# Analysis of Brownfields Cleanup Alternatives

# Mineral County Fairgrounds
# Creede, Colorado

**Prepared for**
**Mineral County Fairgrounds Association**

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## EXECUTIVE SUMMARY

This report presents an Analysis of Brownfields Cleanup Alternatives for the site proposed for the Mineral County Fairgrounds near Creede, Colorado. The site has been impacted from upstream mining and milling operations which resulted in soil contamination. The purpose of the Analysis was to identify and evaluate cleanup alternatives that would mitigate risks to human health and the environment associated with contamination at the site, as required by the Brownfield Grant awarded to the Mineral County Fairgrounds Association. Remediation at the site will be conducted under the Colorado Voluntary Cleanup Plan program.

The cleanup goal at the site is to prevent direct human contact with contaminated soils and to reduce the potential to leach metals into ground and surface waters. The most appropriate land use designation for the site is residential / unrestricted due to the anticipated use of fairgrounds facilities by young children and to enable public access to the entire site. Specific cleanup objectives are to remove or isolate soil with lead concentrations above the residential standard (400 parts per million) and with arsenic concentrations above 70 parts per million. An additional cleanup objective is to ensure that infiltration through contaminated soils is not increased with future land uses and to take measures to reduce infiltration from current levels.

The site consists of an upper bench and a lower floodplain area. The soil in nearly the entire floodplain area contains lead concentrations above residential standards. This contamination extends to over 18 inches in much of the floodplain area. A small area on the northern tip of the upper bench is contaminated to a depth of less than 6 inches. Data indicated that soil with lead concentrations that did not exceed the lead cleanup objective did not exceed the arsenic cleanup objective. Floodplain soils indicated a potential to leach lead exceeding the Colorado Department of Public Health and Environment guidelines. Available data have not indicated that infiltration through soils at the site is impacting Willow Creek.

Two cleanup alternatives were proposed to address cleanup goals at the site (as well as a required no-action alternative). The first alternative was removal of all contaminated soil and placement in a soil repository that would be located above the groundwater table and capped with an impermeable cap. The second alternative was capping of contaminated soil with at least 12 inches of soil and establishing vegetation on the portion of the cap not used for facilities. The proposed alternatives were evaluated and compared. Both cleanup alternatives met the cleanup goals for the anticipated land use at the site. Both protect human health through isolation of contaminated soils from direct contact. The soil removal alternative would provide more protection from leaching, but water quality impacts have not been observed and the capping alternative would not increase, and may decrease, infiltration. However, the alternative to remove all contaminated soil appears not feasible from a funding standpoint as the estimated cost is much more than available funding.

Therefore, the alternative to cap contaminated soils in the site floodplain area with at least 12 inches of soil and establish vegetation on portions of the cap was chosen as the proposed cleanup plan. The plan also includes removal of contaminated soil from the northern tip of the upper bench and areas for a stormwater channel and mitigation wetlands.

## 1. Introduction

This report presents an Analysis of Brownfields Cleanup Alternatives (ABCA) for the site proposed for the Mineral County Fairgrounds near Creede, Colorado. The site is currently unsuitable for public facilities due to soil contamination from historic mining and milling operations in the Willow Creek watershed. The Mineral County Fairgrounds Association (MCFA) was awarded an EPA Brownfield Grant to perform cleanup activities at the site to enable planned land use goals. This ABCA was prepared to identify and evaluate cleanup alternatives that would mitigate risks to human health and the environment associated with contamination at the site, as required by the EPA Brownfield Grant. The ABCA was prepared by the Willow Creek Reclamation Committee (WCRC) who has been assisting the MCFA in grant procurement and administration, site investigation, cleanup evaluation, and project management. The WCRC is committed to helping reclaim and restore areas impacted by historical mining in the Willow Creek watershed.

## 2. Site Location and Description

Figure 1 shows the location of the MCFA site within Colorado and the lower Willow Creek Watershed. The MCFA site is located about 0.75 miles south of the city limits of Creede in Mineral County, Colorado southeast of the junction of Airport Road and Highway 149. The property covers almost 46 acres in the southwest quarter of Section 6, Township 41 North, Range 1 East, (N.M.P.M.) and the elevation is approximately 8,640 feet.

The property is zoned rural by Mineral County. The property has been and is currently open space. Adjacent property uses include rural agriculture and open space to the west, the local airport and residential development to the east, open space to the north, and a recreational vehicle park to the south.

About 28 acres of the site is located within the Willow Creek floodplain, and the remainder of the site is a raised bench. A 0.16 mile portion of Willow Creek flows through the northeastern corner of the site on its way to the Rio Grande located south of the site. This portion of Willow Creek is highly active and braided, and much of the floodplain alluvium consists of coarse gravels and cobbles. Wastewater treatment lagoons for Creede are located just to the north of the site on the western edge of the floodplain. The effluent from the lagoons was directed in the 1980s into an old channel that transverses the property and now supports a string of wetland type plants.

## 3. Sources of Contamination

Mining or milling activities never occurred at the MCFA site. However, the site has been impacted from upstream mining and milling operations. Early mining and milling operations deposited waste directly into Willow Creek, and these wastes may have deposited and been mixed into the floodplain alluvium. Mine waste and/or mill tailings may have also been inadvertently dumped directly on the property. Following termination of direct dumping into Willow Creek, the Humphries mill north of Creede and the Emperious mill in the floodplain north of the MCFA site conveyed mill tailings to sites north and east of the property. Failures of

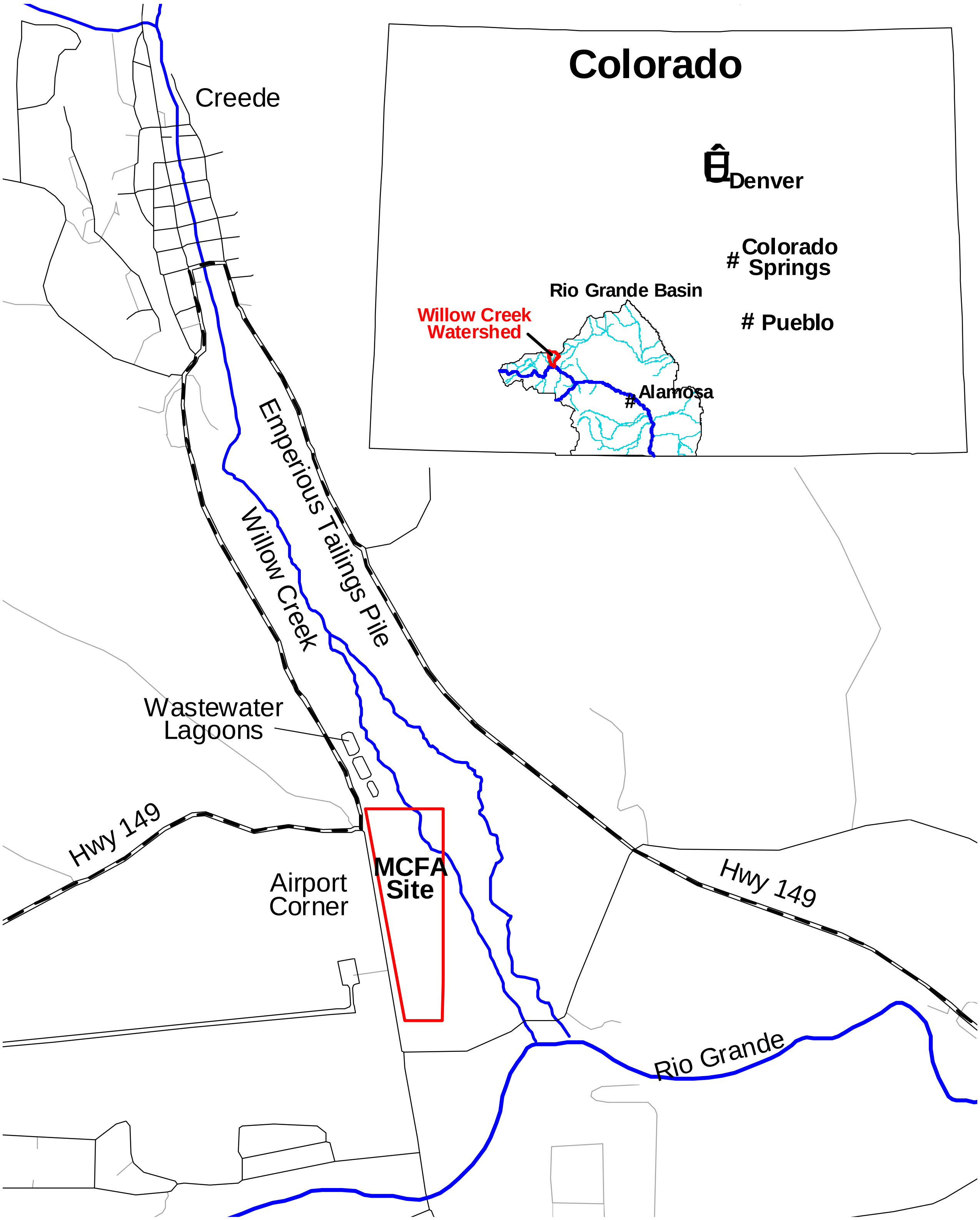


**Figure 1. Location of MCFA Site**

conveyance and impoundment structures on these adjacent properties deposited mill tailings on the property that may have also been transported and mixed around the site by flooding in Willow Creek. The potential also existed for wind transport of mill tailings from adjacent sites, particularly from west of the property.

The surface water of Willow Creek remains heavily impacted by historical mining in the upper reaches of the watershed and contains elevated metals concentrations. The primary source of metal contamination is the Nelson Tunnel upstream of Creede. The cleanup alternatives for the MCFA site do not consider cleanup of Willow Creek, as the creek is impacted upstream of the site.

## 4. Applicable Standards, Exposure Pathways, and Land Use Considerations

Remediation at the MCFA site will be conducted under the Colorado Voluntary Cleanup Plan (VCUP) program. The Colorado VCUP program is managed by the Colorado Department of Public Health and Environment (CDPHE) Hazardous Materials and Waste Management Division. Cleanup actions under the Colorado VCUP program must provide for adequate protection of human health and the environment based on the current and future uses of a property.

### 4.1 Exposure Pathways

The primary exposure pathway for contaminants as a human health concern at the site is direct contact with contaminated soil. Direct soil contact implies risks of ingestion, inhalation, or absorption through the skin of soil contaminants. The primary contaminants of concern related to direct soil contact at the site are lead and arsenic. The primary risk of contamination to the environment from the site is leaching of metals from soils into the groundwater due to water infiltration. The primary contaminants of concern related to soil leaching at the site are lead, cadmium, and zinc.

### 4.2 Applicable Standards

Applicable standards and soil remediation objectives for the Colorado VCUP program related to soil contact and leaching are discussed in the proposed Soil Remediation Objectives Policy Document (CDPHE 1997). The CDPHE produced an additional draft table titled Soil Cleanup Table Value Standards [mg/kg] March 2005 that may soon be implemented to guide soil cleanup. The following table details action levels from the two documents based on land use scenarios.

**Table 1. CDPHE Soil Remediation Objectives for Lead and Arsenic**

| | Direct Soil Contact | | | | | | Leaching with SPLP | | |
|---|---|---|---|---|---|---|---|---|---|
| Land Use: | Residential/Unrestricted | | Commercial | | Industrial | | Leachate Reference | | |
| Contaminant: | Lead | Arsenic | Lead | Arsenic | Lead | Arsenic | Lead | Cadmium | Zinc |
| **CDPHE 1997** | 400 | 0.21 | 2920 | 1.04 | 1460 | 0.82 | 1.1 | - | - |
| **CDPHE 2005** | 400 | 0.39 | 2920 | 3.61 | 1460 | 1.49 | 1.1 | 0.11 | 110 |

Note: All as concentrations in parts per million (mg/kg)

The CDPHE recommended a site specific action level of 70 parts per million (ppm) for arsenic in soil for all land uses as part of the VCUP submitted by Navajo Development, LLC, for the airport corner property adjacent to the MCFA site. This higher arsenic level recognizes the high levels of arsenic that are naturally present in soils in the area. The EPA published soil standards for lead in residential settings in the Federal Register titled 40 CFR Part 745, Lead; Identification of Dangerous Levels of Lead; Final Rule (EPA 2001). The EPA established a standard of 400 ppm by weight bare soil areas in play areas and 1,200 ppm in bare soil in non-play areas.

### 4.3 Land Use

The 1997 CDPHE document describes a residential property as a property that is used for habitation by individuals or properties where more sensitive populations, such as children or the elderly, have the opportunity for exposure to contaminants. Residential soil remediation objectives are also appropriate for educational facilities, health care facilities, child care facilities, and playgrounds. Standards are developed to protect the most sensitive or potentially susceptible individual. Residential standards are designed to protect a young child up to seven years of age who may be exposed to lead in soil on a frequent or daily basis for several months to several years.

Industrial properties can be designated where the primary purpose for facilities is the manufacturing of commodities. Such facilities include power generation facilities, foundries, and machine shops where workers spend only an average of 8 to 9 hours per day at the site and are the primary individuals on any site. Commercial properties can be designated for stores and business enterprises of a retail or wholesale nature. Workers would be the primary individuals of contact although customers could potentially spend several hours per day at certain facilities. For the commercial and industrial scenario, it was assumed that women of child bearing age may work at a facility and are the most susceptible adult in the workplace. Standards were designed to prevent an unacceptable level of blood lead in the mother and fetus. The commercial and industrial land use settings assume that public access is short-term and intermittent compared to daily exposure to workers.

The CDPHE (1997) document states that the most conservative land use setting, residential, is applicable to all sites unless sufficient information is presented to justify the use of a commercial or industrial land use setting. If a land use setting other than residential is proposed, the site must meet all of the following criteria:

a) The site is currently zoned for non-residential use
b) The site is expected to be zoned for non-residential use into the foreseeable future
c) Appropriate and maintainable institutional controls (e.g. deed restrictions, restrictive covenants, ordinances adopted and administered by a local government) will be in force
d) Uses of the facility and uses of zoning of properties within 100 meters of the contaminated area are industrial, commercial or other uses where the exposure is limited and thus does not warrant application of the residential standard.

At the MCFA site, young children may be present in facilities for extended hours, and a caretaker may potentially live at the site. This would indicate that the residential standard would be applicable at the portion of the site with fairgrounds facilities and structures. The floodplain portion of the site could potentially be non-residential. In this case, the floodplain area would have to be fenced off permanently from public usage. It is the current intention that the floodplain area will be open to the public for recreational activities, and a public trail will enhance use of the area. Therefore, it is most appropriate that a residential / unrestricted land use scenario be applied to the entire site.

## 5. Cleanup Goals and Objectives

The cleanup goal at the MCFA site is to cleanup the site to prevent direct human contact with contaminated soils and to reduce the potential to leach metals into ground and surface water. The cleanup objective is to remove and/or isolate soil with lead above the CDPHE residential standard of 400 ppm from direct human contact. The cleanup objective for arsenic is the site specific soil remediation objective developed by CDPHE as part of the VCUP for the adjacent airport corner property (70 ppm). The following table summarizes the soil cleanup objectives at the MCFA site.

**Table 2. Summary of MCFA Soil Cleanup Objectives**

| Land Use Description | Lead (ppm) | Arsenic (ppm) |
|---|---|---|
| Residential/Unrestricted Land Use | 400 | 70 |

The CDPHE guidance for leaching of metals from soils will also considered (Table 1). The cleanup objective is to ensure that the water infiltration through soils that have a potential for leaching metals is not increased with future land uses at the site, and to take measures to reduce the potential for infiltration from current levels.

## 6. Characterization of Contamination

### 6.1 Previous Environmental Investigations

Several investigations have characterized contamination at the MCFA site. Soil samples have been taken throughout the site by the several different studies. Ground water quality has been evaluated at one monitoring well that was installed at the site. Figure 2 shows the location of discrete soil samples and sectors corners for composite samples, and study and sample numbers are indicated at each location. The location of the monitoring well is also indicated in the figure. Brief discussions follow for each characterization study, and data is presented in the appendix.

<u>WCRC Airport Corner Soil Samples</u>
In September 2000, the WCRC worked with the U.S. Army Corps of Engineers, Albuquerque District to investigate soil lead concentrations using X-ray fluorescence (XRF) equipment. The majority of the investigation concentrated on area west of the MCFA site known as airport corner. However, a total of 13 soil samples were taken from the MCFA property and evaluated using XRF. Samples on the upper bench were close to the road on the western edge of the property, and a line of samples were taken into the floodplain. Sample locations are indicated in Figure 2. The XRF data for MCFA property samples are presented in Table A-1 in the Appendix. Lead concentrations ranged from 287 to 1954 ppm on the upper bench and between 3963 and 23,707 ppm in the lower floodplain area.

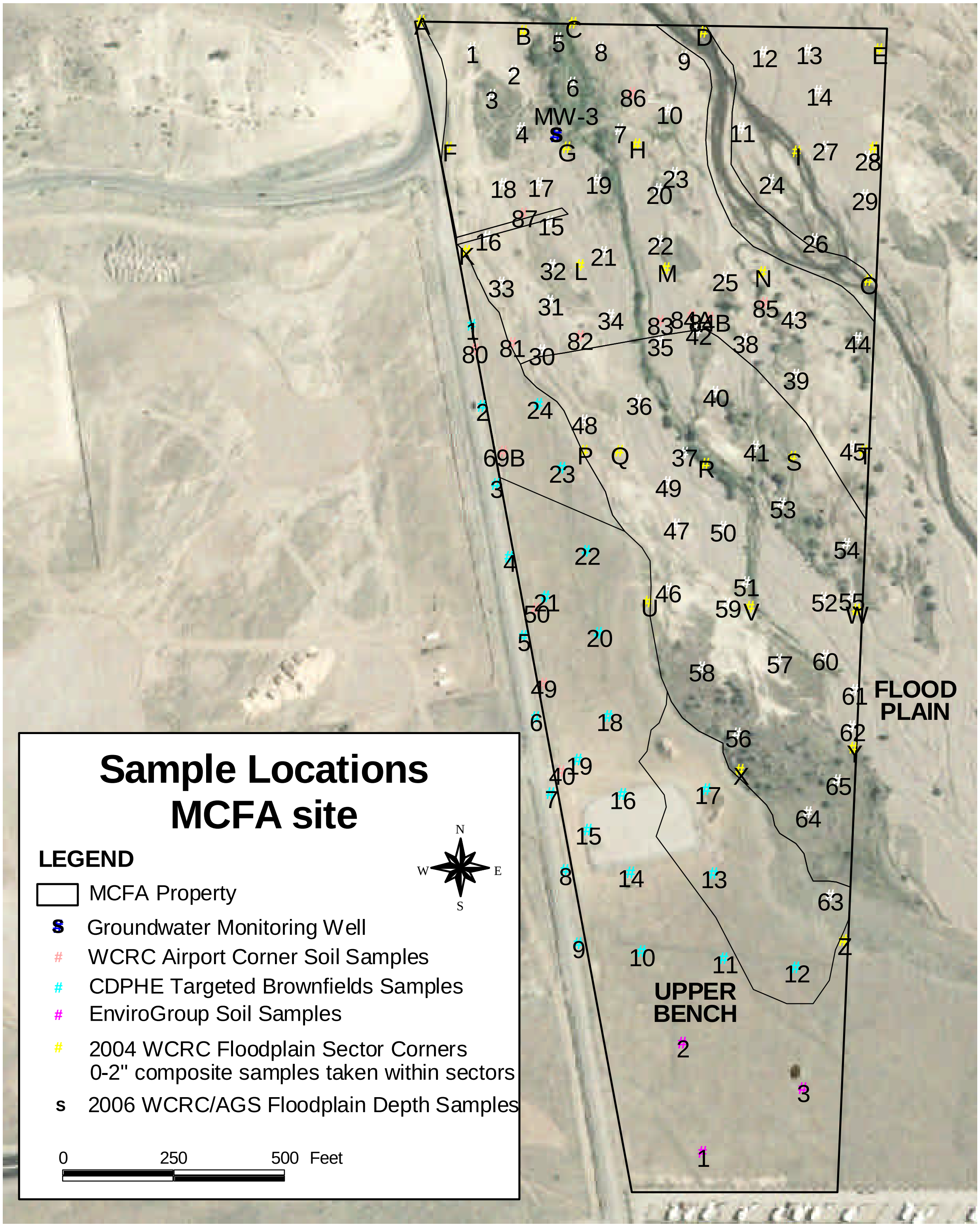


Figure 2. Location of Characterization Study Soil Samples and Monitoring Well

Lead and arsenic were found to be positively correlated (i.e., high levels of arsenic were found to be closely associated with correspondingly high levels of lead). As lead increased, the levels of cadmium and zinc also tended to increase, although not as closely as arsenic. Because of this relationship, and its ubiquitous nature, lead was determined to be an effective indicator of elevated concentrations of arsenic, cadmium, and zinc in the soil.

CDPHE Targeted Brownfields Assessment

In 2002, the CDPHE collected soil samples on the airport corner property and on the upper bench of the MCFA property (CDPHE 2002). A total of 54 soil samples from 24 locations were collected on the northern portion of the upper bench area as shown in Figure 2. Soils samples were collected at three intervals; 0 to 6 inches, 12 to 16 inches, and 30 to 36 inches below ground surface. The samples were analyzed for both arsenic and lead, and the results of samples collected on the MCFA property are presented in Appendix Table A-2. In the 0 to 6 inch depth interval, lead concentrations exceeded 400 ppm in the northern tip of the upper bench. Lead concentrations decreased with depth, with a maximum of 390 ppm in the 12 to 16 inch depth and 140 ppm in the 30 to 36 inch depth. Lead concentrations in the central portion of the upper bench did not exceed 400 ppm. Arsenic concentrations ranged from 1.1 to 44 ppm and also decreased with depth.

EnviroGroup Investigation

In July 2002, EnviroGroup collected a number of soil samples on the Airport Corner Property, and collected 3 samples in the 0 to 2 inch depth on the southern portion of the upper bench area of the MCFA property. Data for samples on the MCFA property are presented in Table A-3 in the Appendix and sample locations are shown in Figure 2. Lead concentrations ranged from 170 to 290 ppm, and arsenic concentrations were 21 ppm.

WCRC Floodplain 0 to 2 inch Depth Composite Soil Samples and SPLP Analysis

The WCRC collected composite samples from 0 to 2 inch depths within the floodplain area of the MCFA property in fall of 2004 (WCRC 2004). Lead concentrations were evaluated using an XRF instrument, and confirmation samples were evaluated using ICP analysis. A set of samples were also evaluated for leachability using the Synthetic Precipitation Leaching Procedure (SPLP) and ICP analysis for cadmium, lead, and zinc. Composite samples were collected within three acre areas for XRF analysis (shown in Figure 2) and five acre areas for SPLP analysis. Appendix table A-4 shows lead concentrations from sector composite samples. Lead concentrations near the surface in the MCFA floodplain area ranged from 2,450 to 11,100 ppm. Table A-5 in the Appendix shows metal concentrations in leachate produced using the SPLP for composite samples collected in the MCFA floodplain. The median concentration of cadmium leached was 0.05 mg/L with only one sample (0.28 mg/L) leaching more than 0.11 mg/L CDPHE Leachate Reference. Zinc leachate averaged 7.6 mg/L and did not exceed the CDPHE Leachate Reference of 110 mg/L (max 41 mg/L). Lead leachate averaged 1.3 mg/L and exceeded the CDPHE Leachate Reference of 1.1 mg/L in 10 of 12 sectors.

WCRC/AGS Floodplain Depth Interval Soil Samples

Following the 2004 WCRC study, it was evident that additional information was needed of the depth of lead contamination in the MCFA floodplain area. American Geological Services (AGS) collected soil samples from various depths within soil profiles in the floodplain area during late September of 2005 (WCRC 2006). Collection depth intervals were from 0 to 3 inches, 3 to 6 inches, 6 to 9 inches, 9 to 12 inches, and 12 to 18 inches. The WCRC evaluated the samples for lead concentration using their XRF instrument during January and February of 2006. A total of 325 samples from 65 sites were collected and analyzed. For XRF analysis in the lab setting, only the portion of "fines" passing a 2mm sieve are prepared and analyzed. For the 2005 sampling, weights of gravel and cobble material not passing through the 2mm sieve were also recorded, and this allowed for calculation of "in-situ" lead concentrations. This in-situ concentration would be more comparable to XRF in field "shots" of in-situ material. Locations for these samples are shown in Figure 2 and concentrations of lead in fines and in-situ at the various depths are shown in Table A-6 in the Appendix. Lead concentrations generally decreased with depth, but lead contamination was encountered in many areas to the 18 inch depth. Lead concentrations in fines ranged from 261 to 18,893 ppm at the 0 to 3 inch depth, to below detection limits to 26,599 ppm at the 12 to 18 inch depth.

WCRC Surface Water Monitoring

The WCRC has been monitoring water quality in Willow Creek every year since 1999. Concentrations of dissolved zinc typically exceed water quality standards by several orders of magnitude in lower Willow Creek and zinc is considered the primary contaminant of concern. Levels of cadmium and lead, and to a lesser degree aluminum, copper, and iron, are also of concern and exceed water quality standards in some locations. Water quality is regularly monitored upstream of the concrete flume and at the confluence of Willow Creek with the Rio Grande. These data indicate that contamination typically increases through the floodplain area, but this increase is generally attributed to seeps related to the Emperious tailings pile. Generally, there has not been sufficient spatial detail in monitoring sites to isolate impacts the fairgrounds site may be having on Willow Creek.

USGS Surface Water Metal Loading Study

In late August, 2000, the USGS assisted by the WCRC evaluated metal loading in the Willow Creek using a tracer technique (Kimball et al 2006). The study was unique in the high number of samples along the length of the Creek, and several samples were taken on the MCFA property and upstream and downstream of the site. Water quality data for these samples are presented in Table A-7 in the Appendix. In addition to samples for total (not filtered) metals, samples were also filtered using both 0.045µm (D) and 0.001µm (UF) membranes. Samples filtered using the standard 0.045µm filter are typically described as dissolved, but may contain some particulates in colloidal form.

A sample (and duplicate) were taken in the western main braid of Willow Creek on the MCFA property near the eastern edge of the site. Two samples were also taken upstream of the MCFA site, and three samples downstream, on the western braid of Willow Creek. In the table, sample labels indicate stream distance in the downstream direction with sample 8725 to the north near the split in the main channel braids and sample 10324 near the confluence with the Rio Grande.

At the time of sampling, a far western channel apparently had a small flow (32 gpm) that began near a potentially contaminated location north of the wastewater treatment lagoons, ran south and was noted to gain seepage from the lagoons, and then into the wetlands area on the MCFA property (In May 2005, the main braid of Willow Creek moved into a portion of this channel). A sample was taken from this channel near the source north of the site (labeled W-8725) and on the MCFA property (W-9335). Sample W-9335 may have included unknown amounts of water from the side channel source and from wastewater lagoon effluent that may have been influenced by soils on the MCFA property. In sample W-9335, concentrations of zinc and cadmium were higher than in the main fork of Willow Creek, but lower than at W-8725. No lead was detected in the sample, although particulate lead was present in Willow Creek.

In the main western braid of Willow Creek, concentrations of zinc and particulate lead decreased in the downstream direction from upstream samples, to the samples on the MCFA site, and to samples collected downstream of the MCFA site. Levels of cadmium generally remained constant from upstream to the MCFA site, but then decreased below the site. Arsenic and dissolved lead were not detected in any of the samples. Decreases in particulate metal forms may indicate that Willow Creek may be depositing particulate metals originating from upstream sources in the floodplain sediments.

WCRC Groundwater Monitoring Well

The WCRC has installed a series of monitoring wells throughout the Willow Creek floodplain area. One well was installed on the MCFA property in 1999. The well is located in the floodplain near the area of wetlands supported by effluent from the wastewater treatment lagoons (see Figure 2), and water quality in the well may be influenced to a certain degree by the effluent. Appendix Table A-8 details water quality data from the well. The well contains levels of zinc, cadmium, and lead that are similar to levels observed in Willow Creek.

## 6.2. Extent of Contamination

Concentrations of lead in soil samples collected on the MCFA site during the various characterization studies are compiled in Figure 3. The left figure shows lead concentrations in the top depth interval collected for each sample location. Sample depth varied from 0 to 2 inches to 0 to 6 inches in the studies. Sample points are colored by exceedance of the lead in soil residential standard (400ppm), and the higher lead commercial standard (2920ppm). All surface soil samples in the floodplain area exceed the residential standard except for one sample in the southern tip of the floodplain. The residential standard was also exceeded on the northern tip of the upper bench. Lead concentrations in the central and southern portions of upper bench generally were below the residential standard. There is some discrepancy along the western edge of the central upper bench. Two samples collected during the WCRC Airport Corner study exceeded the residential standard, but surrounding samples collected by the CDPHE targeted brownfields assessment study at nearby locations showed lead concentrations below the residential standard.

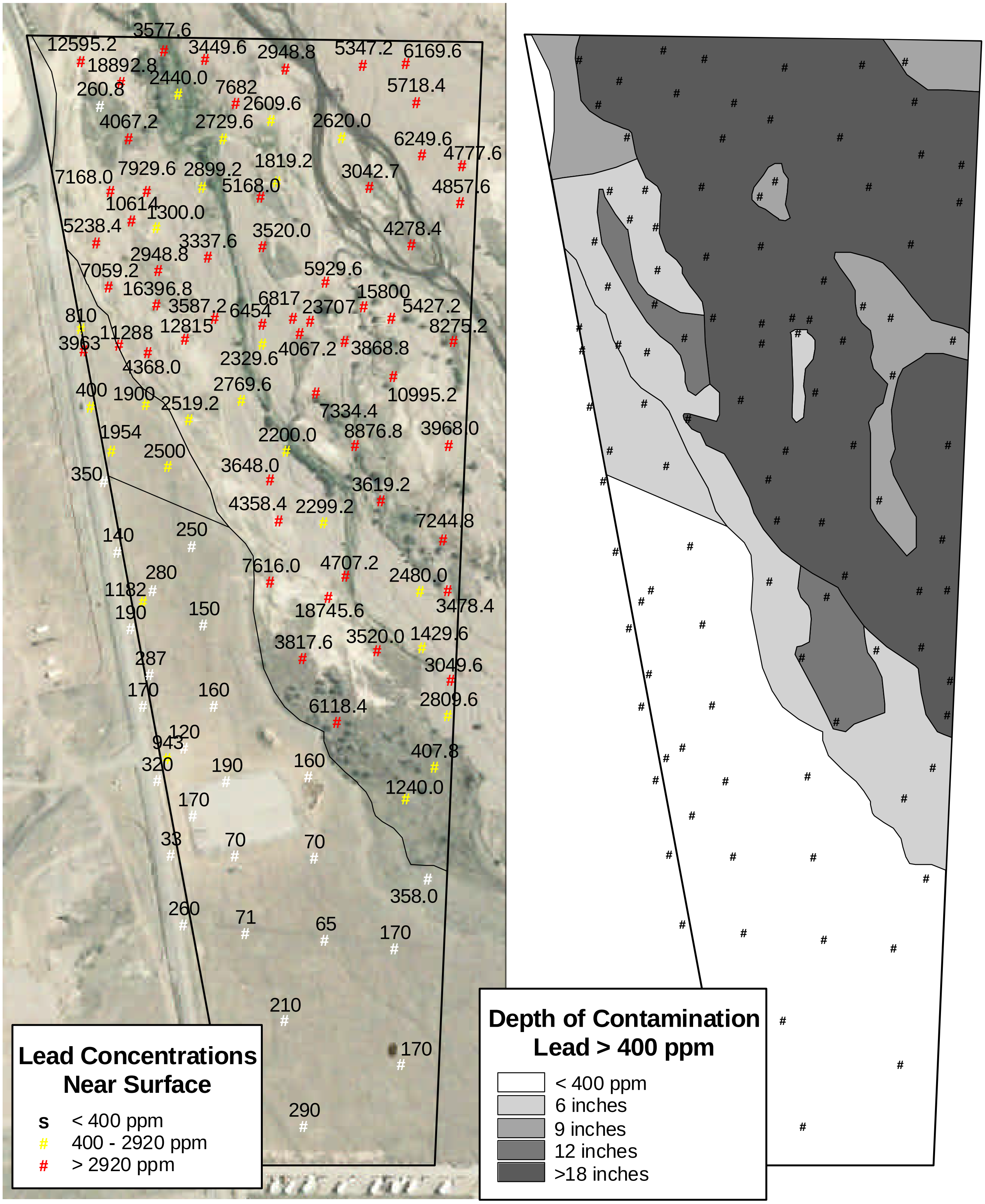


Figure 3. Surface Lead Concentrations and Depth of Lead Contamination

Figure 3 (right side) also compiles data from the studies to indicate general depth of lead contamination considering the 400ppm residential standard. Surface samples from less than six inches were combined to the 0 to 6 inch interval (i.e. the 2006 WCRC/AGS study examined both 0 to 3 inches and 3 to 6 inches). Throughout much of the central floodplain area, lead concentrations are above 400 ppm to at least 18 inches, and this contamination may extend well beyond 18 inches. Contamination depth on the western edge of the floodplain decreases somewhat as the terrain slopes toward the upper bench and is less alluvial, and the contamination on the northern tip of the upper bench is shallow and does not exceed 6 inches.

Water quality data have not indicated that contamination on the MCFA property is impacting the water quality of Willow Creek. In the Kimball et al (2006) study, concentrations of primary metal contaminants generally stayed the same or decreased in the braid of Willow Creek through and below the site. The monitoring well on the site has indicated that levels of metals in the groundwater near the well are similar to levels in Willow Creek.

The SPLP data indicate that lead in floodplain soils may be leachable due to water infiltration. In comparison the reference leaching thresholds proposed by CDPHE, leaching of zinc and cadmium does not appear to be a significant concern. However, as mentioned above, available water quality data do not indicate that leaching from the fairgrounds site is adding significant amounts of lead to Willow Creek as lead concentrations tend to decrease from upstream to downstream of the MCFA site.

## 6.2. Comparison of Contamination to Cleanup Objectives

Nearly the entire floodplain area of the MCFA site exceeds the lead soil cleanup objective of 400 ppm, and the upper 6 inches of the northern tip of the upper bench also exceeds the lead cleanup objective. Although arsenic samples were limited, arsenic concentrations have not been found to exceed the site specific arsenic cleanup objective of 70 ppm, and arsenic levels have not exceeded 21 ppm for samples with lead concentrations below 400 ppm. Soil exceeding the lead cleanup objective should be removed and/or isolated to reduce risks from direct human contact.

Generally, zinc and cadmium do not appear to be leachable from soils at the site to levels above CDPHE reference leachate goals. Leaching results using the SPLP method have indicated that there may be a potential to leach lead from soils to levels above CDPHE reference leachate goals. However, available ground and surface water data have not indicated that significant amounts of lead are leaching from the site and impacting Willow Creek. Therefore, at a minimum, measures should be taken to ensure that water infiltration is not increased through areas of contaminated soils with future land uses at the site.

# 7. Potential Cleanup Alternatives

The following sections discuss and compare potential cleanup alternatives for the MCFA site. Proposed alternatives include removal of contaminated soil and placement in a repository, capping of contaminated soil, and a “no-action” alternative to do nothing. The first two alternatives are sometimes referred to in the text as the soil removal and capping alternatives. Schematics for the first two cleanup alternatives are presented in the following figure.

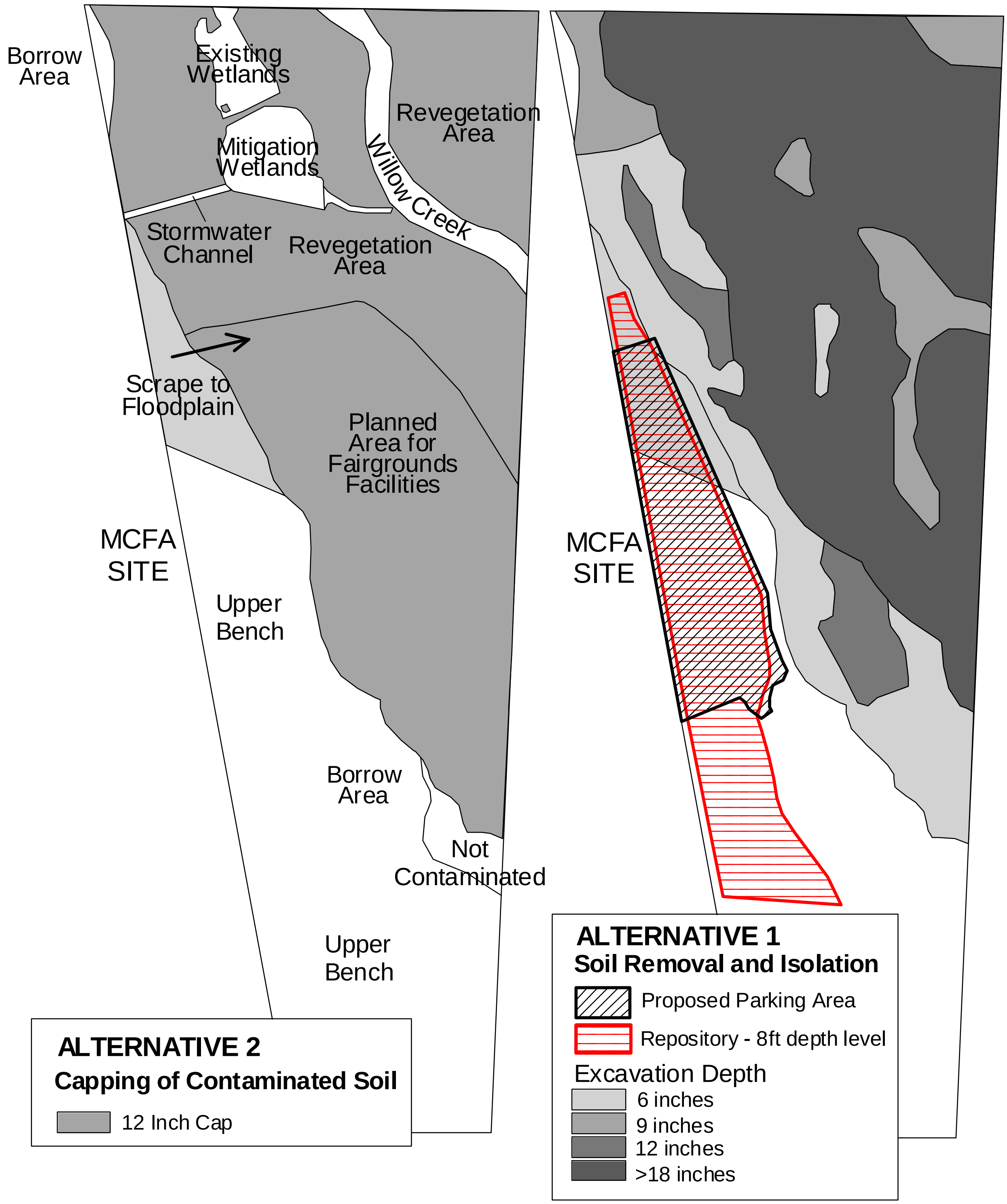


**Figure 4. Schematics of Proposed Cleanup Alternatives**

## 7.1 Alternative 1 - Removal of Contaminated Soil and Placement in Repository

The most extensive cleanup alternative is to excavate all soil with lead concentrations greater than the residential standard (400 ppm) and place this contaminated soil in an on-site repository. The repository would be dug into the upper bench, filled with the contaminated soil, and capped with an impermeable cap. The cap would most likely be constructed of asphalt and used as a parking area for the fairgrounds facilities. The depth of the repository would be limited to ensure that the contaminated soil would remain above groundwater.

Figure 4 shows a general schematic for the soil removal and repository alternative. The depth of excavation required to remove soil with lead above the residential standard is shown in greyscales. In much of the floodplain, contaminated soil was encountered to an 18 inch depth. For volume calculations, a depth of 2 feet was assumed for these areas, but the contaminated soil may extend deeper in some areas. Approximately 70,000 cubic yards of contaminated soil would have to be removed from the floodplain area and from the northern tip of the upper bench.

The upper bench is about 6 feet taller than the adjacent bench, and about 10 feet above the level of the creek in a perpendicular direction. A 6 to 8 foot deep repository could be dug in the upper bench depending on the permanent level of groundwater. A limited amount of contaminated material could also be placed under permanent building foundations or parking areas proposed in the floodplain, but depths would probably be limited to 2 to 4 feet.

Current architectural plans propose a parking area on the upper bench of about 4 acres. For placement of all contaminated material a repository area of 5.5 to 7.3 acres would be needed for repository depths of 8 and 6 feet. The repository could fit within the proposed parking area if the final cap level was raised between 3 and 5 feet above the surrounding land surface. Figure 4 shows the proposed parking area as well as the area of an 8 foot deep non-elevated repository. In order to avoid the need to purchase additional water rights, material dug from the repository would have to be spread into areas where excavation of contaminated soil exposed groundwater.

Local contractors were questioned about approximate earthmoving costs for the alternative. Earthmoving would include excavation of the repository, excavation of contaminated soil and hauling to repository, and spreading of the repository soil into the floodplain. Costs were estimated to be between $350,000 and $500,000 for earthwork. Placement of a 3” asphalt cap would cost approximately $150,000 for a 4 acre area or about $200,000 for a 5.5 acre area. Therefore, the total project cost would be between $500,000 and $750,000. This cost does not include replacing topsoil in excavated areas or re-vegetation of the floodplain.

This option would effectively remove the risk of direct human contact with contaminated soil through isolation of this soil in a repository. The option would also reduce the potential for leaching of metals from the soils at the site as long as asphalt cap was adequately maintained.

Effects on land use due to this alternative would be positive. Successful completion of the alternative would enable use of the site as a public fairgrounds and allow unrestricted public access to all areas of the site including the floodplain. Several additional land use controls would be required, but these land use controls would not be incompatible with the foreseen use of the site into the future. Excavation into the cap or repository would be prohibited without approval from the CDPHE. In addition, the integrity of the asphalt cap would have to be maintained in perpetuity. This maintenance would include repairing any cracks in the cap and potentially re-asphalting the cap after its design life was exceeded. Maintenance of the asphalt cap would imply some continual financial burden on the MCFA.

The alternative is implemental from a construction standpoint if sufficient funds are available. However, the alternative is more costly than originally anticipated. Sufficient funds are not available at this time, and it would be difficult for the MCFA to secure additional funding. Therefore, the alternative may not be feasible from a funding standpoint.

If sufficient funds could be obtained for earthwork and the asphalt cap, it would be difficult to secure additional funds for re-vegetation of the floodplain area. All vegetation and, in many places several feet of soil, would be removed from the floodplain. Vegetation would probably not re-establish easily by itself, and without re-vegetation and possible placement of topsoil, the vegetative, habitat, stream stability, and aesthetic conditions of the floodplain could potentially worsen from current conditions due to the project.

## 7.2 Alternative 2 - Capping of Contaminated Soil

A second alternative to cleanup the MCFA site is placement of a cap over areas with soil lead concentrations greater than the residential standard (400 ppm). A 12 inch cap of soil would effectively isolate the contaminated soil from direct human contact. Buildings and paving could also serve as caps in some places, but fill would probably be placed across the area for fairgrounds facilities prior to construction of foundations or paving. The caps would not be designed to be impermeable, but may tend to decrease infiltration and measures would be taken to ensure water application is not increased. Figure 4 shows the location for capping. Nearly the entire floodplain area would be capped. Contaminated soil on the northern tip of the upper bench would be scraped to a depth of 6 inches into the floodplain area and placed under the cap.

Vegetation would be established on the soil cap in areas not designated for fairgrounds facilities. Figure 4 shows the areas currently planned for fairgrounds facilities and for re-vegetation. The vegetation would minimize potential erosion of the cap, and would tend to increase consumption of precipitation and reduce infiltration through capped materials. After adequate establishment of the vegetation, capped areas would not be irrigated to ensure that water application is not increased from current levels. In areas of fairground facilities, buildings and pavings would reduce erosion potential and tend to reduce infiltration. Stormwater runoff from fairground facilities would be managed so that infiltration through capped materials would not increase.

Vegetation in areas not designated for facilities would be monitored annually until vegetative criteria were met. Re-vegetation would be considered successful when the total cover measured in transects reached 75% of the cover of typical, undisturbed, unimpacted areas with similar moistures and soils near the site. To ensure species diversity, at least two grass species and one forb or shrub species should also be present in the transects. It may be difficult to establish vegetation in some soil cap materials, and it may be necessary to apply an additional layer of topsoil or compost to achieve vegetation goals.

The largest area of wetlands at the site created by the wastewater lagoon effluent would not be covered by the soil cap. Some amount of soil contamination may remain in the wetland soils, but it is not expected that the public will have direct contact with wetland soils. The narrow string of wetlands extending from this area is also supported by the lagoon effluent, and about one acre of these wetlands would be covered by the soil cap. A permit would be required to mitigate this wetland. Permit conditions would govern the required mitigation area although a one-to-one mitigation area of one acre is shown in Figure 4. Contaminated soil to the south of the current large wetland area would be removed and placed under the cap, and the area of mitigation wetlands would be placed in the cleaned area. Contaminated soil would also be removed to establish a conveyance channel between a culvert that has been installed on the northwestern side of the property and the new wetland area. The culvert was installed for a channel to divert stormwater from running onto the central portion of the airport corner property. Contaminated soil may also be removed from some areas near the fairgrounds facilities planned for vegetation landscaping or trees that may require limited irrigation.

The active area of Willow Creek would not be capped as the cap material would be quickly eroded, and stream bed materials are continuously transported into and out of the reach. A corridor would be established for the stream channel and measures taken to stabilize the channel location. A project to restore and stabilize Willow Creek throughout the entire floodplain area is currently being designed by the Natural Resources Conservation Service (NRCS).

Figure 4 details construction areas for Alternative 2. Contaminated soil would be removed from 1.6 acres on the northern tip of the upper bench, about 1.0 acre for the mitigated wetlands, and 0.1 acres for the stormwater channel. A corridor of about 1.2 acres would be left for the Willow Creek channel and not capped. The remaining floodplain area to be capped with at least 12 inches of soil is about 25.6 acres in size. This equates to at least 41,300 cubic yards of cap material. More material may be placed in some areas to raise foundation levels for fairgrounds facilities above flood levels. Approximately 11.5 acres of the capped area is currently planned for fairgrounds facilities and 14.1 acres of the capped area would be re-vegetated. If 2 to 3 inches of topsoil or compost is needed to establish vegetation in non-fairground facility areas, approximately 3800 to 5700 cubic yards would be needed.

Source areas for fill for the soil cap would include an area to the southwest of the floodplain on the MFCA site and an area to the northwest of the site on the airport corner property. The on-site borrow area is currently proposed as a recessed area for onsite parking of horse trailers. The coarser fill from this area could be used when more than 12 inches of fill is desired to raise foundation levels for fairgrounds facilities. The off-site borrow area is a hill composed of relatively soft Creede formation material. Some parts of the Creede formation may be mineralized. However, the WCRC evaluated soil from the hill using XRF and no lead was detected. The Creede formation material may be more expensive to excavate and haul from the off-site area, but the formation does have a significant fine proportion that is of much lower permeability than floodplain sediments and would tend to slow infiltration through the cap and allow increased consumption by vegetation. Surrounding Creede formation materials appear to be fair for vegetative growth. Approximately 22,700 cubic yards of material is needed for the cap in the area planned for re-vegetation on the site.

As with Alternative 1, successful completion of Alternative 2 would be positive for land use and enable use of the site as a public fairgrounds and allow unrestricted public access to the entire site including the floodplain area. Some existing contamination may remain in the current area of wetlands, but it is not expected that the public would contact the soils in these wetlands. Several additional land use controls would be required. Excavation through the soil cap into the contaminated soils would be prohibited without approval by the CDPHE. Adequate vegetative cover would have to be established on areas of the soil cap planned for fairgrounds facilities for the remediation to be considered complete. After vegetation establishment, irrigation in areas of contaminated soils would be prohibited. The soil cap would have to be maintained and areas with significant erosion must be repaired. Potential management of vegetation and erosion would imply some continual burdens on the MCFA.

The estimated cost to scrape the contaminated soil on the northern bench, excavate contaminated soil for the mitigation wetlands and stormwater channel, level topography, place the soil cap, and re-vegetate the non-fairgrounds area of the floodplain is estimated between $200,000 and $300,000. This cost does not include application of topsoil or compost to the site which may also be required to adequately establish vegetation. It is anticipated that if any extra funding is available, it will be used to haul and apply a layer of topsoil or compost. A two inch layer of compost for re-vegetated areas would cost about $200,000, so use of locally available topsoil may be more feasible.

### 7.3 Alternative 3 - No Action Alternative

A No-Action Alternative must be considered as part of the ABCA process. Constructions costs of the No-Action Alternative would obviously be zero although limited costs have already been incurred for site investigations.

As far as land use, the no action alternative would preclude public use of the site for a fairgrounds facility due to lead contamination and risks to young children and pregnant mothers. Although currently not visibly restricted, public access to floodplain areas should be restricted or prohibited in the future if the site is not cleaned up. Environmental conditions and risks would probably not worsen or improve with no action at the site.

### 7.4 Comparison of Alternatives

Both the capping and soil removal alternatives would isolate contaminated soil on the site from direct human contact and effectively reduce the health risks to workers, residents, and the public associated with direct contact with lead contaminated soil. Both of these cleanup alternatives would provide for adequate protection of human health. The no-action alternative would not satisfy requirements for adequate protection of human health as significant lead contamination would still be available for direct human contact at the site.

The soil removal alternative would reduce, and potentially eliminate, infiltration through contaminated soils that have shown a potential to leach metals, particularly lead, into the groundwater. This would fully satisfy environmental protection requirements.

The capping alternative would not eliminate infiltration of water through the contaminated soils on the site, as the cap would not be designed to be impermeable. Infiltration through contaminated soils may be reduced somewhat due to potential use of soils with a lower permeability than current floodplain sediments in the cap, additional cover of areas with structures or paving, establishment of vegetation, and control of stormwater runoff. The requirement to not irrigate capped areas following adequate establishment of vegetation would ensure that water available for infiltration through contaminated soils would not increase above current levels. Available data have not indicated that current levels of infiltration through soils at the MCFA site are impacting Willow Creek. As infiltration would not increase and may decrease, impacts to Willow Creek would not be expected following implementation of the capping alternative. Therefore, the capping alternative should provide for adequate protection to the environment to satisfy requirements of the Colorado VCUP program.

If adequate funding was secured for the soil removal and isolation alternative, it is probable that additional funding would not be secured to replace topsoil and re-vegetate the floodplain area. Therefore, the soil removal alternative could potentially result in negative impacts to vegetative, habitat, stream stability, and aesthetic conditions in the MCFA floodplain. A requirement of the capping alternative would be to restore vegetation to the floodplain area. Therefore, the capping alternative would have positive impacts on vegetation, habitat, and aesthetic conditions in the floodplain. However, it may be necessary to bring in additional topsoil or compost to be able to achieve re-vegetation goals.

Both the soil removal and capping alternatives would necessitate the land use control to prohibit excavation into contaminated soils without approval by the CDPHE. For the soil removal alternative, the asphalt cap would have to be maintained in perpetuity and periodically re-asphalted after its design life was exceeded. For the capping option, the soil cap would have to be maintained to avoid erosion of the cap. Maintenance of adequate vegetative cover at the site may be difficult, especially if drought conditions persist in the area. Therefore, both alternatives would imply continual management and financial burdens on the MCFA. However, these controls are compatible and feasible with future use and management of the site. The no-action alternative would preclude use of the site as a public fairgrounds and is not compatible with the use goals envisioned for the site.

For the soil removal and isolation alternative, the estimated cost of $500,000 to $750,000 is more than the current available cleanup funding. An additional EPA Brownfields grant could probably not be obtained for the site, and other significant funding for cleanup would be difficult to secure. For the soil capping alternative, the estimated cost of $200,000 to $300,000 is feasible given the current available Brownfields related funding. The no-action alternative would obviously incur no cleanup construction costs.

In summary, the soil removal and isolation alternative would provide for protection of human health and the highest degree of protection for the environment. However, the alternative is probably not feasible due to the high cost. The capping alternative would provide for similar human health protection but less environmental protection than the soil removal alternative. However, the alternative is feasible from a funding standpoint and environmental protection is adequate. The alternative would also result in more positive impacts to the vegetative, habitat, and aesthetic conditions of the floodplain than the soil removal alternative. The no-action alternative is obviously feasible, but would not be compatible with the land use goals for the site.

## 8. Selected Alternative and Proposed Cleanup Plan

The alternative “Capping of Contaminated Soil” described above is selected as the most feasible alternative meeting land use goals and is proposed as the cleanup plan for the MCFA site.

The floodplain area of the site will be capped with at least 12 inches of non-contaminated soil. Contaminated soil will be scraped from a 1.6 acre area at the northern tip of the upper bench to a depth of 6 inches. In addition, contaminated soil will be removed from the area for the mitigated wetlands for a stormwater channel. The removed contaminated soil will be placed into the floodplain area, and then covered with the cap. The active Willow Creek stream channel will not be capped. In addition, wetland areas maintained or established at the site will not be capped.

The capped area not envisioned for fairgrounds facilities will be re-vegetated, and re-vegetation will be considered successful when the total cover reaches 75% of the cover of un-impacted areas with similar moistures and soils near the site. Cover will be measured in transects and defined as live stems, litter (dead vegetation both standing and down), moss, and rock. Combinations of rock and moss may not exceed 20 percent of the area. At least two grass species and one forb or shrub species must be present in the transects. To determine cover, five random transects 100 feet long will be measured with determination of cover made at 1-foot intervals. Vegetation monitoring will continue annually during late summer or early fall until the vegetative criteria are met.

The capped floodplain area will not be irrigated once vegetation has been adequately reestablished. An environmental covenant will be placed on the deed of the fairgrounds property to prohibit digging through the 12 inch cap in the floodplain without prior approval of the CDPHE. The MCFA will also be responsible to maintain the cap to prevent erosion.

The proposed cleanup plan is estimated to cost between $200,000 and $300,000. Additional funds may be need if additional topsoil or compost is needed to achieve re-vegetation goals.

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**APPENDIX**

Table A-1. WCRC Airport Corner Soil Sample Data from MCFA Property

| Sample ID | Lead (ppm) |
|---|---|
| 40 | 943 |
| 49 | 287 |
| 50 | 1182 |
| 69B | 1954 |
| 80 | 3963 |
| 81 | 11288 |
| 82 | 12815 |
| 83 | 6454 |
| 84A | 6817 |
| 84B | 23707 |
| 85 | 15800 |
| 86 | 7682 |
| 87 | 10614 |

Table A-2. CDPHE Soil Sample Data from northern and central Upper Bench

| Sample ID | Lead (ppm) | | | Arsenic (ppm) | | |
|---|---|---|---|---|---|---|
| | 0 to 6 inches | 12 to 16 inches | 30 to 36 inches | 0 to 6 inches | 12 to 16 inches | 30 to 36 inches |
| EC01 | 810 | 11 | | 24 | 8.9 | |
| EC02 | 400 | 11 | 12 | 14 | 13 | 3 |
| EC03 | 350 | 66 | | 21 | 10 | |
| EC04 | 140 | 43 | | 11 | 19 | |
| EC05 | 190 | 24 | | 20 | 7.1 | |
| EC06 | 170 | 20 | | 16 | 3.1 | |
| EC07 | 320 | 21 | | 21 | 3.5 | |
| EC08 | 33 | 16 | 140 | 1.4 | 3.2 | 16 |
| EC09 | 260 | 46 | | 19 | 18 | |
| EC10 | 71 | 32 | | 8 | 6.2 | |
| EC11 | 65 | 18 | | 12 | 25 | |
| EC12 | 170 | 14 | | 7.9 | 4.3 | |
| EC13 | 70 | 14 | 68 | 8.7 | 1.1 | 29 |
| EC14 | 70 | 26 | | 8.8 | 6 | |
| EC15 | 170 | 37 | | 9.9 | 6.9 | |
| EC16 | 190 | 33 | 9.4 | 12 | 12 | 2.8 |
| EC17 | 160 | 16 | | 9.8 | 7.9 | |
| EC18 | 160 | 44 | | 9.7 | 13 | |
| EC19 | 12 | 39 | | 11 | 8.4 | |
| EC20 | 150 | 17 | | 11 | 5.2 | |
| EC21 | 280 | 13 | 31 | 14 | 4.7 | 12 |
| EC22 | 250 | 73 | | 12 | 9.3 | |
| EC23 | 2500 | 40 | | 33 | 10 | |
| EC24 | 1900 | 390 | | 44 | 15 | |

Table A-3. EnviroGroup Soil Sample Data from southern Upper Bench

| Sample ID | Lead (ppm) | Arsenic (ppm) |
|---|---|---|
| 1 | 290 | 21 |
| 2 | 210 | 21 |
| 3 | 170 | 21 |

Table A-4. WCRC Floodplain 0 to 2 inch Depth Composite Sample Data

| Sector ID | Lead (ppm) |
|---|---|
| ABFG | 4,530 |
| BCGH | 3,490 |
| CDHI | 3,260 |
| DEIJ | 5,610 |
| FGKL | 3,590 |
| GHLM | 3,920 |
| HIMO | 3,260 |
| IJO | 4,480 |
| KLPQ | 7,520 |
| LMQR | 3,950 |
| MNRS | 5,160 |
| NOST | 11,100 |
| PQUV | 8,680 |
| QRVW | 3,670 |
| RTW | 9,890 |
| UVXY | 9,560 |
| VWY | 3,470 |
| XYZ | 2,450 |

Table A-5. Metals leached using SPLP from WCRC Floodplain Samples

| Sector ID | SPLP Cd (mg/L) | SPLP Pb (mg/L) | SPLP Zn (mg/L) |
|---|---|---|---|
| ABKL | 0.05 | 1.30 | 2.50 |
| BCLM | 0.05 | 1.20 | 1.90 |
| CDMO | 0.05 | 1.30 | 4.01 |
| DEO | 0.05 | 2.00 | 5.90 |
| KMPR | 0.05 | 1.20 | 4.50 |
| MORT | 0.09 | 1.90 | 13.00 |
| PQUV | 0.05 | 1.40 | 5.40 |
| QRVW | 0.05 | 1.90 | 4.00 |
| RTW | 0.28 | 0.59 | 41.00 |
| UVXY | 0.05 | 1.40 | 5.30 |
| VWY | 0.05 | 1.50 | 2.60 |
| XYZ | 0.05 | 0.06 | 0.57 |

Table A-6. WCRC Floodplain Depth Interval Sample Data

| Sample | Lead Concentration (ppm) in fines < 2mm | | | | | "In-Situ" Lead Concentration (ppm) | | | | | Location-UTM NAD83 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth: | 0"-3" | 3"-6" | 6"-9" | 9"-12" | 12"-18" | 0"-3" | 3"-6" | 6"-9" | 9"-12" | 12"-18" | X | Y |
| 1 | 12595.2 | 16844.8 | 21094.4 | 6249.6 | 1524.8 | 10314.2 | 13160.0 | 14018.4 | 4751.8 | 1030.9 | 331256.0 | 4188673.0 |
| 2 | 18892.8 | 10198.4 | 1840.0 | 257.6 | 683.6 | 16915.6 | 9283.2 | 1717.3 | 182.9 | 146.9 | 331284.6 | 4188658.2 |
| 3 | 260.8 | 5704.0 | 11897.6 | 4998.4 | 1009.6 | 97.7 | 3961.1 | 8498.3 | 4192.2 | 797.1 | 331269.6 | 4188641.2 |
| 4 | 4067.2 | 13145.6 | 1929.6 | 203.2 | 94.4 | 1768.3 | 10316.8 | 1691.7 | 203.2 | 39.0 | 331289.9 | 4188618.1 |
| 5 | 3577.6 | 2299.2 | 1729.6 | 2019.2 | 1449.6 | 490.2 | 381.8 | 360.8 | 274.3 | 267.5 | 331315.2 | 4188680.2 |
| 6 | 2440.0 | 1868.8 | 2169.6 | 3019.2 | 3280.0 | 428.6 | 242.7 | 562.4 | 1935.4 | 796.7 | 331325.0 | 4188649.6 |
| 7 | 2729.6 | 1420.0 | 1708.8 | 1659.2 | 1220.0 | 448.7 | 368.3 | 383.0 | 408.7 | 195.3 | 331357.4 | 4188617.9 |
| 8 | 3449.6 | 2760.0 | 2499.2 | 1649.6 | 756.4 | 1094.6 | 780.2 | 591.2 | 183.5 | 106.2 | 331344.4 | 4188674.2 |
| 9 | 2948.8 | 2828.8 | 2249.6 | 2668.8 | 2748.8 | 1857.4 | 468.3 | 378.7 | 507.7 | 527.4 | 331401.4 | 4188667.7 |
| 10 | 2609.6 | 1760.0 | 1868.8 | 1640.0 | 1540.0 | 736.2 | 195.3 | 501.6 | 486.4 | 342.8 | 331391.2 | 4188631.0 |
| 11 | 2620.0 | 2329.6 | 1929.6 | 1549.6 | 1149.6 | 332.9 | 359.3 | 244.4 | 243.8 | 77.1 | 331441.0 | 4188618.6 |
| 12 | 5347.2 | 3827.2 | 3619.2 | 5120.0 | 15891.2 | 1667.7 | 1289.1 | 1057.5 | 2356.2 | 11466.9 | 331456.3 | 4188670.1 |
| 13 | 6169.6 | 15398.4 | 998.4 | 125.9 | 155.1 | 2009.4 | 7866.4 | 741.0 | 98.5 | 105.3 | 331487.0 | 4188671.9 |
| 14 | 5718.4 | 4897.6 | 3228.8 | 3188.8 | 3417.6 | 1892.0 | 614.5 | 361.6 | 517.8 | 460.2 | 331494.0 | 4188643.7 |
| 15 | 1300.0 | 82.8 | 57.6 | <69.3 | 47.9 | 1127.8 | 43.4 | 17.0 | <20.5 | 36.7 | 331309.8 | 4188554.6 |
| 16 | 5238.4 | 603.6 | 153.6 | 182.1 | 85.1 | 4431.7 | 211.8 | 45.1 | 37.6 | 18.7 | 331266.6 | 4188544.2 |
| 17 | 7929.6 | 918.4 | 394.8 | 168.1 | 92.6 | 5407.1 | 426.6 | 62.5 | 24.3 | 18.6 | 331302.8 | 4188581.0 |
| 18 | 7168.0 | 3529.6 | 350.0 | 141.7 | 141.4 | 4443.4 | 577.8 | 48.2 | 25.6 | 36.9 | 331277.3 | 4188580.3 |
| 19 | 2899.2 | 2668.8 | 1880.0 | 1529.6 | 1614.8 | 489.9 | 361.4 | 309.0 | 286.4 | 342.9 | 331342.5 | 4188583.1 |
| 20 | 5168.0 | 3657.6 | 488.4 | 230.8 | 146.0 | 3207.2 | 3279.0 | 459.5 | 225.5 | 142.9 | 331384.0 | 4188576.3 |
| 21 | 3337.6 | 3308.8 | 2299.2 | 2132.8 | 1939.2 | 750.7 | 463.2 | 348.8 | 482.0 | 258.8 | 331346.2 | 4188533.6 |
| 22 | 3520.0 | 2794.4 | 2640.0 | 1828.8 | 3299.2 | 2856.1 | 1152.0 | 732.7 | 309.2 | 539.5 | 331384.6 | 4188541.2 |
| 23 | 1819.2 | 385.4 | 102.3 | 95.1 | 68.7 | 1489.7 | 339.1 | 96.2 | 14.5 | 12.0 | 331395.0 | 4188587.4 |
| 24 | 3042.7 | 1899.2 | 1739.2 | 1668.8 | 1460.0 | 1393.0 | 232.3 | 300.1 | 297.9 | 202.5 | 331461.1 | 4188583.1 |
| 25 | 5929.6 | 2808.8 | 1699.2 | 1589.6 | 1389.6 | 2312.3 | 433.8 | 289.0 | 318.1 | 732.6 | 331429.5 | 4188516.4 |
| 26 | 4278.4 | 2579.2 | 3019.2 | 3079.2 | 1629.6 | 1481.8 | 996.1 | 866.8 | 865.3 | 553.6 | 331491.0 | 4188542.6 |
| 27 | 6249.6 | 3360.0 | 239.1 | 83.9 | <61.8 | 4487.2 | 2573.2 | 221.4 | 67.6 | <28.7 | 331498.4 | 4188606.1 |
| 28 | 4777.6 | 3358.4 | 2628.8 | 2628.8 | 2779.2 | 1884.3 | 1211.1 | 859.8 | 1522.4 | 1587.2 | 331527.1 | 4188599.0 |
| 29 | 4857.6 | 3888.0 | 2689.6 | 3009.6 | 2828.8 | 2115.7 | 553.8 | 707.8 | 659.9 | 805.7 | 331525.6 | 4188572.2 |
| 30 | 4368.0 | 766.4 | 260.4 | 264.1 | 129.4 | 2285.2 | 219.3 | 46.3 | 59.8 | 23.6 | 331303.8 | 4188466.0 |
| 31 | 16396.8 | 15296.0 | 4259.2 | 1149.6 | 293.8 | 13099.0 | 12237.9 | 3661.9 | 1086.5 | 205.1 | 331309.6 | 4188499.8 |
| 32 | 2948.8 | 195.7 | 60.7 | <58.95 | <64.65 | 2801.6 | 189.6 | 59.5 | <58.3 | <29.2 | 331311.1 | 4188524.2 |
| 33 | 7059.2 | 276.8 | 77.0 | <87.83 | <44.55 | 5821.7 | 251.2 | 56.6 | <16.3 | <7.7 | 331275.9 | 4188512.4 |
| 34 | 3587.2 | 2508.8 | 1800.0 | 2320.0 | 3657.6 | 1140.5 | 481.2 | 455.8 | 1024.9 | 872.1 | 331351.0 | 4188490.0 |
| 35 | 2329.6 | 2360.0 | 1939.2 | 1569.6 | 1988.8 | 867.4 | 461.0 | 285.1 | 408.6 | 421.0 | 331385.1 | 4188472.1 |
| 36 | 2769.6 | 2280.0 | 2589.6 | 1549.6 | 1369.6 | 572.1 | 649.7 | 773.8 | 193.1 | 162.9 | 331370.1 | 4188431.9 |
| 37 | 2200.0 | 1779.2 | 1849.6 | 1460.0 | 2228.8 | 398.7 | 326.2 | 432.7 | 281.4 | 311.5 | 331402.0 | 4188396.1 |
| 38 | 3868.8 | 1560.0 | 1824.0 | 850.4 | 803.2 | 1972.7 | 1106.6 | 625.5 | 326.3 | 371.3 | 331443.3 | 4188473.9 |
| 39 | 10995.2 | 5148.8 | 606.4 | 450.8 | 360.4 | 10098.4 | 4539.2 | 521.9 | 417.1 | 229.2 | 331478.2 | 4188449.3 |
| 40 | 7334.4 | 2304.0 | 1788.8 | 863.2 | 341.0 | 4021.4 | 717.6 | 434.3 | 278.5 | 110.0 | 331423.1 | 4188437.4 |
| 41 | 8876.8 | 9158.4 | 6604.8 | 4092.8 | 2209.6 | 6711.6 | 3516.2 | 1978.4 | 479.0 | 402.5 | 331450.7 | 4188399.9 |
| 42 | 4067.2 | 479.8 | 133.2 | 75.6 | 62.1 | 2964.3 | 392.7 | 118.7 | 58.6 | 23.0 | 331411.2 | 4188479.3 |
| 43 | 5427.2 | 694.4 | 392.0 | 78.1 | <62.55 | 4812.7 | 368.6 | 269.8 | 61.0 | <43.7 | 331476.7 | 4188490.4 |
| 44 | 8275.2 | 10195.2 | 4249.6 | 324.4 | 332.2 | 7634.9 | 9990.4 | 3671.3 | 255.1 | 260.1 | 331520.7 | 4188474.1 |
| 45 | 3968.0 | 8473.6 | 17996.8 | 24998.4 | 26598.4 | 2182.8 | 4386.4 | 12248.3 | 17829.0 | 23604.6 | 331517.3 | 4188400.3 |
| 46 | 7616.0 | 816.8 | 164.6 | 90.7 | <57.9 | 6423.8 | 639.5 | 118.4 | 37.2 | <34.8 | 331390.6 | 4188302.8 |
| 47 | 4358.4 | 2708.8 | 1620.0 | 1834.4 | 1908.8 | 2093.6 | 607.9 | 298.6 | 233.6 | 1041.9 | 331396.2 | 4188346.2 |
| 48 | 2519.2 | 712.8 | 64.3 | 77.1 | 2840.0 | 1395.6 | 528.7 | 60.3 | 71.2 | 2047.1 | 331333.0 | 4188418.4 |
| 49 | 3648.0 | 2889.6 | 1880.0 | 1739.2 | 2099.2 | 923.5 | 1035.2 | 207.6 | 267.1 | 387.0 | 331390.2 | 4188375.5 |
| 50 | 2299.2 | 1920.0 | 1819.2 | 1840.0 | 1569.6 | 831.5 | 142.8 | 278.1 | 129.1 | 52.7 | 331428.3 | 4188344.9 |
| 51 | 4707.2 | 4729.6 | 5008.0 | 5280.0 | 2659.2 | 3431.2 | 2362.6 | 3513.6 | 1522.2 | 802.7 | 331444.1 | 4188307.1 |
| 52 | 2480.0 | 3068.8 | 3968.0 | 2120.0 | 1449.6 | 878.3 | 1474.3 | 1011.1 | 375.9 | 283.0 | 331497.2 | 4188296.5 |
| 53 | 3619.2 | 1849.6 | 522.0 | 118.4 | 198.1 | 1936.3 | 1203.4 | 387.2 | 100.7 | 80.6 | 331468.8 | 4188360.8 |
| 54 | 7244.8 | 11699.2 | 8665.6 | 4518.4 | 4617.6 | 6529.3 | 10918.1 | 4220.5 | 2621.5 | 945.3 | 331513.1 | 4188333.1 |
| 55 | 3478.4 | 2249.6 | 1788.8 | 1720.0 | 1788.8 | 1085.0 | 689.7 | 1121.1 | 990.1 | 778.3 | 331516.6 | 4188297.3 |
| 56 | 6118.4 | 8249.6 | 2649.6 | 1440.0 | 345.0 | 5037.7 | 3440.1 | 383.9 | 327.3 | 107.8 | 331438.2 | 4188203.6 |
| 57 | 3520.0 | 973.6 | 173.7 | 220.8 | 160.1 | 2971.8 | 910.2 | 162.0 | 102.1 | 45.8 | 331466.6 | 4188254.2 |
| 58 | 3817.6 | 6537.6 | 837.6 | 405.0 | 94.3 | 3079.5 | 3508.5 | 159.0 | 124.5 | 55.0 | 331413.6 | 4188248.8 |
| 59 | 18745.6 | 11395.2 | 803.8 | 169.4 | 228.0 | 14512.7 | 11157.8 | 725.0 | 145.8 | 116.6 | 331431.5 | 4188292.5 |
| 60 | 1429.6 | 1680.0 | 1584.8 | 1309.6 | 1329.6 | 197.8 | 360.0 | 264.5 | 162.0 | 193.2 | 331498.3 | 4188256.6 |
| 61 | 3049.6 | 1580.0 | 1189.6 | 1120.0 | 1699.2 | 1011.5 | 191.1 | 190.8 | 174.1 | 297.0 | 331518.6 | 4188232.9 |
| 62 | 2809.6 | 2068.8 | 1729.6 | 1939.2 | 2320.0 | 824.0 | 268.6 | 271.8 | 272.0 | 659.6 | 331516.7 | 4188208.0 |
| 63 | 358.0 | 110.3 | <55.65 | 66.2 | 64.1 | 294.3 | 66.0 | <22.6 | 12.4 | 14.1 | 331502.0 | 4188092.1 |
| 64 | 1240.0 | 158.7 | <52.8 | <60.6 | <55.05 | 858.5 | 129.0 | <13.5 | <13.8 | <22.2 | 331486.7 | 4188149.0 |
| 65 | 407.8 | 48.0 | <58.8 | <57 | <39.75 | 296.6 | 35.7 | <26.3 | <32.3 | <16.5 | 331507.0 | 4188171.2 |

Table A-7. Surface Water Quality Data from U.S.G.S. Study (Kimball et al. 2006)

| Relative to Site | Upstream Site | | | On MCFA Site | | | Downstream Site | | |
|---|---|---|---|---|---|---|---|---|---|
| **Stream Dist. ID** | **8725** | **9075** | **W-8725** | **W-9335** | **9482** | **9482** | **9782** | **10082** | **10324** |
| **Source** | Stream | Stream | Stream | Inflow | Stream | Stream | Stream | Stream | Stream |
| **Discharge (gpm)** | 304 | 250 | 32 | 55.4 | 305 | 305 | 308 | 322 | 333 |
| **S. conductance** | 144 | 143 | 176 | 172 | 146 | 147 | 147 | 149 | 147 |
| **pH** | 7.46 | 7.49 | 7.17 | 7.46 | 7.45 | 7.57 | 7.38 | 6.74 | 7.37 |
| **Temperature (C)** | 17.0 | 18.5 | 18.0 | 23.5 | 20.5 | 20.5 | 20.5 | 21.0 | 21.0 |
| **Alkalinity (mg/L)** | 20.7 | 36.9 | 23.0 | | 30.1 | 32.9 | 21.4 | 22.1 | 20.6 |
| **SO4 (mg/L)** | 46.0 | 46.5 | 58.3 | | 48.1 | 48.3 | 48.3 | 48.0 | 47.4 |
| **Cl (mg/L)** | .32 | .32 | .36 | | .45 | .30 | .34 | .32 | .36 |
| **Na (mg/L)** | 4.80 | 5.40 | 5.70 | 4.40 | 4.80 | 4.40 | 3.90 | 4.60 | 4.70 |
| **K_D (mg/L)** | 1 | 1 | 1.1 | 1.5 | 1.2 | 1.1 | 0.99 | 0.94 | 1.1 |
| **K_T (mg/L)** | 0.96 | 0.91 | 1.3 | 2 | 0.92 | 1.1 | 0.99 | 0.85 | 1 |
| **Ca_UF (ug/L)** | 17000 | 18000 | 23000 | 20000 | 17000 | 16000 | 16000 | 17000 | 16000 |
| **Ca_D (ug/L)** | 17000 | 17000 | 20000 | 21000 | 17000 | 18000 | 17000 | 18000 | 18000 |
| **Ca_T (ug/L)** | 17000 | 17000 | 22000 | 20000 | 17000 | 17000 | 17000 | 19000 | 17000 |
| **Mg_UF (ug/L)** | 1700 | 1600 | 1800 | 2000 | 1800 | 1700 | 1500 | 1400 | 1700 |
| **Mg_D (ug/L)** | 1200 | 1200 | 1900 | 1900 | 1100 | 1400 | 1700 | 1800 | 1600 |
| **Mg_T (ug/L)** | 1700 | 1700 | 1700 | 1300 | 1700 | 1600 | 1700 | 1600 | 1800 |
| **Al_UF (ug/L)** | <19 | <19 | <19 | <19 | <19 | <19 | <19 | 110 | <19 |
| **Al_D (ug/L)** | 110 | 86 | <19 | 87 | <19 | 83 | 99 | <19 | <19 |
| **Al_T (ug/L)** | 400 | 200 | <19 | <19 | 170 | 240 | 180 | 160 | 130 |
| **As_UF (ug/L)** | <84 | <84 | <84 | <84 | <84 | <84 | <84 | <84 | <84 |
| **As_D (ug/L)** | <84 | <84 | <84 | <84 | <84 | <84 | <84 | <84 | <84 |
| **As_T (ug/L)** | <84 | <84 | <84 | <84 | <84 | <84 | <84 | <84 | <84 |
| **Cd_UF (ug/L)** | 15 | 16 | 40 | 29 | 15 | 13 | 15 | 17 | 11 |
| **Cd_D (ug/L)** | 19 | 17 | 38 | 31 | 17 | 19 | 16 | 16 | 15 |
| **Cd_T (ug/L)** | 17 | 17 | 41 | 34 | 17 | 18 | 17 | 19 | 15 |
| **Cu_UF (ug/L)** | 48 | 21 | 5 | 2 | 13 | 29 | 11 | 12 | 19 |
| **Cu_D (ug/L)** | 3 | 3 | 3 | 2 | 2 | 10 | 8 | 5 | 13 |
| **Cu_T (ug/L)** | 6 | 11 | 2 | <2 | 4 | 2 | 6 | 5 | 7 |
| **Fe_UF (ug/L)** | <2 | <2 | <2 | <2 | <2 | 8 | <2 | <2 | <2 |
| **Fe_D (ug/L)** | 25 | 20 | 14 | 8 | 19 | 21 | 20 | <2 | 17 |
| **Fe_T (ug/L)** | 110 | 90 | 16 | 17 | 67 | 74 | 70 | 67 | 59 |
| **Pb_UF (ug/L)** | <26 | <26 | <26 | <26 | <26 | <26 | <26 | <26 | <26 |
| **Pb_D (ug/L)** | <26 | <26 | <26 | <26 | <26 | <26 | <26 | <26 | <26 |
| **Pb_T (ug/L)** | 60 | 42 | <26 | <26 | 28 | 33 | 27 | 32 | <26 |
| **Mn_UF (ug/L)** | 540 | 520 | 250 | 89 | 410 | 370 | 360 | 340 | 300 |
| **Mn_D (ug/L)** | 510 | 480 | 250 | 88 | 360 | 390 | 360 | 350 | 330 |
| **Mn_T (ug/L)** | 570 | 520 | 240 | 85 | 390 | 390 | 400 | 350 | 340 |
| **Mb_UF (ug/L)** | 28 | 32 | <6 | 51 | 54 | <6 | 47 | <6 | 12 |
| **Mb_D (ug/L)** | 14 | 20 | <6 | <6 | 21 | <6 | <6 | <6 | 15 |
| **Mb_T (ug/L)** | <6 | <6 | 11 | 33 | <6 | <6 | <6 | <6 | <6 |
| **St_UF (ug/L)** | 140 | 140 | 160 | 150 | 140 | 130 | 130 | 130 | 130 |
| **St_D (ug/L)** | 120 | 120 | 160 | 150 | 110 | 120 | 140 | 140 | 140 |
| **St_T (ug/L)** | 140 | 140 | 150 | 130 | 130 | 130 | 140 | 130 | 140 |
| **Zn_UF (ug/L)** | 2800 | 2566 | 5300 | 4300 | 2555 | 2318 | 2400 | 2134 | 1823 |
| **Zn_D (ug/L)** | 2700 | 2573 | 6000 | 4100 | 2516 | 2475 | 2400 | 2149 | 1841 |
| **Zn_T (ug/L)** | 2800 | 2886 | 6300 | 4300 | 2750 | 2669 | 2400 | 2436 | 2042 |

Note: Stream ID noted with W- indicate far western channel separate from main channel
Site 8725 170 meters upstream of split with east channel, Site 10324 at Rio Grande

Table A-8. WCRC Groundwater Monitoring Well Water Quality Data

| Date | 9/18 1999 | 9/23 1999 | 7/16 2000 | 5/22 2001 | 11/17 2001 | 4/24 2002 | 11/18 2002 | 4/29 2003 | 6/27 2005 |
|---|---|---|---|---|---|---|---|---|---|
| Depth to water | | | 5.17 | | 5.30 | 5.30 | 5.12 | 5.25 | |
| field pH | | 6.7 | 6.8 | 7.1 | 6.4 | 6.7 | 6.4 | 6.2 | 6.47 |
| tALK (mg/L) | | 39 | 127 | 106 | 63 | 137 | 92 | 91 | 102 |
| tHARD (mg/L) | | 71 | 174 | 402 | | | | | |
| TDS (mg/L) | | 110 | 254 | | 264 | 783 | 278 | 205 | |
| TSS (mg/L) | | 20 | 463 | | | | | | |
| Cond (umhos/cm) | | 151 | 446 | | 366 | 520 | 444 | 341 | 579 |
| DO (mg/L) | | 8.0 | 2.3 | | | | | | 0.4 |
| dAl (ug/L) | | 63 | 837 | 0 | 1215 | <3 | 73.7 | 17.6 | <100 |
| tAl (ug/L) | 1949 | 1991 | 1663 | 1774 | | | | | |
| dAs (ug/L) | | 0 | 9 | 0 | | | | | <10 |
| tAs (ug/L) | | 0 | 34 | 20 | | | | | |
| dCa (ug/L) | | 25656 | 68400 | 112202 | 46200 | 60400 | 49400 | 37300 | 96300 |
| tCa (ug/L) | 103354 | 25977 | | 125109 | | | | | |
| dCd (ug/L) | | 0.0 | 13.0 | 15.2 | 6.6 | 8.8 | 14.2 | 5.5 | 14 |
| tCd (ug/L) | 0.6 | 0.0 | 15.0 | 15.0 | | | | | |
| dCu (ug/L) | | 0 | 33 | 2.9 | 27 | 7.1 | 4.3 | 4.4 | <10 |
| tCu (ug/L) | 65.9 | 3.4 | 34 | 10.3 | | | | | |
| dCr (ug/L) | | | | | | | | | <2 |
| dFe (ug/L) | | 24 | 1200 | 0 | 11 | <10 | <10 | <10 | <200 |
| tFe (ug/L) | 2331 | 937 | 3600 | 3228 | | | | | |
| dMg (ug/L) | | 2726 | 2510 | 11021 | 3490 | 5200 | 4300 | 3500 | 7390 |
| tMg (ug/L) | 12060 | 2932 | | 11229 | | | | | |
| dMn (ug/L) | | 0 | 153 | 14 | 98 | 225.4 | 2375 | 1372 | 1550 |
| tMn (ug/L) | 222 | 35 | 325 | 278 | | | | | |
| dNi (ug/L) | | | | | | | | | <3 |
| dPb (ug/L) | | 0 | 44 | 0 | <1 | 3 | <2 | <2 | <5 |
| tPb (ug/L) | 2.5 | 0 | 69 | 25.2 | | | | | |
| dSe (ug/L) | | | | 0 | | | | | <10 |
| tSe (ug/L) | | | | 2 | | | | | |
| dSi (mg/L) | | 24.20 | 22.25 | | 12.78 | 143.2 | 25.60 | 18.90 | |
| tSi (mg/L) | | 34.90 | 26.28 | | | | | | |
| dZn (ug/L) | | 0 | 3020 | 5425 | 1980 | 2269 | 2703 | 1476.5 | 3650 |
| tZn (ug/L) | 141.5 | 15.2 | 3611 | 5980.8 | | | | | |
| NH4 (ug/L) | | | | <50 | | | | | |
| DOC (mg/L) | | 1 | | | 29 | 44 | 5 | <1 | |
| SO4 (mg/L) | | 34.0 | 79.9 | 289.0 | 49.3 | 111.8 | 100.0 | 34.0 | 225 |
| Cl (mg/L) | | 3.0 | 8.9 | 20.0 | 12.9 | 10.6 | 2.1 | 11.7 | 10.5 |
| Na (mg/L) | | | 16.70 | | 17.17 | 18.30 | 25.70 | 16.90 | 26.7 |
| K (mg/L) | | 2.2 | 2.1 | | 1.9 | 4.2 | 2.0 | 1.6 | 4.53 |