Exponent™

Focused Feasibility Study

Collinsville Smelter Site

Prepared for

Phelps Dodge Corporation
Tempe, Arizona

Exponent™

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January 12, 2001

Rita R. Kottke
Oklahoma Department of Environmental Quality
707 North Robinson
Oklahoma City, Oklahoma 73102

Subject: Collinsville Smelter Site - Submittal of final Focused Remedial Investigation and Feasibility Study reports
Contract 8601631.002 0102

Dear Rita:

Enclosed for review by the Oklahoma Department of Environmental Quality (ODEQ) are the final Focused Remedial Investigation (RI) and Feasibility Study (FS) reports for the former Collinsville Smelter Site in Collinsville, Oklahoma. These reports were prepared by Exponent on behalf of Phelps Dodge Corporation. The final RI and FS reports reflect the comments that were provided by ODEQ on the draft versions of these reports as well as other interim submittals that were provided for this site.

Please feel free to call me at (425) 643-9803 if you have any questions regarding these reports or need any additional information.

Sincerely,

Cathy Petito Boyce

Catherine Petito Boyce, S.M.
Project Manager

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Exponent™

Focused Feasibility Study

Collinsville Smelter Site

Prepared for

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Contents

List of Figures

List of Tables

Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CoC	chemical of concern
CoPC	chemical of potential concern
Cyprus Amax	Cyprus Amax Minerals Company
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ODEQ	Oklahoma Department of Environmental Quality
PDC	Phelps Dodge Corporation
PPE	personal protective equipment
PRG	preliminary remediation goal
RAO	remedial action objective
RI/FS	remedial investigation and feasibility study
ROD	record of decision
the Site	Collinsville Smelter Site
TCLP	toxicity characteristic leaching procedure
UCL	upper confidence level

1. Introduction

On behalf of Phelps Dodge Corporation (PDC), Exponent is performing a focused remedial investigation and feasibility study (RI/FS) for the Collinsville Smelter Site (the Site) in Collinsville, Oklahoma (Figure 1-1). This work is being conducted with oversight from the Oklahoma Department of Environmental Quality (ODEQ) under Consent Agreement and Final Order No. 96-115. Given that all historical activities and agreements related to this Site have been conducted by Cyprus Amax Minerals Company (Cyprus Amax), prior to the recent acquisition by PDC, the name Cyprus Amax will generally be used in place of PDC throughout this report.

The overall approach for the Site draws upon the substantial experience that the participating parties (i.e., ODEQ, PDC and its predecessor at the site, Cyprus Amax, and Exponent) have in evaluating similar sites. This past experience, together with the initial available data for the Site, led to selection of a focused approach for the site evaluations and RI/FS. Specifically, although the approach includes all of the elements required for an RI/FS and is consistent with the U.S. Environmental Protection Agency (EPA) National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 CFR 300), experience gained at other sites has been applied to focus efforts on the likely primary contributors to potential risks posed by the Site to human health and the environment. Similarly, previous experience is being applied to more efficiently determine the likely remedial requirements for the Site. An important part of this focused RI/FS has been to ensure that conclusions drawn on the basis of experience at other sites are applicable to the conditions and characteristics of the Site.

1.1 Purpose and Organization of the Feasibility Study

The regulations and guidance developed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) were followed in preparing the feasibility study. These regulations and guidance are presented in the NCP (40 CFR 300.430) and *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. EPA 1988).

The purpose of this feasibility study is to identify and develop remedial action alternatives appropriate for the Site in order to conduct a detailed analysis in accordance with the NCP (40 CFR 300.430(e)(9)). This will allow risk managers to make an informed decision when selecting a remedy that is most appropriate for the Site.

The remainder of Section 1 provides a brief summary of background information regarding the Site. Section 2 summarizes the selection of site-specific preliminary remediation goals (PRGs) as supported by discussions presented in the remedial investigation report (Exponent 2001). A summary of the remedial action objectives (RAOs) and PRGs is presented and the preliminary areas of potential concern for soil are identified. Section 3 identifies potential remedial technologies; screens the technologies based on relative effectiveness, implementability, and cost; and assembles the remaining technologies into remedial action alternatives. Section 4 develops the remedial action alternatives in sufficient detail for the analysis and cost estimate. Section 5 presents the detailed analysis of alternatives. The alternatives are individually evaluated based on seven criteria identified in the NCP. In addition, a comparative analysis is conducted in which the alternatives are compared with one another for each criterion. Section 6 presents and discusses the recommended remedial action alternative.

The analyses presented in this report are based on the initial data collected during the remedial investigation and approaches applied in the draft feasibility study. To address comments received from ODEQ and the site owner, additional site data were collected in February 1998 and modified approaches were applied to determine remediation requirements. These additional data and modified approaches alter the geographic areas identified for remediation, but do not change the general remediation approach. Moreover, additional data that may be collected during the remedial design phase of this project may result in further changes to the area estimates and other calculations presented in this report. As a result, the analyses presented in the main text of the feasibility study have not been changed. Instead, the changes to the remediation requirements that would result from consideration of the February 1998 data and the modified approaches are discussed in Appendix C to this report.

1.2 Background

This section presents a brief summary of background information for the Site. Additional background information is presented in the remedial investigation report (Exponent 2001).

Between 1911 and 1918, a horizontal retort zinc smelter operated at the Site. The smelter was owned and operated by the Bartlesville Zinc Company. Deed records indicate that the Bartlesville Zinc Company owned approximately 220 acres of land surrounding the smelter area. In 1987, the Site was reclaimed in conjunction with the reclamation of a nearby coal mine conducted by the Oklahoma Conservation Commission. No structures related to the former smelter operations currently remain standing at the Site.

The remedial investigation and other previous investigations at the Site indicate elevated concentrations of metals in soils at the Site and in adjacent areas. The source of at least some of these metals appears to be related to former smelter operations at the Site. Based on the analyses presented in the remedial investigation, chemicals of concern (CoCs) in soils are arsenic, cadmium, and lead. Zinc, which was included as a chemical of potential concern (CoPC) in the remedial investigation, was not retained as a CoC in the feasibility study. This refinement of the CoPC list was made because zinc is primarily of concern from an ecological risk perspective and, based on the analyses presented in the remedial investigation, the potential for such risks was determined to be negligible at the Site. The remedial investigation concluded that the only medium of potential concern is soil; thus, only soil remedial actions are presented in this feasibility study.

In addition to soil, a localized area of sediment had concentrations of metals that were greater than the PRGs. As discussed in the remedial investigation report (Exponent 2001), these elevated concentrations appear to be due to use of a small amount of smelter material as rip-rap during bridge construction and not due to surface water transport from the Site. The source of the smelter materials is unknown.

During the remedial investigation, Cyprus Amax mapped the smelter residue located on the Site. At ODEQ's request, Cyprus Amax conducted an additional survey in February 1998 to assess the presence of smelter materials in offsite locations in the vicinity of the Site. The results of this survey are presented in the remedial investigation report (Exponent 2001), including a map showing where smelter materials were observed in nearby offsite locations. As has been discussed with ODEQ, this information will be provided to the appropriate public works officials to ensure their awareness of the presence of these materials during road maintenance and repair activities. No other remedial actions associated with these materials are discussed in this feasibility study.

2. Remedial Action Objectives

This section presents a summary of information supporting selection of PRGs for the Site. A summary of the RAOs and PRGs is presented and the initial areas of potential concern for soil are identified.

2.1 Remedial Action Objectives and Preliminary Remediation Goals

This section presents a summary of the RAOs and PRGs for soil that are established in accordance with the NCP (40 CFR 300.430(e)(2)(i)). RAOs are chemical- and medium-specific goals for protecting human health and the environment, and typically specify the exposure routes, receptors, and risk levels of concern. RAOs provide the basis for deriving PRGs, which are specific contaminant concentrations (e.g., soil concentrations) that are protective of human health and the environment. PRGs also comply with applicable or relevant and appropriate requirements (ARARs). As discussed in Section 6.1 of the remedial investigation report (Exponent 2001), the PRGs developed for the National Zinc Site in Bartlesville, Oklahoma were determined to be protective of human health and the environment at the Site. Thus, they were used as PRGs in these analyses. Final soil cleanup levels will be established upon completion of the RI/FS and the record of decision (ROD).

The RAOs for soil are:

- Prevent ingestion of soil/dust arsenic originating from historical activities at the Site in amounts in excess of a 3×10^{-5} (3 in 100,000) target risk level for developing cancer. For exposures associated with arsenic ingestion, the health agencies in Oklahoma have determined that this risk level is protective of human health.

- Prevent ingestion/direct contact with soil/dust cadmium originating from historical activities at the Site in amounts in excess of the reference dose of 1×10^{-3} mg/kg-day, as adjusted to account for typical daily cadmium intake from food and other background sources.

- Prevent ingestion of soil/dust lead originating from historical activities at the Site that would result in a greater-than-5-percent probability of an individual child or adult having a blood lead concentration greater than 10 μg/dL.

- Prevent adverse health risks resulting from exposures associated with agricultural land use, including ingestion of plants grown in metals-containing soil, consumption of animal products derived from animals eating plants grown in metals-containing soil, and inhalation of fugitive dust during plowing of metals-containing soil.

As discussed in the remedial investigation, the soil cleanup levels developed for use at the Bartlesville site and recommended for use as PRGs for soil at the Site were calculated for arsenic, cadmium, and lead based on several different exposure scenarios and land uses. The PRGs are presented in Table 2-1.

2.2 Estimated Areas of Potential Concern for Soil

This section describes the procedures used to identify the initial estimated areas of potential concern for soil. The areas for soil were calculated based on the initial data collected during the remedial investigation and the PRGs identified for specific land use scenarios (residential/recreational, occupational, or agricultural). Modified area estimates for soil reflecting additional data collected at the Site and discussions with ODEQ and the Site owner are presented in Appendix C. These area estimates also could change based on additional information that may become available. In particular, offsite areas will be refined based on additional sampling to be conducted during the remedial design phase of this project.

2.2.1 Land Use

The Site is located approximately 0.5 mile south of the City of Collinsville, which has a population of 3,514 (1990 Census). The Site is currently zoned for agricultural use. The Site has been and is currently used for grazing cattle (PTI 1996). The City of Collinsville has no current plans to annex the area where the Site is located (Wolfram 1999, pers. comm.). Instead, planners at the Collinsville City Hall have indicated that the City is more likely to focus future development efforts on the areas to the north, west, and east of the current city boundaries. As described in the remedial investigation report, portions of the Site are located within the 100-year and 500-year floodplains of Blackjack Creek designated by the Federal Emergency Management Agency (FEMA). Any construction in these areas is subject to the restrictions established by FEMA on the types and locations of structures that can be insured if built within such zones (44 CFR 59 and 65).

The area surrounding the Site is mostly rural with agricultural land use (primarily grazing) in the general vicinity of the Site. A small residential area to the east includes both trailers and permanent homes, and a trailer park with approximately 10–20 trailers is located to the west of the Site. Occupational populations in offsite areas include workers employed in various commercial establishments. Figure 2-1 provides an approximate overview of offsite land use in the vicinity of the Site.

Although current land use for the Site is agricultural, the northwest corner of the Site, which is located outside of the floodplain, may be suitable for future residential use

(Figure 2-1). In addition, the current Site owner has expressed an interest in potentially developing this portion of the property for residential use in the future. Thus, in this initial feasibility study assessment, future residential use was assumed for this area when assessing remedial alternatives for the northwest portion of the Site. For all other onsite and offsite areas, remedial alternatives were assessed in this feasibility study based on current land use assumptions as reflected in Figure 2-1. This approach is consistent with the approach used at the National Zinc Site in Bartlesville, Oklahoma. Actual land use for both onsite and offsite areas will be determined during the remedial design phase of this project. The modified analyses presented in Appendix C reflect updated discussions with the property owner regarding potential future land use (White 1999), as well as application of buffer zones around current and potential future residential areas. As a result, residential land use is used as the basis for identifying remediation requirements for a larger area than was assumed in the initial analyses.

2.2.2 Onsite Area

During the remedial investigation, composite soil samples were collected in the onsite area from each node of a 100×100-ft sampling grid that extended across the entire Site (PTI 1996; Exponent 2001). Together with the land use information discussed above and summarized in Figure 2-1, these data were used to develop initial estimates of the onsite areas of potential concern. As noted above, based on discussions with ODEQ and the current Site owner, modified approaches were developed to refine the areas of concern. These modified analyses (presented in Appendix C) include additional data collected in the pasture area located to the west of the Site.

As discussed above, in the initial analysis, the current onsite land use (i.e., agricultural) was used as the basis for assessing remedial alternatives for all of the onsite area, with the exception of the northwest portion of the Site as designated in Figure 2-1. For the northwest corner, potential future residential land use was assumed as the basis for the evaluations. PRGs associated with these land uses were applied to identify areas of concern.

In these initial evaluations, average concentrations were used as the basis for comparison with the appropriate PRGs. Average concentrations were used to better approximate the actual patterns of exposure that exposed individuals might have. For example, for those areas where agricultural land use was applied in the evaluations, the types of activities assumed in deriving the PRGs (i.e., plowing or cattle grazing) generally require large land areas. In addition, exposures will likely occur across the entire area used for such activities. Thus, the exposures of individuals performing the plowing or consuming animal products from the cattle will reflect a mixture of exposures and concentrations from locations across the Site. As a result, the evaluations for agricultural land use examined the average concentrations across those areas of the Site where this land use was assumed.

As described in Appendix C, a modified approach for assessing areas requiring remediation was developed. This approach examined average concentrations over smaller site subareas, used modified assumptions regarding potential future land use, and applied a buffer zone between areas where agricultural and residential PRGs were considered for determining remedial requirements.

For the onsite area where agricultural land use was applied to assess remedial alternatives, average concentrations of the CoCs in soil were significantly less than the agricultural PRGs. For lead, the average concentration, 1,282 mg/kg (95 percent upper confidence level [UCL] of 1,480 mg/kg), was a factor of approximately 4 less than the agricultural PRG of 5,000 mg/kg. Similar results were seen for arsenic (with an average concentration of 73 mg/kg [95 percent UCL of 93 mg/kg and a PRG of 200 mg/kg]) and cadmium (with an average concentration of 14 mg/kg [95 percent UCL of 19 mg/kg and a PRG of 300 mg/kg]). These results are consistent with the findings discussed in Section 4.2.1 (*Soils*) of the remedial investigation report (Exponent 2001), where average concentrations were derived for the northern, middle, and southern thirds of the Site. Only the average concentration of arsenic in surface soils in the northern third of the Site (415 mg/kg) was greater than the agricultural PRG.

Exposures occurring during residential land use will also reflect a mix of exposures and concentrations occurring in the area of residential use. As an initial step in evaluating the areas of concern for residential land use, the average CoC concentrations in surface soil in the northwestern portion of the Site were examined. For lead, the average concentration of 3,306 mg/kg (95 percent UCL of 4,524 mg/kg) was a factor of approximately 3.5 times greater than the residential PRG of 925 mg/kg. Similar results were seen for arsenic, with an average concentration of 451 mg/kg (95 percent UCL of 849 mg/kg) and a residential PRG of 60 mg/kg. For cadmium, the average concentration of 36.8 mg/kg (95 percent UCL of 47.4 mg/kg) was less than the residential PRG of 100 mg/kg. Because the average concentrations for lead and arsenic in this area exceeded the residential PRGs, the entire area was designated as an area of concern for the evaluation of remedial alternatives. As a result, more refined analyses (e.g., examining average concentrations in smaller subareas that might better reflect residential lot sizes) were not undertaken.

Thus, based on sampling data collected from the remedial investigation and current and future land use described above, the initially identified potential area of concern was the northwest corner of the property designated for potential future residential use (Figure 2-1). As summarized in Table 2-2, this total onsite potential area of concern is approximately 209,000 ft^2 (4.8 acres). Additional areas were identified for remediation based on the modified approach described in Appendix C. This appendix also presents modified area estimates.

2.2.3 Offsite Area

In the offsite area, composite soil samples were collected on a 500×500-ft grid. This grid density results in uncertain estimates of preliminary areas of concern for offsite areas; however, as an initial estimate, an area of 200×200 ft (40,000 ft^2) was assumed as the affected area for each soil sample grid node where a concentration of one of the CoCs exceeded the PRGs. For those locations near the Site where elevated CoC concentrations were observed, additional offsite sampling may be undertaken as part of the remedial design or remedial action to refine actual areas and volumes.

Based on the remedial investigation data and the preliminary land use designations shown in Figure 2-1, two offsite stations located to the north of the Site (Stations OS42 and OS18 as described in the remedial investigation) exceed land-use-specific PRGs. Thus, in this feasibility study, the total offsite potential area of concern was assumed to be 80,000 ft^2 (1.8 acres). As noted above, the additional soil data collected in February 1998 from the pasture area to the west of the Site were considered together with the onsite soil data in the modified analyses of remediation requirements presented in Appendix C. Thus, this conclusion regarding the potential offsite area of concern is not further modified by additional data collection or analyses.

As shown in Table 2-2, the total combined onsite and offsite area of potential concern was initially estimated at 290,000 ft^2 (6.6 acres). The modified estimate of the area of potential concern is 520,000 ft^2 (12 acres), as documented in Appendix C.

3. Remedial Technology Screening

In this section, technologies that are potentially applicable for remediation of CoCs found at the Site are identified.

Initially, site-specific criteria were used to screen a wide range of technologies and to develop a refined list of potentially feasible technologies that could, in turn, be used to develop remedial action alternatives for the site. These remediation technologies were then evaluated using the following criteria:

- **Effectiveness**—The potential ability of the technology to address site-specific conditions, meet RAOs, and minimize human health and environmental impacts during implementation
- **Implementability**—The technical and administrative feasibility of implementing a technology (administrative considerations include the ability to obtain permits and the availability of workers, equipment, disposal services, and supplies)
- **Cost**—The relative capital and operation and maintenance costs of a technology.

Brief descriptions of the technologies that were considered are provided below. The technologies were screened to determine their applicability to the Site. Technologies retained through this screening process were then considered for incorporation into remedial action alternatives for the Site (Section 4).

3.1 Technology Screening

Potentially applicable technologies for remediation of soil are presented in Table 3-1. The screening of these technologies for the Site is summarized in the table and discussed below.

3.1.1 Institutional Controls

Institutional controls, including monitoring, are usually included as a component of any remedial action alternative. Institutional controls for soil limit disturbance of and direct human exposure to contaminated soil. Common institutional controls include fencing or other physical barriers to restrict access to contaminated areas, and zoning and title notices that place limitations on land use for contaminated areas.

While these measures reduce risk by controlling access to the affected areas, such measures cannot completely limit access to the Site (e.g., trespassing) and do not limit offsite transport of contaminants via storm water or air. Site monitoring is therefore included in any remedy where institutional controls are applied. Short-term monitoring is conducted to ensure that potential risks to human health and the environment are controlled while a remedy is being implemented. Long-term monitoring is conducted to measure the effectiveness of the remedy and thereby ensure that the remedy continues to be protective of human health and the environment. Institutional controls are easily implemented and are retained in this feasibility study as a possible component of overall remediation.

3.1.2 Surface Controls

Surface controls typically include establishing vegetative cover; constructing swales, culverts, and lined channels for drainage control; and applying soil amendments. This technology is effective and easily implemented and is retained for use as a component of capping and other active remedial action alternatives.

3.1.3 Containment

Containment is a technology used to prevent exposure of receptors (e.g., site workers or visitors) to contaminated soil. It can also limit the migration of contaminants.

3.1.3.1 Capping

Capping is a feasible, effective containment measure that minimizes exposures by preventing direct contact with contaminated soil. Capping also prevents offsite migration of contaminants via storm water or airborne dispersion of contaminated soil. Cap designs can include asphalt, concrete, soil, clay, membrane liners, or any combination of these materials. Long-term maintenance and monitoring of a cap is required. Capping is compatible with many potential future land uses. This technology is retained for further consideration.

3.1.3.2 Onsite Consolidation

Onsite soils removed during remedial actions can be placed in designated consolidation areas, as this approach might provide additional protectiveness and flexibility of long-term land use for portions of the Site outside the consolidation area. This technology is retained for further consideration.

3.1.4 Treatment

Treatment technologies include physical and chemical processes that reduce the toxicity, mobility, and/or volume of contaminated soil.

3.1.4.1 Mixing

Mixing is a technology that involves mechanically mixing contaminated surface soil with cleaner soil present beneath the surface, reducing the elevated concentrations of CoCs. Mixing can be performed *in situ* with large tilling equipment or *ex situ* using a cement mixer. In addition, stabilizing agents (e.g., phosphate, fly ash, or lime) can be added to reduce the bioavailablity of CoCs. The depth of mixing is a function of vertical CoC concentration gradients and the physical limitations of mixing equipment. Analyses of CoC concentrations at depth in site soils indicate that mixing would not generally be effective as a remedy because of relatively high CoC concentrations at depths in certain areas. Specifically, in the northwest corner of the Site, lead concentrations in soil following mixing would still be greater than the residential PRG. This technology is retained, however, as a possible supplemental component of active remediation alternatives in selected areas.

3.1.4.2 Soil Washing

Soil washing is an *ex situ* treatment that performs two functions. First, it separates cleaner soil size fractions (typically gravel and sand) from more contaminated soil (typically silts and clays, collectively referred to as fines). Second, it removes contaminants from the soil into washwater for subsequent treatment. Where contaminants are concentrated on fines and fines constitute only a small proportion of soil, soil washing can reduce the volume of contaminated soil requiring subsequent treatment. However, the low sand content and high fines content found at the Site make the soils poorly suited to soil washing. Because of the high percentage of fines and consequent minor reduction of volume requiring treatment that would result from soil washing, this technology is not retained.

3.1.4.3 Chemical Stabilization (Fixation)

Chemical stabilization involves mixing contaminated soil with binding agents, such as lime, fly ash, phosphate, and silicate. These agents form a solid matrix that immobilizes the contaminants, and thereby reduces contaminant mobility (including leachability). This technology can also reduce contaminant bioavailability.

Chemical stabilization is most commonly used for soils contaminated by metals. Metals are typically immobilized by both chemical bonding and physical entrapment. This technology can be applied *in situ* or *ex situ*. This technology is not retained because leaching of CoCs from contaminated soils is not expected to be significant. In addition, this technology is not cost-effective because, relative to other functionally equivalent technologies, it provides minimal additional protection of human health at a substantially higher cost.

3.1.4.4 Vitrification

This technology uses a high-voltage electrical current applied to the soil to immobilize inorganic contaminants in a glasslike mass. Vitrification can be applied *in situ* or *ex situ*. This technology is extremely costly and is not cost-effective relative to other functionally equivalent technologies. Therefore, it is not retained.

3.1.4.5 Encapsulation

This technology, which involves macroencapsulation of contaminated material (*in situ* or *ex situ*), hardens or solidifies the material to prevent contaminant leaching. It differs from stabilization in that no chemical reaction or bonding occurs. Encapsulation is a costly process, most commonly applied to specialized, low-volume wastes (e.g., radioactive materials). At this site, it is inappropriate and not cost-effective over equivalent processes. Therefore, it is not retained.

3.1.5 Removal

As a general response action, soil removal can include large-scale excavation of extensive areas or selective excavation of highly contaminated locations using a backhoe, front-end loader, or other conventional excavation equipment. Excavated soil can be staged (i.e., placed in temporary storage) or immediately delivered for onsite or offsite treatment and disposal. The excavated area may then be backfilled and compacted to predetermined specifications. In certain instances, excavation is also used in conjunction with other general response actions, such as containment, during construction of subsurface structures or other remedial facilities. This technology is retained as a component of overall site remediation.

3.1.6 Disposal

Disposal includes design of an onsite engineered landfill or transport to an offsite regulated landfill.

3.1.6.1 Onsite Engineered Landfill

The appropriate design for an onsite landfill depends on the degree of contamination in the soil to be disposed of. Disposal could be in a solid waste landfill for nonhazardous soil or in a Resource-Conservation-and-Recovery-Act-design (double-lined) hazardous waste landfill. This technology is not retained because is not cost-effective when compared with equivalent alternatives such as capping alone.

3.1.6.2 Offsite Commercial Landfill

Offsite disposal involves removing soil with elevated CoC concentrations from the Site and placing it in a regulated landfill. Although an offsite landfill may not be appropriate for a large volume of untreated soil, it may be appropriate for a small volume of soil or treated soil. Offsite disposal is retained for further consideration.

3.2 Remedial Action Alternatives

Remedial action alternatives were assembled from the technologies and process options retained after screening. This procedure included the following steps:

- Selecting representative process options based on site-specific considerations and experience gained during remedy selection at the Bartlesville and Blackwell sites to simplify the subsequent development and analysis of alternatives

- Providing a range of alternatives for detailed development and analysis, including no action, containment, and disposal alternatives.

Process options not carried forward at this point are not necessarily precluded from further consideration and possible implementation at the Site. These process options may be reconsidered during the remedial design.

The range of remedial action alternatives assembled includes:

- A no-action alternative

- Alternatives that include containment (e.g., capping) or onsite consolidation with capping

- An alternative that includes removal and offsite disposal.

The remedial action alternatives are summarized in Table 3-2. The alternatives are developed in more detail in the next section of the feasibility study for purposes of the detailed analysis, including the development of cost estimates.

3.2.1 No Action

The no-action alternative is the baseline against which all other alternatives must be compared. No action consists of the baseline conditions at the Site as it presently exists. Under this alternative, it is assumed that no future remedial or other actions will be conducted at the Site to control or mitigate exposures to contaminants.

3.2.2 Capping in Place

This alternative would involve capping areas of soil where CoC concentrations are greater than the PRGs associated with the land use identified for the area. The main components of soil capping are:

- Placing a soil cap on top of the contaminated soil, as appropriate, to cover the contamination and provide a substrate for vegetation
- Seeding the soil cap to establish vegetation
- Conducting other remedial actions (e.g., mixing, vegetation enhancement, institutional controls) for portions of the Site, as appropriate.

3.2.3 Consolidation and Capping

This alternative would involve removing soil with concentrations of CoCs exceeding PRGs for the specified land use for an area and placing the soil in a consolidation area located on a portion of the Site. The main components associated with consolidation and capping of soil are:

- Watering the soil or using a comparable technology to suppress dust generated during implementation
- Removing and transporting the soil in trucks from onsite or offsite locations to the onsite consolidation area
- Placing the soil at the Site at a location and in a manner that is compatible with zoning laws and future use
- Placing a soil cap on top of the soil, as appropriate, to cover the contamination and provide a substrate for vegetation
- Seeding the soil cap to establish vegetation

- Conducting other remedial actions (e.g., capping, mixing, vegetation enhancement, institutional controls) for portions of the Site, as appropriate.

3.2.4 Removal and Offsite Disposal

This alternative would be similar to the onsite consolidation alternative, except that excavated soil with concentrations exceeding relevant PRGs would be disposed of in an appropriate landfill. The main components of this alternative are:

- Watering the soil or using a comparable technology to suppress dust generated during implementation
- Excavating the soil, generally using large-scale equipment
- Temporarily stockpiling the soil, as necessary, prior to transport
- Testing the soil to determine whether it is hazardous or nonhazardous
- Transporting the soil in trucks, taking measures to contain the soil in the trucks
- Disposing of the soil in an appropriate offsite nonhazardous waste landfill
- Importing and placing soil on the ground surface from where the soil was removed, if necessary
- Seeding the soil cap to establish vegetation
- Conducting other remedial actions (e.g., institutional controls, mixing, capping, vegetation enhancement) for portions of the Site, as appropriate.

4. Remedial Action Alternative Development

This section presents the development of the remedial action alternatives that were assembled based on the results of the remedial technology screening. The alternatives are developed in more detail for purposes of the detailed analysis and for estimating the capital and operation and maintenance costs. The detailed analysis of alternatives is presented in Section 5. The initial estimated costs are summarized in Section 5 and are presented in detail in Appendix B. As noted above, the final area and volume estimates and corresponding costs will differ based on additional site data that have been or may be collected and on discussions with ODEQ and the current Site owner regarding remediation requirements for the Site.

4.1 Alternative 1: No Action

The no-action alternative is the baseline against which all other alternatives are compared. This alternative consists of the baseline conditions at the Site as it presently exists. Under this alternative, it is assumed that no remedial or other actions will be conducted at the Site to control or mitigate exposures to contaminants.

4.2 Common Components of Active Soil Remediation Alternatives

Components that are common to the active remediation alternatives (i.e., containment or removal) are discussed here as a group in order to limit redundancy in the subsequent discussion of the individual alternatives. These components are:

- Work would be conducted using an appropriate level (Level D or Modified Level D) of personal protective equipment (PPE) based on previous experience with investigations conducted at the Site. The level of PPE may be revised during the course of remediation based on the health and safety monitoring conducted at the Site.
- Access agreements for soil sampling and remediation would be requested from affected property owners and/or residents.
- Temporary fencing would be installed at each affected area for public safety.
- Utility lines would be located, marked, and noted.
- Photographic records of each affected area would be made prior to and upon completion of remediation activities.

- During remediation activities, fugitive dust from the work areas would be controlled through the use of a water spray. Arrangements may be made with individual property owners to utilize a garden hose connected to onsite hydrants or spigots. Alternate arrangements may include the use of a tank truck equipped with a pump and hose. Care will be taken to prevent runoff. The need for and scope of any air monitoring during remediation activities will be considered during the remedial design phase of the project.

- Portions of residential land use areas (such as unpaved driveways) may be addressed by capping (without prior soil removal or treatment) and/or mixing surface soil (with or without the addition of amendments [e.g., lime, fly ash, phosphate, or silicate]).

- Remediation of occupational, agricultural, and recreational land use areas may include, but is not necessarily limited to, capping (without prior soil removal or treatment), mixing of surface soil (with or without the addition of amendments [e.g., lime, fly ash, phosphate, or silicate]), institutional controls, and vegetation enhancement. For example, dirt parking lots may be capped with gravel.

- Equipment would be decontaminated prior to being released from a working area. It is anticipated that decontamination would consist of scraping the residual soil off of the equipment and rinsing the equipment with clean water. Decontamination residues that are generated would be placed in the area to be capped or incorporated into the removed soil.

- Upon completion of remediation activities, the area would be returned to the original grade. Trees, shrubs, and plants that were removed or damaged would be replaced with similar quality plants. Soil would be placed on the ground surface and the area would be revegetated. Fences and other structures that were removed or damaged would be restored to preconstruction conditions. Repair work and replacement of vegetation would be conducted for 1 year.

- Institutional controls (e.g., educational programs, title notices) would be implemented as appropriate.

- Long-term maintenance for the preferred alternative will include periodic inspection of the cap and reseeding and repair, if necessary.

4.3 Alternative 2: Capping in Place

The objective of this alternative is to reduce the potential for direct exposure to contaminated soil beneath the cap, prevent CoCs from being transported to surface water in storm water runoff, and prevent CoC-containing dust from becoming airborne. The cap would reduce infiltration by providing a sloped grade and having a soil/vegetation zone that would facilitate evapotranspiration. This alternative assumes that offsite areas with elevated CoC concentrations are minimal (as will be determined in the remedial design), and can be addressed by mixing or small-scale removal actions.

This alternative involves debris removal, site clearing, preparatory grading, and placement of a 2-ft-thick soil cap over the potential future residential area located in the northwest portion of the Site (Figure 1-2). The cap would consist of a 2-ft layer of clean soil or sand placed over a marker layer (gravel or geotextile). The recommended thickness offers a sufficient barrier to direct exposure without excessive cost, would not be easily penetrated without digging, could be readily repaired if damaged, and is consistent with the capping designs applied in residential areas at the Bartlesville and Blackwell sites. Placement of utility corridors, if necessary, may require some removal of contaminated soil or a thicker cap and lining of the utility trench. These needs and other potential needs associated with residential construction will be determined and addressed in the remedial design phase of this project.

The cap would be constructed by clearing the existing area of any debris or obstructions, grading, placing the geotextile or gravel, and then placing clean fill. Preparatory grading of the underlying soil and cap would be designed to achieve a final slope for proper drainage to a storm drain or drainage ditch, compatible with state and federal regulations and local building codes. Vegetation (grasses) would be established and maintained on the cap using hydroseeding. The cap would require regular inspection and maintenance to counter the effects of settling and erosion, if any.

Institutional controls including title notices and monitoring would be implemented as part of this alternative. The estimated time for completion of this alternative, other than long-term monitoring and maintenance, is approximately 2 months from the date that a contractor is retained and given authorization to proceed.

Final cap design, including specification of capping materials to be used, will be developed in the remedial design phase, and will incorporate the potential for future residential land use. Figure 4-1 shows the extent of the initially proposed cap at the Site. General design assumptions are summarized below:

Capping area:	550 ft × 380 ft (4.8 acres)
Geotextile marker:	210,000 ft^2 (4.8 acres)
Soil fill:	2 ft × 4.8 acres (16,000 yd^3)

4.4 Alternative 3: Consolidation with Capping

This alternative would be the same as the capping in place alternative, except that soil exceeding PRGs in offsite areas would be excavated, transported to a consolidation area, and capped as described above. The consolidation area would be the same area described above for capping in place. For the purposes of the feasibility study, the offsite soil areas potentially exceeding PRGs were estimated to affect an area of approximately 80,000 ft^2, with an average depth of 1.0 ft (3,000 yd^3). As discussed in Appendix C in the analyses incorporating data from the February 1998 sampling, soil from identified locations onsite and in the pasture to the west of the Site would also be incorporated into the consolidation area.

Composite soil samples collected on a predetermined sampling grid would be analyzed to determine whether removal would be required and, if so, the depth of soil to be removed, to a maximum depth of 24 in. in residential areas, and 18 in. in industrial or agricultural areas. These soil removal depths were selected based on removal depths applied at the Bartlesville and Blackwell sites. The soil would be excavated to the predetermined depth using an excavator or backhoe. Small-scale equipment or hand labor would be used to remove soil around shallow utility lines, property boundaries, or foundations, if present.

After soil removal, subsurface composite soil samples would be analyzed for confirmational purposes to determine whether the final remediation levels have been met. The excavated areas would be backfilled with clean soil. Prior to the use of backfill soil, the source area soils would be evaluated to determine that they were clean. After the backfill is placed, regrading and revegetation activities would be conducted, as needed. In areas where soil concentrations exceed final remediation levels after removal, the minimum cap thickness would be 24 in. for residential areas and 18 in. for industrial and agricultural areas.

The excavated soil would be transported in end-dump trucks (or equivalent) to the onsite consolidation area. Water spray would be used as needed to prevent the generation of dust during transport. The soil would be stockpiled at the consolidation area in a manner that would prevent potential runon, runoff, and dust generation.

Following (or in conjunction with) removal activities, stockpiled soil would be used as fill in the consolidation area, and would be graded prior to placement of a cap over the consolidation area. Construction of the cap is described under the capping in place alternative (Section 4.3).

Institutional controls including title notices and monitoring would be implemented as part of this alternative. The estimated time for completion of this alternative, other than long-term monitoring and maintenance, is approximately 4 months from the date that a contractor is retained and given authorization to proceed.

Final volumes of offsite soil and the final cap design will be developed in the remedial design phase, and will incorporate future land use and local building codes. Figure 4-2 shows the initial estimated extent of the consolidation and cap at the Site. General design assumptions are summarized below:

Excavated soil:	80,000 ft^2 × 1 ft depth (3,000 yd^3)
Consolidation area:	550 ft × 380 ft (4.8 acres)
Capping area:	550 ft × 380 ft (4.8 acres)
Geotextile marker:	210,000 ft^2 (4.8 acres)
Soil fill:	2 ft × 4.8 acres for the capped area (16,000 yd^3)
	1 ft × 80,000 ft^2 for offsite areas (3,000 yd^3)

4.5 Alternative 4: Removal and Offsite Disposal

This alternative would be the similar to the consolidation and capping alternative, except that soil exceeding PRGs in offsite and onsite areas would be excavated and transported to a commercial offsite landfill. Soil that would be excavated and transported to the landfill would include the offsite soil areas potentially exceeding PRGs (80,000 ft^2), and the soil exceeding PRGs in the area previously defined for capping or consolidation (209,000 ft^2). For the purposes of the feasibility study, it is assumed that the average removal depth would be 12 in. based on depth profile data. Actual excavation depths could be shallower or deeper in specific locations.

Composite soil samples collected on a predetermined sampling grid would be analyzed to determine whether removal would be required and, if so, the depth of soil to be removed, to a maximum depth of 24 in. The soil would be excavated to the predetermined depth using an excavator or backhoe. Small-scale equipment or hand labor would be used to remove soil around shallow utility lines, property boundaries, or foundations, if present.

After soil removal, subsurface composite soil samples would be analyzed for confirmational purposes to determine whether the final remediation levels have been met. The excavated areas would be backfilled with clean soil. Prior to the use of backfill soil, the source area soils would be evaluated to determine that they were clean. After the backfill is placed, regrading and revegetation activities would be conducted, as needed. In areas where soil concentrations exceed final remediation levels after removal, the minimum cap thickness would be 24 in. for residential areas, and 18 in. for industrial and agricultural areas.

The excavated soil would be transported in end-dump trucks equipped with tarps to a temporary fenced staging area, or directly to the commercial offsite landfill. Full-bed waterproof canvas or plastic tarps would be used on all haul trucks for dust control. The soil would be stockpiled at the staging area in a manner that would prevent potential runon, runoff, and dust generation. Water spray would be used, as needed, when the piles are uncovered to prevent the generation of dust. The piles would be covered with sheet plastic or similar material on a daily basis, if needed.

The stockpiled soil would be sampled to determine the leachability of the CoCs (by EPA's toxicity characteristic leaching procedure [TCLP]) for disposal purposes. For purposes of the feasibility study, it is assumed that the excavated soil would pass the

TCLP. If the soil failed the TCLP, it would be stabilized in an acceptable manner until it passed.

Upon receipt of test results that indicate the soil passes the TCLP, it would be hauled to the landfill in the same type of trucks and using the same preventive measures as previously discussed. The soil would be disposed of at a nonhazardous waste landfill.

Following soil removal, excavated areas would be backfilled with clean soil, graded, and revegetated. The backfill would be placed in the same manner as in the capping in place alternative (i.e., geotextile overlain by soil fill) in the onsite areas, and in the same manner as in the consolidation alternative for offsite areas (i.e., 24 in. in residential areas and 18 in. in occupational or agricultural areas). Construction of the cap and placement of backfill are described under the capping in place alternative (Section 4.3) and consolidation and capping alternative (Section 4.4).

Institutional controls including title notices and monitoring would be implemented as part of this alternative. The estimated time for completion of this alternative, other than long-term monitoring and maintenance, is approximately 8 months from the date that a contractor is retained and given authorization to proceed.

Final volumes of soil will be developed in the remedial design, and will incorporate future land use and local building codes. General design assumptions for these initial estimates are summarized below:

Excavated soil:	290,000 ft^2 × 1 ft depth (11,000 yd^3)
Geotextile marker:	210,000 ft^2 for onsite area only (4.8 acres)
Soil fill:	2 ft × 4.8 acres for the capped area (16,000 yd^3)
	1 ft × 80,000 ft^2 for offsite areas (3,000 yd^3)

5. Detailed Analysis of Alternatives

This section presents a detailed analysis of the remedial action alternatives in accordance with the NCP (40 CFR 300.430(e)(9)). The detailed analysis consists of an assessment of individual alternatives against each of seven evaluation criteria and a comparative analysis that focuses upon the relative performance of each alternative against those criteria. The purpose of the detailed analysis is to provide sufficient information to compare alternatives with respect to the evaluation criteria to allow selection of a remedy (U.S. EPA 1988).

5.1 Evaluation Criteria

The following criteria are used in the detailed analysis of alternatives:

- Overall protection of human health and the environment
- Compliance with ARARs
- Cost
- Long-term effectiveness and permanence
- Short-term effectiveness
- Reduction of toxicity, mobility, or volume through treatment
- Implementability.

There are two additional criteria, state acceptance and community acceptance, which reflect each of the two groups' apparent preferences among or concerns about each alternative. Since ODEQ is the lead agency for the RI/FS and ROD, state acceptance need not be evaluated. Community acceptance will be evaluated in the ROD after the lead agency has received and reviewed public and other agency comments on the feasibility study document and proposed remedial action plan.

The seven criteria are placed into two categories: threshold criteria and primary balancing criteria. An alternative must meet the threshold criteria (overall protection of human health and the environment and compliance with ARARs) to be eligible for selection. The primary balancing criteria include the remaining five of the seven criteria. The balancing criteria represent the main criteria upon which the analysis is based, taking into account technical, cost, institutional, and risk concerns. Each criterion is described in the following paragraphs under its respective category.

5.1.1 Threshold Criteria

5.1.1.1 Overall Protection of Human Health and the Environment

Alternatives are assessed to determine whether they can adequately protect human health and the environment, in both the short and long term, from unacceptable risks posed by the CoCs present at the Site. Such protection is achieved by eliminating, reducing, or controlling exposures to levels established during development of the PRGs. The evaluation of overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

5.1.1.2 Compliance with ARARs

Alternatives are assessed to determine whether they attain ARARs under federal and state environmental laws. Potential ARARs are identified in Appendix A.

5.1.2 Primary Balancing Criteria

5.1.2.1 Cost

Costs for the remedial actions are estimated including capital costs, annual operation and maintenance costs, and the total net present value.

5.1.2.2 Long-Term Effectiveness and Permanence

Alternatives are assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. This includes consideration of the magnitude of residual risk remaining from untreated soil at the conclusion of the remedial activities, and the adequacy and reliability of controls such as containment systems and institutional controls.

5.1.2.3 Short-Term Effectiveness

This criterion of "short-term effectiveness" (i.e., short-term effects) takes into consideration the short-term risks posed to the community during implementation of an alternative, the potential effects on workers during remedial action, the potential environmental effects during remedial action, and the time until protection is achieved.

5.1.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The degree to which alternatives employ treatment that reduces toxicity, mobility, or volume is assessed, including consideration of the amount of CoCs treated, the degree of expected reduction, the degree to which the treatment is irreversible, and the type and quantity of residuals that will remain following treatment.

5.1.2.5 Implementability

The ease or difficulty of implementing the alternatives is assessed by considering the technical feasibility, administrative feasibility, and availability of services and materials.

5.2 Detailed Analysis of Alternatives

The soil remedial action alternatives were compared with each of the seven evaluation criteria. The results are presented in Table 5-1. Cost estimates (based on the initial analyses) are presented as total present worth. Information supporting the detailed analysis is presented in Appendix A (ARARs) and Appendix B (cost estimate), and is supplemented by the information presented in Appendix C.

5.3 Comparative Analysis of Alternatives

Table 5-1 summarizes the relative performance of each alternative for each evaluation criterion. Therefore, only the key results of the evaluation are presented below. The relative ranking of each alternative for the criteria is shown in Figure 5-1. The reader is referred to Figure 5-1 to see the numbering of the alternatives to better follow the discussion below.

5.3.1 Overall Protection of Human Health and the Environment

Overall, all of the active remediation alternatives (Alternatives 2 through 4) would provide the same level of long-term protectiveness. As modified as reflected in Appendix C, the capping alternatives (Alternatives 2 and 3) would provide long- and short-term protection of human health by placing a cap on soil with elevated concentrations of CoCs. Capping would be fully protective if long-term maintenance of the cap, which is included in the alternatives, is provided. Consolidation and capping (Alternative 3) and removal and offsite disposal (Alternative 4) may provide some incremental increase in long-term protectiveness; however, they would have some short-term risks associated with soil handling and transport.

5.3.2 Compliance with ARARs

The active soil alternatives (Alternatives 2, 3, and 4) are essentially comparable for this criterion. Some additional air monitoring and/or control measures may be necessary for the alternatives that include soil removal and handling (Alternatives 3 and 4) to verify compliance during implementation of the remedy with applicable air quality standards. The requirements of the Oklahoma Environmental Quality Act are not met by the no action alternative (Alternative 1).

5.3.3 Cost

The estimated costs for the alternatives are presented in Table 5-1. No action (Alternative 1) by definition has the lowest costs. The capping in place alternative (Alternative 2) has the lowest estimated costs of the active soil remediation alternatives, followed by the consolidation and capping alternative (Alternative 3). The removal and offsite disposal alternative (Alternative 4) has the highest overall cost.

5.3.4 Long-Term Effectiveness and Permanence

This evaluation criterion addresses the results of a remedial action in terms of the risk remaining at the Site after the final remediation levels have been met. As modified as reflected in Appendix C, all of the active soil remediation alternatives (Alternatives 2 through 4) are comparable for this criterion; however, there is more certainty regarding the permanence of the removal and offsite disposal alternative (Alternative 4).

5.3.5 Short-Term Effectiveness

There are some differences in short-term effectiveness among the alternatives with respect to the potential effects on the community and workers during the construction and implementation phase of the remediation. The no action alternative requires no time for implementation. The capping in place alternative (Alternative 2) would take slightly less time than other remediation alternatives that involve soil excavation (Alternatives 3 and 4). Alternatives 3 and 4 could present short-term risks to workers, the environment, and the general public due to onsite handling, transport, and disposal of contaminated soil.

5.3.6 Reduction of Toxicity, Mobility, and Volume Through Treatment

None of the alternatives would result in reduction in toxicity, mobility, or volume; however, the physical mobility of contaminated soil particles resulting from erosion and contact with surface water would be reduced in Alternatives 2, 3, and 4, as modified as reflected in Appendix C.

5.3.7 Implementability

All of the active remediation alternatives are comparable and easily implemented; however, the capping in place alternative (Alternative 2) is more readily implemented than the alternatives involving excavation or removal (Alternatives 3 and 4).

6. Recommended Alternative

This section presents the conclusions of the feasibility study. These conclusions are based on the detailed evaluation of remedial alternatives for the Site, using the results of the remedial investigation, and include the estimated costs for the alternatives. The final remedial program will be based on ODEQ's preferred alternative (as modified by public comments), and will be documented in the ROD, and developed in detail as part of the remedial design.

6.1 Preferred Alternative

In the initial evaluations, capping in place (Alternative 2) was identified as the most effective remedial alternative for overall protection of human health. Capping in place would have fewer short-term impacts on human health than consolidation and capping (Alternative 3) or removal and offsite disposal (Alternative 4). The soil with elevated CoC concentrations would remain in place, there would be minimal potential exposure for remediation workers, and there would be minimal disturbance of the environment during construction activities. Alternatives that involve soil removal (Alternatives 3 and 4) would provide long-term protection of human health, but could present short-term risks to workers, the environment, and the general public due to onsite handling, transport, and disposal.

Based on the data and analyses available at the time that the draft feasibility study was conducted, capping in place was also identified as the most readily implementable alternative. Capping is an effective, proven technology that has been used successfully at all types of sites, including the Bartlesville and Blackwell sites. The caps would use readily available, conventional materials and equipment, and could be quickly implemented. Capping in place would also be the most cost-effective alternative. Capping is an effective alternative, and has lower estimated costs than consolidation and capping or removal and offsite disposal.

As described in Appendix C, based on additional data and modifications to the approach taken to assess exceedances of remediation goals, a number of locations onsite and in the pasture area located to the west of the Site were identified for remediation. Based on these findings, the preferred alternative was refined to incorporate consolidation of soil from these locations within the consolidation area in accordance with the elements described in Alternative 3, consolidation with capping.

In addition, the use of other remedial technologies is not precluded at selected locations where they would be most appropriate. Mixing and removal may be appropriate elements of site remediation as described below:

- Mixing surface soil, as appropriate. For example, if surface soils (e.g., soil from offsite areas delineated during remedial design sampling) only slightly exceed the final remediation levels and mixing the soil for homogenization purposes to a greater depth (e.g., from 0–12 in.) would result in meeting the final remediation levels, then mixing may be conducted. Mixing could also include the addition of amendments (e.g., fly ash, lime, phosphate, or silicate) to stabilize soil.

- Removal and placement of offsite soil exceeding remediation levels in capping areas, as appropriate. For example, if areas of soil (e.g., soil from offsite areas delineated during the remedial design) exceed final remediation levels, and mixing the soil is not feasible, those soils could be removed and placed in the area designated for the soil cap.

7. References

Bowers, T.S., B.D. Beck, and H.S. Karam. 1994. Assessing the relationship between environmental lead concentrations and adult blood lead levels. Risk Anal. 14(2):183–189.

Exponent. 2001. Focused remedial investigation, Collinsville Smelter Site. Prepared for Phelps Dodge Corporation, Tempe, AZ. Exponent, Bellevue, WA.

PTI. 1996. Work plan, Collinsville Smelter Site focused remedial investigation and feasibility study. Prepared for counsel to Cyprus Amax Minerals Company, Englewood, CO. PTI Environmental Services, Bellevue, WA.

U.S. EPA. 1988. Guidance for conducting remedial investigations and feasibility studies under CERCLA. EPA-823-B93-001. Interim final. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

White, K.W. 1999. Letter to P. Lee, Cyprus Amax Minerals Company, no date, regarding remediation of Collinsville smelter site.

Wolfram, R. 1999. Personal communication (telephone conversation with S. Barnett, Exponent, Lake Oswego, OR, on December 8, 1999, regarding future development in the Collinsville area). AICP, City of Collinsville, OK.

Figures

List of Figures

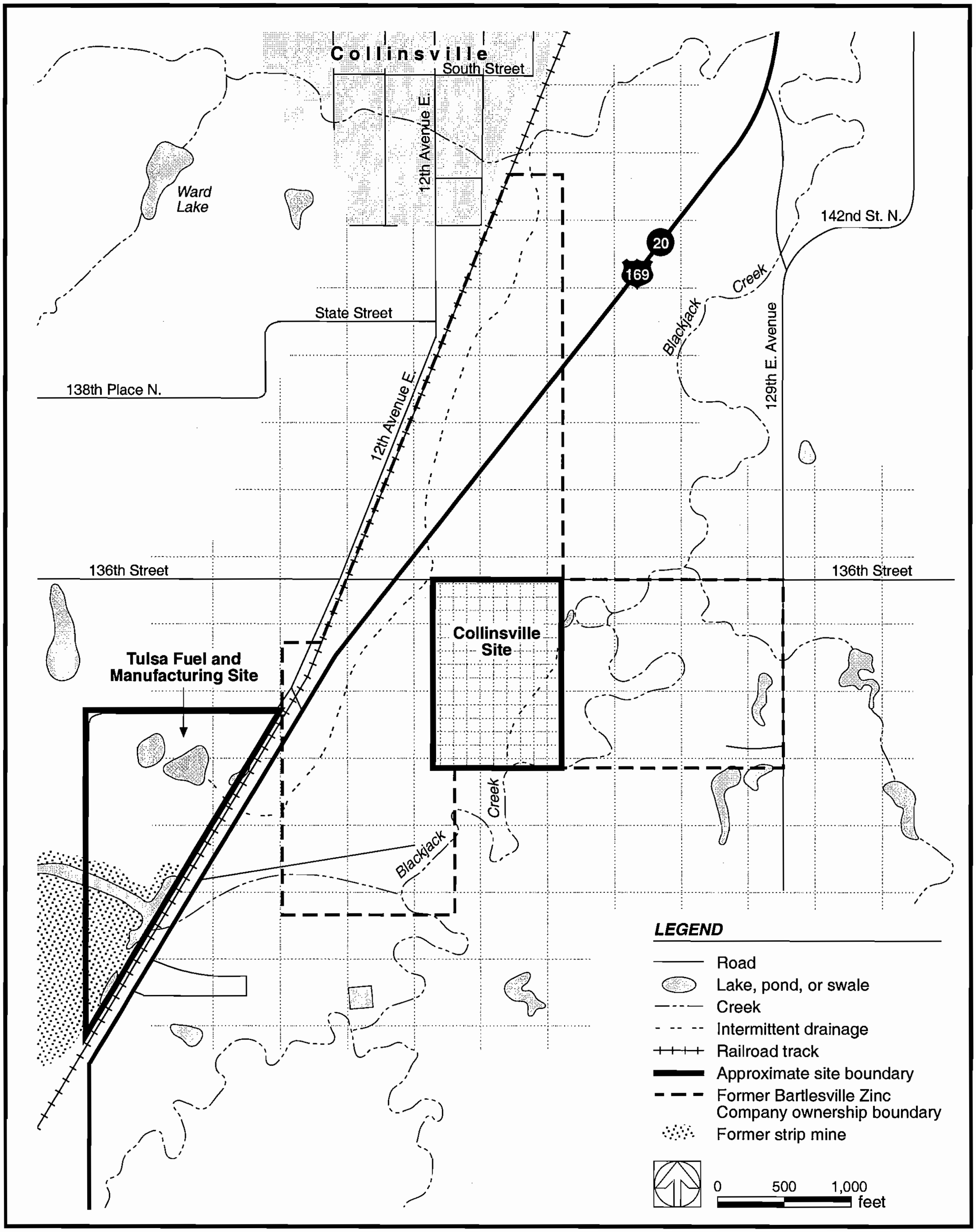

Figure 1-1. Site location – Collinsville, Oklahoma.

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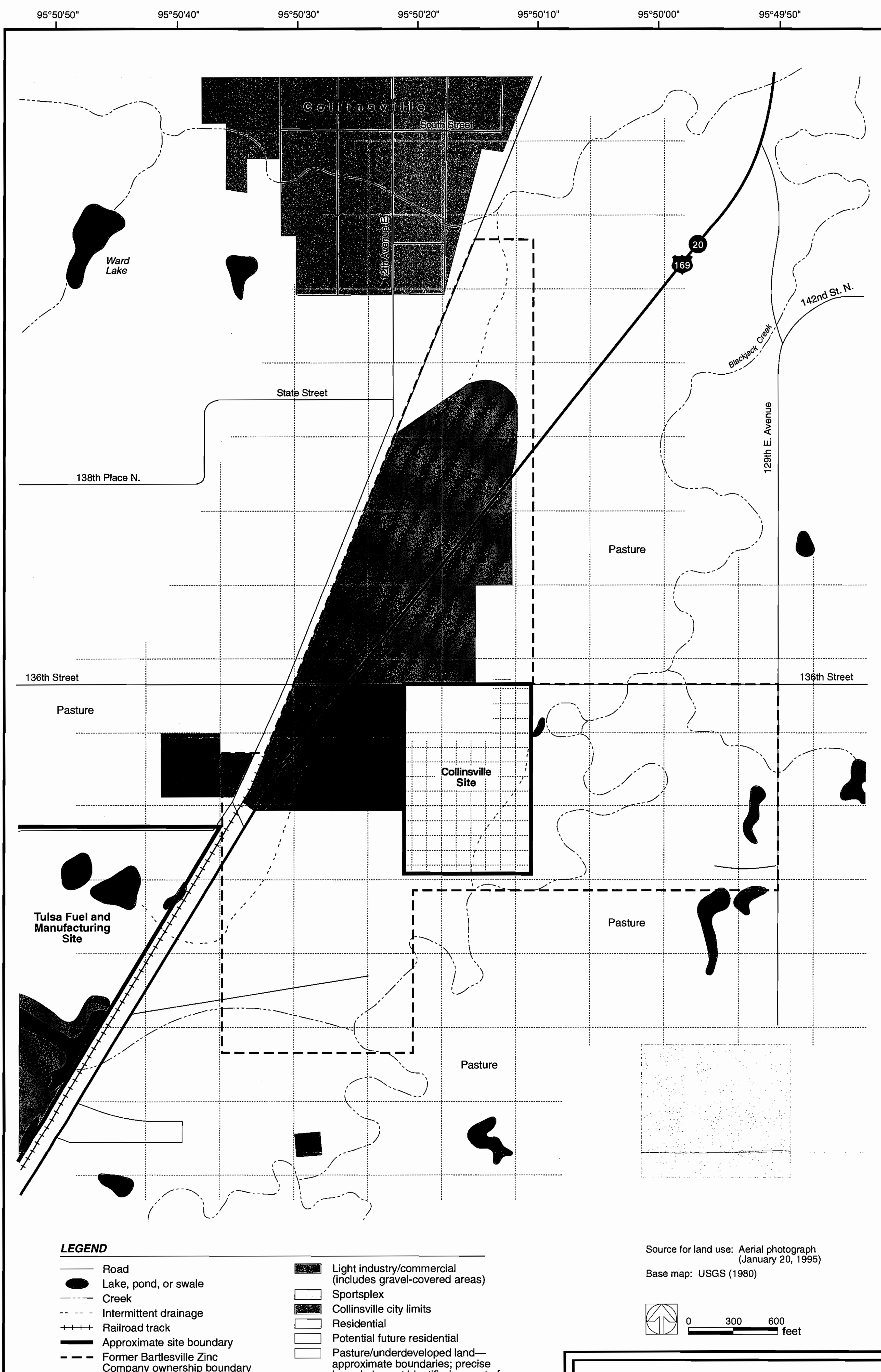

Figure 2-1. Overview of land use.

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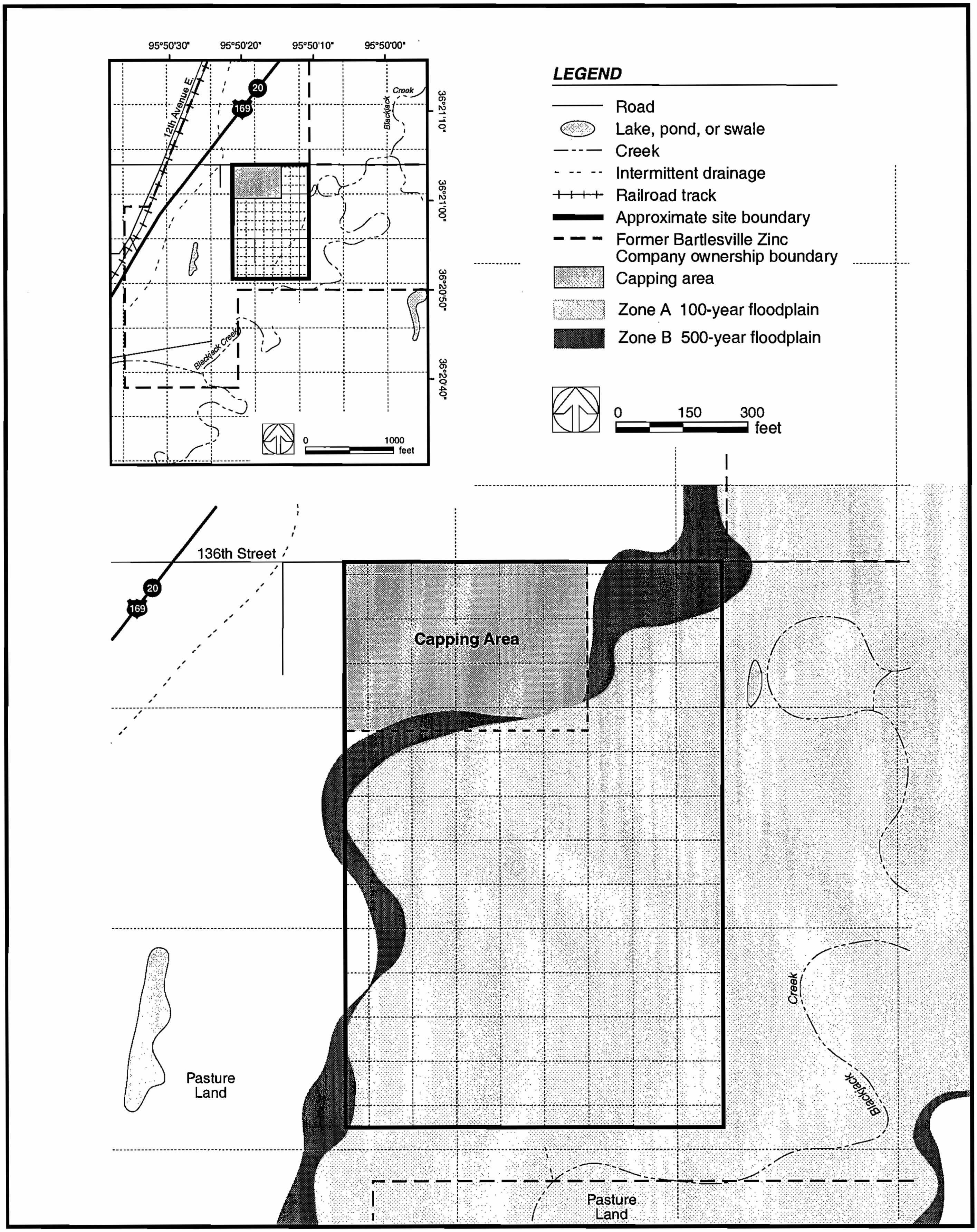

Figure 4-1. Capping area (Alternative 2).

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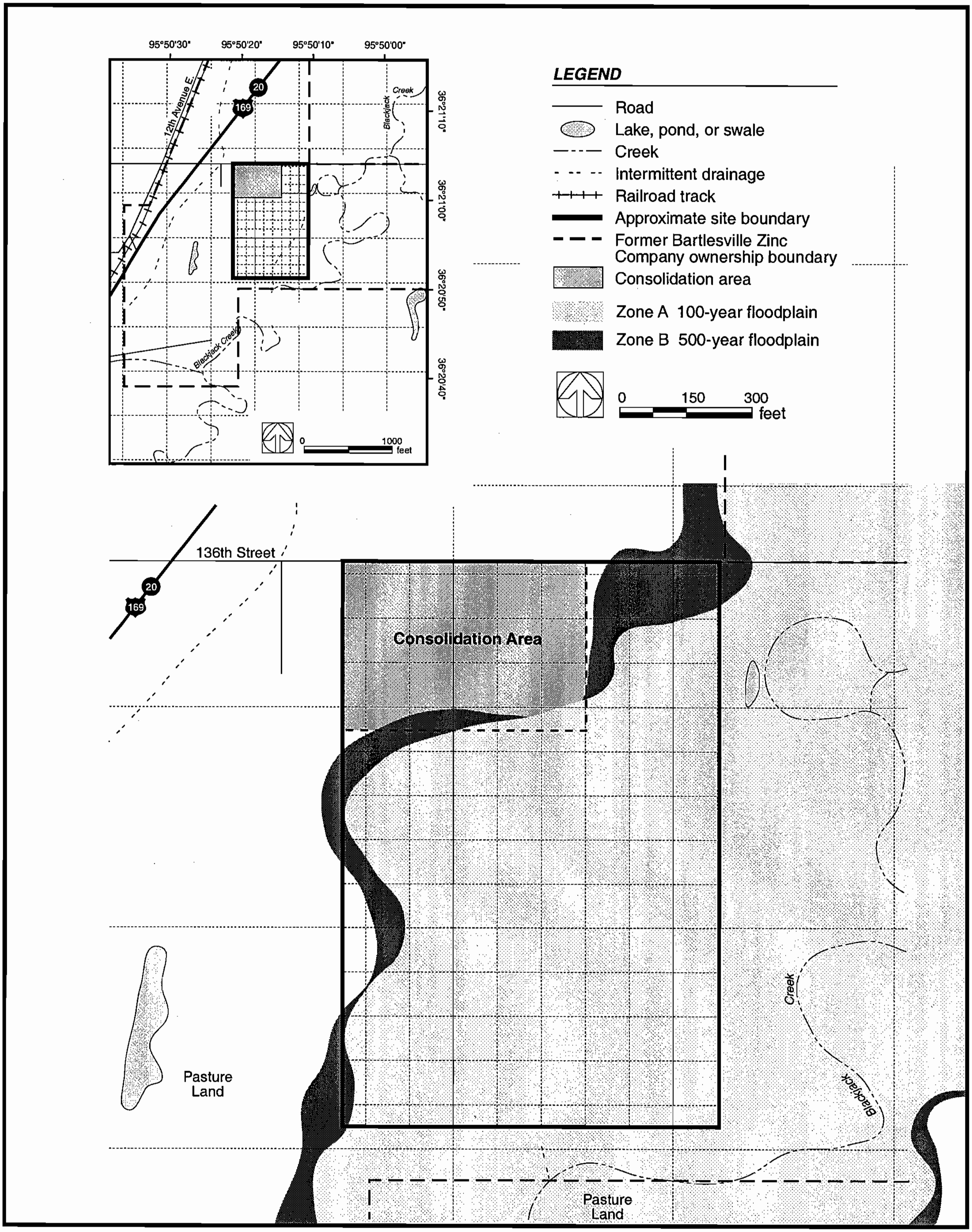

Figure 4-2. Consolidation area (Alternative 3).

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	EVALUATION CRITERIA							
	Threshold		Balancing					
SOIL	Protectiveness	Compliance with ARARs	Long-Term Effectiveness	Short-Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Implementability	Cost	Overall Rating
No Action	○	○	○	●	○	●	●	◔
Capping in Place	●	●	●	●	○	●	◕	◕
Consolidation and Capping	●	●	●	◕	○	◕	◑	◕
Removal and Offsite Disposal	●	●	●	◑	○	◕	◔	◑

LEGEND

- ● Meets or exceeds criteria
- ◕ Meets criteria, with few stipulations
- ◑ Meets criteria, with some stipulations
- ◔ May not attain criteria
- ○ Does not attain criteria

Figure 5-1. Comparison of alternatives.

Tables

List of Tables

Table 2-1. Risk-based PRGs for protection of human health[a]

	Residential/ Recreational	Occupational	Agricultural
Arsenic	60[b]	600[b]	200[c]
Cadmium	100[d]	200[d]	300[c]
Lead	925[e]	2,000[e]	5,000[c]

Note: Values in mg/kg.

PRG - preliminary remediation goal

[a] PRGs are based on cleanup levels selected by the Oklahoma Department of Environmental Quality for use at the National Zinc Site in Bartlesville and information and analyses indicating that these values are applicable for conditions at the Site.

[b] Arsenic PRGs for the residential/recreational and occupational scenarios are based on exposure via ingestion of soil, bioavailability information from the National Zinc Site, and a 3×10^{-5} target risk level for developing cancer.

[c] PRGs for the agricultural scenario are based on exposure via consumption of crops grown in metals-containing soil (cadmium) or agricultural worker exposure to metals-containing dust during plowing (arsenic and lead). Values are based on U.S. Environmental Protection Agency guidance for agricultural exposures associated with land application of metals-containing sewage sludge.

[d] Cadmium PRGs for the residential/recreational and occupational scenarios are based on exposure via ingestion of and dermal contact with soil, bioavailability information from the National Zinc Site, and a target hazard index of 1.

[e] The residential PRG for lead, which is designed to be protective of young children, is calculated using the U.S. Environmental Protection Agency's Uptake/Biokinetic Model Version 0.5 and bioavailability information from the Bartlesville Site. The occupational PRG for lead, which is designed to protect fetuses from adverse effects, is calculated using an adult exposure model (Bowers et al. 1994).

Table 2-2. Initial areas of potential concern for soil[a]

	Area (ft^2)	Area (acres)
Onsite areas[b]	210,000	4.8
Offsite areas[c]	80,000	1.8
Total all areas	290,000	6.6

[a] Areas based on initial remedial investigation data. Areas subsequently modified based on additional data and discussions with the Oklahoma Department of Environmental Quality and current Site owner as reflected in Appendix C.

[b] Based on potential future land use.

[c] Estimated by assigning the remedial soil samples that exceeded the industrial preliminary remediation goal an area of 200 × 200 ft (polygonal method).

Table 3-1. Identification and screening of remediation technologies

Technology	Screening Comments	Retained (Yes/No)
Institutional Controls		
Access restrictions Fencing Warning signs	Potentially applicable as component of overall Site remedy	Yes
Land use restrictions Zoning Title notices	Potentially applicable as component of overall Site remedy	Yes
Site monitoring	Necessary element of Site remedy if elevated levels of CoCs are left in place	Yes
Surface Controls		
Vegetative cover	Potentially applicable as component of overall Site remedy	Yes
Drainage controls	Potentially applicable as component of overall Site remedy	Yes
Dust suppression	Potentially applicable as component of overall Site remedy	Yes
Erosion control	Potentially applicable as component of overall Site remedy	Yes
Containment		
Capping in place Soil cover	Effective for minimizing contaminant migration and/or for reducing risk by preventing direct contact	Yes
Consolidation and capping Onsite consolidation area	Effective for minimizing contaminant migration and/or for reducing risk by preventing direct contact	Yes
Treatment		
In situ mixing	Mixing of the upper 2 ft of soil is unlikely to achieve PRGs in onsite areas with potential future residential use; however, may be applicable at other specific targeted locations	Yes
Ex situ mixing	Mixing of the upper 2 ft of soil is unlikely to achieve PRGs in onsite areas with potential future residential use	No
Soil washing	High percentage of fines in silt and clay soil at Site reduces likely effectiveness of the technology	No
Chemical stabilization	Minimal increase in protectiveness over equivalent processes	No
Vitrification	Extremely costly technology; not cost-effective over equivalent processes	No
Encapsulation	Extremely costly; not cost-effective over equivalent processes	No
Removal		
Excavation Backhoe Front-end loader Bulldozer Scraper	Effective in reducing long-term risk at the Site	Yes
Disposal		
Onsite engineered landfill	Effective technology, but not cost-effective	No
Offsite commercial landfill	Effective in reducing long-term risk at the Site	Yes

Note: CoC - chemical of concern
PRG - preliminary remediation goal

Table 3-2. Summary of remedial action alternatives for detailed analysis

No action
Capping in place[a]
Consolidation and capping[a]
Removal and offsite disposal[a]

[a] Alternatives may include other remedial actions for portions of the Site, as appropriate. These remedial actions may include, but are not necessarily limited to, capping (without prior soil removal or treatment), mixing of surface soil, institutional controls, and revegetation.

Table 5-1. Detailed evaluation of alternatives

NCP Evaluation Criteria	Alternative 1 No Action	Alternative 2 Capping in Place	Alternative 3 Consolidation and Capping	Alternative 4 Removal and Offsite Disposal
Threshold Criteria				
Overall protection of human health and the environment	Would not be effective because it would not meet PRGs.	Would be fully effective as long as cap is maintained.	Same as Alternative 2.	Same as Alternative 2.
Compliance with ARARs	Would not meet the requirements of the Oklahoma Environmental Quality Act.	Complies with ARARs.	Complies with ARARs. Consolidated soil unlikely to exceed TCLP.	Complies with ARARs. Excavated soil unlikely to exceed TCLP.
Primary Balancing Criteria				
Long-term effectiveness and permanence	Would not be effective because it would not meet PRGs.	Would be fully effective as long as cap is maintained.	Same as Alternative 2.	Similar to Alternatives 2 and 3; however, there is more certainty with the permanence of removal and offsite disposal.
Short-term effectiveness	Potential short-term exposure to soil containing elevated levels of CoCs would continue.	Work would be conducted according to state and federal health and safety regulations. There could be short-term risks to site workers during construction.	Similar to Alternative 2; however, there could be short-term risks to workers and the general public due to onsite handling and transport of contaminated soil.	Similar to Alternative 3; however, there could be a marginal increase in short-term risks to site workers and general public due to transport and disposal of contaminated soil.
Reduction of toxicity, mobility, or volume through treatment	There would be no reduction of toxicity, mobility, or volume through treatment.	The physical mobility of contaminated soil would be reduced.	Same as Alternative 2.	Same as Alternative 2.
Implementability	Easily implemented, but fails to meet regulatory criteria.	Easily implemented.	Easily implemented, although not as readily as Alternative 2.	Easily implemented, although not as readily as Alternative 3.
Cost—total present net worth ($ thousands)[a]	0	615	779	4,142

Note: ARAR - applicable or relevant and appropriate requirement
CoC - chemical of concern
PRG - preliminary remediation goal
TCLP - toxicity characteristic leaching procedure

[a] Cost estimates of alternatives were prepared in 1996. See Table C-1 for an updated estimate of Alternative 3, the preferred alternative.

Appendix A

Applicable or Relevant and Appropriate Requirements

Potential ARARs for the Collinsville Smelter Site, Collinsville, Oklahoma

This appendix lists the potential applicable or relevant and appropriate requirements (ARARs) and criteria to be considered (TBC criteria) for soil at the Collinsville Smelter Site in Collinsville, Oklahoma. The information in this appendix supports the detailed evaluation of alternatives in Section 5 of the feasibility study.

As discussed in Section 1 of the feasibility study, this report was prepared in accordance with regulations and guidance developed under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA); therefore, ARARs applicable to CERCLA sites are included. Because this feasibility study relies heavily on experience gained at other sites, a detailed, independent analysis of ARARs was not completed. Instead, ARARs developed for the National Zinc Site in Bartlesville, Oklahoma (ODEQ 1996) are recommended for use at this Site, and are presented in Tables A-1 and A-2. It should be noted, however, that the Collinsville Smelter Site is not a CERCLA site.

The following sections provide a brief discussion of ARARs, substantive and administrative requirements, and the different types of ARARs.

ARARs and TBC Criteria

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300) and the Superfund Amendments and Reauthorization Act of 1986 (SARA) require that remedial actions achieve protection of human health and the environment. In addition, the selected remedy must attain ARARs promulgated under federal or state law. An ARAR may describe a regulatory requirement against which the remedial action alternatives are reviewed. The selected alternative must comply with ARARs unless a waiver is warranted. ARARs are defined as follows:

> An *applicable requirement* is a promulgated federal or state standard that specifically addresses a hazardous constituent, remedial action, location, or other circumstance at a site. To be applicable, the remedial actions or the circumstances at the site must be within the intended scope and authority of the requirement.
>
> A *relevant and appropriate requirement* is a promulgated federal or state requirement that addresses problems or situations similar to those

encountered at a site, even though the requirement is not legally applicable.

Nonpromulgated federal and state standards and policies and guidance documents are not ARARs. These are criteria to be considered when remediating a site to protect human health and the environment. These nonpromulgated, nonbinding criteria are referred to as TBC criteria.

Substantive and Administrative Requirements

Onsite CERCLA response actions are exempt from the administrative requirements (e.g., permits) of other environmental and public health laws, but are required to comply with the substantive requirements of those laws. In this way, substantive requirements may be applicable or relevant and appropriate whereas administrative requirements are not. The purpose of the waiver of administrative requirements is to allow for an expedited response to remediate sites where normal administrative processes could pose significant delays to remedial actions. As noted above, the Collinsville Smelter Site is not a CERCLA site.

The U.S. Environmental Protection Agency (EPA) guidance defines substantive requirements as those requirements that pertain directly to actions or conditions in the environment; for example, quantitative health- or risk-based restrictions upon exposure to types of constituents (e.g., drinking water maximum contaminant levels [MCLs]), technology-based requirements for actions taken upon constituents, and restrictions upon activities in special locations are all substantive requirements.

Administrative requirements are defined as those mechanisms that facilitate the implementation of the substantive requirements of a statute or regulation; for example, the approval of or consultation with administrative bodies, issuance of permits, documentation, reporting, recordkeeping, and enforcement are all administrative requirements. It is important to understand that while *onsite* remediation activities are exempt from administrative requirements by CERCLA §121(e), *offsite* remedies are subject to all necessary permits and compliance with administrative requirements (U.S. EPA 1988).

Types of ARARs

There are three types of ARARs: chemical-specific, action-specific, and location-specific. Chemical-specific ARARs are health-risk- or ecological-risk-based concentration limits for specific constituents (e.g., federal and state drinking water standards). Action-specific ARARs are technology-based requirements that are prompted by the type of remedial action under consideration (e.g., National Pollutant Discharge Elimination System [NPDES] requirements for discharges to surface water). Location-specific ARARs restrict certain activities based on the location of the site (e.g., in a wetlands, floodplain, or historical site area).

TBC criteria include nonpromulgated policies, advisories, and guidance issued by the federal or state government (e.g., Health Effects Assessments).

ARARs that appear to be the most likely to pertain to site remediation activities are summarized in Tables A-1 and A-2. No specific ARARs were identified for the Collinsville Site location.

Table A-1. Chemical-specific ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Application
Federal		
Solid Waste Disposal Act and Resource Conservation and Recovery Act (RCRA)	40 CFR Part 261	Applicable. Some of the soils that will be removed from the Site could exhibit the characteristic of toxicity. Any soils that exhibit this characteristic will require treatment.
Clean Air Act and National Ambient Air Quality Standards	40 CFR Part 50	Relevant and appropriate during construction activities.
State		
Oklahoma Hazardous Waste Management Regulations	OAC 252:200	Applicable. Same reason as above.
Oklahoma Environmental Quality Act (Oklahoma Environmental Quality Code)	27A Oklahoma Statutes, Supp. 1996 Section 2-1-101 et. seq.	Applicable. Soil contamination is a public nuisance.
Oklahoma Air Pollution Control Regulations	OAC 252:100	Applicable if air concentrations are above the maximum allowable increase due to remedial action.

Source: ODEQ (1996).

Note: No location-specific ARARs were identified.

Table A-2. Action-specific ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Application
Federal		
Solid Waste Disposal Act, RCRA Subtitle C	40 CFR Parts 261, 264, and 265	Applicable. Portions may be relevant and appropriate to storage and treatment of waste for offsite shipment.
Occupational Safety and Health Administration (OSHA) regulations	29 CFR 1910	Applicable. During the remedial action at the Site, it is the responsibility of employers involved in activities on the Site to conform with the requirements of OSHA.
State		
Oklahoma Hazardous Waste Management regulations	OAC 252:200	See criteria for 40 CFR Parts 261, 264, and 265.
Oklahoma Air Pollution Control regulations	OAC 252:100	Applicable if sufficient emissions were generated as a result of construction activities.
Oklahoma Solid Waste Management regulations	OAC 252:500 and 510	Applicable to any offsite disposal of nonhazardous waste. Relevant and appropriate to any possible onsite disposal options.

Appendix B

Cost Estimate

Cost Estimates

This appendix presents cost estimates for soil remedial action alternatives for the Collinsville Smelter Site in Collinsville, Oklahoma. As discussed in the main text of the feasibility study, the cost estimates used in this report and presented in this appendix were derived based on the initial site data collected during the remedial investigation. These conceptual-level cost estimates were prepared in 1996 to assist in project evaluations including comparisons of remedial action alternatives. The actual costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope and schedule, and other variables. As a result, the actual project costs will vary from the estimates presented herein.

TABLE B-1. NO ACTION

COST COMPONENT DESCRIPTION	QUANTITY	UNITS	UNIT COST	TOTAL COST	ASSUMPTIONS
CAPITAL COSTS				$0	
CAPITAL COST TOTAL				$0	
OPERATIONS & MAINTENANCE COST				$0	
TOTAL OPERATIONS AND MAINTENANCE				$0	
TOTAL PRESENT WORTH COST				$0	

TABLE B-2. CAPPING IN PLACE

COST COMPONENT DESCRIPTION	QUANTITY	UNITS	UNIT COST	TOTAL COST	ASSUMPTIONS
CAPITAL COSTS					
Mob/Demob/Site preparation	1	LS	$20,000	$20,000	
Prepare surface	1	LS	$15,000	$15,000	Allowance for reworking surface
Geotextile	210,000	SF	$0.15	$31,500	60 mil nonwoven geotextile per 95 ER Cost Book 33 08 0531
Soil cap	16,000	CY	$10.00	$160,000	Soil from offsite placed in lifts; includes cost of soil and transport to Site
Seeding	4.8	AC	$1,436	$6,900	Seeding per 95 ER Cost Book 18 05 0402
Water truck	1	LS	$5,000	$5,000	Truck rental plus operator for 2 months
Surveying	1	LS	$2,500	$2,500	Survey of capped area
Title notices	1	LS	$10,000	$10,000	Estimated costs for attorneys to prepare title notices
CONSTRUCTION COST SUBTOTAL				$250,900	
OVERHEAD & PROFIT			30%	$75,300	
SUBTOTAL				$326,200	
Contingencies			20%	$65,200	
CONSTRUCTION COST TOTAL				$391,400	
Other Costs					
Administrative Costs			5%	$19,600	
Engineering Oversight During Construction			20%	$78,300	
Permits and Legal			5%	$19,600	
IMPLEMENTATION COST TOTAL				$508,900	
Engineering Design Cost			20%	$101,800	
CAPITAL COST TOTAL				$610,700	
OPERATIONS & MAINTENANCE COST					
Cap maintenance				$3,860	Assume $500/year for 10 years for reseeding; 5% discount rate
TOTAL OPERATIONS AND MAINTENANCE				$3,860	
TOTAL PRESENT WORTH COST				$615,000	

CA790306\Ca79cost.xls\B-2

TABLE B-3. CONSOLIDATION AND CAPPING

COST COMPONENT DESCRIPTION	QUANTITY	UNITS	UNIT COST	TOTAL COST	ASSUMPTIONS
CAPITAL COSTS					
Mob/Demob/Site preparation	1	LS	$20,000	$20,000	
Excavate/load/haul offsite soil	3,000	CY	$5.00	$15,000	Allowance for excavation and transport to consolidation area
Place soil and prepare surface	1	LS	$20,000	$20,000	Allowance for spreading soil and regrading
Geotextile	210,000	SF	$0.15	$31,500	60 mil nonwoven geotextile per 95 ER Cost Book 33 08 0531
Soil cap	19,000	CY	$10.00	$190,000	Soil from offsite placed in lifts; includes cost of soil and transport to Site
Seeding	6.6	AC	$1,436	$9,500	Seeding per 95 ER Cost Book 18 05 0402
Water truck	1	LS	$10,000	$10,000	Truck rental plus operator for 4 months
Surveying	1	LS	$2,500	$2,500	Survey of capped area
Sampling and analytical costs	1	LS	$10,000	$10,000	Allowance for confirmation sampling
Title notices	1	LS	$10,000	$10,000	Estimated costs for attorneys to prepare title notices
CONSTRUCTION COST SUBTOTAL				$318,500	
OVERHEAD & PROFIT			30%	$95,600	
SUBTOTAL				$414,100	
Contingencies			20%	$82,800	
CONSTRUCTION COST TOTAL				$496,900	
Other Costs					
Administrative Costs			5%	$24,800	
Engineering Oversight During Construction			20%	$99,400	
Permits and Legal			5%	$24,800	
IMPLEMENTATION COST TOTAL				$645,900	
Engineering Design Cost			20%	$129,200	
CAPITAL COST TOTAL				$775,100	
OPERATIONS & MAINTENANCE COST					
Cap maintenance				$3,860	Assume $500/year for 10 years for reseeding; 5% discount rate
TOTAL OPERATIONS AND MAINTENANCE				$3,860	
TOTAL PRESENT WORTH COST				$779,000	

TABLE B-4. REMOVAL AND OFFSITE DISPOSAL

COST COMPONENT DESCRIPTION	QUANTITY	UNITS	UNIT COST	TOTAL COST	ASSUMPTIONS
CAPITAL COSTS					
Mob/Demob/Site preparation	1	LS	$30,000	$30,000	Includes staging area
Excavate/load/stage offsite soil	3,000	CY	$5.00	$15,000	Allowance for excavation, transport to staging area, and loading
Excavate/load/stage onsite soil	11,000	CY	$5.00	$55,000	Allowance for excavating, staging, and loading soil
Transport soil to landfill	14,000	CY	$10.00	$140,000	Based on Mintech's estimate for the Bartlesville Site (PTI 1994)
Tipping fee for soil at landfill	21,000	TN	$60.00	$1,260,000	Estimate for tipping non-hazardous waste. 1.5 tons/CY
Geotextile	210,000	SF	$0.15	$31,500	60 mil nonwoven geotextile per 95 ER Cost Book 33 08 0531
Soil cap	19,000	CY	$10.00	$190,000	Soil from offsite placed in lifts; includes cost of soil and transport to Site
Seeding	6.6	AC	$1,436	$9,500	Seeding per 95 ER Cost Book 18 05 0402
Water truck	1	LS	$15,000	$15,000	Truck rental plus operator for 6 months
Surveying	1	LS	$2,500	$2,500	Survey of excavation area
Sampling and analytical cost	1	LS	$10,000	$10,000	Allowance for confirmation sampling and landfill profiling
Title notices	1	LS	$10,000	$10,000	Estimated costs for attorneys to prepare title notices
CONSTRUCTION COST SUBTOTAL				$1,768,500	
OVERHEAD & PROFIT			30%	$530,600	
SUBTOTAL				$2,299,100	
Contingencies			20%	$459,800	
CONSTRUCTION COST TOTAL				$2,758,900	
Other Costs					
Administrative Costs			5%	$137,900	
Engineering Oversight During Construction			15%	$413,800	
Permits and Legal			5%	$137,900	
IMPLEMENTATION COST TOTAL				$3,448,500	
Engineering Design Cost			20%	$689,700	
CAPITAL COST TOTAL				$4,138,200	
OPERATIONS & MAINTENANCE COST					
Cap maintenance				$3,860	Assume $500/year for 10 years for reseeding; 5% discount rate
TOTAL OPERATIONS AND MAINTENANCE				$3,860	
TOTAL PRESENT WORTH COST				$4,142,000	

Appendix C

Documentation of Modified Approach for Determining Remedial Needs

Documentation of Modified Approach for Determining Remedial Needs

In the draft focused feasibility study for the former Collinsville Smelter Site (the Site), estimated areas of potential concern for soil were identified by comparing observed metals concentrations with identified preliminary remediation goals (PRGs) for likely site uses. Soils requiring remediation were identified based on these comparisons. The analyses were used to support evaluations of remedial needs, options, and costs. This appendix describes the modifications to the originally proposed approach that were developed to address comments received from the Oklahoma Department of Environmental Quality (ODEQ) on the draft focused feasibility study. This information was previously provided for ODEQ's review in a technical memorandum submitted on September 26, 1997 (PTI 1997). Additional modifications have been undertaken based on discussions with the property owner regarding her preferred future use of the property, as documented in the attached letter (Attachment C1; White 1999). The locations identified for remediation based on consideration of the modified approach, ODEQ's concerns, and the property owner's wishes are described below.

In the draft focused feasibility study, average metals concentrations for onsite soils were compared with relevant PRGs based on likely patterns of exposure at the Site. Two subareas of the Site were identified based on likely land use. Because the current and likely future use of the Site is agricultural, this land use was applied for most of the Site. An area in the northwest corner of the Site was identified, however, as potentially suitable for future residential development because of its location outside of the 100-year and 500-year floodplains of Blackjack Creek. Thus, PRGs based on residential land use were used as the basis for comparison in this area. Because the average concentrations of both lead and arsenic in this area exceeded the residential PRGs for these chemicals, the entire area was identified as an area of concern. For the remainder of the onsite area, the average concentrations of all chemicals of concern (CoCs) were less than the PRGs based on agricultural land use. As a result, no remedial needs were identified for the agricultural area in the draft focused feasibility study.

In their written and verbal comments on the draft focused feasibility study, ODEQ commented on several elements of the proposed approach. First, because of the heterogeneous nature of the concentrations observed in some portions of the Site, ODEQ questioned the use of average concentrations calculated across large site areas as the basis for comparison with PRGs. Second, ODEQ expressed concern regarding potential access by children residing near the site to areas with elevated metals concentrations. The use of buffer zones around areas of different land use was suggested as a mechanism to address such concerns.

In response to ODEQ'S comments, the following modifications were made to the approach presented in the draft focused feasibility study:

- **Use of a buffer zone**—An approximately 150- to 200-ft buffer zone was designated around existing residential areas and those areas identified as potentially suitable for future residential development (e.g., the area in the northwest corner of the Site).[1] As described below, PRGs based on residential land use were used as the basis for comparison with soil concentrations in the buffer zone area.

- **Modified averaging approach**—To identify areas requiring remediation in the buffer zone, the approach of using average concentrations for the overall site area was modified. For the buffer zone, average concentrations were calculated for every two-by-two combination of grid station results in the buffer zone (i.e., various combinations of two adjacent grid stations and the two grid stations located directly to the south).

This approach is described in more detail below.

After completion of the draft focused feasibility study, additional surface soil data were collected during February 1998 in the pasture located to the west of the originally designated Site. These data were incorporated into the evaluation process described in this appendix. Based on agreements reached with the property owner, potential future residential land use was considered in assessing remedial needs for this area. The same residential PRGs and modified averaging approach that were applied in the buffer zone analyses were used to evaluate this area.

As noted above, remedial needs for the buffer zone area and the pasture to the west of the Site were assessed by comparing average concentrations for various combinations of grid station results with the PRG established assuming residential land use. An optimization method based on simulation routines (using Generator® software) was used to identify a remediation strategy (or set of remediation locations) that most efficiently achieve the remedial goals. The optimization calculations were performed based on lead concentrations because lead is 1) the primary CoC at the site, 2) the most extensive data are available for lead concentrations, and 3) as discussed in Section 4.2 *Affected Media* of the focused remedial investigation (Exponent 2001), soil concentrations of the other CoCs are highly correlated with lead concentrations.

The optimization method operates by calculating moving average concentrations for each two-by-two grid station combination present in the buffer zone area. The method identifies various sets of specific grid station locations for remediation, assuming that the

[1] The location of this area has been moved slightly from the initially identified location based on discussions with the property owner and site regrading considerations.

concentration present at those locations will be removed and replaced with soil containing a nominal background concentration (e.g., 20 mg/kg). Based on agreements reached in discussions with ODEQ, all individual grid station locations in the buffer zone and the pasture to the west of the originally designated Site where the observed concentration exceeds twice the residential PRG (1,850 mg/kg) were selected for remediation. Other potential locations for remediation were selected based on the criteria of the optimization method. The resultant combination of existing soil sample concentrations and post-remediation concentrations for each iteration was evaluated using the optimization method, and the degree to which it meets the criteria established for the analyses was assessed.

The degree to which each set of possible remediation locations attains the goals of the optimization process was calculated based on the following criteria:

- The degree to which the average concentration for any two-by-two grid station combination in the buffer zone area exceeds the residential PRG (925 mg/kg)
- The number of grid station locations selected for removal.

The optimization program was run until obtaining the solution that best attained the goals of the optimization process (i.e., until further modifications in the set of locations selected for remediation did not improve the attainment of the above-stated criteria). The remedial needs associated with the grid stations identified in that solution were then evaluated.

For the remainder of the Site where agricultural land use is assumed (i.e., excluding the buffer zone), the PRG based on agricultural land use was used to assess potential remedial needs.

The results of these analyses identified 22 grid stations for remediation in the buffer zone and in the pasture to the west of the Site where potential future residential land use was used as the basis for evaluation. These locations are shown in Figure C-1. The average lead concentrations that would result following remediation of the identified locations are shown in Figure C-2, and the underlying concentrations comprising the average concentrations are shown in Figure C-3.

The average lead concentration in soil in the remaining agricultural area was substantially less than the agricultural PRG (5,000 mg/kg); thus, no additional locations in this area were identified for remediation. Remedial needs for the northern portion of the Site identified as an area of potential future residential development are the same as identified in the main text of the focused feasibility study.

These results would yield the following area and volume estimates for soil identified for remediation:

- Onsite soil in buffer zones: 120,000 ft^2 (4,400 yd^3)
- Soil from pasture to west of Site: 100,000 ft^2 (3,700 yd^3).

These analyses slightly changed the estimate of the onsite area designated for capping (300,000 ft^2), but did not change the estimate of the potential offsite area of concern (80,000 ft^2). The above volume calculations assume that the 100 × 100-ft areas associated with the identified grid stations would be excavated to a depth of 1 ft and that the excavated soil would be moved to the consolidation area in the northern portion of the site. Clean backfill would be placed into the excavated locations. These estimates would increase the total combined area of potential concern in onsite and offsite locations, including the pasture to the west of the Site, from 290,000 ft^2 (6.6 acres; as presented in the main text of the focused feasibility study) to 520,000 ft^2 (12 acres). A conceptual design plan for the property owner's land that implements the remediation needs identified by the optimization process is provided in Attachment C2.

The estimated cost associated with this larger area would be approximately $1.9 million using the feasibility study unit cost assumption. The basis for this cost estimate is shown in Table C-1.

References

Exponent. 2001. Focused remedial investigation, Collinsville Smelter Site. Prepared for Phelps Dodge Corporation, Tempe, AZ. Exponent, Bellevue, WA.

PTI. 1997. Remedial investigation report, Collinsville Smelter Site. Prepared for Cyprus Amax Minerals Company, Englewood, CO. PTI Environmental Services, Bellevue, WA.

White, K.W. 1999. Letter to P. Lee, Cyprus Amax Minerals Company, no date, regarding remediation of old smelter site.

Figures

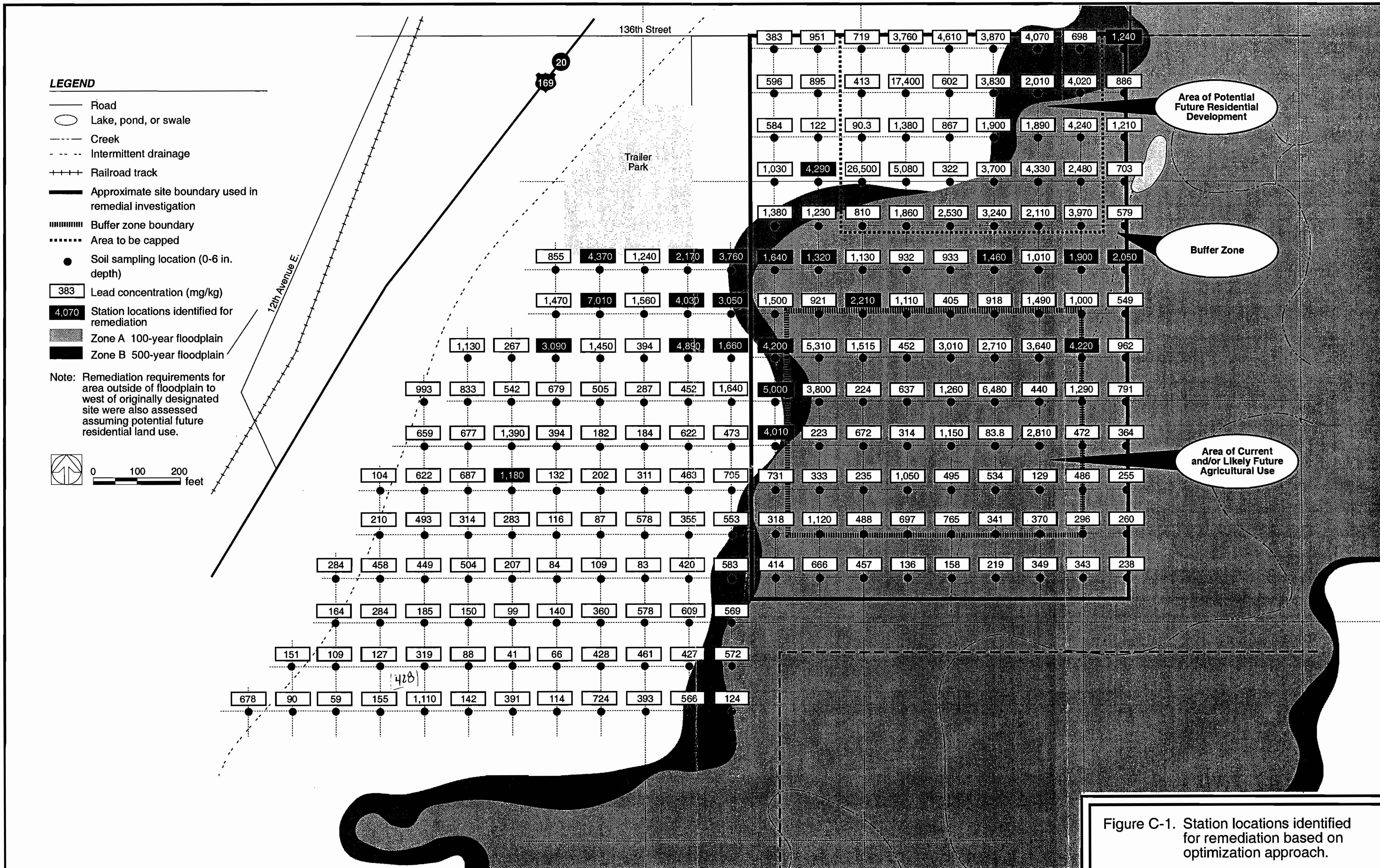

Figure C-1. Station locations identified for remediation based on optimization approach.

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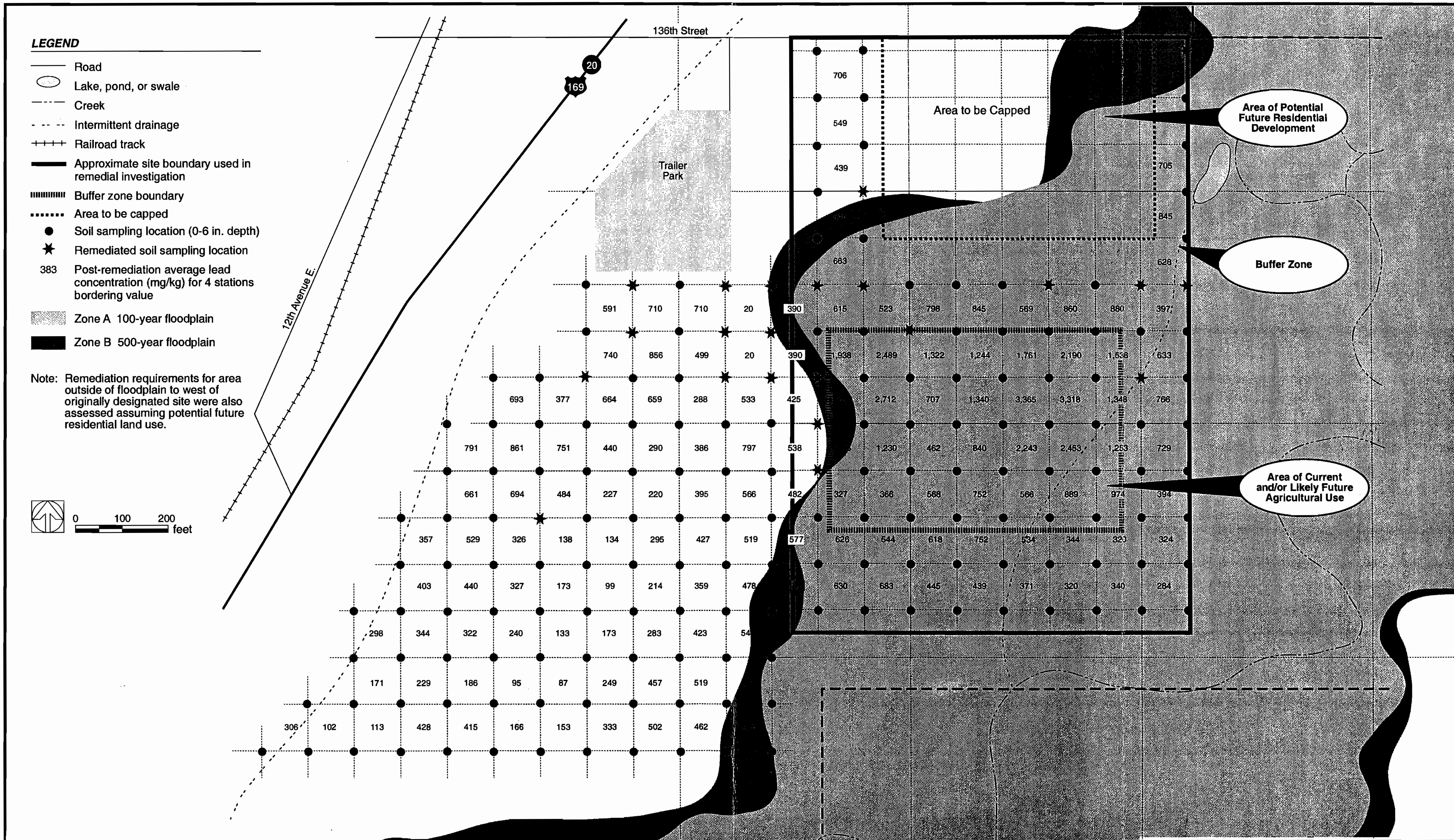

Figure C-2. Average lead concentrations following remediation of soil from identified locations.

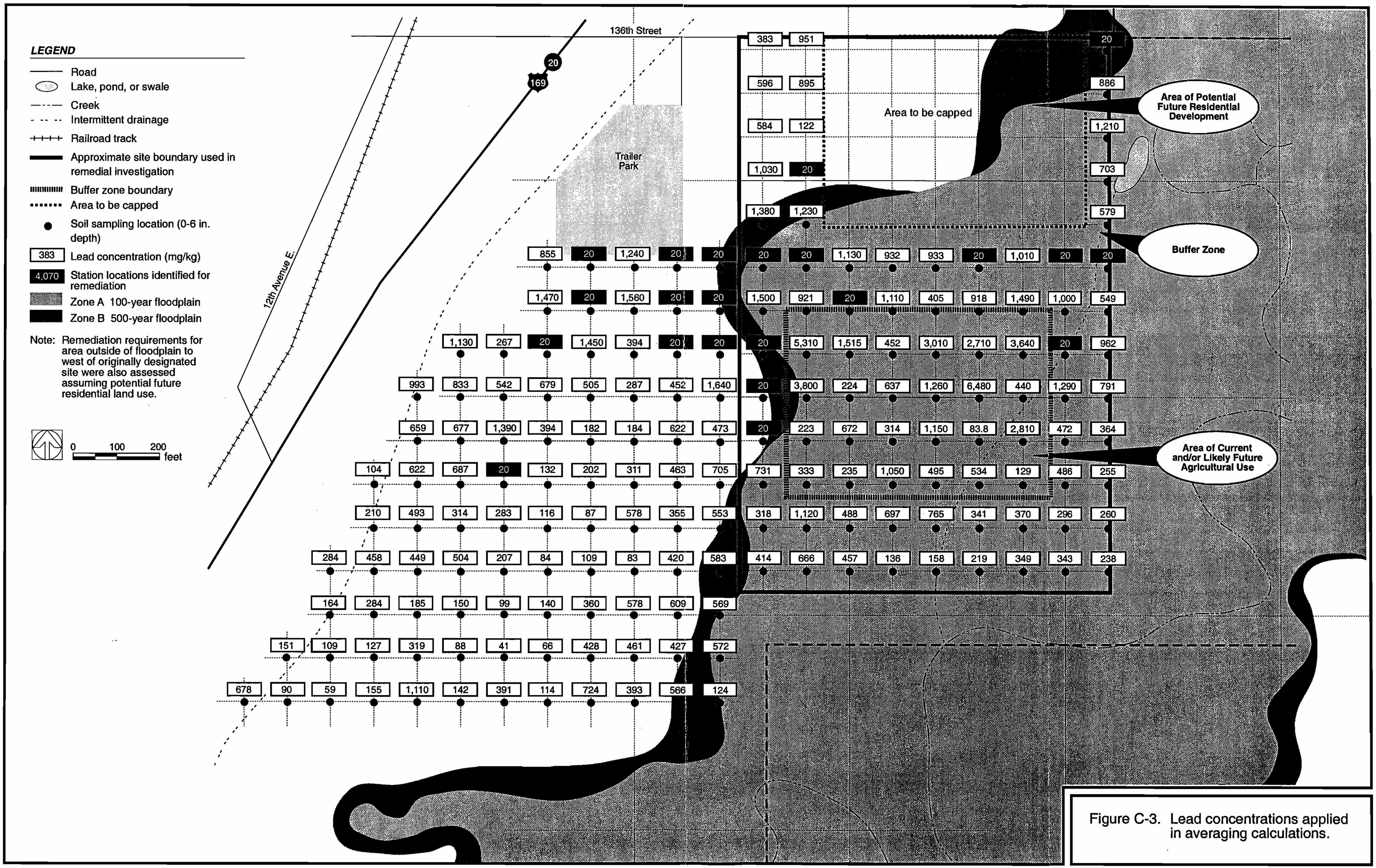

Figure C-3. Lead concentrations applied in averaging calculations.

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Table

Table C-1. Consolidation and capping (preferred alternative)

Cost Component Descirption	Quantity	Units	Unit Cost	Total Cost	Assumptions
Capital Costs					
Mob/demob/site preparation	1	LS	$20,000	$20,000	
Onsite area - excavate/load/haul soil	4,440	CY	$5.00	$22,200	Remediation of onsite soils (120,000 SF)
NW pasture area - excavate/load/haul soil	3,700	CY	$5.00	$18,500	Remediation of soil from the NW pasture unit (100,000 SF)
Offsite area - excavate/load/haul soil	2,960	CY	$5.00	$14,800	Allowance for remediation of other offsite areas (est. of 80,000 SF)
Place soil and prepare surface	1	LS	$20,000	$20,000	Allowance for spreading soil and regrading (est.)
Geotextile over consolidation area	300,000	SF	$0.57	$171,000	60 mil nonwoven geotextile per 99 ER Cost Book 33 08 0531
Soil cap and remediation area backfill	33,330	CY	$14.13	$470,900	Soil from offsite placed in lifts; includes cost of soil and transport to Site
Seeding	13.8	AC	$1,860	$25,700	Seeding per 99 ER Cost Book 18 05 0401 and 02
Water truck	1	LS	$10,000	$10,000	Truck rental plus operator for 2 months (est.)
Surveying	1	LS	$2,500	$2,500	Survey of capped area
Sampling and analytical costs	1	LS	$10,000	$10,000	Allowance for confirmation sampling
Title notices	1	LS	$10,000	$10,000	Estimated costs for attorneys to prepare title notices
CONSTRUCTION COST SUBTOTAL				$795,600	
OVERHEAD & PROFIT			30%	$238,700	
SUBTOTAL				$1,034,300	
Contingencies			20%	$206,900	
CONSTRUCTION COST TOTAL				$1,241,200	
Other Costs					
Administrative Costs			5%	$62,100	
Engineering Oversight during Construction			20%	$248,200	
Permits and Legal			5%	$62,100	
IMPLEMENTATION COST TOTAL				$1,613,600	
Engineering Design Cost			20%	$322,700	
CAPITAL COST TOTAL				$1,936,300	
Operations & Maintenance Cost					
Cap maintenance				$7,722	Assume $1,000/year for 10 years for reseeding/cap maintenance; 5% discount rate
TOTAL OPERATIONS AND MAINTENANCE				$7,722	
TOTAL PRESENT WORTH COST				$1,944,000	

Attachment C1

Documentation of Owner's Preferred Future Use of Property

KAREN W. WHITE
13519 NORTH 95TH EAST AVENUE
COLLINSVILLE, OK 74021

PATRICK LEE, MANAGER, ENVIRONMENTAL ENGINEERING
CYPRUS AMAX MINERALS COMPANY
P.O. BOX 3299
ENGLEWOOD, CO 80155-3299

DEAR MR. LEE:

THANK YOU FOR FOR HAVING A MEETING WITH MY FAMILY AND I TO DISCUSS THE REMEDIATION OF THE OLD SMELTER SITE ON MY PROPERTY SOUTHEAST OF COLLINSVILLE.

I APPRECIATE ALL THE WORK CYPRUS AMAX HAS DONE ON THIS SITE, AND I AM NOT TRYING TO BE DIFFICULT, BUT I DO WANT TO UNDERSTAND THE PROCESS BEFORE THE WORK BEGINS.

AT OUR MEETING OF JUNE 23, 1999, WE TALKED ABOUT POSSIBLE RESIDENTIAL AREAS IN THE PROPOSED REMEDIAL SITE. IF I AM REMEMBERING CORRECTLY, YOU SAID THAT ALL THE LAND NOT IN THE FLOOD PLAIN, BUT WITHIN THE DESIGNATED CLEAN-UP AREA, WILL BE RESTORED TO RESIDENTIAL STANDARDS. THIS WOULD BE THE AREA ALONG THE SOUTH EDGE OF 136TH STREET NORTH AND EAST OF THE EXISTING MOBILE HOME PARK; ALSO EIGHT ACRES DIRECTLY SOUTH OF THE MOBILE HOME PARK THAT IS NOT IN THE FLOOD PLAIN. YOU ALSO SAID IT WOULD BE POSSIBLE TO CUT DOWN THE HEIGHT OF THE NORTHWEST CORNER OF THE PROPERTY AND LEVEL OFF THAT SAME AREA ALONG THE EXISTING FENCE LINE ON 136TH STREET NORTH.

OUR DISCUSSION INCLUDED TALK ABOUT BURYING THE CONTAMINATED ROCKS AND SOILS, COVERING THOSE PLACES WITH GOOD QUALITY TOP SOIL AND RESEEDING THE BARE GROUND WITH GRASS (BERMUDA IF POSSIBLE). I DO NOT REMEMBER DISCUSSING FENCES BUT AM ASSUMING THAT ANY FENCES REMOVED FOR REMEDIATION WILL BE REPLACED, AND THAT PRECAUTIONS WILL BE TAKEN REGARDING THE CATTLE GRAZING IN THAT AREA.

I UNDERSTAND THAT PEOPLE WILL HAVE TO BE INFORMED ABOUT THE CONTAMINATED SOILS AND ROCKS BELOW THE SURFACE OF THE GROUND, AND ALSO THAT THERE IS NO DANGER TO HUMANS OR ANIMALS IF THOSE SOILS AND ROCKS ARE UNCOVERED AS LONG AS THEY ARE REPLACED IN A LIKE MANNER.

THE PRECEDING COMMENTS ABOUT THE REMEDIATION OF MY PROPERTY ARE AGREEABLE WITH ME, MY HUSBAND AND MY CHILDREN.

SINCERELY YOURS,

Karen W. White

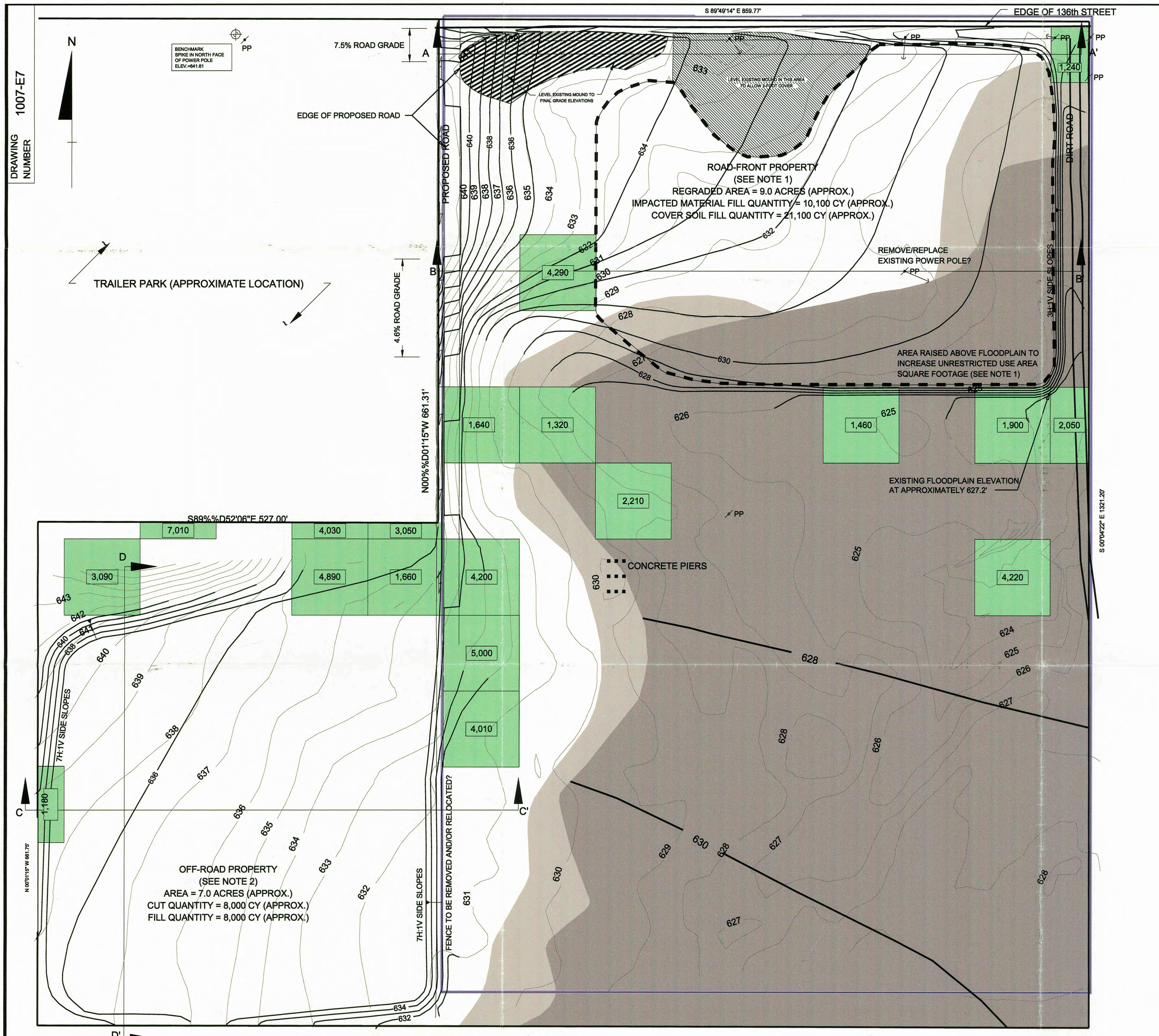
KAREN W. WHITE

Attachment C2

Conceptual Regrading Plan

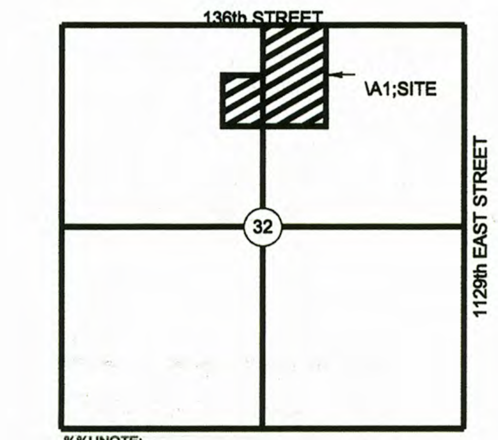
(Reprinted from Files Provided by EMC^2)

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	2/7/00	ISSUED FOR FINAL FOCUSED FEASIBILITY STUDY COLLINSVILLE SMELTER SITE	C.L.V.	T.S.L.	J.M.F.



REFERENCES:

TOPOGRAPHY BASEMAP PROVIDED BY G & A ASSOCIATES, 'TOPOGRAPHICAL SURVEY FOR MR. LEWIS KEITH, A PART OF: SEC 32, T-22-N, R-14-E', DRAWING FILENAME: G99185, DATED 6/16/99. FLOODPLAIN DELINEATION IS APPROXIMATE BASED ON FLOOD INSURANCE RATE MAP, COMMUNITY-PANEL NUMBER 400462 0035 B, EFFECTIVE DATE: SEPTEMBER 16, 1982. APPROXIMATE SITE BOUNDARY IS BASED ON FIGURE 1 FROM EXPONENT'S NOVEMBER 6, 1998 "COLLINSVILLE SMELTER SITE- SUBMITTAL OF SUPPLEMENTAL DOCUMENTATION REGARDING THE APPROACH FOR IDENTIFYING REMEDIATION AREAS" CORRESPONDENCE TO THE OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY (ODEQ).



%%UNOTE:
PERIMETER BOUNDARY SURVEY BY JIM RICHARD BROWN DATED NOV. 27, 1979

GENERAL LOCATION MAP

SCALE: 1"=2000'

NOTES:

1. ROAD-FRONT PROPERTY WILL BE REMEDIATED TO RESIDENTIAL STANDARDS TO PROVIDE A LEVEL RESIDENTIAL BUILDING SITE BY EITHER: EXCAVATING IMPACTED MATERIALS TO A MAXIMUM TWO-FOOT DEPTH AND BACKFILLING WITH IMPORTED CLEAN SOIL; OR COVERING IMPACTED MATERIALS WITH TWO FEET OF IMPORTED CLEAN SOIL. ROAD-FRONT PROPERTY REGRADING ASSUMES THAT LOCAL ORDINANCES ALLOW FILLING OF FLOODPLAINS WITHOUT EXTENSIVE COUNTY OR WETLAND PERMITS APPLICATIONS WITH RESTRICTIONS DURING THE PERMITTING PROCESS. IF NOT, ROAD-FRONT PROPERTY DEVELOPMENT WILL BE IMPLEMENTED ONLY OUTSIDE THE FLOODPLAIN AREA.
2. OFF-ROAD PROPERTY REGRADING WILL PRODUCE A SECOND LEVEL RESIDENTIAL BUILDING SITE AFTER EXCAVATING IMPACTED MATERIALS FOR CONSOLIDATION IN THE ROAD-FRONT PROPERTY AREA AND USING A BALANCED CUT/FILL OF REMAINING CLEAN SOILS.
3. THE EXCAVATE/BACKFILL AREAS WILL BE EXCAVATED TO A MAXIMUM TWO-FOOT DEPTH AND REPLACED WITH BORROW AREA MATERIAL FROM AN OFF-SITE BORROW SOURCE. THESE AREAS WERE IDENTIFIED FOR REMEDIATION BASED ON OPTIMIZATION APPROACH (OPTIMIZATION RESULTS PROVIDED BY EXPONENT ON FEBRUARY 3, 2000).

LEGEND

4,220	EXCAVATE/BACKFILL AREA WITH LEAD CONCENTRATION (PARTS-PER-MILLION) (SEE NOTE 3)
	CONSOLIDATION AREA BOUNDARY (5.3 ACRES)
632	FINAL CONTOURS (FEET, MSL)
632	EXISTING CONTOURS (FEET, MSL)
628	EXISTING 100-YEAR BASE FLOOD ELEVATION LINE (FEET, MSL)
	EXISTING 100-YEAR FLOODPLAIN (ZONE A4)
	EXISTING 500-YEAR FLOODPLAIN (ZONE B)
PP	POWER/TELEPHONE POLE
	GUY ANCHOR
EOH	ELECTRIC OVERHEAD LINE
X	FENCELINE
	PROPERTY LINE
	BENCHMARK
	DIRECTION OF DRAINAGE FLOW
	APPROXIMATE SITE BOUNDARY USED IN REMEDIAL INVESTIGATION (SEE REFERENCES)
A A'	CROSS-SECTION LOCATION AND DESIGNATION (SEE FIGURE 2)

SCALE IN FEET: 60 0 60 120

CONTOUR INTERVAL = 1 FOOT

FORMER SMELTER SITE AREA CONCEPTUAL REGRADING PLAN COLLINSVILLE, OKLAHOMA

PREPARED FOR

CYPRUS AMAX MINERALS CO. ENGLEWOOD, COLORADO

Preliminary - Not For Construction

EMC² Environmental Management Consultants Corporation

DATE:	2/7/00	FIGURE 1	DRAWING NUMBER 1007-E7
SCALE:	AS SHOWN		

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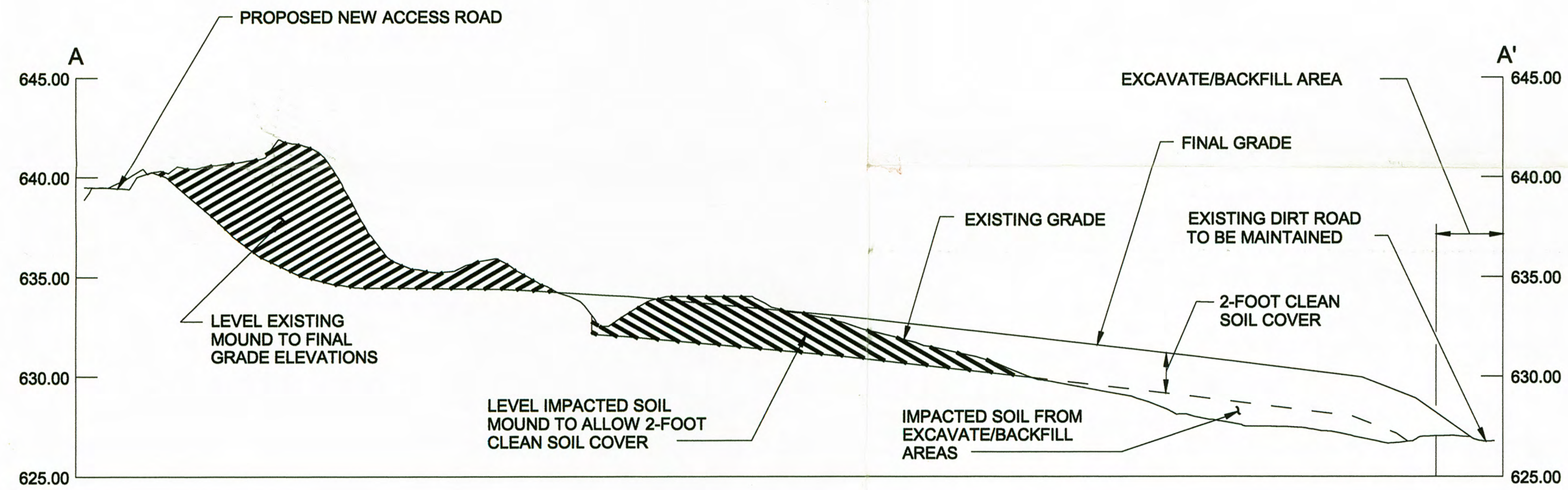
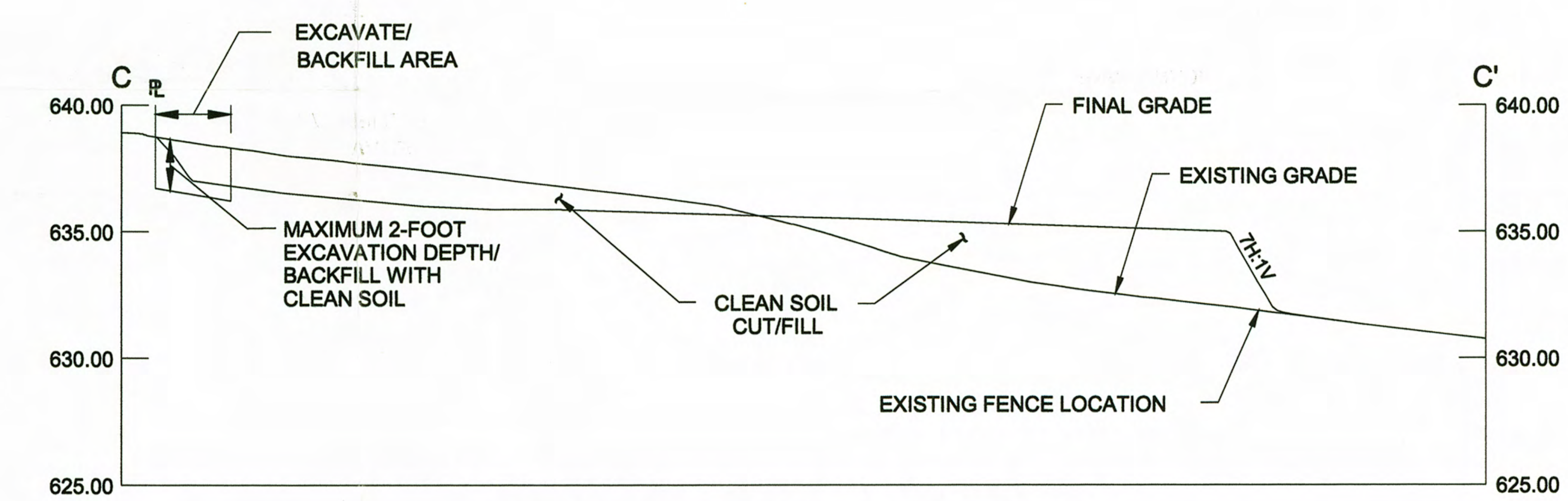
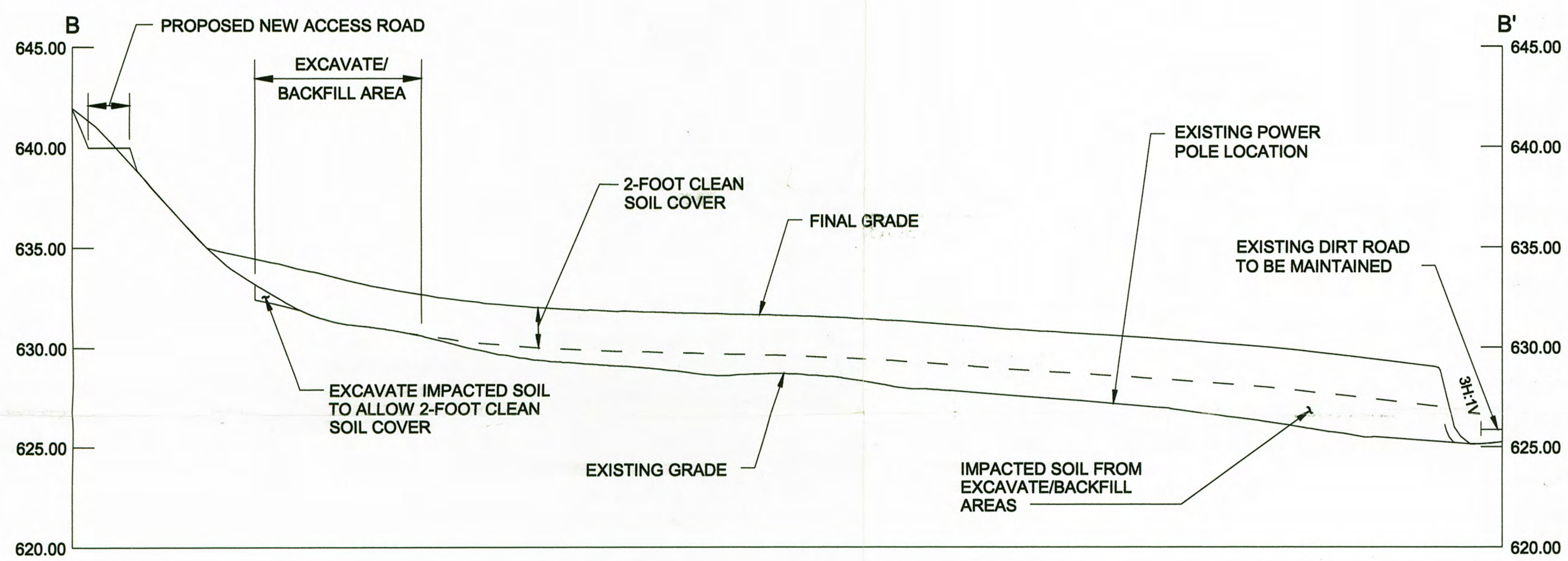
DRAWING NUMBER 1007-E8



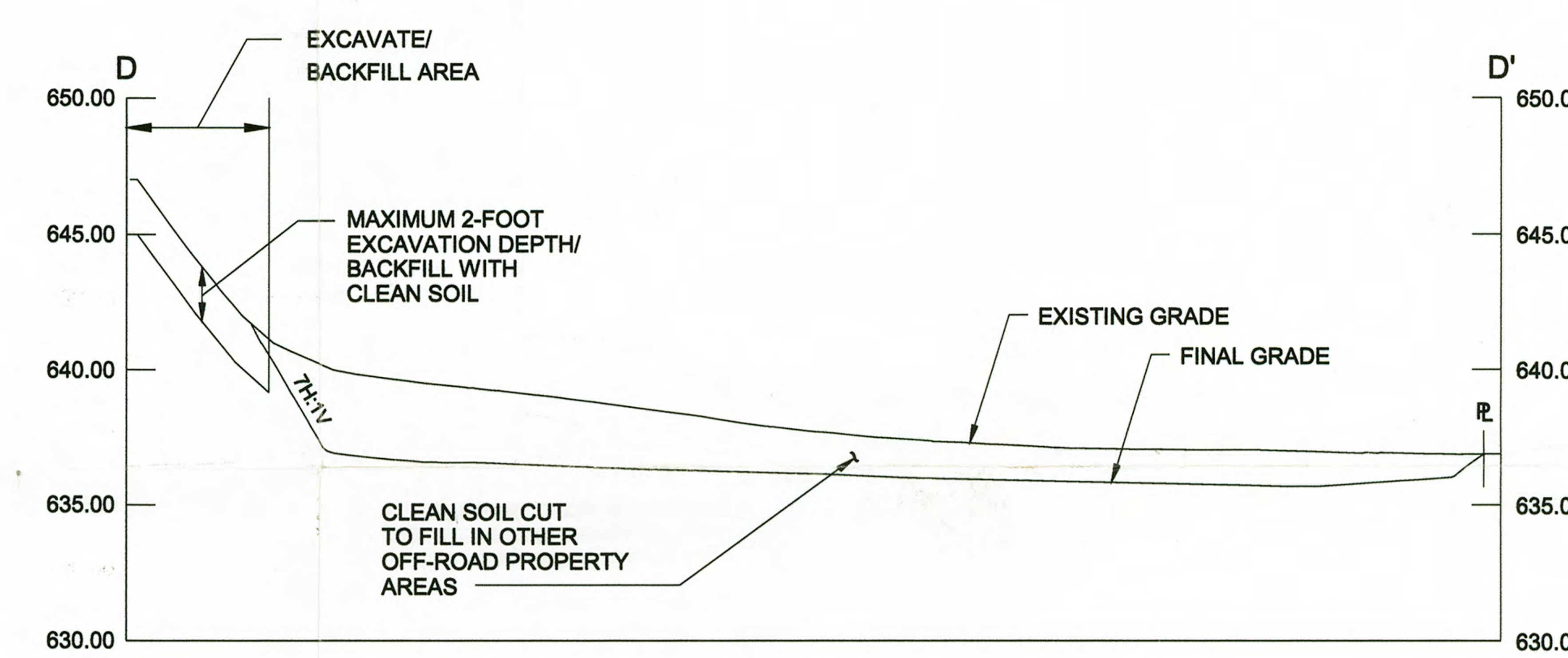
ROAD-FRONT PROPERTY CROSS-SECTION A-A'
(LOOKING NORTH)



OFF-ROAD PROPERTY CROSS-SECTION C-C'
(LOOKING NORTH)



ROAD-FRONT PROPERTY CROSS-SECTION B-B'
(LOOKING NORTH)



OFF-ROAD PROPERTY CROSS-SECTION D-D'
(LOOKING EAST)

HORIZONTAL SCALE IN FEET (ALL CROSS-SECTIONS)
60 0 60 120

NOTES:

1. SEE FIGURE 1, "FORMER SMELTER SITE AREA CONCEPTUAL REGRADING PLAN - COLLINSVILLE, OKLAHOMA" FOR CROSS-SECTION LOCATIONS.

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FORMER SMELTER SITE AREA
CONCEPTUAL REGRADING PLAN
CROSS-SECTIONS
COLLINSVILLE, OKLAHOMA
PREPARED FOR

CYPRUS AMAX MINERALS CO.
ENGLEWOOD, COLORADO

EMC2 Environmental Management Consultants Corporation

DATE:	2/7/00	FIGURE 2	DRAWING NUMBER 1007-E8	1
SCALE:	AS SHOWN			

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	2/7/00	ISSUED FOR FINAL FOCUSED FEASIBILITY STUDY COLLINSVILLE SMELTER SITE	C.L.V.	T.S.L.	J.M.F.

8600A79.001 0306 | Apr 04,2000 | Fig 2 | fig 2 layout | I:\collinsville\projects\dwgs.apr