Mining-Related Contamination of the Spring River Flood Plain in Cherokee County, Kansas

A proposal written for the U.S. Environmental Protection Agency, Region VII

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Introduction

Historical mining activity in the Tri-State Mining District of southeast Kansas, southwest Missouri, and northeast Oklahoma (figure 1), has resulted in a substantial ongoing input of cadmium, lead, and zinc to the environment. Recent studies by the U.S. Geological Survey, in cooperation with the U.S. Fish and Wildlife Service and the Kansas Department of Health and Environment, documented cadmium, lead, and zinc concentrations in sediment that far exceeded background levels as well as probable-effects guidelines for adverse biological effects (Pope, 2005; Juracek, 2006). These studies sampled deposited sediment in the Spring River and its tributaries, Tar Creek, and Empire Lake in Cherokee County, Kansas. Adverse effects of the mining-related contamination on freshwater mussels was documented by Angelo et al. (2007).

However, the contamination is not confined to stream channels and lake beds. During high flows, contaminated sediment is carried out of the channels and deposited on the adjoining flood plains. Limited evidence of flood-plain contamination was provided by two near-channel samples of surficial flood-plain soil that were collected near the Spring River and Shoal Creek upstream from Empire Lake (Juracek, 2006, sites SRF-1 and SCF-1). For the Spring River flood-plain sample, cadmium and lead concentrations exceeded the threshold-effects guideline for adverse biological effects and the zinc concentration exceeded the probable-effects guideline. For the Shoal Creek flood-plain sample, the cadmium concentration was near the threshold-effects guideline and lead and zinc concentrations were greater than the threshold-effects guideline. Also, a sample of the original Spring River flood plain in the bottom of a sediment core collected from Empire
Figure 1. Location of lead and zinc mined areas in the Tri-State Mining District, Kansas, Missouri, and Oklahoma.
Lake contained cadmium, lead, and zinc concentrations that exceeded the probable-effects guideline (Juracek, 2006).

Objectives and Scope

The specific objectives of this proposed study are to:
(1) Determine the magnitude of contamination in the Spring River flood plain;
(2) Determine how flood-plain contamination along the Spring River varies with distance from the channel, with distance downstream, and in relation to particle size; and
(3) Determine the depth of contamination in the Spring River flood plain.

Geographically, this proposed study is limited to the Spring River flood plain in southeast Cherokee County, Kansas. If needed, the scope may be expanded to include tributary flood plains.

Relevance and Benefits

Flood-plain contamination is an important environmental concern given the potentially toxic effects of the contaminated sediment on wildlife. Moreover, the contaminated flood plains are a concern because the stored sediment may be remobilized and reintroduced into the aquatic environment (e.g., by floods and channel-bank erosion). Given the importance of flood-plain contamination as an issue for environmental restoration, an understanding of the magnitude and extent of the contamination is needed. The information provided by this proposed study will be used by the U.S. Environmental Protection Agency (USEPA) to assess flood-plain contamination as part of the development of an overall remediation plan.

Approach

Mining-related contamination in the Spring River flood plain will be assessed in two phases. In phase I, a surface-soil reconnaissance survey of flood-plain contamination will be completed. Within Cherokee County, all 1-mi² sections that are located mostly (i.e., at least 50%) or completely on the Spring River flood plain will be identified (about 30 sections total) and divided into quadrants. For each section, a quadrant will be randomly
selected for sampling. For each selected quadrant, the soil will be sampled to a depth of 2 cm at the four corners and the center (figure 2). An equal volume of soil will be collected at each of the five locations, combined, and homogenized to provide a composite sample for each quadrant. All samples will be analyzed for trace elements using XRF methods at the USEPA laboratory in Kansas City, Kansas. Each sample will be analyzed to determine trace-element concentrations in the bulk sample as well as the <63-micron fraction. Grain size will be analyzed on the bulk samples (i.e., sand vs. silt vs. clay). Additionally, to verify comparability with previous studies (i.e., Pope, 2005; Juracek, 2006), 10% of the samples will be analyzed (bulk and <63-micron fraction) using spectroscopic methods at the USGS Sediment Trace Element Partitioning Laboratory in Atlanta, Georgia. Field conditions permitting, the sampling for phase I will be completed by the summer of 2009.

In phase II, the depth of contamination in the flood plain will be assessed by selective coring. For this purpose, a series of six transects will be established. The transects will be strategically located to assess changes in contamination with distance downstream. Proposed transect locations are: (1) between the Missouri state line and the Center Creek confluence, (2) between the Center and Turkey Creek confluences, (3) between the Turkey and Short Creek confluences, (4) between the Short Creek confluence and Empire Lake, (5) between Empire Lake and the Willow Creek confluence, and (6) downstream of the Spring Branch confluence near the Oklahoma state line (figure 3). Each transect will extend perpendicularly away from, and on either side of, the Spring River to a predefined terminus (e.g., the valley wall and (or) a preset elevation). A limited number of non-transect sites also may be cored (e.g., "hotspots" identified in the surface-soil reconnaissance). Field conditions permitting, the coring for phase II will be completed in the fall of 2009.

Along each transect, regularly-spaced soil cores will be collected to provide a representative data set of soil chemistry. A total of 3-5 cores per transect is planned. Each core will be analyzed on site for trace-element content by USEPA using XRF if possible (note: moisture content in the soil cores may preclude the effective use of XRF in the field). Coring at each site will be to a depth of 16 feet, baseline trace-element content, or refusal, whichever occurs first. All core samples (bulk and <63-micron fraction) will be
Figure 2. Proposed sampling scheme to assess soil contamination in the Spring River flood plain. The white squares represent the quadrants for a selected 1-mi$^2$ section. The red stars represent the sampling locations for a randomly-selected quadrant.
Figure 3. Proposed transect locations (shown in red) for coring on Spring River flood plain.
analyzed for trace elements using XRF at the USEPA laboratory. The bulk core samples will be analyzed for grain size (i.e., sand vs. silt vs. clay).

Together, the surface-soil reconnaissance and coring will provide the information necessary to determine how soil contamination varies with distance from the river channel, with distance downstream, and with depth in the subsurface. Potentially, the results may be used to estimate the volume of contaminated flood-plain soil along the Spring River in Cherokee County.

Quality control for the chemical analysis of soil samples will be provided by an evaluation of within-site and analytical variability. Within-site variability will be evaluated by two methods. First, through the collection and analysis of sequential-replicate samples at 10% of the surface-soil sampling quadrants. Second, 10% of the quadrants also will be sampled at 15-20 locations to assess the representativeness of the 5-location sampling design. Analytical variability will be assessed by three methods. First, through the analysis of split-replicate samples (10% of total). Second, every sample will be analyzed three times to assess variability on a per-sample basis. Finally, the accuracy of laboratory analyses for selected chemical constituents will be evaluated on the basis of variation between the analyses of standard reference samples and the most-probable values for those constituents.

The project timeline is provided in table 1.

Roles of Project Participants

The participants in this study are the USGS Kansas Water Science Center (WSC), the USGS Missouri WSC, and the USEPA. Specific roles of each participant are as follows:

USGS Kansas WSC: preparation of quality assurance and sampling plan, project management, surface-soil sampling at about 30 quarter sections, delivery of surface-soil samples to USEPA, data analysis and interpretation, report preparation, and report processing and publication.

USGS Missouri WSC: coring at 20-30 sites, delivery of cores to USEPA.
USEPA: obtain permission to access sites for soil sampling and coring, assist with soil sampling and coring, analysis of all surface-soil and core samples using XRF, grain-size analysis (sand vs. silt and clay) for all bulk samples (surface-soil and core).

Product
A colleague-review draft of a report will be provided to USEPA by December 31, 2010 (contingent on receipt of all laboratory data by March 31, 2010). A final published report will be completed by September 30, 2011. The report will include a summary of previous studies that investigated mining-related contamination in Cherokee County.

Budget
Quality assurance and sampling plan preparation .................................................. $10,000
Flood-plain surface soil sampling ......................................................................... $30,000
Flood-plain coring ................................................................................................. $34,000
Laboratory analysis ............................................................................................... $4,000
Data analysis and interpretation ............................................................................. $60,000
Report preparation ................................................................................................ $50,000
Report processing and publication ........................................................................ $25,000
Total ...................................................................................................................... $213,000

References
Table 1. Project timeline.

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FA – Funding Agreement
QA – Quality Assurance Plan Development and Approval
FS – Flood-Plain Surface-Soil Sampling
FC – Flood-Plain Coring
LA – Laboratory Analysis
DA – Data Analysis and Interpretation
RP – Report Preparation, Processing, and Publication