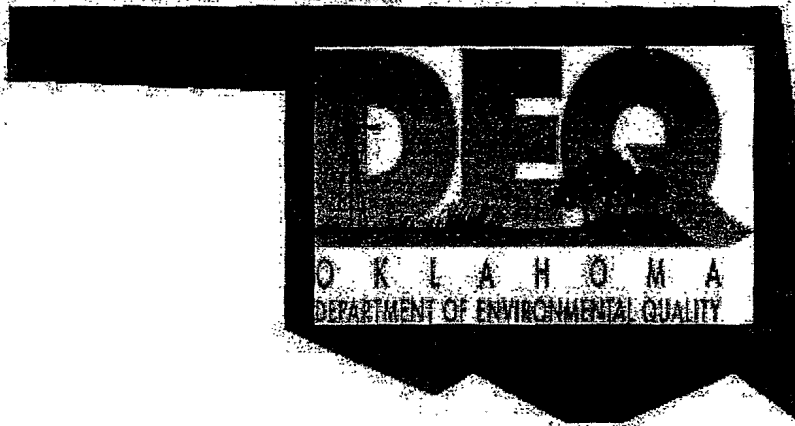


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**GROUNDWATER REMEDIATION UNIT
RECORD OF DECISION**



**BLACKWELL ZINC SITE
BLACKWELL, OKLAHOMA**

Prepared by
OKLAHOMA
DEPARTMENT OF ENVIRONMENTAL QUALITY

August 15, 2003

In 1992, the Oklahoma State Department of Health (OSDH), entered into a Consent Order with the BZC, the City of Blackwell, and the BIA regarding the investigation and cleanup of contamination resulting from historical operations of the Blackwell Zinc smelter. The goal of the 1992 Consent Order was to ensure that an appropriate investigation and remediation of the Site were conducted under state oversight to protect human health and the environment. On July 1, 1993, the newly created DEQ assumed the environmental duties of the OSDH.

In April 1994, the DEQ and EPA signed a memorandum of understanding (MOU) for a pilot project to allow the State to use its authority to complete a Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)-quality Site investigation and remediation. The EPA agreed to defer a final determination to list the Site on the National Priorities List (NPL) as long as the pilot project proceeded in a timely manner and achieved CERCLA-quality results.

Initial investigations of groundwater conditions in Blackwell were carried out between 1991 and 1997. Results are summarized in the *Blackwell Technical Report 95-12* (Mintech 1995) and the *Blackwell Zinc Site Groundwater Focused Feasibility Study* (PTI 1998). On the basis of these studies, the DEQ, in August 1998, issued a Proposed Plan that identified monitored natural attenuation with institutional controls as the preferred remedial action alternative for the GRU. In response, the City of Blackwell filed extensive comments on the 1998 Proposed Plan, largely relating to concerns about the ongoing potential for infiltration of metals-bearing groundwater to the City's wastewater collection and treatment facilities. Infiltration of metals-bearing groundwater to the City's storm drain collection system was detected in 1998. In December 1999, Phelps Dodge Corporation acquired Cyprus Amax Minerals Company, parent of BZC. In February 2000, the Water Quality Division of the DEQ issued a Notice of Violation (NOV) to the City of Blackwell alleging several violations of the City's National Pollutant Discharge Elimination System (NPDES)/Oklahoma Pollutant Discharge Elimination System (OPDES) Permit for its wastewater treatment plant (WWTP). Among the violations were failures of the Whole Effluent Toxicity (WET) test criteria for treated effluent from the WWTP, which were attributed to infiltration of groundwater containing elevated concentrations of cadmium and zinc into the wastewater collection system.

In March 2000, the DEQ Water Quality Division issued a related but separate NOV to Phelps Dodge Corporation citing violations that included: 1) causing pollution to waters of the state in violation of the state public nuisance statute; 2) discharging a pollutant into waters of the state without a permit; and 3) introducing into a Publicly-Owned Treatment Works (POTW) as a user, a pollutant which causes a pass-through interference on the operation of the POTW.

*Infiltration
10 yrs
ago!*



In June 2000, the DEQ entered into a Consent Order with the City of Blackwell and Phelps Dodge Corporation. This Consent Order required the parties to correct the violations listed in the NOV's and to address the outstanding remediation issues at the Site, particularly those related to the GRU. Subsequently, the City and PDC proposed, and the DEQ accepted, a plan of action for addressing the NOV's and remediating groundwater in the GRU. This plan included additional studies to further characterize groundwater contamination in the GRU and the preparation of the SFFS/ASFSS to identify new remedial action alternatives for the GRU. This process has been the subject of multiple amendments to the June 2000 Consent Order.

The 2001 SFFS, ASFSS, and SBRA provide the technical basis for the DEQ's selection of a remedial action for addressing groundwater contamination in the GRU. Groundwater investigations and the associated regulatory process for the GRU have been ongoing since 1991. The table below provides a chronological summary of the key events and studies that provide much of the background and context for the DEQ's identification of a remedial action for the GRU.

CHRONOLOGICAL SUMMARY OF KEY EVENTS AND GROUNDWATER STUDIES	
1916 to 1974	<i>Operation of the Blackwell Zinc Company smelter</i>
1974	<i>Smelter facility closed and site donated to the Blackwell Industrial Authority</i>
1991-1995	<i>Groundwater Remedial Investigation</i>
1995	<i>Blackwell Technical Report 95-12 (Mintech 1995)</i>
1996	<i>Work Plan: Blackwell Zinc Site, Groundwater Remediation Unit, Focused Feasibility Study (PTI 1996)</i>
January 1998	<i>Focused Feasibility Study, Blackwell Zinc Site, Groundwater Remediation Unit (PTI 1998)</i>
August 1998	<i>Groundwater Remediation Unit Proposed Plan (DEQ 1998a)</i>
October 2000	<i>Supplemental Groundwater, Surface Water, and Sewer Investigation (Exponent 2000a)</i>
May 2001	<i>Supplemental Focused Feasibility Study (Montgomery Watson 2001)</i>
January 2002	<i>Work Plans for Laboratory and Field Analysis to Support the Focused Feasibility Study Addendum of In-Situ Remediation of Groundwater, Blackwell, Oklahoma (Exponent 2002)</i>
December 2001 to Nov 2002	<i>Implementation of laboratory and field treatability studies, including supplemental source characterization, electron-donor injection field testing, and PRB laboratory column testing at the University of Waterloo</i>
December 2002	<i>Addendum to the Supplemental Focused Feasibility Study (Integral 2002)</i>
June 2003	<i>Revised Proposed Plan for the GRU (DEQ 2003)</i>
August 2003	<i>Supplemental Baseline Risk Assessment: Groundwater Risk Evaluation, Blackwell Zinc Site (HSWMR 2003)</i>

COMMUNITY PARTICIPATION

The involvement of local citizens in this project has been a major goal of DEQ, PDC, and the City of Blackwell. In 1992, a steering committee of local representatives that included all potentially affected stakeholders in the community was established by DEQ and the City of Blackwell. During the early phases of the project, the steering committee served as a mechanism to voice local concerns directly to the regulatory agencies throughout the project. Public meetings to discuss important developments were advertised in the local newspaper and were held in the evening following steering committee meetings. Throughout the remedy selection process for the GRU, the DEQ, PDC, and the City have continued to participate jointly in meetings with the public regarding selection of the remedial action. All significant information has been released through the public meeting process in order to allow concerned local citizens to receive and respond to it.

see attached Comments by steering Committee member

As described previously, the DEQ initially issued a Proposed Plan for the GRU in August of 1998. The City of Blackwell filed extensive comments on the 1998 Proposed Plan, largely relating to concerns about the ongoing potential for infiltration of metals-bearing groundwater to the City's wastewater collection and treatment facilities. Additional investigations of site conditions and an extensive further evaluation of remedial action alternatives were performed to address these concerns. The findings are presented in the 2001 SFFS and the ASFFS. The Revised Proposed Plan was released to the public for review and comment on June 16, 2003, and a public notice was published in the local newspaper. The public comment period for the Revised Proposed Plan was open from June 16, 2003, through July 16, 2003. A public meeting to discuss the Proposed Plan was held on July 10, 2003 in Blackwell. The responses to comments received are included as part of this ROD in the Responsiveness Summary. This ROD will be placed in the Administrative Record. The Administrative Record is available at the Blackwell City Hall, the Blackwell Public Library, and at the DEQ office in Oklahoma City, Oklahoma.

SCOPE AND ROLE OF RESPONSE ACTION FOR THE GROUNDWATER REMEDIAL UNIT WITHIN THE OVERALL SITE STRATEGY

The Site has been divided for administrative purposes into three operable units, called the Soil Remediation Unit, the Ecological Remediation Unit, and the Groundwater Remediation Unit. The DEQ previously issued Records of Decision (RODs) for the Soil Remediation Unit and the Ecological Remediation Unit. The ROD for the Soil Remediation Unit was issued in April 1996 and addressed soil contamination in residential, recreational, and commercial/industrial areas that are subject to human health risk-based remediation goals. The ROD for the Ecological Remediation Unit was issued in March 1998 and addressed grasslands, riparian areas, and streams subject to ecological risk-based remediation goals for sediment and surface water. Because it was recognized

that surface water issues are directly tied to groundwater conditions in Blackwell, the ecological ROD deferred the selection and implementation of a final remedy for surface water until the remedy for the GRU was determined.

The GRU is the subject of this ROD. The GRU (Figure 2) encompasses the area of cadmium and zinc contamination in groundwater that extends from the former smelter site (Onsite Subarea) to the vicinity of Ferguson Avenue and First Street (Ferguson Avenue Subarea). It also includes interconnected surface water features and subsurface sanitary sewers and storm drains that are subject to infiltration of contaminated groundwater (Figure 2). Cadmium and zinc concentrations in groundwater are highest within the Onsite Subarea and the Ferguson Avenue Subarea.

SITE CHARACTERISTICS

Chemicals of Concern

Past Blackwell Zinc smelter operations resulted in groundwater contamination beneath Blackwell. Cadmium and zinc are the constituents of concern in the GRU. The plume of contaminated groundwater is generally bounded by Doolin Avenue to the north, Ferguson Avenue to the south, 20th Street to the west, and Main Street to the east (Figure 2). The DEQ considers the elevated concentrations of cadmium and zinc in groundwater to be a potential risk to human health and environment of the area.

Principal Threat Waste (Sources of Contamination)

The principal threat waste (i.e., the primary source of cadmium and zinc releases to groundwater) is residual process water that was used in the cadmium recovery process at the former smelter from the 1950s to the early 1970s. The solution—which is acidic and contains elevated concentrations of zinc, cadmium, and sulfate—was stored in a pond near the southeast corner of the former smelter facility (Figure 2). Although the pond was lined with asphalt for a portion of its operational life, substantial volumes of the zinc sulfate solution seeped into the subsurface. Because of its high concentrations of sulfate, metals, and other chemical constituents, the process solution was denser than naturally occurring groundwater and migrated downward to the bedrock that forms the base of the shallow groundwater system. Although the zinc sulfate pond was permanently drained and backfilled when the smelter closed in 1974, concentrations of cadmium and zinc in groundwater have remained relatively constant in the GRU since groundwater studies began in the early 1990s. This strongly suggests the presence of an ongoing subsurface source of these metals that extends in a heterogeneous fashion between the Onsite Subarea and the Ferguson Avenue Subarea. Sampling results obtained during the groundwater investigation provide evidence that metals from the zinc sulfate pond accumulated and remain near the top of the bedrock in the Onsite Subarea, and that some

of the metals also migrated and accumulated in the Ferguson Avenue Subarea. Sampling results also indicate that residual solution from the pond is present in the shallow clay unit above the groundwater table immediately beneath the former pond.

To a much lesser extent, leaching from smelter residuals that remain in surface and subsurface soils on the former smelter site is also believed to contribute some cadmium and zinc to groundwater (PTI 1998). Soils remediation has occurred as part of the Soils Remediation Unit (SRU), including excavation and removal of soils, consolidation, and capping. Soil remediation on the BIA property is unlikely to have significantly reduced the leaching potential of cadmium and zinc, because the residual sources of cadmium and zinc to groundwater are believed to be present primarily in subsurface soils and/or the water-bearing zone itself which were not addressed as part of the SRU.

Feasibility studies have shown the infeasibility of directly removing the "principal threat" subsurface sources of groundwater contamination. Analyses of remedial alternatives have therefore targeted technologies for reducing the mobility and the toxicity of the impacted groundwater itself, with a longer-term goal of depleting the sources of contamination.

Nature and Extent of Contamination

Groundwater

The cadmium and zinc groundwater plume extends from the Onsite Subarea to the Ferguson Avenue Subarea (Figure 2). The affected aquifer is a layer of sand and gravel that begins about 8 to 15 feet below ground surface (bgs) and extends down to a total depth of up to 40 feet. Groundwater in this shallow aquifer flows generally to the east-southeast from the Onsite Subarea towards the Ferguson Avenue Subarea. As summarized in the table on the next page, the plume contains cadmium at concentrations of up to approximately 29 mg/L, and zinc at concentrations up to 297 mg/L. The highest concentrations occur in the Onsite Subarea and the Ferguson Avenue Subarea, as shown on Figure 2. Concentrations are somewhat lower in the intermediate region of the plume between the two subareas. Cadmium and zinc groundwater concentrations have been relatively stable since groundwater was initially characterized in 1991. This stability in cadmium and zinc concentrations indicates an ongoing source that continues to release these constituents into groundwater, influencing water quality over a broad area.

*sewer
replacement
would
encounter
groundwater
@ this dept*

TOTAL CADMIUM AND ZINC CONCENTRATIONS IN THE PLUME AREA OF THE BLACKWELL GRU				
Area	Cadmium		Zinc	
	Minimum	Maximum	Minimum	Maximum
Onsite Subarea	0.005	28.7	< 0.010	297
Ferguson Ave Subarea	0.005	29.2	< 0.010	297
Plume Center	0.005	4.7	0.029	55.1

Note: All concentration values are in units of mg/L.

Sanitary Sewers and Storm Drains

Almost all of the contaminated groundwater in the GRU is captured by infiltration into leaking sanitary sewer lines and storm drains in the Ferguson Avenue Subarea. Groundwater that enters the sanitary sewer lines subsequently flows to the City of Blackwell's municipal WWTP. Infiltration to the storm drain system discharges to the Ferguson Avenue Tributary through an outfall beneath the Main Street Bridge. Groundwater infiltration to the sanitary sewers and storm drains has provided nearly complete hydraulic control of the plume, preventing its expansion beyond the current extent shown on Figure 2. A small amount of contaminated groundwater, however, is not captured by the leaking sewers and seeps through the banks of the Ferguson Avenue Tributary between 6th Street and Main Street.

Concentrations of total cadmium and zinc in the influent and effluent streams of the City of Blackwell's WWTP have varied widely over the last several years. It is believed that these variations depend on changes in groundwater elevations that occur in response to climate, specifically precipitation, which, in turn, lead to variable rates of infiltration of contaminated groundwater into the leaking sanitary sewer lines. During especially wet periods, metals that pass through the WWTP have resulted in periodic violations of the City's NPDES/OPDES permit conditions for discharge of treated wastewater effluent to the Chikaskia River.

Surface Water

The shallow groundwater system in Blackwell is hydraulically interconnected with surface water in the Ferguson Avenue Tributary and the Legion Park Tributary (Figure 1). Both tributaries flow from west to east and ultimately drain to the Chikaskia River. Shallow groundwater discharges into the channels of both tributaries, forming isolated perennial pools in their upstream sections, and perennial flow conditions in their downstream sections.

In the upstream portions of the Ferguson Avenue Tributary west of Main Street, cadmium and zinc concentrations are less than 0.5 mg/L cadmium and 2 mg/L zinc. These concentrations are much lower than in the groundwater plume itself, but periodically

Some residents within the GRU currently use residential wells for outdoor garden watering. A recent survey of these well owners conducted by the City of Blackwell confirmed that none of the well owners uses groundwater as a drinking water source. High-quality, treated drinking water supplies are provided throughout Blackwell by the City.

Summary of Site Risks

The DEQ evaluated potential risks to human health and the environment that may be posed by contaminated groundwater as part of the site investigation and remedy selection for the GRU and the Ecological Remediation Unit. Potential risks to human health associated with exposure to groundwater and interconnected surface water are described in the SBRA (HSWMR 2003). Potential risks to ecological receptors associated with exposure to groundwater-derived cadmium and zinc in surface water and sediments are presented in several documents, including the *Blackwell Zinc Site Ecological Assessment* (PTI 1996), the *Ecological Remediation Unit Proposed Plan* (DEQ 1997), and the *Ecological Remediation Unit Record of Decision* (DEQ 1998b). Potential human health and ecological risks are summarized below.

Summary of Potential Human Health Risks

The primary human health risks associated with conditions in the GRU are ingestion of and/or direct contact with cadmium in contaminated groundwater and/or interconnected surface water. Exposures to cadmium are of concern because cadmium has a tendency to accumulate in the body. As it accumulates, there may be damage to the kidneys and development of hypertension. There are also data which suggest inhalation of cadmium may be associated with development of certain kinds of cancer. However, cadmium is not released from water to air, and thus; inhalation of cadmium is not a complete exposure pathway for groundwater or surface water. Therefore, no exposure pathway presently exists for the GRU relative to carcinogenic risk. Zinc at this site is not considered a significant threat to human health but is of potential concern for ecologically sensitive areas.

The SBRA considered five potential pathways of direct human exposure to contaminated groundwater and five potential indirect human exposure pathways via contact with secondary media potentially containing elevated concentrations of cadmium and zinc derived from groundwater. The pathways that were evaluated quantitatively and the associated Hazard Indexes are summarized by location in the table on the next page. A Hazard Index greater than 1.0 indicates a potentially unacceptable risk associated with a given exposure pathway.

Remedial Action Objectives

Remedial Action Objectives (RAOs), which maybe derived from the ARARs and other sources, are chemical-specific and medium-specific goals for protecting human health and the environment. RAOs typically specify the exposure routes, receptors, and risk levels of concern. The following RAOs have been established for the GRU to protect human health, prevent expansion of the groundwater plume, prevent degradation of natural ecosystem, and comply with sewage discharge regulations:

Protect Human Health

- Prevent human ingestion of groundwater drawn from those regions within the aquifer that have been affected by metals at concentrations that exceed established federal maximum contaminant levels (MCLs) for drinking water supplies.
- Protect recreational users from risks associated with exposure to elevated cadmium concentrations in the Ferguson Avenue Tributary and Legion Park Tributary.

Prevent Expansion of the Groundwater Plume

- Prevent the migration of metals-bearing groundwater beyond the current configuration of the metals plume in the aquifer beneath the City of Blackwell, and stabilize or reduce cadmium and zinc concentrations in groundwater.

Prevent Degradation of Natural Ecosystems

- Prevent any adverse impact on the aquatic ecology in the Chikaskia River caused by the discharge of metals-bearing groundwater from the former zinc smelter site.
- Prevent deterioration in water quality in the Ferguson Avenue Tributary that would result in deterioration of existing ecological conditions.

Comply with Wastewater Effluent Discharge Permit Regulations

- Prevent a point-source discharge from occurring in the Ferguson Avenue Tributary that does not meet Oklahoma water quality standards.
- Eliminate violations of the City's National/Oklahoma Pollutant Discharge Elimination System (NPDES/OPDES) permit for discharge of treated sanitary sewer effluent to the Chikaskia River due to metals-bearing groundwater from the former smelter entering the sanitary sewer system.
- Prevent metals-bearing groundwater that is entering the City's WWTP from causing the City to be unable to manage wastewater treatment sludge consistent with federal sludge disposal requirements.

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THE RESPONSIVENESS SUMMARY

The DEQ prepared this Responsiveness Summary to provide written responses to comments submitted regarding the Proposed Plan of Action for the Groundwater Remediation Unit (GRU) at the Blackwell Zinc (BZ) site.

Public notice announcing the July 10, 2003 public meeting and 30-day comment period following the public meeting was printed in the Blackwell Journal-Tribune on June 13 and June 15, 2003. A front-page press release was printed in the Blackwell Journal-Tribune on June 17, 2003 and again the day of the public meeting on July 10, 2003.

Approximately nineteen people were in attendance at the public meeting. The public was given the opportunity to make comments or ask questions. The following questions were received by the DEQ at the public meeting. No written comments were received.

1. Comment:

The commenter asked if he would have to pay anything for his well to be plugged.

Response:

All costs associated with plugging or capping a groundwater well will be the responsibility of Phelps Dodge, Inc. In addition, an incentive of one thousand dollars will be paid to each participant in the well plugging program. Every existing well located within the Groundwater Protection Area will be either plugged or capped. It will be the choice of each property owner whether the well is plugged or capped.

2. Comment:

The commenter asked if any consideration has been given to the age of existing groundwater wells. The commenter explained that he has a well that is only four years old and the cost of developing that well was more than the cost of developing a much older well.

Response:

The groundwater plugging program is currently under development and has not been finalized. Phelps Dodge, Inc. is interested in specific input from citizens to help them determine if the well plugging program needs to be modified to address possible citizens that have more expensive wells than others and/or a greater number of wells on a single property than others. As the program currently stands, each property owner will receive one thousand dollars for participating in the well plugging program.

3. Comment:

The commenter noted that during the presentation of the Proposed Plan, one of the slides depicted that metals have settled in areas of depression within the aquifer. The commenter asked how the metals could be removed from the low-lying areas in the aquifer.

Response:

It is believed that the settled metals located in the low-lying areas of the aquifer will be removed gradually over time. This remedial process is a long-term process. Water extraction pumps will be installed at the lower end of the groundwater plume area and into the base of the aquifer. As groundwater is pulled from the ground it will move across the low-lying, high metal concentration areas picking up some of the metals. Over time, the theory is that the concentration of settled metals in low-lying areas will decrease. As metal-contaminated groundwater is pulled from the aquifer, new groundwater will constantly replenish the aquifer. The design phase of the remediation will assist in determining specific approaches to the remedial process.

4. Comment:

The commenter noted that the Proposed Plan suggested that the groundwater was going to be pulled out of the ground at about 200 gallons-per-minute and asked if the groundwater would also be treated at 200 gallons-per-minute or would there be a separate storage tank to hold the groundwater until it could be treated.

Response:

The groundwater will be pumped into a reactor vessel that will treat the groundwater by removing the metals. The groundwater will be treated at the same rate it is being pumped.

5. Comment:

The commenter asked who will be responsible for the cost of cleaning up the groundwater and how much that is expected to be.

Response:

Phelps Dodge, Inc. is the primary responsible party at this site. Phelps Dodge, Inc. will carry the entire cost of cleaning up groundwater at this site. The projected cost of the cleanup of the groundwater at this site is about 6 million dollars.

6. Comment:

The commenter asked if the bioreactor would produce any gas.

Response:

There will be some hydrogen sulfide gas produced as a result of the biological process, however; that gas will be contained in the reactor and managed. The hydrogen sulfide gas will react with and remove the metals in the groundwater. Any excess gas will be cycled back into the reaction chamber. The reactor system will also have a scrubber system that will be designed to capture any excess hydrogen sulfide gas that is not needed. There will be very little gas in this system at any given time, and even if some were to escape the system, it would not present a significant hazard. The reactor system will also have a sensor that will monitor the amount of gas in the system.

7. Comment:

The commenter noted that the biological treatment process may produce some odors like any other water treatment plant and asked where the biological treatment plant would be located.

Response:

One of the advantages of using a biological reactor is that the majority of odors can be contained. The location of the biological treatment system will not be solely determined based on odors created by the process. The DEQ currently prefers locating the treatment plant at the drinking water plant due to its central location in town and its close proximity to the head of the groundwater plume. The final decision on treatment plant location will be made jointly by the City, the DEQ, and Phelps Dodge Inc. during the remedial design phase.

8. Comment:

The commenter asked how much room the biological treatment system would take.

Response:

The entire system should not take more than about 1500 to 2000 square feet.

9. Comment:

The commenter asked how the depth of the groundwater plume was determined.

Response:

The depth to the groundwater and to the bottom of the aquifer was determined by taking samples over the entire area of the plume. Additionally, samples of the clay and shale material were collected to determine what is below the aquifer. The sampling showed that there is a sand unit from about ten to fifteen feet below the ground down to about thirty or forty feet below the ground at Blackwell. Below that there is a shale and clay layer.