

DRAFT

PHASE I DAMAGE ASSESSMENT PLAN

FOR CHEROKEE COUNTY, KANSAS

Prepared for the Cherokee County Trustee Council

State of Kansas
Kansas Department of Health and Environment
Kansas Department of Wildlife and Parks

U.S. Department of the Interior
U.S. Fish and Wildlife Service

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June 28, 2004

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EXECUTIVE SUMMARY

Cherokee County, Kansas is part of the Tri-State Mining District, which 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, and zinc were released into the Cherokee County environment. Cadmium, lead, and zinc are hazardous substances because they are potentially toxic to a wide variety of plants and animals.

Under relevant Federal and state laws, the State of Kansas and the U.S. Department of the Interior (DOI) are the Trustees for the natural resources in Cherokee County. Natural resources include surface waters (rivers, lakes, streams, etc.), ground water, soils, air, plants, and animals. As Trustees, the State of Kansas and DOI serve as stewards for these resources within Cherokee County 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 has 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:

- Pre-assessment,
- Assessment planning,
- Injury determination and quantification,

- Pathway determination,¹ and
- Damage determination and restoration.

DOI and the State of Kansas have begun a NRDA for Cherokee County. To date, the Trustees have completed the pre-assessment phase, which culminated with the release of the Pre-Assessment Screen (KS and DOI 2003).² In the PAS, the Trustees concluded that:

- Releases of hazardous substances (cadmium, lead, and zinc) have occurred;
- Natural resources for which the Trustees can assert Trusteeship are, and/or likely have been, adversely impacted as a consequence of the releases;
- The quantity and concentration of the released substances are sufficient to potentially cause injury to natural resources;
- The data necessary to pursue a NRDA are readily available or can be obtained at a reasonable cost; and,
- Currently completed or planned response actions are insufficient to completely compensate the public for past and ongoing injuries to natural resources.

Having completed the pre-assessment phase, the Trustees have moved on to the assessment planning phase and have produced this Phase I 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 Cherokee County NRDA (Table 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.

Kansas Department of Health and Environment
Attn: Mr. Leo Henning
Bureau of Environmental Remediation
1000 SW Jackson St., Suite 410
Topeka, Kansas 66612-1367

The public can learn more about the Cherokee County NRDA by visiting the website:

<http://mountain-prairie.fws.gov/nrda/CherokeeCounty.htm>.

¹ 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.

² The PAS is available at: <http://mountain-prairie.fws.gov/nrda/CherokeeCounty.htm>.

Table ES-1 Currently Planned Cherokee County NRDA Studies	
Study Name	
<i>Injury Determination and Quantification</i>	
Surface Water: Exceedances of Regulatory Standards and Literature-Based Impact Thresholds	
Surface Water Sediments: Exceedances of Regulatory Standards and Literature-Based Impact Thresholds	
Aquatic biota: Fish, Shellfish, and other Aquatic Macroinvertebrates	
Aquatic biota: Waterfowl	
Terrestrial biota: Small Mammals	
Terrestrial biota: Other Terrestrial Fauna	
Terrestrial biota: Vegetative Communities, Impacts at Current and Former Mine Waste Pile Locations	
Ground Water: Exceedances of Regulatory Standards	
Soils: Exceedances of Literature-Based Impact Thresholds	
<i>Pathway Determination</i>	
Preliminary Contamination Allocation	

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CHAPTER 1

INTRODUCTION

Cherokee County is located in the southeastern corner of Kansas (see Figure 1). Portions of this county and neighboring counties in Missouri and Oklahoma, collectively known as the Tri-State Mining District, 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. Altogether, the Tri-State Mining District is approximately 500-square miles in area. This Assessment Plan describes proposed damage assessment activities within the 115 square mile portion of the Tri-State Mining District that falls within Cherokee County, Kansas (EPA 1997).

Cherokee County Superfund History

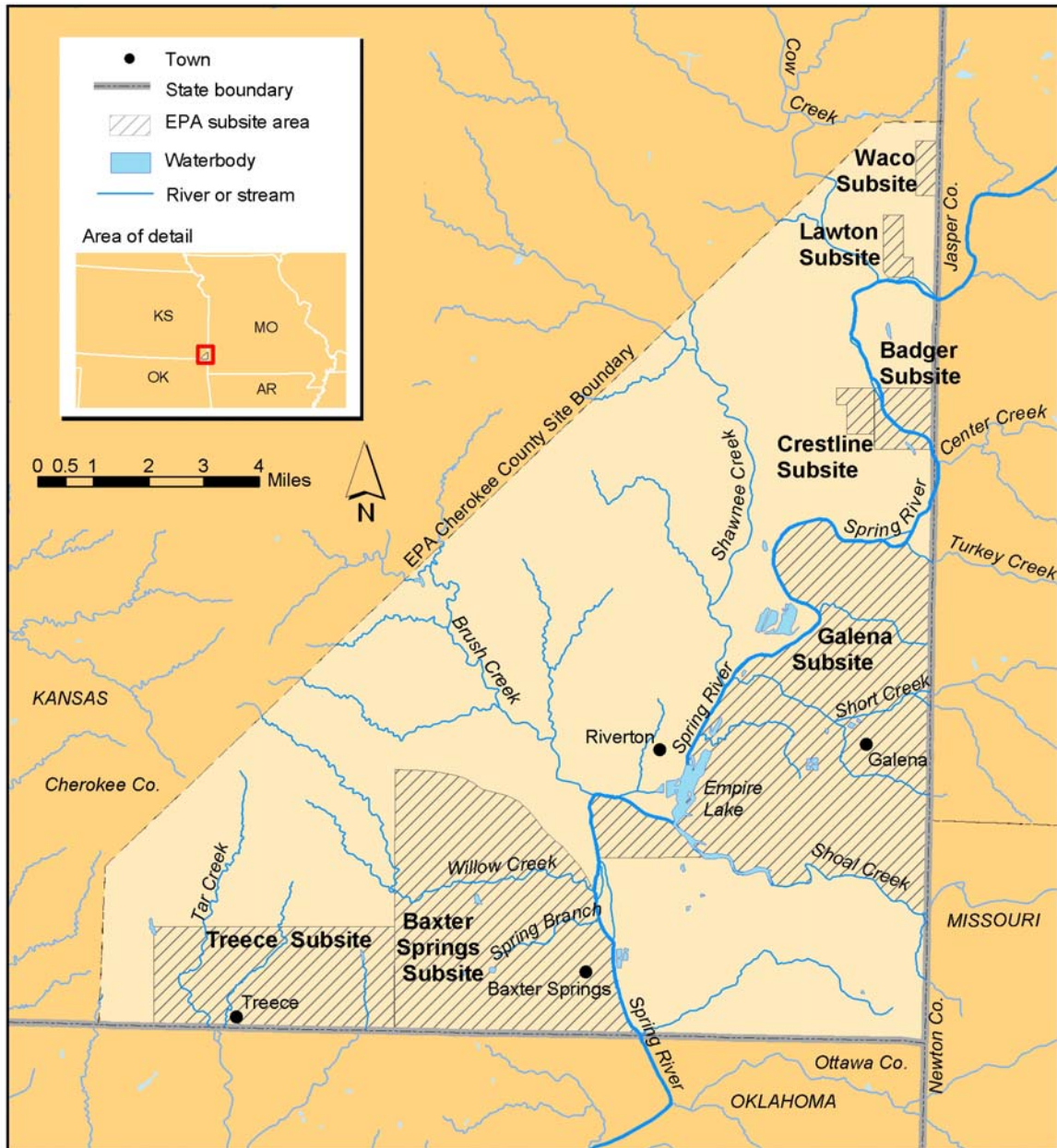
Beginning over two decades ago, the U.S. Environmental Protection Agency (EPA) began to evaluate threats posed to human health and the environment by mining-related releases of hazardous substances, particularly metals, in the Tri-State Mining District. Based on this evaluation, the EPA placed each state's portion of the Tri-State Mining District on its National Priorities List (NPL), and each state's portion of the district became one or more distinct Superfund sites.³ The resulting Superfund sites are: the Oronogo-Duenweg Mining Belt Superfund Site (Jasper County, MO), the Newton County Superfund Site (Newton County, MO), the Cherokee County Superfund Site (referred to hereafter as the Cherokee County Site), and the Tar Creek Superfund Site (Ottawa County, OK). The Cherokee County Site was added to the NPL in 1983.

EPA has divided the Cherokee County Site into a number of subsites, and into different operable units (OUs).⁴ These divisions facilitate the identification, selection, and implementation of remedial activities at the sites. Figure 1 shows the seven subsites within the Cherokee County Site. EPA has conducted cleanups at some of the identified OUs, while cleanup actions for others are in progress. This Assessment Plan addresses proposed assessments of trust resources for the entire Cherokee County Site.

³ 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.

⁴ A subsite is a geographically distinct portion of a Superfund site. An operable unit is a term for each of a number of separate activities undertaken as part of a Superfund site cleanup. For example, the Galena subsite in Cherokee County has several operable units, including residential soils, ground water/surface water, and alternate water supply.

Figure 1
Cherokee County Superfund Site



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 Cherokee County, 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 Kansas Department of Health and Environment (KDHE). 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:

- Pre-assessment,
- Assessment planning,
- Injury determination and quantification,
- Pathway determination,⁵ and
- Damage determination and restoration.

NRDAs begin with a preassessment phase, and the end product of that phase is a Preassessment Screen (PAS). The Cherokee County Trustees (hereinafter referred to as the Trustees) issued a PAS in 2003 (KS and DOI 2003).⁶ The PAS confirmed the following:

- (a) Heavy metals have been and are being released into the Cherokee County 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

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 The PAS is available at: <http://mountain-prairie.fws.gov/nrda/CherokeeCounty.htm>.

- (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 Cherokee County Trustees have decided to pursue additional NRDA activities. To that end, the Trustees have begun the assessment planning phase and have developed this Phase I Assessment Plan (Plan). This Plan describes activities that will gather and 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. The Trustees anticipate, for example, that this plan will be modified and/or a Phase II plan will be released to address potential restoration needs (after accounting for actions already taken or planned through Superfund and any other cleanup programs or efforts).

This Plan focuses on the Cherokee County portion of the Tri-State Mining District. It does not address assessing the potential for injuries to natural resources beyond the State of Kansas, although it does include natural resource damages resulting from mining-related releases of hazardous substances in adjacent areas (for instance, Missouri) that migrate into, and contribute to, natural resource injuries within Cherokee County. For natural resource injuries in Oklahoma and Missouri, equivalent documentation is to be developed by the relevant Trustees for those states.

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

- **Chapter 2 (Background)** discusses Cherokee County'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 Cherokee County NRDA: Phase I)** provides an overview of injury and pathway 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

Natural Resources in Cherokee County

Cherokee County lies within the geological provinces of the Ozark Plateau and Cherokee Lowlands. The county 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 Cherokee County 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 county'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.

Surface Water Resources: Rivers, Lakes, Streams

Surface water resources in the Cherokee County Site include the Spring River, its tributaries, and Empire Lake. Tar Creek is another significant surface water resource; it joins the Neosho River⁸ near Miami, Oklahoma upstream of the Neosho's confluence with the Spring River.

Spring River

The Spring River flows southwest into the state from Missouri, entering Cherokee County about ten miles north of Galena (Figure 1). It exits southward into Oklahoma, where it converges with the Neosho River to form the Grand River. In Kansas, the Spring River drains 500 square miles and flows through, near, or adjacent to areas heavily impacted by mining, including the Lawton, Badger, Galena, Baxter Springs, Waco, and Crestline Superfund subsites (KDHE 1980).

The Spring River is one of the state's most valued surface water resources. It ranks fifth in annual average flow and third-highest in critical low flow (United States Geological Survey (USGS) WATSTORE database). Upstream of the confluence with Center Creek, the river supports at least 74 fish and 23 mussel species, including the federally and state-threatened Neosho madtom (*Noturus placidus*). Ten other resident fish and shellfish species are listed as threatened or endangered in the State of Kansas, and 35 species are designated as in need of

⁸ The Neosho River is a major Kansas river, located west of Cherokee County. It flows southward through Kansas and enters Oklahoma.

conservation (Appendix A). As shown in Figure 2, some reaches support high-quality riparian corridor habitat.⁹

The Spring River's importance as a natural resource has been recognized by a number of organizations. KDHE classifies the river as an exceptional state water and a special aquatic life use water (KDHE 2003). The Kansas Department of Wildlife and Parks (KDWP) classifies the Spring River as critical habitat for numerous threatened and endangered species (for example Neosho madtom) and as a highest-valued fishery resource (Moss and Brunson 1981). The National Parks Service classifies the river as an outstandingly remarkable stream for scenic, recreational, fishing, and wildlife attributes (NPS 1982).

Figure 2
Spring River Riparian Corridor



Spring River, especially in its more downstream reaches, has elevated metals levels (CH2M Hill 1987). KDHE's 2004 303(d) list indicates that the lower river is impaired by lead,

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.

copper, and zinc.¹⁰ Elevated metals concentrations appear to be impacting the river's aquatic life. 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. Mussel populations also appear to have been impacted: Obermeyer *et al.* (1995) reported that only the portion of the river upstream of Center Creek is rich with these organisms. 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]."

Spring River Tributaries

As shown in Figure 1, key tributaries of the Spring River, ordered from north to south and entering on the east (E) or west (W) side, are as follows: Cow Creek (W), Center Creek (E), Turkey Creek (E), Shawnee Creek (W), Short Creek (E), Shoal Creek (E), Brush Creek (W), Willow Creek (W), and Spring Branch (W). Similar to the Spring River, some of these tributaries are habitat to valued aquatic animals including threatened and endangered species (Appendix A). The following paragraphs briefly describe key characteristics of each.

Cow Creek is the major Kansas tributary to the Spring River in the northern region of the watershed (KDHE 1980). It originates in Crawford County and flows southeast before converging with the Spring River in Cherokee County (KDHE 1980). Cow Creek drains coal-mined and agricultural areas (Dames & Moore 1995), and receives treated sewage effluents and storm runoff from the City of Pittsburg, Kansas (City of Pittsburg 2003). KDHE's 2004 303(d) list states that Cow Creek is impaired by sulfate.

Center Creek is an Ozarkian stream located in Missouri that joins the Spring River near the Kansas/Missouri border. Center Creek is a significant contributor of metal contaminants to the Spring River (Davis and Schumacher 1992); indeed, KDHE (1980) states that "Short and Center Creeks contribute the greatest amount of lead-zinc mine pollutants to the Spring River in Kansas," and Davis and Schumacher (1992) found that lead and zinc levels exceeded chronic aquatic life criteria (ALC)¹¹ from 1965 to 1989. KDHE monitoring data collected during the past two decades confirm the continuation of high metals loadings from Center Creek and other tributaries to the Spring River (KDHE 2004). Dames & Moore (1995) suggest that fish communities in the creek continue to be impacted by elevated metals concentration, as fish are both more diverse and more abundant upstream of Oronogo-Duenweg relative to downstream.

Turkey Creek also flows through Missouri before joining the Spring River south of Center Creek, just west of the border in Kansas. Like Center and Short Creeks, Turkey Creek is a

¹⁰ 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. Kansas's 2004 303(d) list is available at <http://www.kdhe.state.ks.us/tmdl/NE2004.html> (visited 5/19/04).

¹¹ Aquatic life criteria (ALC), are water quality standards issued by EPA and are designed to protect aquatic life from acute (short-term) and chronic (long-term) effects of contaminants. ALC also serve as guidance to states and tribes authorized to establish their own water quality standards under Section 304a of the Clean Water Act.

typical Ozarkian stream, characterized by alternating pools and riffles with a mixture of sand, gravel, and boulder streambed bottoms (Dames & Moore 1995). Turkey Creek flows through Joplin, Missouri and receives discharges from several industries and several sewage treatment plants, as well as runoff from historical mine-related areas (Dames & Moore 1995). Davis & Schumacher (1992) characterized this creek as Missouri's most contaminated interstate stream.

During some high flow sampling events in Missouri, neither cadmium nor lead concentrations exceeded chronic ALC; however, data suggest that runoff from the Oronogo-Duenweg subsite causes Turkey Creek to exceed chronic ALC for zinc (Dames & Moore 1995). Further, 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). KDHE’s 2004 303(d) list states that Turkey Creek is impaired by cadmium, lead, copper, and zinc. Some parts of the creek contain visible mine waste bars (Figure 3).

Figure 3
Turkey Creek with Mine Waste Bars



Shawnee Creek originates in north-central Cherokee County. It merges with Little Shawnee Creek before joining the Spring River near the Galena subsite. KDHE’s 2004 303(d) list indicates that water quality impairments in Shawnee Creek include contamination by lead, zinc, copper, and fecal coliform.

Short Creek (Figure 4) passes through Missouri and the Galena subsite before joining the Spring River. The creek is highly contaminated with metals (Ferrington *et al.* 1989). KDHE (1980) similarly indicates Short Creek is "extremely polluted [in Kansas] with toxic heavy metals concentrations, especially zinc... This is reflected in the benthic samples by the continuous low taxa numbers... as well as the complete absence of the pollution sensitive mayfly-stonefly groups." CH2M Hill (1987) remarks that "[t]he USGS results show that Short Creek was a major contributor of zinc to the Spring River... Based on these [USGS] data, Short Creek was also the largest contributor of cadmium and lead loadings." KDHE's 2004 303(d) lists states that water quality impairments in Short Creek include contamination by cadmium, copper, lead, and zinc.

Figure 4
Portion of Short Creek near Galena, with Algae



Shoal Creek runs through Missouri, forms the southern border of the Galena subsite, and joins the Spring River at Empire Lake. The creek has been described as “the only Ozark-type stream in Kansas” (KDHE 1980).¹² As an Ozarkian stream, Shoal Creek has exceptionally clear water and a rocky bottom (Figure 5). These features make Shoal Creek “unique... for its aesthetic qualities” (KDHE 1980).

Parts of Shoal Creek suffer from metals contamination. KDHE’s 2004 303(d) list indicates that water quality impairments in Shoal Creek include contamination by lead and zinc. Ferrington *et al.* (1989) note that the Shoal Creek arm of the Empire Lake reservoir “has higher concentrations of metals than expected” and “it must be concluded that movements of metals out of tailings areas via one or more of these intermittent streams [that join with Shoal Creek]... contribute significantly to the elevated metals concentrations in sediments of the Shoal Creek arm.”

Data on unionid mussel communities in Shoal Creek suggest that the creek undergoes a radical transformation in character downstream of Joplin, Missouri. Specifically, the unionid mussel community, which is readily apparent upstream of the city, is essentially absent in downstream reaches (KDHE 2004). Cope (1985) found only a single living mussel plus a small number of dead mussels at a Shoal Creek station south of the Galena subsite. Obermeyer *et al.* (1997) found the Neosho mucket (*Lamslis 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.

Figure 5
Shoal Creek at Low Flow near Schermerhorn Park



¹² Although Center Creek is also an Ozarkian stream, only a very small portion of the creek lies within Kansas. Most of Center Creek is in Missouri.

Brush Creek is an intermittent¹³ stream that originates in the northwestern portion of the Spring River basin and flows southeasterly before converging with the Spring River near Riverton, Kansas (KDHE 1980). The water quality is minimally affected by mine drainage, since there was little mining activity in its watershed (KDHE 1980).

Willow Creek is an intermittent tributary that runs through the Baxter Springs subsite and also contributes to Spring River metal loads. KDHE (1980) found that during times of high runoff or mine "dewatering" operations, high concentrations of metal contaminants were introduced into the Spring River via Willow Creek. Dames and Moore (1993a) found that mine water discharged into the creek from the Bruger shafts, and that shaft discharge may account for a significant part of the metal load carried by the creek. The mine water discharge contained zinc concentrations that can be acutely toxic to resident aquatic organisms, although some data suggest that populations of key aquatic species have not been significantly reduced (Dames & Moore 1993a). As part of the ongoing Superfund process, EPA is attempting to control minewater discharge to the creek by limiting recharge to the mine workings in the vicinity of the Bruger shafts (USEPA 1997).

Spring Branch is an intermittent tributary to the Spring River with a watershed of 3.3 square miles, all of which is contained in the Baxter Springs subsite (Dames & Moore 1993a). Land use in the Spring Branch watershed is primarily agricultural but also includes the city of Baxter Springs (Dames & Moore 1993a). Water quality in the Spring Branch has been and continues to be impacted by past mining activities; for example, Dames & Moore (1993a) stated that mill waste areas are still present in 16 percent of its watershed, and outwash tailings are located in the stream channel. Similarly, "cadmium and zinc concentrations exceeded chronic ALC in all samples tested," and lead concentrations exceeded ALC during periods of higher flow. Part of the high metal loads in Spring Branch were attributed to overflow from the Ballard tailings impoundment, a site that was addressed in EPA's ROD for the Baxter Springs/Treece OU (USEPA 1997).

Empire Lake

Empire Lake, located near Riverton, was created by a dam first erected in the early 1900s. The lake is owned by the Empire District Electric Company, which uses lake water as a coolant in its coal-fired power plant. Considerable sediment has accumulated behind the dam, resulting in shallow water depths throughout most of the lake: KDHE's 2004 303(d) list states that the lake is impaired by siltation. In part because of this sedimentation, the lake "is thought to act as a sink for both nutrients and heavy metals" (KDHE 1980). Ferrington *et al.* (1989) evaluated the lake's benthic invertebrate community and concluded that "the main effect of high concentrations of cadmium, lead and zinc in the sediments of Empire Lake is reduction of the standing crop density of aquatic macroinvertebrates, and presumably overall productivity of the reservoir system."

¹³ Intermittent, streams and creeks only contain flowing water for part of the year. The rest of the year, they contain standing pools separated by dry areas.

Tar Creek

Tar Creek is the principal stream in the Treece subsite, and flows into Oklahoma from Cherokee County where it joins the Neosho River (Dames & Moore 1993a). Available data suggest that Tar Creek is highly impacted by metal concentrations. Dames & Moore (1993a) indicate that the concentration of zinc in Tar Creek exceeds levels that are acutely toxic to some of the more sensitive species that could inhabit these ephemeral streams, and therefore could be affecting the species composition. Fish numbers in the lower segment of the Kansas section of Tar Creek were low relative to other streams in the subsite, and the only fish collected were of the sunfish family (*Centrarchidae*) (Dames & Moore 1993a). KDHE's 2004 303(d) list indicates that Tar Creek is impaired by lead, cadmium, zinc, and sulfate.

Geologic Resources

Cherokee County lies within the Ozark Plateau and Cherokee Lowlands geographical provinces. The Ozark Plateau is characterized by thin, rocky soil and steep slopes, while the Cherokee Lowlands have gentler slopes and deeper soils more suitable to cropland (Dames & Moore 1993a). In its natural state, the soils support diverse ecosystems, such as tallgrass prairie and deciduous woodland.

Many of the geologic resources within the Cherokee County Site are either currently covered by mine waste piles or fall within the footprints of former piles. These areas tend to have higher metals concentrations than occur in other, nearby areas: in the Baxter Springs and Treece subsites, for example, researchers found that near-pile soils had metal concentrations that “are generally higher than concentrations in agricultural and A Horizon [surficial] soils (Dames & Moore 1993a). Furthermore, mill site soils had concentrations “similar to bulk chat values.”

Ground Water

Two major aquifers, one shallow and one deep, underlie the Cherokee County mining area. The shallow aquifer, called the Boone aquifer, is comprised of Mississippian limestones, which also contain the lead-zinc deposits mined in the area (Dames & Moore 1993b). The rock underlying the Boone aquifer is impermeable limestone, which confines the aquifer and largely prevents downward movement of the water (Dames & Moore 1993a). Water from the surface (for example, precipitation) can sink into the ground and enter the Boone through natural areas of permeability in the limestone or through mine workings (Dames & Moore 1993a), recharging the aquifer.

During times of heavy precipitation, ground water in the Boone aquifer discharges into mine shafts and drill holes, as observed in the Baxter Springs subsite in June 1990 (Dames & Moore 1993a). Some discharge also occurs directly from the Boone along the streambeds of tributaries to the Spring River (Dames & Moore 1993a).

The Boone aquifer was once routinely used as a source of drinking water by the residents of Galena. EPA determined that metal contamination of the aquifer was significant enough to render the water unsafe to drink and in 1997 provided an alternate water supply as part of its

selected remedial action for the Galena Alternate Water Supply OU (EPA 1997). The selected remedy included the provision of water from the deep aquifer, called the Roubidoux, to area residents. At the current time, there is little evidence of contamination in the Roubidoux (Dames & Moore 1993a).

The Roubidoux is the principal source of water for public, industrial, domestic, and stock supplies for the area (Dames & Moore 1993b). Its ground water tends to flow out of Cherokee County to the west, then turns south towards Oklahoma (Dames & Moore 1993a). Recharge occurs via precipitation falling on the western flank of the Ozark Dome in Missouri (Dames & Moore 1993a). There may also be downward leakage from the Boone through fractures and well shafts, but evidence suggests that this is not a significant source of recharge (Dames & Moore 1993a). Discharge occurs primarily through removal for human needs (Dames & Moore 1993a).

The Roubidoux is used not only by Cherokee County residents but also by residents of neighboring Missouri and Oklahoma. A recent study of water supplies in Missouri's Jasper and Newton Counties noted that "groundwater withdrawals from the [Roubidoux] 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).

Biotic Resources

Aquatic and Amphibious Species

Cherokee County's aquatic organisms include a wide variety of plants and animals. Among these are a number of larger or recreationally important fish species such as smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), walleye (*Stizostedion vitreum*), and many others.¹⁴ Some fish species inhabit subsidence pits and flotation tailings ponds; these consist primarily of green sunfish, although local residents report that largemouth bass and crappie may also be found in some mine or mill ponds (Dames & Moore 1993a). Certain ponds are stocked and may support non-native fish species (Dames & Moore 1993b). Although few formal fish surveys have been conducted in ephemeral streams, some likely support yellow bullhead, black bullhead, green sunfish, various minnow species, red shiner (*Cyprinella lutrensis*), slough darter (*Etheostoma gracile*), brook silverside (*Labidesthes sicculus*) and mosquitofish (*Gambusia spp.*) (Dames & Moore 1993b). The Ozark cavefish (*Amblyopsis rosae*) is present throughout parts of the Ozark uplift in Missouri and Oklahoma and may also be present in Cherokee County. Several species of fish found in Cherokee County have

¹⁴ Additional larger or recreationally important fish in the area include: shortnose gar (*Lepisosteus platostomus*), river carpsucker (*Carpionodes carpio*), white sucker (*Catostomus commersoni*), black bullhead (*Ameiurus melas*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), white bass (*Marone chrysops*), rock bass (*Ambloplites rupestris*), green sunfish (*Lepomis cyanellus*), warmouth (*Lepomis gulosus*), bluegill (*Lepomis macrochirus*), spotted bass (*Micropterus punctulatus*), white crappie (*Pomoxis annularis*), black crappie (*Pomoxis nigromaculatus*), and many others (Cross and Collins 1995).

special status:¹⁵ the Kansas- and federally-listed threatened Neosho madtom, the Kansas-threatened Arkansas darter (*Etheostoma cragini*) and redspot chub (*Nocomis asper*), and several species in need of conservation (SINC) (Appendix A). The “Surface Water Resources” section above presents some available evidence of potential contaminant-related injuries to Cherokee County fish.

Freshwater mussels occur in both the Spring and Neosho River basins. 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.¹⁶ Other Federal candidate species found in the Spring River include Ouachita kidneyshell (*Ptychobranhus occidentalis*), western fanshell (*Cyprogenia aberti*), and rabbitsfoot (*Quadrula cylindrica cylindrica*, Appendix A). The “Surface Water Resources” section above presents some available evidence of potential contaminant-related injuries to Cherokee County mussels.

Cherokee County amphibians include a number of special-status species (Appendix A). The Shoal Creek drainage basin is believed to host three state-listed endangered species of salamander: the cave salamander (*Eurycea lucifuga*), the graybelly salamander (*Eurycea multiplicata*), and the grotto salamander (*Typhlotriton splaeus*) (CH2M Hill 1988). State-designated threatened (T) or endangered (E) amphibian species with designated critical habitat in the Cherokee County Spring River basin include: cave salamander (E), many-ribbed salamander (*Eurycea multiplicata*, E), grotto salamander (E), eastern newt (*Notophthalmus viridescens*, T), longtail salamander (*Eurycea longicauda*, T), eastern narrowmouth toad (*Gastrophryne carolinensis*, T), green frog (*Rana clamitans*, T), and spring peeper (*Pseudacris crucifer*, T) (Collins *et al.* 1995, KAR 2003).

Birds

Birds make use of both aquatic and terrestrial habitat in Cherokee County. The North American Breeding Bird Survey effort regularly surveys birds through the Tri-State District, including parts of Cherokee County, and has identified at least 100 species in the district as a whole (Beyer *et al.*, forthcoming). Water-affiliated species observed during these surveys in Cherokee County include the great blue heron (*Ardea herodias*), several egret species, and mallard (*Anas platyrhynchos*) (Sauer *et al.* 2001, as cited in Beyer *et al.*, forthcoming). Dames & Moore (1993a) report that larger species, such as duck, geese, herons, egrets, pelicans, swans and shorebirds specifically use Spring River and Empire Lake, among other wetlands. Waterbirds observed in the Baxter Springs/Treece subsite include the Canada goose (*Branta canadensis*), mallard, wood duck (*Aix sponsa*), blue-winged teal (*Anas discors*), great blue heron, and an egret of indeterminate species (Dames & Moore 1995).

¹⁵ “Special-status” species include Kansas-designated and federally-designated threatened or endangered species, as well as Kansas-designated Species In Need of Conservation (SINC).

¹⁶ The abundance of this mussel declines appreciably below Center Creek, and it appears to be absent below Turkey Creek.

Bird species attracted to native prairie and other open areas include, but are not limited to, the common bobwhite (*Colinus virginianus*), mourning dove (*Zenaida macroura*), western meadowlark (*Sturnella neglecta*), and field sparrow (*Spizella pusilla*) (Dames & Moore 1993a). The North American Breeding Bird Survey effort observed all these in Cherokee County as well as numerous other bird species (Sauer *et al.* 2001, as cited in Beyer *et al.*, forthcoming). Dames & Moore (1993a) report the presence of wild turkey (*Meleagris gallopavo*), owls, hawks, thrushes, and woodpeckers in the Baxter Spring/Treece subsite. Special-status avian species include the state and federally-threatened bald eagle (*Haliaeetus leucocephalus*), plus two SINC species—the cerulean warbler (*Dendroica cerulea*) and Henslow's sparrow (*Ammodramus henslowii*, Appendix A).

Recent studies suggest that some bird species in the Tri-State District may have been injured as a consequence of metals exposure. Waterfowl, robins, cardinals, and young swallows collected from the Kansas and Oklahoma portions of the Tri-State Mining District had significantly elevated body tissue lead levels relative to birds from non-mining areas; in addition, the delta-aminolevulinic acid dehydratase (ALAD, an enzyme involved in the formation of hemoglobin) activities in robins, cardinals, and waterfowl, were less than 50 percent of those in birds from non-mining areas (Beyer *et al.*, forthcoming).¹⁷ Lead levels in some Tri-State birds are consistent with levels identified in scientific studies as being associated with lead poisoning (Beyer *et al.*, forthcoming). Additionally, Carpenter *et al.* (forthcoming) documented a case of zinc poisoning in a trumpeter swan (*Cygnus buccinator*) 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 Tri-State Mining District. These are the first confirmed reported cases of zinc poisoning of waterfowl associated with mining wastes, although how widespread this poisoning might be is currently unclear (Carpenter *et al.*, forthcoming). Cherokee County birds may also have been impacted by mining-related habitat losses (see “Vegetation” section below).

Mammals

Cherokee County mammals rely on both aquatic and terrestrial habitats. Muskrat, mink, and beaver can be found near wetlands and along streams (Dames & Moore 1993a). Mammals observed in both the Baxter Spring/Treece subsite and on the Missouri side of the Spring River include raccoon (*Procyon lotor*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), red fox (*Vulpes vulpes*), grey fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), bobcat (*Lynx rufus*), mink (*Mustela vison*), opossum (*Didelphis virginiana*), eastern cottontail (*Sylvilagus floridanus*), whitetail deer (*Odocoileus virginianus*), badger (*Taxidea taxus taxus*), squirrels, shrews, and various other small rodents (Dames & Moore 1993a, Dames & Moore 1995). Special-status mammals include the Kansas-threatened eastern spotted skunk (*Spilogale putorius*) and the Kansas- and federally-endangered gray bat (*Myotis grisecens*) (Appendix A).

¹⁷ ALAD inhibition is an indication of lead exposure.

Vegetation

In Cherokee County, croplands, grasslands, woodlands, and wetlands are interspersed with spaces dominated by mining impacts (Dames & Moore 1993a). 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, 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 forb¹⁸ species (Figure 6) and their seed banks¹⁹ are exceptionally rich, even in areas used as hay meadows (Figure 7). Native prairie areas may also support important native rangeland grass species, such as the big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparius*), and Indiangrass (*Sorghastrum nutans*) (Dames & Moore 1993a).

Figure 6

Black-Eyed Susan (*Rudbeckia hirta*, a forb) in a Native Prairie



¹⁸ Forbs are herbaceous, non-grass species.

¹⁹ Seed banks are reserves of viable seeds present naturally on the surface and in the soil.

Figure 7
Native Prairie Hay Meadow near Spring River Wildlife Area



About nine percent of Cherokee County acreage is forested. These woodlands tend to occur as irregular areas or strips and as riparian corridors (Dames & Moore 1993). Woodlands also occur as strips on upland drainageways and on steep upland slopes. 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. The southwest corner of the county is the most biologically diverse region of the state in terms of the number of native woody species. There are no known special-status terrestrial plants in Cherokee County.

The Trustees have estimated that approximately 4,000 terrestrial acres in Cherokee County have been affected by mining activities (KS and DOI 2003). Chat piles in the Cherokee County Site do not support normal stands of terrestrial vegetation. In addition, terrestrial vegetation has been significantly altered because of hazardous substances at sites where chat piles formerly existed but have since been removed. Plant communities in many of these areas now provide little habitat for birds and wildlife. Vegetation communities adjacent to mine wastes also appear to have been affected, though to a lesser extent, and the ability of these areas to provide habitat may have been impaired as well (KS and DOI 2003).

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 soils, sediments, and surface waters throughout Cherokee County, and substantial relevant data for NRDA assessment purposes

already exist. The Trustees recognize that other contaminants and conditions adversely affect natural resource in Cherokee County. For example, some Cherokee County surface waters are impaired by one or more of the following: low dissolved oxygen, siltation, eutrophication, fecal coliform bacteria, sulfate, and chlordane, as well as other metal contaminants (KDHE 1998). After reviewing Phase 1 assessment results, the Trustees will consider additional contaminants of concern, which may include but are not limited to the impairments listed above. The following paragraphs, however, focus on the primary contaminants of concern, their toxicology, and associated environmental hazards.

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). Freshwater²⁰ animals tend to be most heavily impacted by cadmium contamination (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 hardness²¹ (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 toxic²² 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 and the livers and kidneys of vertebrates (ATSDR 1999c; Scheuhammer 1987, as cited in Eisler 2000).

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

²⁰ Freshwater refers to waters that are not saline (salty).

²¹ Water hardness is a measure of the content of certain naturally-occurring elements in water, especially calcium and magnesium.

²² 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.

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).

Aquatic animals have been demonstrated to 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).

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). As noted previously, recent studies have found evidence of zinc poisoning in birds collected from the Oklahoma and Kansas portions of the Tri-State Mining District (Carpenter *et al.*, forthcoming; Sileo *et al.* 2003). The geese had zinc concentrations in their livers that the authors state are “comparable with those in waterfowl killed by Zn in laboratory studies or accidentally killed by ingesting zinc pennies in zoos.” Liver and pancreas zinc levels in the Picher, Oklahoma trumpeter swan diagnosed with zinc poisoning were also elevated (Carpenter *et al.*, forthcoming). 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).

Sources of Contaminants

History of Mining in Cherokee County

The history of mining goes back over 150 years in the Tri-State Mining District. Mining for lead and zinc began first in Missouri in the 1850s and by the 1870s spread to Cherokee County, Kansas, and finally to Ottawa County, Oklahoma by the early 1900s (Dames & Moore 1993a). Production in Cherokee County peaked in the 1920s and 1930s, then diminished until it ceased in the 1970s (Dames & Moore 1995; KS and DOI 2003). 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 area 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).

Although shallow mining was used in some areas such as Galena, (Brosius and Sawin 2001), most mining operations in the district used underground techniques (Dames & Moore 1993a). Room-and-pillar methods, in which rooms were mined for their ore while leaving pillars to support the roof, were common (Brosius and Sawin 2001). 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 1993a).

Dames & Moore (1993a) indicates that "[e]arly mining was characterized by a multitude of small operators on 40-acre tracts with each operator conducting mining, drilling, and milling operations. This resulted in numerous shafts, waste piles, and mine structures." When higher grade ore deposits were depleted in the 1930s, larger companies could still profitably operate in the area due to central milling practices and improved technologies (Dames & Moore 1993a).

Once removed from the mines, ore was processed, and this processing produced a variety of wastes, including waste rock, chat, and tailings as described below:

- Waste rock, known as bullrock (Figure 8), 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 (Dames & Moore 1993a).
- Chat (Figures 9 and 10) 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 1993a).
- Tailings (Figure 11) 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 usually sluiced into a dammed pond in a water slurry. Therefore, many tailings piles contain ponded water (Dames & Moore 1993a).

Figure 8
Bullrock and Chat Pile at Crestline Subsite



Figure 9
Chat at Crestline Subsite



Figure 10
Chat Pile at Waco Subsite



Figure 11
Tailings Impoundment at Waco Subsite



Mining wastes once covered 4,000 acres in southeastern Cherokee County (Brosius and Sawin 2001). Although much of the Kansas waste has been removed, a considerable quantity still remains. As of 1993, the Treece and Baxter Springs subsites alone contained 3.2 million cubic yards of chat and 4.2 million cubic yards of other wastes, both of which covered about 1,250 acres (Dames & Moore 1993a).

Smelting, the process of melting or fusing ore for the purpose of separating and refining the metal, also contributed to heavy metal contamination in Cherokee County. Initially, there may have been crude log smelters associated with each mine (Dames & Moore 1995). In addition, a smelter operated at Galena in Cherokee County from about 1920 to 1970 (USACE 1995).

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 water. This water became contaminated by contact with the ore remaining in the mine walls or left behind by the miners (Brosius and Sawin 2001), and some leached into surrounding areas of groundwater and/or discharged to surface waters.

Piles of mine wastes (bullrock, chat, and tailings) also contributed to past and ongoing contamination. Mine wastes frequently contain elevated levels of metals, contaminating soils in and around the piles. In the Baxter Springs and Treece subsites, for example, researchers found that "average concentration of Cd, Fe [iron], Pb, Mn [manganese], and Zn are above baseline levels for non-agricultural soils in the immediate vicinity of surficial waste piles" (Dames & Moore 1993a).

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 1993a). 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 1993a).

Waste piles on the surface also increase ground water recharge by impeding runoff into surface waters: the water is both retained in pore spaces in the piles and is physically prevented from becoming runoff (CH2M 1987). This puts highly oxygenated rain water into contact "with a much larger quantity (surface area) of metal-rich sulfide minerals than originally present in the premining condition," 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 Boone aquifer discharges to the streambeds of Spring River tributaries (Dames & Moore 1993a).

Subsidence ponds²³ (Figure 12) 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, the Spring Branch (an ephemeral creek that runs through the Baxter Springs subsite) is "entirely contained within an area impacted by mining and streamflow is supported, at least over the short term, by seepage from a large chat-wash pond (Ballard Pond) in the upper part of the basin. It is believed that much of the dissolved cadmium present within the stream originates from this industrial pond"²⁴ (Dames & Moore 1993b).

The result of all these activities is past and ongoing exposure of natural resources - land, water, plants and animals - to harmful concentrations of metals, likely 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.

Figure 12
Subsidence Pond at Waco Subsite



²³ 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).

²⁴ This area was addressed in the EPA's 1997 ROD for the Baxter Springs/Treece subsite: "[t]ailing impoundments...in the Spring Branch Drainage and...in the Willow Creek drainage will be drained, filled, regraded, recontoured, capped with soil/clay cover systems, and revegetated to prevent deposition of tailings in Spring Branch and Willow Creek during storm events. Approximately 28 acres of tailings, which are surface water loading sources, will be remediated under this action."

Confirmation of Exposure²⁵

A substantial body of information is already available demonstrating past and ongoing exposure of Cherokee County natural resources to contaminants of concern. For example:

- KDHE has developed a long-term dataset that demonstrates high levels of lead, cadmium, and zinc in many of the surface waters of Cherokee Country, and exceedances of relevant water quality standards for these metals are common (Kansas Water Database);
- Some data on sediment concentrations of cadmium, lead, and zinc are available from Short Creek and other streams. These data specify concentrations that exceed published toxicity benchmarks for the protection of aquatic life (Allen and Wilson 1992; Ferrington *et al.* 1989; Jones *et al.* 1997 as cited in KS and DOI 2003);
- During the course of EPA’s (ongoing) work on the Cherokee County Superfund Site, a significant body of data has been collected documenting high concentrations of contaminants in mine wastes at levels that exceed both national average soil concentrations and concentrations thought to be toxic to vegetation (CH2M Hill 1989, Danes & Moore 1993b, Veith 1994, and EPA 1988, all as cited in KS and DOI 2003);
- Various studies have found concentrations of these metals in the shallow (Boone) aquifer that are higher than background concentrations and that exceed State of Kansas water quality criteria as well as standards promulgated under the Safe Drinking Water Act and Clean Water Act (Dames & Moore 1993a, b; Parkhurst 1987 as cited in KS and DOI 2003); and,
- Recent work has found evidence of lead and zinc poisoning in waterfowl in the Tri-State District (Carpenter *et al.* forthcoming, Sileo *et al.* 2003, Beyer *et al.*, forthcoming).

Altogether, these data confirm that natural resources in the Cherokee County area have been, and continue to be, exposed to elevated levels of these metals.

²⁵ 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.

Preliminary Determination of Recovery Period²⁶

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.

As noted in previous sections of this Plan, substantial mining activities in Cherokee County and neighboring areas were undertaken for more than a century, and measurements of lead, cadmium and zinc in the environment demonstrate that these contaminants have been present at levels associated with adverse impacts to natural resources in Cherokee County for decades. The Trustees will evaluate recovery periods for particular resources as part of the damage assessment activities identified in this Plan.

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 lead, cadmium and zinc have been and continue to be present in a wide variety of natural resources within Cherokee County. 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 Cherokee County are likely to persist for decades or longer.

²⁶ The DOI NRDA regulations require that an assessment plan include a preliminary estimate of the time needed for injured resources to recover (43 CFR §11.31(a)(2)).

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.*).

Assertion of Trusteeship²⁷

Trustees are responsible for managing natural resources for the public. The DOI and the State of Kansas are Trustees for natural resources in the State of Kansas and have developed a state-wide memorandum of Agreement (MOA) forming a Trustee Council. This Trustee Council is charged with pursuing NRDA activities for trust natural resources within the State of Kansas, including the Cherokee County Site.²⁸

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, the Governor of the State of Kansas, in a letter to Robert Stewart, DOI, dated September 25, 1997, has designated the Secretary of the KDHE as the natural resource trustee for the State of Kansas. In addition, the Kansas Department of Wildlife and Parks (KDWP) has entered into a Letter of Intent with KDHE (letter dated October 2000), to cooperate on behalf of the public, providing technical expertise on natural resources, including their supporting ecosystems, within the boundary of the State of Kansas or belonging to, managed by, controlled by, or appertaining to the State of Kansas. KDHE is the Lead Administrative Trustee for this NRDA.

The authorities under which the State of Kansas may act include, but are not limited to: Nongame and Endangered Species Conservation Act (Kansas Statute Annotated (K.S.A.) 32-957

²⁷ 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)).

²⁸ 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)).

et. seq.): general authorities of the Secretary of Wildlife and Parks (K.S.A. 32-702, Policy Statement and K.S.A. 32-807, Powers of the Secretary of Wildlife and Parks); the general authority of the Secretary of Health and Environment (K.S.A. 65-161, 65-170 and 171 *et. seq.*, water and public health; K.S.A. 65-3452a *et. seq.* Hazardous Substances; K.S.A. 65-3430 *et. seq.*, Solid and Hazardous Waste; K.S.A. 65-3001 *et. seq.* Air Quality).

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 at the Cherokee County Site is the U.S. Fish and Wildlife Service Regional Director for Region 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 has 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 resource 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.

Determination to Pursue a Type B Assessment²⁹

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 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 Cherokee County Site 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.

Steps in the NRDA Process

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

Pre-Assessment

During the pre-assessment phase, available data were collected and assessed to determine whether to proceed with a damage assessment. The results of this effort have been summarized in a PAS (KS and DOI 2003), which is available at:

<http://mountain-prairie.fws.gov/nrda/CherokeeCounty.htm>.

In the PAS, 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,

²⁹ 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)).

- (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) an official Notice of Intent to perform an assessment, dated January 22, 2003. Based on these 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 have developed this document as a Phase I Assessment Plan, which outlines routes of investigation to be pursued in the near future. As a Phase 1 plan, the Trustees consider this to be a living document, which will continue to be developed and refined as the NRDA progresses and as additional information becomes available.³⁰ 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.

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 use of a phased assessment process and studies described in this Phase I AP are clearly 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 Phase II assessment activities (if any) in light of Phase I results and preliminary evaluations of restoration/compensation needs. The results of such analyses will be presented at the conclusion of the assessment process in the Report of Assessment prepared by Trustees.

³⁰ 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 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. 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;³¹
- 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)). The result is an estimate of the total extent of resources (and their services) that need to be restored, replaced or otherwise compensated.

To determine and quantify injury to natural resources, the Trustees may rely on existing data and studies, or they may pursue targeted additional primary data collection activities as needed.

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.

³¹ 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).

Damage Determination and Restoration

In this last phase, the Trustees estimate monetary damages resulting from the release of a hazardous substance, and determine how to restore, replace, or acquire the equivalent of the injured resources and the services those resources provide. This can be done by establishing the value of the injured resources and the services they provide, or by calculating the cost of projects that will restore or replace the injured resources and their services. A variety of economic and other techniques exist that the Trustees may utilize.

A key document in this phase of the NRD process is the Restoration and Compensation Determination Plan (RCDP), in which the Trustees evaluate several restoration alternatives, select a preferred alternative, and preliminarily estimate its cost. When ready, the RCDP will be released to the public, and comments will be requested.

Coordination With Other Government Agencies, the Public, and PRPs³²

Coordination with Other Government Agencies

The Trustees are pursuing Cherokee County 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 1983 under its Superfund program, the EPA included parts of Cherokee County on the National Priorities List and has since selected and implemented specific cleanup projects for some parts of the site.

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 or 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 Cherokee County Trustees meet regularly with the EPA and the Trustees for the Missouri 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 Phase I Assessment Plan will make use of data generated through the Superfund process, as well as research undertaken through other processes or efforts.

³² 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)).

Importance of Public Participation

As stewards for the Cherokee County 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.

Kansas Department of Health and Environment
Attn: Mr. Leo Henning
Bureau of Environmental Remediation
1000 SW Jackson St., Suite 410
Topeka, Kansas 66612-1367

The public can best keep informed of ongoing NRDA developments in the Cherokee County NRDA process by visiting the website:

<http://mountain-prairie.fws.gov/nrda/CherokeeCounty.htm>.

The Trustees also recognize the special interests of Cherokee County landowners. Much of the land in Cherokee County is privately held, and conducting some of the research projects described in this Plan would 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 Cherokee County area over the years is extensive; some no longer exist due to bankruptcy, dissolution, buyouts, mergers and similar corporate events. A partial list of current, viable companies that engaged in mining and/or mining-related activities in Cherokee County and released metals in the Cherokee County environment includes: AMAX Industries, ASARCO Inc., Blue Tee Corporation, Childress Royalty Company, Doe Run Company, E.I. DuPont de Nemours & Company, Gold Fields Mining Corporation, NL Industries Inc., Sunoco Inc., and Viacom International Inc.

Some companies that mined or that participated in mining-related activities in Missouri are also relevant to this NRDA process. Mining activities in neighboring Missouri counties released contamination into surface waters that flow from Missouri into Kansas. PRPs unique to Missouri include (but are not necessarily limited to): Acme Land Company, Connor Investment Company, FSN Inc., Kellogg Brown & Root Inc., and USX Corporation. The Trustees may identify other PRPs in the course of pursuing this NRDA.

DOI's NRDA regulations require that the Trustees develop, as appropriate, procedures to split samples,³³ 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.

Kansas Department of Health and Environment
Attn: Mr. Leo Henning
Bureau of Environmental Remediation
1000 SW Jackson St., Suite 410
Topeka, Kansas 66612-1367

Invitation for Cooperative Assessment

At several points in the pre-assessment phase, the Trustees invited the PRPs to participate in a cooperative assessment of the Cherokee County Site. 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. 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 Cherokee County 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 damage claims.

³³ Split samples consist of taking a single sample and dividing it into two parts, so that each party can conduct its own analysis.

CHAPTER 4

THE CHEROKEE COUNTY NRDA: PHASE I

The purpose of this Phase I Damage Assessment Plan is to set forth near-term assessment activities the Trustees intend to pursue as part of the Cherokee County natural resource damage assessment. As a Phase I plan, this document focuses primarily on studies relating to the injury determination and quantification phases of a NRDA. A major focus of proposed Phase I activities is the evaluation of already existing data to identify the nature and extent of natural resource injuries. This is a cost-effective approach, as a substantial amount of metals contamination data in the environment has been collected as part of the Superfund process, ongoing monitoring work by Kansas state agencies, academic research, and other processes and programs. In addition, this approach is expected to generate timely information for potential settlement discussions with PRPs and identify gaps in data needed for injury assessment purposes that may become the subject of later, Phase II activities.

The Trustees recognize that pathway determination and damage determination/restoration are also integral phases of the NRDA process, and this document describes some preliminary pathway studies while acknowledging that a more complete suite of pathway and damage determination/restoration studies will likely be required. As noted above, additional injury determination and quantification studies and/or refinements to the studies described in this document may also be required. This assessment plan will be modified, or a Phase II Assessment Plan will be developed in the event that the Trustees determine that additional NRDA studies are necessary. A revised (or new) plan will be released to the public for review and comment as appropriate.³⁴

For purposes of this Phase I NRDA, 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;

³⁴ 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)).

- Ground water resources; and
- Geologic resources.

The Trustees intend to concentrate their initial 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.

NRDA studies can be placed into the following broad categories: (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 in the near term. Studies may be added, revised, or removed from consideration based on public comments and the acquisition of additional information. Detailed study plans will be developed at a later stage, in coordination with the principal investigator(s) responsible for each proposed study.

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.

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)). Cherokee County's 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 Cherokee County, including (but not necessarily limited to) the Spring River and its tributaries, Empire Lake, and Tar Creek. The following studies are aimed at evaluating the nature and extent of these injuries.

Surface Water: Exceedances of Regulatory Standards and Literature-Based Impact Thresholds

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:³⁵

- (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 resource 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 across space and time based on comparisons of measured and/or modeled concentrations of lead, zinc and cadmium to regulatory standards and literature-based thresholds for impacts to animals.

Approach: The Trustees will identify relevant water quality standards for comparison to available surface water metals contamination data from Cherokee County. In their initial review, the Trustees have determined that a number of relevant water quality standards exist for the primary contaminants of concern. 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 Kansas aquatic life criteria. The Trustees will also review relevant technical literature to identify surface water contamination thresholds for lead, zinc and cadmium at which fish and other aquatic species may experience adverse effects.

Next, the Trustees intend to identify and collect existing Cherokee County surface water metals contamination data. Several data sources are known to exist. For instance, KDHE has an ongoing, long-standing water quality sampling program that collects information on cadmium, lead, and zinc concentrations throughout the state. This program includes four permanent and six rotational water quality sampling locations in the Spring River basin. Additional datasets also exist, for instance, those listed in CH2M Hill (1987). Altogether, the Trustees plan to gather existing data and compare them to relevant regulatory and literature-based standards to

³⁵See DOI’s NRDA regulations for a complete description of injury definitions to surface waters and other natural resources (43 CFR §11.62).

determine where and when exceedances occurred and to identify temporal and spatial data gaps. Data will also be gathered and evaluated for purposes of determining the resources' baseline condition (that is, the condition that would have been expected had mining-related releases of hazardous substances not occurred).

After compiling available existing water quality data, the Trustees may determine that additional sampling is necessary to better quantify the extent of the natural resource injury. In that event, the Trustees may engage in additional targeted data-collection activities. These activities may focus on contaminant levels at various locations (for instance, in additional Spring River tributaries, upstream and downstream of tributaries or other potential input sources), different flow conditions, and/or different seasons.

Surface Water Sediments: Exceedances of Regulatory Standards and Literature-Based Impact 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 lead, cadmium and zinc 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 surface water sediment resources across space and time based on comparisons of measured and/or modeled sediment concentrations of lead, zinc and cadmium to regulatory standards and literature-based thresholds for impacts to aquatic animals.

Approach: The Trustees will identify sediment thresholds (that is, concentrations of contaminants in sediments), exceedances of which are indicative of injury to aquatic species, particularly benthic invertebrates. 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 Kansas has currently established regulatory standards for lead, zinc or cadmium contamination in sediments. The Trustees will also review the technical literature to identify sediment contamination thresholds for lead, zinc and cadmium at which benthic invertebrates and other species may experience adverse effects (for example, MacDonald *et al.* 2000, and Jones *et al.* 1997 as cited in KS and DOI 2003). The Trustees will evaluate these and similar reports from the technical literature to identify thresholds most relevant for Cherokee County NRDA purposes.

The Trustees will collect existing Cherokee County sediment data (for example, Allen and Wilson 1992, Ferrington *et al.* 1989) for comparison to identified impact thresholds. Data will also be gathered and evaluated for purposes of determining the sediments' baseline condition (that is, the condition that would have been expected had mining-related releases of hazardous substances not occurred). Preliminary Trustee review of available data sources suggests that existing sediment chemistry data are limited in geographic and temporal scope. If confirmed through additional review, the Trustees may engage in targeted sediment contamination data-collection activities. The Spring River and Empire Lake are candidates for such supplemental investigations.

Sediment chemistry data are anticipated to have important implications for other Cherokee County NRDA studies, such as the aquatic biota investigations described below. To maximize the efficiency of the data collection and to ensure comparability of analytical results, the collection of sediment data will be undertaken in close coordination with other NRDA efforts.

Aquatic Organisms

Biologic resources, including aquatic organisms, are a key component of this damage assessment. As part of Phase I 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 Cherokee County aquatic biota.

Fish, Shellfish, and Other Aquatic Macroinvertebrates

Many species of aquatic organisms are present in Cherokee County surface waters, and some may have been and/or continue to be impacted by metals contamination. Nineteen species of fish found in the Spring River have special status. These include the Kansas- and nationally-listed threatened Neosho madtom (*Noturus placidus*), the Kansas-listed threatened species Arkansas darter (*Etheostoma cragini*), the Kansas threatened redspot chub (*Nocomis placidus*), and 16 SINC fish species (Appendix A).

A number of threatened and endangered mussel species also live in the waters of Cherokee County. 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.

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.

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 across space and time.

Approach: As of the date of this plan, consumption advisories or bans have not been issued by the State of Kansas for any fish or shellfish species present in Cherokee County surface waters. Preliminary Trustee analysis indicates that concentrations of metals in fish,³⁶ although significantly elevated, do not exceed tolerance levels established under section 402 of 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.

The methods used to evaluate existing data and the specific injuries that are assessed will be dependent on the types of data that are available. For instance, the Trustees may collect information on measured and/or modeled contamination levels in aquatic organisms and

³⁶ As of the date of this plan, metals data in Cherokee County shellfish were not available.

compare these levels with effects thresholds identified in the technical literature. In addition, the Trustees note that KDHE's ongoing Stream Biological Monitoring Program collects data on mussel and macroinvertebrate communities throughout the state. Using these data, the Trustees may be able to compare Cherokee County aquatic communities with those at suitable reference sites. These comparisons will consider factors such as similarity of habitat and potential non-mining related impacts. Depending on the results of preliminary efforts, the Trustees may also pursue laboratory-based or *in situ* (at the site) ecotoxicological studies.

Waterfowl

The Trustees are concerned that Cherokee County birds, including waterfowl, may be suffering from adverse effects as a consequence of exposure to cadmium, lead, and/or zinc. As part of Phase I 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 Cherokee County.

Approach: The Trustees will gather and review existing data on Cherokee 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.

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.

Small Mammals

Cherokee County supports 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 Cherokee County, 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 Cherokee County (for example, data collected as part of the Baxter Springs/Treece ecological risk assessment, Dames & Moore 1993b). 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 Cherokee 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.

Other Terrestrial Species

Cherokee County supports 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.

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

Although most of the Cherokee 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 Cherokee 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 Cherokee County, and to evaluate the health of the plant communities at these sites in comparison to suitable reference locations.

Approach: 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. As part of this effort, available soils data (for example, Dames & Moore 1993a) will also be gathered and evaluated for their utility. If available data are insufficient, additional data collection activities may be conducted.

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.

Cherokee County’s ground water resources include the Roubidoux and Boone aquifers. Both aquifers have been used as drinking water supplies to local residents; the Roubidoux has also been used as a source of industrial, domestic, and livestock water.

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, surface water resource 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 will identify relevant Federal and State of Kansas water quality standards, the exceedance of which would constitute an injury. In their initial review, the Trustees have determined that a number of relevant water quality standards exist for the primary contaminants of concern. These standards include criteria promulgated under the Clean Water Act and the Safe Drinking Water Act.

The Trustees intend to identify and compile existing Cherokee County ground water quality data: for example, EPA collected ground water data from pits and taps during the course of its Superfund process. Altogether, the Trustees plan to gather extant data and compare them to relevant water quality standards to determine where and when exceedances occurred. Data will also be gathered and evaluated for purposes of determining the aquifer's baseline condition (that is, the condition that would have been expected had mining-related releases of hazardous substances not occurred). During the course of this analysis, the Trustees may determine that additional sampling is necessary to better quantify the extent of the injury. In that event, the Trustees may engage in additional targeted data-collection activities.

Ground water contribution to injuries of other resources is an important consideration; however, such evaluation is more likely appropriately conducted after Phase I studies are completed, and the spatial and temporal extent of injuries to other Cherokee County resources is better known.

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)). Cherokee County’s geologic resources are a high priority to the Trustees because they support key terrestrial habitats such as native prairies, and these habitats are in turn important to terrestrial 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 Cherokee County. The following study is aimed at evaluating the nature and extent of these injuries.

Soils: Exceedances of Literature-Based Impact Thresholds

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 including lead, zinc and cadmium 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. Preliminary Trustee review suggests that a number of potentially relevant thresholds exist for the contaminants of concern. The Trustees will continue their review of the literature and identify thresholds that are most applicable to Cherokee County.

The Trustees will also collect and evaluate existing Cherokee County soil data, including the soil and mine waste analytical chemical data collected during the course of EPA’s Superfund activities (for example, Dames & Moore 1993a). Data will also be gathered and evaluated for purposes of determining the soils’ baseline condition (that is, the condition that would have been expected had mining-related releases of hazardous substances not occurred). Based on a preliminary review of this information, the Trustees anticipate that insufficient soil data exists for adequately evaluating injury to soils. If so, the Trustees may decide to collect and analyze additional soil and/or mine waste samples. The measured values will be compared to relevant literature-based thresholds to assess the probability that soil invertebrates, vegetation or other terrestrial animals may be (or may have been) injured as a consequence of exposure to metals-contaminated soils.

Co-located soil contamination data will be a key component of other Cherokee County NRDA studies. To maximize the efficiency of the data collection and to ensure comparability of analytical results, collection of any soil data will be undertaken in close coordination with assessment efforts required as part of other NRDA studies.

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 Cherokee County are complex. Past mining operations have caused the release of lead, cadmium and/or zinc directly or indirectly into the Cherokee County environment. The Trustees will consider the need for and focus of additional pathway studies after completion of the Phase I activities identified in this Plan.

Preliminary Contamination Allocation

The Trustees intend to conduct a preliminary study that (a) identifies PRPs associated with specific current and former mine waste locations, and (b) evaluates the relative contributions of different mine waste piles (and therefore different PRPs) to associated contamination and natural resource injuries. Mine wastes are an important source of metals contamination within the County, and this preliminary study will begin to assess the relative responsibility of the various PRPs for contamination and associated natural resource adverse impacts at different locations.

Objective: To associate contamination in (and injuries to) Cherokee County terrestrial, surface water, and ground water resources with specific current or former PRPs.

Approach: The Trustees plan to conduct a GIS-based³⁷ analysis that may include mapping mine waste footprints, lease and property boundaries, stream segments, ground water gradients, and other information. The scope of the analysis may not be limited to Cherokee County but could also include potential contaminant sources from outside of the county (for instance, inputs via creeks flowing from Missouri). The Trustees intend to use these data to apportion damages for injuries to natural resources associated with mine waste piles, including potential injuries to associated stream segments and areas of terrestrial and groundwater contamination.

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.

Implementation of the damage determination phase is dependent upon completion of a Restoration and Compensation Determination Plan (RCDP). Among other tasks, the RCDP lists a range of restoration or other compensation alternatives, selects one or more alternatives as appropriate to pursue, and provides a rationale supporting that selection. While the DOI NRDA regulations allow Trustees to include the RCDP as part of the Assessment Plan, the Trustees in this case have determined that it is not practicable to complete the RCDP at this time. The DOI regulations also allow development of the RCDP later in the NRDA process. The Trustees will prepare and release a draft RCDP for public review when they have determined that adequate information is available. The Trustees similarly believe that it is premature at this stage to propose specific damage determination or restoration studies, anticipating that such studies are likely to be best accomplished in a Phase II assessment plan or similar document.

³⁷ GIS stands for geographic information systems and consists of a set of tools for overlaying and spatially analyzing different kinds of geographic information (for example, political boundaries, river and stream locations, property boundaries, land use information, etc.).

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CHAPTER 5

QUALITY ASSURANCE MANAGEMENT

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 to this effort are the FWS guidelines developed under the Information Quality Act of 2001. All information developed in this NRDA will be in compliance with these guidelines.

This Phase I Assessment Plan includes studies that evaluate existing datasets as well as studies that generate new 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 new data and analyses developed by Federal and state agencies, academics, and information developed under the auspices of other activities or programs. For new studies that are specifically undertaken to support the NRDA process, appropriate study-specific QAPs will be developed according to the general principles described below.

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, a cross-study analytical chemistry QAP will be developed 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.

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 Cherokee County Site 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 study plan.

In general, a study plan must provide sufficient detail to demonstrate that:

- the project technical and quality objectives are identified and agreed upon;

- the intended measurements, data generation, or data acquisition methods are appropriate for achieving project objectives;
- assessment procedures are sufficient for confirming that data of the type and quality needed and expected are obtained; and
- any limitations on the use of the data can be identified and documented (EPA 2001).

Accordingly, specific study plans developed for this assessment will include the four elements called for by EPA:

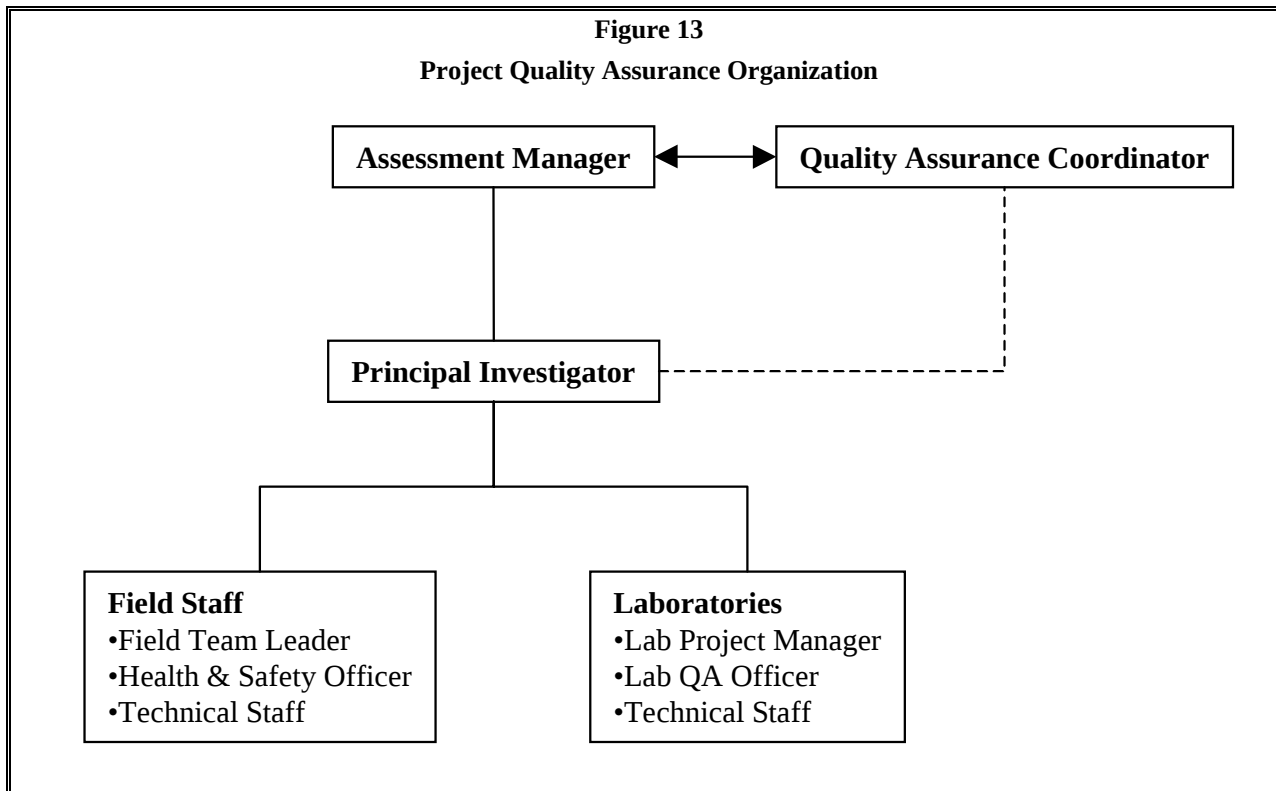
- **Project Management** - documents that the project has a defined goal(s), that the participants understand the goal(s) and the approach to be used, and that the planning outputs have been documented;
- **Data Generation and Acquisition** - ensures that all aspects of project design and implementation including 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** - assesses the effectiveness of the implementation of the project and associated QA and QC activities; and,
- **Data Validation and Usability** - addresses the QA activities that occur after the data collection or generation phase of the project is completed.

Project Management

Effective implementation of projects' objectives requires clear project organization, which 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. Figure 13 below presents a reasonable generic personnel plan for a NRDA project.

The Assessment Manager is the designated Trustee representative (from USFWS or the State of Kansas) 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 the Cherokee County 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: reviewing/assisting the Principal Investigator with the development of project-specific study plans; 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 Cherokee County NRDA study.



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.

Data Generation and Acquisition

All studies under the direction of the Trustees that are specifically undertaken in support of the Cherokee County 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 QA Coordinator or designee. Each study plan should describe and/or include, at a minimum:

- 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).³⁸ 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.

³⁸ EPA's GLPs were promulgated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Toxic Substances Control Act (TSCA) (40 CFR Part 160 for FIFRA and 40 CFR Part 792 for TSCA). Adherence to EPA's GLPs is not required in NRDA; however, adherence to GLP standards helps ensure the quality and integrity of test data.

Assessment and Oversight

To ensure that the study plan for each project is implemented effectively, the QA Coordinator will review quality assurance/quality control plans for all Trustee studies that generate data. The QA Coordinator or designee will also audit all such studies. 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.

Data Validation and Usability

In addition to the assessment and oversight activities described previously, analytical data will be considered for validation 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 2002).

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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 USC 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 Kansas 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.

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 pre-assessment 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 USC 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 In Need of Conservation (SINC) - a species that is likely to become a threatened species within the foreseeable future, as designated by the State of Kansas.

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 Kansas 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 Cherokee County Site, the Trustee Council includes the United State Department of the Interior (DOI) and the State of Kansas.

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.

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REFERENCES

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- 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). 1999b. ToxFAQs: Lead. Accessed 11/25/03 at <<http://www.atsdr.cdc.gov/tfacts13.html>>.
- Agency for Toxic Substances and Disease Registry (ATSDR). 1999c. Toxicological Profile: Cadmium. Health Effects. Accessed 4/8/04 at <<http://www.atsdr.cdc.gov/toxprofiles/tp5-c2.pdf>>.
- Allen, G.T., and Wilson, R.M. 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.
- Beyer, W.N., J. Dalgarn, S. Dudding, J.B. French, R. Mateo, J. Miesner, L. Sileo, and J. Spann. Zinc and lead poisoning in wild birds in the Tri-State Mining District (OK, KS, MO). Archives of Environmental Contamination and Toxicology. Forthcoming.
- 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 4/12/04 at <http://www.kgs.ukans.edu/Publications/pic17/pic17_1.html>.
- Carpenter, James W., Andrews, Gordon A., Beyer, W. Nelson. Zinc toxicosis in a wild trumpeter swan (*Cygnus buccinator*). Journal of Wildlife Diseases. Forthcoming.
- CH2M Hill. 1987. Technical memorandum: Water quality of surface water in the Cherokee County Site area Kansas. 102-7L37/W68540. July 29.
- CH2M Hill. 1988. Final draft groundwater and surface water operable unit feasibility study: Galena Subsite, Cherokee County Site, Kansas. Volume 1 of 3. February 26.
- City of Pittsburg. 2003. Stormwater Utility Feasibility Study. Accessed 1/28/04 at <http://www.pittks.org/stormwater/sw_report.pdf>.
- Cross, F. B. and J. T. Collins. 1995. Fishes in Kansas. Natural History Museum, University of Kansas, Lawrence, Kansas. 315 pp.

- Collins, J.T., S.L. Collins, J. Horak, D. Mulhorn, W. Busby, C.C. Freeman and G. Wallace. 1995. An illustrated guide to endangered or threatened species in Kansas. University Press of Kansas. 140 pp.
- Cope, C.H. 1985. The Spring River drainage basin: A Kansas resource in need of a management plan. Project completion report, Contract No. 40.
- Dames & Moore. 1993a. Final remedial investigation for Cherokee County, Kansas, CERCLA Site: Baxter Springs/Treece subsites. January 27.
- Dames & Moore. 1993b. Final ecological risk assessment for Cherokee County, Kansas, CERCLA site: Baxter Springs/Treece subsites. March 24.
- Dames & Moore. 1995. Final Remedial Investigation Neck/Alba, Snap, Oronogo/Duenweg, Joplin, Thoms, Carl Junction, and Waco Designated Areas. Jasper County Site. Jasper County, Missouri. Prepared for the Jasper County Respondents and the U.S. Environmental Protection Agency. October 31, 1995.
- 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., Taylor, M.C., Taylor, K.W., Hodson P.V. 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.
- Eisler, Ronald. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, and Animals. Volume 1: Metals. Boca Raton: Lewis Publishers, 2000.
- Ferrington, Leonard C. Jr., O. Karmie Galle, Mary Anne Blackwood, Chris A. Wright, Franz J. Schmidt and Joy 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.
- Kansas Administrative Regulations (KAR). 2003. Nongame, threatened and endangered species. Office of the Secretary of State, Kansas Administrative Regulations 115-15-1 and 115-15-2, 5:600-606.
- Kansas Department of Health and Environment (KDHE). 1980. Water Quality Investigations of Lead-Zinc Mine Drainage Effect on Spring River and Associated Tributaries in Kansas 1978-1979. Water Quality Management Section. December 1980.
- Kansas Department of Health and Environment (KDHE). 2004. 2004 TMDLs for the Neosho Basin. Accessed 5/19/04 at <<http://www.kdhe.state.ks.us/tmdl/NE2004.html>>.

- Kansas Department of Health and Environment (KDHE). 2003. Kansas Surface Water Register. November 12. Accessed 5/19/04 at: <<http://www.kdhe.state.ks.us/befs/download/2003register.pdf>>.
- Kansas Department of Health and Environment (KDHE). 2004. Unpublished water quality data. Kansas Surface Water Quality Database. Topeka.
- 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. Arch. Environ. Contam. Toxicol. 39:20-31.
- National Park Service (NPS). 1982. Rivers, Trails & Conservation Program - Kansas Segments. Accessed 4/9/04 at <<http://www.nps.gov/ncrc/programs/rtca/nri/states/ks.html>>.
- Obermeyer, B.K., D.R. Edds, and C.W. Prophet. 1995. Distribution and abundance of Federal "candidate" mussels (*Unionidae*) in southeastern Kansas. Final Report, Contract Number 36, Kansas Department of Wildlife & Parks, Emporia.
- Obermeyer, B.K., Edds, D.R., Prophet, C.W., and Miller, E.J. 1997. Freshwater mussels (*Bivalvia: Unionidae*) 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.
- Sileo, N., W.N. Beyer and R. Mateo. 2003. Pancreatitis in wild zinc-poisoned waterfowl. Avian Pathology 32(6):655-660.
- State of Kansas and U.S. Department of the Interior (KS and DOI). 2003. Preassessment screen and determination: Cherokee County Superfund Site, Cherokee County, Kansas.
- U.S. Corps of Engineers (USACE). 1995. Remedial Action Report for Operable Unit #05 - Ground Water/Surface Water of the Galena Subsite, Cherokee County Superfund Site, Cherokee County, Kansas. September. 19 pp.
- U.S. Environmental Protection Agency (EPA). 1997. EPA Superfund Record of Decision: Cherokee County OUs 3 & 4, Cherokee County, Kansas. EPA 541-R97-073. August.
- U.S. Environmental Protection Agency (EPA). 2001. EPA Requirements for quality assurance project plans for environmental data operations. EPA/QA/R-5. EPA/240/B-01/003. March.
- U.S. Environmental Protection Agency (EPA). 2002. Guidance on environmental data verification and data validation. EPA/QA/G-8. EPA/240/R-05/004. November.

- U.S. Geological Survey. WATSTORE Streamflow Characteristics File. Accessed 1/9/04 at <<http://water.usgs.gov/GIS/metadata/usgswrd/sfbc.html>>.
- 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. Cadmium - Environmental Aspects. International Programme on Chemical Safety: Environmental Health Criteria 135. Published under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation, and the World Health Organization. Geneva.

APPENDIX A ENDANGERED, THREATENED, AND SINC** SPECIES IN CHEROKEE COUNTY			
Species	Habitats	Federal Status	Kansas Status
Invertebrates			
Bleedingtooth (<i>Venustaconcha ellipsiformis</i>)	Spring River		Endangered
Creeper (<i>Strophitus undulatus</i>)	Spring River, Cow Creek		SINC**
Elktoe (<i>Alasmidonta marginata</i>)	Spring River		Endangered
Fatmucket (<i>Lampsilis siliquoidea</i>)	Spring River, Cow Creek		SINC**
Fawnsfoot (<i>Truncilla donaciformis</i>)	Spring River		SINC**
Flutedshell (<i>Lasmigona costata</i>)	Spring River		Threatened
Neosho midget crayfish (<i>Orconoctes macrus</i>)	Spring River		SINC**
Neosho mucket (<i>Lampsilis rafinequeana</i>)	Spring River	Candidate	Endangered
Ouachita kidney-shell (<i>Ptychobranhus occidentalis</i>)	Spring River		Threatened
Rabbitsfoot (<i>Quadrula cylindrica cylindrica</i>)	Spring River		Endangered
Round pigtoe (<i>Pleurobema sintoxia</i>)	Spring River		SINC**
Spike (<i>Elliptio dilatata</i>)	Spring River		SINC**
Wabash pigtoe (<i>Fusconaia flava</i>)	Spring River, Cow Creek		SINC**
Wartyback (<i>Quadrula nodulata</i>)	Spring River		SINC**
Western fanshell (<i>Cyprogenia aberti</i>)	Spring River		Endangered
Yellow sandshell (<i>Lampsilis teres</i>)	Spring River, Cow Creek, Brush Creek		SINC**
Fish			
Arkansas darter (<i>Etheostoma cragini</i>)	Spring River, Shoal Creek, other creeks	Candidate	Threatened
Banded darter (<i>Etheostoma zonale</i>)	Spring River, Shoal Creek		SINC**
Banded sculpin (<i>Cottus carclinae</i>)	Shoal Creek		SINC**
Black redhorse (<i>Moxostoma duquesnei</i>)	Spring River, Shoal Creek		SINC**
Bluntnose darter (<i>Etheostoma chlorosoma</i>)	Various small streams in Spring River Basin		SINC**
Gravel chub (<i>Erimystax x-punctatus</i>)	Spring River, Shoal Creek		SINC**
Greenside darter (<i>Etheostoma blennioides</i>)	Spring River, Shoal Creek		SINC**

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Species	Habitats	Federal Status	Kansas Status
Neosho madtom (<i>Noturus placidus</i>)	Spring River	Threatened	Threatened
Northern hogsucker (<i>Hypentelium nigricans</i>)	Shoal Creek, Cow Creek		SINC**
Ozark minnow (<i>Notropis nubilus</i>)	Shoal Creek		SINC**
Plains minnow (<i>Hybognathus placitus</i>)	Spring River		SINC**
Redspot chub (<i>Nocomis asper</i>)	Spring River, creeks		Threatened
River darter (<i>Percina shumardi</i>)	Spring River		SINC**
River redhorse (<i>Moxostoma carinatum</i>)	Spring River		SINC**
Slough darter (<i>Etheostoma gracile</i>)	Various small streams in Spring River Basin		SINC**
Speckled darter (<i>Etheostoma stigmaeum</i>)	Spring River, Shoal Creek		SINC**
Spotfin shiner (<i>Cyprinella spiloptera</i>)	Spring River, Shoal Creek, Brush Creek		SINC**
Spotted sucker (<i>Minytrema melanops</i>)	Brush Creek, Willow Creek		SINC**
Stippled darter (<i>Etheostoma punctulatum</i>)	Spring River and various small streams in Spring River Basin		SINC**
Amphibians			
Cave salamander (<i>Eurycea lucifuga</i>)	caves, springs in forested areas		Endangered
Dark-sided salamander (<i>Eurycea longicauda melanopleura</i>)	moist areas near streams, in or near caves		Threatened
Eastern narrowmouth toad (<i>Gastrophryne carolinensis</i>)	moist woodland areas		Threatened
Eastern newt (<i>Notophtalmus viridescens louisianensis</i>)	ponds, small lakes, marshes, ditches		Threatened
Graybelly salamander (<i>Eurycea multiplicata griseogaster</i>)	cave springs or streams with rock crevices		Endangered
Green frog (<i>Rana clamitans melanota</i>)	streams, backwaters, impoundments		Threatened
Grotto salamander (<i>Typhlotriton spelaeus</i>)	cave streams		Endangered
Northern crawfish frog (<i>Rana areolata circulosus</i>)	poorly drained lowland meadows		SINC**
Northern spring peeper (<i>Pseudacris crucifer</i>)	small ponds or pools near woodlands		Threatened
Reptiles			
Alligator snapping turtle (<i>Macrolemmys temminckii</i>)	Spring River		SINC**
Northern redbelly snake (<i>Storeria occipitomaculata</i>)	woodlands		Threatened

APPENDIX A ENDANGERED, THREATENED, AND SINC** SPECIES IN CHEROKEE COUNTY			
Species	Habitats	Federal Status	Kansas Status
Mammals			
Eastern spotted skunk (<i>Spilogale putorius interrupta</i>)	woodlands, rocky grasslands		Threatened
Gray bat (<i>Myotis grisescens</i>)	possibly in caves or mine shafts	Endangered	Endangered
Birds			
Bald eagle (<i>Haliaeetus leucocephalus</i>)	riparian areas	Threatened	Threatened
Cerulean warbler (<i>Dendroica cerulea</i>)	riparian woodlands		SINC**
Henslow's sparrow (<i>Ammodramus henslowii</i>)	grasslands		SINC**
Source: Allen & Wilson (1992), modified with updated information from KDHE.			
Notes:			
** Species In Need of Conservation-- a species that is likely to become a threatened species within the foreseeable future, as designated by the State of Kansas.			