SITE-SPECIFIC ADDENDUM TO
RESTORATION OF ABANDONED MINE SITES (RAMS)
WORK PLAN

WILLOW CREEK – CREEDE, COLORADO

October 4, 2002

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1.0 INTRODUCTION

1.1 Site Information

Willow Creek is a tributary to the Rio Grande, located south of Creede, in southwestern Colorado. Tailings from silver mines of the Creede Silver Mining District are located in a large pile in the alluvial valley of Willow Creek, downstream from the town. It is suspected that the tailings are a source of metals contamination to groundwater that may discharge to the Rio Grande, thereby degrading the water quality.

This project is the top priority for funding by the Colorado Division of Mining and Geology (CDMG). The contaminants of concern (mainly Zinc) from Willow Creek may affect the Rio Grande. The United States Army Corps of Engineers (USACE) has a Civil Works presence in Creede, due to its responsibility for a concrete-lined segment of Willow Creek that flows through the town.

1.2 RAMS Program

The USACE has been provided authority for Restoration of Abandoned Mine Sites (RAMS) through the Water Resource Development Act (WRDA) 1999, Section 560. This program is a regionally focused and stakeholder responsive program for the restoration of abandoned and inactive non-coal mines where water resources (ecosystem/habitat) have been degraded by past mining practices. This authority is intended to allow the USACE to provide support to agencies that manage lands impacted by past mining.

This document is prepared as the Site-Specific Addendum (SSA) to the General RAMS Work Plan (USACE, 2002). The General RAMS Work Plan was written to encompass all investigative activities to be accomplished by various districts of the USACE under the RAMS program. The purpose of this SSA is to present methods and procedures for conducting a site characterization of the Willow Creek drainage basin area.

This SSA describes the media, locations, analyses, frequencies, and techniques associated with the major field tasks and will be used in conjunction with the General RAMS Work Plan. The General RAMS Work Plan contains a more complete discussion of the RAMS program, along with a thorough discussion of the following: sampling requirements; field quality control; chemical data quality objectives; project organization and quality control responsibility; laboratory, analytical, and preparation procedures; sample collection, handling, and documentation procedures; preventative maintenance procedures; calibration procedures and frequency; corrective action; and data reduction. This document references the General RAMS Work Plan for field activities and contains site-specific information not included in the General RAMS Work Plan. The USACE will coordinate in advance to obtain stakeholder buy-in on all work proposed to be performed by the USACE, to ensure that the proposed work is supportive of stakeholders efforts in the area. The stakeholders will provide assistance to the USACE by obtaining any necessary right of entry (ROE) or other access agreements to the identified locations. Stakeholders will provide to the USACE, at stakeholders cost, copies of all previous reports or data regarding the project site. Each stakeholder will identify a point of contact

(POC) to assist with answering questions from the USACE or other stakeholders. Well locations will be determined and specified by the stakeholders.

1.3 Objective and Tasks

The primary objective of this field investigation is to determine metals loading from a tailings pile on the Willow Creek drainage basin area, approximately 1 mile south of the town of Creede. Soil samples acquired during drilling activities along with a single round of groundwater samples will be collected in accordance with this SSA. The stakeholders (Willow Creek Reclamation Committee) will specify well locations to the USACE. The Willow Creek Reclamation Committee will provide containers for waste (soils and tailings only). In addition, the Willow Creek Reclamation Committee will provide the utilities clearance before the UASCE drilling rig arrives on site. The well locations will be chosen to help define a suspected groundwater contaminant plume migrating from the tailings piles. The following tasks are proposed in order to satisfy the objective established for the Willow Creek site:

- Install and develop four to five groundwater-monitoring wells located within the flow path of the suspected contaminant plume. The fifth groundwater monitoring well is contingent on available time.

- Drill a borehole to measure the depth of the tailings pile. An additional borehole may be drilled if time allows.

- Collect soil samples from the borehole(s) located within the tailings pile for metals and leachate analysis.

- Collect groundwater samples from each of the four to five monitoring wells for laboratory analysis of metal contaminants.

- Additional wells and/or borings are contingent upon the time allowed. The USACE is scheduled for five days of actual fieldwork at the Willow Creek project. Decisions for additional monitoring wells and/or borings well be made and approved in the field. All supplies needed for additional work will be brought to the site by USACE in the event that time allows for additional tasks to be performed.

2.0 FIELD ACTIVITIES

The project will be executed using the USACE in-house staff from the Omaha and Albuquerque Districts. The following Standard Operating Procedures (SOPs), located in Appendix A of the General RAMS Work Plan, will be adhered to during the course of the field activities:

A1 Surface Soil/Rock Sampling Equipment and Procedures
A2 Drilling Equipment and Procedures

A3 Subsurface Soil/Rock Sampling Equipment and Procedures
A4 Soil/Rock Homogenization Equipment and Procedures
A5 Lithologic Description of Surface and Subsurface Soil Samples
A6 Boring Log Completion
A7 Investigative Derived Waste Procedures
A8 Monitoring Well Design, Installation, and Abandonment Procedures
A9 Monitoring Well Development Equipment and Procedures
A10 Groundwater Sampling Equipment and Procedures
A12 Equipment Decontamination Procedures
A13 Sample Handling, Documentation, and Tracking Procedures
A14 Field Documentation

The following sections provide site-specific information, including collection, analysis, and handling requirements of samples for the Willow Creek project, that either is not found in, or amends, the General RAMS Work Plan. Reference to the General RAMS Work Plan is provided.

2.1 Well Installation, Completion, and Development

Omaha District will provide the drilling crew, equipment, and materials to install, complete, and develop four to five 2-inch diameter groundwater-monitoring wells. Albuquerque District will provide a field geologist to work with the drilling crew, complete boring logs, and collect soil samples. The decision on the depth of the screens will be made in the field and based on current and historic water table elevation. It is assumed that the groundwater is under unconfined conditions, and will be encountered in the unconsolidated fluvial deposits found within the Willow Creek floodplain. For estimating purposes, the four to five wells identified as CO-WC-MW-16, CO-WC-MW-17, CO-WC-MW-18, CO-WC-MW-19 and CO-WC-MW-20 are assumed to be limited to a depth of 20 feet.

Ideally, drilling will be accomplished using 4¼-in ID hollow-stem augers with a continuous sample barrel. Conditions may dictate switching to 6 1/4-inch ID hollow-stem augers with a continuous sample barrel. Conditions may also warrant converting the drilling rig to air-percussion. Historical drilling methods deployed for previous monitoring well installations indicate that air-percussion was performed. The size of the materials encountered during drilling will dictate which drilling equipment is most ideal. The field geologist will note in the field logbook soil characteristics, when changes in soil type occur, and when groundwater is first encountered in order to prepare lithologic logs of each borehole.

A 1-foot thick layer of 20-40 Colorado Silica sand will be poured into the borehole prior to casing placement (1-foot padding). Well casing will consist of 2-inch nominal diameter PVC pipe. The well screens will be continuous slot, wire wound, non-clogging type screen, and will be 10 feet in length. The boring will be sufficiently deep to accommodate the 1-foot padding, 10 feet of screen, and at a minimum, 7 feet of solid PVC casing below ground surface (bgs). The well screen will be sealed at the bottom

with a solid cap. Solid casing attached to the top of the screen will be of sufficient length to extend approximately 3 ft above the ground surface. Casing components will attach via flush threaded joints, or PVC collars, without the use of glues.

Well completion following casing placement consists of installing the filter pack, bentonite pellet plug, grout seal, and protective steel casing with locking cap. The filter pack, and bentonite seal, will be placed by pouring down the annular space between the augers and well casing. The remaining annular space will be grouted to the surface. The top of the filter pack will be approximately 2 feet above the top of the well screen. A 2-foot thick bentonite plug will be place above the filter pack using 3/8-inch bentonite pellets. The pellets will be allowed to hydrate for 2 hours before sealing the well with grout. The well will be filled with enough grout (cement with 2% - 5% bentonite by volume) to fill the annular space surrounding the well casing to the ground surface. A 4-inch square by 5-foot long steel protective casing equipped with locking cap should be placed into the grout to a depth of approximately 2 feet bgs. Due to concerns over the potential for frost heave, a well pad will be constructed using crushed gravel. The well pad will be approximately 4 feet in diameter, up to 3-inches thick adjacent to the well, and will gently slope away from the well. The field geologist will calculate the estimated quantity of materials needed for each well in the field logbook and record actual quantities used.

Drilling and completion of the four to five monitoring wells will require approximately 1 day of mobilization and 2 days of fieldwork. Well development will be accomplished before bentonite seal and grout are placed in the wells with a portable groundwater pump.

2.2 Soil Sampling

One or two boreholes will be drilled through the tailings pile to approximately 5 feet below the bottom of the tailings, in to native soil, to determine its depth. Borehole drilling will be concurrent, and cost included, with drilling the four to five groundwater-monitoring wells. Up to six samples of the tailings material will be collected from the tailings pile for chemical analyses. One or two soil samples will be collected at total depth, in native soil, for chemical analysis. Soil samples will be collected using a 4 ½ auger with a continuous sampler. The samples of the tailings pile will be obtained from near the top, approximate middle, and approximate bottom of the boring. The exact thickness of the tailings pile is not know, but is estimated to be 15 to 20 feet thick at its highest point; therefore, samples will be collected at approximately 10-foot intervals. Samples will be collected at approximately 1, 10 and 20 feet bgs for tailings, and at approximately 25 feet bgs for native soil. Upon completion of the boring, the four sample intervals will be retained and submitted for analyses. The remaining cuttings from the borehole will be containerized in drums provided by the Willow Creek Restoration Committee. Samples collected for analysis will be stored in the appropriately sized laboratory cleaned glass jars. Collection depth and sampling location coordinates obtained from a hand-held GPS device, with approximate accuracy of ±20 feet, will be recorded in the field logbook. Borehole abandonment will include plugging and grouting of the borehole with neat cement amended with 2% – 5% bentonite (by volume) and will

occur concurrent, and cost included, with completion of the monitoring wells. Abandonment will be preformed by placing a bentonite pellet plug from total depth of the borehole to a least 2 feet above the surface of the native soil, and into the tailings pile. Bentonite pellets will be placed in the borehole through the center of the hollow-stem auger in order to maintain borehole integrity and minimize cave-in. The hollow-stem auger will be incrementally lifted to allow the bentonite pellets to fill in the borehole. The pellets will be hydrated in 2-foot increments until appropriate thickness of the plug is placed at bottom of the borehole. Under no circumstance will the borehole(s) be advance to depth that encounters groundwater. In the unlikely event that groundwater is encountered, drilling will be stopped immediately and the borehole will be abandoned as described above. However, groundwater is expected to be lower than borehole total depth. Historical water table data indicate that groundwater levels are lowest during winter months and to the east of Willow Creek. Table 2.1 below includes groundwater elevation data collected on 11/15/2001 and 4/24/2002.

Table 2.1 MONITORING WELL DATA

Well ID	Coordinates		Well Elevation (in feet)	Well Casing Standpipe Length	Historical Groundwater Depths (in feet)	
	Northing	Easting			Spring 2002	Fall 2001
MW1	4188119.670	332063.001	8616.265	Unknown	21.2	20.3
MW2	4188833.768	331680.472	8657.605	Unknown	12.05	14.8
MW3	4188612.161	331312.807	8652.747	Unknown	5.3	5.3
MW5	4189118.920	331317.488	8681.643	1.6	4.2	6.85
MW6	4189276.587	331296.945	8692.163	1.4	Dry	Dry
MW7	4189300.679	331161.933	8698.722	1.5	7.3	7.87
MW8	4189384.654	331184.927	8697.023	1.5	2.6	2.8
MW9	4189556.154	331078.995	8718.465	1.6	5.9	6
MW10	4189545.859	331028.133	8714.224	1.45	2.05	2.19
MW11	4189697.661	330980.669	8728.557	1.5	5.05	5.27
MW12	4189800.085	330869.110	8733.356	1.5	2.5	0.67
MW13	4190000.896	330732.788	8748.614	1.5	1.8	2.11
MW14	4190132.107	330771.897	8758.389	1.5	1.4	2.35
MW15	4190276.992	330832.974	8768.682	1.5	4.75	5.58

Note: Groundwater depths were determined by subtracting the standpipe length from recorded groundwater depth, and therefore, represent groundwater depths (in feet) from ground surface

Based on the available data, groundwater appears to be shallow near Willow Creek and deeper towards the tailings pile (to the east). The borehole location will be placed at the south end of the tailings pile and as far east as possible to minimize to the possibility of encountering groundwater during drilling. In addition, the existing monitoring wells will be sounded to determine current groundwater depth. If groundwater appear shallower than expected, a decision will be made in the field concerning the borehole location and depth.

Soil sample preservation, holding time, and required containers are given in the Table 2.2.

Table 2.2
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES
SOIL SAMPLES

Parameter	Container	Preservation	Maximum Holding Times	
			Extraction	Analysis
Soil Waste Pile Sample*				
Metals	1 x 8 oz Glass	Ice to 4^0C	6 months (Mercury - 28 days)	6 months (Mercury - 28 days)
Water Leachate**				
Leachate metals			6 months (Mercury - 28 days)	6 months (Mercury - 28 days)
Leachate pH				ASAP***
Leachate Acid concentration				ASAP***
Conductivity				ASAP***

* One 8 oz jar obtained in the field from each area is sufficient for all analyses.
** The water leachate process is performed in the laboratory.
*** ASAP in this instance means as soon as possible after leachate is obtained

2.3 Groundwater Sampling

One round of groundwater sampling will occur approximately 2 weeks following well development. Groundwater sampling is estimated at 1 day for mobilization, 1-2 days for sampling, and 1 day for demobilization. Depth to water will be measured and recorded prior to well purging. Three well volumes will be purged using a portable submersible pump. Field parameters including pH, specific conductance, temperature, oxidation-reduction potential, dissolved oxygen, and turbidity will be measured. Field parameters must stabilize prior to sample collection. Stabilization is attained when measured values of temperature, specific conductance, oxidation-reduction potential, and turbidity are within 5%, and pH is within 0.2 units, over three consecutive readings. A peristaltic geopump with a 0.45-micron in-line filter will be used to field filter all samples for dissolved metals analyses, and filtering will be done before preservation. All samples will be appropriately preserved in the field (nitric acid to a pH of <2). Personnel collecting groundwater samples will wear personal protective equipment (PPE) gloves. Groundwater samples will be collected directly into the sample container.

Groundwater sample preservation, holding time, and required containers are given in the Table 2.3.

Table 2.3
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR WATER SAMPLES

Parameter	Container	Preservation	Maximum Holding Times:	
			Extraction	Analysis
Dissolved Metals	500 ml Plastic	Field filtered, Nitric, Acid to pH of <2, and ; Iced to 4^0C	NA	6 months (Mercury - 28 days)
Total Metals	500 ml Plastic	Nitric Acid to pH <2 and Iced to 4^0C	NA	6 months (Mercury - 28 days)
Alkalinity	500 ml Plastic	Ice to 4^0C	NA	14 days
Sulfate			NA	28 days
Chloride			NA	28 days

1 One 500 ml container is sufficient for Sulfate, Chloride, and Alkalinity analysis.
2 NA = Not Applicable

2.4 Sample Labeling

Sample containers will be labeled according to the General RAMS Work Plan. The Laboratory Identification Management System (LIMS) number is **LIMS#** 6704. The sample identification (ID) scheme presented in SOP A13 will use the following designations:

- **CO** for Colorado RAMS (replaces UU project designation)
- **WC** for Willow Creek (replaces VVVV designation)
- **SB** designates soil boring sample
- **MW** designates groundwater samples collected from a monitoring well
- Leading number indicates sampling location (**16 – 20** designates monitoring wells, **1 - 2** designates tailings pile boreholes)
- Trailing number identifies the depth that samples were collected in feet

An example label for a soil sample collected at 5 feet bgs from the tailings pile borehole is:

CO-WC-SB01-5

An example QC duplicate sample label could have the identification label of (sample depth is fictitious):

CO-WC-SB01-7

An example identification label for a groundwater sample collected from WC-MW-20 is:

CO-WC-MW20

An example QC duplicate sample label could have the identification label of (monitoring well ID is fictitious):

CO-WC-MW22

2.5 Sample Shipping

Sample containers will be custody-sealed, and double-packed in sealed plastic bags. Samples may be accumulated for up to 5 working days and shipped weekly to the laboratory in a batch. Samples will be packed in a picnic-type cooler for shipping and cooled to 4 degrees Celsius immediately following collection. Bubble bags or pre-cut foam blocks will provide cushioning and secure the samples during shipment. Absorbent materials will be placed in the bottom of the cooler to contain spills from samples broken during shipping. Ice or blue-ice-packs used for cooling will be bagged to contain melt water and condensation. Chain-of-custody documents will be sealed in waterproof bags and included in the shipping cooler. The shipping cooler will be sealed and secured prior to being relinquished to the transport company. The cooler will be shipped by FedEx or UPS overnight mail or carried directly to the laboratory at the following address:

US Army Corps of Engineers
Environmental Chemistry Branch (ECB) Laboratory
ATTN: WES-EE-Q (Sample Custodian)
420 South 18th Street
Omaha, NE 68102
Telephone: (402) 444-4314.

The shipping cooler and its contents will be inspected and inventoried upon receipt at the analytical laboratory. The temperature and condition of the samples will be documented upon receipt. The analytical laboratory will contact the Field Geologist immediately if there are any discrepancies in the shipment documentation and provide sample receipt documentation with their analysis report.

3.0 SAMPLE ANALYSIS

Four to five groundwater samples and three to six soil samples, along with required Quality Control (QC) samples, will be obtained for chemical analysis for this project. The USACE Environmental Chemistry Branch (ECB) Laboratory will perform sample analyses. Soil samples will be analyzed using the CDMG procedure to test for the presence of metals and analysis for pH, acidity, and conductivity. Groundwater samples will be analyzed for total metals, dissolved metals, alkalinity, chloride, and sulfate. **Tables 3.1 and 3.2** summarizes methods used to analyze groundwater and soil samples from the Willow Creek site:

Table 3.1
GROUNDWATER SAMPLE ANALYSIS METHODS

Parameter	Matrix	Method
Total and Dissolved Metals*	water	EPA Method 3005/6010B
Alkalinity	water	EPA Method 310.2
Chloride	water	EPA Method 325.2
Sulfate	water	EPA Method 375.2

- Al, Ca, Cd, Cu, Fe, Mg, Mn, Pb, Zn

Table 3.2
MINING WASTE SAMPLE ANALYSIS METHODS

Parameter	Matrix	Method
Metals*	Soil	EPA Method 3500/6010B
Leachate	Soil	Colo DMG Procedure**
Metals*	Leachate water	EPA Method 3005/6010B
PH	Leachate water	USDA 8C
Acidity	Leachate water	EPA Method 305.1
Conductivity	Leachate water	EPA Method 375.2/9050A

* Al, Ca, Cd, Cu, Fe, Mg, Mn, Pb, Zn

** This extraction consists of combining a 2 : 1 mixture of deionized water and solid, and let set for a set period time. The filtered extract is then analyzed for metals.
The deionized water leachate is collected as follows: 150 mL (dry volume) of the prescreened soil is placed in a 1-liter plastic beaker along with 300 mL of deionized water. This is vigorously mixed for 15 seconds; the top is wrapped in plastic, then let settle for 90 minutes. This time is the time it will generally take for the soils fraction to settle out. The liquid is then filtered through a fine grade soil filter (approximately 2 micron). A portion of the liquid is analyzed for total acidity, pH, and specific conductance. The remaining liquid sample is acidified with nitric acid and analyzed for selected total metals.

Data quality objectives are based on those given in the RAMS General Work Plan. The analytical results will be used to gain information about the extent of metals loading from various mine sites into the associated drainage basin. The criteria in order to attain these goals are given in the General Work Plan, 2002, and/or given in this section. The Method Detection Limit (MDL), Method Reporting Limit (MRL), and QC criteria that will meet the data objectives for metals are given in Tables 6-5 and 6-6 of the RAMS General Work Plan, 2002. The MDL, MRL, and QC criteria that will meet the data objectives for Alkalinity, Chloride and Sulfate are given in Table 6-7 of the General Work Plan, 2002.

4.0 SAFETY REQUIREMENTS

Information on health and safety issues is located in the RAMS Site Safety and Health Plan (SSHP), July 2002. A Modified Level D will be used for Personal Protection Equipment (PPE). Required PPE will consist of steel-toed, steel-shank safety boots and hard-hat. Safety glasses and latex or nitrile gloves will be worn during sample collection.

5.0 QUALITY CONTROL REVIEW

QC review requires evaluation of field and analytical procedures and review of data to ensure QC compliance was met.

5.1 Field Quality Control

The project team will review all documentation in field logbooks for completeness. A review of the placement or coordinates of each sample will be performed to ensure that this correlates to sample nomenclature. Placement and frequency of the QC samples will be reviewed to ensure compliance to set criteria.

5.2 Laboratory Quality Control

Upon completion of soil and groundwater analyses, the analyst will calculate the final sample results and associated QC results from the raw data. The analyst will review all raw data for any peaks that appear suspect or have any effect on the data. The analyst will review all analytical instrument parameters such as internal standards, retention times, and controls to ensure compliance. The analyst will also review accuracy of equations, including units, and also QC results for the analytical batch. Another laboratory person will perform a second data and instrument review. This will give a check on instrument performance, interpretation, and calculation of the data results. Before the data package is released, the Quality Control Officer of the lab will perform a third level of review to ensure complete data accuracy and compliance. The three levels of laboratory review of the data package will be performed on 100% of the data. Receiving temperature of the samples, holding times, and a complete case narrative of the QC will be submitted with each data package.

5.3 Data Evaluation

The project chemist will make a separate review of a portion of the data package obtained from the laboratory. This will include a review of the Case Narrative that is included in the data package. If noted deficiencies are not encountered, it can be assumed that the data package, as obtained from the laboratory, is of sufficient quality to perform batch validation. The batch data evaluation will be performed on 100% of the data packages obtained from the laboratory. The National Functional Guidelines will provide evaluation guidance. Parameters and QC results used in the validation are:

- Holding times
- Sample temperatures during shipment and before analysis

- Blanks (trip and method)
- LCS
- MS/MSD
- Surrogates

Data evaluation consists of comparing the above six items, along with other checks as given in section 5.7 of the General Work Plan, 2002, to set project criteria and flag data values accordingly. The evaluation will include sample holding times and shipment and holding temperatures and any noncompliance. Also included in the evaluation are results from batch blank and spike sample analyses and whether they meet set criteria. Data tables will be produced for all analytical data along with resulting data qualification flags.

6.0 REPORT REQUIREMENTS

The report documenting this field effort will consist of the following:

- Summary of field activities
- Map of sampling locations
- Table of monitoring well location coordinates and measured field parameters
- Monitoring well detail schematics
- Table of analytical results and applicable state groundwater standards
- Summary of data quality based on data evaluation

Recommendations for any future investigations

7.0 REFERENCES

2002, United States Army Corp of Engineers Omaha District, Restoration of Abandoned Mine Sites General Work Plan.

2002, United States Army Corps of Engineers Albuquerque District, Site Safety and Health Plan - Colorado Restoration of Abandoned Mines (RAMS) Project
Drilling of Soil Borings, Monitoring Well Installation and Development
Soil and Groundwater Sampling
Global Positioning Satellite (GPS) surface water monitoring,
Installation of mechanical, hydrogeologic and climatic instrumentation
Conduct topographic and geophysical surveys
Various sites throughout Colorado