PREASSESSMENT SCREEN AND DETERMINATION
Jasper County Superfund Site, Jasper County, Missouri

by

Missouri Department of Natural Resources
U.S. Department of Interior

This is the Preassessment Screen for the Oronogo-Duenweg Mining Belt Superfund Site, also known as, and referred to herein as, the Jasper County Superfund Site, located in Jasper County, Missouri. This document has been prepared by the Missouri Department of Natural Resources (MDNR) and the U.S. Department of the Interior (DOI) who are Trustees for natural resources at the Jasper County Superfund Site (individually and collectively referred to hereinafter as "Trustees").

AUTHORITY

The Comprehensive Environmental Response, Compensation, and Liability Act (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 (FWPCA), as amended, 33 U.S.C. 1251 et seq., authorize the Federal Government, States and Indian tribes to recover damages for injuries to natural resources and their supporting ecosystems, belonging to, managed by, appertaining to, or otherwise controlled by them.

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

Through Executive Orders and the NCP, the President has designated the Secretary of the DOI to act on behalf of the public as trustee for natural resources and their supporting ecosystems, managed or controlled by the DOI. The official authorized to act on behalf of the Secretary at the Jasper County Superfund Site, Jasper County, Missouri, is the Regional Director for Region 2 of the U.S. Fish and Wildlife Service.

PURPOSE

The purpose of this Preassessment Screen is to provide a rapid review of readily available information on discharges or releases of hazardous substances and the potential resulting impacts on natural resources at the Jasper County Superfund Site, Jasper County, Missouri for which the DOI or MDNR may assert trusteeship under section 107(f) of CERCLA.

Federal Regulations at 43 CFR § 11.23(a) provide for the Trustees to complete a Preassessment Screen and make a determination as to whether there is a reasonable

probability of making a successful claim for natural resource damages before assessment efforts are undertaken. This document fulfills that requirement and follows the structure of Federal Regulations at 43 CFR Part 11. These regulations provide a method for the assessment of natural resource damages resulting from a release of hazardous substances under CERCLA. Adherence to the methods set forth in these regulations is not mandatory and does not preclude the Trustees' use of alternate methods of assessing damages or arriving at a negotiated settlement with potentially responsible parties.

SITE INFORMATION

The Jasper County Site is located within the Tri-State Mining District which encompasses the northwest edge of the Ozark Uplift in Missouri, west and south through Kansas and Oklahoma to the eastern fringe of the Great Plains. There are three separate but adjacent superfund sites within the Tri-State Mining District; the Jasper County Site, the Cherokee County Superfund Site in Cherokee County, KS and the Tar Creek Superfund Site in Ottawa County, OK.

This Preassessment Screen addresses only the Jasper County Superfund Site portion of the Tri-State Mining District and the various designated areas within and without Jasper County that comprise the Jasper County Site. The Trustees recognize that there may be injuries to natural resources, resulting from releases within the Jasper County Site that occur outside of the State of Missouri. This Preassessment Screen does not cover those injuries or damages outside of the State of Missouri that have or may result from releases or discharges from within the Jasper County Site. Injuries or damages outside of the State of Missouri that have or may result from releases or discharges from within the Jasper County Site may be addressed as part of separate actions at the Cherokee County and Tar Creek sites. The Trustees are Partners of the Tri-state Mining District Natural Resource Restoration Inter-governmental Partnership. As such, the Trustees are communicating, coordinating, and cooperating with other Partners and Natural Resource Trustees throughout the Tri-State Mining District.

1) Time, quantity, duration and frequency of the discharge or release

Contaminants at the Jasper County Superfund Site are consistent with waste produced through the mining, milling and smelter processes that took place at this location starting in the mid-19th century. Mine production for lead and zinc peaked in 1916 and continued until 1957. Sources of hazardous substances at the site include subsurface sources associated with underground mine workings, and surface sources associated with the placement and disposal of mine wastes. Flooded mine shafts and underground mine workings have exposed mineralized areas, leading to the contamination of groundwater as it has come into contact with ore and subsurface wastes. Injured groundwater estimates at the Jasper County Superfund Site range between 400,000 to 740,000 acre-feet. Contaminated groundwater, in turn, serves as a surficial source as seeps. Other surficial sources of hazardous substances include chat piles, tailing sites, development and waste rock piles, subsidence ponds and contaminated soils.

Unvegetated and partially vegetated mine wastes cover over 3,600 acres of the Jasper County Superfund Site. In addition, soils within 200 ft of mine waste piles also contain hazardous substances that are on average several times greater than background soils with maximum concentrations up to three orders of magnitude greater than background. These contaminated soils within 200 ft. of the waste piles cover approximately 4,000 additional acres at the site.

2) The hazardous substances released

Much of this waste is highly contaminated with hazardous substances, including cadmium (CAS # 7440439), lead (CAS # 7439921) and zinc (CAS # 7440666). These compounds or mixtures have been identified under CERCLA §101 (14) as hazardous substances (40 CFR §302, Table 302.4).

3) History of the current and past use of the Site

The topography of Jasper County is largely one of low rolling hills and plateaus at elevations of approximately 1,000 feet above sea level. The principal drainage system for Jasper County is the Spring River Basin and its tributaries, the most important of which are Shoal Creek, Turkey Creek, Short Creek, Center Creek, Spring River and the North Fork of the Spring River. The land uses in this area are unimpacted natural land, mining-related, urban, and arable agriculture (mainly wheat, sorghum, corn, soybeans, and hay).

Lead and zinc mining began in Jasper County in the mid-19th century and reached peak production around 1916. Diminishing production led to the closure of the mining industry in Jasper County by 1957. After nearly 150 years of mining and smelting, chat piles, tailings sites, development and waste rock piles, and subsidence ponds were and are prominent features of the landscape. While it has been estimated that a substantial portion of the mine waste has been removed from the Jasper County Superfund Site to provide, *inter alia*, aggregate for buildings and roads, thousands of acres of wastes still remain on the surface of the ground.

4) Relevant operations occurring at or near the Site

Mining operations were principally underground and involved sinking shafts to subsurface ore bodies. In general, the raw ore was brought to the surface and crushed in stages with the metals being separated by gravity separation or flotation. Waste rock, development rock, chat, and tailings materials were usually dumped at the surface in waste piles. Many wastes were re-milled as more efficient separation techniques became available. Initially there may have been crude log smelters associated with each mine. However, these smelters were later consolidated, and by the late 1800s only three remained in Jasper County.

5) Additional hazardous substances potentially released from the Site

Other hazardous substances potentially released from the Jasper County Superfund Site include copper (CAS # 7440-50-8), selenium (CAS # 7782-49-2) and acid mine drainage.

6) Potentially responsible parties
The Potentially Responsible Parties at this site include, but are not limited to, Acme Land Company; ASARCO, Inc.; Blue Tee Corporation (Beazer East, Inc.); Childress Royalty Company; Conner Investment Company; E.I. duPont de Nemours and Company; FSN, Inc.; Gold Fields Mining Corporation; Kellogg Brown & Root, Inc.; NL Industries Inc.; Paramount Communications (Viacom, Inc.); St. Joe Minerals Corporation (The Doe Run Company); Sun Company, Inc. (Sunoco, Inc); and, USX Corporation (United States Steel Corporation).

No Statutory Exclusions from Liability under CERCLA Apply at this Site
Damages resulting from the discharge or release of the hazardous substances at the Jasper County Superfund Site were not identified in any environmental impact statement, pursuant to the National Environmental Policy Act (NEPA), as amended {42 U.S.C. 4321 et seq.}, or any similar review or document.

The release of the hazardous substances at the Jasper County Superfund Site are ongoing and did not occur wholly before enactment of CERCLA, nor the 1977 amendments to the FWPCA. Injuries to natural resources and resultant damages to the public from the release or discharge of the hazardous substances are ongoing and did not occur wholly before enactment of CERCLA, nor the 1977 amendments to the FWPCA.

The hazardous substances at the Jasper County Superfund Site are not pesticide products registered under FIFRA (7 U.S.C. 135-135k). Damages resulting from the discharge or release of the hazardous substances at the Jasper County Superfund Site did not result from the application of a FIFRA registered pesticide product.

Damages resulting from the discharge or release of the hazardous substances at the Jasper County Superfund Site did not result from any federally permitted release as defined in CERCLA §101(10).

The hazardous substances are not recycled oil products as described in CERCLA §107(a)(3) or (4). Damages resulting from the discharge or release of the hazardous substances at the Jasper County Superfund Site did not result from release of a recycled oil product.

Preliminary identification of pathways
Surficial mine and mill wastes, soils, and groundwater all act as sources of hazardous substances (including Cd, Pb, and Zn) to the environment at the Jasper County Site. Hazardous substances can be released directly from these sources into the air, groundwater, surface water, and soils.

Smelters can release metals directly into the air, where they can potentially be moved and later deposited in another location. In addition, air can entrain metals as it flows over fugitive dust sources such as chat piles.

Rain water percolating through the mine waste piles can leach hazardous substances into the soil beneath the waste pile. Groundwater can also be affected as it flows through underground mine workings and comes into contact with exposed ore bodies.

Surface water can receive hazardous substances directly from erosion of various types of mine waste products during runoff. In addition, infiltration of water into waste piles can mobilize hazardous substances into solution, resulting in contaminated runoff to surface water.

Air, groundwater, surface water, and soils may receive hazardous substances not only directly from the sources, but also from each other. Air can transport hazardous substances and deposit them directly into surface water or onto soils. Hazardous substances can also move back and forth between ground and surface water through discharge and recharge.

Terrestrial and aquatic biota may be exposed to contaminants in environmental media either directly (for example, plants exposed directly to hazardous substances in soils) or indirectly through food chain transfer.

Average concentrations of cadmium, lead and zinc in the shallow aquifer of the Jasper County Superfund Site exceed background concentrations by up to one order of magnitude. Mean cadmium concentrations in surface water are as high as one order of magnitude greater than background, and mean lead and zinc concentrations are as high as two to three orders of magnitude above background. Cadmium, lead and zinc concentrations in sediments of affected areas are greater than site background concentrations by one to two orders of magnitude. Soil cadmium, lead and zinc concentrations in Jasper County are elevated over background concentrations by as much as one to two orders of magnitude.

Concentrations of all three metals are elevated in fish and invertebrate tissues from organisms collected in Jasper County. Little background data exist for metals concentrations in the tissues of terrestrial biota, however, studies of earthworms from Jasper County indicate that organisms closer to mine wastes have more elevated concentrations of hazardous substances than those further away (Fitzpatrick et al., 1999).

Exposed Areas

Areas exposed to the released hazardous substances include the waters, wetlands, banks, sediments, soil and biota of the Jasper County Superfund Site. In addition, areas downstream of the Jasper County Superfund Site may be impacted.

Exposed Water Estimates

The principal drainage system for Jasper County is the Spring River Basin and its tributaries, the most important of which are Shoal Creek, Turkey Creek, Short Creek, Center Creek, Spring River, and the North Fork of the Spring River. All of these

streams may be impacted by the release of hazardous substances as well as the intermittent channels which provide flow to these streams. Turkey Creek, Center Creek, and Short Creek have been impacted by the release of hazardous substances as is demonstrated by recorded exceedances of water quality criteria.

Estimates of Concentrations

Remedial Investigation data from Dames & Moore (1995) and CDM (1995) show that the shallow aquifer groundwater continues to exceed groundwater criteria for several different contaminants. The Dames & Moore data from the seven designated areas include over 170 samples taken from over 88 different locations. At least 34 samples exceeded the 5 µg/L cadmium criterion, with three samples containing cadmium concentrations in excess of 100 µg/L. The 15 µg/L lead criterion was exceeded in 35 samples, with seven samples containing lead in excess of 100 µg/L and one with nearly 300 µg/L lead, almost 20 times greater than the lead criterion. The zinc criterion of 5,000µg/L was exceeded in 16 samples from the seven designated areas, including five samples in excess of 9,100 µg/L (the CWA criterion) and two greater than 20,000 µg/L.

Two studies (Barks, 1977 and Dames and Moore, 1995) included water samples from Center Creek. In both studies, some samples had zinc concentrations exceeding the ambient water quality criteria (AWQC) criteria maximum concentration (CMC), and a distinct trend of increasing zinc concentrations were seen in samples taken downstream in Center Creek. In the 1970s, zinc concentrations exceeded the criterion of 210 µg/L, with a maximum of over 500 µg/L. A sample from the 1980s taken from near Smithfield, Missouri contained 250 µg/L zinc (Spruill, 1984). Zinc concentrations were lower by the early 1990s during sampling for the Remedial Investigation. However, a sample near Oronogo and one near Carl Junction did contain zinc in excess of the CMC (Dames & Moore, 1995). Concentrations of zinc in Turkey Creek have often exceeded the AWQC CMC. Barks (1977) measured zinc as high as 500 µg/L near Joplin. All three of the Remedial Investigation samples taken downstream of mining activity in Turkey Creek contained zinc well in excess of the CMC (Dames & Moore, 1995), and a maximum of 350 µg/L when hardness was less than 100mg/L. These data indicate that zinc concentrations have been and most likely continue to be sufficient to cause injury to Turkey Creek. Few samples have been collected from Short Creek in Jasper County: Barks (1977) analyzed one sample, Spruill (1984) analyzed two samples, and Dames & Moore (1995) analyzed two samples. Barks (1977) reported cadmium and lead samples in excess of the current criteria continuos concentration (CCC; 3.7 and 5.3mg/L, respectively), and zinc in excess of the CMC (210 mg/L). The zinc concentration was 1,600µg/L, an order of magnitude greater than the CMC. Spruill (1984) did not detect any cadmium or lead, but zinc was as high as 670 µg/L. The samples from the Remedial Investigation contained low hardness (70-80mg/L) and therefore had lower criteria. Cadmium exceeded the CCC in both samples, lead in one sample, and zinc in both samples, with zinc concentrations as high as 489 µg/L, nearly five times greater than the CMC at that hardness (Dames & Moore, 1995).

Chat samples from all the designated areas contain average cadmium concentrations

ranging from 29 to 63 mg/kg, average lead concentrations from 580 to 1,010mg/kg, and average zinc concentrations from 7,000 to 16,230 mg/kg. Maximum concentrations of cadmium were 80-362 mg/kg, lead 844-13,000 mg/kg, and zinc 19,300-55,000 mg/kg (Dames & Moore,1995). These concentrations are up to three orders of magnitude greater than background soil concentrations. In addition, in the seven Jasper County designated areas, maximum copper and selenium concentrations were elevated above background; the maximum copper concentration exceeded 500mg/kg, over 30 times greater than background, and maximum selenium concentrations were more than twice the background concentration. The average and maximum concentrations of cadmium, copper, lead, selenium and zinc in tailings from the seven Jasper County designated areas were higher than those in chat or waste rock. Dames & Moore (1995) measured concentrations as high as 644 mg/kg cadmium, 379 mg/kg copper, 24,100 mg/kg lead, 17 mg/kg selenium, and 71,500 mg/kg zinc. These maximum concentrations range from 35 to 1,430 times greater than background concentrations. The average cadmium concentrations in the soils near the mine waste ranged from 14 mg/kg up to nearly 45 mg/kg, and maximum concentrations ranged from 21 to 152 mg/kg, some 40 to 300 times greater than background. Average lead concentrations ranged from 96 to 1,800 mg/kg, with maximum reported concentrations as high as 11,000 mg/kg, some 550 times greater than background. With the exception of 57 mg/kg of zinc reported in near-site soils by Fitzpatrick et al. (1999), the average zinc concentrations ranged from 1,200 to 6,500 mg/kg. The maximum concentration of 45,400 mg/kg measured in transition soils is three orders of magnitude greater than background.

Potentially Affected Resources

Natural resources and their supporting ecosystems that have been or potentially have been affected by the discharge or release of the hazardous substances, include but are not limited to: groundwater, surface water (including sediments) and biological resources including aquatic and terrestrial plants and microorganisms; aquatic and aquatic dependent mammals; fish; and migratory birds including waterfowl, shorebirds, raptors and songbirds.

Site response investigations have documented impacts to groundwater, surface water and terrestrial environments. A 1998 Record of Decision (ROD) for Operable Unit #4 was issued for groundwater to provide bottled or public drinking water because of exceedances of groundwater drinking standards. For terrestrial environments, concentrations of cadmium, lead and zinc at unvegetated and partially vegetated mine wastes are on average one to three orders of magnitude greater than background soil concentrations. Soils within 200 ft of mine waste piles contain cadmium, lead and zinc concentrations that are on average several times greater than background soils with maximum concentrations up to three orders of magnitude greater than background. Concentrations of hazardous substances including cadmium, lead and zinc in and adjacent to mine wastes greatly exceed national and state average soil concentrations and also exceed concentrations known to be toxic to individual plant species (Dames and Moore, 1995; Kabata-Pendias and Pendias, 1992).

Mine water, seeps, and ponds are also sources of cadmium, lead and zinc. Flooded

mine shafts contain highly elevated concentrations of metals. Measured concentrations of zinc in one mine opening exceeded the estimated acute toxicity threshold for warmwater fish. Measured concentrations of cadmium in several mine openings exceed estimated chronic toxicity thresholds for warmwater fish. For surface waters, concentrations of zinc that are known to result in behavioral avoidance by trout have been measured in Turkey Creek, Center Creek and Short Creek (Woodward et al., 1997). Lead and zinc concentrations in Center Creek and Shoal Creek benthos, and cadmium concentrations in Spring River benthos exceed levels known to be associated with adverse dietary effects on trout (Woodward et al., 1994; Farag et al., 1997). In toxicity tests, water from Turkey Creek, Center Creek and Short Creek were acutely toxic to fathead minnows and *Ceriodaphnia dubia* and pore water from Center Creek sediments were acutely toxic to *Daphnia magna* (Dames and Moore, 1995). The number of fish species in Center and Short Creek, the number of total fish caught in Center Creek and the number of metal sensitive minnows in Center and Turkey Creek are reduced in mining-impacted reaches of these surface waters compared to nonimpacted reaches (Dames and Moore, 1995). Also, studies have indicated that zinc and cadmium may be suppressing populations of Neosho madtoms (Wildhaber et al, 1998), as well as other fish and invertebrates in the Spring River downstream of Center Creek. In addition, benthic invertebrate species richness and the number of metal sensitive benthic invertebrate organisms in Center, Shoal, Short and Turkey Creeks are reduced in mining-impacted reaches of surface waters compared to nonimpacted reaches (Dames and Moore, 1995; Schmitt et al., 1997; Allert et al., 1997).

Water samples from abandoned mine sites and from the shallow water aquifer contain concentrations of hazardous substances including cadmium, lead and zinc that exceed Safe Drinking Water Act criteria and State of Missouri groundwater standards (10 CSR 20-7.031). For some locations, these hazardous substances exceed the criteria up to three orders of magnitude.

Declines in aquatic insect biomass and metal accumulation by aquatic insects are considered potential threats to the endangered gray bat (*Myotis grisescens*), thus interfering with ecological service flows. The threatened Neosho madtom (Noturas placidus) and Ozark cavefish (*Amblyopsis rosae*) also may have been directly affected by degraded water quality at the site and the loss/contamination of prey base.

Plant communities in the Jasper County Superfund Site have been highly modified to the extent that they now provide little habitat for wildlife and the phytotoxic effects of hazardous substance in mine wastes could be responsible for some or all of the observed injuries to the vegetative communities (Dames and Moore, 1995; CDM, 1995). Wildlife species have responded to this degraded habitat by avoiding barren and vegetated chat (Cedar Creek Associates, 1999).

Other Considerations

Data is available to document the initial severity of contamination and extent of degradation of environmental quality at the Jasper County Superfund Site. Site response investigations have documented impacts to groundwater, surface water and terrestrial environments. A 1998 Record of Decision (ROD) for Operable Unit #4 was issued for groundwater to provide bottled or public drinking water because of exceedances of groundwater drinking standards. The Ecological Risk Assessment for the Jasper County Superfund Site has developed data indicating degradation of surface waters and terrestrial environments. Additional studies have been conducted by the Responsible Parties and screening studies have been initiated by the Trustees. Response actions that have been implemented as well as those being planned and evaluated in the assessment area will not sufficiently restore, replace, or provide compensation for injured natural resources without further action.

PREASSESSMENT SCREEN DETERMINATION

Based upon a review of readily available data and an evaluation of the preassessment determination criteria, summarized in this document, the Trustees have reached the following conclusions:

Discharges or releases of hazardous substances have occurred;
Natural resources for which the Trustees may assert trusteeship under CERCLA and FWPCA have been adversely affected by the discharge or release of hazardous substances;
The quantity and concentration of the released hazardous substances are sufficient to potentially cause injury to natural resources;
Data sufficient to pursue an assessment are readily available or likely to be obtained at a reasonable cost; and
Response actions planned will not sufficiently remedy the injury to natural resources without further action.

The Trustees hereby determine that further investigation and assessment is warranted and should be carried out at this site in accordance with Federal Regulations at 43 CFR §11, Subparts C and E. The Trustees further determine that current information indicates that there is a reasonable probability of making a successful natural resources damage claim pursuant to section 107 of the CERCLA and section 311 of the FWPCA and that all criteria and requirements in 43 CFR part 11, generally, and 43 CFR § 11.23(a)-(g), § 11.24 and § 11.25, specifically, have been satisfied.

The information provided and conclusions made in this Preassessment Screen shall be used to direct further investigations and assessments and is not intended to preclude consideration of other resources later found to be affected or other parties found to be responsible for releases.

References

Allert, A.L., M.L. Wildhaber, C.J. Schmitt, D. Chapman, and E. Callahan. 1997. Toxicity

of Sediments and Pore-waters and their Potential Impact on Neosho Madtom, *Noturus placidus,* in the Spring River System Affected by Historic Zinc-Lead Mining and Related Activities in Jasper and Newton Counties, Missouri; and Cherokee County, Kansas: Final Report to the U.S. Fish and Wildlife Service, Columbia Missouri. Prepared by U.S. Geological Survey Biological Resources Division, July.

Barks, J.H. 1977. Effects of Abandoned Lead and Zinc Mines and Tailings Piles on Water Quality in the Joplin Area, Missouri. U.S. Geological Survey Water-Resources Investigations
77-75. August. 49 pp.

CDM. 1995. Addendum to the Site Characterization Report in Support of Remedial Investigation Activities for the Iron Gate Extension Area for the Iron Gates, Belleville, and Klondike Designated Areas of the Jasper County Site, Jasper County, Missouri. Prepared for the U.S. EPA by CDM Federal Programs Corporation. November.

Cedar Creek Associates. 1999. Report on Wildlife Utilization of Barren Chat Piles in the Seven Jasper County DAs. Prepared for Environmental Management Services, Fort Collins, CO. January. 95 pp.

Dames & Moore. 1995. Volume I 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. EPA, Region VII. October.

Farag, A.M., D.F. Woodward, W. Brumbaugh, J.N. Goldstein, E. MacConnell, C. Hogstrand, and F.T. Barrows. 1997. Dietary effects of metals-contaminated invertebrates from the Coeur d'Alene River, Idaho, on cutthroat trout. *Transactions of the American Fisheries Society.*

Fitzpatrick, L.C., B.J. Venables, and J.A. Mota. 1999. Study of Indigenous Earthworms at the Jasper County, Missouri Superfund Site: Relationships of Earthworm Distribution, Abundance and Body-burden Concentrations of Cd, Pb and Zn to Metal Concentrations and Physico-chemical Properties of Soil, and Potential Toxicity Associated with Exposure to Soil Metals. Prepared for Environmental Management Services Co., Fort Collins, CO. December 9.

Kabata-Pendias, A. and H. Pendias. 1992. *Trace Elements in Soils and Plants*. CRC Press, Boca Raton.

Schmitt, C.J., M.L. Wildhaber, A.L. Allert, and B.C. Poulton. 1997. The Effects of Historic Zinc-Lead Mining and Related Activities in the Tri-States Mining District on Aquatic Ecosystems Supporting the Neosho Madtom, *Noturus Placidus,* in Jasper County, Missouri; Ottawa County, Oklahoma; and Cherokee County, Kansas. Final Report. Prepared by U.S. Geological Survey for the U.S. EPA, Region VII. January 27.

Spruill, T.B. 1984. Assessment of Water Resources in Lead-Zinc Mined Areas in Cherokee County, Kansas, and Adjacent Areas. USGS Open-File Report 84-439. 102 pp.

Wildhaber, M.L., A.L. Allert, C.J. Schmitt, V.M. Tabor, D. Mulhern, and K.L. Powell. 1998. Both Contaminants and Habitat Limit Neosho Madtom (*Noturus Placidus*) Numbers in the Spring River, A Midwestern Warmwater Stream Effected by Runoff From Historic Zinc and Lead Mining. 9-13 pp.

Woodward, D.F., W.G. Brumbaugh, A.J. DeLonay, E.E. Little, and C.E. Smith. 1994. Effects on rainbow trout fry of a metals-contaminated diet of benthic invertebrates from the Clark Fork River, Montana. *Transactions of the American Fisheries Society* 123:51-62.

Woodward, D.F., J.N. Goldstein, and A.M. Farag. 1997. Cutthroat trout avoidance of metals and conditions characteristic of a mining waste site: Coeur d'Alene River, Idaho. *Transactions of the American Fisheries Society* 126:699-706.

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