2349, 1810, and 835 pounds/acre, respectively)."[18] Relative to the distant sites, these amount to productivity losses of 23 percent for "near" sites, and 65 percent for "mine-affected" sites. This kind of pattern is consistent with a mobilization of hazardous contaminants from the piles into surrounding areas, which in turn causes injury to those areas.

2. **Impacts have been associated with contaminant concentrations, under both field and laboratory conditions.** Pierzynski and Fick (2007) sampled areas near Joplin, Missouri that are impacted by mine wastes. The authors found decreases in species richness with higher zinc concentrations. Higher zinc concentrations also were associated with undesirable changes in species dominance–e.g., common ragweed dominance instead of big bluestem or little bluestem. Furthermore, concentrations of zinc in many plant tissue samples were “well above the previously reported ranges of phytotoxicity,” and greenhouse-grown native grasses that were not nutrient or water-limited but that were exposed either to zinc sulfate or to collected mine wastes, also showed dose-dependent reductions in biomass generation. Considering this and other evidence, the authors conclude that even though factors such as nutrient deficiencies and poor water holding capacity “may also inhibit plant growth… the field results indicate that Zn plays a role in poor vegetative growth.”

3. **Contaminant concentrations in mine wastes, in adjacent soils, and in plant tissues exceed phytotoxicity thresholds identified in the literature.** As noted above Pierzynski and Fick (2007) found concentrations of zinc in Jasper County plant tissues in mine-affected areas to exceed concentrations associated with phytoxicity. Other researches have reached similar conclusions. For instance, the Jasper County Remedial Investigation found average zinc levels to be approximately 600 ppm in "mine-affected" vegetation, and nearly 900 ppm

[18] Dames & Moore (1995) define "near" sites as those within 200 feet of mining-related areas, while distant sites are those further than 200 feet but within the boundaries of an EPA designated area (DA). Mining-affected areas include those areas that have been reclaimed (i.e., recontoured or reseeded), those that are vegetated with more than 20 percent cover composed either of herbaceous, shrubby, and/or woody species. In their vegetative analysis, Dames & Moore (1995) did not evaluate areas of mining waste with less than 20 percent cover.

in "near site" vegetation, while noting that a "tolerable level of zinc in plants is estimated to be 50 ppm," and that "zinc phytotoxicity for most species has been reported to occur at 500 ppm with notable yield reductions at concentrations greater than 600 ppm" (Dames & Moore 1995). Zinc levels in plants grown in Jasper County tailings, in greenhouse experiments, were still "potentially at or near what is considered toxic levels" (Brown et al. 2005). Black & Veatch (1998) found mean contaminant concentrations in the soils of distant, near, and mine-affected sites to greatly exceed U.S. Department of Energy phytotoxicity screening values.

Aquatic and Amphibious Species

Jasper and Newton Counties' aquatic organisms include a wide variety of plants and animals.

Fish. Local fish species include a number of larger or recreationally important fish species such as smallmouth bass (*Micropterus dolomieui*), rock bass (*Amploplites rupestris*), longear sunfish (*Lepomis megalotis*), and several sucker species (Dames & Moore 1995). Smaller fish species include minnows and darters. Some fish species inhabit subsidence pits and flotation tailings ponds; these consist primarily of bluegill and common carp, with fewer numbers of largemouth bass, and green sunfish (Dames & Moore 1995).

Several species of fish found in Jasper and Newton Counties have special status: the Missouri endangered and federally threatened Ozark cavefish (*Amblyopsis rosae*), the Missouri-listed rare and federal candidate Arkansas darter (*Etheostoma cragini*), the Missouri endangered and federally threatened Neosho madtom (*Noturus placidus*), and several other species of conservation concern (MDC 2000) (Appendix A). In a study of its distribution, Pflieger (1992) observed that the largest remaining populations of the Arkansas darter may be in southwestern Missouri streams. The Neosho madtom is only known to occur in one stretch of Spring River below its confluence with the North Fork close to the Kansas border, and discontinuously throughout other streams in its range (Schmitt 1994).

Toxicity tests of the surface waters, pore waters and sediments in Center, Shoal, and Turkey Creeks and the Spring River indicate that mining-derived metals are present and may be toxic to the Neosho madtom and other aquatic organisms especially in the lower Spring River (Allert *et al.* 1997, Crawford 1993, Dames & Moore 1995). Furthermore, fish sampled from three subsidence ponds and open pits exhibited external abnormalities: two spotted bass had gross evidence of internal abnormality including hemorrhagic skin, liver cysts, and granular texture of the liver (Dames & Moore 1995).

Ozark cavefish. The Missouri endangered and federally threatened Ozark cavefish (*Amblyopsis rosae*) warrants particular discussion. The Ozark cavefish is a small, blind, pinkish-white fish existing only in karst habitat in the southwestern Ozarks. Unlike other local fish species, the cavefish is completely dependent on groundwater, living in solution caves within karst topography, occasionally being observed in wells, springs, or caves containing perennial groundwater streams or pools.

Underground streams and springs are fed by infiltration of surface waters, and cavefish conservation focuses on avoiding harmful activities within karst recharge areas that could degrade groundwater quality. Much of the underground mining in Jasper and Newton Counties took place in the karst systems that support the endangered Ozark cavefish. These activities resulted in the contamination of area groundwater and may have impacted this species.

FWS is not aware of any studies that have evaluated the sensitivity of ground water dwelling organisms such as the Ozark cavefish to contaminants. However, EPA has developed surface water criteria for the protection of aquatic life, and FWS has preliminarily compared data on contaminant levels in ground water samples taken from mineshafts and wells to these criteria, in particular, the Criterion Continuous Concentrations for cadmium, lead, and zinc (EPA 2002c). The evaluated data were generated during remedial investigation sampling in Jasper County (Dames & Moore 1995) and represent 173 samples covering 89 locations.

Of these samples, 75 exceeded the cadmium criterion, 32 exceeded the lead criterion, and 88 exceeded the zinc criterion. These exceedances suggest that the Ozark cavefish may have suffered from past and/or ongoing adverse effects caused by metals contamination.

Mussels. Freshwater mussels occur in the Spring River basin. Obermeyer *et al.* (1997) found the Neosho mucket, a candidate species for Federal listing, to be relatively abundant in the Spring River between Stott City, Missouri and the river's confluence with Center Creek. Clarke and Obermeyer (1996) recognize the Spring River basin as supporting "unusual diverse and precious mussel faunas." Special-status species found in the Spring River in Missouri include the western fanshell (*Cyprogenia aberti*) and rabbitsfoot (*Quadrula cylindrica cylindrical*) (Appendix A). Only one amphibian species, the northern crawfish frog (*Rana areolata circulosa*), is listed as a species of conservation concern in Jasper and Newton Counties.

Available information suggests that mussels have been adversely affected by metals. Mussel communities are severely degraded, and in some cases completely absent, due to metals contamination in parts of the Spring River. For example, mussel densities drop precipitously in the Spring River below the confluences of Center and Turkey Creeks. Mussels appear to be absent in the lower reaches of these and several other mining impacted tributaries, in contrast with species diversity and abundance seen at reference locations (Clark and Obermeyer 1996, Pope 2005, Angelo *et al.* 2007). In addition, areas where mussels are absent correspond with high metals contamination in the sediments of the Spring River and associated tributaries (Pope 2005, Angelo et al. 2007).

Amphibians. Metals exposure may also have affected local amphibians. A study of amphibian distribution and health across land use types in neighboring Cherokee County, Kansas, indicated significantly decreased density of adults and tadpoles (Anderson and Arruda 2006). The authors also found significantly lower rates of egg hatching and

significantly higher rates of malformations in tadpoles[19] at the mining sites in Kansas when compared with natural sites in the same geographic region (ibid.).[20] The mine-affected site showed the lowest species richness, with only four species to the nine different species at the natural sites.

Other aquatic organisms. Benthic macroinvertebrates exhibit high concentrations of metals at the mouths of the three major Spring River tributaries (Wildhaber *et al.* 1997 as cited in Allert *et al.* 1997), and benthic communities in some waterways appear to have deteriorated (Davis and Schumacher 1992).

The "Surface Water Resources" section above presents additional evidence of potential contaminant-related injuries to Missouri Tri-State Mining District fish, mussels, and other aquatic organisms, organized by waterway.

Birds

Birds make use of both aquatic and terrestrial habitat in the Missouri TSMD. These areas generally fall within the Osage Plains physiographic area, in which over 100 bird species breed (Fitzgerald et al. 2000). Special-status avian species occurring in the Missouri portion of the Tri-State Mining District include the federal candidate and Missouri listed rare Henslow's sparrow (*Ammodramus henslowii*), the state endangered barn owl (*Tyto alba*), and others (Appendix A). In recent years, populations of special-status species such as the greater prairie chicken (*Tympanuchus cupido*), northern harrier (*Circus cyaneus*), Swainson's hawk (*Buteo swainsoni*), and cerulean warbler (*Dendroica cerulean*) have declined. (Fitzgerald *et al.* 1997, Fitzgerald *et al.* 2000).

Recent studies suggest that some bird species in the Tri-State Mining District may have been injured as a consequence of metals exposure. In particular, Carpenter et al. (2004) documented a case of zinc poisoning in a trumpeter swan that settled on a mill pond in Picher, Oklahoma; and Sileo et al. (2003) found evidence of zinc poisoning in Canada geese and a mallard collected from the Oklahoma and Kansas portions of the TSMD. These appear to be the first confirmed reported cases of environmental zinc poisoning of free-ranging wild birds reported in the literature (Sileo et al. 2003).

Available evidence suggests that lead is also injuring local birds. Robins, cardinals, swallows, and waterfowl collected from the Tri-State Mining District[21] had significantly elevated body tissue lead levels relative to birds from non-mining areas (Beyer et al. 2004). In addition, for robins, cardinals, and waterfowl, biochemical markers indicated lead exposure (Beyer et al. 2004) and injury.[22] Lead levels in some Tri-State Mining

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[19] No tadpoles were found in the lead-zinc mining site during two intensive searches; eggs hatched in the lab from this site resulted in tadpoles with twice the rate of stunted growth malformations, compared to specimens collected in natural sites.

[20] We note that the study focused on two mining sites in Kansas, one in a historical coal mining area, the other in the lead zinc mining TSMD. Agricultural sites were also chosen and showed decreased density and higher rates of malformation compared to natural sites, but not as severe as those effects seen in mining areas.

[21] Birds were collected from Cherokee County (KS), Ottawa County (OK), and Jasper County (MO).

[22] In particular, researchers found evidence of inhibition of the enzyme delta-aminolevulinic acid dehydratase (ALAD), an enzyme involved in the formation of hemoglobin. ALAD activities in robins, cardinals, and waterfowl were less than 50

District birds were consistent with levels identified in scientific studies as being associated with lead poisoning (ibid.).

Missouri Tri-State Mining District Site birds may also have been impacted by mining-related habitat losses (see "Vegetation" section above). Less vegetative cover and lower quality vegetative habitat mean fewer insects, fruits, and seeds for smaller birds to consume. Plants also provide food for small mammals, which in turn are the prey of larger birds, and in fact, raptor abundance in tallgrass prairies has been shown to be positively related to "aboveground net primary productivity," a measure of plant growth (Reed *et al.* 2004). Mining-related impacts to plants therefore represent a loss of habitat that can reverberate through the food web to the highest-level predators. Cedar Creek Associates, Inc. (1999) found only a few avian species to make any use of barren chat piles in Jasper County, and the Jasper County Remedial Investigation found that "the majority of distant sites [distant from mine waste piles] appeared to support larger bird populations than the near sites" (Dames & Moore 1995). The authors state that this difference is "likely the result of differences in habitat features or vegetation," referencing the previously-noted differences in vegetation cover and productivity between distant and near-pile sites (ibid.).

Mammals

Missouri Tri-State Mining District mammals rely on both aquatic and terrestrial habitats. Mammals observed within seven of the Jasper County DAs include raccoon (*Procyon lotor*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*), whitetail deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), mice, shrews, voles and various other small rodents (Dames & Moore 1995, Cedar Creek Associates 1999). Special-status mammals include the Missouri-endangered plains spotted skunk (*Spilogale putorius interrupta*), the Missouri species of concern black-tailed jackrabbit (*Lepus californicus*), and the federally-endangered gray bat (*Myotis grisescens*) (Appendix A). Many rodents inhabit the DAs, with white-footed mice, deer mice, and hispid cotton rats the most prevalent (Dames & Moore 1995).

Lack of vegetation in barren chat mining areas limits habitat and food resources for mammals. A study of wildlife usage of barren mine sites found that mammals' primary usage of such sites was for travel across them to more vegetated adjacent areas (Cedar Creek Associates, Inc. 1999). Dames & Moore (1995) found that most mammals preferred sites with varied vegetation and structure. In some cases this was provided by former mine sites that produced changing topography and wetland-like areas near subsidence ponds. Larger mammals, such as deer, were typically found at sites distant from mine wastes, with mature vegetation.

Small mammals may also be experiencing direct toxic effects from exposure to metals in the mining wastes. Preliminary trapping work found a significantly less diverse small mammals community at mine-impacted sites in Cherokee County, Kansas compared to

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percent of those in birds from non-mining areas, a reduction that constitutes an injury under DOI's NRDA regulations (43 CFR 11.62 (f)(4)(v)(D)). ALAD activities in swallows were not evaluated.

reference sites (Patricola-Simpson et al. undated). Furthermore, deer mice at the mine-impacted sites suffered from significantly reduced body condition, increased parasitic infections, abnormal gastrointestinal bacterial microflora, and histopathologic changes in their brains (ibid.). It is possible that small mammals in the vicinity of mine wastes and/or contaminated land in Jasper and Newton Counties are experiencing similar impacts.

2.2 CONTAMINANTS OF CONCERN

For Phase 1 assessment planning purposes, the Trustees will focus on cadmium (Cd), lead (Pb), and zinc (Zn), contaminants that have significant potential for toxicity to many plants and animals. They are commonly found at elevated levels in soil, sediment, ground water, and surface water throughout Jasper and Newton Counties, and some relevant data for NRDA assessment purposes already exist. The Trustees recognize that other contaminants and conditions adversely affect natural resource in Jasper and Newton Counties. After reviewing Phase 1 assessment results, the Trustees will consider additional contaminants of concern. The following paragraphs, however, focus on the primary contaminants of concern, their toxicology, and associated environmental hazards.

2.2.1 CADMIUM

Cadmium (Cd) is not biologically essential or beneficial to any known living organism and is toxic to all known forms of life (Eisler 2000). Freshwater[23] animals tend to be affected by cadmium at lower concentrations than marine organisms (WHO 1992). Impacts to freshwater animals include death, reduced growth, and inhibited reproduction (Eisler 2000). In freshwater systems, the lethal effects of cadmium can be reduced by limiting exposure time and increasing water hardness[24] (Eisler 2000). Sublethal effects of cadmium in freshwater organisms include decreases in plant standing crop, decreases in growth, inhibition of reproduction, immobilization, and population alterations (Eisler 2000). Mammals and birds are comparatively resistant to the toxic[25] effects of cadmium, though exposure to high levels can be fatal (Eisler 2000).

Animals can be exposed to environmental cadmium through inhalation or ingestion. Cadmium is a known carcinogen, a known teratogen, and a probable mutagen (Eisler 2000; ATSDR 1999a). Studies investigating carcinogenicity have focused on mammals. Cadmium has been shown to cause tumors in the prostate, testes, and hematopoietic (blood-related) systems in rats (ATSDR 1999c). Based on studies in mice and bacteria, cadmium may be mutagenic (Ferm and Layton 1981, as cited in Eisler 2000). When present, cadmium is detected in particularly high concentrations in the leaves of plants

[23] Freshwater refers to waters that are not saline (salty).

[24] Water hardness is a measure of the content of certain naturally-occurring elements in water, especially calcium and magnesium.

[25] Toxins cause direct injury to an organism as a result of physiochemical interaction. Carcinogens cause cancer (for example, tumors, sarcomas, leukemias). Mutagens cause permanent genetic change. Teratogens cause abnormalities during embryonic growth and development.

and the livers and kidneys of vertebrates (ATSDR 1999c; Scheuhammer 1987, as cited in Eisler 2000).

2.2.2 LEAD

Lead (Pb) is not biologically essential or beneficial to any known living organism (Eisler 2000). It can be incorporated into the bodies of individual organisms by inhalation, ingestion, absorption through the skin, and (in mammals), placental transfer from the mother to the fetus (Eisler 2000). Toxic in most chemical forms, lead negatively affects survival, growth, reproduction, development, and metabolism of most animals under controlled conditions, but its effects are substantially modified by numerous physical, chemical, and biological variables. Younger, immature organisms tend to be more susceptible to lead toxicity (Eisler 2000). When absorbed in excessive amounts, lead has carcinogenic or co-carcinogenic properties (Eisler 2000). In large amounts, it is also a mutagen and a teratogen (Eisler 2000).

It has been demonstrated that aquatic animals experience adverse effects such as reduced survival, impaired reproduction, and reduced growth (Eisler 2000). As with cadmium, increased water hardness decreases lead bioavailability to aquatic animals (Wong *et al.* 1978 and NRCC 1973, both as cited in Eisler 2000). Early research suggested that birds are unlikely to show adverse effects from environmental lead (except when lead objects such as shot are directly ingested); however, there is now a growing body of evidence linking waterfowl poisoning with ingestion of lead-contaminated sediments, especially in the Coeur d'Alene area of Idaho (Chupp and Dalke 1964, Blus *et al.* 1991, Beyer *et al.* 1998, Heinz *et al.* 1999, all as cited in Eisler 2000). There are few data regarding the effect of environmental lead on mammalian wildlife (Eisler 2000).

Lead also can harm plant species. Generally, large amounts must be present in soils before terrestrial plants are affected, although sensitivity varies widely between species (Demayo *et al.* 1982). Effects of lead toxicity in plants include reduced plant growth, photosynthesis, mitosis, and water absorption (Demayo *et al.* 1982).

2.2.3 ZINC

Zinc (Zn) is an essential trace element for all living organisms, and zinc deficiency in animals can cause a variety of adverse effects (Eisler 2000; ATSDR 1995). Zinc is also toxic at high concentrations, although its toxicity depends on its chemical form and other environmental parameters (Eisler 2000). Zinc is not carcinogenic, although in certain chemical forms, zinc can be mutagenic (Thompson *et al.* 1989, as cited in Eisler 2000). Zinc is teratogenic to frog and fish embryos, but there is no conclusive evidence of teratogenicity in mammals (Dawson *et al.* 1988 and Fort *et al.* 1989, both as cited in Eisler 2000).

Environmental effects of excess zinc can be significant at relatively low concentrations (Eisler 2000). Terrestrial plants can die from excess zinc in the soil (Eisler 2000). Freshwater animals can also experience adverse effects, including reduced growth, reproduction, and survival (Eisler 2000). Ducks experience pancreatic degeneration and death when fed diets containing high concentrations of zinc (Eisler 2000). Mammals can generally tolerate greater than 100 times their minimum daily zinc requirement (NAS

1979, Wentink *et al.* 1985, Goyer 1986, Leonard and Gerber 1989, all as cited in Eisler 2000), but levels that are too high affect their survival, metabolism, and well-being (Eisler 2000).

2.3 SOURCES OF CONTAMINANTS

2.3.1 HISTORY OF MINING IN JASPER AND NEWTON COUNTIES

Production Overview

The history of mining goes back over 150 years in the Tri-State Mining District. Mining for lead and zinc began first in Newton and Jasper Counties, Missouri in the 1850s and by the 1870s spread to Cherokee County, Kansas, reaching Ottawa County, Oklahoma by the early 1900s (Dames & Moore 1993b). More specifically, lead mining began in 1848 at the present location of the cities of Joplin and Granby, Missouri. Zinc production began with the development of railroads and availability of smelters in the area in 1872 (Dressel *et al.* 1989). For the period 1850-1950, the district produced 50 percent of the zinc and 10 percent of the lead in the United States. Altogether, the mines in the district produced 23 million tons of zinc concentrates and four million tons of lead concentrates (Brosius and Sawin 2001). The Tri-State Mining District ranks first in terms of past zinc production in the United States, and fourth in terms of past lead production (Long *et al.* 1998). Production in the Missouri portion of the Tri-State Mining District peaked in the 1920s, then diminished until it largely ceased in 1957 (Dames & Moore 1995). In the Oronogo/Duenweg DA alone, five million tons of ore-containing rock was mined annually during the boom period of 1904 to 1918 (Stewart 1990).

Mining Methods

Mining in the area included some shallow surface excavation plus ten large open-pit mines, situated within seven Jasper County DAs. However, most mining operations in the district used underground techniques (Dames & Moore 1995). Room-and-pillar methods, in which rooms were mined for their ore while leaving pillars to support the roof, were common, especially for the relatively thin and broad sheet-ground deposits that principally composed the Oronogo/Duenweg DA (Stewart 1990). Some of the mined rock layers were aquifers (that is, they were saturated with ground water), such that constant pumping was required to keep the mines dry as mining operations continued (Dames & Moore 1993b; EPA 2003b). In some cases, the mined areas collapsed if rock pillars were not left in place during mining, or if they were later removed. This resulted in subsidence areas that forced closure of mines.

Hundreds of small mining outfits operated in the Oronogo/Duenweg DA and throughout the area in the early years (Stewart 1989a). These operations relied on hand crushing and other techniques to separate ores from associated materials and produce good grade concentrates (Stewart 1989a). Technical improvements in mining and milling processes made it profitable to reopen early mines and remill the previously generated wastes (CDM 1995). Lower production followed World War I, but World War II saw increased mining operations again with the reopening of the Oronogo/Duenweg DA. During this last production phase post World War II, two-thirds of mined tonnage from the

Oronogo/Duenweg DA was milled off-site at the large Eagle-Picher company facility in Oklahoma (Stewart 1989a).

Ore processing produced a variety of wastes, including waste rock, chat, and tailings. Smelting, in turn, produced slag, clinker, and flux wastes, as described below:

- Waste rock, known as bullrock, or development rock (Exhibit 18), consists of cobble to boulder-sized rocks that were excavated but not milled. It includes rock that overlay an ore body, rock removed in the creation of air shafts, and mined rock containing little usable ore. Waste rock is primarily unmineralized limestone, jasperoid, and shale (Dames & Moore 1995).
- Chat (Exhibits 19 and 20) consists of a mixture of gravel- to fine-sized mill waste, often mixed with sand-sized particles. Chat was produced as part of the initial milling of the mined rock. Chat piles are a dominant geographic feature in the Tri-State Mining District, although much of the gravel-sized chat has been removed and sold as fill for roadbeds or for other uses (Dames & Moore 1995).
- Tailings (Exhibit 21) are sand and silt-sized mine wastes, left over after the final milling of the ore and the flotation of metals from crushed rock, or created as a by-product of washing chat. Tailings were commonly deposited in settling basins. There is less tailings waste in the Jasper and Newton County areas than in Oklahoma or Kansas because the processes that produce the most tailings only came into common usage after the height of mining production in Missouri (Dames & Moore 1995).
- Slag, a smelting waste, is composed of iron compounds and oxides of minerals associated with ores. It was skimmed from molten metal during the smelting process, and left in small volumes near smelting areas. The majority of slag once present in the Jasper County DAs has been removed for use in construction, and rock-wool insulation, although some slag piles remain in Newton County (Dames & Moore 1995, CDM 1995).
- Clinker, a boiler residue, was discarded from steam plants fired by coal and wood that powered the mines and mills through the early 1900s. Clinker is composed of dust particles and remainders of coal used in heating operations; some clinker is present in small piles within the Jasper County DAs (Dames & Moore 1995).
- Flux was used to separate slag from the metal-bearing ores. It is primarily a combination of silica and lime with smaller alumina and magnesia constituents. Some flux is present in small piles within the Jasper County DAs (Dames & Moore 1995).

EXHIBIT 18 BULLROCK AT THE ORONOGO/DUENWEG DESIGNATED AREA

EXHIBIT 19 CHAT PILE IN EPA SOIL REPOSITORY AT ORONOGO/DUENWEG DESIGNATED AREA

EXHIBIT 20 CHAT

EXHIBIT 21 TAILINGS IMPOUNDMENT AT WACO DESIGNATED AREA

A quantity of 150 million tons of mining wastes once covered the Missouri Tri-State Mining District Site. Although a substantial amount of the Missouri waste has been removed for use in buildings and roads, a considerable quantity still remains (MDNR and DOI 2002). As of 1995, about nine million tons remained in the Jasper County site (Dames & Moore 1995). In Granby, and to a lesser extent in Wentworth, and Stark City, Newton County, a number of tailings and chat piles remain. One estimate states that 10- to 20,000 tons of tailings remain in Granby (Jacobs Engineering Group 1995).

2.3.2 MINING AND METALS CONTAMINATION

Mining activities release metals into the environment through a variety of pathways. When active mining ceased, pumping of the excavated mine areas stopped, and the remaining rooms and tunnels filled with ground water (Stewart 1990). This water became contaminated by contact with the minerals exposed during mining, ore remaining in the mine walls, and some leached into surrounding areas of ground water and/or discharged to surface waters (Barks 1977).

Piles of mine wastes have also contributed to past and ongoing contamination. Mine wastes contain elevated levels of metals, contaminating soils under and around the piles (Angle 1999, Dames & Moore 1995, CDM 1995). In addition to contaminating adjacent soils, chat piles collect water, resulting in "perched water" within the piles. These act as precipitation storage sites, slowly releasing contaminated water after a recharge event (Dames & Moore 1993b). Streams and ponds that receive drainage from perched water or water that filters through mine and mill waste deposits have elevated metals concentrations relative to upstream (Dames & Moore 1993b, USGS 1976 in EPA 2003b).

Waste piles on the surface may increase ground water recharge by impeding runoff into surface waters: some water is retained in pore spaces in the piles and is physically prevented from becoming runoff. This puts highly oxygenated rain water into contact with a larger surface area of metal-rich minerals and may increase contaminant levels as the retained water trickles down into the ground water. Contaminated ground water in turn can contribute to metals loading in some streams. For instance, the shallow aquifer discharges to the streambeds of Spring River tributaries (Dames & Moore 1995).

Smelting, the process of melting or fusing ore for the purpose of separating and refining the metal, also contributed to heavy metal contamination in Jasper and Newton Counties. Initially, there may have been crude log smelters associated with each mine (Dames & Moore 1995). All of the major mining camps in Newton County are believed to have had smelters, including two in the Iron Gates Extension DA and others in Granby and Neosho. The Eagle-Picher smelter in the Joplin DA operated for over 100 years, resulting in lead concentrations in nearby residential soils sufficient to prompt yard soil removal at over 2,400 sites (Dames & Moore 1995, EPA 2002a). EPA identified an additional 17 potential smelter locations in the Joplin DA, and smelters also operated in the Oronogo/Duenweg DA (Dames & Moore 1995). Smelter wastes including slag, flux, and clinker, all contain metals. Dames & Moore (1995) found elevated concentrations of lead, zinc, and cadmium in slag as compared with DA soils. In flux samples, nickel in

particular exceeded concentrations typically found in mill waste. Nickel concentrations in clinker samples were higher than in chat (Dames & Moore 1995).

Subsidence ponds[26] (Exhibit 22) and chat/tailings ponds can receive runoff from the surface and can in turn release wastes to surface waters and/or ground water. For instance, Shoal Creek receives runoff from subsidence ponds in its course through the Iron Gates Extension DA area (CDM 1995).

The result of all these activities is past and ongoing exposure of natural resources–land, water, plants and animals–to metals, potentially causing injuries to these resources and the services they provide to humans and the environment. The Trustees intend to investigate and document these losses through the studies set forth in this Phase 1 Assessment Plan.

EXHIBIT 22 SUBSIDENCE PIT NEAR WEBB CITY

[26] Subsidence ponds are areas where underground excavations have caused the surface above it to sink, and into which water has pooled. This occurred sometimes because, during the final phase of mining, operators would "rob the pillars" within their underground room-and-pillar mines, causing collapse of the mine roof and the creation of a subsidence (Brosius and Sawin 2001).

2.3.3 CONFIRMATION OF EXPOSURE[27]

A substantial body of information is already available demonstrating past and ongoing exposure of Jasper and Newton Counties' natural resources to contaminants of concern. For example:

- Metal concentrations, particularly those of zinc, have exceeded the ambient water quality criteria (AWQC) and criteria maximum concentration (CMC) in Center Creek, Turkey Creek, Short Creek., Shoal Creek, and the Spring River (Exhibits 4 and 8; MDNR and DOI 2002).
- Sediment concentrations of metals in these waterways exceed published toxicity benchmarks for the protection of aquatic life (Exhibits 3 and 7, MacDonald *et al.* 2000, Persaud and Jaagumagi 1996);
- During the course of EPA's work on the Missouri Tri-State Mining District Superfund sites, data have been collected documenting high concentrations of contaminants in mine wastes and nearby soils at levels that exceed both national average soil concentrations and concentrations thought to be toxic to vegetation (Dames & Moore 1995);
- Various studies have found concentrations of metals in the shallow aquifer that are higher than background concentrations by up to an order of magnitude and that exceed ground water criteria (MDNR and DOI 2002); and,
- Recent work has found evidence of lead and zinc poisoning in songbirds and waterfowl in the Tri-State Mining District (Carpenter *et al.* 2004, Sileo *et al.* 2003, Beyer *et al.* 2004).

Altogether, these data confirm that natural resources in the Jasper and Newton Counties have been, and continue to be, exposed to elevated levels of these metals.

2.3.4 PRELIMINARY DETERMINATION OF RECOVERY PERIOD[28]

Recovery period is defined under 43 CFR §11.14(gg) as "either the longest length of time required to return the services of the injured resource to their baseline condition, or a lesser period of time selected by the authorized official and documented in the Assessment Plan." Several factors can influence estimates of recovery time, including ecological succession patterns, growth or reproductive patterns, life cycles, ecological requirements of plants and animals (including their reaction or tolerance to the hazardous substance involved), biological recruitment potential, the bioaccumulation and extent of hazardous substances in the food web and the chemical, physical and biological removal rates of the hazardous substances.

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[27] The DOI's NRDA regulations require that exposure of at least one of the natural resources identified as potentially injured "has in fact been exposed to the released substances" (43 CFR §11.37(a)). This Plan confirms that a variety of potentially-injured resources have been exposed to contaminants of concern, including cadmium, lead, and zinc.

[28] The DOI NRDA regulations require than an assessment plan include a preliminary estimate of the time needed for injured resources to recover (43 CFR §11.31(a)(2)).

As noted in previous sections of this Plan, substantial mining activities in Jasper and Newton Counties and neighboring areas were undertaken for more than a century, and measurements of metals in the environment demonstrate that these contaminants have been present at levels associated with adverse impacts to natural resources in Jasper and Newton Counties for decades.

Data from similar sites in other locations, and research presented in the technical literature, suggest a recovery period on the order of at least decades in the absence of active remediation or restoration efforts beyond those already implemented or planned. Metals are elements and may change their chemical form or become dispersed in the environment, but they do not break down. Elevated levels of metals have been and continue to be present in a wide variety of natural resources within the Missouri Tri-State Mining District. Available information suggests that natural processes will take a very long time to remove the contamination or render it biologically unavailable, given the amounts present and the environmental processes involved.

The Trustees recognize that implemented or planned actions through Superfund or other programs may hasten the recovery of some resources, at some locations. However, information currently available to the Trustees indicates that planned or implemented actions are not sufficient in scope or design to change the preliminary finding that adverse mining-related impacts to natural resources in Jasper and Newton Counties are likely to persist for decades or longer.

CHAPTER 3 | ROLE OF TRUSTEES

This chapter provides information about the Trustees, their jurisdiction, and the NRDA process that the Trustees plan to follow. It also addresses a number of regulatory issues, as required by the DOI's NRDA regulations (43 CFR §11.10 *et. seq.*).

3.1 ASSERTION OF TRUSTEESHIP

Trustees[29] are responsible for managing natural resources for the public. The DOI and the Missouri Department of Natural Resources are Trustees for natural resources in the State of Missouri and have developed a state-wide memorandum of Understanding (MOU) forming a Trustee Council. This Trustee Council is charged with pursuing NRDA activities for trust natural resources within the State of Missouri, including the Missouri portions of the Tri-State Mining District.[30]

CERCLA as amended (42 U.S.C. 9601 *et. seq.*), the Oil Pollution Act of 1990 (OPA), 33 U.S.C. 2701 *et. seq.*, and the Federal Water Pollution Control Act (the "Clean Water Act" (CWA)), as amended (33 U.S.C. 1251 *et. seq.*), authorize the Federal government, states, and Indian tribes to recover, on behalf of the public, damages for injuries to, destruction of, or loss of natural resources belonging to, managed by, appertaining to, or otherwise controlled by them (42 CFR §9607(f)(1); 9601(16)). Under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), when there is injury to, destruction of, loss of, or threat to the supporting ecosystems of natural resources, the Trustees are also authorized to act (40 CFR Subpart G § 300.600).

In accordance with 42 U.S.C. 9607(f)(2)(B) and the NCP (40 CFR § 300.600), the Governor of the State of Missouri, has designated the Director of MDNR as the natural resource trustee for the State of Missouri. MDNR acts on behalf of the public, as a trustee for natural resources, including their supporting ecosystems, within the boundary of Missouri or belonging to, managed by, controlled by, or appertaining to Missouri. MDNR is the Lead Administrative Trustee for this NRDA.

The state authorities under which the State of Missouri may act include, but are not limited to the Missouri Constitution, 1945, Art. IV, Sections 40(a)-47; Chapter 252, RSMo, Department of Conservation – Fish & Game; Chapter 254, RSMo, State Forestry Law; Chapter 644, RSMo – Missouri Clean Water Law; Sections 260.350-260.434, RSMo; Missouri Hazardous Waste Management Law; Sections 260.500, et seq., RSMo,

[29] Under the DOI's NRDA regulations, an assessment plan "shall also include a statement of the authority for asserting trusteeship, or co-trusteeship" (43 CFR §11.31(a)(2)).

[30] More precisely, DOI's NRDA regulations state that the Trustees may restore, rehabilitate, replace, and/or acquire the equivalent of the injured resources and services to their baseline condition (43 CFR §11.82(b)(iii)).

Missouri Hazardous Waste Clean Up Law; and the regulations duly promulgated under the statutes set out above.

The MDNR and Missouri Department of Conservation (MDC) entered into a Memorandum of Understanding whereby the two state agencies agreed to work together to assess injuries to natural resources and obtain damages for those injuries. MDC also serves as an expert on the flora and fauna of the state for the MDNR.

In accordance with 42 U.S.C. 9607(f)(2)(A) and the NCP, 40 CFR §300.600, the President has designated the Secretary of the DOI to act on behalf of the public as trustee for those natural resources and their supporting ecosystems that are managed or controlled by the DOI. The authorities under which the DOI may act include, but are not limited to: Endangered Species Act (ESA), as amended, 16 U.S.C. 1531 *et. seq.*; and the Migratory Bird Treaty Act (MBTA), as amended, 16 U.S.C. 701 *et. seq.* The official authorized to act on behalf of the Secretary for the Tri-State Mining District sites is the U.S. Fish and Wildlife Service Regional Director for Region 2.

3.2 OVERVIEW OF NRDA

NRDA efforts are intended to restore natural resources to their baseline condition–that is, the expected condition of the resources had the releases not occurred (43 CFR §11.14(e)). The NRDA regulations also allow Trustees to seek compensation for the interim loss of public resources and the services they would have provided if not for the injury(ies) caused by the contamination (43 CFR §11.15 and 11.83).

Under CERCLA, DOI promulgated regulations to guide Trustees in their evaluation of injuries to natural resources resulting from the release of hazardous substances. These guidelines describe methods for the Trustees to use when:

(a) Making the decision to pursue a NRDA;

(b) Determining the quantity of injured natural resources;

(c) Determining the amount of restoration or other compensation required to fix or replace the injured resources and to compensate the public for interim service losses; and,

(d) Planning/constructing projects designed to implement the restoration options.

Assessment procedures laid out in DOI's regulations are not mandatory and do not preclude the use of alternate methods. However, DOI methods provide a useful framework for assessing injury and evaluating the need for, type and scale of restoration and/or compensation.

3.2.1 DETERMINATION TO PURSUE A TYPE B ASSESSMENT[31]

The DOI regulations specify that NRDA may fall into one of two broad categories: Type A and Type B. Type A assessments are focused on marine and/or Great Lakes

[31] The DOI NRDA regulations require that an assessment plan identify whether Type A or Type B procedures, or a combination, will be used during the course of the assessment (43 CFR §11.31(b)).

environments and are intended for smaller sites impacted by more minor discharges of relatively short duration. Type B assessments usually comprise a more comprehensive set of studies and analyses, and this type of assessment is warranted when a Type A assessment is not.

The Missouri Tri-State Mining District is large and inland. The discharge or release occurred over a period of decades. The magnitude of the discharge was not minor, and the spatial and temporal extent and heterogeneity of exposure conditions and potentially affected resources are not suitable for application of the simplifying assumptions and averaged data and conditions contained in Type A procedures. Suitable Type A procedures are not available for these circumstances, and so the Trustees have determined that a Type B assessment is required.

3.2.2 STEPS IN THE NRDA PROCESS

As outlined in DOI's NRDA regulations, the NRDA process contains a number of phases. These include: preassessment, assessment planning, injury determination and quantification, pathway determination, and damage determination. The Trustees have completed the preassessment phase and are currently in the assessment planning phase. The following paragraphs describe each phase in more detail.

Preassessment

During the preassessment phase, available data were collected and assessed to determine whether to proceed with damage assessments for Jasper and Newton Counties. The results of these efforts are summarized in Preassessment Screens (MDNR and DOI 2002 and 2008, respectively), which are available at:

- http://www.dnr.mo.gov/env/hwp/news/final-jasper-county-pas-tds-02-06-18.pdf
- http://www.dnr.mo.gov/env/hwp/docs/newton-county-mine-tailingspas2008.pdf

In the Preassessment Screens, the Trustees concluded that:

(a) Releases of hazardous substances occurred;

(b) Natural resources for which the Trustees can assert Trusteeship are, and/or likely have been, adversely impacted as a consequence of the releases;

(c) The quantity and concentration of the released substances are sufficient to potentially cause injury to natural resources;

(d) The data necessary to pursue a NRDA are readily available or can be obtained at a reasonable cost; and,

(e) Currently completed or planned response actions are insufficient to completely compensate the public for past and ongoing injuries to natural resources.

In addition, as part of this phase, the Trustees have sent the identified potentially responsible parties (PRPs) for both counties an official Notice of Intent (NOI) to perform an assessment, dated August 30, 2002 and January 18, 2008, respectively. Based on the

above criteria, the Trustees determined that there is a reasonable probability of making a successful NRD claim, and that they would proceed with the preparation of an Assessment Plan.

Assessment Planning

The assessment planning phase is intended to ensure that the assessment occurs in a systematic and planned manner and at a reasonable cost. It culminates in the production of an assessment plan, such as this document.

The Trustees developed this document to describe routes of investigation to be pursued. The Trustees consider this a living document, which will continue to be developed and refined as the NRDA progresses and as additional information becomes available.[32] Potential changes to this Plan may include the addition of new studies and/or the modification of planned studies identified in this document. If significant changes are made to this Plan, the changes will be made available for review by the public prior to implementation of the modified plan. If the changes are insignificant, the changes will be made available for review by the public, but implementation of the modification will not be delayed as a result of the public review.

In addition to the creation of the Plan itself, another part of this phase is the development of a preliminary estimate of damages, or PED (43 CFR §11.38(a)). The PED estimates the approximate costs of restoration, rehabilitation, replacement, and/or acquisition of equivalent resources required to compensate the public for the injured resources. The PED's purpose is to help ensure that the choice of studies and methodologies set forth in the Plan are cost-effective. Ideally, a PED would be completed as part of the assessment planning phase; however, if existing data are insufficient to make the damage estimate, the PED may be completed at a later stage (43 CFR §11.38(d)(2)).

The Trustees believe that the studies described in this Plan are cost-effective, given (as described in Chapter 4) the heavy reliance on the analysis of existing data and the anticipated substantial geographic and temporal extent of contamination and adverse impacts. The Trustees will consider focus, design, scale and associated costs of additional, potential assessment activities (if any) in light of the results and preliminary evaluations of restoration/compensation needs identified through studies described in this Plan. The results of such analyses will be presented at the conclusion of the assessment process in the Report of Assessment prepared by Trustees.

Injury Determination and Quantification

In this phase, the Trustees undertake investigations to determine and quantify the extent of injuries to natural resources resulting from releases of hazardous substances. To determine and quantify injuries, the Trustees may rely on existing data and studies, or they may pursue targeted additional primary data collection activities as needed.

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[32] The DOI NRDA regulations allow an assessment plan to be modified at any stage of the assessment as new information becomes available (43 CFR §11.32(e)(1)).

Injury determination entails evaluating whether injuries have occurred as a result of such releases. There are a number of ways in which resources can be injured. Examples include, but are not limited to, the following:

- Concentrations of hazardous substances exceeding relevant Federal or state regulatory standards (for example, water quality standards);
- Environmental media such as waters or sediments containing concentrations of hazardous substances sufficiently high to result in toxic effects to biota including plants, fish, shellfish, amphibians/reptiles, birds, and/or mammals;[33]
- Contaminant-induced changes in the community structure of plants and animals (changes in species composition);
- Contaminant-induced impairments in reproduction;
- Death, disease/deformities/malformations, and other kinds of adverse effects; and
- Losses of services to humans (for example, impaired drinking water or irrigation water, loss of fishing/hunting opportunities, loss of wildlife viewing opportunities).

Once injury has been determined to one or more resources or resource services, the next step is to "quantify" identified injuries by documenting the amount, severity and duration of adverse effects in terms of changes from baseline conditions (43 CFR §11.71(b)(2)). Baseline refers to the conditions that would have existed had the releases of hazardous substances not occurred (43 CFR §11.72(b)(1)). The condition of the injured resources, or the services provided by the injured resources, will be compared to baseline conditions to estimate the amount of restoration or service replacement required. Historical data or data from control areas will be used (43 CFR 11.72(d)).

The result of injury quantification is an estimate of the total extent of resources (and their services) that need to be restored, replaced or otherwise compensated.

Pathway Determination

The goal of the pathway determination phase is to identify routes of exposure whereby natural resources are (or were) exposed to hazardous substances. This serves to link releases of hazardous substance to past/ongoing injuries. As noted above, Trustees may rely on existing data and studies and/or pursue targeted additional primary data collection activities.

Damage Determination and Restoration

In this phase, the Trustees estimate damages and select restoration projects. Damages are defined as "…the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources as set forth in Section 107(a) or 111(b) of CERCLA" (43 CFR §11.14(1)).

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[33] Exposure of biota to hazardous substances may occur either via direct contact with the substances or via indirect means (for example, bioconcentration, bioaccumulation, and/or biomagnification through food chains).

In estimating damages, it is necessary to determine the type of restoration project and scale (or size) of the project necessary to compensate for the injuries to natural resources and their services, as characterized in the injury determination and quantification phase.

An important step in damage determination is generation of the Restoration and Compensation Determination Plan (RCDP). In the RCDP, the Trustees evaluate several restoration alternatives that would "restore, rehabilitate, replace, and/or acquire the equivalent of the services provided by the injured natural resources that have been lost", taking into account the period of time over which these services would continue to be lost (43 CFR §11.82(b)(2)(i)). The restoration alternatives may range from "intensive action … to return the various resources and services provided by those resources to baseline conditions as quickly as possible" to "natural recovery with minimal management actions" (43 CFR §11.82(c)(1)).

The Trustees then evaluate the identified restoration alternatives relative to a variety of factors (43 CFR §11.82(d)), select a preferred alternative, and preliminarily estimate its cost (43 CFR §11.81(a)(1)). At the discretion of the authorized official, the RCDP may also estimate the compensable value of the services lost to the public. The compensable value is "the amount of money required to compensate the public for the loss in services provided by the injured resources between the time of discharge or release and the time the resources and the services those resources provided are fully returned to their baseline conditions" (43 CFR §11.83(c)).

When ready, the RCDP will be released to the public, and comments will be requested.

In total, damages include:

- Damages that are calculated based on injuries (i.e., the cost of implementing restoration activities sufficient in type and quality to compensate for the estimated injuries, and potentially including compensable values) (43 CFR §11.15(a)(1), §11.83(b), §11.83(c));
- The costs of emergency restoration efforts (43 CFR §11.15(a)(2)); and
- Reasonable and necessary costs of assessment (43 CFR §11.15(a)(3)).

In determining damages, the Trustees will take care to avoid double recovery (43 CFR §11.15(d)).

3.2.3 COORDINATION WITH OTHER GOVERNMENT AGENCIES, THE PUBLIC, AND PRPS[34]

Coordination with Other Government Agencies

The Trustees are pursuing NRDA activities in a cost-effective manner, and as part of that commitment are carefully coordinating assessment activities with relevant actions of other governmental agencies. EPA is one such agency. In 1990 and 2003 under its

[34] The DOI NRDA regulations include a variety of provisions addressing issues of inter-agency coordination (for example, 43 CFR §11.31(a)(3)); they also require that the assessment plan is made available to the public and to any identified PRPs for review (43 CFR §11.32(c)(1)).

Superfund program, the EPA included parts of Jasper and Newton Counties on the National Priorities List and has since selected and implemented specific cleanup projects for some parts of the sites.

The Superfund program and NRDA serve different but complementary purposes. EPA's actions within the Superfund framework are aimed at reducing or eliminating possible risks to human health and the environment. In some cases, these cleanup actions may also address all or a portion of identified injuries to natural resources. NRDA efforts are designed to restore injured natural resources not fully addressed by EPA actions, by returning impacted resources to baseline conditions. At the discretion of the Trustees, NRDA efforts may also seek to recover damages for the period of time during which natural resources were injured (that is, to recover interim losses).

To the extent possible, it is important for EPA and NRDA activities to be sufficiently closely coordinated to avoid duplication of effort and ensure cost efficiency. The Missouri Tri-State Mining District Trustees meet regularly with the EPA and the Trustees for the Kansas and Oklahoma portions of the Tri-State Mining District in order to ensure timely communication and enhance the coordination of related efforts. Further, Trustee assessment activities proposed in this Plan will make use of data generated through the Superfund process, as well as research undertaken through other processes or efforts.

Importance of Public Participation

As stewards for Jasper and Newton County's natural resources, the Trustees represent the interests of the public. The opinions, suggestions, and other input of the public are therefore important factors that the Trustees consider when making decisions during the course of a NRDA.

As noted above, a number of documents produced during the course of the NRDA will be released to the public and comments requested. Specific anticipated opportunities for public involvement include commenting on this Plan and on Trustee restoration planning work products. Each public comment period will last for at least 30 days. Comments may be submitted in writing to the address below.

Ms. Frances Hayes Klahr
Missouri Department of Natural Resources
Division of Environmental Quality
P.O. Box 176
Jefferson City, MO 65102-0176

The Trustees also recognize the special interests of Jasper and Newton County landowners. Much of the land in Jasper and Newton Counties is privately held, and conducting some of the assessment projects described in this Plan will require the scientists conducting the project to have access to certain private properties. The Trustees understand that this access is dependent on the permission of the landowners and will work with landowners to secure the needed permissions before beginning fieldwork activities.

Potentially Responsible Parties (PRPs)

The total list of companies that have mined in the Jasper and Newton County areas over the years is extensive; some no longer exist due to bankruptcy, dissolution, buyouts, mergers and similar corporate events. A partial list of companies that engaged in mining and/or mining-related activities in Jasper and Newton Counties and released metals in the Missouri Tri-State Mining District environment includes: Acme Land Company, AMAX Industries, ASARCO Inc., Blue Tee Corporation, Inc., Burlington Northern & Santa Fe Railway Company, Connor Investment Company, E.I. DuPont de Nemours & Company, Eagle-Picher Industries, Inc., Eljer Plumbingware, Incorporated, FSN, Inc., Gold Fields Mining Corporation, Kellogg Brown & Root, Inc., NL Industries Inc., Northern & Santa Fe Railway Company, Paramount Communications, Inc. (Viacom, Inc.), St. Joe Minerals Corporation (The Doe Run Company), Sun Refining and Marketing Company (Sunoco), USX Corporation (United States Steel Corporation) (Notice of Intent to Perform NRDA 2002, 2008). The Trustees may identify other PRPs in the course of pursuing this NRDA. As part of the NOI, all companies identified to date have been invited to participate in the assessment planning process.

DOI's NRDA regulations require that the Trustees develop, as appropriate, procedures to split samples,[35] share data, and engage in other information-exchange opportunities with the PRPs (43 CFR §11.31(a)(4)). The Trustees will coordinate with the PRPs on these issues. To facilitate the data-sharing process, the Trustees will provide the PRPs with the opportunity to obtain a copy of data used in the assessment. If a PRP wishes to receive such data, a written request identifying the data desired should be submitted at the address below.

Ms. Frances Hayes Klahr
Missouri Department of Natural Resources
Division of Environmental Quality
P.O. Box 176
Jefferson City, MO 65102-0176

***

Mr. David Mosby
Columbia Missouri Field Office
U.S. Fish and Wildlife Service
101 Park DeVille Dr., Suite A
Columbia, MO 65203

Invitation for Cooperative Assessment

In the Notices of Intent (2002, 2008), the Trustees invited the PRPs to participate in a cooperative assessment of the Missouri Tri-State Mining District Superfund sites. (In addition, some PRPs, have invited the Trustees to provide comments as part of the

[35] Split samples consist of taking a single sample and dividing it into two parts, so that each party can conduct its own analysis.

Remedial Investigation/Feasibility Study process.) Cooperative assessments have the potential to open a dialog, identify areas of agreement, enhance the quality of the studies, reduce costs, and expedite restoration of injured resources.

To date, different PRPs have indicated different degrees of interest in participating in such an assessment; however, none have shown interest in a cooperative agreement. At this point in time, no specific agreements have been made between any parties with respect to the pursuit of a cooperative assessment; however, it is possible that at some future point the Trustees and one or more PRPs may choose to engage in some cooperative efforts. As the Missouri Tri-State Mining District NRDA progresses, the Trustees retain the right to participate in cooperative assessment activities with one or more PRPs at any time. The Trustees also retain the right, subject to public review and comment, to settle some or all of their natural resource damages claims.

The purpose of this Damage Assessment Plan is to set forth assessment activities the Trustees currently intend to pursue as part of the Missouri Tri-State Mining District natural resource damages assessment. One significant focus of the proposed activities is the evaluation of already existing data to identify the nature and extent of natural resource injuries. A substantial amount of metals contamination data in the environment has been collected as part of the Superfund process, ongoing monitoring work by Missouri state agencies, academic research, and other processes and programs. Metals contamination in sediment, and vegetation, and mussel data were collected as part of the Missouri (and other Tri-State) Trustee claims development in the Asarco LLC bankruptcy, Southern District of Texas (Case No. 05-21207). Evaluating available information is therefore a significant focus of the activities described in this chapter. It is a cost-effective approach and furthermore is expected to generate timely information for potential settlement discussions with PRPs.

The Trustees have made significant progress in the pursuit of some of the studies described in this assessment plan.[36] Where this is the case, progress to date is summarized, and initial results are presented, such as in Exhibits 3 and 4 for surface water and sediments.

As described in this Plan, the Trustees plan to continue to pursue these and other studies. The Trustees will continue to review and evaluate information assembled to date. It may be that available information provides a sufficient basis to evaluate certain injuries. For other potential injuries, less information is available, and the Trustees anticipate that more extensive data-gathering, potentially including primary research, will be required.

For purposes of this Plan, the Trustees have selected the following natural resources as their immediate focus:

- Surface water resources, including water and sediments;
- Aquatic biota, including fish, shellfish, aquatic macroinvertebrates, and aquatic-dependant birds;
- Terrestrial biota, including mammals, birds, and vegetative communities;
- Ground water resources; and

36 The Trustees undertook certain assessment-related activities for purposes of developing a claim for natural resource damages for the Asarco bankruptcy (In re: Asarco LLC, et al. No. 05-21207, S.D. Texas Bkcy.)

- Geologic resources.

The Trustees intend to concentrate their efforts on the above resources because of the existence of data that indicate contaminant exposure and/or injury to these resources, and due to the availability of information on the sensitivity of these resources to the contaminants of concern. The Trustees fully recognize, however, that other natural resources may also have been injured as a consequence of exposure to mining-related hazardous substances. At some future date, the Trustees may decide to pursue additional investigations of injury to these resources.

As shown in Exhibit 23, the NRDA process includes a number of phases: (a) injury determination and quantification, (b) pathway determination, and (c) damage determination and restoration. DOI's NRDA regulations provide a number of definitions of resource injury (43 CFR §11.62), including exceedances of various regulatory criteria, adverse physiological responses, malformations, reproductive impairment, disease, and death. DOI's NRDA regulations also provide guidance for other study types, as discussed in more detail below.

The remainder of this chapter briefly describes those NRD studies that the Trustees intend to pursue or are in the course of pursuing (Exhibit ES-1). Studies may be added, revised, or removed from consideration based on public comments and the acquisition of additional information. For studies that entail substantial new research (as distinct from those that involve only the evaluation of existing data), detailed study plans will be developed in coordination with the principal investigator(s) responsible for each proposed study.

4.1 INJURY DETERMINATION AND QUANTIFICATION

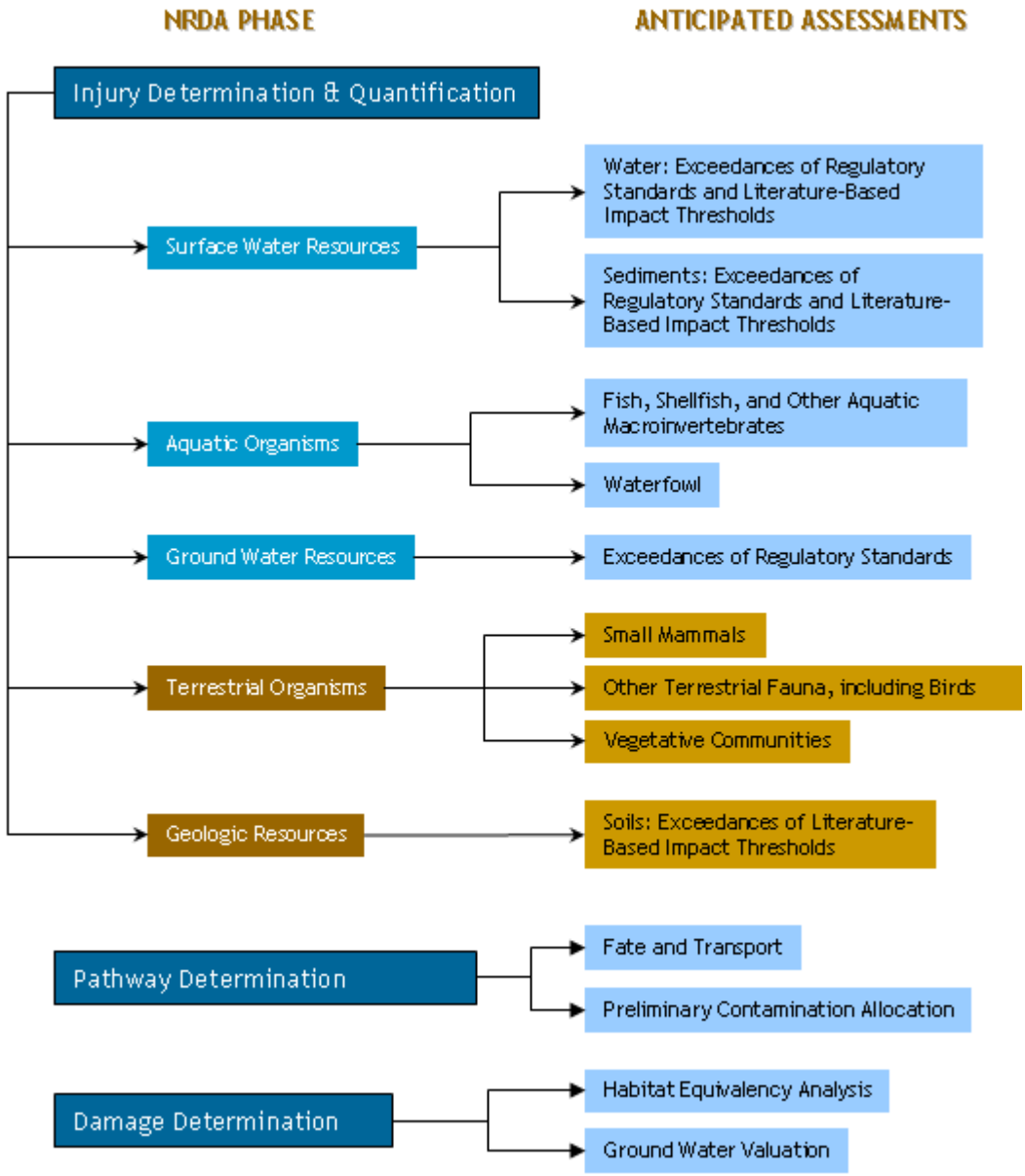
During the injury determination and quantification phases of a NRDA, the Trustees undertake investigations to identify natural resources that have been injured as a consequence of the release of hazardous substances, and to quantify the extent to which those resources have been injured across space and time, relative to baseline conditions.

4.1.1 SURFACE WATER RESOURCES

Surface water resources are defined as "the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline" (43 CFR §11.14(pp)). Jasper and Newton Counties' surface waters are an important resource. In addition to providing recreational opportunities, surface waters support a wide variety of aquatic animals, including a number of threatened and endangered species.

The Trustees believe that mining activities have impacted–and continue to impact–the surface water resources in the Missouri Tri-State Mining District. The following studies are aimed at evaluating the nature and extent of these injuries.

EXHIBIT 23 OVERVIEW OF PHASE I ASSESSMENTS



STATUS: SUBSTANTIAL PROGRESS

Surface Water: Exceedances of Regulatory Standards

Injury Definition: DOI's NRDA regulations define injury to surface water resources in several ways. In general, surface waters are determined to be injured when:

(a) At least two water samples are collected, either separated by a distance of at least 100 feet, or collected at different times (43 CFR §11.62(b) (2));

(b) The concentrations and duration of hazardous substances exceed certain standards set by the state or Federal government (for instance, drinking water standards promulgated under the Safe Drinking Water Act or water quality criteria established under the Clean Water Act);

(c) The surface water met the standards or criteria prior to the release; and

(d) The surface water has a "committed use" as a public water supply, as habitat for aquatic life, or other purpose as specified in the regulations (43 CFR §11.62(b)(1)).

Alternately, surface water resources are injured when other natural resources (for instance, biological resources) become injured as a consequence of exposure to the surface waters (43 CFR §11.62(b)(1)(v)).

Objective: To document injuries to surface water resources based on comparisons of measured and/or modeled concentrations of lead, zinc and cadmium to regulatory standards.

Approach: The Trustees have identified relevant water quality standards for comparison to available surface water metals contamination data from Jasper and Newton Counties. These standards include EPA's ambient water quality criteria as promulgated under the Clean Water Act; criteria promulgated under the Safe Drinking Water Act, and State of Missouri aquatic life criteria. Exhibit 24 in this Plan indicates the available designated uses for waterways in Jasper and Newton Counties.

The Trustees have also identified a number of existing Jasper and Newton County surface water metals contamination data sources. For instance, data were gathered during the Jasper County site's Superfund-related activities (*e.g.,* CDM 1995, Dames & Moore 1995), and Davis and Schumacher (1992) developed a compilation of water quality data. The State has one ambient water quality monitoring station near the Kansas border on Turkey Creek and another on Center Creek. The U.S. Geological Survey (USGS) has monitoring stations in the area (USGS 2006-2007), and relatively recent EPA sampling data are also available (EPA 2006b).

The Trustees have compiled these and other data and have undertaken some comparisons of available water quality data with relevant water quality standards (e.g., Exhibits 4 and 8). These analyses suggest that zinc, cadmium, and lead concentrations have exceeded water quality criteria at a number of locations in the TSMD. In the future, the Trustees anticipate refinements of this analysis. These refinements may include (but are not necessarily limited to): assembly of additional available water quality data at site and/or

reference locations, further comparisons with water quality standards (particularly Missouri state standards), and further spatial evaluations of the data.

After completing the compilation and evaluation of available existing water quality data, the Trustees may determine that additional sampling is necessary to better evaluate this natural resource injury. For instance, some sampling programs had sufficiently high detection limits that it was not possible to determine whether exceedances of water quality standards existed at certain locations and times. Consequently, the Trustees may engage in additional targeted surface water data-collection activities.

EXHIBIT 24 SURFACE WATER RESOURCES IN JASPER AND NEWTON COUNTIES - DESIGNATED USES

DESIGNATED USE[a]	SPRING RIVER	NORTH FORK	CENTER CREEK	TURKEY CREEK	SHORT CREEK[b]	SHOAL CREEK
Irrigation	X		X		N/A	X
Livestock & wildlife watering	X	X	X	X	N/A	X
Protection of warm water aquatic life and human health – fish consumption	X	X	X	X	N/A	X
Cool water fishery	X		X		N/A	X
Cold water fishery			X		N/A	X
Whole body contact recreation	X		X	X	N/A	X
Secondary contact recreation	X	X	X		N/A	X
Drinking water supply					N/A	X
Industrial	X		X		N/A	X

Notes:

a. These represent designated uses within some portion of Jasper and/or Newton Counties. Not all designated uses apply to all parts of the waterway.

b. Short Creek is an intermittent waterway and is designated as a "losing stream" – *i.e.*, a stream that distributes 30 percent or more of its flow during low flow conditions through natural processes into a bedrock aquifer within two miles' flow distance downstream of an existing or proposed discharge. It does not have state-designated uses.

Source: Code of State Regulations, Rules of Department of Natural Resources, Division 20 - Clean Water Commission, Chapter 7- Water Quality (10 CSR 20-7), Tables H and J (11-3-05).

STATUS: SOME PROGRESS

Surface Water Sediments: Exceedances of Regulatory Standards and Toxicity Thresholds

Under DOI's NRDA regulations, the bed, bank, and shoreline sediments, including suspended sediments, are considered to be part of the surface water resource. Bed and bank sediments are key components of aquatic ecosystems, supporting benthic fauna and potentially serving as a source of contaminants to the aquatic foodweb, as sediments are ingested by many faunal species, either as the species' primary source of sustenance or

incidentally during foraging. The Trustees intend to evaluate the concentrations of metals in sediments to assess the degree to which these substances may be causing adverse effects to exposed aquatic species.

Injury Definition: DOI's NRDA regulations define injury to surface water sediments in several ways. In general, these sediments are determined to be injured when:

(a) Concentrations of substances on bed, bank or shoreline sediments are sufficient to cause the sediment to exhibit characteristics identified or listed pursuant to section 3001 of the Solid Waste Disposal Act, 42 U.S.C. 6921 (43 CFR §11.62(b)(1)(iv)),

or

(b) Other natural resources (for example, biological resources) become injured as a consequence of exposure to the sediments (43 CFR §11.62(b)(1)(v)).

Objective: To document injuries to sediment resources based on comparisons of measured and/or modeled sediment concentrations of metals, especially lead, cadmium, and zinc, to regulatory standards and literature-based thresholds for impacts to aquatic animals. Sediment toxicity studies may also be conducted.

Approach: The Trustees have identified sediment quality values–that is, concentrations of contaminants in sediments–exceedances of which are suggestive of injury to aquatic species, particularly benthic invertebrates (e.g., MacDonald et al. 2000, Persaud and Jaagumagi 1996).

Furthermore, the Trustees note that lead and cadmium are listed as toxic substances under Section 3001 of the Solid Waste Disposal Act. The Trustees will seek existing lead and cadmium sediment contamination data generated by the procedures specified in the Solid Waste Disposal Act regulations, for comparison to toxicity standards in the regulations. (Otherwise, neither the Federal Government nor the State of Missouri has currently established regulatory standards for metals contamination in sediments.)

The Trustees have compiled a considerable quantity of existing Jasper and Newton County sediment data. For example, Dames & Moore (1995), CDM (1995), and Jacobs Engineering (1995) present information on the concentrations of metals in Missouri TSMD sediments. Additional data sources include Allert *et al.* (1997), EPA (2006a,b), and USGS (2006-2007). Furthermore, in 2007 the Trustees collected contamination information data from area gravel bars (Mosby 2007).

Based on data assembled to date, Exhibit 6 in this Plan presents average sediment concentrations, while Exhibit 7 presents a comparison of measured values identified to date against certain literature-based sediment quality values. Exhibit 3 illustrates the geographic distribution of exceedances of these sediment quality values for zinc.

In the future, the Trustees anticipate refinements of these analyses. These refinements may include but are not necessarily limited to: assembly of additional available sediment quality data at site and/or reference locations, further geospatial evaluation of exceedances of sediment quality values, and site-specific sediment toxicity evaluations

(e.g., to develop site-specific toxicity thresholds). For instance, the USGS is currently researching the toxicity of area sediments to juvenile mussels (Kemble *et al.* 2007, Kunz *et al.* 2007). In connection with all these efforts, the Trustees may choose to engage in additional targeted sediment contamination data-collection activities.

4.1.2 AQUATIC BIOTA

Biologic resources, including aquatic organisms, are a key component of this damage assessment. As part of the anticipated assessment activities, the Trustees will use existing data to evaluate potential injuries to fish, shellfish, and benthic communities. The Trustees may also collect new field data to assist with the evaluation of the health of Missouri Tri-State Mining District aquatic biota.

STATUS: SOME PROGRESS

Fish, Shellfish, and Other Aquatic Macroinvertebrates

Many species of aquatic organisms are present in Missouri Tri-State Mining District surface waters, and some may have been and/or continue to be impacted by metals contamination. Eleven species of fish found in the area have special status. These include the Missouri- and nationally-listed threatened Neosho madtom (*Noturus placidus*), the Federal candidate (and Missouri-listed threatened) species Arkansas darter (*Etheostoma cragini*), the Missouri-listed endangered redfin darter (*Etheostoma whipplei*), the federally threatened (Missouri endangered) Ozark cavefish (*Amblyopsis rosae*), which lives in ground water, and eight SCC fish species (Appendix A).

Benthic fauna are also an important part of freshwater ecosystems. In addition to their function as an indicator of the suitability of sediments to support aquatic life, they are also part of the food chain to higher trophic-level organisms, including certain fish species. A number of SCC mussel species live in the waters of Jasper and Newton Counties (Appendix A). Mussels serve as a food resource for other aquatic and terrestrial predators, filter particulate matter from the water column which improves water quality, provide biogenic structure as habitat, and facilitate the benthic invertebrate community by altering the availability of resources through nutrient excretion and biodeposition (Spooner and Vaughn 2006). Mussels are good indicators of the ecological health of surface water communities. Their immobile nature as adults helps ensure that their status reflects local environmental parameters. In addition, mussels require suitable host fish for parts of their life cycle. The ability of mussels to thrive in a particular area therefore provides an indirect indication of the status of the host fish community as well.

Crayfish are another important benthic organism group. Crayfish are the largest and longest-lived crustaceans in North American freshwater ecosystems (Hobbs 1993) and comprise a major fraction of the total macroinvertebrate biomass of streams, often acting as keystone predators (Momot 1995, Rabeni *et al.* 1995). Their foraging behavior allows crayfish to serve as detrivores, herbivores, and carnivores, and they can play a dominant role in nutrient/energy cycling and in the trophic dynamics of surface waters (Hobbs 1993, Momot 1995, Whitledge and Rabeni 1997). Crayfish also serve as a prey item for aquatic and terrestrial predators including other invertebrates, fish, amphibians, reptiles, birds, and mammals (Probst *et al*. 1984, Rabeni *et al.* 1995, Hobbs 1993). They can also

accumulate metals: crayfish downstream of mining activities in southeastern Missouri had elevated metals in comparison to reference locations (Besser et al. 2007).

Injury Definition: DOI's NRDA regulations define injury to biotic resources in several ways. In general, biota are determined to be injured when:

(a) Organisms are exposed to sufficiently high concentrations of hazardous substances to cause adverse impacts, including death, malfunctions in reproduction, disease, or physiological malfunctions, amongst other effects (43 CFR §11.62(f)(1)(i)),

or

(b) Tissue concentrations exceed action of tolerance levels established under section 402 of the Food, Drug and Cosmetic Act, 21 U.S.C 342, in edible portions of organisms (43 CFR §11.62(f)(1)(ii)),

or

(c) Tissue concentrations exceed levels for which an appropriate state health agency has issued directives to limit or ban consumption of such organism (43 CFR §11.62(f)(1)(iii)).

Objective: To document injuries to aquatic organisms.

Approach: As of the date of this plan, consumption advisories or bans have not been issued by the State of Missouri for any fish or shellfish species present in Jasper and Newton County surface waters, and there are no established tolerance or action levels established for metals other than mercury in finfish tissues under the Food, Drug and Cosmetic Act. Preliminary injury analyses for aquatic species will therefore focus on part (a) of the above injury definition.

In all cases, the Trustees will maximize use of existing datasets and established, ongoing sampling or monitoring programs. Initial steps will therefore include the collection and review of existing data and evaluation of the utility of these data in the context of NRDA injury assessment requirements. If needed, the Trustees may undertake additional data-generation activities.

For example, the Trustees are aware of recent and ongoing research efforts that are directly relevant to the issue of aquatic injury. As discussed previously (and summarized in Exhibit 3), Angelo et al. (2007) presents a considerable amount of data on the status and health of area mussel communities. In addition, the USGS is currently researching the toxicity of area sediments to juvenile mussels (Kemble *et al.* 2007, Kunz *et al.* 2007). The Trustees have also received a proposal from the USGS to investigate the potential impacts of TSMD metal contamination on local crayfish. Potential study measurements include metal concentrations in crayfish, species densities and composition, and physical and chemical habitat parameters, among others. The Trustees may choose to support these or similar efforts.

The Trustees may also investigate the Ozark cavefish (*Amblyopsis rosae*). This species has been observed in a number of counties in southwest Missouri, including parts of

Jasper and Newton Counties. Groundwater degradation, including contaminants from lead and zinc mines, have been identified as a potential reason for population declines throughout the cavefishes historic range.[37] The Trustees may evaluate this possibility through laboratory toxicity studies.

STATUS: PLANNED

Waterfowl

The Trustees are concerned that Missouri Tri-State Mining District birds, including waterfowl, may be suffering from adverse effects as a consequence of exposure to cadmium, lead, and/or zinc. As part of assessment activities, the Trustees will use existing data to evaluate potential injuries to these species. The Trustees may also collect new field data to assist with the evaluation of the health of these animals.

Injury Definition: Injury to biological resources includes death, malfunctions in reproduction, disease, and physiological malfunctions, amongst other effects (43 CFR §11.62(f)(1)(i)). In addition, certain physiological malfunctions are specifically identified as an injury in the NRD regulations, including ALAD inhibition: "[i]njury has occurred when the activity level of whole blood ALAD in a sample from the population of a given species at an assessment area is significantly less than mean values for a population at a control area, and ALAD depression of at least 50 percent can be measured… This biological response may be used to determine injury to bird and mammal species that have been exposed to lead" (43 CFR §11.62(f)(4)(v)(D)).

Objective: To document the extent of adverse metals contamination-related impacts to bird species present in Jasper and Newton Counties.

Approach: The Trustees will gather and review existing data on Jasper and Newton County birds. This review will be broad in scope, potentially including information on species abundance and habitat use, metals concentrations and sensitivity to metals exposure, and other information. The Trustees will then select one or more species to evaluate and will develop a bird collection and evaluation study plan, which will likely initially focus on waterfowl but may be expanded to include other avians. Although specific endpoints are to be determined, the Trustees anticipate that this effort will likely include (but would not be limited to) measurements of metals in bird tissues, measures of ALAD inhibition, and histopathological characterization. Birds from suitable reference areas will also be evaluated.

4.1.3 TERRESTRIAL ORGANISMS

Biologic resources, including terrestrial organisms, are an important part of this damage assessment. The Trustees will use existing data to evaluate the potential exposure of terrestrial birds and/or mammals to contaminants of concern. The Trustees will also gather available data on potential injuries to these species groups and may collect additional field data to assist with these efforts.

STATUS: PLANNED

Small Mammals

[37] See http://mdc.mo.gov/nathis/endangered/endanger/cavefish/, viewed 5-28-08.

Jasper and Newton Counties support a wide range of mammalian species, including small species such as mice and shrews. These species fill an important niche in terrestrial ecosystems by feeding on seeds, nuts, insects, and other items and in turn serving as prey to mammalian (fox, badger) and avian (eagles, hawks, and owls) predators. The Trustees intend to gather preliminary information about contaminant concentrations in small mammals, in part to evaluate potential injuries to these species but also with a focus on determining the extent to which these species might serve as pathways through which other, higher trophic-level species, may be exposed to contaminants of concern. This study therefore has elements of both injury determination and pathway determination.

Injury Definition: Injury to biological resources includes death, malfunctions in reproduction, disease, and physiological malfunctions, amongst other effects (43 CFR §11.62(f)(1)(i)).

Pathway definition: Biological resources may serve as a pathway to other resources (43 CFR §11.63(f)(1)). In that case, chemical analysis of the organisms and/or their tissues may be performed (43 CFR §11.63(f)(3) and (4)).

Objectives: To document the extent of adverse, metals contamination-related impacts to small mammal species present in Jasper and Newton Counties, and to evaluate the extent to which small mammals may be serving as a pathway of the contaminants of concern to other biological receptors.

Approach: The Trustees will compile and review existing data on small mammals in Jasper and Newton Counties (*e.g.*, Dames & Moore 1995). The review will be broad in scope, potentially including information on species abundance and habitat use, metals levels and sensitivity to metal exposure, and other information. The Trustees anticipate that relatively little information exists on the extent of exposure of Jasper and Newton County small mammals to contaminants of concern. The Trustees therefore anticipate that they will then select one or more species to evaluate and will design a small mammal collection and evaluation study plan.

STATUS: PLANNED

Other Terrestrial Fauna, Including Birds

Jasper and Newton Counties support a wide variety of terrestrial species, including larger mammals, a variety of bird species, reptiles, and others. The Trustees will use existing data to evaluate potential injuries to these species. The Trustees may also collect new field data to assist with the evaluation of the health of these animals.

Injury Definition: Injury to biological resources includes death, malfunctions in reproduction, disease, and physiological malfunctions, amongst other effects (43 CFR §11.62(f)(1)(i)).

Objective: To document injuries to terrestrial animals across space and time.

Approach: In all cases, the Trustees will maximize use of existing datasets and ongoing sampling or monitoring programs. Initial steps will therefore include the compilation and review of existing data, and evaluation of the utility of these data. The methods used to evaluate existing data and the specific injuries that are assessed will be dependent on the

types and quality of available data. If needed, the Trustees may engage in additional data-generation activities.

STATUS: SOME PROGRESS

Vegetative Communities: Impacts at Current and Former Mine Waste Pile Locations

Although many of the Jasper and Newton County mine waste piles have been removed over the years, some piles remain, and preliminary Trustee evaluations of available data suggest that soils near current and former piles may still have elevated levels of metals. These levels may be sufficiently high to be phytotoxic (that is, toxic to plants). The health of plant communities is important to the Trustees because these communities provide valuable habitat for terrestrial fauna, including mammals, local birds, and migratory birds.

Injury Definition: Plant communities in the Jasper and Newton County area are injured to the extent that they suffer from "adverse changes in viability including: death… physiological malfunctions (including malfunctions in reproduction) or physiological deformities" (43 CFR §11.62(f)(1)(i)). Reduced or eliminated plant cover, and/or changes in plant species composition are potential "adverse changes" that may be considered by the Trustees as part of this evaluation.

Objective: To document the areal extent and locations of current and former mine waste piles in Jasper and Newton Counties, and to evaluate the health of the plant communities at these sites in comparison to suitable reference locations.

Approach: As described previously in this Plan, some site-specific screening-level phytotoxicity investigations have been undertaken (e.g., Pierzynski and Fick 2007), and these studies suggest that area mine wastes are likely phytotoxic. Toxic substances have the potential to reduce cover and to cause changes in plant community structures. Therefore, the Trustees will measure the occurrence, composition, and density of plant cover at (and near) an appropriate number of current or former mine waste sites and in reference areas. Initial evaluations of native prairie sites, chat piles, areas adjacent to chat piles, and capped-revegetated mine wastes have been conducted in the broad TSMD area. These efforts have generally confirmed that floristic quality is highest at native prairies, followed by capped-revegetated mine wastes, areas near chat piles, and the chat piles themselves.

The Trustees expect to continue to explore the issues of phytotoxicity and impacts on plant community structure. In particular, the Trustees anticipate exploring the potential for phytotoxicity through laboratory studies. Legumes are one potential target for such studies. The ability of legumes to fix nitrogen[38] gives them an important role in native and restored prairie habitats. Study elements are expected to include the identification of test species, the selection of test media (chat) across a range of metal concentrations, the use of appropriate control growth media, and the measurement of endpoints. Endpoints may include seedling survival, seedling height, tissue chlorosis and necrosis, numbers of leaves, above- and below-ground biomass, and photosynthetic activity, among others.

[38] "Fixing" nitrogen means converting atmospheric nitrogen into chemical forms that are usable by plants and other organisms.

The Trustees may also conduct further evaluations of plant community structure at different sites within the Missouri TSMD.

4.1.4 GROUND WATER RESOURCES

The phrase "ground water resources" means "water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which ground water moves. It includes ground water resources that meet the definition of drinking water supplies" (43 CFR §11.14(t)). Ground water and surface waters may be interconnected: ground water may discharge to surface water through streambeds, sometimes providing a significant part of the base flow levels of streams or creeks. Ground water can be replenished (recharged) by surface water flows from streambeds and by precipitation.

Jasper and Newton Counties' ground water resources include deep and shallow aquifers. Both aquifers have been used as drinking water supplies to local residents; the shallow aquifer has also been used for watering livestock and gardens, and for industrial purposes.

STATUS: SOME PROGRESS

Ground Water: Exceedances of Regulatory Standards

Injury Definition: DOI's NRDA regulations define injury to ground water resources in several ways. In general, ground water is determined to be injured when:

(a) At least two ground water samples are collected from the same hydrologic unit, separated by a distance of at least 100 feet (43 CFR §11.62(c)(2));

(b) Concentrations and duration of hazardous substances exceed certain standards set by the state or Federal government (for example, drinking water standards promulgated under the Safe Drinking Water Act or water quality criteria established under the Clean Water Act),

(c) The ground water met the standards or criteria, or was potable, prior to the release, and

(d) The ground water has a "committed use" as a public or domestic water supply (43 CFR §11.62(c)(1)(i) through (iii)).

Alternately, ground water resources are injured when concentrations of substances are sufficient to have caused injury to other resources when these resources are exposed to ground water (43 CFR §11.62(c)(1)(iv)).

Objective: To document exceedance-based injuries to ground water resources across space and time.

Approach: The Trustees have identified relevant Federal and State of Missouri water quality standards, the exceedance of which would constitute an injury. These standards include criteria promulgated under the Clean Water Act and the Safe Drinking Water Act.

The Trustees intend to identify and compile existing Jasper and Newton County ground water quality data (*e.g.,* Dames & Moore 1995; USEPA 1991, as cited in Dames & Moore 1997; CDM 1995; Jacobs Engineering 1995). Older data (*e.g.,* Barks 1977, Feder *et al.* 1969) may be of use in understanding whether and how contaminant concentrations

have changed over time. Data gathered to date indicate that exceedances of relevant water quality criteria have occurred in the Boone Aquifer.

Altogether, the Trustees plan to continue to compile available data and compare them to relevant water quality standards to determine where and when exceedances occurred. During the course of this analysis, the Trustees may determine that additional sampling and/or modeling is necessary to better quantify the injury. In assessing the extent of injury, the Trustees will consider factors such as baseline condition (that is, the condition that would have been expected had mining-related releases of hazardous substances not occurred), plume extent, and sustainable yield, among others.

4.1.5 GEOLOGIC RESOURCES

Geologic resources are defined as "those elements of the Earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of ground [water] and surface water resources" (43 CFR §11.14(s)). The Missouri Tri-State Mining District's geologic resources are a high priority to the Trustees because they support key terrestrial habitats such as native prairies and forests, and these habitats are in turn important to terrestrial plants and animals, including a number of Federal and state-listed threatened and endangered species (Appendix A). The Trustees believe that the release of hazardous substances as a consequence of mining activities has impacted some of the geologic resources in the Missouri Tri-State Mining District. The following study is aimed at evaluating the nature and extent of these injuries.

Soils: Exceedances of Literature-Based Impact Thresholds

STATUS: SOME PROGRESS

Injury Definition: DOI's NRDA regulations provide several definitions of injury to geologic resources. Specifically, geologic resources are injured when concentrations of hazardous substances are either "sufficient to have caused injury to ground water, as defined in paragraph (c) of this section, from physical or chemical changes in gases or water from the unsaturated zone; … [or are] sufficient to cause a toxic response to soil invertebrates… [or are] sufficient to cause a phytotoxic response such as retardation of plant growth" (43 CFR §11.62(e)). In general, geologic resources are injured when other natural resources (for example, plants or animals) become injured as a consequence of exposure to the soil (43 CFR §11.62(e)(11)).

Objective: To document the concentrations of heavy metals in soils and assess the potential for harm to terrestrial organisms.

Approach: The Trustees will identify soil thresholds (that is, concentrations of contaminants in soils) from the technical literature, exceedances of which result in adverse impacts to soil invertebrates such as insects or earthworms and/or plants. The Trustee efforts to date resulted in the identification of a both general and site-specific phytotoxicity soil quality thresholds for the contaminants of concern (e.g., Efroymson et al. 1997; EPA 2005a,b,c; Dames & Moore 1993a; CH2M Hill et al. 1987; Levy et al. 1999; Pierzynski and Schwab 1993; Pierzynski and Fick 2007). These thresholds were developed using a variety of means and are suitable for different purposes. The Trustees will continue their review of the literature to identify thresholds that are most applicable to the area.

The Trustees have also assembled a body of soil data from areas impacted by mining activities, including the soil and mine waste analytical chemical data collected during the course of EPA's Superfund activities (for example, Dames & Moore 1995, CDM 1995). Other data sources include Angle (1999), Jacobs Engineering Group (1995), and Mosby (2007). As the Trustees continue to evaluate this information, they may determine that the collection of additional soil and/or mine waste samples is necessary. The Trustees expect, for instance, that relatively little information is available about contaminant concentrations in floodplain areas. Such areas may be one target for future data collection activities.

The measured values will be compared to relevant literature-based thresholds to evaluate whether soil invertebrates, vegetation or other terrestrial animals may be (or may have been) injured as a consequence of exposure to metals-contaminated soils. Initial comparisons (detailed results not presented here) suggest that concentrations of metals in both mine wastes and adjacent areas are likely to be sufficiently high as to be phytotoxic.

4.1.6 INJURIES FROM CLEANUP ACTIVITIES

STATUS: PLANNED

Injury Definition: The Trustees may recover damages not only for natural resource injuries resulting from the release of hazardous substances but also for natural resource injuries "reasonably unavoidable as a result of response actions taken or anticipated" (43 CFR §11.15 (a)(1)).

Objective: To identify, characterize, and quantify injuries resulting from completed or planned cleanup activities and corrective actions undertaken by the response agencies to protect public welfare and the environment.

Approach: Cleanup activities such as dredging, soil removal, and capping can impact natural resources and habitats. The Trustees will, on an ongoing basis, identify past and planned cleanup activities undertaken by response agencies. The Trustees will develop methods to assess the effects of these activities on relevant natural resources such as surface waters and geologic resources, and will estimate the scale and duration of such impacts. The Trustees will rely on existing information when possible but if needed may also conduct new research.

4.2 PATHWAY DETERMINATION

Pathway studies identify the source(s) of hazardous substances and trace the fate and transportation of these substances through the environment (for instance, through air, ground water, surface water, sediments, soils, and food webs). A pathway "may be determined by either demonstrating the presence of the … hazardous substance in sufficient concentrations in the pathway resource or by using a model" (43 CFR §11.63(a)(2)).

Elements of pathway determination can also be inherent in certain injury studies. For example, the small mammal study will be designed to determine the degree to which small mammals may serve as a pathway to their predators. Furthermore, surface water is considered to be injured if "[c]oncentrations and duration of substances sufficient to have caused injury … to ground water, air, geologic, or biological resources, when exposed to

surface water, suspended sediments, or bed, bank, or shoreline sediments" (43 CFR §11.62(b)(v)). In the event that it is determined that injury to a resource such as fish has occurred or is occurring, and exposure to surface water was sufficient to have caused the injury, then the pathway has been established for fish.

Pathway issues in the Missouri Tri-State Mining District are complex. Past mining operations have caused the release of metals directly or indirectly into the Jasper and Newton County environment. Dames and Moore (1995) have developed a pathway/loadings analysis for zinc in the Spring River.

STATUS: SUBSTANTIAL PROGRESS

4.2.1 FATE AND TRANSPORT

The Trustees have begun to compile and document available information establishing a pathway between source areas (e.g., mine waste piles, smelter emissions, mine water) and exposed natural resources (e.g., surface waters, geologic resources, ground water, and biota). Based on information reviewed to date, the Trustees believe that a variety of pathways exist whereby source areas have contaminated natural resources. Such pathways include the contamination of ground water from abandoned mine workings; leaching and erosion from surface wastes into surface water and ground water; dissolved and particulate transportation of metals within waterways; aeolian transport of contaminated dusts; ground water bed load into surface waters; and food web transfer, among others.

Objective: To identify the major pathways through which natural resources have been exposed to contaminants of concern

Approach: The Trustees plan to continue to evaluate existing information, including measured concentrations of hazardous substances and the locations. The Trustees will develop a report presenting this information, including a conceptual site model. If necessary, the Trustees may engage in additional targeted data-gathering activities to supplement available information.

4.3 DAMAGE DETERMINATION AND RESTORATION

The purpose of this phase is to "establish the amount of money to be sought in compensation for injuries to natural resources" (43 CFR §11.80(b)). This compensation generally includes funds needed for "rehabilitation, replacement, and/or acquisition of equivalent natural resources and the services those resources provide" (43 CFR §11.82 (a)) as well as funds to compensate the public for "interim" losses of resources experienced until the injured resources and their uses are returned to baseline condition.

STATUS: SOME PROGRESS

4.3.1 HABITAT EQUIVALENCY ANALYSIS

Habitat equivalency analysis (HEA) is a widely used approach to estimate natural resource injuries and quantifying associated damages. A HEA estimates injuries (and required compensation for the injuries) in terms of lost ecological services rather than dollars. For example, if contamination in Year X results in the functional loss of one acre of habitat, a HEA will calculate the loss to be one service acre-year (SAY), for that year. If this habitat is expected to be injured for a period in excess of one year, it is necessary to add these injuries across years (e.g., one service-acre year lost in Year X, another service

acre-year lost in the following year, and so forth). Because economic theory holds that services received in one year are not exactly equal to the same services if received in some other year, it is necessary to convert each years' services into a common unit before adding them together. This conversion into a common unit, or "present value," is accomplished through a process called discounting, and typically uses a three percent discount rate.

In addition to estimating ecological losses across time, a HEA can also be used to estimate the ecological benefits provided by a hypothetical restoration project. These ecological benefits, also measured in service acre-years, can be estimated across time and compared with the ecological losses. The size of the restoration project can then be "scaled" to the injury, such that the estimated ecological benefits would offset estimated losses. The cost of implementing such a project (or set of projects) becomes the estimate of damages associated with the particular injury.

Objective: The Trustees may generate HEAs to quantify injuries across time and to calculate the necessary scale of compensatory restoration projects. The Trustees may also estimate damages as the cost of implementing such projects.

Approach: The Trustees will rely on available information and new information generated from the ongoing and planned injury studies to select key inputs for the HEA (e.g., percent injury estimates). The Trustees will consider available information about the likely future persistence of injuries given past and planned remediation activities and will estimate the scale of required compensatory restoration activities. Compensatory restoration activities that may be evaluated in the context of a HEA include, but are not necessarily limited to: habitat preservation, prairie restoration, riparian corridor restoration, dredging, and primary restoration measures targeted at terrestrial mine/mill wastes.

STATUS: SOME PROGRESS

4.3.2 GROUND WATER VALUATION

Groundwater injury determination and quantification efforts are expected to produce an estimate for lost ground water in a volumetric unit such as gallons or acre-feet.

Objective: To quantify damages (i.e., the amount of compensation required) for the loss of ground water services associated with contamination.

Approach: Damage determination work thus far has focused on the replacement cost approach (although the Trustees will consider other approaches as appropriate). Replacement costs represent the cost of undertaking one or more projects that would result in the production of an equivalent quantity of water, in present value terms, to that which is lost due to contamination. Replacement costs may be estimated based on the protection of uncontaminated ground water elsewhere, on funding local water use efficiency and conservation measures, on the costs of appropriate surface water engineering projects designed to provide alternate water supply, and/or potentially other project types. The ground water valuation study will identify and evaluate the replacement cost options and estimate damages as the project size and/or cost of implementing one or more options.

CHAPTER 5 | QUALITY ASSURANCE MANAGEMENT

The Trustees recognize the importance of ensuring the quality of data generated or relied upon during the course of this natural resource damage assessment. Indeed, the DOI NRDA regulations require the trustees to develop a Quality Assurance Plan (QAP) that "satisfies the requirements listed in the NCP and applicable EPA guidance for quality control and quality assurance plans" (43 CFR §11.31(c)(2)). Such a plan is needed to ensure the validity of data collected as part of the NRDA and to provide a solid foundation for the Trustees' subsequent decisions. Also relevant are FWS guidelines developed under the Information Quality Act of 2001. All information developed in this NRDA will be in compliance with these guidelines.

The Trustees note that this Damage Assessment Plan includes studies that evaluate existing datasets as well as studies that generate new information. Different quality assurance/quality control approaches are appropriate for these different types of information.

With respect to the evaluation of existing data, the study's principal investigator (PI) will carefully document the source of all data, available information about quality assurance/quality control procedures used by the original investigator, and any data qualifiers or other information restricting application of the data. This approach will also be applied to pilot/preliminary data that may be generated by Federal and state agencies, data generated by academics, and information developed under the auspices of other activities or programs (e.g., routine monitoring programs).

Substantial new studies that are specifically undertaken under the direction of the Trustees to support the Missouri Tri-State NRDA will have a prepared study plan that will be completed prior to the initiation of any work. These study plans will be submitted to, and approved by, the Trustees and copied to the QA Coordinator or designee. Such study plans will include a study-specific QAP developed in accordance with the general principles described below.

In addition, the Trustees note that a number of the new studies contemplated in this Plan potentially include the collection and chemical analysis of environmental samples such as sediments, soils, water samples, or organisms. To ensure consistency in chemical measurements amongst these studies, the Trustees intend to develop a cross-study analytical chemistry QAP according to the general principles described below. If, during the course of this assessment, the Trustees identify additional cross-study QA issues for which a cross-study QAP would help ensure data quality, additional QAPs will also be developed in accordance with the principles below.

5.1 QAP CONTENT - GENERAL

As noted by EPA (2001), QAPs will "vary according to the nature of the work being performed and the intended use of the data" and as such, need to be tailored to match the specific data-gathering needs of a particular project. The NRDA effort for the Missouri Tri-State Mining District will entail a variety of widely-different data-gathering efforts; therefore, it is not appropriate to develop a single, detailed QAP to cover all these activities. Instead, the Trustees will ensure that individual study plans adequately address project-specific quality assurance issues. The discussion in this document therefore focuses on the required elements of an acceptable QAP.

5.2 QAP ELEMENTS

EPA (2001) calls for QAPs to address the following four groups of elements:

- **Project Management.** The elements in this group are aimed at ensuring that the project has a defined goal(s), that the participants understand the goal(s) and the approach to be used, and that the planning outputs have been documented.
- **Data Generation and Acquisition.** The elements in this group are designed to ensure that appropriate methods for sampling, measurement and analysis, data collection or generation, data compiling/handling, and quality control (QC) activities are documented and employed.
- **Assessment and Oversight.** These elements address activities for assessing the effectiveness of the implementation of the project and associated QA and QC activities, helping ensure that the project plan is implemented as intended.
- **Data Validation and Usability.** These elements occur after the data collection or generation phase of the project is completed and help determine whether the collected data conform to the specified criteria and satisfy project objectives.

The following paragraphs discuss these issues in more detail.

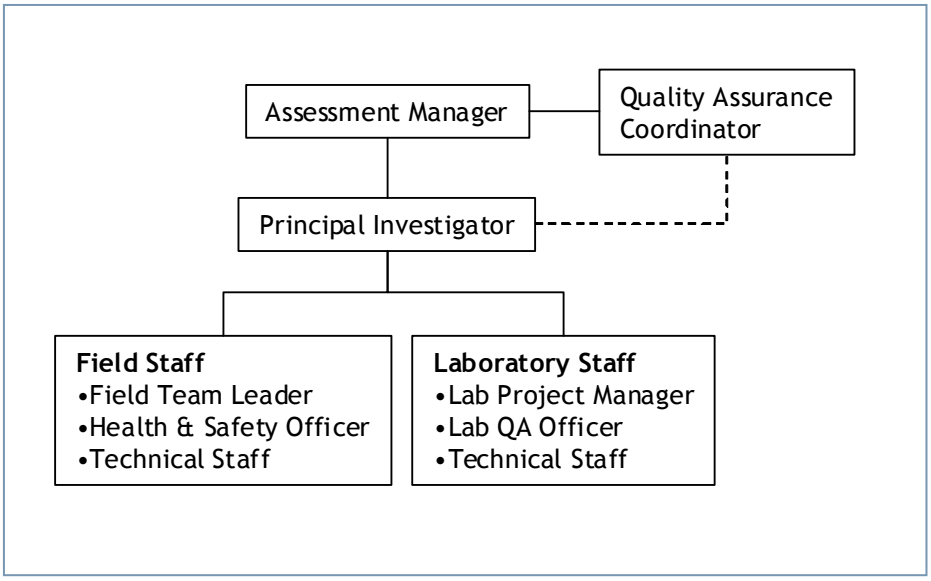
5.2.1 PROJECT MANAGEMENT

A project's QAP shall include provisions for ensuring effective project management. This includes carefully defining the roles and responsibilities of each project participant. Unambiguous personnel structures help ensure that each individual is aware of his or her specific areas of responsibility, as well as clarifying internal lines of communication and authority, which is important for decision-making purposes as projects progress. Individuals' and organizations' roles and responsibilities may vary by study or task, but each person's role and responsibility should be clearly described in the project's study plan. Exhibit 25 below presents one potential personnel plan for a NRDA project.

In this example plan, the Assessment Manager is the designated Trustee representative (from USFWS or the State of Missouri) with responsibility for the review and acceptance of the project-specific study plan. This individual is also responsible for ensuring that the project's goals and design will meet the broader requirements of this NRDA. The Assessment Manager coordinates efforts with Quality Assurance Coordinator and oversees the Study Principal Investigator.

The Quality Assurance (QA) Coordinator oversees the overall conduct of the quality system. Appointed by the Trustees, this individual's responsibilities include, but are not limited to: conducting audits and ensuring implementation of both project-specific and overall plans; archiving samples, data, and all documentation supporting the data in a secure and accessible form; and reporting to the Trustees. To ensure independence, the person serving as QA Coordinator will not serve as either the Assessment Manager or as a Principal Investigator for any Missouri Tri-State Mining District NRDA study.

EXHIBIT 25 PROJECT QUALITY ASSURANCE ORGANIZATION



Study-specific PIs oversee the design and implementation of particular NRDA studies. Each PI has the responsibility to ensure that all health, safety, and relevant QA requirements are met. If deviations from the study plan occur, the PI (or his/her designee) will document these deviations and report them to the Assessment Manager and the QA Coordinator.

The Field Team Leader (FTL) supervises day-to-day field investigations, including sample collection, field observations, and field measurements. The FTL generally is responsible for ensuring compliance with all field quality assurance procedures defined in the study plan. Similarly, the Laboratory Project Manager is responsible for monitoring and documenting the quality of laboratory work. The Health & Safety Officer (who may also be the Field Team Leader) is responsible for ensuring adherence to specified safety protocols in the field.

5.2.2 DATA GENERATION AND ACQUISITION

The study plan, including the study-specific QAP, will describe in detail the anticipated data generation and acquisition activities. At a minimum, each such plan should describe and/or include the following:

- Project objectives;
- Rationale for generating or acquiring the data;
- Proposed method(s) for generating or acquiring the data, including descriptions of (or references to) standard operating procedures (SOPs) for all sampling or data-generating methods and analytical methods;
- Types and numbers of samples required;
- Analyses to be performed;
- Sampling locations and frequencies;
- Sample handling and storage procedures;
- Chain-of-custody procedures;
- Data quality requirements (for instance, with respect to precision, accuracy, completeness, representativeness, comparability, and sensitivity);
- Description of the procedures to be used in determining if the data meet these requirements;
- Description of the interpretation techniques to be used, including statistical analyses.

In addition, to the extent practicable, laboratories will be required to comply with Good Laboratory Practices (GLPs). This includes descriptions of maintenance, inspections of instruments, and acceptance testing of instruments, equipment, and their components, as well as the calibration of such equipment and the maintenance of all records relating to these exercises. Documentation to be included with the final report(s) from each study will include field logs for the collection or generation of the samples, chain of custody records, and other QA/QC documentation as applicable.

5.2.3 ASSESSMENT AND OVERSIGHT

Each study's QAP shall include provisions for appropriate assessment and oversight of the study while it is in progress. Such assessment and oversight may (for example) include provisions for checking the accuracy with which data are recorded and transferred between media (e.g., between notebooks and electronic spreadsheets), ensuring adherence to SOPs, ensuring the accuracy of sample labeling, or other measures as appropriate to the study.

Although the study's PI will have assessment and oversight responsibilities, it is also anticipated that the QA Coordinator or designee will audit all substantial new studies undertaken under the direction of the Trustees to support the Missouri Tri-State NRDA. Audits will include technical system audits (for instance, evaluations of operations) as well as scrutinizing data and reports (for instance, evaluations of data quality and adequacy of documentation).

If, in the professional opinion of the QA Coordinator, the results of an audit indicate a compromise in the quality of the collection, generation, analysis, or interpretation of the

data, the QA Coordinator has the authority to stop work by oral direction. Within two working days of this direction, the QA Coordinator will submit to the Trustee Council a written report describing the necessity for this direction. The Trustee Council will review the findings of the QA Coordinator and render its own determination.

5.2.4 DATA VALIDATION AND USABILITY

In addition to the assessment and oversight activities described previously, a study's QAP may provide for the validation of analytic data by an independent third party. Prompt validation of analytical data can assist the analyst or analytical facility in developing data that meet the requirements for precision and accuracy. If undertaken, it is expected that data validation will use the project-specific study plans and EPA Guidance on Environmental Verification and Validation (EPA 2002b).

GLOSSARY

Assessment Plan - a plan created by the Trustees and reviewed by the public that serves as a means of evaluating whether the approach used for assessing damages is likely to be cost-effective and meets the definition of reasonable cost; includes descriptions of the natural resources and geographical areas involved, the methodologies proposed for injury assessment, and a statement of trusteeship.

Baseline - the condition or conditions that would have existed at the assessment area had the discharge of oil or release of hazardous substance under investigation not occurred.

Bullrock - waste rock that consists of cobble- to boulder-sized rocks that were excavated but not milled. Bullrock includes rock that overlay an ore body, rock removed in the creation of air shafts, and mined rock containing little usable ore.

Cadmium (Cd) - a natural element in the earth's crust, usually found as a mineral combined with other elements such as oxygen, chlorine, or sulfur. All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Most cadmium used in the United States is extracted during the production of other metals like zinc, lead, and copper. Cadmium does not corrode easily and has many uses, including batteries, pigments, metal coatings, and plastics.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - Public Law 95-510 as amended, 42 U.S.C. Sec. 9601 *et. seq.*. Commonly known as Superfund, CERCLA provides broad Federal authority to respond to situations involving the past disposal of hazardous substances; regulates the cleanup of sites where hazardous substances are located, and the distribution of cleanup costs among the parties who generated and handled hazardous substances at these sites. CERCLA is also the authority under which DOI's NRDA regulations were promulgated.

Chat - a mixture of gravel- to fine-sized mill waste, often mixed with sand-sized particles. Chat was produced as part of the initial milling of the mined rock. Chat piles are a dominant geographic feature in the Tri-State Mining Area, although much of the gravel-sized chat has been removed and sold as fill for roadbeds or for other uses.

Code of Federal Regulations (CFR) - the general and permanent rules published in the Federal Register by the Executive departments and agencies of the Federal Government.

Damage determination – a natural resource damage assessment phase that involves analyzing information gathered in the injury quantification phase and establishing the amount of money to be sought in compensation for natural resource injuries. The amount sought is based on the cost of restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services they provide.

Damages - the amount of money sought by the natural resource Trustee(s) as compensation for injury, destruction, or loss of natural resources as set forth in section 107(a) or 111(b) of CERCLA.

Endangered species - any species listed pursuant to the laws of the State of Missouri and /or the Federal Endangered Species Act as being in danger of extirpation throughout all or a significant portion of its range.

Geologic resources - those elements of the earth's crust such as soils, sediments, rocks, and minerals, including petroleum and natural gas, that are not included in the definitions of ground and surface water resources.

Ground water resources - water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which water moves. This definition includes ground water resources that meet the definition of drinking water supplies.

Habitat - place where a plant or animal species naturally exists.

Hardness - a quality of water generally measured as the concentration of calcium and magnesium in the water.

Hazardous substance - substances designated in sections 311(b)(2)(A) or 307 (a) of the Federal Water Pollution Control Act; any element, compound, mixture, solution or substance as defined in section 102 of CERCLA; any hazardous waste having the characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act; any hazardous air pollutant listed under section 112 of the Clean Air Act; and any imminently hazardous chemical substance or mixture with respect to which the Administrator has taken action pursuant to section 7 of the Toxic Substances Control Act (does not include petroleum, natural gas, or synthetic gas).

Injury - a measurable adverse change, either long- or short-term, in the chemical or physical quality of the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance, or exposure to a product of reactions resulting from the discharge of oil or release of a hazardous substance.

Injury determination – a natural resource damage assessment phase that provides the documentation and methods for identifying whether one or more natural resources have been injured as a result of the release of a hazardous substance.

Injury quantification - a natural resource damage assessment phase that establishes the extent of the injury to resources in terms of the loss of the service that the injured resource would have provided had the release not occurred.

Lead (Pb) - a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead is released to the broader environment through a variety of human activities including burning fossil fuels, mining, and manufacturing. Lead's many uses include the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. Because of health concerns, environmental loading of lead from gasoline, paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years.

Mining wastes – rocks and by-products of mining and milling, which includes but is not limited to bullrock, chat, and tailings.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) – required under CERCLA and the Clean Water Act, this is the Federal government's plan for responding to oil spills and hazardous substance releases. The NCP is codified at 40 CFR Part 300.

National Priorities List (NPL) - a list of sites prepared according to the statutory criteria of the hazard ranking system that evaluates the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States; Appendix B of the National Contingency Plan.

Natural resource damage assessment (NRDA) – under CERCLA and OPA, the process of collecting, compiling, and analyzing information, statistics, or data to determine natural resource damages.

Natural resources - land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction or alienation, any member of an Indian tribe. These natural resources have been categorized into the following five groups: surface water resources, ground water resources, air resources, geologic resources, and biological resources.

Nickel (Ni) - a naturally-occurring hard, bright, silver-white metal that is malleable and ductile. Nickel is resistant to corrosion and is frequently used in alloys (*e.g.,* stainless steel) and in galvanic plating. In the chemical industry, nickel is also frequently used as a catalyst.

Oil Pollution Act of 1990 (OPA) - codified at 33 U.S.C. §§ 2702-2761, this act has a number of provisions. These include providing the Federal government with enhanced capabilities for oil spill response, contingency planning, and natural resource damage assessment..

Pathway - the route or medium through which an oil or a hazardous substance is or was transported from the source of the discharge or release to the injured resource.

Potentially responsible party (PRP) - a company, government, or person legally responsible for (amongst other things) cleaning up the pollution at a hazardous waste site as described in Section 107(a) of CERCLA. There may be more than one PRP for a particular site.

Preassessment Screen (PAS) – a document produced during the preassessment phase of a NRDA; it is used by Trustees as the basis for determining whether a discharge or release of hazardous substances warrants the continuation of NRDA activities.

Quality Assurance Plan (QAP) - a document describing in comprehensive detail the necessary quality assurance, quality control, and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria.

Remediation - actions undertaken to clean up or remove released hazardous substances from the environment, or to prevent or minimize the potential for the hazardous substances to endanger public health or the environment.

Restoration - actions undertaken to return an injured resource to its baseline condition, as measured in terms of the injured resource's physical, chemical, or biological properties, or the services it previously provided, when such actions are in addition to response actions completed or anticipated, and when such actions exceed the level of response actions determined appropriate to the site pursuant to the National Contingency Plan.

Safe Drinking Water Act (SDWA) - Public Law 93-523 as amended, 42 U.S.C. 300f *et. seq.*; ensures that the water that comes from the tap in the United States is fit to drink (according to EPA national drinking water standards), and prevents contamination of ground water.

Smelting - the process of extracting a metal from its ores by heating; the chemical reduction of the oxide of the metal with carbon in a furnace.

Species of Conservation Concern (SCC) - a species that is considered rare or threatened in the State of Missouri by the Missouri Department of Conservation's Natural History Division.

Subsidence - Areas where underground excavations have caused the surface above it to sink, and into which water may have pooled.

Superfund - see CERCLA.

Surface water resources - the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline and sediments in or transported through coastal and marine areas. This term does not include ground water or water or sediments in ponds, lakes, or reservoirs designated for water treatment under the Resource Conservation and Recovery Act of 1976 or the Clean Water Act and applicable regulations.

Tailings - sand- and silt-sized mine wastes, left over after the final milling of the ore and the flotation of metals from crushed rock, or created as a by-product of washing chat. Tailings were usually sluiced into a dammed pond in a water slurry, and many tailings piles contain ponded water.

Threatened species - any species listed pursuant to the laws of the State of Missouri and /or the Federal Endangered Species Act which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Tributary - a lower order-stream compared to a receiving waterbody. "Tributary to" indicates the larger stream into which the reported stream or tributary flows.

Trustee - any Federal natural resources management agency designated in the NCP [National Contingency Plan] and any State agency designated by the Governor of each State, pursuant to section 107(f)(2)(B) of CERCLA, that may prosecute claims for damages under section 107(f) or 111(b) of CERCLA; or an Indian tribe, that may commence an action under section 126(d) of CERCLA.

Trustee Council - a council composed of one representative from each natural resource Trustee. For the Missouri Tri-State Mining District , the Trustee Council includes the United State Department of the Interior (DOI) and the Missouri Department of Natural Resources.

Water quality standard - law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

Zinc (Zn) - a bluish-white shiny metal that is one of the most common elements in the earth's crust. Zinc's commercial uses include coatings to prevent rust, in dry cell batteries, and mixed with other metals to make brass. Zinc compounds are widely used in industry to make paint, rubber, dye, wood preservatives, and ointments.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. ToxFAQs: Zinc. Accessed 11/25/03 at <http://www.atsdr.cdc.gov/tfacts60.html>.

Agency for Toxic Substances and Disease Registry (ATSDR). 1999a. ToxFAQs: Cadmium. Accessed 11/25/03 at <http://www.atsdr.cdc.gov/tfacts5.html>.

Agency for Toxic Substances and Disease Registry (ATSDR). 1999c. Toxicological Profile: Cadmium. Health Effects. Accessed 4/1/08 at <http://www.atsdr.cdc.gov/toxprofiles/tp5-c2.pdf>.

Allen, G.T. and R.M. Wilson. 1992. Trace elements and organic compounds in the Spring River basin of southeastern Kansas in 1988. Prepared by U.S. Fish and Wildlife Service. January. 60 pp.

Allert, A.L., M.L. Wildhaber, C.J. Schmitt, D. Chapman, and E. Callahan. 1997. Toxicity of Sediments and Pore-Waters and their Potential Impact on Neosho Madtom, *Noturus placidus*, in the Spring River System Affected by Historic Zinc-Lead Mining and Related Activities in Jasper and Newton Counties, Missouri; and Cherokee County, Kansas. Final Report to the U.S. Fish and Wildlife Service. July 1997.

Anderson, L.R. and J.A. Arruda. 2006. Land Use and Anuran Biodiversity in Southeast Kansas, USA. Amphibian and Reptile Conservation 4(1):46-59.

Angelo, R.T., M.S. Cringan, D.L. Chamberlain, A.J. Stahl, S.G. Haslouer, and C.A. Goodrich. 2007. Residual effects of lead and zinc mining on freshwater mussels in the Spring River Basin (Kansas, Missouri, and Oklahoma, USA). Science of the Total Environment 384:467-496.

Angle, J.S. 1999. Functional and structural analysis of soil from the Superfund Site in Jasper County, Missouri. Final Report to Environmental Management Services Company. January 4, 1999.

Barks, J.H. 1977. Effects of Abandoned Lead and Zinc Mines and Tailings Piles on Water Quality in the Joplin Area, Missouri. U.S. Geological Survey, Water-Resources Investigations 77-75. August 1977.

Besser, J.M., W.G. Brumbaugh, T.W. May, and C.J. Schmitt. 2007. Biomonitoring of lead, zinc, and cadmium in streams draining lead-mining and non-mining areas, southeast Missouri, USA. Environ. Monit. Assess 129:227-241.

Beyer, W.N., J. Dalgarn, S. Dudding, J.B. French, R. Mateo, J. Miesner, L. Sileo, and J. Spann. 2004. Zinc and lead poisoning in wild birds in the Tri-State Mining District (OK, KS, MO). Archives of Environmental Contamination and Toxicology.

Black & Veatch. 1998. Final Jasper County Superfund Site baseline ecological risk assessment (ERA). Jasper County, Missouri. Prepared for U.S. Environmental Protection Agency, Region VII. USEPA Work Assignment No. 005-RSP-0736. May.

Brosius, L. and R.S. Sawin. 2001. Lead and zinc mining in Kansas. Kansas Geological Survey, Public Information Circular (PIC) 17. Web version created October 2001. Accessed 4/1/08 at <http://www.kgs.ku.edu/Publications/pic17/pic17_1.html>.

Brown, S., B. Christensen, E. Lombi, M. McLaughlin, S. McGrath, J. Colpaert, and J. Vangronsveld. 2005. An inter-laboratory study to test the ability of amendments to reduce the availability of Cd, Pb, and Zn in situ. Environmental Pollution 138:34-45.

Carpenter, J.W., G.A. Andrews, and W.N. Beyer. 2004. Zinc toxicosis in a wild trumpeter swan (*Cygnus buccinator)*. Journal of Wildlife Diseases.

CDM Federal Programs Corporation (CDM). 1995. Addendum to the Site Characterization Report in Support of Remedial Investigation Activities for the Iron Gates Extension Area for the Iron Gates, Belleville, and Klondike Designated Areas of the Jasper County Site, Jasper County, Missouri. Prepared for U.S. Environmental Protection Agency, Region VII, Superfund Branch. Contract Number 68-W9-0021. November 29, 1995.

Cedar Creek Associates, Inc. 1999. Report on Wildlife Utilization of Barren Chat Piles in the Seven Jasper County DAs. Prepared for Environmental Management Services. January 1999.

CH2M Hill, Black & Veatch, ICF, PRC, and Ecology and Environment. 1987. Assessment of the toxicity of arsenic, cadmium, lead and zinc in soil, plants, and livestock in the Helena Valley of Montana for East Helena Site (Asarco), East Helena, Montana. Reclamation Research Unit, Montana State University, Bozeman, MT. Prepared for U.S. EPA Hazardous Site Control Division Contract No. 68-01-7251, 206 p.

Clarke, A.H. and B.K. Obermeyer. 1996. A Survey of Rare and Possibly Endangered Freshwater Mussels (Mollusca: Unionidae) of the Spring River Basin (with observations on the Elk River basin), in Missouri. Final Report to the U.S. Fish and Wildlife Service, Contract Number 60181-2-1621. April 30, 1996.

Cope, C.H. 1985. The Spring River drainage basin: A Kansas resource in need of a management plan. Project completion report, Contract No. 40.

Crawford, R., S. Clifford, and T. Ely. 1993. Toxicity Identification Evaluation, Tributary of Grove Creek, Jasper County, Missouri. Final Report for Missouri Department of Natural Resources, Divisions of Environmental Quality, Environmental Services Program. July 7, 1993.

Dames & Moore. 1993a. Final ecological risk assessment for Cherokee County, Kansas, CERCLA site: Baxter Springs/Treece subsites. March 24.

Dames & Moore. 1993b. Final remedial investigation for Cherokee County, Kansas, CERCLA Site: Baxter Springs/Treece subsites. January 27.

Dames & Moore. 1995. Final Remedial Investigation Neck/Alba, Snap, Oronogo/Duenweg, Joplin, Thoms, Carl Junction, and Waco Designated Areas. Jasper County Site Oronogo/Duenweg. Jasper County, Missouri. Prepared for the Jasper County Respondents and the U.S. Environmental Protection Agency. October 31, 1995.

Dames & Moore. 1997. Final Feasibility Study for the Ground-Water Operable Unit of the Jasper County Superfund Site, Jasper County, Missouri. December 12, 1997.

Davis, J.V. and J.G. Schumacher. 1992. Water-quality characterization of the Spring River Basin, southwestern Missouri and southeastern Kansas. U.S. Geological Survey Water-Resources Investigations Report 90-4176. 112 pp.

Demayo, A., M.C. Taylor, K.W. Taylor, and P.V. Hodson. 1982. Toxic effects of lead and lead compounds on human health, aquatic life, wildlife, plants, and livestock. CRC Crit. Rev. Environ. Control 12(4):257- 305.

Dressel, W.M., M.C. McFarland, and J.C. Brown Jr. 1989. Post-mining hazards of the Kansas-Missouri-Oklahoma Tri-State zinc-lead mining district. In Guidebook to the Geology and Environmental Concerns in the Tri-State Lead-Zinc District, Missouri, Kansas, Oklahoma. Missouri Academy of Science Geology & Geophysics Section. Joplin, Missouri. April 28, 1989.

Eisler, R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 1: Metals. Boca Raton: Lewis Publishers.

Efroymson, RA, M.E. Will, G.W. Suter II, and A.C. Wooten. 1997b. Toxicological benchmarks for screening contaminants of potential concern for effects on terrestrial plants: 1997 Revision. Oak Ridge National Laboratory, U.S. Department of Energy. Oak Ridge, Tennessee. November.

Feder, G.L., J. Skelton, H.G. Jeffery, and E.J. Harvey. 1969. Water Resources of the Joplin Area, Missouri. Water Resources Report 24. Water Resources Division, U.S.G.S. March 1969.

Ferrington, L.C. 1995. Final Report: Summary of Water Chemistry, Sediment Chemistry, Fish Populations and Macroinvertebrate Communities for Selected Sites at the Galena Sub-site of the Cherokee County Superfund Site, Cherokee County, Kansas, within the Tri-State Mining District, Phase II. Technical Report No. 83 of the Kansas Biological Survey, University of Kansas.

Ferrington, L.C. 2002. Summary of Water Chemistry and Macroinvertebrate Communities for Selected Sites at the Galena Sub-site of the Cherokee County Superfund Site, Cherokee County, Kansas, within the Tri-State Mining District: Year Three of Phase III.

Ferrington, L.C. Jr., O.K. Galle, M.A. Blackwood, C.A. Wright, F.J. Schmidt, and J.M. Jobe. 1989. Occurrence and biological effects of cadmium, lead, manganese and zinc in the Short Creek/Empire Lake aquatic system, in Cherokee County, Kansas. Kansas Water Resources Research Institute, Contribution #277, Report #G1563-06. For U.S. Department of the Interior Geological Survey. June.

Ferrington, L.C., S.M. Stringer, and S.T. Stringer. 2000. Summary of Water Chemistry and Macroinvertebrate Communities for Selected Sites at the Galena Sub-site of the Cherokee County Superfund Site, Cherokee County, Kansas, within the Tri-State Mining District: Year Two of Phase III.

Fitzgerald, J. 1997. Second Draft, Partners in Flight, Bird Conservation Plan. Physiographic Area 19: The Ozark/Ouachitas. Missouri Department of Conservation. December 29, 1997.

Fitzgerald, J., B. Busby, M. Howery, R. Klataske, D. Reinking, and D. Pashley. 2000. Partners in Flight Bird Conservation Plan for the Osage Plains (Physiographic Region 33). American Bird Conservancy.

Grand River Dam Authority, U.S. Fish and Wildlife Service, Oklahoma Water Resources Board. 2004. Ecological Risk Assessment: Evaluating concentrations of Cadmium, Chromium, Lead, and Zinc in Lake Hudson, Oklahoma. Agencies Response to FERC - Additional Information Request.

Hobbs III, H.H. 1993. Trophic relationships of North American freshwater crayfishes and shrimps. Milwaukee Public Museum Contributions in Biology and Geology, No. 85. June 15.

Hope, R.N. 2001. Heavy Metals in Fluvial Sediments of the Picher Mining Field, Northeast Oklahoma. Master's Thesis.

Imes, J.L. and L.F. Emmett. 1994. Geohydrology of the Ozark Plateaus Aquifer System, in parts of Missouri, Arkansas, Oklahoma, and Kansas. Regional Aquifer-System Analysis-Central Midwest. U.S. Geological Survey Professional Paper 1414-D.

Jacobs Engineering Group, Inc. 1995. Final Expanded Site Inspection Report for Newton County Mine Tailings Site, Newton County, Missouri. EPA Contract No. 68-W8-0122, EPA Region VII. July 1995.

Kansas Department of Health and Environment (KDHE). 2005. Neosho River Basin Total Maximum Daily Load. Water Body/Assessment Unit: Spring River Watershed, including Shoal Creek, Short Creek, Shawnee Creek, Turkey Creek and Center Creek. Water Quality Impairment: Metals (Lead, Zinc, Copper & Cadmium). Available at <http://www.kdheks.gov/tmdl/ download/spring_metals.pdf>, viewed 5/21/08. Summary information also available at <http://www.kdheks.gov/tmdl/netmdl.htm>.

Kansas Department of Health and Environment (KDHE). 2006. Unpublished electronic data (KDHE database.xls).

Kemble, N., C. Ingersoll, J. Kunz, and N. Wang. 2007. Development of a method for conducting whole-sediment toxicity tests with juvenile freshwater mussels. Poster presented at the Society of Environmental Toxicology and Chemistry North America 28th Annual Meeting, Milwaukee, WI, 11-15 November.

Kiner, L.K., C. Vitello, and K. Hash, Missouri Department of Conservation. 1997. Spring River Basin Inventory and Management Plan. Missouri Department of Conservation, Springfield, Missouri. August 1, 1997.

Kunz, J.L., N.N. Kemble, C.G. Ingersoll, N. Wang, A. Roberts, J.F. Dwyer, D. Mosby, and C. Barnhart. 2007. Evaluation of the toxicity of metal-contaminated sediments in the Spring River drainage basin of Missouri to juvenile mussels (*Lampsilis siliquoidea*) and amphipods (*Hyalella azteca*). Poster presented at the Society of Environmental Toxicology and Chemistry North America 28th Annual Meeting, Milwaukee, WI, 11-15 November.

Levy, D.B., E.F. Redente, and G.D. Upoff. 1999. Evaluating the phytotoxicity of Pb-Zn tailings on bluestem (*Andropogon gerardii vituman*) and switchgrass (*Panicum virgatum L.*). Soil Science 164(6):363-375.

Long, K.R., J.H. DeYoung, Jr., and S.D. Ludington. 1998. Database of significant deposits of gold, silver, copper, lead, and zinc in the United States. Part A: Database description and analysis. U.S. Geological Survey Open File Report 98-206A.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology 39(1):20-31.

McFarland, M.C. 1989. Division of Geology and Land Survey, Department of Natural Resources. Safety and Environmental Hazards in the Missouri Portion of the Tri-State Zinc-lead Mining District. In Guidebook to the Geology and Environmental Concerns in the Tri-State Lead-Zinc District, Missouri, Kansas, Oklahoma. Missouri Academy of Science Geology & Geophysics Section. Joplin, Missouri. April 28, 1989.

Missouri Department of Natural Resources (MDNR) and U.S. Department of the Interior (DOI). 2002. Preassessment Screen and Determination. Jasper County Superfund Site, Jasper County Missouri. Accessed 5/21/08 at http://www.dnr.mo.gov/env/hwp/news/final-jasper-county-pas-tds-02-06-18.pdf.

Missouri Department of Natural Resources (MDNR) and U.S. Department of the Interior (DOI). 2008. Preassessment Screen and Determination. Newton County Mine Tailings Superfund Site, Newton County Missouri. Accessed 3/12/08 at < http://www.dnr.mo.gov/env/hwp/docs/newton-county-mine-tailingspas2008.pdf>.

Missouri National Heritage Program. 2005. Missouri Species and Communities of Conservation Concern Checklist. Appendix A. Missouri Department of Conservation. Jefferson City, Missouri. 53 pp.

Missouri Fish and Wildlife Information System (MOFWIS). 2005. Conservation Commission of Missouri. Accessed 9/26/05 at http://mdc4.mdc.mo.gov/applications/mofwis/search1.asp.

Missouri National Heritage Program. 2004. Accessed 9/22/05 at http://www.conservation.state.mo.us /cgi-bin/heritage/.

Missouri Department of Conservation (MDC). 2000. Missouri Animals of Conservation Concern, Missouri Plants of Conservation Concern. Accessed 5/21/08 at <http://www.mdc.mo.gov/nathis/endangered/>.

Missouri Department of Natural Resources (MDNR). 2004. Missouri 2002 303(d) list (modified). May. Accessed 5/21/08 at <http://www.dnr.mo.gov/env/wpp/waterquality/2002_303d_list.pdf>.

Missouri Department of Natural Resources (MDNR). 2005. Total Maximum Daily Load Information Sheet, Turkey Creek. Accessed 5/12/08 at <http://www.dnr.mo.gov/env/wpp/tmdl/info/3216-3217-turkey-ck-info.pdf>

Missouri Department of Natural Resources (MDNR). 2006a. North Fork Spring River, Jasper County, Missouri, Total Maximum Daily Load. Accessed 1/18/08 at < http://www.epa.gov/Region7/water/pdf/n_fork_spring_river_tmdl_112206.pdf >

Missouri Department of Natural Resources (MDNR). 2006b. Total Maximum Daily Load Information Sheet, Center Creek. Accessed 1/18/08 at < http://www.dnr.mo.gov/env/wpp/tmdl/info/3203-center-ck-info.pdf >

Missouri Department of Natural Resources (MDNR). 2007a. 2004/2006 303(d) List Approved by Clean Water Commission on April 20, 2007. Accessed 1/18/08 at < http://www.dnr.mo.gov/env/wpp/waterquality/documents/303dlist-cwcapproved.pdf>.

Missouri Department of Natural Resources (MDNR). 2007b. Missouri Well Construction Rules. Private Water Wells, Heat Pump Systems, Private Installations and Monitoring Wells: Authorizing Statutes—256.600 to 256.640 RSMo. Rolla, Missouri, May, 2007.

Missouri Water Quality 305(b) Report. Reviewed 1/18/08 at < http://www.dnr.mo.gov/env/wpp/waterquality/305b/index.html>.

Momot, W.T. 1995. Redefining the role of crayfish in aquatic ecosystems. Reviews in Fisheries Science 3(1):33-63.

Mosby, D. 2007. Unpublished XRF gravel bar data. Provided by the U. S. Fish and Wildlife Service.

National Park Service (NPS). 1982. Rivers, Trails & Conservation Program - Kansas Segments. Accessed 9/20/05 at <http://www.nps.gov/ncrc/programs/rtca/nri/states/mo.html>.

Obermeyer, B.K., D.R. Edds, C.W. Prophet, and E.J. Miller. 1997. Freshwater mussels (*Bivalvia: Uniondae*) in the Verdigris, Neosho, and Spring River basins of Kansas and Missouri, with emphasis on species of concern. American Malacological Bulletin 14(1):41-55.

Parkhurst, D.L 1987. Chemical Analyses of Water Samples from the Picher Mining Area, Northeast Oklahoma and Southeast Kansas. U.S. Geological Survey Open-File Report 87-453.

Parkhurst, D.L., M. Doughten, and P.P. Hearn. 1988. Chemical Analyses of Stream Sediment in the Tar Creek Basin of the Picher Mining Area, Northeast Oklahoma. U.S. Geological Survey Open-File Report 88-469.

Patricola-Simpson, C., S. Wisely, S. Brown, D. Gasper, S. Narayanan, and J. Miesner. Undated. Ecological toxicology of a Tri-State small mammal community. Poster presentation.

Pflieger, W.L. 1992. Distribution and Status of the Arkansas Darter (*Etheostoma cragini*) in Missouri. Final Report, Endangered Species Project SE-01-22. Missouri Department of Conservation. May 11, 1992.

Persaud, D. and R. Jaagumagi. 1996. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Report for the Ontario Ministry of the Environment ISBN 0-7778-9248-7. Ontario, Canada. January.

Pierzynski, G.M. and W. Fick. 2007. Zinc phytotoxicity in the Tri-State Mining Region: Field and greenhouse studies. Final Report. Funding provided by the United States Department of Interior, Fish and Wildlife Service.

Pierzynski, G.M., and A.P. Schwab. 1993. Bioavailability of zinc, cadmium, and lead in a metal-contaminated alluvial soil. J. Environ. Qual. 22:247-254.

Pope, L.M. 2005. Assessment of Contaminated Streambed Sediment in the Kansas Part of the Historic Tri-State Lead and Zinc Mining District, Cherokee County, 2004. U. S. Geological Survey. Scientific Investigations Report 2005-5251.

Probst, W.E., C.F. Rabeni, W.G. Covington, and R.E. Marteney. 1984. Resource use by stream-dwelling rock bass and smallmouth bass. Trans. Amer. Fish. Soc. 113:283-294.

Rabeni, C.F., M. Gossett, and D.D. McClendon. 1995. Contribution of crayfish to benthic invertebrate production and trophic ecology of an Ozark stream. Freshwater Crayfish 10:163-173.

Reed, A.W., Kaufman, G.A., Rintoul, D.A., and Kaufman, D.W. 2004. Influence of prey abundance on raptors in tallgrass prairie. The Prairie Naturalist 36(1):23-31.

Schmitt, C.J. 1994. Draft Report The Effects of Historic Zinc-Lead Mining and Related Activities on Ecosystems Supporting the Neosho Madtom, *Noturus placidus* in Jasper County, MO; Ottawa County, OK; and Cherokee County, KS. March 15, 1994.

Schmitt, C.J., M.L. Wildhaber, A.L. Allert, and B.C. Poulton. 1997. The Effects of Historic Zinc-Lead Mining and Related Activities in the Tri-States Mining District on Aquatic Ecosystems Supporting the Neosho Madtom, *Noturus placidus*, in Jasper County, Missouri; Ottawa County, Oklahoma; and Cherokee County, Kansas. Final Report to the U.S. Environmental Protection Agency, Region VII, Kansas City, Kansas. January 7, 1997.

Sileo, N., W.N. Beyer, and R. Mateo. 2003. Pancreatitis in wild zinc-poisoned waterfowl. Avian Pathology 32(6):655-660.

Spooner, D.E. and C.C. Vaughn. 2006. Context-dependent effects of freshwater mussels on stream benthic communities. Freshwater Biology 51:1016-1024.

Spruill, T.B. 1987. Assessment of Water Resources in Lead-Zinc Mined Areas in Cherokee County, Kansas and Adjacent Areas. U.S. Geological Survey Water Supply Paper 2268.

Stewart, D.R. 1989a. Memorandum Report: Milling Practices Oronogo-Duenweg Mining Belt. Webb City, MO. March 2, 1989.

Stewart, D.R. 1990. Zinc-Lead Mine Production. Oronogo-Duenweg Mining Belt, Jasper-Newton Counties, Missouri (1850-1957). January 1990.

U.S. Environmental Protection Agency (EPA). 2001. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5. EPA/240/B-01/003. March.

U.S. Environmental Protection Agency (EPA). 2002a. Fact Sheet. The Oronogo/Duenweg (Jasper County) Mining Belt Site. Jasper, Missouri. Region 7. August 2002.

U.S. Environmental Protection Agency (EPA). 2002b. Guidance on Environmental Data Verification and Data Validation. EPA QA/G-8. Office of Environmental Information. EPA/240/R-02/004.

U.S. Environmental Protection Agency (EPA). 2002c. National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047.

U.S. Environmental Protection Agency (EPA). 1998. Record of Decision Declaration: Ground Water, Oronogo-Duenweg Mining Belt Site, Operable Unit 4, Jasper County, Missouri. July 1998.

U.S. Environmental Protection Agency (EPA). 2003a. Site Description. Newton County Mine Tailings Site. Accessed 5/21/08 at <http://www.epa.gov/region7/cleanup/npl_files/mod981507585.pdf>.

U.S. Environmental Protection Agency (EPA). 2003b. Hazard Ranking System Documentation, Newton County Mine Tailings. EPA ID No. MOD981507585. April 15, 2003.

U.S. Environmental Protection Agency (EPA). 2004. Fact Sheet. Five-Year Review Completed. Oronogo-Duenweg Mining Belt Site, Jasper County, Missouri. Region 7. March 2004.

U.S. Environmental Protection Agency (EPA). 2005a. Ecological Soil Screening Level for Cadmium. Interim Final. OSWER Directive 9285.7-65. March.

U.S. Environmental Protection Agency (EPA). 2005b. Ecological Soil Screening Level for Lead. Interim Final. OSWER Directive 9285.7-70. March.

U.S. Environmental Protection Agency (EPA). 2005c. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55. February.

U.S. Fish & Wildlife Service. Threatened and Endangered Species System (TESS). Accessed 9/20/05 at <http://ecos.fws.gov/tess_public/servlet/gov.doi.tess_public.servlets.UsaLists?usMap=1&status=listed&state=MO>.

U.S. Environmental Protection Agency (EPA). 2006a. STORET Legacy Data Center database. Online. Accessed December 2006 at http://www.epa.gov/storet/dbtop.html. Maintained by United States Environmental Protection Agency.

U.S. Environmental Protection Agency (EPA). 2006b. Stream Investigation, Kansas, Missouri, and Oklahoma. Water and sediment sampling data. Provided electronically.

U.S. Fish and Wildlife Service (USFWS). 2007. Unpublished Grand Lake XRF sampling data.

U.S. Geological Survey (USGS). 2006-2007. USGS Water-Quality Data for the Nation. Online. Accessed various times at http://waterdata.usgs.gov/nwis.

Whitledge, G.W. and C.F. Rabeni. 1997. Energy sources and ecological role of crayfishes in an Ozark stream: Insights from stable isotopes and gut analysis. Can. J. Fish. Squat. Sci. 54:2555-2563.

Wildhaber, M.L., A.L. Allert, C.J. Schmitt, V.M. Tabor, D. Mulhern, K.L. Powell, and S.P. Sowa. 2000. Natural and anthropogenic influences on the distribution of the Neosho madtom in a midwestern warmwater stream. Trans. Am. Fish. Soc. 129:243-261.

Wittman, J., V. Kelson, and T. Wilson. 2003. Draft community data summary report: Source of supply investigation for Southwestern Missouri. Wittman Hydro Planning Associates. January 8. Accessed 4/12/04 at http://www.wittmanhydro.com/WHPA/home/ pubs/sw_mo/summary-report.pdf.

World Health Organization (WHO). 1992. Environmental Health Criteria 135: Cadmium. Geneva. Available 4/1/08 at <http://www.inchem.org/documents/ehc/ehc/ehc135.htm >.

Yoo, J.L. and D.M. Janz. 2003. Tissue-specific HSP70 levels and reproductive physiological responses in fishes inhabiting a metal-contaminated creek. Archives of Environmental Contamination and Toxicology 45:110-120.

Assessment Plan for Jasper and Newton Counties, Missouri
Final Report, June, 2009

Approval Signature:

Mark N. Templeton, Director
Missouri Department of Natural Resources

Assessment Plan for Jasper and Newton Counties, Missouri

Final Report, June, 2009

Approval Signature:

Dr. Benjamin Tuggle
Director, Region 2 and Authorized Official
U.S. Fish and Wildlife Service

APPENDIX A

ENDANGERED, THREATENED, AND SPECIES OF CONSERVATION CONCERN (SCC) IN JASPER AND NEWTON COUNTIES, MISSOURI

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ENDANGERED, THREATENED, AND SPECIES OF CONSERVATION CONCERN (SCC) IN JASPER AND NEWTON COUNTIES, MISSOURI

SPECIES	HABITATS	COUNTY	FEDERAL STATUS	MISSOURI STATUS
Plants				
Alabama lip-fern (*Cheilanthes alabamensis*)	Calcareous rocks, bluffs.	Newton		SCC
Auriculate false foxglove (*Agalinis auriculata*)	Prairies, old fields, road beds, and other dry, open areas with a history of disturbance.	Newton		SCC**
Barbara's buttons (*Marshallia caespitosa var caespitosa*)	Prairies.	Jasper, Newton		SCC
Coontail (*Ceratophyllum echinatum*)	Slow-moving water.	Newton		SCC
Common leastdaisy (*Chaetopappa asteroides*)	Rocky open woods, prairies, glades.	Jasper		SCC
Green false foxglove (*Agalinis viridis*)	Wet meadows.	Jasper		SCC
Low prickly pear (*Opuntia macrorhiza*)	Dry open areas	Newton		SCC
Muhlenberg's nut-rush (*Scleria reticularis var pubescens*)	Recently dessicated muddy or sandy lake bed, and fluctuating lakeshores.	Jasper		SCC
Oklahoma sedge (*Carex oklahomensis*)	Bottomland and upland prairies, fens, sloughs, stream and pond margins.	Jasper		SCC
Ozark chinquapin (*Castanea pumila var ozarkensis*)	Upper slopes of dry oak-hickory forests.	Newton		SCC
Pinnate dogshade (*Limnosciadium pinnatum*)	Wetlands.	Newton		SCC
Regal fritillary (*Speyeria idalia*)	Tall-grass prairie.	Newton		SCC
Sedges (*Carex arkansana; Carex fissa var fissa*)	Grassland, moist depressions of upland prairies, disturbed, marshy areas, and low areas along roadsides.	Jasper		SCC
Pale gerardia (*Agalinis skinneriana*)	Periodically disturbed environments of dry prairies, rocky open glades and dry open woods.	Jasper		SCC

SPECIES	HABITATS	COUNTY	FEDERAL STATUS	MISSOURI STATUS
Small spike rush (*Eleocharis parvula var anachaeta*)	Wet soil, usually in brackish or saline areas.	Jasper		SCC
Soapberry (*Sapindus drummondii*)	Riparian communities.	Jasper, Newton		SCC
Tradescant aster (*Aster dumosus var strictior*)	Wet meadows, swampy open land, wet woods, wet prairies.	Jasper		SCC
Invertebrates				
Bristly cave crayfish (*Cambarus setosus*)	Underground rivers and streams.	Jasper, Newton		SCC
Neosho mucket (*Lampsilis rafinequeana*)	Obligate riverine species preferring shallow clean flowing water in fine to medium gravel substrates. Present in parts of Spring River, Center Creek, and Shoal Creek.	Jasper, Newton	Candidate	SCC
Purple Lilliput (*Toxolasma lividus*)	Small to medium streams, in gravel.	Jasper, Newton		SCC
Rabbitsfoot (*Quadrula cylindrica cylindrica*)	Clear streams with gravel substrate and moderate, stable currents. Present in parts of the Spring River.	Jasper		SCC
Western fanshell (*Cyprogenia aberti*)	Creeks to large rivers with rock, gravel and soft mud bottoms, including parts of the Spring River.	Jasper		SCC
Fish				
Arkansas darter (*Etheostoma cragini*)	Riffles and pools of springs and spring branches with thick growths of watercress; typical habitat is shallow water with some type of cover and no strong currents. Present in parts of Spring River and Shoal Creek, and spring-fed tributaries to Shoal Creek.	Jasper, Newton	Candidate	SCC
Bluntface shiner (*Cyprinella camura*)	Riffles with noticeable current in moderately turbid permanent streams with moderate to high gradient and gravel or rubble bottom. Present in parts of Spring River.	Jasper, Newton		SCC
Channel darter (*Percina copelandi*)	Sluggish riffles and pools with silt-free gravel bottom. Present in parts of Spring River and large tributaries.	Jasper, Newton		SCC
Ghost shiner (*Notropis buchanani*)	Pools and backwaters of large streams and rivers with moderately clear water, low gradient and quiet water.	Jasper		SCC

SPECIES	HABITATS	COUNTY	FEDERAL STATUS	MISSOURI STATUS
Least darter (*Etheostoma microperca*)	Sloughs, oxbows, spring pools and pools of streams, in areas with clear, quiet water and dense vegetation, with mud, sand or organic bottoms.	Jasper, Newton		SCC
Neosho madtom (*Noturus placidus*)	Medium to moderately large streams with clear water and gravel or rubble bottom. Usually found in riffles with moderate current. Present in parts of the Spring River.	Jasper	Threatened	Endangered
Ozark cavefish (*Amblyopsis rosae*)	Cave streams and spring outlets with clear, cold water and (most often) rubble bottom.	Jasper, Newton	Threatened	Endangered
Plains topminnow (*Fundulus sciadicus*)	Oxbows, sloughs, backwaters and pools of streams with clear, quiet water and dense beds of submergent vegetation.	Newton		SCC
Prairie mole cricket (*Gryllotalpa major*)	Prairies, soil underground.	Jasper, Newton		SCC
Redfin darter (*Etheostoma whipplei*)	Riffles of permanent streams with gravel bottoms.	Jasper		Endangered
Western slim minnow (*Pimephales tenellus tenellus*)	Clear permanent streams with little or no current and gravel or rubble bottoms. Present in Spring River and larger tributaries.	Jasper		SCC
Amphibians				
Northern crawfish frog (*Rana areolata circulosa*)	Native prairie, or former prairie areas in low meadows and pastures. Occasionally in floodplains. Breed in waterholes and ditches.	Jasper, Newton		SCC
Reptiles				
Great plains skink (*Eumeces obsoletus*)	Grassland with flat rocks.	Newton		SCC
Mammals				
Black-tailed jackrabbit (*Lepus californicus*)	Large contiguous native grasslands with adjacent legume and crop fields. Prefer grazed areas with scattered clumps of taller vegetation.	Jasper, Newton		Endangered
Gray bat *(Myotis grisescens)*	Caves. Forage over streams, rivers and reservoirs.	Jasper, Newton	Endangered	Endangered
Plains spotted skunk (*Spilogale putorius interrupta*)	Tallgrass prairies, brushy areas, forests.	Jasper, Newton		Endangered

SPECIES	HABITATS	COUNTY	FEDERAL STATUS	MISSOURI STATUS
Birds				
Barn owl (*Tyto alba*)	Cropland, pasture, herbaceous rangeland; nests in cavity trees and barns or grain elevators.	Jasper		Endangered
Cerulean warbler (*Dendroica cerulean*)	Mature deciduous forests, particularly in floodplains or other wet habitats.	Jasper		SCC
Great blue heron (*Ardea herodias*)	Nest in mature to old growth bottomland forests. Forage in marshes, backwaters, streams, ditches and along pond margins.	Jasper, Newton		SCC
Greater prairie chicken (*Tympanuchus cupido*)	Grassland tracts with diverse structure and species composition, and dense stands of native grass or shrub thickets.	Jasper, Newton		Endangered
Greater roadrunner (*Geococcyx californianus*)	Mixed brush and open land with herbaceous vegetation generally less than 0.5 m tall.	Newton		SCC
Loggerhead shrike (*Lanius ludovicianus*)	Savanna, woodland, shrub mix.	Jasper, Newton		SCC
Northern harrier (*Circus cyaneus*)	Open fields, prairies, native grass plantings and shallow marshes.	Jasper, Newton		Endangered
Painted bunting (*Passerina ciris*)	Savannah/shrub/ woodland matrix.	Jasper, Newton		SCC
Sora (*Porzana Carolina*)	Marshes with dense emergent vegetation and shallow water.			SCC
Swainson's hawk (SW region) (*Buteo swainsoni*)	Prairies or grasslands with open groves and scattered trees	Jasper, Newton		SCC

Sources:

a. Dames & Moore (1995)
b. Missouri National Heritage Program. 2004. Accessed 9/22/05 at <http://www.conservation.state.mo.us/cgi-bin/heritage/>
c. Missouri National Heritage Program (2005)
d. Missouri Animals of Conservation Concern, Missouri Plants of Conservation Concern. Accessed 12-19-05 at <http://www.mdc.mo.gov/nathis/endangered/>
e. U.S. Fish and Wildlife Service. 2005. Threatened and Endangered Species System (TESS). Accessed 9-20-05 at: <http://ecos.fws.gov/tess_public/servlet/gov.doi.tess_public.servlets.UsaLists?usMap=1&status=listed&state=MO>.
f. Missouri Fish and Wildlife Information System (MOFWIS). 2005. Conservation Commission of Missouri Accessed 9/26/05 at <http://mdc4.mdc.mo.gov/applications/mofwis/search1.asp>.
g. U.S. Department of Agriculture, Natural Resource Conservation Service. 1997 - Northeastern Wetlands Flora @ PLANTS Database. Accessed 12/19/05 at <http://plants.usda.gov/>.

Notes:

** SCC - Species of Conservation Concern-- a species that is considered rare or threatened in the State of Missouri by the Missouri Department of Conservation's Natural History Division.

APPENDIX B

STUDY-SPECIFIC WORK PLANS

APPENDIX C

RESPONSIVE SUMMARY