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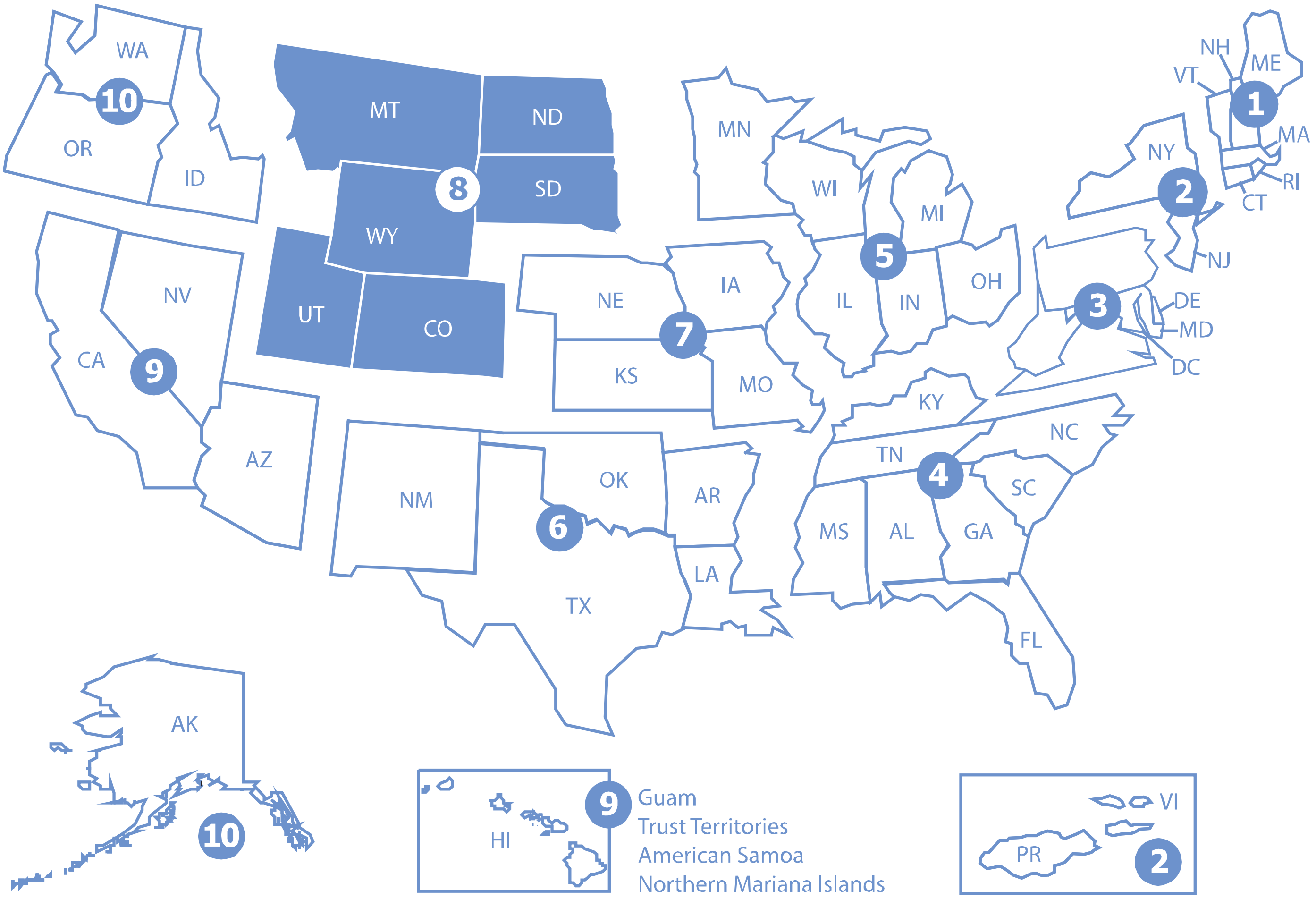
Office of Solid Waste and Emergency Response

Support Document for the Revised National Priorities List Final Rule – Colorado Smelter



Support Document for the Revised National Priorities List Final Rule

Colorado Smelter

December 2014

Site Assessment and Remedy Decisions Branch
Office of Superfund Remediation and Technology Innovation
Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

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Executive Summary

Section 105(a)(8)(B) of CERCLA, as amended by SARA, requires that the EPA prepare a list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States. An original National Priorities List (NPL) was promulgated on September 8, 1983 (48 FR 40658). CERCLA requires that EPA update the list at least annually.

This document provides responses to public comments received on the Colorado Smelter site, proposed on May 12, 2014 (79 FR 26922). This site is being added to the NPL based on an evaluation under EPA's Hazard Ranking System (HRS) in a final rule published in the *Federal Register* in September 2014.

Introduction

This document explains the rationale for adding the Colorado Smelter site in Pueblo, Colorado to the National Priorities List (NPL) of uncontrolled hazardous waste sites and provides responses to public comments received on this site listing proposal. The EPA proposed this site to the NPL on May 12, 2014 (79 FR 26922). This site is being added to the NPL based on an evaluation under the Hazard Ranking System (HRS) in a final rule published in the *Federal Register* in December 2014.

Background of the NPL

In 1980, Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. Sections 9601 *et seq*. in response to the dangers of uncontrolled hazardous waste sites. CERCLA was amended on October 17, 1986, by the Superfund Amendments and Reauthorization Act (SARA), Public Law No. 99-499, stat., 1613 *et seq*. To implement CERCLA, EPA promulgated the revised National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300, on July 16, 1982 (47 FR 31180), pursuant to CERCLA Section 105 and Executive Order 12316 (46 FR 42237, August 20, 1981). The NCP, further revised by EPA on September 16, 1985 (50 FR 37624) and November 20, 1985 (50 FR 47912), sets forth guidelines and procedures needed to respond under CERCLA to releases and threatened releases of hazardous substances, pollutants, or contaminants. On March 8, 1990 (55 FR 8666), EPA further revised the NCP in response to SARA.

Section 105(a)(8)(A) of CERCLA, as amended by SARA, requires that the NCP include

> criteria for determining priorities among releases or threatened releases throughout the United States for the purpose of taking remedial action and, to the extent practicable, take into account the potential urgency of such action, for the purpose of taking removal action.

Removal action involves cleanup or other actions that are taken in response to emergency conditions or on a short-term or temporary basis (CERCLA Section 101). Remedial action is generally long-term in nature and involves response actions that are consistent with a permanent remedy for a release (CERCLA Section 101). Criteria for placing sites on the NPL, which makes them eligible for remedial actions financed by the Trust Fund established under CERCLA, were included in the HRS. EPA promulgated the HRS as Appendix A of the NCP (47 FR 31219, July 16, 1982). On December 14, 1990 (56 FR 51532), EPA promulgated revisions to the HRS in response to SARA, and established the effective date for the HRS revisions as March 15, 1991.

Section 105(a)(8)(B) of CERCLA, as amended, requires that the statutory criteria provided by the HRS be used to prepare a list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States. The list, which is Appendix B of the NCP, is the NPL.

An original NPL of 406 sites was promulgated on September 8, 1983 (48 FR 40658). At that time, an HRS score of 28.5 was established as the cutoff for listing because it yielded an initial NPL of at least 400 sites, as suggested by CERCLA. The NPL has been expanded several times since then, most recently on September 22, 2014 (79 FR 56515). The Agency also has published a number of proposed rulemakings to add sites to the NPL. The most recent proposal was on September 22, 2014 (79 FR 56538).

Development of the NPL

The primary purpose of the NPL is stated in the legislative history of CERCLA (Report of the Committee on Environment and Public Works, Senate Report No. 96-848, 96th Cong., 2d Sess. 60 [1980]).

> The priority list serves primarily informational purposes, identifying for the States and the public those facilities and sites or other releases which appear to warrant remedial actions. Inclusion of a facility or site on the list does not in itself reflect a judgment of the activities of its owner or operator, it does not require those persons to undertake any action, nor does it assign liability to any person. Subsequent government actions will be necessary in order to do so, and these actions will be attended by all appropriate procedural safeguards.

The NPL, therefore, is primarily an informational and management tool. The identification of a site for the NPL is intended primarily to guide EPA in determining which sites warrant further investigation to assess the nature and extent of the human health and environmental risks associated with the site and to determine what CERCLA-financed remedial action(s), if any, may be appropriate. The NPL also serves to notify the public of sites EPA believes warrant further investigation. Finally, listing a site may, to the extent potentially responsible parties are identifiable at the time of listing, serve as notice to such parties that the Agency may initiate CERCLA-financed remedial action.

CERCLA Section 105(a)(8)(B) directs EPA to list priority sites among the known releases or threatened release of hazardous substances, pollutants, or contaminants, and Section 105(a)(8)(A) directs EPA to consider certain enumerated and other appropriate factors in doing so. Thus, as a matter of policy, EPA has the discretion not to use CERCLA to respond to certain types of releases. Where other authorities exist, placing sites on the NPL for possible remedial action under CERCLA may not be appropriate. Therefore, EPA has chosen not to place certain types of sites on the NPL even though CERCLA does not exclude such action. If, however, the Agency later determines that sites not listed as a matter of policy are not being properly responded to, the Agency may consider placing them on the NPL.

Hazard Ranking System

The HRS is the principle mechanism EPA uses to place uncontrolled waste sites on the NPL. It is a numerically based screening system that uses information from initial, limited investigations—the preliminary assessment and site inspection—to assess the relative potential of sites to pose a threat to human health or the environment. HRS scores, however, do not determine the sequence in which EPA funds remedial response actions, because the information collected to develop HRS scores is not sufficient in itself to determine either the extent of contamination or the appropriate response for a particular site. Moreover, the sites with the highest scores do not necessarily come to the Agency's attention first, so that addressing sites strictly on the basis of ranking would in some cases require stopping work at sites where it was already underway. Thus, EPA relies on further, more detailed studies in the remedial investigation/feasibility study that typically follows listing.

The HRS uses a structured value analysis approach to scoring sites. This approach assigns numerical values to factors that relate to or indicate risk, based on conditions at the site. The factors are grouped into three categories. Each category has a maximum value. The categories are:

- likelihood that a site has released or has the potential to release hazardous substances into the environment;
- characteristics of the waste (toxicity and waste quantity); and
- people or sensitive environments (targets) affected by the release.

Under the HRS, four pathways can be scored for one or more threats as identified below:

- Ground Water Migration (S_{gw})
  - drinking water

- Surface Water Migration (S_{sw})
  The following threats are evaluated for two separate migration components, overland/flood migration and ground water to surface water.
  - drinking water
  - human food chain
  - sensitive environments

- Soil Exposure (S_s)
  - resident population
  - nearby population
  - sensitive environments

- Air Migration (S_a)
  - population
  - sensitive environments

After scores are calculated for one or more pathways according to prescribed guidelines, they are combined using the following root-mean-square equation to determine the overall site score (S), which ranges from 0 to 100**:**

$$S = \sqrt{\frac{S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2}{4}}$$

If all pathway scores are low, the HRS score is low. However, the HRS score can be relatively high even if only one pathway score is high. This is an important requirement for HRS scoring because some extremely dangerous sites pose threats through only one pathway. For example, buried leaking drums of hazardous substances can contaminate drinking water wells, but—if the drums are buried deep enough and the substances not very volatile—not surface water or air.

Other Mechanisms for Listing

There are two mechanisms other than the HRS by which sites can be placed on the NPL. The first of these mechanisms, authorized by the NCP at 40 CFR 300.425(c)(2), allows each State and Territory to designate one site as its highest priority regardless of score. The last mechanism, authorized by the NCP at 40 CFR 300.425(c)(3), allows listing a site if it meets the following three requirements:

- Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Public Health Service has issued a health advisory that recommends dissociation of individuals from the release;
- EPA determines the site poses a significant threat to public health; and
- EPA anticipates it will be more cost-effective to use its remedial authority than to use its emergency removal authority to respond to the site.

Organization of this Document

The following section contains EPA responses to site-specific public comments received on the proposal of the Colorado Smelter site on May 12, 2014 (79 FR 26922). The site discussion begins with a list of commenters, followed by a site description, a summary of comments, and Agency responses to each comment. A concluding statement indicates the effect of the comments on the HRS score for the site.

Glossary

The following acronyms and abbreviations are used throughout the text:

%	Percent
Agency	U.S. Environmental Protection Agency
AMC	Anaconda Minerals Company
AOC	Area of Observed Contamination
ARR	Analytical Results Report
ASARCO	American Smelting and Refining Company
ATSDR	Agency for Toxic Substances and Disease Registry
BLL	Blood Lead Level
CDC	Center for Disease Control and Prevention
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. Sections 9601 *et seq.*, also known as Superfund
CF&I	Colorado Fuel and Iron Company
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CRP	Community Relations Plan
CSM	Conceptual Site Model
DQA	Data Quality Assessment
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
FR	Federal Register
HRS	Hazard Ranking System, Appendix A of the NCP
HRS score	Overall site score calculated using the Hazard Ranking System; ranges from 0 to 100
µg	Microgram
µg/dl	Microgram per deciliter
mg/kg	Milligram per kilogram
NCP	National Oil and Hazardous Substances Pollution Contingency Plan, 40 C.F.R. Part 300
NPL	National Priorities List, Appendix B of the NCP
PPM	Parts per million
PA	Preliminary Assessment
QAPP	Quality Assurance Project Plan

RCRA	Resource Conservation and Recovery Act
Ref.	Reference
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SOP	Standard Operating Procedure
SQL	Sample Quantitation Limit
START	Superfund Technical Assessment and Response Team
SWMU	Solid Waste Management Unit
TSOP	Technical Standard Operating Procedure
UOS	URS Operating Services
USGS	United States Geological Survey
VA	United States Department of Veterans Affairs
XRF	X-ray Fluorescence

1. List of Commenters and Correspondence

EPA-HQ-SFUND-2014-0318-0004	Correspondence, dated January 21, 2014, from the Honorable John W. Hickenlooper, Governor of the State of Colorado to Shaun McGrath, Regional Administrator, U.S. EPA Region 8.
EPA-HQ-SFUND-2014-0318-0005	Correspondence, dated June 11, 2012, from the James B. Martin, Regional Administrator, U.S. EPA Region 8 to the Honorable John W. Hickenlooper, Governor of the State of Colorado.
EPA-HQ-SFUND-2014-0318-0006	Comment, submitted May 14, 2014, from an anonymous commenter.
EPA-HQ-SFUND-2014-0318-0007	Comment, submitted May 19, 2014, from an anonymous commenter.
EPA-HQ-SFUND-2014-0318-0008	Comment, submitted June 13, 2014, from an anonymous commenter.
EPA-HQ-SFUND-2014-0318-0009	Comment, submitted July 8, 2014, from Matt Reed, Conservation Programs Coordinator, Sierra Club, Rocky Mountain Chapter.
EPA-HQ-SFUND-2014-0318-0010	Comment, submitted July 9, 2014, from Joe Kocman and Pam Kocman.
	Comment attachment, dated January 21, 2014, Correspondence from Governor John W. Hickenlooper, Colorado to Shaun McGrath, Regional Administrator, U.S. EPA Region 8.
	Comment attachment, submitted July 9, 2014, Guidelines for the Superfund Designation "Letter to the Governor."
	Comment attachment, January 10, 2014, Correspondence from Sandra K. Daff (Pueblo City Councilwoman), Pam Kocman (Eiler Heights Neighborhood Association), and David C. Balsick (Bessemer Association for Neighborhood Development) to the Honorable John W. Hickenlooper, Governor of the State of Colorado.
	Comment attachment, December 31, 2013, Correspondence from the City Council, City of Pueblo, Colorado and the Board of County Commissioners, Pueblo County, Colorado, to the Honorable John W. Hickenlooper, Governor of the State of Colorado.
EPA-HQ-SFUND-2014-0318-0011	Comment, submitted July 9, 2014, from Joe Kocman and Pam Kocman.
EPA-HQ-SFUND-2014-0318-0012	Comment, submitted July 9, 2014, from Joe Kocman and Pam Kocman.

EPA-HQ-SFUND-2014-0318-0013	Comment, submitted July 9, 2014, from Joe Kocman and Pam Kocman.
EPA-HQ-SFUND-2014-0318-0014	Comment, submitted July 10, 2014, from Joe Kocman and Pam Kocman.
EPA-HQ-SFUND-2014-0318-0015	Comment, dated July 10, 2014, from Eileen Dennis (Board President, Terry A. Heart (Board Member), Michael J. Nerenberg (Board Member), Donald Moore (Board Member), Pueblo City-County Health Department Board of Health.
EPA-HQ-SFUND-2014-0318-0016	Comment, dated July 13, 2014, from Velma Campbell, MD, MPH.
EPA-HQ-SFUND-2014-0318-0017	Comment, dated July 8, 2014, from Terry A. Hart, Commissioner, Board of County Commissioners.
EPA-HQ-SFUND-2014-0318-0018	Comment, dated July 11, 2014, from Ross Vincent, Chair, Sierra Club, Sangre de Cristo Group.
EPA-HQ-SFUND-2014-0318-0019	Comment, dated July 11, 2014, from Pam, Don, and Joshua DiFatta.
EPA-HQ-SFUND-2014-0318-0020	Comment, dated July 11, 2014, from Merril Coomes, including four figures[1] and three tables.
	Comment attachment, U.S. EPA, SOP #SRC-OGDEN-02 Surface Soil Sampling.
	Comment attachment, Discussion of Particulate Deposition and Soil Lead Concentration Distribution at the Historic Colorado Smelter Site.
	Comment attachment, Colorado Background Soil Lead.
	Comment attachment, EPA Region 8 Conceptual Site Model for Historic Smelters.
	Comment attachment, Analysis of lead concentration vs. Distance from the Historic Colorado Smelter Site.

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[1] Note that the figures attached to Mr. Coomes' comment submittal are subject to restricted access via Regulations.gov (the website providing public users ease of access to federal regulatory content and a way to submit comments on agencies' regulatory documents published in the Federal Register) due to inclusion of Google Maps-related copyrighted data. The document can instead be viewed at the USEPA Docket Center (Public Reading Room. Address: USEPA West 1301 Constitution Ave, NW Room 3334 Washington, DC 20004 Telephone: 202-566-1744 Fax: 566-9744 Email: docket-customerservice@epa.gov), or at the EPA Region 8 docket (contact information for the EPA Region 8 docket: Sabrina Forrest, Region 8, U.S. EPA, 1595 Wynkoop Street, Mailcode 8EPR-B, Denver, CO 80202-1129; 303/312-6484).

Comment attachment, Soil Remediation may not Reduce Child Blood Lead Levels.

2. Site Description

The Colorado Smelter site (the Site) as identified in the HRS documentation record at proposal includes three areas or sources of contamination: (1) an area of observed contamination (AOC) in residential soils referred to as AOC A; (2) residual slag material that remains on-site referred to as AOC B; and (3) historic smelter stacks that emitted particulates that were dispersed to areas surrounding the Site resulting in contamination of the soil in the neighborhoods located nearby. AOC A involves 176 residences scored as subject to Level I or Level II concentrations. (See Figure 1 of this support document showing AOCs A and B.)

The Colorado Smelter, also known as the Boston Smelter or the Eilers Smelter, after its builder, Anton Eilers, operated from 1883 until 1908. The former smelter, located in Pueblo, Colorado, south of the Arkansas River at the south end of Santa Fe Avenue, was one of five smelters operating in the City of Pueblo and its nearby subdivisions between the 1880's and the 1920's. These included the Colorado Smelter, the Pueblo Smelter, the Philadelphia Smelter, the Massachusetts Smelter, and the Blende Smelter. (See Figure 3 of this support document for these smelter locations.)

The Colorado Smelter facility components changed over the course of its operation. The Colorado Smelter facility included a blast furnace building that measured 127 feet long, 45 feet wide, and 39 feet high, and housed 4 water-jacketed blast furnaces with a melting capacity of 168 tons of ore per day. Historical maps, including official city maps and Sanborn Fire Insurance maps, show the location of the Colorado Smelter and other smelters in Pueblo. Comparison of Sanborn Maps of 1889 and 1904/05 reveals the smelter underwent considerable expansion to the south to Mesa Avenue with the addition of several roaster houses and a 200-foot-tall brick chimney and two 125-foot-tall chimneys in the southern part of the facility. The further addition of two more blast furnaces by 1904/05 increased the capacity of the smelter by fifty percent. Historical photographs of the Colorado Smelter show the smelter building and smoke stacks with smoke plumes drifting southeast. Some of the slag generated by the smelter was removed and used as track ballast, although significant amounts of slag remain at the property. In 1923, the smelter stack was demolished and some of the bricks were used to build a school. At present, there are remnants of destroyed buildings and large slag piles at the Colorado Smelter property.

Several previous investigations have been performed at the Colorado Smelter and at nearby locations by the Colorado Department of Public Health and Environment (CDPHE) and the United States Environmental Protection Agency (EPA) including an investigation that was conducted at the Santa Fe Street Bridge, adjacent to and north of the Colorado Smelter facility. CDPHE performed the first sampling event for the Santa Fe Avenue Bridge Culvert/Colorado Smelter on April 14, 1992. A sample of the slag pile, SF-SS-3, was found to contain lead at a concentration of 1,950 milligrams per kilogram (mg/kg) (equivalent to parts per million [ppm]). Two residential soil samples collected near the smelter, samples SF-SO-02 and SF-SO-03, contained lead at concentrations of 239 and 336 mg/kg, respectively. Other investigations included a more geographically extensive sampling by CDPHE in September 1994; an in-situ X-ray Fluorescence (XRF)[2] screening investigation of the Colorado Smelter facility performed by the EPA on May 10, 1995; a detailed investigation of the Colorado Smelter slag pile performed by the EPA on August 17 and18, 1995; and a preliminary assessment (PA) report prepared by CDPHE in 2008.[3]

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[2] XRF is an instrumental analytical technique used to determine the elemental composition of a sample by bombarding a sample with X-rays and measuring the fluoresced X-rays characteristic to each element.

[3] See the following references of the HRS documentation record at proposal: Reference 14, describing results from the September 1994 investigation; Reference 15, describing results from the May 10, 1995 investigation; Reference 16, describing results from the August 17 and 18, 1995 activities; and Reference 19 for the PA report.

A study of the metal content of surface soils in Pueblo conducted by affiliates of Colorado State University was published in 2006 (also referred to in this support document as the Diawara study). A total of 68 soil samples were collected at 33 locations in a coarsely spaced grid. The average lead concentration was 88 ppm, over 5 times the average for the conterminous U.S. of 16 ppm and twice the average of 35 ppm reported for soils in the Front Range Urban Corridor of Colorado. The average arsenic concentration was 12.6 ppm, 2.4 times higher than the average of 5.2 ppm reported for the conterminous U.S., and 3.6 times higher than the average of 3.5 ppm reported for soils in the Front Range Urban Corridor.

In 2010, CDPHE prepared a Site Inspection Sampling and Analysis Plan (the CDPHE May 2010 SAP) and sampling activities were conducted June 21–23, 2010. Soil and waste sample results from this investigation were used in the HRS documentation record at proposal to establish AOC A and AOC B. Soil samples were collected from 57 locations including 47 residential properties, 3 vacant lots, 1 road right-of-way, 4 slag piles, and 2 background areas. The results of this CDPHE 2010 site inspection were detailed in a CDPHE June 2011 Analytical Results Report (ARR). Additionally, six surface water samples, including one duplicate, were collected from on-site, probable points of entry (PPE) to surface water, and the Arkansas River. Four co-located sediment samples were also collected. All surface water and sediment samples were sent to an analytical laboratory for analysis of metals through EPA's Contract Laboratory Program (CLP). The samples were submitted to ChemTech Consulting Group for analysis of total and dissolved metals by ICP-MS (ILM05.4). None of these samples, however, were submitted for XRF analysis.

The CDPHE 2010 site inspection background soil samples were collected approximately 2 miles northwest of the Colorado Smelter and outside the area likely to be impacted by emissions from the former smelter. The suitability of these samples to represent background soil levels of arsenic and lead for this site was corroborated based on: 1) correspondence with the U.S. Geological Survey (USGS) regarding naturally occurring soil metal levels; 2) the results of three background soil samples collected on September 29, 1994, for the Santa Fe Avenue Bridge Culvert ESI; and 3) the results of a 2006 study of arsenic, cadmium, lead and mercury in surface soil in Pueblo.

All of the CDPHE 2010 site inspection soil samples were collected using a multi-incremental sampling technique. Residential yards with homes were divided into one to four zones, or decision units, including the front yard, back yard, and side yards. (See Figure 2 of this support document for CDPHE 2010 site inspection soil sample locations.) The number of zones sampled per residence depended on site-specific conditions such as the size of the side yards and the extent of paved areas. In each zone, five individual aliquots[4] were collected. Based on the small lot sizes, all of the individual aliquots for all 47 residential properties' samples were collected within 200 feet of the houses. Five individual aliquots were also collected from four vacant lots or road rights-of-way, two background areas and four slag piles. All samples were collected from the top 2 inches of the ground surface. A total of 434 individual samples were collected in 1-quart plastic bags.

All of the collected soil samples were analyzed using XRF. Additionally, a subset of the soil samples were submitted for confirmatory analysis through the EPA's CLP as a quality control (QC) protocol for XRF analysis. The basis for the Colorado Smelter site score is the CLP data; specifically, CLP analytical results of individual aliquot samples.

These CLP data were used to establish an area of observed contamination (AOC A) for lead for residential soils. XRF analyses are also presented to provide additional evidence supporting the background and release sample concentrations and to provide confirmation that the area between the observed contamination sample locations, as defined by CLP aliquot samples, is contaminated. Data from this CDPHE 2010 site inspection were also used to establish an AOC for the slag pile (AOC B) based on CLP aliquot samples. (See Figure 1 of this support document depicting AOC A and AOC B.)

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[4] In this context, an aliquot is an individual sample collected for chemical analysis.

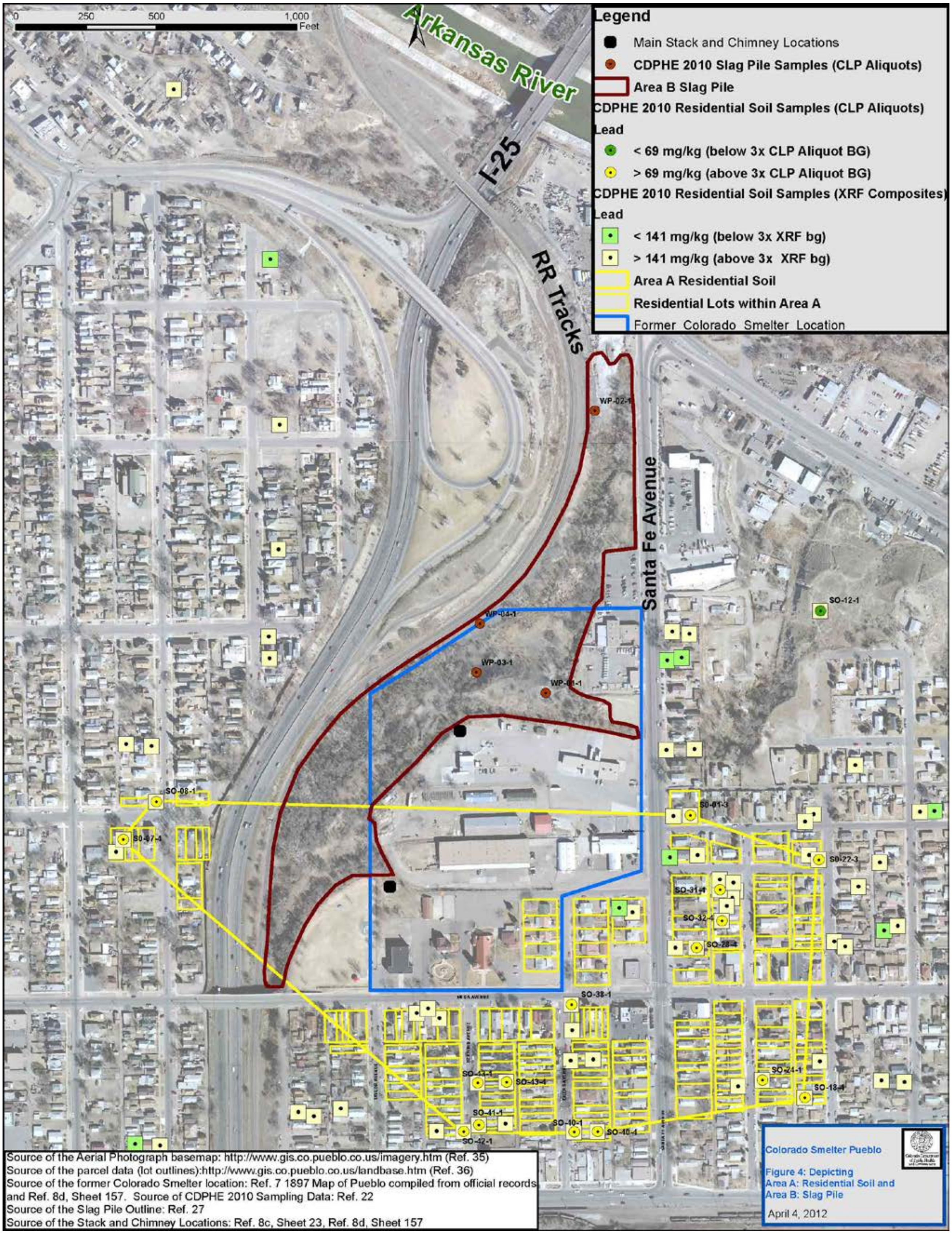
All 434 of the aliquot samples were delivered to URS Operating Services (UOS), EPA's Superfund Technical Assessment and Response Team (START) laboratory in Denver, Colorado. The samples were analyzed directly in the bags using the XRF. Subsequently, the samples were composited, dried, sieved, placed in method-specific polyethylene sample cups per EPA Method SW-846 6200 guidelines, and analyzed with XRF. The 434 aliquot samples were thus combined into 87 multi-increment samples (also known as composite samples), including 77 residential soil samples (from 47 different properties), 3 vacant lot samples, 1 road right-of-way sample, 2 background samples, and 4 source samples. In summary, a total of 521 samples, including 434 individual aliquots and 87 composites, were analyzed for metals in soil with XRF using applicable sections of EPA Method 6200.

Fifty-seven samples, representing the full range of lead concentrations of the sample set (and selected based on XRF analysis results), were submitted for confirmatory analysis through the EPA's CLP as a QC protocol for XRF analysis. Prepared composite samples (in XRF cups) were sent intact, and aliquot samples were divided evenly after homogenization and XRF analysis. Eleven composite samples and 46 aliquot samples (including 2 duplicates) for analysis under the CLP were delivered to: Sentinel, Inc., 4733 Commercial Drive, Huntsville, Alabama 35801via Federal Express. The samples were analyzed for Target Analyte List (TAL) Metals without mercury by Atomic Emission Spectroscopy-Inductively Coupled Plasma (AES-ICP), by EPA Method CLP ISM01.2.

Both CLP and XRF data were validated. And, a comparison between XRF and laboratory lead results was performed using a routine statistical regression analysis. A correlation graph for lead results in the two data sets, XRF and CLP analyses, is presented in the CDPHE June 2011 ARR and in the March 2012 Data Quality Assessment (DQA) prepared by UOS, EPA's START 3 contractor. The coefficient of correlation (r^2) value for lead was 0.869, demonstrating there is excellent correlation between the XRF and CLP lab data. Any data sets demonstrating an r^2 value of 0.85 to 1.0 is considered a definitive data quality level, meaning the sets show statistically similar results.

The HRS documentation record at proposal details that smelter stack emissions contain particulates of heavy metals, and that in the smelting process, it is not possible to separate all the desired metal from other products including slag and flue dust. Samples of the slag generated by the Colorado Smelter contain lead and arsenic, and the ore from the Madonna mine processed at the Colorado Smelter contained 30 percent lead. While the Agency could not sample flue dust samples from the Colorado Smelter, flue dust samples collected from the Anaconda Minerals Company (AMC) smelter in Montana contained arsenic and lead at concentrations up to 14,300 ppm and 55,000 ppm, respectively. Slag from the AMC smelter contained arsenic and lead at concentrations of 217 ppm and 3,120 ppm, respectively. In comparison, the average concentrations of arsenic and lead in slag for the Colorado Smelter based on 9 CLP aliquot samples are 503 and 10,333 ppm, respectively, further indicating that stack emissions from the Colorado Smelter also contained arsenic and lead.

Prevailing winds at the Colorado Smelter during the time of operation were out of the north and northwest as noted on Sanborn Fire Insurance Maps for the years 1883-1904. Wind rose diagrams from a meteorological station located just south of the Colorado Smelter on the Rocky Mountain Steel Mill for the time periods January 1, 2003 - December 31, 2005, and March 1, 2008 - February 28, 2009, show prevailing winds out of the west-northwest, supporting this general wind direction. AOC A is located within 1,800 feet of the northern (and most distant) smoke stack and within 1,663 feet of the southern (and closer) smoke stack (see Figure 1 of this support document). The proximity of the stacks to AOC A, along with the historic prevailing wind direction, provide additional evidence that at least a portion of the significant increase in lead and arsenic in AOC A is attributable to the Colorado Smelter stacks. This attribution is also corroborated by the 1995 ARR for the Santa Fe Avenue Bridge Culvert study and the study of the metal content of surface soils in Pueblo conducted by affiliates of Colorado State University and published in 2006 (the Diawara study).



Source of the Aerial Photograph basemap: http://www.gis.co.pueblo.co.us/imagery.htm (Ref. 35)
Source of the parcel data (lot outlines):http://www.gis.co.pueblo.co.us/landbase.htm (Ref. 36)
Source of the former Colorado Smelter location: Ref. 7 1897 Map of Pueblo compiled from official records and Ref. 8d, Sheet 157. Source of CDPHE 2010 Sampling Data: Ref. 22
Source of the Slag Pile Outline: Ref. 27
Source of the Stack and Chimney Locations: Ref. 8c, Sheet 23, Ref. 8d, Sheet 157

Figure 1: AOC A Residential Soil and AOC B Slag Pile.

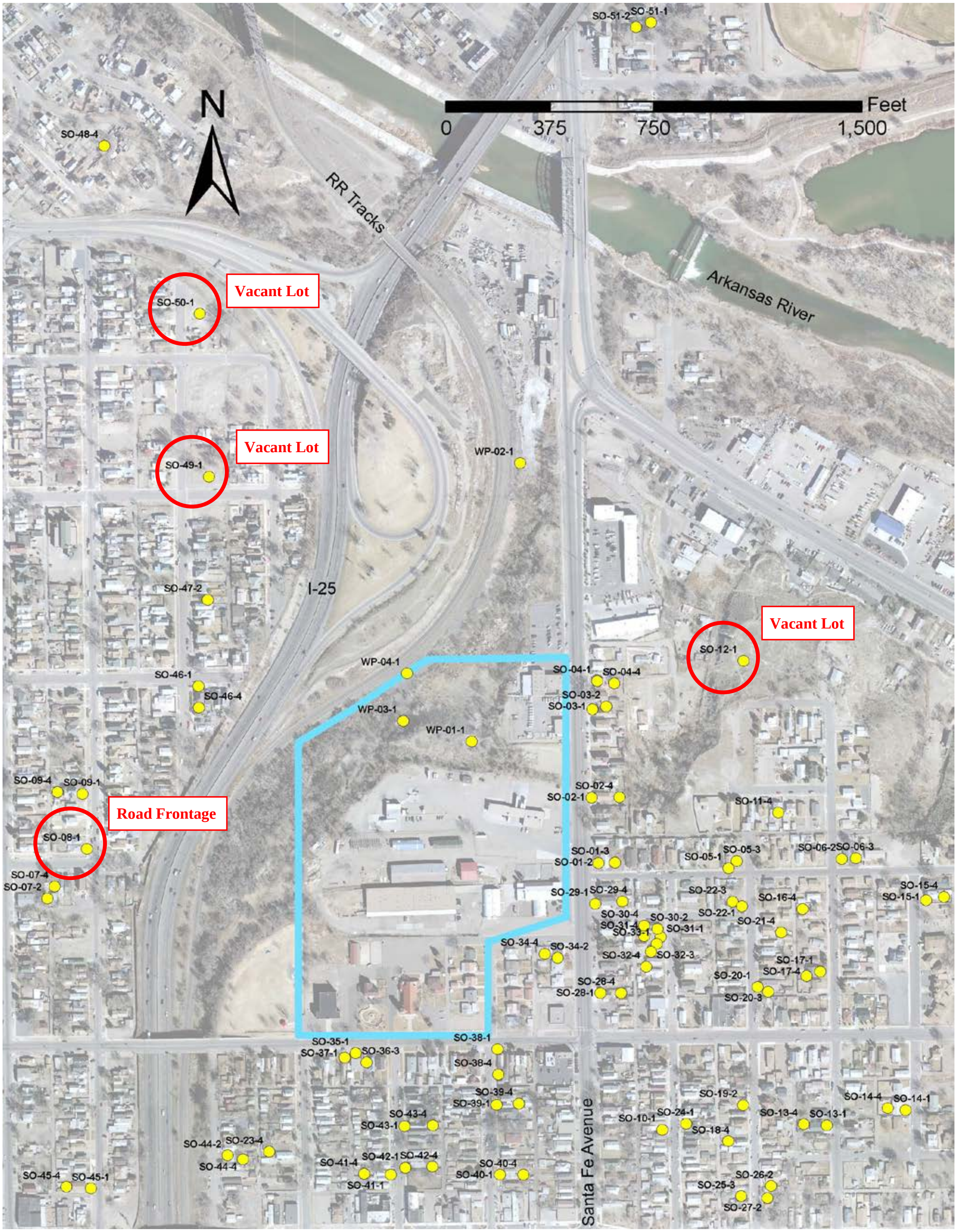
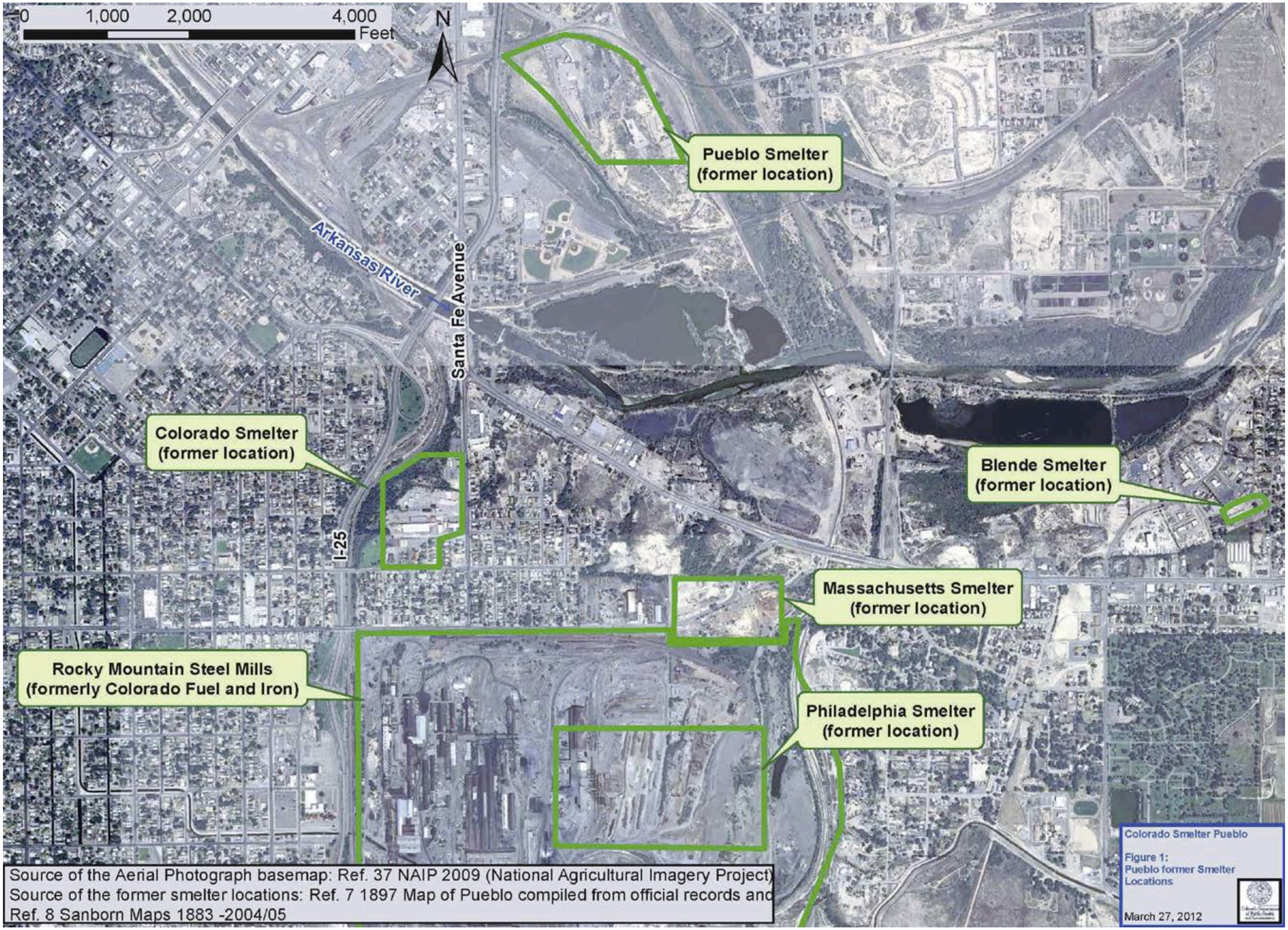


Figure 2: CDPHE 2010 site inspection sample locations.



Source of the Aerial Photograph basemap: Ref. 37 NAIP 2009 (National Agricultural Imagery Project)
Source of the former smelter locations: Ref. 7 1897 Map of Pueblo compiled from official records and
Ref. 8 Sanborn Maps 1883 -2004/05

Figure 3: Pueblo Former Smelter Locations.

3. Summary of Comments

The Honorable John Hickenlooper, Governor of Colorado; Terry Hart; the Pueblo City-County Health Department Board of Health; the City Council, the City of Pueblo; the Board of County Commissioners, Pueblo County; Velma Campbell; Pam, Don, and Joshua DiFatta; the Sierra Club Rocky Mountain Chapter; and the Sangre de Cristo Group of the Sierra Club all expressed their support for the placement of the Site on the NPL. The Honorable John Hickenlooper, Governor of Colorado; Sandra Daff, Pueblo City Councilwoman; Eiler Heights Neighborhood Association; the Bessemer Association for Neighborhood Development; Joe and Pam Kocman; and one anonymous public commenter provided support for the placement of the Site on the NPL with conditions.

Several public commenters opposed the listing of the Colorado Smelter site on the NPL. Two anonymous public commenters commented that the placement of the Site on the NPL will negatively impact property values because banks will not provide Federal Housing Administration-insured or U.S. Department of Veterans Affairs (VA) loans for subsequent purchase of homes in the Site vicinity. Joe and Pam Kocman asserted that homeowners should not bear the cost associated with testing and abatement. One anonymous public commenter commented that it was suspicious that the EPA was listing the Colorado Smelter site at this time due to the proposed listing coinciding with the American Smelting and Refining Company (ASARCO) 2009 bankruptcy settlement. One anonymous public commenter commented that the EPA had not clarified the extent of the Site.

Two anonymous commenters commented regarding the risk associated with the levels of contaminants detected, noting that the blood lead levels of arsenic and lead were very low. Mr. Merril Coomes commented that the EPA Superfund remedial goals for lead levels in residential soil are inconsistent with Center for Disease Control and Prevention (CDC) recommendations. Joe and Pam Kocman asserted that the EPA should change its blood lead level to coincide with levels acceptable to the CDC. In addition Mr. Coomes questioned whether the cleanup of the emissions from the smelter would actually result in the reduction of risk.

Mr. Coomes identified several items that he asserted were either missing from the public docket or not discussed in the provided documentation and should be provided for review or prepared; these items include a Data Quality Assessment Report, Quality Assurance Project Plan (QAPP) for the Site, Conceptual Site Model (CSM), Standard Operating Procedures (SOPs), SOP-specified Site Diagrams, and a complete set of PA XRF data. Mr. Coomes requested an extension to the comment period to review the several documents requested related to the proposed listing of the Colorado Smelter site on the NPL.

Mr. Coomes questioned the EPA’s adherence to EPA guidance related to quality assurance and data quality. Mr. Coomes commented that EPA’s Guidance was not followed in the preparation of the CDPHE May 2010 SAP. Mr. Coomes asserted that the EPA did not follow relevant EPA Region 8 guidance for the evaluation of lead at residential properties, commenting that the quality of the data resulting from the investigation is suspect. Mr. Coomes further stated that “[s]imply stating that the historic Colorado Smelter released contaminants [is] insufficient.” Mr. Coomes also asserted that a relevant SOP was not followed in sample collection, resulting in questionable data quality. Mr. Coomes further commented that the sampling logs indicate that the sampling procedures identified in the SOP were not followed. Mr. Coomes also noted several perceived factual errors in reports/documents related to the CDPHE 2010 site inspection related to the number and type of samples collected.

Mr. Coomes made several assertions regarding the background lead levels used in HRS documentation record including:

- The background lead levels are inconsistent with a previous Colorado Smelter report.
- Lead-based paint or emissions from leaded gasoline are not discussed as possible sources of lead in the HRS documentation record.

- Other studies, specifically the Diawara study and USGS data, provide different background lead levels.

Mr. Coomes asserted that in the comparison of composite sample results versus individual aliquot results, a high bias is apparent in the composite sample results, and how this bias was introduced has not been explained.

Mr. Coomes commented that attribution of hazardous substances to the Site was questionable, asserting:

- The EPA assumed the smelter was the main source of lead contamination.
- The attribution of hazardous substances "is based on the fact that other potential lead sources were not investigated or described."
- The collected soil samples and analysis do not support the model of the smelter as the source contamination based on the ratio of lead to arsenic in the collected soil samples.
- A concentration or cluster of locations where lead concentrations exceeded 100 ppm near the Colorado Smelter site was not present.
- An even distribution of lead in soil with distance from the smelter was not present.
- There are large differences between the smallest and largest lead concentrations within these sample areas based on the five aliquot results.
- Arsenic/lead ratios in some collected soil samples exceed the highest ratio for slag.

Based on these points, Mr. Coomes concluded that the data support additional lead sources, and the arsenic levels in soil samples did not result from particulate deposition from the Colorado Smelter.

3.1 General Support for Listing

Comment: The Honorable John Hickenlooper, Governor of Colorado; Terry Hart, Chairman, Board of County Commissioners; the Pueblo City-County Health Department Board of Health; the City Council, City of Pueblo, Colorado and the Board of County Commissioners, Pueblo County, Colorado; Velma Campbell; and Pam, Don and Joshua DiFatta, expressed support for listing the site on the NPL. The Sierra Club Rocky Mountain Chapter, the Sangre de Cristo Group of the Sierra Club, the Pueblo City-County Health Department Board of Health, and Velma Campbell supported the placement of the site on the NPL due to public health concerns and the benefits to people and communities impacted by lead and arsenic contamination. The City Council, City of Pueblo, and the Board of County Commissioners expressed support for the placement of the site on the NPL due to potential positive economic impacts, possible federal financing of remediation, and potential boosts to the economic and potential community improvements as a result of listing the site on the NPL.

Response: The Colorado Smelter site is being added to the NPL. Listing makes a site eligible for remedial action funding under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the EPA will examine the Site to determine the appropriate response action(s). Actual funding may not necessarily be undertaken in the precise order of HRS scores, however, and upon more detailed investigation may not be necessary at all in some cases. The EPA will determine the need for using Superfund monies for remedial activities will be determined on a site-by-site basis, taking into account the NPL ranking, State priorities, further site investigation, other response alternatives, and other factors as appropriate.

3.2 Conditional Support for EPA Cleanup

Comment: The Honorable John Hickenlooper, Governor of Colorado; Sandra Daff, Pueblo City Councilwoman; Eiler Heights Neighborhood Association; the Bessemer Association for Neighborhood Development; Joe and Pam Kocman; and one anonymous public commenter provided conditional support for EPA cleanup and the placement of the site on the NPL and submitted multiple conditions for their support for listing. These conditions include the following.

- Governor Hickenlooper requested:
    - That "protections are put in place to be responsive to the concerns of the local community" (referring also to the requests from Councilwoman Daff, the Eiler Heights, and Bessemer community in letters attached to the Governor's comment), and that EPA address concerns listed by elected officials (referring to a joint letter from the City Council, City of Pueblo, and Board of County Commissioners, Pueblo county, also attached to the Governor's comment).
    - Community involvement in the Superfund process, specifically noting soil remediation levels and Superfund liability.
    - The funding of the project "through completion without interruption to avoid any delays."
    - Notification and use of local businesses for Superfund process contracting opportunities.
    - Conducting the cleanup in a "timely, effective and collaborative fashion."
- Joe and Pam Kocman and one anonymous public commenter provided support for listing contingent upon timely clean up occurring within five years and three years following listing, respectively. (The anonymous public commenter asserted that NPL listing for the Site should stop, but assuming it moves forward, asserted this condition.)
- Joe and Pam Kocman expressed provisional support for listing provided that comprehensive home cleanup be undertaken, modifications to the EPA testing and remediation models regarding acceptable children's blood lead levels occur, and Governor Hickenlooper's specifications outlined in his letter of support be fulfilled, including timely cleanup and addressing the concerns of the community. Joe and Pam Kocman also expressed that if the EPA cannot guarantee that future costs associated with soil testing and abatement will not be borne by homeowners, they would not support listing.

Response: As noted in section 3.1, General Support for Listing, of this support document, the Colorado Smelter site is being added to the NPL. Listing makes a site eligible for remedial action funding under CERCLA, and the EPA will examine the Site to determine the appropriate response action(s), if any.

Regarding community involvement, the Superfund program offers numerous opportunities for public participation at NPL sites. The EPA Regional Office develops a Community Relations Plan (CRP) before remedial investigation and feasibility study (RI/FS) field work begins. The CRP is the "work plan" for community relations activities that the EPA will conduct during the entire cleanup process. In developing a CRP, Regional staff interview State and local officials and interested citizens to learn about citizen concerns, site conditions, and local history. This information is used to formulate a schedule of activities designed to keep citizens apprised and to keep the EPA aware of community concerns. Typical community relations activities include:

- Public meetings at which the EPA presents a summary of technical information regarding the site and citizens can ask questions or comment.
- Small, informal public sessions at which EPA representatives are available to citizens.
- Development and distribution of fact sheets to keep citizens up-to-date on site activities.

For each site, an "information repository" is established, usually in a library or town hall, containing reports, studies, fact sheets, and other documents containing information about the site. The EPA Regional Office continually updates the repository and must ensure that the facility housing the repository has copying capabilities.

After the RI/FS is completed and the EPA has recommended a preferred cleanup alternative, the EPA Regional Office sends to all interested parties a Proposed Plan outlining the cleanup alternatives studied and explaining the process for selection of the preferred alternative. At this time, the EPA also begins a public comment period during which citizens are encouraged to submit comments regarding all alternatives. Once the public comment period ends, the EPA develops a Responsiveness Summary, which contains EPA responses to public comments.

The Responsiveness Summary becomes part of the Record of Decision (ROD), which provides official documentation of the remedy chosen for the site.

In addition, the EPA makes every attempt to ensure that community relations is a continuing activity designed to meet the specific needs of the community. Anyone wanting information on a specific site should contact the Community Relations staff in the appropriate EPA Regional Office. For the Colorado Smelter site, the EPA has carried out several communications and meetings with members of the public and local officials/leaders. See Attachment 5, Colorado Smelter Outreach Timeline, of this support document for a brief list. Further, the EPA and CDPHE have committed staff for this purpose, and hired a neutral facilitator since April 2014 to assist with monthly meetings to form a community advisory group.

To the extent these comments would condition the listing of the Site on any specific remedial goals, the EPA notes that it is premature at this stage to discuss what remedial actions, if any, will occur at the Site after it's placement on the NPL. As discussed in the proposed rule and throughout this final rulemaking, listing makes a site eligible for CERCLA financed remedial action. What remedies, if any, will be performed at the Site occurs at a later stage in the Superfund process, i.e., after completion of the remedial investigation/feasibility study.

Regarding remediation timing and remedy selection (as well as funding for remediation), such as those submitted by Joe and Pam Kocman, and regarding cleanup goals (including health-related goals), see also section 3.7, Remediation and Cleanup Levels, of this support document.

3.3 Consistency with Data Quality Program

Comment: Mr. Coomes questioned the EPA's adherence to EPA policies and guidance related to quality assurance and data quality objectives in performing the planning for and collection of the data (and related documents) used in the site inspection.

Mr. Coomes stated:

> EPA has specific Policy and Program Requirements for the Mandatory Agency-Wide Quality System, CIO 2105.0 (formerly EPA Order 5360.1 A2,) and the applicable Federal regulations establish a Quality System that applies to all EPA organizations as well as those funded by EPA.

Mr. Coomes also stated:

> The listing document does not address quality assurance. The project has not followed the Mandatory Agency-Wide Quality System, CIO 2105.0 (formerly EPA Order 5360.1 A2,). The documents supporting the listing do not discuss concepts that support making defensible decisions.

Mr. Coomes further stated: "there is no discussion/documentation of: 1 .Data Quality Objectives used in planning the study . . . 2. Quality Assessment Project Plan." Mr. Coomes asserted that "[t]he project did not incorporate EPA's mandatory quality system.

In discussing the CDPHE May 2010 SAP (included as Reference 20 of the HRS documentation record at proposal), Mr. Coomes noted that the existing data quality objectives section "does not even define the use of the data (only one example)," and claimed that "EPA's data quality objectives guidance was not followed in planning or performing this study."

Response: The EPA followed the HRS to place the site on the NPL, and was consistent with all applicable policies and guidance. None of the comments submitted identify any error in the HRS score or the decision to list the Site. And, all the documents relied upon in performing the HRS evaluation and showing the policies and guidances were followed were available to the public. As set out further below:

- Purpose of the HRS: The HRS is a screening model that uses limited information and resources to determine whether a site should be placed on the NPL. Regarding data quality, for an HRS evaluation, the data used need not be absolutely perfect, as long as the EPA has presented a rational explanation to address the use of the data in an HRS evaluation.
- Data Quality for the CDPHE 2010 Site Inspection: Planning and reporting documents related to the CDPHE 2010 site inspection described data quality objectives and established the quality of the data generated from site inspection activities. The CDPHE 2010 site investigation was designed to provide data for use in an HRS evaluation, and the data used to generate an HRS site score for this site is of sufficient quality for determining that the Site qualifies for listing on the NPL based on an HRS evaluation.
- HRS Data Quality Objectives: The HRS itself contains data quality objectives for the purpose of carrying out an HRS evaluation, and the CDPHE 2010 site inspection analytical results used to score the Site meet these objectives.
- Effect of Comments on HRS Score: Comments asserting EPA has been inconsistent with a particular policy or guidance document have not documented any defect in any particular HRS scoring factor.

Purpose of the HRS

First, an HRS is a special type of investigation and overarching policies and guidance must be read in context. The HRS is a screening model that uses limited resources to determine whether a site should be placed on the NPL for possible Superfund response. The HRS is intended to be a “rough list” of prioritized hazardous sites; a “first step in a process—nothing more, nothing less.” Eagle Picher Indus. v. EPA, 759 F.2d 922, 932 (D.C. Cir. 1985) (Eagle Picher II).

As an example of the data quality objectives for an HRS evaluation, and, specifically related to analytical data quality, the U.S. Court of Appeals for the D.C. Circuit has specifically ruled on the use of analytical data in the scoring of a site using the HRS when there were possible weaknesses in the laboratory analysis. In the case of Board of Regents of the University of Washington v. EPA, 86 F.3d 1214 (DC Cir. 1996), the Court, in response to the petitioner's challenge regarding the quality of the data being fed into the complex HRS model—specifically, when there were issues dealing with the analysis—stated that “EPA does not face a standard of absolute perfection. . . . Rather, it is statutorily required to ‘assure to the maximum extent feasible,’ that it ‘accurately assesses the relative degree of risk,’” [emphasis in original] and that “[i]t would hardly make sense for the courts to respond to the resulting evidence by treating a lab’s findings as fatally defective whenever it comes up short in any way.” The Court also said that “[i]f there are ‘minor contractual deficiencies,’ the appropriate response is to review the deficiencies on a ‘case-by-case’ basis to determine their impact on the ‘usability of the data.’” Also in this decision, the Court repeated a statement in an earlier NPL HRS case (Eagle–Picher Indus., Inc. v. EPA, 759 F.2d. 905, 921, D.C. Cir. 1985) in explanation of when EPA has met its obligations as: “The EPA has thus ‘examined [the] relevant data and . . . articulated a rational explanation for its action.’” [clarification in original] See also City of Stoughton v. EPA, 858 F.2d 747, 756 (D.C. Cir. 1988) (“It is not necessary that EPA's decisions as to what sites are included on the NPL be perfect, nor even that they be the best.”); CTS Corp. v. EPA, 759 F.3d 52, 61 (D.C. Cir. 2014) (same).

Further, as set out in the HRS documentation and this response to comments document, the data EPA relied on (including the results of the CDPHE 2010 site inspection) met the standards of the Administrative Procedure Act by being ‘relevant, material, and not repetitious,’ see 5 U.S.C. § 556(d), such that EPA was entitled to weigh it according to its truthfulness, reasonableness, and credibility. See, e.g., Veg-Mix, Inc. v. U.S. Dept. of Ag., 832 F.2d 601, 606 (D.C. Cir. 1987).

Data Quality for the CDPHE 2010 Site Inspection

Regarding data quality associated with the CDPHE June 2011 ARR and the site inspection activities, the EPA and the CDPHE followed all relevant policies and guidance related to quality assurance and data quality objectives in collecting, analyzing, and using the data to perform the HRS evaluation.

First, an HRS evaluation is performed based on information available to characterize a site. In accordance with the NCP, a site inspection may be carried out to generate data for this purpose (see the NCP at 40 CFR 300.420[c][iii]). In comments directly addressed in this section and other sections of this support document, Mr. Coomes alleges deficiencies related to several documents such as the March 2000 CDPHE QAPP, CDPHE May 2010 SAP, CDPHE June 2011 ARR, and the March 2012 DQA.[5] These are planning/reporting documents for the CDPHE 2010 site inspection, and the information from this site inspection was included in data used to generate an HRS score for the Site. However, the exact planning/reporting documentation (as well as other reference material) used in performing an HRS evaluation is not explicitly specified by the HRS.

Further, the EPA had approval authority and used this authority for the CDPHE Quality Assurance documentation, which included the March 2000 CDPHE QAPP and the CDPHE May 2010 SAP (included as Reference 20 of the HRS documentation record at proposal). The March 2000 CDPHE QAPP covers site assessment activities conducted by the State on behalf of the EPA and was approved by representatives of EPA Region VIII as shown on page i of that document, included as Attachment 1 of this support document. The CDPHE May 2010 SAP, specific to the CDPHE 2010 site inspection, was also approved by a representative of EPA as shown on the cover pages of that document (included as Reference 20 of the HRS documentation record at proposal). These documents are consistent with CIO 2105.0 (formerly EPA Order 5360.1) and described how data and information were going to be collected, analyzed, and assessed. The CDPHE May 2010 SAP, in its Objectives and Decision Rules sections, clarifies that the purpose of the site inspection is to collect data for use in conducting an HRS evaluation (see pages 1-2, 11-12 of Reference 20 of the HRS documentation record at proposal). The technical details and procedures for collection and selection of data were also described, and the data quality indicators of precision, accuracy, representativeness, completeness, comparability and sensitivity were evaluated. All data was determined usable as qualified (as limited by the analytical data validation and data quality assessment process).

Analytical precision was demonstrated through the use of duplicate samples. Ten percent of the multi-increment soil samples analyzed by XRF were sent for laboratory confirmatory analysis. The results generated by both XRF and Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) demonstrated correlation indicating a definitive data quality level, meaning the sets show statistically similar results. Additionally, the duplicate sample results were within acceptable criteria for both the XRF and CLP analysis of soil samples. A duplicate surface water sample was submitted to the CLP lab blind, and results of the analysis were within control limits.

The accuracy of the analytical data was verified through use of several quality control samples, including standards, blanks, and spikes. See section 3.3.2, Completion of Data Quality Assessment, for more detail on data

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[5] A QAPP is a document that describes policy, organization, and functional activities, and the data quality objectives and measures necessary to achieve adequate data for use in site evaluation and HRS activities. A SAP generally documents procedural/analytical requirements for a site-specific one-time/time-limited project that involves the collection of samples of water, soil, sediment or other media to characterize areas of potential environmental contamination, and addresses elements specified in the related QAPP (CDPHE May 2010 SAP is a specific planning document for the CDPHE 2010 site inspection). The CDPHE June 2011 ARR is a report describing the results from the site inspection activities. The March 2012 DQA is a report assessing data quality related to the results from the site inspection activities, and is focused on correlation between soil sample lead XRF results and soil sample CLP laboratory results.

quality control.[6] Representativeness was achieved by adherence to technical standard operating procedures (TSOPs) for sampling procedures, adherence to field and laboratory quality assurance/quality control procedures, appropriateness of sample location, and achieving the acceptance criteria specified in the CDPHE May 2010 SAP.

A review of the CDPHE May 2010 SAP, field log books, and laboratory data packages reveals no deviations or failures in the procedures and data that are being used for decision making at the Site (as detailed on pages 38-39 of the CDPHE June 2011 ARR, included as Reference 22 of the HRS documentation record at proposal). As further explained below, the Colorado Smelter site inspection met project and data quality objectives with regard to the HRS requirements.

The CDPHE generic QAPP is cited as a reference in the CDPHE June 2011 ARR (the analytical results report for the CDPHE 2010 site inspection). As stated in the proposed rule (79 FR 26926, Part II) this generic QAPP reference document has been accessible via the EPA Region 8 Regional Docket. Nonetheless, in response to Mr. Coomes' comments, the Agency has included the referenced QAPP as Attachment 1 of this response document.

Finally, in Mr. Coomes' comments asserting EPA has not adhered to relevant policy and guidance, he makes several related claims of deficiencies in documentation related to the planning and reporting for the CDPHE 2010 site inspection. However, as shown in this support document, the CDPHE 2010 site inspection planning and reporting documentation was sufficient at proposal. (These documents and alleged deficiencies are further addressed in section 3.3.1, Sampling and Analysis Plan; 3.3.2, Completion of Data Quality Assessment; and 3.4, Adequacy of Public Docket/Requests for Additional Documents, of this support document).

HRS Data Quality Objectives

In addition to the data quality associated with the CDPHE June 2011 ARR and the site inspection activities, the HRS states the data quality objectives for the purpose of carrying out an HRS evaluation, including associating hazardous substances with a source and establishing observed contamination; the HRS evaluation of the Site was consistent with these HRS objectives. The HRS data quality objectives for associating a substance with a source based on analytical samples (other than contaminated soil) are detailed in HRS Section 2.2.2, Identify hazardous substances associated with a source, and specify that the analytical data document the substance to be present in a sample at a concentration at or above the detection limit. Hence, the analytical data need only be qualitatively accurate—they must be sufficient to show the presence of a hazardous substance, but need not accurately determine its exact concentration.

The HRS Section 1.1, Definitions, defines "source" in part as:

> [a]ny area where a hazardous substance has been deposited, stored, disposed, or placed, plus those soils that have become contaminated from migration of a hazardous substance.

For associating a substance with a source, HRS Section 2.2.2, Identify hazardous substances associated with a source, states:

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[6] Additionally, the samples used to establish observed contamination for the Site were analyzed under the EPA CLP. This program was "developed for CERCLA waste site samples to fill the need for legally defensible analytical results supported by a high level of quality assurance and documentation" (HRS Section 1.1). A key part of the CLP program is to document the quality of the analytical results through the analysis of quality control samples commensurate with the analysis for field samples and by tracking the capabilities of the analytical procedures to provide accurate results when analyzing samples with variable physical properties.

> consider those hazardous substances documented in a source (for example, by sampling, labels, manifests, oral or written statements) to be associated with that source when evaluating each pathway.

Thus, to associate a hazardous substance with a source, the substance must be documented to be in an area where it was deposited, stored, disposed, or placed, or to be soil contaminated through hazardous substance migration.

For sources that are not composed of contaminated soil, any substance that can be documented to be present in the waste material in the source can be associated with that source. When samples are of waste materials, background sampling is unnecessary, since the presence of the wastes is evidence that the hazardous substances have been deposited, stored, disposed, or placed in the source.

The HRS data quality objectives for establishing observed contamination are included in HRS Section 5.0.1, General considerations, and HRS Table 2-3. The contaminant concentration in the release sample(s) must be either 1) three times above the background concentration for the media being evaluated, or 2) at or above the sample quantitation or detection limit if the background level is below the appropriate detection limit. This involves a quantitative comparison to background, and the data quality objective for establishing observed contamination is that the concentration of a contaminant must be sufficiently quantitatively accurate to ensure that one of the two above criteria spelled out in HRS Table 2-3 is met.

HRS Section 5.0.1, *General considerations*, states in relevant part:

> - Consider observed contamination to be present at sampling locations where analytic evidence indicates that:
>   –A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (**see table 2–3 in section 2.3 for the criteria for determining analytical significance**), and
>   –This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil). [emphasis added]

HRS Table 2-3, referred to by HRS Section 5.0.1, *General considerations*, states:

> - If the background concentration is not detected (or is less than the detection limit), an observed release is established when the sample measurement equals or exceeds the sample quantitation limit.
> - If the background concentration equals or exceeds the detection limit, an observed release is established when the sample measurement **is 3 times or more above the background concentration**. [emphasis added]

Thus, again, the data quality must be of sufficient quantitative accuracy to identify that contaminated sample results are significantly above background levels (and not an artifact of sampling or analysis variation); and it must be known that the contaminated sample is within 2 feet of the surface.

As further detailed in section 3.3.2, Completion of Data Quality Assessment, of this support document, an overall data usability assessment conducted for data generated during the CDPHE 2010 site inspection found all data usable as qualified (as limited by the data validation and data quality assessment process). Thus, CDPHE 2010 site inspection analytical results presented in the HRS documentation record and used to associate hazardous substances with sources and establish areas of observed contamination were assessed for qualitative and quantitative accuracy prior to use in HRS scoring and are sufficient for HRS purposes.

Effect of Comments on HRS Score

Finally, in many instances specifically addressed in later parts of this support document, Mr. Coomes has claimed that EPA has been inconsistent with a particular policy or guidance document, but has not explained how such an inconsistency would affect the HRS Site score or the decision to list the Site on the NPL. However, courts have held that the "dialogue between administrative agencies and the public is a two-way street." Northside Sanitary Landfill, Inc. v. Thomas, 849 F.2d 1516, 1520 (D.C. Cir. 1988) (citing Home Box Office, Inc. v. FCC, 567 F.2d 9 (D.C. Cir. 1977)). A commenter "cannot merely state that a particular mistake was made," rather it must show "why the mistake was of possible significance in the result the agency reaches." See id. at 1519. As explained further throughout this support document, the methods employed in listing the Site pursuant to the HRS either satisfied the concerns raised in Mr. Coomes' comments, or the documents he is inquiring about are not applicable and are not required by the HRS to be presented to the public as part of an HRS evaluation.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.3.1 Sampling and Analysis Plan

Comment: Mr. Coomes submitted comments questioning the adequacy of the SAP for the ARR in respect to EPA's Data Quality Program. He asserted that "[a]lthough the Sampling and Analysis Plan (SAP) included a Data Quality Objectives (DQO) Section 5.0, EPA Data Quality Objectives, EPA's Guidance[7] was not followed in preparation of the Sampling and analysis [*sic*] Plan." Mr. Coomes pointed to the February 2006 EPA document Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4 EPA/240/B-06/001. Mr. Coomes argued that "[s]imply stating that the historic Colorado Smelter released contaminants [is] insufficient (it says 'trust us')." Mr. Coomes identified several alleged issues that he contended "require additional input from the EPA to ensure the public understands the rationale of the investigation." Mr. Coomes contended that this "lack of documented planning results in data quality that does not [*sic*] sufficient to support defensible decision-making." Related to the SAP, Mr. Coomes called into question whether a conceptual site model (CSM) or decision rules and acceptable uncertainty had been sufficiently considered and conveyed.

Response: The CDPHE May 2010 SAP adequately discusses the CSM and decision rules for the CDPHE 2010 site inspection and for an HRS evaluation, providing CSM details related to identifying sources, hazardous substances, and exposure routes, and decision rule details such as the problem statement, decision, decision inputs, defining study boundaries, developing decision rules, and defining tolerance limits on decision rules. The CSM and decision rules are set out in the CDPHE May 2010 SAP, and are also built into the HRS itself for HRS scoring purposes, as further detailed in the below subsections.

It is assumed that the SAP referenced by Mr. Coomes in his comments is the CDPHE May 2010 SAP (included as Reference 20 of the HRS documentation record at proposal). Also, the data quality objectives are addressed in section 7 (not section 5), Data Quality Objectives Process, of that SAP.

Further, as detailed in section 3.16, Attribution, of this support document, the attribution of hazardous substances (lead and arsenic) in the residential soil AOC to the Site is properly attributed and consistent with the HRS. The Colorado Smelter is reasonably documented to have released lead and arsenic contaminants through historical operations, via smelter stack emissions that were deposited in the AOC surrounding the Colorado Smelter stacks.

Specific comments on the presentation of a CSM and decision rules/acceptable uncertainty are addressed in the following subsections:

- 3.3.1.1 Conceptual Site Model
- 3.3.1.2 Decision Rules and Acceptable Uncertainty

3.3.1.1 Conceptual Site Model

Comment: Mr. Coomes asserted that “a CSM was not prepared and reported to the public.” Mr. Coomes stated:

> Therefore, the public has little understanding of release mechanisms, transport pathways, affected media, and intake routes, because EPA has not explained these concepts and how they apply at the Colorado Smelter Site. It is not acceptable to expect the public to take EPA's word that chemicals from the smelter "contaminated" the area without adequate documentation of the release mechanism, transport mechanism, and intake routes. This information would have been provided if EPA had followed their DQO guidance.

In discussing a model for the Site, Mr. Coomes referred to a “lead particulate ‘rainfall’” concept in Attachment 2 to his comment document. Mr. Coomes requested that if the description in Attachment 2 to his comment document does not fit EPA’s conceptual site model, the EPA “explain how the data support the EPA-proposed CSM.” Mr. Coomes also requested that the CSM to be generated explain how the variability in soil lead concentrations with distance is consistent with a particulate deposition model.

Response: The EPA followed the HRS in generating an HRS site score, qualifying the Site for the NPL, and none of the comments have shown that score to be incorrect. The HRS does not require that a CSM be explicitly described or presented in the HRS documentation record or its supporting references. Furthermore, the CDPHE May 2010 SAP does discuss the CSM for the CDPHE 2010 site inspection considering that an HRS evaluation would be performed. The conceptual site model is set out in that document, and is also built into the HRS itself for HRS scoring purposes.

In general, a CSM is an idealized model of processes at a site which may act as a planning tool for investigating the site. A CSM can be developed for various stages of a Superfund process (e.g., for a site inspection, a site-specific risk assessment, for remediation activities, etc.).

The CSM for the HRS evaluation of all possible sites being evaluated includes consideration of such exposure/risk assessment components as the sources of contaminants and the magnitude of the contamination, mechanisms by which contaminants may migrate, the fate and transport of contaminants during migration, the exposure routes into receptors, the identification and quantification of targets (receptors), and finally, the estimation of the relative risk among sites. The HRS factor values used in determining an HRS score reflect these factors and the HRS algorithm for combining these factor values into a relative site score links these components together.

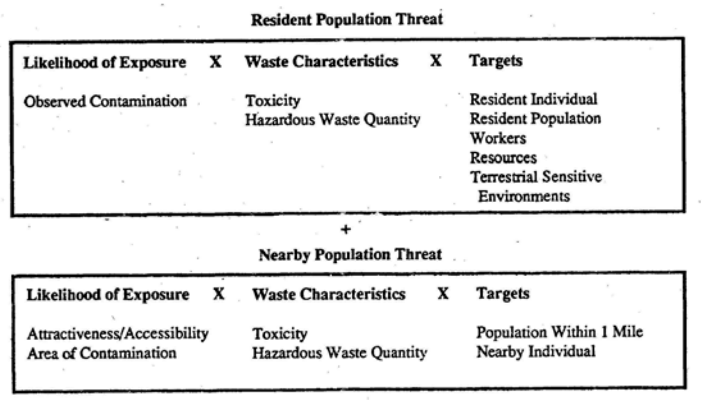
CSMs may take different forms depending on the program or action/activity being planned. However, there is no HRS requirement that CSMs be developed or explicitly spelled out in the documents supporting the HRS evaluation (i.e., the HRS documentation record or its supporting references). And, CSMs also need not replicate the figure provided by the commenter, but could include drawings or narrative descriptions of the site, source areas, and how site-related contamination could impact target populations. In the CDPHE May 2010 SAP, the CSM is offered in a narrative format within Section 6.0, Preliminary Pathway Analysis (see pages 4-10 of Reference 20 of the HRS documentation record at proposal). This text includes several relevant discussions, such as:

- Identifying sources (e.g., waste piles)
- Identifying related hazardous substances (various metals)
- Potential routes of human exposure (e.g., ingestion of soil)
- Consideration of contaminated media within each pathway considered in the SAP, how contamination may have come to each pathway media, and target populations or environmental targets potentially affected by each pathway.

Furthermore, for the purposes of an HRS evaluation, the generic CSM for the entire HRS is also built into the HRS itself. HRS Section 2.1.3, *Common evaluations*, lays out evaluations common to all HRS pathways:

- Characterizing sources.
    –Identifying sources (and, for the soil exposure pathway, areas of observed contamination [see section 5.0.1]).
    –Identifying hazardous substances associated with each source (or area of observed contamination).
    –Identifying hazardous substances available to a pathway.
- Scoring likelihood of release (or likelihood of exposure) factor category.
    –Scoring observed release (or observed contamination).
    –Scoring potential to release when there is no observed release.
- Scoring waste characteristics factor category.
    –Evaluating toxicity.
    –Combining toxicity with mobility, persistence, and/or bioaccumulation (or ecosystem bioaccumulation) potential, as appropriate to the pathway (or threat).
    –Evaluating hazardous waste quantity.
    –Combining hazardous waste quantity with the other waste characteristics factors.
    –Determining waste characteristics factor category value.
- Scoring targets factor category.
    –Determining level of contamination for targets.

The sample pathway score sheet shown in HRS Table 2-1 shows how these elements fit into the HRS scoring approach. And, Figure 8 of the preamble to the HRS shows how scoring elements specific for the soil exposure pathway fit into the HRS evaluation (including the resident population threat scored for the Colorado Smelter site), as follows:



Resident Population Threat

Likelihood of Exposure	X	**Waste Characteristics**	X	**Targets**
Observed Contamination		Toxicity Hazardous Waste Quantity		Resident Individual Resident Population Workers Resources Terrestrial Sensitive Environments

+

Nearby Population Threat

Likelihood of Exposure	X	**Waste Characteristics**	X	**Targets**
Attractiveness/Accessibility Area of Contamination		Toxicity Hazardous Waste Quantity		Population Within 1 Mile Nearby Individual

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.3.1.2 Decision Rules and Acceptable Uncertainty

Comment: Mr. Coomes requested that the data quality objectives section of the SAP be rewritten to address inadequacies and submitted to the public for review. Mr. Coomes commented that the data quality objectives section of the SAP "does not include a single decision statement," and that the related topic of acceptable uncertainty was also not discussed. Mr. Coomes noted that such a discussion "would also include a defined 'gray zone' so one can determine whether the acceptable uncertainty is appropriate for the decisions to be made." Mr. Coomes asserted that a discussion of acceptable uncertainty "is required to determine the number of samples (each medium) and the analytical detection limits necessary to support the defined decisions." Mr. Coomes further asserted that the EPA should describe the specific data and quantity needed to support the acceptable uncertainty, and noted "the required data, decision statement, and decision criteria are different for various media tested." Mr. Coomes added that "[e]ven though EPA did not evaluate the HRS for other media, samples of other media were collected and analyzed and should have been included in the DQO section."

Response: The EPA followed the HRS in generating an HRS site score, qualifying the Site for the NPL, and none of the comments have shown that score to be incorrect. The HRS does not require that decision rules and acceptable uncertainty related to screening site investigations be explicitly described in the presentation of the evaluation to the public (i.e., in the HRS documentation record or its supporting references). Regardless, the CDPHE May 2010 SAP does adequately address the topics of decision rules and acceptable uncertainty for the CDPHE 2010 site inspection and for an HRS evaluation, and decision rules for the purposes of an HRS evaluation are built into the HRS itself.

The CDPHE May 2010 SAP addresses data quality objectives in: section 2.0, Objectives, describing overall site inspection objectives (on pages 1-2 of Reference 20 of the HRS documentation record at proposal); and section 7.0, Data Quality Objectives Process, discussing the problem statement, decision, decision inputs, defining study boundaries, developing decision rules, defining tolerance limits on decision rules, and optimizing the sample design (on pages 10-12 of Reference 20 of the HRS documentation record at proposal). This approach was consistent with the specifications in the CDPHE generic QAPP included as Attachment 1 of this support document.

The decision rules for the CDPHE site inspection (e.g., If, Then statements) are present in narrative format and contained in Step 5 of section 7 of the CDPHE May 2010 SAP. The decision rules consist of comparisons to background concentrations and relevant health-based benchmarks, consistent with the HRS regulation. As further discussed in section 3.14, Identification of Observed Contamination – Significant Increase Criteria, of this support document, the HRS specifies the criteria for identifying a significant increase in hazardous substances and establishing observed contamination in soil (based on criteria detailed in HRS Sections 5.0.1, General considerations, 2.3, Likelihood of release, and HRS Table 2-3). Also, these decision rules note that additional action may be recommended if metals concentrations exceed applicable benchmarks. Additionally, Sections 5.1 and 11.0 of the CDPHE June 2011 ARR discuss the data's acceptability and usability for the HRS evaluation and listing the site on the NPL (see pages 7-8, 25-39 of Reference 22 of the HRS documentation record at proposal).

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.3.2 Completion of Data Quality Assessment

Comment: Mr. Coomes commented on the assessment of CDPHE 2010 site inspection data, asserting that "a Data Quality Assessment Report (that agrees with the EPA guidance for such a document) has not been distributed for review." Mr. Coomes requested that "[i]f EPA believes this project does not require the suggested analysis, please provide the support for this decision in terms [of] project quality." Mr. Coomes points to EPA Order CIO 2105.0, Policy and Program Requirements for the Mandatory Agency-wide Quality System. (Mr. Coomes also referred to the EPA guidance document Practical Methods for Data Analysis, EPA QA/G-9, QA97 Version, EPA/600/R-96/084, January 1998.)

Response: The EPA followed the HRS in generating an HRS site score, qualifying the Site for the NPL, and none of the comments have shown that score to be incorrect. The HRS does not require that any specific data quality assessment for analytical results generated by site investigations be performed or explicitly described in the HRS documentation record or its supporting references. However, consistent with EPA policy and guidance, a data quality assessment was performed and is available in the HRS package at proposal in the CDPHE June 2011 ARR and March 2012 Data Quality Assessment, and the data was found acceptable for HRS purposes.

An overall data quality assessment was conducted for data generated during the 2010 CDPHE 2010 site inspection (summarized on pages 25-39 of the CDPHE June 2011 ARR, Reference 22 of the HRS documentation record at proposal[7]); this assessment found that all data are usable as qualified (as limited by the data validation and data quality assessment process), considering aspects including:

- field quality control procedures
- data validation and interpretation
- data quality indicators (i.e., precision, accuracy/bias, representativeness, completeness, comparability, sensitivity)

A data quality assessment was also specifically generated for the CDPHE 2010 site inspection XRF results (the March 2012 Data Quality Assessment, Reference 28 of the HRS documentation record at proposal). This assessment was primarily concerned with XRF lead results and their correlation/comparability to CLP laboratory results. This analysis found that lead correlation is definitive between the XRF and CLP data sets, taking into account the following parameters:

- sample preparation
- sample analysis
- analysis quality assurance/quality control
- data validation
- data quality indicators (bias, sensitivity, precision, representativeness, completeness, and comparability)

Regarding the EPA guidance document, Practical Methods for Data Analysis, EPA QA/G-9, QA97 Version, EPA/600/R-96/084, January 1998, this document was not cited in planning documents used for the 2010 CDPHE 2010 site inspection; more applicable guidance[8] as well as the HRS-specific requirements were cited and used in planning.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.4 Adequacy of Public Docket/Requests for Additional Documents

Comment: Mr. Coomes requested that several documents and other information be provided for public review and to complete his analysis of the proposal to add the Site to the NPL.

Response: The documents and information provided with the HRS package at proposal were sufficient for the purposes of conducting an HRS evaluation for the Site. Other related documents were available from the EPA Region 8 docket upon request as instructed in the *Federal Register* notice of the proposal of the Colorado Smelter site to the NPL (79 FR 26926). These documents together provide for all data quality program requirements. As

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[7] During the process of responding to comments a minor error on page 25 of the CDPHE June 2011 ARR (Reference 22 of the HRS documentation record at proposal) was noted. The sentence on that page stating "[t]here were four types of data included in the data quality assessment for the **Fountain Foundry** project . . ." [emphasis added] This sentence should state instead that "[t]here were four types of data included in the data quality assessment for the **Colorado Smelter** project . . ." [emphasis added]

[8] For example, in the March 2000 CDPHE generic QAPP included as Attachment 1 of this support document, pages 1, 13, and 41 describe relevant policy and guidance documents considered in preparing the QAPP, and Appendix B to that QAPP includes copies of several standard operating procedure documents. Similarly, pages 1 and 19-20 of the CDPHE 2010 SAP (Reference 20 of the HRS documentation record at proposal), describe guidance documents and standard operating procedures considered in preparing the SAP.

explained below, the documents and information Mr. Coomes requested were either available to him or were not used in the HRS evaluation of the Colorado Smelter site. Prior to and throughout the comment period for the proposal of this site to the NPL, EPA Region 8 and the CDPHE received no requests for additional documents or information. As set out in this support document, the information the Agency provided in the HRS package at proposal was sufficient to support the HRS evaluation of the Site and provide the public with a meaningful opportunity to participate in this rulemaking.

Specific documents requested by Mr. Coomes are addressed in the following subsections:

- 3.4.1 Project-specific QAPP
- 3.4.2 Sampling and Analysis Plan/Data Quality Objectives
- 3.4.3 Project Plan and SOPs
- 3.4.4 SOP-specified Site Diagrams
- 3.4.5 Data Quality Assessment (DQA)
- 3.4.6 Preliminary Assessment XRF Data

3.4.1 Project-specific QAPP

Comment: Mr. Coomes requested a copy of the QAPP associated with the CDPHE 2010 site inspection activities. Mr. Coomes noted that this QAPP is listed as Reference 1 of the CDPHE June 2011 ARR (Reference 22 of the HRS documentation record at proposal); he commented that the QAPP "cannot be located and is critical to evaluate the quality of the collected data." If a QAPP is not available, Mr. Coomes requested a project-specific QAPP be prepared. Mr. Coomes included several other related comments:

- "It is important that this QAPP be available for public review before listing the site. Without the QAPP, documentation of the listing is incomplete."
- "A thorough review of documents supporting site listing cannot be completed without this additional document. Without reviewing this document, the quality of data used to support site listing is suspect."
- [The QAPP] "***must be made available*** in the document repository in order to evaluate whether or not the data quality are appropriate to support decision-making for decisions that were not defined in the DQO section of the SAP" [emphasis in original]
- "The actual CDPHE QAPP is critical to preparing specific comments on the proposed listing. Therefore, these comments are not complete and an extension of time is requested to review the QAPP that was actually used."
- "The ARR discusses data quality in terms of precession, accuracy, comparability, and representativeness, but does not follow more rigorous analysis which is appropriate for important decisions such as listing a site."
- "EPA guidance states that the quality of the data must be related to the decisions identified in the Data Quality Objectives prepared for the Sampling and Analysis Plan (SAP). The QAPP at the repository in Pueblo does not address the SAP DQOs and is not acceptable documentation for the Colorado Smelter Investigation."

Response: As explained above in section 3.3, Consistency with Data Quality Program, of this support document, the generic QAPP that is cited as a reference in the CDPHE June 2011 ARR (Reference 22 of the HRS documentation record at proposal) has been available during the comment period of the proposed rulemaking upon request to the Region 8 EPA docket, as indicated in the *Federal Register* notice (79 FR 26926), or at CDPHE's Record Center at 4300 Cherry Creek Drive South, Denver, CO 80246. Although no such request was received, EPA is including the generic QAPP as Attachment 1 of this document in response to Mr. Coomes' comments.

As further discussed in section 3.11.5, QAPP and Appendix H, of this support document, Mr. Coomes discussed a separate QAPP he located in the Pueblo Rawlins Public Library repository. That QAPP was not attached to Mr. Coomes comments, and no specific citation to the QAPP was provided by Mr. Coomes. It is thus not clear to which QAPP Mr. Coomes is referring, or for which site that QAPP was used. However, based on Mr. Coomes' related assertions, it is clear that the unidentified QAPP is not relevant to the CDPHE 2010 site inspection (and this QAPP is not the QAPP cited in relevant CDPHE 2010 site inspection planning documents).

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.4.2 Sampling and Analysis Plan/Data Quality Objectives

Comment: Mr. Coomes requested that the data quality objectives section of the CDPHE May 2010 SAP (Reference 20 of the HRS documentation record at proposal) be rewritten to address inadequacies, to be consistent with EPA guidance, to address decision rules and acceptable uncertainty, and to identify specific data and quantity to support acceptable uncertainty; Mr. Coomes requested this be submitted to the public for review.

Mr. Coomes requested that the EPA "prepare a site-specific CSM that provides a written description of release mechanisms, chemical transport pathways and exposure intake mechanisms in a manner that the educated lay public can understand." Mr. Coomes stated that EPA investigative reports must include a CSM, and that this should be done before the Site is listed. If a CSM is not prepared, Mr. Coomes requested that EPA provide a rationale for not doing so.

Mr. Coomes further stated: "there is no discussion/documentation of . . . Data Quality Objectives used in planning the study . . . Please prepare for review an investigation-specific Data Quality Objectives document." Mr. Coomes commented that "[t]his is actually the first step of Data Quality Assessment[11] when the DQOs are not clearly defined in the SAP."[9]

Response: The CDPHE May 2010 SAP included as Reference 20 of the HRS documentation record at proposal was adequate for developing data for an HRS evaluation. Furthermore, Mr. Coomes was mistaken in each of the alleged deficiencies he described related to the SAP, and the associated topics were sufficiently addressed:

- As described in section 3.3.1, Sampling and Analysis Plan, of this support document and its subsections, although not required by the HRS, the CDPHE May 2010 SAP did provide a discussion of the CSM, decision rules, and acceptable uncertainty.

- As further detailed in section 3.3, Consistency with Data Quality Program, of this support document, the data quality objectives for the CDPHE 2010 site inspection were documented in the CDPHE May 2010 SAP, as well as being inherent in the structure of the HRS itself. Provision of additional documentation discussing data quality objectives is not necessary prior to promulgating the Site to the NPL.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

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[9] Mr. Coomes cites reference 11 of his comment submittal, EPA Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA97 Version, EPA/600/R-96/084, January 1998.

3.4.3 Project Plan and SOPs

<u>Comment</u>: Mr. Coomes asserted that the SOP provided to the City of Pueblo for soil collection was not followed. (Mr. Coomes referred to SOP #SRC-OGDEN-02, *Surface Soil Sampling*, included as Attachment 1 of his comment document, docket ID EPA-HQ-SFUND-2014-0318-0020.) Mr. Coomes commented that a project plan has not been available for public review. Mr. Coomes therefore requested that copies of the project plan and SOP "actually used in the study" be provided for public review.

Mr. Coomes commented that the SOP provided to the City of Pueblo is not in the Pueblo Rawlins Library Repository, and should be included for public review.

Mr. Coomes claimed that "a second SOP is cited for the project, but is apparently not available" (pointing to "Comment 1" of his comment document).

<u>Response</u>: As further described in section 3.12, Identification of Observed Contamination – Soil Collection Technique, of this support document, the SOP Mr. Coomes cited related to these comments (SOP #SRC-OGDEN-02, Surface Soil Sampling, included as Attachment 1 of his comment document) was not used during the CDPHE 2010 site inspection and is not relevant to the data generated during that event. The CDPHE May 2010 SAP used for the CDPHE 2010 site inspection was provided as Reference 20 of the HRS documentation record at proposal.

Regarding a "second SOP" mentioned as missing by Mr. Coomes, it is unclear to what Mr. Coomes is referring. Within the context of this assertion, Mr. Coomes points to "Comment 1" of his comment document; however, that comment appears to discuss the allegedly missing QAPP, not a missing SOP.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.4.4 SOP-specified Site Diagrams

<u>Comment</u>: Mr. Coomes commented that site diagrams showing sampling locations at each property are required by the SOP (referring to SOP #SRC-OGDEN-02, *Surface Soil Sampling*, included as Attachment 1 of his comment document). However, Mr. Coomes asserted these diagrams were not available for review, and requested copies of the diagrams claiming they "are critical to evaluate the potential contributions of lead-based paint to the soil surrounding houses in this very old neighborhood."

<u>Response</u>: The SOP Mr. Coomes asserted requires that site diagrams showing sampling locations at each property be generated (SOP #SRC-OGDEN-02, *Surface Soil Sampling*, included as Attachment 1 of his comment document) was <u>not</u> used during the CDPHE 2010 site inspection activities and is not cited in relevant planning documents (e.g., the CDPHE May 2010 Sample and Analysis Plan, included as Reference 20 of the HRS documentation record at proposal, or the March 2000 CDPHE QAPP for Site Assessments Under Superfund, included as Attachment 1 of this support document). SOP #SRC-OGDEN-02 and its specifications are not applicable to the CDPHE 2010 site inspection activities. Figure 3 of the HRS documentation record at proposal provides the generic soil sampling schematic followed during CDPHE 2010 site inspection activities.

Furthermore, the HRS purpose for which such site diagrams could be used is to show that a given soil sample establishing observed contamination is within 200 feet of a scored residence in order to evaluate the population associated with that residence under the resident population threat. However, site diagrams are not needed to show this for CDPHE 2010 site inspection. As further discussed in section 3.15, Identification of Observed Contamination – Contaminated Samples, of this support document, page 23 of the HRS documentation record at proposal pointed out that all of the individual aliquots for all the residential properties sampled during the CDPHE

2010 site inspection were collected within 200 feet of the residences, as the associated properties are all less than 200 feet in width and length.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.4.5 Data Quality Assessment

Comment: Mr. Coomes commented that "a Data Quality Assessment Report (that agrees with the EPA guidance for such a document) has not been distributed for review," and requested such a document be made available for review. Mr. Coomes requested that "[i]f EPA believes this project does not require the suggested analysis, please provide the support for this decision in terms [of] project quality." Mr. Coomes points to EPA Order CIO 2105.0, Policy and Program Requirements for the Mandatory Agency-wide Quality System.

Mr. Coomes pointed to the EPA guidance document Practical Methods for Data Analysis, EPA QA/G-9, QA97 Version, EPA/600/R-96/084, January 1998. Mr. Coomes requested that EPA prepare a data quality assessment (DQA) document consistent with this guidance that:

> has at least the following steps: (l) Review the Data Quality Objectives (DQOs) and Sampling Design: (2) Review the DQO outputs to assure that they are still applicable: (3) if DQOs have not been developed, develop DQOs before evaluating the data (e.g., for environmental decisions for environmental decision, the following are needed: define the statistical hypothesis and specify tolerable limits on decision errors; for estimation problems, define an acceptable confidence or probability interval width). Review the sampling design and data collection documentation for consistency with the DQOs.

Response: As described in section 3.3.2, Completion of Data Quality Assessment, of this support document, a data quality assessment was performed for the CDPHE 2010 site inspection data and was available in the docket at Site proposal. This data quality assessment included an overall data quality assessment that was conducted for data generated during the 2010 CDPHE 2010 site inspection (in the CDPHE June 2011 ARR, Reference 22 of the HRS documentation record at proposal), and a data quality assessment specifically generated for the 2010 CDPHE 2010 site inspection XRF results (the March 2012 Data Quality Assessment, Reference 28 of the HRS documentation record at proposal).

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.4.6 Preliminary Assessment XRF Data

Comment: Mr. Coomes commented on the CDPHE 2008 PA report (Reference 19 of the HRS documentation record at proposal), noting that XRF data for several of the sample locations shown in Figure 7 of that report were not listed in Table 7 of the report. Mr. Coomes asserted XRF data are missing for samples XRF-031, XRF-037, XRF-039, XRF-040, XRF-041, XRF-042, XRF-043, XRF-044, XRF-045, XRF-046, XRF-047, XRF-048, XRF-049, XRF-050, XRF-051, and XRF-052. Mr. Coomes concluded the report is incomplete, and requested the missing data to allow him to complete his analysis of the distribution of contaminants and to complete his comments.

Response: Analytical results from the CDPHE 2008 PA report were not directly used in the HRS documentation record at proposal to associate hazardous substances with a source or establish areas of observed contamination for the Site. However, the CDPHE 2008 PA report (Reference 19 of the HRS documentation record at proposal) was not incomplete. The CDPHE 2008 PA report provides a summary of previous investigations that are relevant to the Colorado Smelter site. Regarding the specific sample results mentioned by Mr. Coomes:

- Samples XRF-031 and XRF-037 are contained in Table 7 of the CDPHE 2008 PA report.
- Samples XRF-039, XRF-040, XRF-041, XRF-042, XRF-043, XRF-045, XRF-046, XRF-047, XRF-048, XRF-049, XRF-050, XRF-051, and XRF-052 were collected for a separate investigation of the nearby Blende Smelter and, although shown on Figure 7 of the CDPHE 2008 PA report, these were not included in Table 7 because they are not considered relevant to the Colorado Smelter PA.[10]
- Sample XRF-44 was never collected and is not depicted on Figure 7.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.5 Requests to Extend Comment Period

Comment: Mr. Coomes noted that he had requested in his comments that the EPA provide additional information, stating the information "is needed to perform a meaningful review." Mr. Coomes added "[t]his may require significantly extending the comment period." As detailed in section 3.4, Adequacy of Public Docket/Requests for Additional Documents, of this support document, Mr. Coomes included in his comments several requests for documents and information. Specifically regarding the extension of the comment period, he requested the following:

- A copy of the QAPP associated with the CDPHE 2010 site inspection activities. Mr. Coomes asserted "[t]he actual CDPHE QAPP is critical to preparing specific comments on the proposed listing. Therefore, these comments are not complete and an extension of time is requested to review the QAPP that was actually used."

- "[A] Data Quality Assessment Report (that agrees with the EPA guidance for such a document)." Mr. Coomes commented that such a report "has not been distributed for review," and requested such a document be made available for review, noting this may require a time extension for comments. Mr. Coomes asserted that "[a] complete review of the proposed listing cannot be made until a DQA report has been commented upon."

- Data that Mr. Coomes asserted is missing from the CDPHE 2008 PA report (Reference 19 of the HRS documentation record at proposal). Mr. Coomes noted that an extended comment period will be needed to complete his comments using the additional data.

Response: As explained in the responses provided in sections 3.4, Adequacy of Public Docket/Requests for Additional Documents, and 3.3, Consistency with Data Quality Program, of this support document, the information provided in the HRS package at proposal was sufficient to support the HRS evaluation of the Site and provide the public with a meaningful opportunity to participate in this rulemaking. The 2010 CDPHE 2010 site inspection was performed as planned; the planning and performance of the investigation was documented; data obtained were assessed and determined to be appropriate for their intended use as input for an HRS evaluation. The documents and information relied upon for the HRS evaluation were provided at proposal, and this final rulemaking does not result in a significant change from the proposed rulemaking. The comment period will not be re-opened.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

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[10] The sample results for the Blende Smelter investigation are available from EPA Region 8 on request.

3.6 Risk to Human Health and the Environment

Comment: Two anonymous public commenters, Joe and Pam Kocman, and Mr. Coomes submitted comments related to risk posed by the Site and mitigation of that risk.

Two anonymous public commenters presented arguments regarding blood levels of toxins and the associated risk from the levels detected. Two anonymous public commenters stated that blood levels of both arsenic and lead were very low and not of significant concern. One anonymous public commenter stated that only 6 of 99 individuals tested had elevated levels of lead in their blood. Another anonymous public commenter commented that no individual showed elevated blood arsenic levels above 5 micrograms per deciliter (µg/dl). These two anonymous public commenters concluded that the health problems are overstated and that lead-based paint could be responsible for elevated blood lead levels. Further, one anonymous public commenter questioned that if a health risk was so great, why it took the EPA two years to begin any action after testing for contaminants.

Joe and Pam Kocman commented that the EPA should change its acceptable blood lead level from 10 µg/dl to 5 µg/dl to be consistent with levels that coincide with current acceptable levels according to the CDC. Joe and Pam Kocman further commented that children's blood lead levels in the area showed elevated levels above 5 µg/dl and stated that remediation should be undertaken to reduce blood lead levels in children. However, Joe and Pam Kocman cited a study that was conducted in Baltimore, Maryland[11] (that contained similar lead soil level concentrations as those in homes in the Eilers neighborhood), which found that soil remediation alone did not reduce blood lead levels in children and commented that soil abatement alone will not significantly reduce the blood lead levels. Joe and Pam Kocman commented that EPA should work with other Agencies to remediate more than just neighborhood soil so that blood lead levels can be reduced to below 5 µg/dl.

Mr. Coomes submitted several comments discussing health-based cleanup goals and questioned whether such goals would yield a reduction in risk to the population affected by the Site.

Response: Regarding questions of the level of risk posed by the Site, placing a site on the NPL is not based on a site-specific risk assessment, nor does listing require that a site-specific risk assessment be performed prior to the listing. A site-specific risk assessment is performed later in the Superfund process, following more extensive sampling.

The HRS is not a site-specific risk assessment. A site specific risk assessment quantifies the risk to receptors actually posed by releases at a site. The HRS is a numerically based screening tool that the Agency uses to assess the relative degree of risk to human health and the environment posed by a site compared to other sites subject to review based on a screening level knowledge of site conditions. The HRS score is used to determine whether a site is eligible for placement on the NPL. The NPL is intended primarily to guide EPA in determining which sites warrant further investigation to assess the nature and extent of public health and environmental risks associated with a release of hazardous substances, pollutants or contaminants. See 79 FR 26922 (Proposed Rule, Colorado Smelter site, May 12, 2014); see also 55 FR 51532 (Final Rule, Hazard Ranking System, December 14, 1990). CERCLA § 105(a)(8)(a) requires EPA to determine NPL priorities based on the "relative risk or danger to public health or welfare, or the environment." The criteria EPA applies to determine this relative risk or danger is codified in the HRS, and is the Agency's primary tool for deriving a site score based on the factors identified in CERCLA. The HRS evaluation and score above 28.50 represents EPA's determination that the Site may pose a relative risk or danger to human health and the environment and warrants further investigation under CERCLA.

The issue at hand is the placement of the Site on the NPL based on an HRS evaluation, not the appropriate levels of lead or arsenic exposure according to the CDC or other agency, and these comments do not show any error in the HRS evaluation. As part of the standard Superfund process, once the Site is on the NPL, the investigations

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[11] Citing to the "Three City Abatement Study" (citation not provided by commenter).

performed to characterize the Site will be evaluated for completeness, further information will be collected if deemed necessary to adequately characterize the risks posed by the Site, and based on this information, a risk assessment decision will be made determining if and what remedial action is necessary to protect human health and the environment.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.7 Remediation and Cleanup Levels

Comment: Mr. Coomes, one anonymous public commenter, the City of Pueblo, the Eiler Heights Neighborhood Association, the Bessemer Association for Neighborhood Development, and Joe and Pam Kocman submitted comments related to future remediation and cleanup goals.

Mr. Coomes questioned EPA Superfund lead cleanup levels, and their potential effectiveness at the Colorado Smelter site. Mr. Coomes asserted that EPA Superfund remedial goals for lead in residential soil are inadequate based on the CDC recommendations. Mr. Coomes commented that CDC recommendations include reducing the blood lead level (BLL) to 5 µg/dl; but, EPA Superfund guidance instead recommends no more than five percent of children with BLLs greater than 10 µg/dl and no more than one percent of children with BLLs greater than 15 µg/dl. Mr. Coomes requested that the EPA explain how these goals are protective of children's health. Mr. Coomes also requested that the EPA explain how the EPA's approach will be protective of children's health for those living in the Site area. Mr. Coomes stated, "[n]ote that child blood lead tests have not identified that five percent of the population has BLLs greater than l0 µg/dl, which EPA has as a cleanup goal." Mr. Coomes further requested the EPA "explain how the soil removal to 400 ppm will protect the 0.5 to 4- year olds will be protected [*sic*] when soil containing "less than" 400 ppm is not remediated."

Mr. Coomes stated:

> [T]he EPA cleanup goal for residential properties contaminated with lead is to have no more than 5 percent of the children with blood lead levels greater than 10 µg/dl and no more than 1 percent of the children with blood lead levels greater than 15 µg/dl. None of the children tested in the proposed Superfund area, or all of Pueblo, have blood lead levels as great as the EPA Superfund cleanup goal. Please explain how a Superfund soil cleanup will protect children's health. Yes, I know that EPA does not use blood lead measurements to evaluate a site as clean or contaminated, but it appears that the position of protecting children's health by remediating soil lead is weak—especially since the 400 ppm "action" level is not protective of all ages of children.

Mr. Coomes asserted that the "most applicable" guidances for the Eilers neighborhood related to soil lead levels are the U.S. Department of Housing and Urban Development guidance and Toxic Substances Control Act guidance on the subject.[12]

Mr. Coomes commented on the results of EPA's 1991 study, Three City Urban Soil-Lead Demonstration Project, Midterm Project Update, and stated that the results of this study "should be presented to the Pueblo public" to give them an understanding of the effects of soil remediation on children's blood lead levels. Mr. Coomes stated "it is not clear that soil remediation would result in a meaningful or even measurable decrease in Eilers children's BBL [*sic*]."

Mr. Coomes stated:

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[12] Mr. Coomes cited the April 2001 EPA fact sheet, Identifying Lead Hazards in Residential Properties, EPA 747-F-O1-002; and the U.S. Department of Housing and Urban Development document, Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing, Office of Healthy Homes and Lead Hazard Control, Second Edition, July 2012.

> In the Eilers area, the average soil lead of all individual residential yard samples is 280 ppm and yard averages ranged from 48 to 651 ppm. Assuming that EPA's $15 million dollar study was accurate, replacing Eilers soil would result in an average BLL decrease range of 0.13 to 0.25 µg for the average yard.

Mr. Coomes characterized such a reduction as "insignificant."

Mr. Coomes added that the "EPA study of the Eilers neighborhood did not identify or test play areas even though the Sampling and Analysis plan stated they would."

Mr. Coomes questioned why the Site is being proposed to the NPL, as he asserted that "the evidence does not support doing so."

Additionally, one anonymous public commenter submitted comments asking how the listing is to proceed. The City of Pueblo, the Eiler Heights Neighborhood Association, and the Bessemer Association for Neighborhood Development submitted a list of items that they state EPA should complete before placing the site on the NPL. The Eiler Heights Neighborhood Association stated that "Nothing less than these 'EXPECTATIONS' is acceptable since this is the only way to guarantee our children's health." Joe and Pam Kocman commented that if a comprehensive cleanup cannot be completed in a timely manner (less than 5 years) then EPA should use its emergency response authority to clean up Eiler neighborhood properties that have been identified as contaminated.

Response: Remedial actions and site-specific cleanup criteria are developed at a later stage in the Superfund process, after NPL listing; decisions related to these actions and criteria are not required to be completed prior to promulgation of a site to the NPL. Consistent with CERCLA, the EPA has in place an orderly procedure for identifying sites where releases of substances addressed under CERCLA have occurred or may occur, placing such sites on the NPL, evaluating the nature and extent of the threats at such sites, responding to those threats, and deleting sites from the NPL. The purpose of the initial two steps (identifying sites where releases of substances addressed under CERCLA have occurred, or may occur and placing such sites on the NPL) is to develop the NPL, which identifies for the States and the public those sites that appear to warrant remedial action (56 FR 35842, July 29, 1991). The evaluation or RI/FS phase involves onsite testing to assess the nature and extent of the public health and environmental risks associated with the site and to determine what CERCLA-funded remedial actions, if any, may be appropriate; during this process, site-specific conditions, including determination of exposure scenarios specific to the location, are used to develop site-specific cleanup criteria based on risk. After a period of public comment, the Agency responds to those threats by issuing a Record of Decision which selects the most appropriate alternative. The selected remedy is implemented during the remedial design/remedial action phase. Finally, the site may be deleted from the NPL when the Agency determines that no further response is appropriate.

None of these comments identified any error in the HRS score. This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.8 Purpose of Listing

Comment: One anonymous public commenter expressed suspicion regarding the EPA's motive in listing the Site at this time, arguing that the Colorado Smelter has not operated in 100 years; the commenter noted that EPA Superfund funding was reduced in 1994 following revision of the CERCLA tax on chemicals and petroleum, and characterized it as "curious that the interest in the Eiler's Neighborhood coincides with a [*sic*] the ASARCO 2009 Bankruptcy settlement, which provided the EPA with $1.79 billion to 'clean up' over 80 sites around the country." The same commenter inquired why other sites that appear to be more dangerous in other parts of the U.S. are not cleaned up first.

Response: Funding-related issues are not considered when determining if a Site qualifies for the NPL, and need not be made prior to promulgation of the site to the NPL. The EPA's actions to evaluate the Site using the HRS and list the Site are consistent with the requirements of CERCLA and SARA, and the statutory purpose of the NPL, which is to inform the public of possible threats and identify those sites which appear to warrant further investigation and/or remediation.

The primary purpose of the NPL is stated in the legislative history of CERCLA (Report of the Committee on Environment and Public Works, Senate Report No. 96-848, 96th Cong., 2d Sess. 60 [1980]), as follows (in relevant part):

> The priority list serves primarily informational purposes, identifying for the States and the public those facilities and sites or other releases which appear to warrant remedial actions.

The EPA has clearly, via this listing, identified for the States and the public both the sources and release (the smelter stack air emissions, the slag pile, and contaminated soil) that are currently scored using the HRS.

As previously noted in this support document, the selection of remedy—if any is found necessary—and any associated funding is a step carried out at a later stage of the Superfund process.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.9 Impacts of Listing

Comment: Two anonymous public commenters and Joe and Pam Kocman submitted comments related to the impact of listing the Site on the NPL.

Two anonymous public commenters stated that placing the site on the NPL will negatively impact property values because the homes in the Eiler neighborhood will no longer be marketable. These commenters also stated that property values are dropping because banks will not provide Federal Housing Administration-insured loans or VA loans to purchase homes located in the Eiler neighborhood. One of the anonymous public commenters also stated that because of the loss of value to Eiler neighborhood homes, the commenter considers this listing designation as an illegal taking of the commenter's property. Joe and Pam Kocman expressed that homeowners should not bear any future costs of testing and possible abatement.

Response: Indirect economic factors such as those raised by the commenters are generally not considered in the assessment of whether a site belongs on the NPL. However, even if such factors were considered, the alleged negative impacts noted by the commenters would be caused by the contamination in the area, not by placing the site on the NPL. The EPA also notes that there are benefits associated with listing a site, including the potential for Federally-financed remedial actions; the acceleration of privately financed, voluntary cleanup efforts; and increased support for state funding responses at particular sites.

The Agency's actions in this rulemaking do not result in any taking of private property in violation of the Fifth Amendment. This listing does not impose any obligations on any entities. This listing also does not set standards or a regulatory regime, and imposes no liability or costs. The listing does not interfere with any compensable property interests of private property owners, and merely reflects the EPA's judgment that a significant release or threat of release has occurred, and that the Site is a priority for further investigation.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.10 Extent of Site

Comment: One anonymous public commenter noted that the EPA has not defined the extent of the Site boundaries and is therefore unable to determine the scope of contamination at the Site.

Response: CERCLA Section 105(a)(8)(A) requires the EPA to list national priorities among the known "releases or threatened releases" of hazardous substances; thus, the focus is on the release, not precisely delineated boundaries. On March 31, 1989 (54 FR 13298), the EPA stated:

> HRS scoring and the subsequent listing of a release merely represent the initial determination that a certain area may need to be addressed under CERCLA. Accordingly, the EPA contemplates that the preliminary description of facility boundaries at the time of scoring will need to be refined and improved as more information is developed as to where the contamination has come to be located; this refining step generally comes during the RI/FS stage.

The Agency notes however, that the full extent of a "Site" for Superfund purposes is not determined at the time of listing. Placing a site on the NPL is based on an evaluation, in accordance with the HRS, of a release or threatened release of hazardous substances, pollutants, or contaminants. That the EPA initially identifies and lists the release based on a review of contamination at a certain parcel of property does not necessarily mean that the site boundaries are limited to that parcel.

Until the investigations at the Site are complete and a remedial action (if any) selected, the EPA can neither estimate the extent of contamination at the site, nor describe the ultimate dimensions of the NPL site. Even during a remedial action, such as removing contaminated soils or sediments, the EPA may find that the contamination has spread further than previously estimated, or is not as extensive as estimated.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.11 Comments on Reference Material and Factual Errors

Comment: Mr. Coomes submitted several comments regarding the information presented in references and other perceived factual errors in the HRS package.

Response: The specific comments are addressed in the following sections:

- 3.11.1 Number of Aliquots per Multi-increment Sample
- 3.11.2 Number of Locations Sampled
- 3.11.3 Classification of Grab Samples
- 3.11.4 2011 Analytical Results Report Reference List Items
- 3.11.5 QAPP and Appendix H

3.11.1 Number of Aliquots per Multi-increment Sample

Comment: Mr. Coomes quoted page 23 of the HRS documentation record at proposal as stating that "[i]n each zone, 5 individual aliquots were collected (Ref. 22, p. 12)" (referring to the soil sampling zones at residential yards used in the CDPHE 2010 site inspection). However, Mr. Coomes noted that this is incorrect, identifying that multi-increment sample CO-SO-34-4 contained only four aliquots. Mr. Coomes asserted that "this affects the 'completeness' of the data set and quality analyses should be repeated."

Response: Mr. Coomes is correct that for sample CO-SO-34-4 results for only 4 out of the 5 aliquots were available. However, the completeness of the CDPHE 2010 site inspection was found to be sufficient according to the data quality assessment performed. Furthermore, neither composite results nor individual aliquot results of multi-increment sample CO-SO-34-4 were used to infer contamination within AOC A or to set AOC boundaries. Therefore, the number of aliquots collected has no impact on the decision to promulgate the site to the NPL.

Page 8 of Reference 28 of the HRS documentation record at proposal, the March 2012 Data Quality Assessment, addresses this missing aliquot, stating:

> Completeness is a measure of the amount of valid data obtained from a measurement system. The actual percentage of completeness is less important than the effect of completeness on the data set. All samples collected by CDPHE were analyzed by XRF as planned, with the exception of sample COSO344.2, which was missing from the sample set upon arrival to the EPA warehouse. All 57 confirmation samples were analyzed by the CLP laboratory as planned.

Thus, five aliquots for CO-SO-34-4 were collected, but one aliquot was lost in shipping; no impact to data quality was identified.

And, XRF data were presented as additional evidence of contamination within the AOC. As stated on page 24 of the HRS documentation record at proposal:

> [T]he site score is based on CLP data, specifically CLP analytical results of individual aliquot samples. Within Areas of Observed Contamination (AOCs) based on CLP aliquot samples (Table 3 and Table 5 of this HRS documentation record) XRF multi-increment sample results are also presented (Table 4 and Table 6 of this HRS documentation record). The HRS allows for inferring contamination within an AOC for contaminated soil (Ref. 1, p. 51646). XRF analyses are presented to provide additional evidence supporting the background and release sample concentrations and to provide additional evidence that the area between the observed contamination sampling locations is contaminated.

Thus, CLP analyses were used to establish AOC A for scoring purposes, and XRF analyses were presented to support the inference of contamination within the AOC.

Further, as shown in Table 4: Residential Soil XRF Composites on pages 33-37 of the HRS documentation record at proposal, multi-increment sample CO-SO-34-4 was not used to infer contamination at that associated property; CO-SO-34-2 was presented in that table as evidence of contamination at this property (and, as shown on page 22 of Reference 28 of the HRS documentation record at proposal, five aliquots were collected/analyzed for this zone).

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.11.2 Number of Locations Sampled

Comment: Mr. Coomes questioned the documentation of the number of samples collected, asserting that:

> Appendix G indicates that 8 sample sites were sampled on June 21, 2010 (The sample log book indicates 16 sites were samples [*sic*]), Appendix G indicates that 30 sites were sampled on June 22, 2010 (The sample log book indicates 31 sites were sampled, and Appendix G indicates the 18 sites were sampled on Jun 21, 2010 (the sample log book indicates 20 sample sites were sampled).

Mr. Coomes requested that the EPA correct this apparent inconsistency, contending that "[t]his type of reporting reflects on the overall quality of the investigation and reports."

Response: As shown below, the numbers are consistent with the references and analysis types they are associated with and there is therefore no impact on the quality of the investigation and reports, or on the HRS evaluation of the Site.

The EPA assumes that by "Appendix G," Mr. Coomes is referring to Appendix G of Reference 28 of the HRS documentation record at proposal, the March 2012 Data Quality Assessment. This appendix contains CDPHE chain-of-custody documents for sampling activities conducted by CDPHE in June 2010. The EPA also assumes that by "sample log book," Mr. Coomes is referring to the field log book for June 2010 CDPHE sampling activities included as Reference 21 of the HRS documentation record at proposal.

Regarding samples collected on June 21, 2010, Appendix G of Reference 28 of the HRS documentation record at proposal is a chain-of-custody for soil and source samples submitted for XRF analysis (8 samples). The sample locations listed as collected on June 21, 2010, on field log book pages 1-3 of Reference 21 of the HRS documentation record at proposal additionally include eight surface water and sediment sample locations, which were not submitted for XRF analysis.

Regarding samples collected on June 22, 2010, Mr. Coomes has miscounted: both the chain-of-custody forms in Appendix G of Reference 28 of the HRS documentation record at proposal and field log book pages 4-8 of Reference 21 of the HRS documentation record at proposal list 31 locations sampled.

Regarding samples collected on June 23, 2010, again, chain-of-custody forms in Appendix G of Reference 28 of the HRS documentation record at proposal list the 18 locations from which samples were submitted for XRF analysis. Field log book pages 4-8 of Reference 21 of the HRS documentation record at proposal include those sample locations plus an additional two samples (a surface water sample and a sediment sample) that were not submitted for XRF analysis.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.11.3 Classification of Grab Samples

Comment: Mr. Coomes commented that the data quality assessment report refers to residential aliquot samples as grab samples. However, Mr. Coomes stated that:

> The only grab samples identified in the May 10, Sampling and Analysis Plan (CON000802700) are for 1. A sample of water collected by the county (p 7), background (p 13), waste pile (p13) and soil on the banks of the river (p15). She [*sic*] residential soil samples were collected based on Figure 3 of the SAP.

Mr. Coomes requested that the EPA correct one of those documents (the SAP or the data quality assessment report) and "provide a description of the actual sample collection type, so there is agreement."

Response: Both the March 2012 Data Quality Assessment and the May 2010 Sampling and Analysis Plan (References 28 and 20 of the HRS documentation record at proposal, respectively) are correct in identifying the type of samples collected. All of the samples collected during the CDPHE June 2010 site inspection activities (including individual soil aliquots collected for a multi-increment sample) may be considered grab samples in the sense that there was no field compositing of the samples. (In discussing residential soil sampling, page 15 of Reference 20 of the HRS documentation record at proposal, the CDPHE May 2010 SAP, notes that "[n]o

compositing, drying, or sieving of the samples will occur in the field. [emphasis added]" Page 12 of Reference 22 of the HRS documentation record at proposal, the associated analytical results report, confirms that following collection, the samples "were brought back to Denver and delivered to URS Operating Services (UOS)" and then "[l]ater, UOS combined the samples into 88 multi-increment samples".) Furthermore, whether a sample is classified as an "aliquot" sample or a "grab" sample is not relevant to an HRS evaluation; rather, for HRS purposes it is only relevant whether or not the sample represents the contamination in the environment.[13]

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.11.4 2011 Analytical Results Report Reference List Items

Comment: Mr. Coomes pointed to the reference list included in the CDPHE June 2011 ARR, Reference 22 of the HRS documentation record at proposal, questioning whether entries 58 and 59 in that report are intended to refer to the same document or different documents. (Both reference list entries name the *Sampling and Analysis Plan for the Colorado Smelter Site*, May 2010.) If different, Mr. Coomes requested that both copies be supplied for review.

Response: The References list on pages 42-45 of Reference 22 of the HRS documentation record at proposal is an endnote-style list, with an entry for each citation to a reference within the body of the report text. Reference list entries 58 and 59—as well as entries 3 and 61—refer to the same document, the May 2010 *Sampling and Analysis Plan for the Colorado Smelter Site*.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.11.5 QAPP and Appendix H

Comment: In several instances, Mr. Coomes refers to a QAPP "provided in the Pueblo Rawlins Public Library" and an "Appendix H" that was "provided by EPA," and makes comments on these documents.

Regarding the QAPP "provided in the Pueblo Rawlins Public Library," Mr. Coomes made the following comments:

- "The QAPP that is provided in the Pueblo Rawlins Public Library was written by an unknown organization and not the CDPHE who had sample collecting responsibility."
- "EPA guidance states that the quality of the data must be related to the decisions identified in the Data Quality Objectives prepared for the Sampling and Analysis Plan (SAP). The QAPP at the repository in Pueblo does not address the SAP DQOs and is not acceptable documentation for the Colorado Smelter Investigation."
- Mr. Coomes noted this QAPP "appears to be generic and not related to the Colorado Smelter site Investigation," and "was written by an unknown organization and not the CDPHE who had sample collecting responsibility."

Regarding "Appendix H," Mr. Coomes made the following comments:

- "Appendix H provided by EPA appears to be from an unrelated investigation "Gowanus Canal Remedial Investigation, Brooklyn, New York", as indicated in Table 3' (of that document): Screening Level Comparison to Nondetects."

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[13] See also section 3.12, Identification of Observed Contamination – Soil Collection Technique, of this support document, which further explains HRS requirements for establishing observed contamination.

- "Appendix H is a Data Quality Assessment that only evaluates the ***quality*** of the data after the samples are collected and analyzed. That document mentions a project-specific QAPP three times as the UFP-QAPP. UFP is not defined in the document. The importance of a project-specific QAPP is implied in Appendix H. Appendix H obviously does not apply to the Colorado Smelter, since the word "smelter" is not even in the document."

Response: The QAPP and "Appendix H" documents referred to by Mr. Coomes in his comments appear to be unrelated to the Colorado Smelter site, and thus comments based on these documents are not relevant to the decision to list the Site on the NPL.

Regarding the QAPP found by Mr. Coomes at the local public library, this QAPP was not attached to Mr. Coomes comments, and therefore not available for inspection by the EPA. However, based on Mr. Coomes' related assertions, such as that the QAPP in question was not generated by CDPHE, it is clear that this QAPP was not used in planning the CDPHE 2010 site inspection and is not cited in relevant planning documents (e.g., the CDPHE May 2010 Sample and Analysis Plan, included as Reference 20 of the HRS documentation record at proposal). The CDPHE generic QAPP actually used in planning the CDPHE 2010 site inspection is cited as a reference in the CDPHE June 2011 ARR. This generic QAPP is included as Attachment 1 of this response document. Therefore, Mr. Coomes' comments related to the QAPP he found at the public library are not relevant to the CDPHE 2010 site inspection activities or the NPL listing of the Site.

Similarly, regarding the "Appendix H" document mentioned by Mr. Coomes, Mr. Coomes has not provided a copy of this document or clarified what overarching document to which it is appended. Based on some of Mr. Coomes comments, the "Appendix H" document he is referring to appears to be an appendix to the Gowanus Canal Remedial Investigation report—an EPA document generated for a separate Superfund site in New York.[14] Comments related to this document are not relevant to the CDPHE 2010 site inspection activities or the NPL listing of the Site.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.12 Identification of Observed Contamination – Soil Collection Technique

Comment: Mr. Coomes called into question the usability, comparability, and representativeness of the soil samples results presented in the HRS documentation record and used in the HRS evaluation based on claimed issues with the sampling technique used and asserted inconsistency with an SOP Mr. Coomes stated was provided to the City of Pueblo by the EPA.

Mr. Coomes asserted that "[r]eview of that the Standard Operating Procedure (SOP) provided to the City of Pueblo demonstrates that the SOP was not followed, resulting in questionable data quality from the study." (Mr. Coomes refers to SOP #SRC-OGDEN-02, *Surface Soil Sampling*, included as Attachment 1 of his comment submittal, docket ID EPA-HQ-SFUND-2014-0318-0020.) Mr. Coomes commented that the "actual procedures used to collect samples yield [*sic*] analytical data have not been made available," and concluded "the collected data are not sufficient to support defensible decision-making."

Mr. Coomes commented that the SOP instructed that:
- the soil samples be collected with Shelby tubes,
- new gloves be used at each sample point, and
- a sample location diagram be generated before sample collection.

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[14] Copies of the remedial investigation report for the Gowanus Canal site, including the "Appendix H" to which Mr. Coomes appears to be referring are available at http://www.epa.gov/region2/superfund/npl/gowanus/ri_docs.html.

However, Mr. Coomes asserted that sampling logs show that "samples were collected very rapidly, without sufficient time to follow the SOP provided to the City of Pueblo." Mr. Coomes commented:

> The sampling log book shows that Samples CO-SO-38 through CO-SO-45, 80 individual samples at 8 properties, were collected in an average time of 1 minute and 23 seconds per sample. That is insufficient time to change gloves between each sampling location to prevent cross contamination, use Shelby tubes for sample collection, make a sketch of the sample locations in the yard, and use decontamination procedures. . . . Other sample collection times include: 5 properties; CO-SO-29, 30, 31, 32, and 33, collected 80 samples at 1 minute and 47 seconds for each sample. Another series of samples for four properties; CO-SO-13, 14, 15, and 16 collected 60 samples at 1 minute and 43 seconds each. This analysis clearly demonstrates that the SOP was not followed.

Mr. Coomes noted that related to soil samples used to establish AOC A, page 23 of the HRS documentation record states, "All samples were collected from the top 2-inches of the ground surface (Ref. 22, p. 12)." However, Mr. Coomes also claimed that inappropriate soil sampling equipment different from that specified in the SOP was used, stating:

> The photo documentation supporting the investigation clearly shows the sampling equipment to be a small folding shovel. This sampling equipment is shown in the photo documentation section of the report. It is not clear how a specific 0 to 2-inch soil horizon can be accurately sampled using this crude sampling equipment. . . . if a small shovel was used (no plastic scoops as shown in earlier reports) [p]lease document how the 0 to 2-inch soil horizon was accurately sampled.

Mr. Coomes requested that the EPA "provide documentation that supports using a shovel to collect soil samples to consistently collect the same sample horizon is an accurate methodology" and "[e]xplain how the potential variability affects the data analysis and the 'comparability' and 'representiveness' of the sample data when Shelby tubes are not used to sample a specific soil horizon." Mr. Coomes further stated that:

> Since field duplicate samples were not collected for the Colorado Smelter Study, the potential variation in data resulting from the undocumented sampling method (which is not described in the SOP supplied to the City of Pueblo) is of unknown quality and is of uncertain used [*sic*] to support listing the site.

Mr. Coomes requested that the EPA "discuss this critical issue and how it affects decision-making."

Separately, Mr. Coomes asserted that the EPA did not follow relevant EPA Region 8 guidance for the evaluation of lead at residential properties. Mr. Coomes cited the EPA April 2000 document, *Region VIII Superfund Program Residential Soil Lead Sampling Guidance*. Mr. Coomes alleged this guidance was not referenced or followed in the site investigation, and therefore "the quality of the collected data is suspect and cannot be used to support defensible decision-making." Mr. Coomes commented, "a conceptual site model (CSM) was not included or discussed, although EPA Region 8 guidance provides an example, specifically for historic smelting operations." Mr. Coomes asserted there should have been a discussion of release mechanisms, transport pathways, and receptor populations for each chemical of concern. Mr. Coomes asserted this omission results in a lack of understanding by the public regarding the problems at the Site and what EPA is attempting to do, thus failing one of the objectives of EPA investigative reports.

<u>Response</u>: The SOP cited by Mr. Coomes was not used in planning the CDPHE 2010 site inspection. All of the soil and source samples used in the HRS evaluation for the Site were collected from the top two inches of the soil surface using dedicated, disposable plastic scoops, and a separate plastic scoop was used for each individual

sample, consistent with the CDPHE May 2010 SAP developed for the CDPHE 2010 site inspection.[15] And, as explained below, soil sample results used in scoring the Site met data quality objectives specific to the HRS, which are those relevant to listing (e.g., the objectives related to the collection of data of sufficient quality to determine whether the site qualifies for NPL listing via an HRS evaluation).

First, the SOP Mr. Coomes cited related to his comments (SOP #SRC-OGDEN-02, *Surface Soil Sampling*, included as Attachment 1 of his comment document) was not used during the CDPHE 2010 site inspection and is not cited in relevant planning documents (e.g., the CDPHE May 2010 Sample and Analysis Plan, included as Reference 20 of the HRS documentation record at proposal, or the March 2000 CDPHE QAPP for Site Assessments Under Superfund, included as Attachment 1 of this support document). Mr. Coomes did not indicate in his comments why he believes this SOP is connected to the CDPHE 2010 site inspection. SOP #SRC-OGDEN-02 and its specifications are not relevant to the CDPHE 2010 site inspection activities, and therefore not relevant to the data used for the HRS evaluation of the Site.

The HRS requires in identifying observed contamination for an HRS evaluation that the contamination be within the top two feet of soil (an HRS data quality objective). HRS Section 5.0.1, *General considerations*, states in relevant part:

> - Consider observed contamination to be present at sampling locations where analytic evidence indicates that:
>   –A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (see table 2–3 in section 2.3 for the criteria for determining analytical significance), and
>   –This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil).

There is no HRS requirement that evidence of observed contamination be limited to the top two inches of soil; however, a sample from the top two inches meets this data quality objective.

On the subject of soil samples used to identify the residential soil area of observed contamination, page 23 of the HRS documentation record at proposal notes that "[a]ll samples were collected from the top 2-inches of the ground surface (Ref. 22, p. 12)."

Page 12 of Reference 22 of the HRS documentation record at proposal (the CDPHE June 2011 ARR) cited above, also notes soil collection within the top two inches. And, page 25 of that ARR notes that "[a]ll Technical Standard Operating Procedures (TSOPs) for field activities as specified in the Approved[58] SAP were followed" (referring to the CDPHE May 2010 SAP).

Page 15 of the CDPHE May 2010 SAP (Reference 20 of the HRS documentation record at proposal) states:

> Samples will be collected from 0-2" or slightly deeper depending on landscaping including grass cover. Where grass is present the sod will be peeled back to allow for sample collection and immediately replaced. The samples will be collected with decontaminated stainless steel spoons or disposable plastic scoops.

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[15] Note that, an SOP is generally an established Regional, State, or contractor procedure to address non-site specific investigation activities and issues. These procedures may cover topics such as sampling protocols, chain-of-custody requirements, and quality assurance sampling requirements. In contrast, a SAP generally documents procedural/analytical requirements for a site-specific one-time/time-limited project that involves the collection of samples of water, soil, sediment or other media to characterize areas of potential environmental contamination, and addresses elements specified in the related quality assurance project plan.

As shown in the photolog of the ARR (pages 60-75 of Reference 22 of the HRS documentation record at proposal) the CDPHE sampling crew carried a small shovel in case it was necessary to peel back sod to allow for soil sampling; however this was not necessary for any of the yards sampled as dry loose dirt was always available. A shovel was not used to collect any samples.

Regarding the timing of sample collection, all collected source, background, and residential soil samples were placed into zip-top polypropylene bags (see page 26 of Reference 22 of the HRS documentation record at proposal) using the dedicated scoops; and, no additional soil sample treatment/compositing or analysis was performed in the field. Therefore, very little time was needed to collect each sample.

Regarding duplicate samples, CDPHE followed procedures described in the CDPHE May 2010 SAP to guide field sampling. The SAP did not call for the collection of field duplicate soil samples because of the typical heterogeneity expected in grab soil samples.

Regarding the EPA Region 8 Superfund Program Residential Soil Lead Sampling Guidance, this guidance document is not required to be followed for an HRS evaluation.[16] Additionally, page 1 of this guidance document notes that it “is not intended to replace other guidance documents relating to Program specific activities, SOPs, QAPPs, etc.” It also notes that its purpose is to “[d]efine the nature and extent of contamination and determine where elevated concentrations of lead are present at levels posing an unacceptable risk to humans.” However, as further explained in section 3.6, Risk to Human Health and the Environment, of this support document, an HRS evaluation is not based on a site-specific risk assessment; instead, the HRS is a numerically based screening tool that the EPA uses to assess the relative degree of risk to human health and the environment posed by a site compared to other sites subject to review (a site-specific risk assessment is part of a later step in the Superfund process).

While the CDPHE did not cite the EPA Region 8 Superfund Program Residential Soil Lead Sampling Guidance in the CDPHE May 2010 SAP, it has become common practice for residential soil sampling to include various concepts and procedures described in that guidance, while also following EPA’s site inspection guidance, which helps direct sample collection for proper application of the HRS.[17] For the Colorado Smelter site, the site inspection program staff collected more than one aliquot or increment from multiple decision units at each property sampled during the site inspection. All of the samples collected for the site inspection were collected as grab samples (i.e., there was no field-compositing of any samples), which is typical of CERCLA site inspections. These procedures were correctly performed by CDPHE and are described in Section 8.2.3 of the CDPHE May 2010 SAP, included as Reference 20 of the HRS documentation record at proposal (see Reference 20, pages 14-15 and Figure 3).

Furthermore, as explained in section 3.3, Consistency with Data Quality Program, of this support document, soil sample results used in scoring the Site met data quality objectives specific to the HRS, which are those relevant to listing.

Regarding the CSM, as further detailed in section 3.3.1.1, Conceptual Site Model, of this support document, although the HRS does not require that a CSM be generated or explicitly described to the public (in the HRS documentation record or its supporting references), such a model was included in the CDPHE May 2010 SAP in a

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[16] The Region 8 sampling guidance document referred to by Mr. Coomes is available at http://www2.epa.gov/region8/residential-soil-lead-sampling-guidance-document.

[17] See also page 1 of CDPHE 2010 SAP, included as Reference 20 of the HRS documentation record at proposal, which notes that the SAP was prepared in accordance with the EPA “Guidance for Performing Site Inspections Under CERCLA”, Interim Final, September 1992, the “Region 8 Supplement to Guidance for Performing Site Inspections Under CERCLA,” and the CDPHE Generic Quality Assurance Project Plan (QAPP) (CDPHE HMWMD 2000).

narrative format; and, for the purposes of an HRS evaluation, a CSM used for the relative evaluation of all sites is also built into the HRS itself.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.13 Identification of Observed Contamination – Background Level

Comment: Mr. Coomes submitted several comments asserting that the lead background levels used to establish observed contamination in the HRS documentation record at proposal were low and available data instead support a greater background lead level of around 100 mg/kg.

Mr. Coomes stated:

> The background lead concentrations (two samples) identified in the Colorado Smelter Site Inspection Analytical Results Report[8] June 22, 2011[8] were 47 and 22 mg/kg. Those data are in conflict with the background soil lead in an earlier Colorado Smelter report [Citing Sample Report Santa Fe Avenue Bridge Culvert Pueblo, Colorado COD #98257252513, February 22, 1994.] That report identified a background soil lead concentration of 111 mg/kg (Sample SF-SO-1, -Table 4 of reference 8).

In discussing background lead concentrations, Mr. Coomes also commented that the EPA has not discussed lead-based paint or emissions from leaded gasoline as significant sources in the HRS documentation record. Mr. Coomes pointed to previous EPA studies[18] on other areas of the country, noting that urban area soil lead levels found in those studies were "much greater than those found in the Eilers neighborhood" and the "EPA should not consider the Eilers soil lead levels as out of the ordinary."

Mr. Coomes also pointed to the results from two other studies[19] asserting the results support a background level of 100 ppm and requested EPA provide a detailed discussion why they do not support that value, as follows:

> Please review the Diawara[1] and USGS[13] data and explain why specific samples that were collected in undeveloped areas cannot represent background soil lead concentration, which could approach approximately 100 ppm. The USGS data also support background soil lead concentrations of this magnitude. If EPA considers it not logical to consider those data as representative of background please provide a detailed discussion to support that position.

From the Diawara study, Mr. Coomes specifically mentions two sample locations (Diawara sites 8A and 8B) as being 4.3 miles upwind of the Colorado Smelter site, distant from urban areas and residential development/commercial activity; Mr. Coomes contends that these samples exhibit lead concentrations of approximately 100 ppm and represent background lead soil levels.[20] Mr. Coomes commented that such background levels are supported by the USGS study data (noting 72 soil sample results from that document

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[18] Mr. Coomes cites the EPA 1991 document, Three City Urban Soil-Lead Demonstration Project, Midterm Project Update, and the EPA January 1998 document, Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA97 Version, EPA/600/R-96/084.

[19] Mr. Coomes cites two studies: (1) Diawara, Moussa M., et al. 2006. Arsenic, Cadmium, Lead, and Mercury in Surface Soils, Pueblo, Colorado: Implications for Population Health Risk. Environmental Geochemistry and Health, 28:297-315. This document (hereafter referred to as the 2006 Diawara study) is included as Reference 11 of the HRS documentation record at proposal. (2) Schaklett et al Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States, USGS paper 1270, 1984.

[20] Mr. Coomes points to Figure 3 of his comment submittal, on which he has plotted the locations of Diawara sample locations 8A and 8B. The Diawara study sample locations and lead concentrations may also be found on pages 300 and 302-303 of Reference 11 of the HRS documentation record at proposal.

summarized in Attachment 3 to his comment document on discussion and presentation of USGS data). Mr. Coomes stated "[t]wenty percent (15 of 72) of the county soil lead concentrations were 50 ppm or greater. More than five percent (4 of 72) were 100 ppm lead."

Response: The background samples and associated background lead concentrations used in establishing observed contamination for lead concentrations in the HRS documentation record were selected appropriately and consistently with the HRS. And, the HRS documentation record at proposal presented substantial information to show their suitability to set background levels for the purpose of establishing observed contamination.

The HRS does not contain instructions on or define conditions for establishing background levels of contaminants; background samples should be suitable for comparison to observed contamination samples to establish that the identified significant increase evaluated is not the result of the sampling and analysis methods employed. For the soil exposure pathway, the HRS addresses background only in the context of identifying observed contamination. HRS Section 5.0.1, *General considerations*, states:

> Evaluate the soil exposure pathway based on areas of observed contamination:
>
> - Consider observed contamination to be present at sampling locations where analytic evidence indicates that:
>   –A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (see table 2–3 in section 2.3 for the criteria for determining analytical significance), *and*
>   –This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil).

HRS Section 2.3, Likelihood of Release, states in part, "[t]he criteria in table 2-3 are also used in establishing observed contamination for the soil exposure pathway."

The portions of HRS Table 2-3 used to establish observed contamination and the AOC are cited as follows:

> Sample Measurement ≥ Sample Quantitation Limit[a]
> An observed release is established as follows:
>
> - If the background concentration is not detected (or is less than the detection limit), an observed release is established when the sample measurement equals or exceeds the sample quantitation limit[a].
> - If the background concentration equals or exceeds the detection limit, an observed release is established when the sample measurement is 3 times or more above the background concentration.

Thus, background levels are used for the purpose of identifying a significant increase in hazardous substances.

The HRS uses background levels to show that a hazardous substance is present at concentrations significantly above background levels for a site. The background sample locations used to determine the significant increase from the release from the Colorado Smelter sources are representative of the level that would be present if the release from the Colorado Smelter sources were not present. And, the sampling methods employed for background and observed contamination samples would have minimized effects of other sources, such as lead-based paint on houses and emissions from leaded gasoline.

The HRS documentation record at proposal presents support for the suitability of the background soil samples used in establishing observed contamination. Page 23 of the HRS documentation record at proposal discusses background samples, stating:

> CDPHE performed a Site Inspection on the Colorado Smelter in 2010 (Ref. 22). Sampling activities were conducted from June 21 – 23, 2010 (Ref. 21). Samples were collected from 57 locations including 47 residential properties, 3 vacant lots, 1 road right-of-way, 4 slag pile samples, and 2 background samples (Ref. 22, pp. 12, 21). Background soil samples were collected from an open field approximately 2 miles northwest of the Colorado Smelter and outside the area likely to be impacted by emissions from the former smelter (Ref. 22, p. 21).

Page 23 of the HRS documentation record at proposal also notes the soil samples were collected using the same multi-incremental sampling technique, and that:

> Five individual aliquots were also collected for each of the vacant lots, road right-of-way, background and slag pile samples. All samples were collected from the top 2-inches of the ground surface (Ref. 22, p. 12).

Pages 23-24 of the HRS documentation record at proposal further discuss that background and contaminated soil samples were subjected to the same analytical process, including XRF aliquot/composite sample analysis and CLP confirmatory aliquot/composite analysis for a subset of the contaminated samples and one background sample. And, results from CLP and XRF analyses were validated.

On strategy for background sample location, page 25 of the HRS documentation record at proposal states:

> The background locations were selected to obtain soil samples that were sufficiently far enough away that they were unlikely to be impacted by aerial deposition from the stacks. A map of the surficial geology of the Pueblo area by the United States Geologic Survey (USGS) (Ref. 23 and Ref. 24) was used to compare background and release samples. The map shapefiles were downloaded from the USGS webpage [a copy of the USGS surficial geology of the Pueblo area map is available online[21]] and imported into ArcMap. A map (Ref. 25) was created and shows that the background samples were collected in a Holocene-age unit designated as “xci” and described as a sandy clay disintegration residuum (Ref. 24, p. 13). In comparison, the release samples collected from areas surrounding the former smelter were collected in a Holocene-age unit designated as “es” and described as an eolian sand (Ref. 24, p. 8).

And, page 25 of the HRS documentation record at proposal addresses the possible influence of naturally occurring arsenic and lead levels, stating:

> The suitability of the background samples for comparison to release samples for metals concentrations for the purpose of determining if a release sample is greater than three-times the background concentration is supported by correspondence on February 27, 2012 from the USGS (Ref. 33). Regarding naturally occurring arsenic and lead levels in the surficial units from which samples were collected, the USGS states that the “xci” unit is formed from in-situ weathering of the Pierre Shale, known to be enriched in trace elements including arsenic and, less so, lead. In comparison, the “es” unit would be expected to have lower concentrations of naturally occurring arsenic and lead (Ref. 33). Therefore, the surficial geologic unit “xci” from which the background samples were collected would, if anything, be expected to be biased high relative to the release samples collected from within the “es” unit.

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[21] See http://pubs.usgs.gov/mf/2002/mf-2388/mf-2388_print.pdf

Page 26 of the HRS documentation record at proposal presents the background concentrations for CLP aliquot sample CO-BG-02 1.5 as 15.8 mg/kg[22] lead and 9.5 mg/kg arsenic; these results are used in setting background levels for the identification of CLP aliquot samples meeting observed contamination criteria and establishing the boundaries of AOC A. Page 27 of the HRS documentation record at proposal presents the background concentrations from XRF composite samples CO-SO-BG-01 and CO-SO-BG-02 as 47 mg/kg lead/16 mg/kg arsenic, and 22 mg/kg lead/13.5 mg/kg arsenic, respectively; these results are used in setting background levels for the identification of XRF composite samples meeting observed contamination criteria and to provide additional evidence of contamination within AOC A.

Finally, page 25 of the HRS documentation record at proposal offers additional evidence substantiating the soil background concentrations of arsenic and lead used in establishing observed contamination.

> Three background soil samples collected on September 29, 1994 (Refs. 14b, pp. 10-14; 14c, p.2) for the Santa Fe Avenue Bridge Culvert Expanded Site Investigation (Ref. 14) corroborate arsenic and lead background soil concentrations presented in Tables 1 and 2 of this HRS documentation record. Background soil samples SO1, SO2, and SO3 for the Santa Fe Avenue Bridge Culvert Expanded Site Investigation were collected from three locations located several miles from the Colorado Smelter (Ref. 14b, pp. 13, 14). Arsenic concentrations for these samples ranged from 5.0 ppm to 6.1 ppm and lead concentrations ranged from 13.9 ppm to 32.5 ppm (Ref. 14, p. 18, p. 40; Ref 14c, pp. 18-20).
>
> A study of arsenic, cadmium, lead and mercury in surface soils in Pueblo (Ref. 11) also corroborate background arsenic and lead concentrations presented in Tables 1 and 2 of this HRS documentation record. A local map of lead concentrations (Ref. 11, p. 305, Figure 3) in Pueblo indicates soil samples collected at sites 31A/31B in the northern portion of the study area (Ref. 11, Figure 1) should best represent background conditions. At sites 31A and 31B arsenic concentrations are 13.2 ppm and 14.7 ppm, and lead concentrations are 18 ppm and 30 ppm, respectively (Ref. 11, Table 1, p. 303).

Regarding the lead result of 111 mg/kg for sample SF-SO-1 pointed to by Mr. Coomes and shown in CDPHE 1994 Sample Report, Santa Fe Avenue Bridge Culvert (Reference 13 of the HRS documentation at proposal), this is likely not a viable representation of background levels for the Site because of the sample's proximity to the Colorado Smelter. SF-SO-1 is located approximately 0.7 mile west of the Colorado Smelter (see Figure 9 of Reference 13 of the HRS documentation record at proposal) and is expected to be within the area impacted by aerial deposition from the stacks due to its close proximity to the Colorado Smelter and area known to be contaminated by aerial deposition. Background samples CO-BG-01 and CO-BG-02 used in the HRS documentation record at proposal in the identification of observed contamination, were from approximately 2 miles northwest of the Colorado Smelter.

Regarding the Diawara study samples, Mr. Coomes suggests using Diawara samples 8A and 8B for background—with lead levels of 99 and 100 ppm, respectively, as shown on page 302 of Reference 11 of the HRS documentation record at proposal. However, there is no indication that these locations are more appropriate than other Diawara study sample locations that might be considered as background samples within that study, including Diawara samples 9A/9B, 10A/10B, 11A/11B, 29A/29, or 31A/31B, all of which show lead concentrations comparable to the CDPHE 2010 site inspection background samples with lead levels of 48, 36, 22,

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[22] On page 26 of the HRS documentation record at proposal, this result is noted as being qualified as estimated during data validation, and is adjusted per the EPA Fact Sheet, "Using Qualified Data to Document an Observed Release and Observed Contamination," (Reference 48 of the HRS documentation record at proposal) to provide an estimated maximum possible concentration of 22.75 mg/kg lead prior to use in evaluation of contaminated samples for meeting HRS observed contamination criteria.

28, 53, 30, 38, 23, 18 and 30, respectively, as shown on page 303 of Reference 11 of the HRS documentation record at proposal. (For sample locations, see also Figure 1 of the Diawara study on page 300 of Reference 11 of the HRS documentation record at proposal.) Also, the Diawara study sample locations may not be as representative of background levels, due to less screening out of other sources and proximity to other smelters in the area. As quoted above, the HRS documentation record at proposal does mention Diawara study samples 31A/31B as supporting the concentrations found in background samples CO-BG-01 and CO-BG-02.

Additionally, it appears that the Diawara study samples were prepared for analysis using a different procedure that could impact the lead analysis results: they were sieved prior to analysis. Page 299 of Reference 11 of the HRS documentation record at proposal states that:

> Samples were taken from the top 5-cm of soil and placed in freezer bags. For each sample a subset was sieved to particles less than 2 mm in diameter and stored in glass containers for chemical analysis.

It is not clear that the results from the sieved portions of soil samples analyzed for the Diawara study would be directly comparable to the results from the CDPHE 2010 site inspection CLP aliquot soil samples used in establishing AOC A, which were not sieved. Of the soil particle size fractions, it is possible that lead tends to associate more with one fraction than another; therefore, the smaller particle size fraction included in Diawara studies may be skewed relative to the CDPHE 2010 site inspection samples (e.g., flue dust from the Colorado Smelter stacks would likely exist in smaller particle size, and sieving would tend to select for those particles, impacting comparability). And, the analytical method used to generate Diawara study results is not specified; again, based on a possible difference in analyses, it is uncertain whether these Diawara study results would be either directly comparable to those from the CDPHE 2010 site inspection CLP aliquot soil samples used to establish AOC A, which were generated via CLP methodology, or directly comparable to XRF-analyzed composite sample results presented as additional evidence of contamination within AOC A (i.e., it is possible that differences in sample preparation, digest procedures, analytical precision/accuracy, etc., between the methodologies do not yield directly comparable results).

On the subject of the USGS study data cited by Mr. Coomes, the EPA cannot replicate or verify the analysis or assertions made by Mr. Coomes regarding the background soil lead levels. In response to this comment, the EPA has reviewed Attachment 3 of Mr. Coomes comment document, and the USGS Professional Paper 1270[23] cited by Mr. Coomes as the source of his tabular and graphical data presented in his Attachment 3, based on the samples and sample characteristic data presented. However, these data do not appear to be derived from that particular USGS paper. It appears that the tabular data presented in Mr. Coomes Attachment 3 may be derived instead from USGS Open-File Report 81-197[24], although this reference is not cited by Mr. Coomes. Regardless of these issues, from the pool of data in USGS Open-File Report 81-197, the two USGS soil samples from Pueblo County listed exhibited lead concentrations of 20 ppm and 30 ppm (mg/kg); these concentrations are supportive of the background lead levels used in the HRS documentation record at proposal. Additionally, according to page 2 of the USGS Open-File Report 81-197, soil samples were pulverized and sieved and the minus-2 millimeter fraction used for analysis, and the analysis employed was a semi-quantitative six-step emission spectrographic method. Similar to the Diawara study results, it is not clear that results from these sieved samples would be directly comparable to CDPHE 2010 site inspection CLP aliquot soil sample results used to establish AOC A. And it is uncertain whether these USGS study results would be either directly comparable to those from the CDPHE 2010 site inspection CLP aliquot soil samples used to establish AOC A, which were generated via CLP methodology, or directly comparable to XRF-analyzed composite sample results presented as additional evidence of contamination within AOC A.

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[23] A complete copy of USGS Professional Paper 1270 is available at http://pubs.usgs.gov/pp/1270/.

[24] A complete copy of USGW Open File Report 81-197 is available at http://pubs.er.usgs.gov/publication/ofr81197. An excerpt of this report is included as Attachment 3 of this support document.

Regarding the 1991 EPA document, Three City Urban Soil-Lead Demonstration Project, Midterm Project Update, referred to by Mr. Coomes, the data collected for this study are not representative of background levels for the Colorado Smelter site. While the EPA study identified lead levels in urban areas, specifically three different cities—Boston, MA; Baltimore, MD; and Cincinnati, OH—the identified lead concentrations within the study are applicable to the three cities evaluated and the industries and other contamination sources specific to those cities; these levels are not representative of site-specific factors that may be influencing background lead levels at the Colorado Smelter site. Further, the study areas selected in each city for that study were intentionally areas with elevated soil lead levels (not randomly chosen areas), and were not meant to be representative of lead concentrations in each city.[25] Hence, the data included in the EPA study on urban soil lead levels are not relevant to establishing site-specific background levels for the Colorado Smelter site.

Finally, even if the highest lead concentration Mr. Coomes proposes as a reasonable background concentration—111 mg/kg lead—were used to set the lead background level, many of the sample results used to establish observed contamination based on lead would still meet observed contamination criteria. The lead sample results would exceed three times that number—333 mg/kg (20 out of the 31 CLP aliquot sample lead results shown in Table 3 of the HRS documentation record at proposal). Although the resulting hypothetical AOC A based on only the samples with concentrations greater than 333 mg/kg would shrink based on that exercise, the sample locations still documenting observed contamination established via arsenic concentrations and the related Level I targets scored based on those locations would not change. And, the Site score would not change even if the targets score were based solely on those points of arsenic observed contamination and Level I targets.[26]

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.14 Identification of Observed Contamination – Significant Increase Criteria

<u>Comment</u>: Mr. Coomes called into question the criteria used to identify a significant increase in hazardous substances over background levels in samples used to document the presence, location, and level of observed contamination. Mr. Coomes stated:

> EPA compared three times the background concentration of lead to identify a need for investigation. This criterion is generally used to determine whether there has been a release from a source, and are [*sic*] not criteria used to list a site on Superfund.

<u>Response</u>: The criteria used to establish observed contamination in the HRS documentation record at proposal are consistent with the HRS and are criteria specifically used in evaluating a site for NPL listing. Using a hazardous substance in a contaminated sample exhibiting concentrations three times or more the background level to establish observed contamination is part of HRS-specified criteria.

HRS Section 5.0.1, *General considerations*, identifies the significant increase criteria, and states in relevant part:

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[25] See page 3 of the 1991 EPA document, Three City Urban Soil-Lead Demonstration Project, Midterm Project Update, available online at http://nepis.epa.gov/Exe/ZyPDF.cgi/2000QLHH.PDF?Dockey=2000QLHH.PDF.

[26] The waste characteristics factor category value would remain unchanged as well since the hazardous substances scored would still include arsenic and lead. And, even though AOC A might shrink in the hypothetical scenario, the waste quantity AOC A contributes to the score is minimal compared to that contributed by the slag pile AOC B. Therefore, considering a likelihood of exposure value of 550, a waste characteristics factor category value of 100, and a resident population targets factor category value of 205 (based solely on the Level I concentrations score of 155 established by arsenic points of observed contamination and the resulting resident individual score of 50), the soil exposure pathway score would remain 100.00 and the Site score would remain 50.00 in this hypothetical scoring.

- Consider observed contamination to be present at sampling locations where analytic evidence indicates that:
  –A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (**see table 2–3 in section 2.3 for the criteria for determining analytical significance**), and
  –This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil). [emphasis added]

HRS Section 2.3, *Likelihood of release,* introduces Table 2-3 which is used to identify observed releases in the ground water, surface water, and air pathways and observed contamination in the soil exposure pathway—the pathway evaluated for this site. HRS Section 2.3 states in part to "[u]se the criteria in table 2–3 as the standard for determining analytical significance. (The criteria in table 2–3 are also used in establishing observed contamination for the soil exposure pathway, see section 5.0.1.)"

HRS Table 2-3 is contained in HRS Section 2.3, *Likelihood of release*, referred to by HRS Section 5.0.1, General considerations, and establishes the mathematical requirements for establishing observed contamination or observed releases; it states in relevant part:

- If the background concentration is not detected (or is less than the detection limit), an observed release is established when the sample measurement equals or exceeds the sample quantitation limit.
- If the background concentration equals or exceeds the detection limit, an observed release is established when the sample measurement **is 3 times or more above the background concentration**. [emphasis added]

Tables 3 and 4 on pages 29-36 of the HRS documentation record at proposal present three-times-background for each analyte (in a column labeled "3xBG/SQL") to show that the related contaminated soil sample results meet HRS criteria for establishing observed contamination, consistent with the HRS.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.15 Identification of Observed Contamination – Contaminated Samples

Comment: Mr. Coomes asserted that, in the comparison of composite sample results versus individual aliquot results, a high bias is apparent in the composite sample results. Mr. Coomes noted this "is after EPA made a correction for one of the composite lead values, (CO-SO-20-3)." Mr. Coomes points to Figure 4 of his comment document, stating, "Figure 4 compares the difference between the average lead for the aliquots and lead concentration of the composite sample. The average difference is 43.3 ppm, a value that is greater than the EPA's identified "background" concentration (37.5ppm)."[27]

Mr. Coomes commented that the composite results were "19 percent larger than the mathematically combined amounts from the five individual samples. EPA has not explained how this bias was introduced, but places the quality of the data is in question."

Response: The samples used to establish observed contamination and the AOC meet all HRS data quality objectives for identifying contaminated samples for the purposes of the HRS evaluation. Despite any tendency for composite sample XRF results to be greater than related aliquot sample XRF results, they still met the HRS significant increase criteria for establishing observed contamination by showing a significant increase above the

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[27] Figure 4 of Mr. Coomes' comment submittal is included as Attachment 6 of this support document.

background levels established using the same type of sample. Further, the difference between composite results and aliquot results is expected given the different sample treatment.

As explained below, CLP aliquot sample results were used to establish the boundaries of observed contamination in residential soils associated with AOC A. XRF composite sample results (the subject of Mr. Coomes' bias arguments) were only used to provide additional evidence of the extent of contamination within AOC A. Furthermore, composite samples are not required by the HRS; any individual aliquot result within 200 feet of a residence meeting observed contamination criteria is sufficient to establish observed contamination and score the residence under the HRS resident population threat.

HRS Section 5.0.1, *General considerations,* describes how to document observed contamination and an AOC, stating in relevant part:

> - Consider observed contamination to be present at sampling locations where analytic evidence indicates that:
>   –A hazardous substance attributable to the site is present at a concentration significantly above background levels for the site (see table 2–3 in section 2.3 for the criteria for determining analytical significance), and
>   –This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil).
> - Establish areas of observed contamination based on sampling locations at which there is observed contamination as follows:
>   –For all sources except contaminated soil, if observed contamination from the site is present at any sampling location within the source, consider that entire source to be an area of observed contamination.
>   –For contaminated soil, consider both the sampling location(s) with observed contamination from the site and the area lying between such locations to be an area of observed contamination, unless available information indicates otherwise.
> - If an area of observed contamination (or portion of such an area) is covered by a permanent, or otherwise maintained, essentially impenetrable material (for example, asphalt) that is not more than 2 feet thick, exclude that area (or portion of the area) in evaluating the soil exposure pathway.
> - For an area of observed contamination, consider only those hazardous substances that meet the criteria for observed contamination for that area to be associated with that area in evaluating the soil exposure pathway (see section 2.2.2).
>
> If there is observed contamination, assign scores for the resident population threat and the nearby population threat, as specified in sections 5.1 and 5.2. If there is no observed contamination, assign the soil exposure pathway a score of 0.

HRS Section 5.1, *Resident Population Threat,* states:

> Evaluate the resident population threat only if there is an area of observed contamination in one or more of the following locations:
>
> - Within the property boundary of a residence, school, or day care center *and* within 200 feet of the respective residence, school, or day care center, or
> - Within a workplace property boundary *and* within 200 feet of a workplace area, or
> - Within the boundaries of a resource specified in section 5.1.3.4, or
> - Within the boundaries of a terrestrial sensitive environment specified in section 5.1.3.5.

> If not, assign the resident population threat a value of 0, enter this value in table 5–1, and proceed to the nearby population threat (section 5.2).

There is no requirement that composite samples be used and no detailed requirements for any specific sample type. Therefore, any aliquot soil sample within 200 feet of a scored residence meeting observed contamination criteria is sufficient to identify observed contamination and evaluate the population associated with that residence under the resident population threat of the HRS. As noted on page 23 of the HRS documentation record at proposal, all the individual aliquots for all the residential properties sampled during the CDPHE 2010 site inspection were collected within 200 feet of the houses, as the associated properties are all less than 200 feet in width and length (this was not contested by commenters).

Regarding XRF composite sample results, page 24 of the HRS documentation record at proposal states that the CLP results from <u>aliquot</u> samples were used to establish AOC A, and that XRF results from <u>composite</u> samples were only used as additional evidence of contamination; it states:

> In this HRS documentation record the site score is based on CLP data, specifically CLP analytical results of individual aliquot samples. Within Areas of Observed Contamination (AOCs) based on CLP aliquot samples (Table 3 and Table 5 of this HRS documentation record) XRF multi-increment sample results are also presented (Table 4 and Table 6 of this HRS documentation record). The HRS allows for inferring contamination within an AOC for contaminated soil (Ref. 1, p. 51646). XRF analyses are presented to provide additional evidence supporting the background and release sample concentrations and to provide additional evidence that the area between the observed contamination sampling locations is contaminated.

Those CLP aliquot contaminated sample results and XRF composite contaminated sample results are shown in Tables 3 and 4 on pages 29-36 of the HRS documentation record at proposal.

Page 24 of the HRS documentation record at proposal notes that these results are supported by the XRF results from <u>aliquot</u> samples:

> It should be noted that the XRF aliquot data comprises a larger, and therefore more robust, data set than either the laboratory data or the XRF composite data and that the XRF aliquot data set corroborates the HRS score derived and presented in this documentation record. All data obtained during the June 21-23, 2010 sampling event are presented in the ARR (Ref. 22) and DQA (Ref. 28). XRF composites and aliquot sample lead concentrations are illustrated on Figures 6 and 7 contained as References 32a and 32b to this HRS documentation record.

Thus, as explained above, the observed contamination present in AOC A was established using samples that met all HRS data quality objectives.

Furthermore, the difference between composite sample lead results and aliquot sample lead results is expected given the different sample preparation for each sample type. Pages 23-24 of the HRS documentation record at proposal state that:

> A total of 434 individual samples were collected into 1-quart plastic bags. All 434 of the sample aliquots were delivered to URS Operating Services (UOS), EPA’s Superfund Technical Assessment and Response Team (START) laboratory in Denver, Colorado (Ref. 22, p. 4;Ref. 22b; Ref. 28, Appendix G) where they were analyzed using an Innov-X model Omega X-Ray Fluorescence analyzer (XRF) (Ref. 28 p. 2). The samples were analyzed directly in the bags using the XRF (Refs. 22, p. 12; 28, p. 1). Subsequently, the samples were composited, dried, sieved, placed in method specific polyethylene sample cups per EPA Method SW-846 6200 guidelines

> (Ref. 29, pp. 19, 20), and analyzed with the XRF (Ref. 28, p.1). The 434 aliquots were thus combined into 87 multi-increment samples (also known as composite samples) . . .

Therefore, as part of sample processing per analytical method specifications, composite samples were sieved and dried (aliquot samples were not). This processing would be expected to increase measured lead concentrations, and can explain the "bias" calculated by Mr. Coomes, for two reasons. First, moisture can be a negative interference for XRF analysis, and thus more moist samples (the aliquot samples) will tend to yield lower analyte measurements than drier samples (the composite samples) [28]. And second, a sieved sample (the composite sample) will contain a greater proportion of smaller particles than a non-sieved sample (an aliquot sample); as the lead-bearing material deposited from the Colorado Smelter was likely composed of fine-grained flue dust, a sieved sample would likely exhibit a greater lead concentration than a non-sieved sample. However, these differences did not introduce an inaccuracy in the comparison between background and release samples presented in the HRS documentation record, because CLP aliquot release samples were compared to CLP aliquot background samples and XRF composite release samples were compared to XRF composite background samples (within each background/release sample set, compared samples were subject to the same sample preparation techniques and same resulting effects on lead concentrations).

Regarding Mr. Coomes statement that the "average difference is 43.3 ppm, a value that is greater than the EPA's identified 'background' concentration (37.5ppm)," this is not the background lead level that was used in the HRS documentation record at proposal. Page 26 of the HRS documentation record at proposal presents the lead concentration from CLP aliquot background sample CO-BG-02 1.5 as 15.8 mg/kg lead; this result is used in setting background levels for the identification of CLP aliquot samples meeting observed contamination criteria and establishing the boundaries of AOC A. Page 27 of the HRS documentation record at proposal presents the lead concentrations from XRF composite background samples CO-SO-BG-01 and CO-SO-BG-02 as 47 mg/kg lead and 22 mg/kg lead, respectively; these results are used in setting background levels for the identification of XRF composite samples meeting observed contamination criteria and to provide additional evidence of contamination within AOC A. A value of 37.5 was not used as a background concentration in the HRS documentation record at proposal.

Additionally, if the purpose of Mr. Coomes' statement was to call into question the background levels used in the HRS documentation record at proposal by comparing the magnitude of the background levels to the average difference value he calculated, such a comparison is not statistically appropriate and does not negate the validity of those background levels. That is, as described above, the average difference between the composite sample results and the aliquot sample results represents the difference between two different sample preparation processes. Because the two sets of data are developed in different ways, it is inappropriate and not meaningful to compare this average difference value to results generated by either individual sample preparation process (the aliquot samples results or the composite sample results).

Regarding the correction of one of the composite lead values, in sample CO-SO-20-3, it was explained in Reference 22a of the HRS documentation record at proposal that:

> The error appears on page 19 (in-text Table 8) of the Analytical Results Report where the lead concentration for sample SO-20-3 is incorrectly reported to be 632 part per million (ppm). The correct lead concentration for this sample is 362 ppm. The error is also contained in Figure 6. The rest of the ARR is correct, including the summary table at the end of the ARR.

And, SO-20-3 was not used in establishing observed contamination at the Site.

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[28] For example, see page 6200-5 of Reference 29 of the HRS documentation record at proposal (EPA Method 6200). See also page 7 of the EPA Region 4 Science and Ecosystem Support Division Operating Procedure SESDPROC-107-R2, Field X-Ray Fluorescence Measurement, available at http://www.epa.gov/region4/sesd/fbqstp/Field-XRF-Measurement.pdf.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.16 Attribution

Comment: Mr. Coomes submitted comments calling into question the attribution of hazardous substances to the Site based on his review of data cited by EPA. Mr. Coomes asserted that the EPA "assumes that the smelter was the primary, or only, source of lead contamination" and that "[t]his conclusion is based on the fact that other potential lead sources were not investigated or described."

Mr. Coomes commented that particulate from stack emissions should deposit "uniformly in the area and be more concentrated downwind of the stack, but generally decreasing with distance from the source." Mr. Coomes argued that the distribution of lead concentrations "does not support a particulate deposition model from a point source." Based on the EPA's model of the Site, Mr. Coomes contended that:

> Assuming that the smelter is the source of contamination, the ratio of lead to arsenic should be uniform over the 'contaminated' area and decrease in concentration with distance from the source. The collected soil samples and analysis do not support this Conceptual Site Model concept.

Further, Mr. Coomes commented that the data quality objective guidance calls for a site-specific CSM to be prepared and claims that one is not present; Mr. Coomes therefore asserts that the "release mechanisms, transport pathways, affected media, and intake routes" are not explained and the attribution of hazardous substances to the Site cannot be made.

Response: The attribution of hazardous substances (lead and arsenic) in the residential soil AOC to the Site is properly established consistent with the HRS. The Colorado Smelter is reasonably documented to have released lead and arsenic contaminants through historical operations via smelter stack emissions that were deposited in the AOC surrounding the Colorado Smelter stacks.

HRS Section 5.0.1, *General considerations*, states:

> Evaluate the soil exposure pathway based on areas of observed contamination:
>
> • Consider observed contamination to be present at sampling locations where analytic evidence indicates that:
>
> > –A hazardous substance **attributable to the site** [emphasis added] is present at a concentration significantly above background levels for the site (see Table 2–3 in section 2.3 for the criteria for determining analytical significance), *and*
> >
> > –This hazardous substance, if not present at the surface, is covered by 2 feet or less of cover material (for example, soil).
>
> Establish areas of observed contamination based on sampling locations at which there is observed contamination as follows:
>
> > . . . .
> >
> > –For contaminated soil, consider both the sampling location(s) with observed contamination from the site and the area lying between such locations to be an area of observed contamination, unless available information indicates otherwise.

> • If an area of observed contamination (or portion of such an area) is covered by a permanent, or otherwise maintained, essentially impenetrable material (for example, asphalt) that is not more than 2 feet thick, exclude that area (or portion of the area) in evaluating the soil exposure pathway.
>
> • For an area of observed contamination, consider only those hazardous substances that meet the criteria for observed contamination for that area to be associated with that area in evaluating the soil exposure pathway (see section 2.2.2).

Page 21 of the HRS documentation record at proposal discusses hazardous substances that are associated with the Site sources:

> It has been documented that smelter stack emissions contain particulates of heavy metals (Ref. 42, pp. 53, 55; Ref. 43, p. 170). Samples of the slag generated by the Colorado Smelter contain lead and arsenic (Ref. 22, pp. 58, 59) and it is reasonable to conclude that particulate emissions from the Colorado Smelter stacks also contained lead and arsenic. In addition, the ore from the Madonna mine processed at the Colorado Smelter contained 30 percent lead (Ref. 4, p.34, Ref. 5). In the smelting process, it is not possible to separate all the desired metal from other products including slag and flue dust (Ref. 44, p. 92). Flue dust samples collected from the Anaconda Minerals Company (AMC) smelter in Montana contain arsenic and lead at concentrations up to 14,300 ppm and 55,000 ppm, respectively (Ref. 45, pp. 38, 98, 106). Slag from the AMC smelter contains arsenic and lead at concentrations of 217 ppm and 3,120 ppm, respectively (Sample AM-SO-06) (Ref. 50, Table 2, p. 46). In comparison, the average concentration of arsenic and lead in slag for the Colorado Smelter based on nine CLP aliquot samples is 503 ppm and 10,333 ppm, respectively (Ref. 28, Table 1, p. 14) further indicating that stack emissions from the Colorado Smelter also contained arsenic and lead.

Pages 38-39 of the HRS documentation record at proposal further discuss the attribution of hazardous substances identified in the AOC to the Site in the attribution section:

> Between the 1880's and the 1920's, five smelters operated in the City of Pueblo and its nearby subdivisions. These included the Colorado Smelter, the Pueblo Smelter, the Philadelphia Smelter, the Massachusetts Smelter, and the Blende Smelter (Ref. 4, pp. 1-5; Figure 1 of this HRS documentation record). In addition to the smelters, the Colorado Fuel and Iron Co. (CF&I) located south of the Colorado Smelter (Figure 1) began operations in Pueblo in the late 1800s processing pig iron to make steel and iron products (Ref. 11, p. 298). This facility continues in operation under the name Rocky Mountain Steel Mills. The facility is an active Resource Conservation and Recovery Act (RCRA) facility with dozens of solid waste management units (SWMUs) in various stages of assessment and cleanup. The mill continues to operate under a state Resource Conservation and Recovery Act permit (CO-05-09-29-01) and a Clean Air Act Title V Operating Permit (95OPPB086) (Ref. 19, p. 3).
>
> Historical photographs (Ref. 4, p. 32, Ref. 9) of the Colorado Smelter show plumes of smoke carried by wind being dispersed away from the stacks to the southeast. Sanborn Fire Insurance maps (Ref. 8) show drawings of the Colorado Smelter and note the height of the main smoke stack as 135 feet and a 200-foot-tall brick chimney for the roaster house as well as several other stacks (Ref. 8c, Sheet 23, Ref. 8d, Sheet 157).
>
> Prevailing winds at the Colorado Smelter during the time of operation were out of the north and northwest as noted on Sanborn Fire Insurance Maps for the years 1883-1904 (Refs. 8a, p.1; 8b, p.

> 1; 8c, p. 1; 8d, p. 1). Wind rose diagrams from a meteorological station located just south of the Colorado Smelter on the Rocky Mountain Steel Mill for the time period January 1, 2003 - December 31, 2005 and March 1, 2008 - February 28, 2009 show prevailing winds out of the west-northwest (Ref. 46, pp. 1-3).
>
> …
>
> The area of area of [*sic*] observed contamination as shown on Figure 4 of this HRS documentation record is located within 1800 feet of the northern (and most distal) smoke stack depicted and within 1663 feet of the southern (and more proximal) smoke stack depicted. The proximity of the stacks to the area of observed contamination along with the historic prevailing wind direction is evidence that at least a portion of the significant increase in lead and arsenic in AOC A is attributable to the Colorado Smelter stacks.
>
> The map (Ref. 14a) from the 1995 ARR for the Santa Fe Avenue Bridge Culvert (Ref. 14) shows the spatial distribution of arsenic and lead contamination in soils surrounding the five smelters that were operating in Pueblo from 1878 (Ref. 4, p. 13) until 1921 (Ref. 4, pp. 114-115). The map shows a pattern that indicates a significant increase in lead and arsenic levels adjacent to the Colorado Smelter.
>
> The study of the metal content of surface soils in Pueblo conducted by affiliates of Colorado State University published in 2006 (Ref. 11) also show an increase in lead concentration near the Colorado Smelter. Sites 19A/19B and 20A/20B located southeast of the Colorado Smelter indicate lead concentrations ranging from 149 ppm to 287 ppm (Ref. 11, Figure 1 and Table 1; Ref. 47).
>
> The increase in lead soil concentrations in residential areas proximal to the Colorado Smelter based on data from the Colorado Smelter Site Inspection ARR (Ref. 22) is illustrated by Figures 6 and 7 (Refs. 32a and 32b). These maps present the lead soil concentration using graduated symbols that graphically depict lead concentrations which are hence easily observed to be higher in the residential areas immediately south and east of the Colorado Smelter.
>
> For the area of observed contamination comprising 176 residential properties a portion of the significant increase is attributable to the Colorado Smelter. The presence of lead and arsenic soil contaminated to levels meeting HRS Table 2-3 criteria indicate lead and arsenic were emitted from the smelter's smoke stacks and deposited on nearby soil.

As presented in the HRS documentation record and references cited therein, arsenic and lead are associated with emissions from the Site sources. The HRS documentation record at proposal explains that historical photographs show plumes of smoke travelling away from the stacks to the southeast. Further, it explains that because the slag generated by the Colorado Smelter during the refining process contains lead and arsenic, it is reasonable to conclude that emissions from the Colorado Smelter stacks also contained lead and arsenic. This is consistent with similar current smelter operations that are known to emit the same substances present in their slag and flue dust. Therefore, the arsenic and lead identified in the local residential soils as being significantly above background sample concentrations was correctly identified as observed contamination and was correctly attributed to the Site, consistent with the HRS; and, it is reasonable to conclude that emissions from Site Source 3, Smelter Stack air emissions, which contain arsenic and lead resulting from operations at the site, caused the significant increase of hazardous substances in the AOC.

Regarding Mr. Coomes comments on data quality objectives and the CSM, while the HRS documentation record does not specifically refer to a CSM, as quoted above, the Source and Attribution sections of the HRS documentation record identify the hazardous substances (lead and arsenic), the process that released contamination (the smelting process), the method of transport (Smelter emissions and plumes of smoke), and the affected media (contaminated soil). As outlined in section 3.3, Consistency with Data Quality Program, of this support document, and further demonstrated in this section of this support document and its subsections, the data used to establish observed contamination at the Site are sufficient to support the attribution of lead and arsenic in the residential soil to releases of lead and arsenic from the Colorado Smelter facility.

The following subsections of this support document address specific assertions regarding the attribution of hazardous substances to the facility:

- 3.16.1 Attribution – Distribution of Lead in Soil – Lack of Concentration Cluster
- 3.16.2 Attribution – Distribution of Lead in Soil - Variability
- 3.16.3 Attribution – Arsenic Levels in Soil *vs* Arsenic Levels in Slag
- 3.16.4 Attribution – Arsenic/Lead Ratios – Distribution of Arsenic Relative to Lead
- 3.16.5 Attribution – Comparison of Site-related and Greater Area-related Datasets
- 3.16.6 Attribution – Other Sources

3.16.1 Distribution of Lead in Soil – Lack of Concentration Cluster

Comment: Mr. Coomes commented that based on his review of analytical data there was no lead concentration cluster near the Colorado Smelter. Mr. Coomes inspected results in the 2006 Diawara study (Reference 11 of the HRS documentation record at proposal) and plotted on a map locations where the lead concentrations exceeded 100 ppm (this plot is included as Figure 2 of Mr. Coomes comment submission[29], docket ID EPA-HQ-SFUND-2014-0318-0020). Mr. Coomes asserted that:

> There is no not [*sic*] a concentration (or cluster) of these locations near the Historic Colorado Smelter Site. In fact, the "high" lead soils are distributed over the entire investigative area (all of Pueblo), except the far Northern portion of that investigation, which has only recently been (sparsely) developed for residential use. Site 19A (177 ppm lead) is adjacent to Eilers, on the South side of Northern Avenue. That location may be suspect because it is adjacent to the existing Steel Mill and across Northern Avenue from the site. This suspicion is confirmed by examining the relatively high lead in sample 20B (149 ppm), which is located South East of the Steel Mill operation, and is close to the commercial metal operation.

Mr. Coomes requested that the EPA "explain how the Colorado Smelter emitted lead-containing particulate, but high (greater than 100 ppm) soil lead concentrations are not located or concentrated immediately surrounding the Historic Colorado Smelter site." Mr. Coomes stated that the "collected data do not support the EPA assumption that soil lead concentrations decrease with increased distance from the Historic Colorado Smelter" and requested this be addressed in the "Listing Document and supporting documentation."[30]

Response: Regarding Mr. Coomes' assertion that there is no support that lead concentrations are highest clustered around the facility and decrease with distance from the historic Colorado Smelter, this assertion is incorrect. The data presented in the HRS documentation record (specifically the data presented in figures shown in References

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[29] Mr. Coomes plotted on Figure 2 of his comment submittal locations where the Diawara study sample lead concentrations exceeded 100 ppm. All of the Diawara study sample locations and lead concentrations may also be found on pages 300 and 302-303 of Reference 11 of the HRS documentation record at proposal.

[30] Mr. Coomes pointed to Figure 1 of his comment submittal, noting it is a reproduction of Figure 7 from Reference 17 of the HRS documentation record at proposal. (However, he cites instead to Reference 19, which appears to contain the figure that is the basis for his Figure 1; this figure shows sample locations from 1994/1995 CDPHE soil collection activities.) Mr. Coomes explains he added 0.5, 1.0, and 1.5 distance rings to his Figure 1.

14, 32a, and 32b of the HRS documentation record at proposal) illustrate this decreasing gradient to be present—there is a concentration cluster near the historic Colorado Smelter. (See Figures 4, 5, and 6, of this support document below based on these references. Additionally, Figures 5a and 5b of this support document represent the CDPHE 2010 site inspection composite sample XRF lead results, focusing on soil samples, and varying plot size and color based on concentration.) The EPA does not claim that this gradient extends throughout the city or region as the commenter may be asserting, but rather that in the immediate vicinity of the smelter facility, the soil lead concentrations decrease as the distance from the historic smelter stack increases. Additionally, several of the residential soil samples in AOC A near the Colorado Smelter contain lead concentrations well above 100 mg/kg (the level Mr. Coomes' equated with "high" concentrations). See Figures 5 and 6 of this support document[31].

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[31] See also pages 51-59 of Reference 22 of the HRS documentation record at proposal for a full list of CDPHE 2010 site inspection soil sample results.

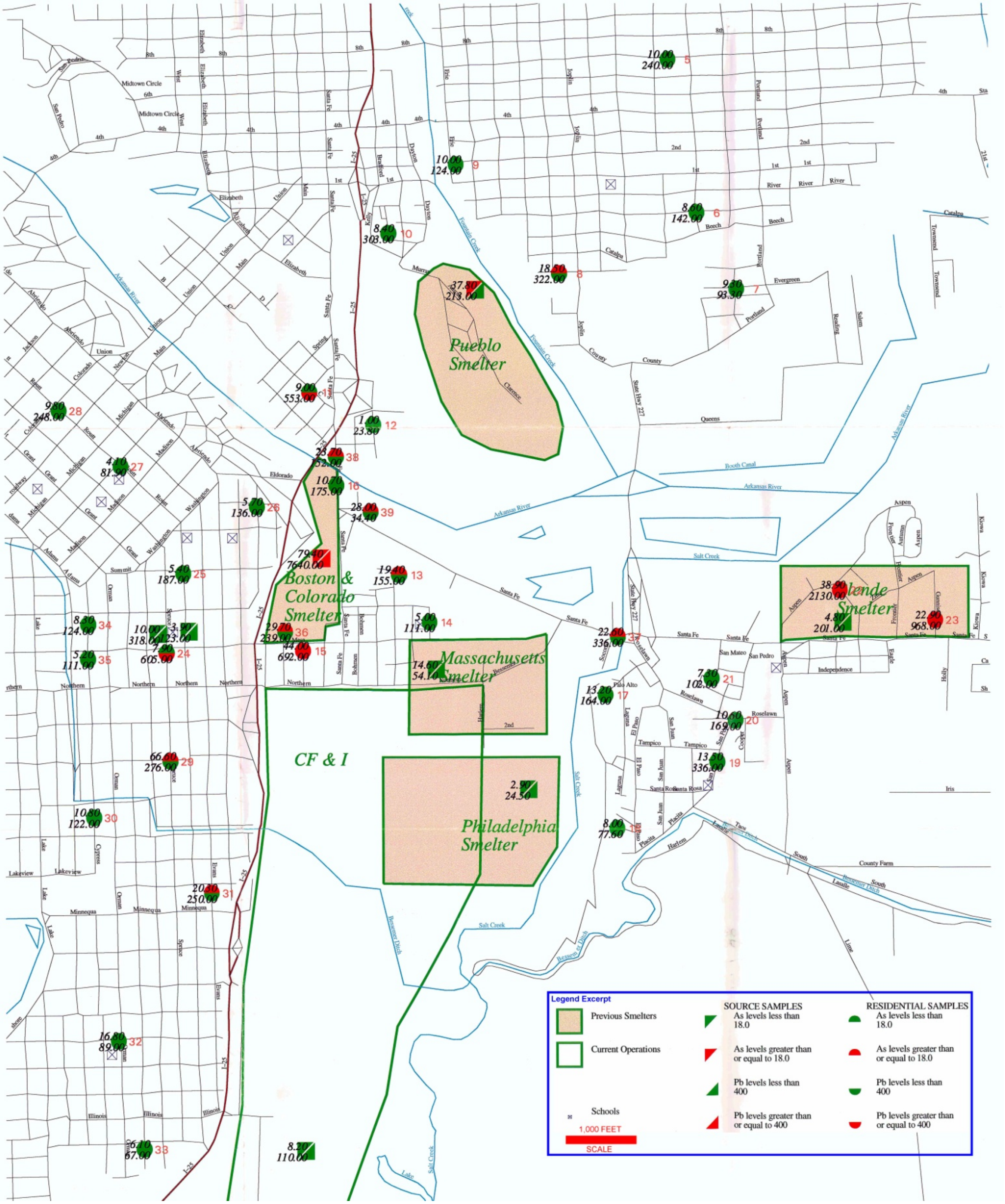

Figure 4: CDH 1995 expanded site inspection report results. (Modified figure from Reference 14a of the HRS documentation record at proposal: cropped, and legend excerpted.)

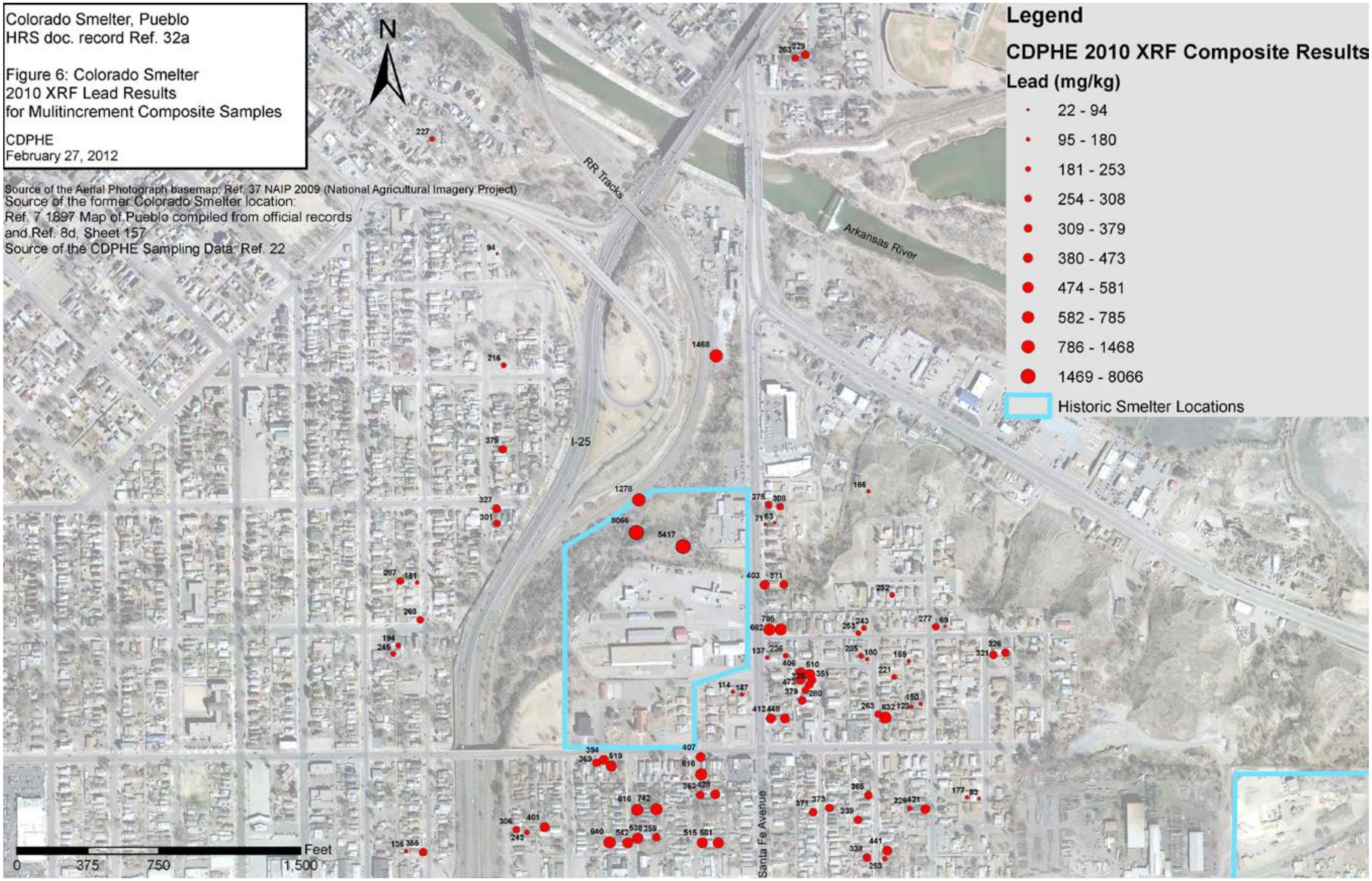

Figure 5: CDPHE 2010 site inspection composite sample XRF lead results. (Figure from Reference 32a of the HRS documentation record at proposal. Cropped.)

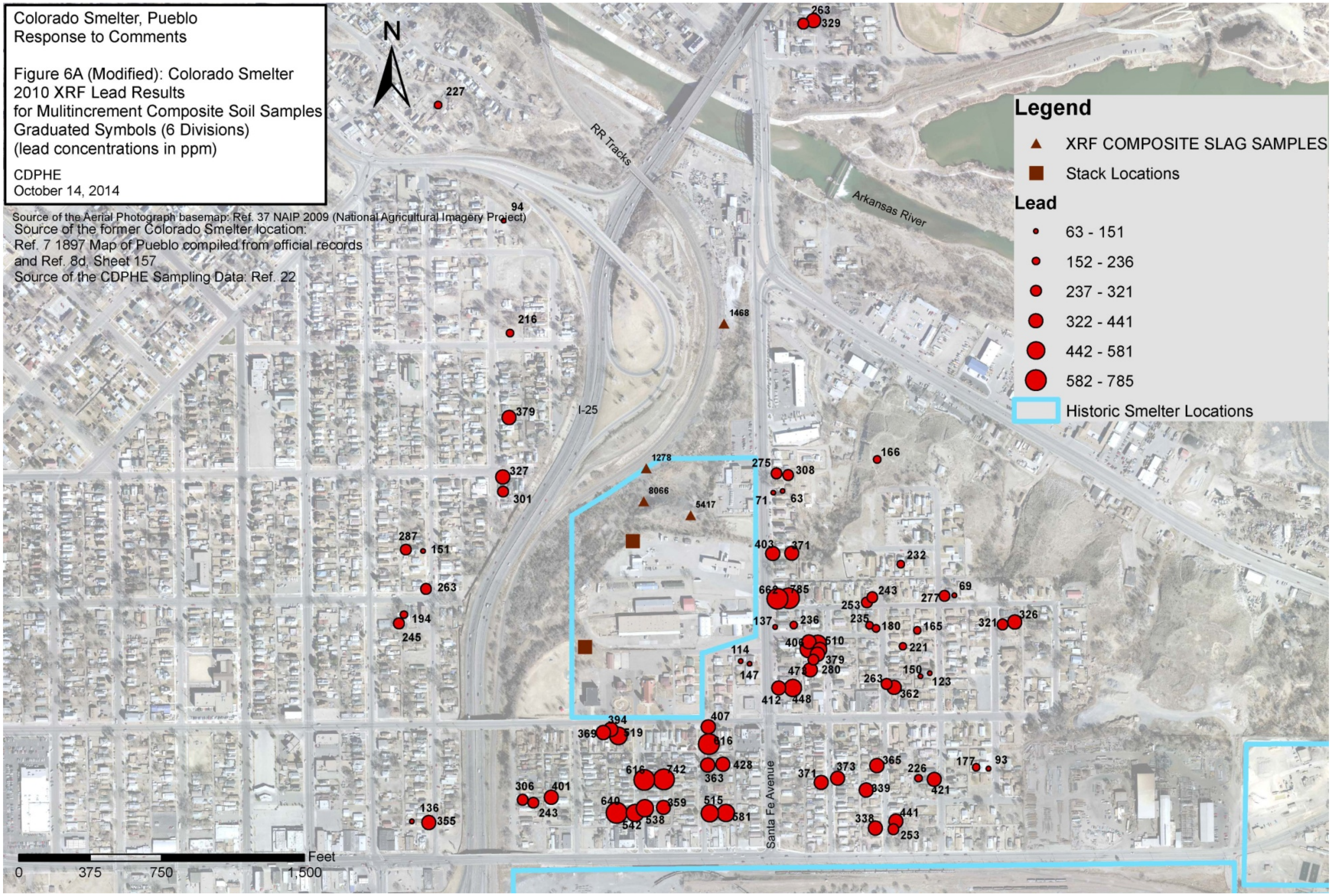

Figure 5a: CDPHE 2010 site inspection composite sample XRF lead results, focused on soil results. (Figure from Reference 32a of the HRS documentation record at proposal. Cropped. Plot point size varied by concentration only for soil results).

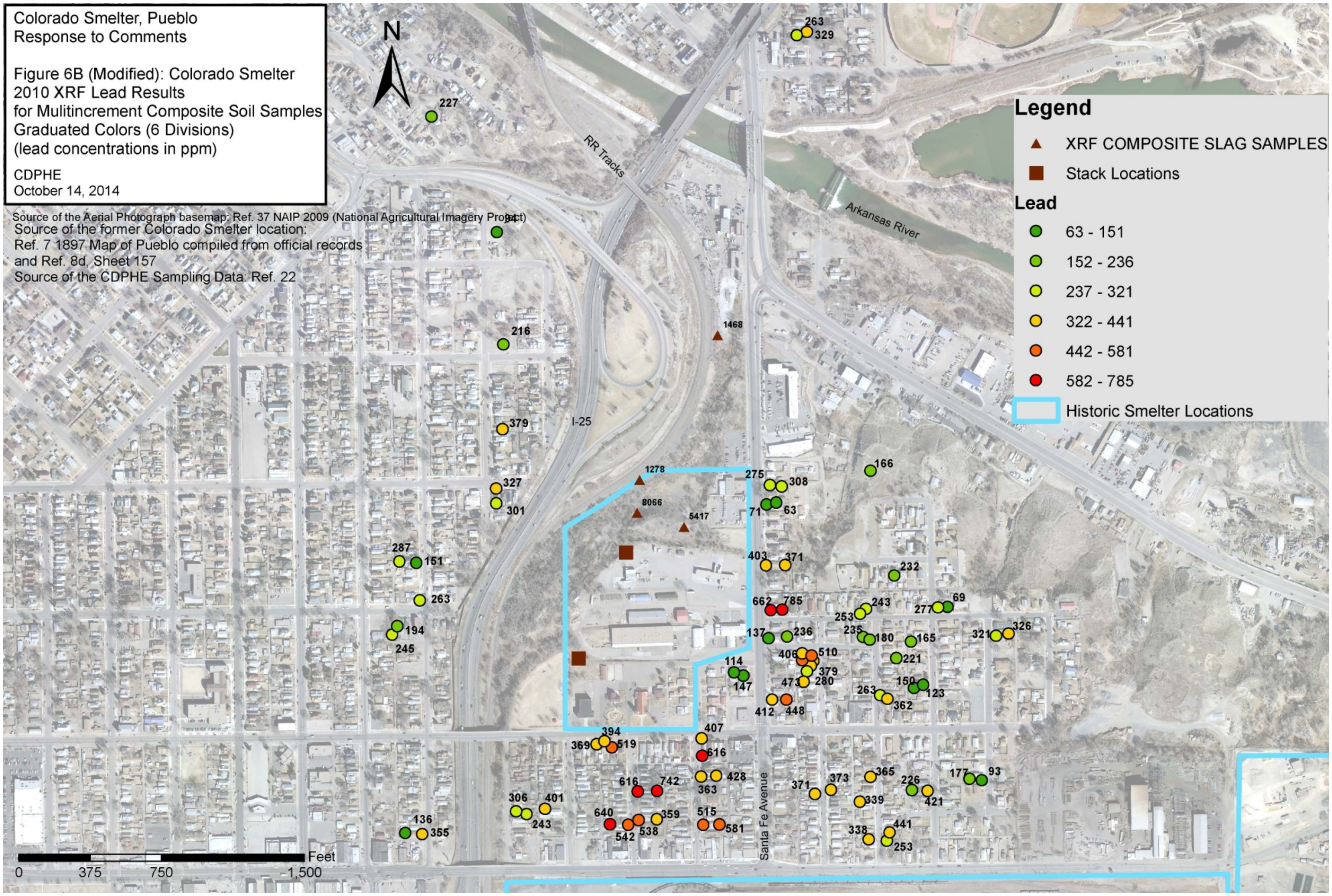

Figure 5b: CDPHE 2010 site inspection composite sample XRF lead results, focused on soil results. (Figure from Reference 32a of the HRS documentation record at proposal. Cropped. Plot point color varied by concentration only for soil results).

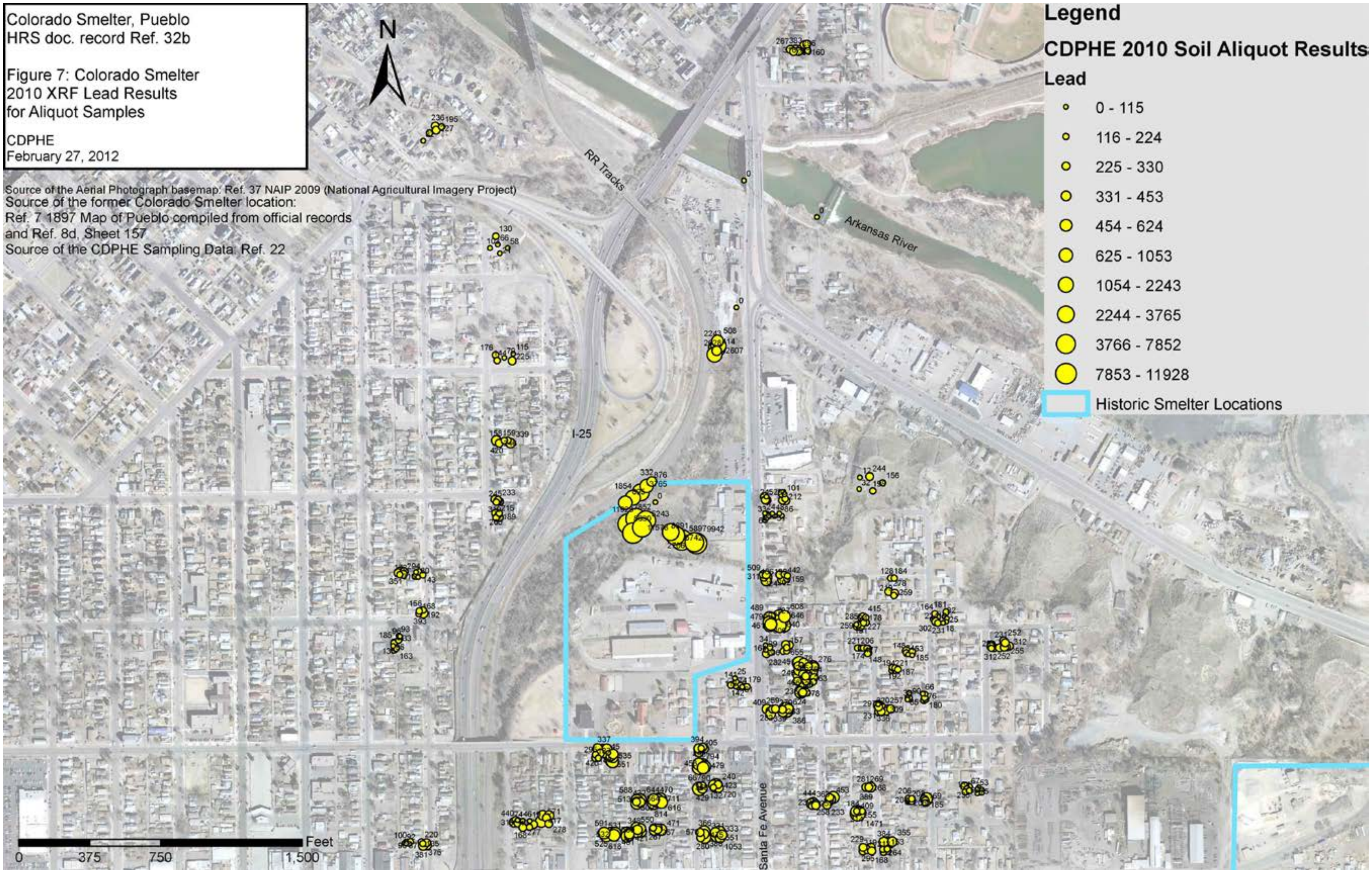

Figure 6: CDPHE 2010 site inspection aliquot sample XRF lead results. (Figure from Reference 32a of the HRS documentation record at proposal. Cropped.)

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.16.2 Distribution of Lead in Soil – Variability

Comment: Mr. Coomes commented that if the Colorado Smelter was the source of the lead soil contamination, the lead "should have been quite evenly distributed over the Eilers area" with some "relatively small differences." But, Mr. Coomes asserted the EPA's data do not support this and commented that lead is not evenly distributed over the Eilers neighborhood area.

On the individual residential property scale, Mr. Coomes contended that vacant lots sampled exhibited on average only 53% of the lead concentrations found at residential lots. Mr. Coomes also noted that soil collected from roadways had lower lead concentrations than residential yard samples. Mr. Coomes argued that such "uneven or spotty" distribution is not consistent with EPA's model of the Site.

On the scale of the composite sample zones[32] on each sampled property within the AOC, Mr. Coomes asserted that, because the sample areas within each yard are small, the amount of lead deposited "in the individual sample areas, where five separate samples were collected, should be very similar, based on the assumed EPA model." But, Mr. Coomes contended "there are large differences" between the smallest and largest lead concentrations within these sample areas based on the five aliquot results. As evidence, Mr. Coomes commented that:

- Background sample areas showed a maximum difference of 25 ppm lead
- Vacant lots showed a maximum difference of 51 ppm
- Eight residential yard areas showed a maximum difference of 51 ppm or less
- Thirty-three residential yard areas showed a maximum difference between 51 to 200 ppm
- Eighteen residential yard areas showed a maximum difference between 200 to 300 ppm
- Sixteen residential yard areas showed a maximum difference greater than 300 ppm
- One residential yard zone showed a maximum difference of 1,287 ppm.

Mr. Coomes stated "[t]hese large concentration differences in such small areas are inconsistent with EPA's assumption the smelter emissions are the major soil lead contamination source in Eilers."

Mr. Coomes also requested EPA explain why arsenic is "concentrated in very small areas of the Site soil, rather than in a more even concentration distribution as expected from fugitive or stack particulate deposition."

Response: Regarding Mr. Coomes assertion that if the Colorado Smelter was the source of the lead soil contamination, the lead "should have been quite evenly distributed over the Eilers area" with some "relatively small differences" and that the lack of this even distribution disproves the EPA's model of the Site, this is incorrect. As discussed below, there are multiple reasons why lead and arsenic levels might spatially vary from property to property, and even within a single property, but still exhibit an overall decrease with distance.

A substantial amount of the contamination from the Colorado Smelter operations would have been emitted during operation of the facility, which took place more than a century ago. Over that time period, it is likely that the lead and arsenic concentrations deposited as a result of Colorado Smelter operations have been affected by many processes (e.g., weathering, addition of fresh soil/removal of contaminated soil during landscaping/yard work) and therefore the remaining contamination would be expected to exhibit some spatial variation. Furthermore, soil is not a homogeneous matrix, and therefore some variability is introduced by the matrix itself. However evenly the deposition of contaminants originally occurred, it is expected that some variability would be introduced over

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[32] Composite sample zones refer to the 5-point multi-increment zones illustrated on Figure 3 of the HRS documentation record at proposal.

time on the very small scale (within a sampling zone in a portion of a yard), on the small scale on each individual property (between sampling zones), and on the larger scale between properties and blocks in the city. Examples of variables that could impact variation in the concentration gradient include: landscaping (soil/plant addition or removal), property shapes (wind shadows), vegetation types on different properties (wind shadows, erosion), road paving/utility work, and other factors. Such variability does not negate the overall concentration gradient within the nearby vicinity of the Colorado Smelter facility.

Regarding the CDPHE 2010 site inspection vacant lot and roadway samples, the fact that the average of the lead results from these samples is lower compared to the overall average for the CDPHE 2010 site inspection residential soil samples is <u>not</u> inconsistent with EPA's model of the Site. The range of the CDPHE 2010 site inspection residential soil samples XRF composite lead results is 63-785. The XRF composite lead results for vacant lot samples CO-SO-12-1, CO-SO-49-1, and CO-SO-50-1 are 166, 216, and 94 mg/kg, respectively. The roadway sample (which is not from a vacant lot but rather located near the road on a lot with a house) CO-SO-08-1 XRF composite lead result is 263. These results are within the mid-low end of the range of the other soil results. This is expected, given that these samples are generally upwind of the Colorado Smelter based on prevailing wind direction (see Figure 2 of this support document for sample locations), and given the distance of these locations from the Colorado smelter.[33]

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.16.3 Arsenic Levels in Soil vs Arsenic Levels in Slag

<u>Comment</u>: Mr. Coomes questioned the source of the arsenic in the AOC. Mr. Coomes cited the CDPHE 1994 Sample Report, Santa Fe Avenue Bridge Culvert (Reference 13 of the HRS documentation at proposal) and specifically commented that arsenic levels in soil were greater than those in slag, and quoted a portion of page 19 of the 1994 Sample Report, which states:

> It should be noted that the arsenic concentrations in the contaminated soils are higher than the arsenic found in either the slag, seep or culvert discharge. This points to perhaps another source in the area or long term atmospheric deposition.

<u>Response</u>: It appears that the basis of Mr. Coomes' comment was a comparison of a single slag sample and five soil samples which, given the variation in concentrations that Mr. Coomes comments on in section 3.16.2, Distribution of Lead in Soil – Variability, of this support document, is likely too few samples on which to draw a definitive conclusion. In fact, based on a larger sample set, the concentration of arsenic is higher in the slag pile than in residential soils.

Mr. Coomes' concentration values are based on the results from the CDPHE 1994 Sample Report, Santa Fe Avenue Bridge Culvert (Reference 13 of the HRS documentation at proposal); that study was more limited than the CDPHE 2010 site inspection. The 1994 Sample Report discusses one slag pile sample and five soil samples. During the CDPHE 2010 site inspection, soil samples were collected from 47 residential lots, 3 vacant lots, and 1 road frontage (each lot included multiple zones that were sampled; each zone usually included 3 to 5 discrete samples). Additionally, four waste pile locations (slag piles) were sampled as part of this CDPHE 2010 site inspection, with each location again consisting of several multi-increment samples. As can be seen from the results of this much more extensive sampling, Table 3 of the HRS documentation record at proposal shows CDPHE 2010 site inspection AOC A residential soil samples with arsenic results up to 343 mg/kg. Table 5 of the

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[33] See also Figure 5 of this support document showing the relevant composite sample lead results plotted, and pages 51-59 of Reference 22 of the HRS documentation record at proposal for a full list of CDPHE 2010 site inspection soil sample results.

HRS documentation record at proposal shows CDPHE 2010 site inspection slag pile samples with arsenic results up to 1,740 mg/kg. Thus, the levels of arsenic are actually higher in slag samples than residential soil samples.

Additionally, the arsenic contained in the slag does not represent the total arsenic that may have been emitted or blown from the facility. As explained in quoted text from the HRS documentation record above, historical data from another smelting operation—an AMC smelter in Montana—showed that much more arsenic and lead may be contained in the flue dust than in the slag. Therefore, it is possible that soils affected by flue dust emissions could appear lead/arsenic enriched relative to slag.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.16.4 Arsenic/Lead Ratios – Distribution of Arsenic Relative to Lead

Comment: Mr. Coomes suggested that the arsenic/lead ratios should be the same throughout the AOC if the contamination resulted from aerial deposition. Mr. Coomes commented that, based on EPA's assertion that lead and arsenic contamination in soil is the result of smelter emissions, a long-term deposition of arsenic-containing particulate would be accompanied by a parallel deposition of lead-containing particulate. Mr. Coomes contended that therefore the ratio of arsenic concentrations to lead concentrations "should be constant over the investigative area." However, Mr. Coomes commented that these ratios are "not consistent and the variation is very large."

Mr. Coomes examined available data and made several points:

- Based on sample data included in the EPA 1995 ARR (Reference 15 of the HRS documentation record at proposal), Mr. Coomes calculated that the ratio of arsenic/lead in slag ranges from 0.007 to 0.029.[34]
- Based on soil sample XRF data included in Table 8 of the CDPHE June 2011 ARR (Reference 22 of the HRS documentation record at proposal), Mr. Coomes calculated the ratio of arsenic/lead in soil ranges from 0.057 to 0.44, with an average of 0.125.
- Mr. Coomes listed several of these soil samples with arsenic/lead ratios that exceeded the highest ratio for slag, 0.029.

Mr. Coomes asserted the data "supports the position that there are additional and significant lead sources unrelated to the smelter operation or arsenic" and that "smelter emissions were not the major contributor to soil lead and arsenic." Mr. Coomes also stated that "[i]t is clear that the arsenic did not result from deposition of particulate from the Historic Colorado Smelter" and noted, "other sources of arsenic . . . were not evaluated by EPA."

Response: Mr. Coomes is incorrect in asserting that arsenic/lead ratios do not support the attribution of soil lead and arsenic levels to the Colorado Smelter. It is unlikely that a constant ratio of arsenic to lead would be found at this site. Given that releases were documented from an operation that closed more than 100 years ago, there are many different, naturally occurring physical and chemical reactions that may act on the two substances differently because lead and arsenic have different physical and chemical properties (e.g., physical and chemical weathering). Additionally, it is incorrect to assume that the various sources at the Site (stack emissions, slag, and fugitive dust) would contain uniform ratios of lead and arsenic throughout the facility's operation.

Mr. Coomes bases many of his arguments on the assertion that the ratio of arsenic concentrations to lead concentrations "should be constant over the investigative area;" this assumption is likely incorrect for various reasons. First, changes in the facility processes (differences in input ore, process efficiency, etc.) over time would

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[34] Mr. Coomes notes that some of the arsenic values he used in his calculations were "J"-qualified, but were used in his analysis without modification.

introduce variability in the arsenic/lead ratio being emitted from the facility and, coupled with the variation in wind direction during each specific process timeframe, would introduce some variability into the arsenic/lead ratio detected in soils. Second, as previously mentioned, a substantial amount of the contamination from the Colorado Smelter operations would have been emitted during operation of the facility more than a century ago. From the end of facility operations to present day, it is likely that the lead and arsenic concentrations deposited as a result of Colorado Smelter operations have been affected by many processes such as weathering, addition of fresh soil/removal of contaminated soil during landscaping/yard work, etc. And, it is possible that weathering of the arsenic over the last century did not evenly affect arsenic and lead in the soil (e.g., extraction of these two metals from soil via rainwater may take place at different rates). Finally, soil is not a homogeneous matrix, and therefore some variability is introduced by the matrix itself. Therefore, there is no reason to expect that the ratio of arsenic to lead from emitted from smelter activities over such a long period would remain constant in the environment.

Mr. Coomes' direct comparison of arsenic/lead ratios found in slag to those found in soils is also likely faulty. Of the contributions of arsenic and lead in soil from the Colorado Smelter, a significant portion may have come from the stack emissions including flue dust (as opposed to dust derived from slag). As described above, the arsenic and lead levels found in flue dust may vary greatly from those found in slag. There is therefore no reason to expect the arsenic/lead ratios found in soil to match those found in slag.

Specifically regarding Mr. Coomes' comment on other sources allegedly not evaluated, see section 3.16.6, Other Sources, of this support document.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.16.5 Comparison of Site-related and Greater Area-related Datasets

<u>Comment</u>: Mr. Coomes questioned that contaminant concentrations actually decreased with distance from the Colorado Smelter. Mr. Coomes performed analysis of contaminant concentration data for samples near the Site and compared them to samples located farther from the Site (less affected by the Site), and asserted that, based on a statistical analysis, the "data sets are from the same population," calling into question the Colorado Smelter as a significant contributor of arsenic to soils at the Site.

Mr. Coomes examined the arsenic concentrations identified in "all arsenic concentrations identified in the ARR[9] [see footnote on citation[35]]", and arsenic concentrations identified in the 2006 Diawara study (Reference 11 of the HRS documentation record at proposal), and applied the Wilcoxon Rank Sum Test[36]. Mr. Coomes presented the results in Table 3 of his comment document. Mr. Coomes asserted that "[t]he analysis demonstrated that the two arsenic data sets are from the same population at a 1 percent significance level." Mr. Coomes commented that the Diawara samples were from residential and rural areas, and "many so distant that the area was not affected by the historic smelter operations." Mr. Coomes concluded that this shows "the Historic Smelter did not contribute significant arsenic to the Site soil."

Mr. Coomes requested that "analyses reportedly performed[16] by EPA that demonstrated results contrary to those presented in Table 3 be made available for public review" (referring to reference 16 of his comment submittal, a

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[35] Mr. Coomes cites to entry 9 of the reference list in his comment document, which refers to the CDPHE 1994 Sample Report, Santa Fe Avenue Bridge Culvert (Reference 13 of the HRS documentation at proposal). But, based on the investigation results included in Table 3 of his comment document, it would appear the values he compared to the Diawara study results are actually XRF composite soil sample results from the CDPHE June 2011 ARR (Reference 22 of the HRS documentation record at proposal), which is entry number <u>8</u> in the reference list of his comment document.

[36] Mr. Coomes asserts that use of the Wilcoxon rank sum test to compare populations of data is supported by an EPA OSWER directive (EPA 540-R-01-003 OSWER 9285.7-41 September 2002).

"[v]erbal response to question at an EPA Public meeting in Pueblo"). Mr. Coomes requested that EPA provide "any analyses EPA performed on the data that demonstrate the site arsenic concentrations are different than those reported by Daiawara. [*sic*]"

Response: Mr. Coomes' statistical comparison of the Diawara Study data to the CDPHE 2010 site inspection data does not demonstrate that lead concentrations remain uniform with distance in the immediate vicinity of the Colorado Smelter. Mr. Coomes is incorrect in his assertion that the Diawara Study soil lead dataset (including sampling locations less affected by the Site) is statistically similar to the CDPHE 2010 site inspection soil lead dataset. And, Mr. Coomes applied a statistical test that is less than ideal for the data and comparison he was attempting to make. Mr. Coomes' conclusions regarding the data are incorrect.

Mr. Coomes presented a statistical comparison of the CDPHE 2010 site inspection composite soil sample XRF arsenic results to those previously published by Diawara using the Wilcoxon Rank-Sum test (an unpaired two-sample comparison of medians). Mr. Coomes' results indicated that there was no statistically significant difference between the two datasets at the 1% significance level. The EPA could not reproduce the results of Mr. Coomes' analysis, even using the data set he presented. If anything, the EPA's analysis using the same testing process, the results indicated a distinct difference between the two datasets because they have distinctly different mean values. [37]

Furthermore, the purpose of the Wilcoxon Rank-Sum test (an unpaired two-sample comparison of medians) is to compare the medians of two distinct data sets to determine whether they come from the same sample. However, the Diawara study included data from multiple distinct sites, and the purpose of this effort was never to make conclusions about a single population. As such, using these data to represent a single "background" population is misleading, and comparing them to the CDPHE 2010 site inspection soil results using the Wilcoxon Rank-Sum (or any other two-sample comparison test) does not make sense. Additionally, focusing on the median of a set of data has little meaning in this context, as the CDPHE 2010 site inspection soil data were designed to identify hot spots, i.e., determine locations where high concentrations are occurring. Therefore, the commenter's comparison of the midpoint of the distribution (using the median) rather than the upper percentiles of the distribution again does not provide evidence contradicting that the soil contamination scored as observed contamination is attributable to the Colorado Smelter.

And, the EPA has also previously explained, when Mr. Coomes brought this issue up at a prior public hearing regarding the Site, that Mr. Coomes' conclusions are erroneous on this matter, as documented in an August 31, 2012, letter from the EPA to the Pueblo City Council, included as Attachment 2 of this support document:

> Mr. Coomes' assertion that arsenic concentrations identified in Eilers area samples are identical to those characterized during the 2006 "Pueblo-wide" soil study [the Diawara study] is simply not correct. EPA technical staff including Charles Partridge, PhD, EPA toxicologist, and Robert

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[37] EPA reviewed Mr. Coomes' submitted calculations, and could not reproduce them using the submitted data. However, EPA performed the Wilcoxon Rank-Sum test using two different software applications, and using the dataset values as provided in Table 3 of Mr. Coomes' comment submission, in the columns labeled "BKGRD RESULTS" and "INVEST RESULTS"; each application calculation indicated that the median concentration was statistically significantly higher in the CDPHE 2010 site inspection dataset compared to the Diawara dataset at the 1% significance level. Therefore, EPA disagrees that the submitted analysis provided evidence contradicting that the soil contamination scored as observed contamination is attributable to the Colorado Smelter. These calculations are shown in Attachment 4, Wilcoxon Rank-Sum Test Calculations, of this support document. The two software applications used were SAS Version 9.2 (PROC NPAR1WAY procedure) and NCSS Version 9 Statistical Software. For both applications, a one-sided Wilcoxon Rank-Sum test was performed to determine whether the median concentration was significantly higher in the ARR dataset compared to the background dataset. As shown in Attachment 4 of this support document, the Z-statistic generated by the test using both applications was $Z = -9.2332$, with a p-value < 0.0001, indicating that one can conclude at the 1% significance level that the ARR median concentration is significantly greater than the background median concentration.

> Edgar, PhD, EPA statistician, reviewed the data from the 2006 Colorado State University-Pueblo (CSU-Pueblo) – “Pueblo-wide” soil study and compared it to the data collected in the Eilers neighborhood in support of listing the Colorado Smelter site. Based on rigorous analysis using five different statistical tests, **EPA determined that the soil arsenic data collected from the Eilers neighborhood are indeed statistically significantly higher when compared to the soil arsenic data from the 2006 CSU-Pueblo study**. [emphasis added]

The 2012 EPA letter provides a figure comparing the Diawara study soil arsenic data to CDPHE 2010 site inspection soil arsenic data. The letter states:

> [T]he average concentration of 12.4 milligrams per kilogram (mg/kg) for the CSU-Pueblo samples is much lower than the EPA/CDPHE study's average concentration of 55.4 mg/kg samples. Additionally all 66 of the CSU-Pueblo samples contained less than 70 mg/kg arsenic and approximately 92 percent of the CSU-Pueblo samples contained 20 mg/kg or less of arsenic. None of the CSU-Pueblo samples contained greater than 70 mg/kg of arsenic; whereas there were samples with arsenic concentrations exceeding 70 mg/kg and as high as 210 mg/kg in the EPA/CDPHE study’s samples. This figure dramatically illustrates the increased levels of arsenic in the soils surrounding the Colorado Smelter site when compared to those levels of arsenic found in soils across the City of Pueblo.

The figure from the 2012 EPA letter is shown below:

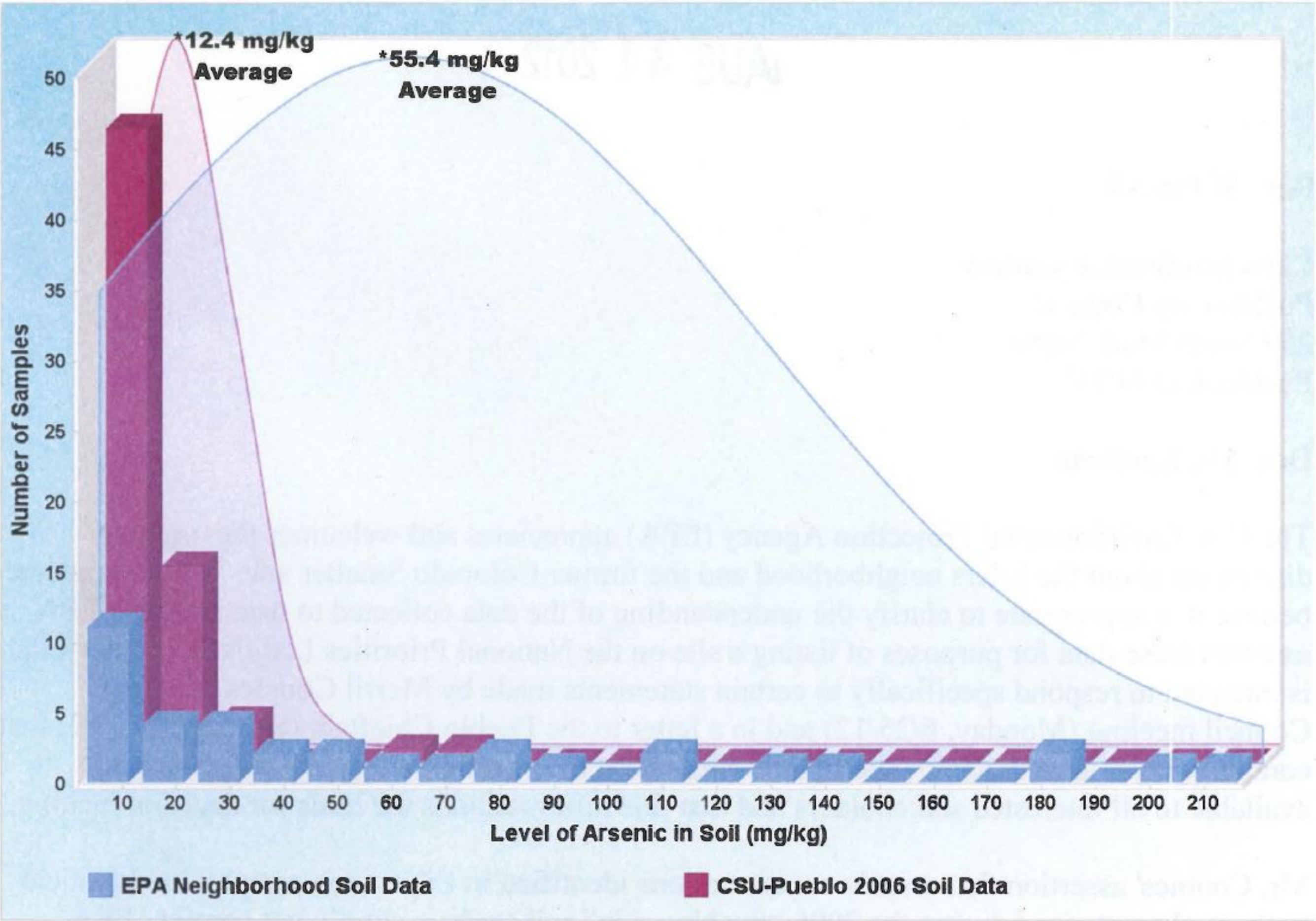

Figure 7: Comparison of Diawara study soil arsenic data to CDPHE 2010 site inspection soil arsenic data.

Thus, the datasets are statistically different, and Mr. Coomes' related conclusion that his analysis shows that the Colorado Smelter did not contribute significant arsenic to the Site soil is invalid.

Regarding the reference 16 of Mr. Coomes' comment submittal, a "[v]erbal response to question at an EPA Public meeting in Pueblo," it is not clear to what public meeting verbal response Mr. Coomes is referring, and therefore the EPA cannot respond specifically to this element of Mr. Coomes' comment.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

3.16.6 Other Sources

Comment: Mr. Coomes challenged whether other sources of lead and arsenic were properly considered in establishing attribution of the contaminant increase to the Colorado Smelter operations. Regarding lead sources, he asserted that the EPA has not discussed lead-based paint or emissions from leaded gasoline as significant sources in the HRS documentation record. Mr. Coomes pointed to previous EPA studies[38] on other areas of the country, noting that urban area soil lead levels found in those studies were "much greater than those found in the Eilers neighborhood" and the "EPA should not consider the Eilers soil lead levels as out of the ordinary." Mr. Coomes offered several reasons to attribute lead levels to lead-based paint:

- Based on historical housing data, Mr. Coomes commented that "half of the homes in Pueblo were built before 1971 and were likely [*sic*] have lead-based-paint," and that "[t]he Pueblo Chieftain reported November 24, 2012 that 23.8 % of homes in the city of Pueblo were built prior to 1940 (definitely lead-based-paint)." Mr. Coomes contended "this information should be discussed in the listing document."
- Mr. Coomes noted based on his arguments related to the "large concentration differences" within the small composite sampling zones, that "logical conclusion, based on analysis of the EPA data, is that another source of lead (likely lead-based paint – some of the homes were built before smelter operation stopped) is contributing significantly greater amounts of lead to soil than historic smelter emissions." Mr. Coomes pointed to the analysis he performed in Attachment 2 to his comment document.
- Mr. Coomes noted the likelihood of lead-based paint in neighborhood housing, contending that "the concentration of soil lead does not decrease with distance from the Historic smelter site [pointing to his analysis in Attachment 5 to his comment document]," and therefore concluded that "the primary source of lead is lead-based paint."
- Mr. Coomes stated that "[o]nly four of the 279 aliquots had lead content greater than 1200ppm. Because the homes in this area are old and have lead-based paint . . . there does not appear to be a significant soil lead hazard."

Mr. Coomes commented that "[a] significant source of arsenic for residential yards is the historic application of pesticides." Mr. Coomes pointed to lead arsenate—commonly used as a pesticide until the 1950s—and noted its arsenic/lead ratio is 0.241, and that the average ratio he calculated for CDPHE June 2011 ARR soil samples is 0.125. Mr. Coomes stated, "[i]t is clear that other sources of arsenic (for example arsenic-containing pesticides) were not evaluated by EPA." Mr. Coomes requested it be explained why pesticides were not considered by the EPA as a source of arsenic. Mr. Coomes requested that the EPA "include an evaluation of other probable arsenic sources in the documentation supporting the listing."

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[38] Mr. Coomes cites the EPA 1991 document, Three City Urban Soil-Lead Demonstration Project, Midterm Project Update, and the EPA January 1998 document, Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA97 Version, EPA/600/R-96/084.

Mr. Coomes also commented that "high soil lead concentration was identified at a historic blacksmith's shop. EPA did not discuss previous land use in their reports."

Mr. Coomes asserted that another source not discussed by EPA is fugitive dust emissions from materials handling operations, which would have larger particle sizes that settle over shorter distances from the origin compared to stack emissions.

Response: As required by the HRS, the EPA determined that at least a portion of the significant increase in contaminants identified in observed contamination in the Eilers neighborhood is attributable to the Colorado Smelter based on information including the proximity of the Colorado Smelter to AOC A, predominant wind direction, and the distribution of contaminants showing a concentration pattern indicating a significant increase in lead and arsenic levels adjacent to the Colorado Smelter (as shown in Figures 4, 5, 5a, 5b, and 6, of this support document). While there may be other possible non-site sources of lead and arsenic, as described in HRS documentation record text quoted above in section 3.16, Attribution, of this support document, the EPA did consider the effects of such sources (i.e., four other historical smelters in the city and CF&I/Rocky Mountain Steel Mills facility), and none of the other identified alternative sources of lead and arsenic could explain the significant increase in contamination in the AOC. Nor does the presence of these alternative sources demonstrate EPA's attribution rationale is incorrect. And, these other sources/facilities pointed to by Mr. Coomes do not explain the soil lead concentration gradient present in the neighborhood around Colorado Smelter.

Regarding lead-based paint, soil sampling procedures employed during the CDPHE 2010 site inspection would have mitigated any related effects. Reference 39 of the HRS documentation record at proposal, a CDPHE memorandum describing the residential soil sampling methodology for the CDPHE 2010 site inspection, states that:

> The sampling team collected all samples from open, exposed dirt areas at least 10 feet away from the house away from roof drip lines to minimize the potential for soil contamination sourced by lead-based paint.

Regarding leaded gasoline, Mr. Coomes offers no specific information indicating that the observed contamination of lead in Site soils would be attributable to historical leaded gasoline emissions. In fact, Mr. Coomes comments that soil collected from a roadway contained lower lead concentrations than residential yard samples. Additionally, several of the samples used to establish observed contamination are from the back yard of residential lots (zone 4)[39]. In general, these sample locations are farther from roads and would be less affected by historical leaded gasoline emissions from nearby roadways, and yet they still exhibit observed contamination levels of lead. Additionally, as shown in Table 4 of the HRS documentation record, many of the XRF zone 4 composite sample lead levels in these samples (ranging from 339-742 mg/kg) exceed the road frontage sample CO-SO-08 XRF composite result (263 mg/kg) (this sample was collected at a location on a residential lot closer to the road). The fact that road frontage sample CO-SO-08 was from a property to the west of the Colorado Smelter (upwind based on the prevailing wind direction) and that the zone 4 locations mentioned are all downwind of the Colorado Smelter supports the scenario in which the historical emissions from the Colorado Smelter are the dominant factor influencing AOC A soil lead levels.

Furthermore, any contributions from lead-based paint or historical leaded gasoline emissions to soil contamination would not explain the soil lead concentration gradient near the Colorado Smelter described in the HRS documentation record and references at proposal.

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[39] Reference 39 of the HRS documentation record at proposal explains that in the CDPHE 2010 site inspection sample naming convention, "zone 4" at a residential lot represented the back yard. As shown in Table 3 of the HRS documentation record, the following zone 4 samples met observed contamination criteria: CO-SO-18 4.5, CO-SO-28 4.3, CO-SO-31 4.5, CO-SO-32 4.4, CO-SO-40 4.1, CO-SO-40 4.2, CO-SO-40 4.3, CO-SO-43 4.1, CO-SO-43 4.3, and CO-SO-43 4.4.

Regarding Mr. Coomes' assertion that the EPA has not considered pesticide application as a possible source of arsenic, such a claim is speculative and not supported by the available evidence or by any site-specific documentation provided by Mr. Coomes. As explained above, EPA has offered substantial information attributing lead and arsenic in Site soils to the Colorado Smelter. Mr. Coomes noted that the arsenic/lead ratios in the soil are more similar to the ratio in lead arsenate pesticides than those in slag. But, as previously explained, the arsenic/lead ratios in soil—even at the time of deposition—would not necessarily be expected to match that in slag; and the currently existing arsenic/lead ratios in soil may have changed significantly since the original smelter-related deposition occurred a century ago; therefore, direct comparisons to ratios in slag or ratios in pesticides are not relevant to this site-specific attribution discussion. Further, the EPA presented a concentration gradient for arsenic from the smelter to local residential soils that showed decreasing concentrations with distance from the smelter (see Figures 5, 5a, and 5b of this support document); if the arsenic contamination were due to pesticide application there would be no decreasing concentration gradient with increased distance from the smelter as pesticide applications would be more uniformly distributed in the local neighborhoods.

Similarly, regarding the blacksmith's shop, Mr. Coomes offers no information indicating that the observed contamination of lead in Site soils would be attributable to the blacksmith's shop instead of the Colorado Smelter, and provides no information showing the location of the blacksmith's shop or analytical evidence to explain why it should be considered as contributing to the contamination at the Site.

Regarding possible fugitive dust emissions contributions from the Colorado Smelter facility to AOC A soils, again Mr. Coomes provides no specific evidence to support this; while such contributions could have occurred, they remain speculation. Even if fugitive dust emission contributions were considered, they would be attributable to the Colorado Smelter facility.

This comment results in no change to the HRS score and no change in the decision to place the Site on the NPL.

4. Conclusion

The original HRS score for the Colorado Smelter site was 50.00. Based on the above responses to public comments, the final scores for the Colorado Smelter site are:

Ground Water:	Not scored
Surface Water:	Not scored
Soil Exposure:	100.00
Air Pathway:	Not scored
HRS Score:	50.00

Attachment 1

March 2000 CDPHE QAPP for Site Assessments Under Superfund

COLORADO DEPARTMENT OF PUBLIC HEALTH
AND ENVIRONMENT
HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION

1876

QUALITY ASSURANCE PROJECT PLAN

FOR SITE ASSESSMENTS UNDER SUPERFUND

REVISION 01

MARCH, 2000

COLORADO DEPARTMENT OF PUBLIC HEALTH
AND ENVIRONMENT
HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION

QUALITY ASSURANCE PROJECT PLAN
FOR SITE ASSESSMENT UNDER SUPERFUND

RECEIVED
APR 14 2000
HAZARDOUS MATERIALS
AND WASTE MANAGEMENT

1876

Approved: PGSmith Date: 3/17/00

Pat Smith, Site Assessment Manager, EPA Region VIII

Approved: Date: 3/17/0

Tony Medrano, Quality Assurance Officer, EPA Region VIII

Approved: Joseph Vranka Date: 10 March 2000

Joseph Vranka, Superfund Unit Leader, CDPHE

Approved: Martin O'Grady Date: 3-8-00

Martin O'Grady, Quality Assurance Officer, CDPHE

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APPENDICES

ABBREVIATIONS AND ACRONYMS

AA	Atomic absorption
ASC	Analytical Services Coordinator
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
CDPHE	Colorado Department of Public Health and Environment
CLP	Contract Laboratory Program
DLs	Detection limits
DQO	Data quality objective
EPA	U.S. Environmental Protection Agency
ERP	Emergency Response Program
FSP	Field Sampling Plan
GC/MS	Gas chromatography/mass spectrometry
HRS	Hazard Ranking System
IC	Ion chromatography
ICP	Inductively coupled plasma
IR	Infrared spectroscopy
PCB	Polychlorinated biphenyls
QA	Quality assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and Analysis Plan
SHSP	Site Health and Safety Plan
SOP	Standard operating procedure
SOW	Statement of work
SUL	Superfund PA/SI Unit Leader
XRF	X-ray fluorescence

1.0 INTRODUCTION

> *Quality Assurance (QA) is an integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.*
>
> *Quality Control (QC) is the overall system of technical activities that measures the attributes and performance of a process, item or service against defined standards to verify that they meet the stated requirements established by the customer; the QC system includes operational techniques and activities that are used to fulfill requirements for quality.*

This Quality Assurance Project Plan (QAPP) was prepared by the Colorado Department of Public Health and Environment (CDPHE) for the U.S. Environmental Protection Agency (EPA) Region VIII. EPA Order 5360.1, Change 1, "Policy and Program Requirements for the Mandatory Agency-Wide Quality System" (U.S. Environmental Protection Agency (EPA) 1998) requires that all environmental data collection activities that are performed by or on behalf of the EPA, be supported by an approved QAPP prior to the start of data collection activities, except as specified by Region VIII emergency response/time-critical removal policies. This QAPP was prepared in accordance with the EPA guidance documents entitled, "EPA Requirements for Quality Assurance Project Plans, Interim Final EPA QA/R-5" (EPA 1999), "Quality Assurance/Quality Control Guidance for Removal Activities" and EPA Region VIII "Minimum Requirements for Field Sampling Activities" (EPA 1996).

Data collection requirements are often determined by the Hazard Ranking System (HRS). Regional and National Preliminary Assessment and Site Inspection (PASI) guidances offer strategies and common guidelines on scope of effort for Site Assessment Investigations relative to the HRS.

This QAPP presents elements common to many environmental data collection activities. The purpose of this QAPP is to:

- Describe how the CDPHE Site Assessment (SA) program Quality System will be applied to a specific project;
- Justify proposed environmental data operations;
- Integrate all technical quality aspects of environmental data operations for a specific project;
- Provide project- or task-specific blueprints for how QA and QC are to be applied to obtain the type and quality of data needed for a specific decision or use; and
- Identify and document limitations on the use of the data.

The QAPP, a project-specific Sampling and Analysis Plan (SAP), a Site Health and Safety Plan (SHSP), and Standard Operating Procedures (SOPs) collectively form the set of plans for individual projects.
The level of detail and the QA/QC specified in the project plans are based on the scope of work, cost, technical requirements, site-specific conditions and the intended use of the data. The EPA has defined four categories that vary the level of detail and content requirements for QAPPs. Table 1-1 illustrates these Category requirements. The CDPHE SA program primarily incorporates the requirements of Category III,

Interim Studies, which include projects with environmental data operations performed as interim steps in a larger group of operations. Such projects include work producing results that are used to evaluate and select options for preliminary assessments, site inspections, and Hazard Ranking System (HRS) Packages of potential Superfund site listings.

SOPs are used for all activities affecting the quality of data or measurements conducted for a project. SOPs provide standardized and written guidelines for field, laboratory and reporting operations. SOPs are consistent with current regulations and guidelines, are clear and concise, and contain directions that can be followed in a stepwise manner. The EPA encourages the use of SOPs as attachments to project documents to reduce the size of the document and the time required to prepare it. CDPHE has prepared SOPs, "Standard Operating Procedures." The SOPs cover sampling protocols and technical operations.

EPA QA/R-5 requires that a QAPP address 25 topics or elements in four subject areas. Region VIII requires that 16 of these 25 elements be addressed. The elements contained within this QAPP are grouped to reflect the general processes of:

- Project Management - Sections 1 through 5;
- Measurement/Data Acquisition - Sections 6 through 11;
- Assessment/Oversight - Section 12; and
- Data Validation and Usability - Sections 13 and 14.

TABLE 1-1
Use Category Chart

Category	Description	Element
Project Management	Title and Approval Sheet	A1
	Table of Contents	A2
	Distribution List	A3
	Project/Task Organization	A4
	Problem Definition/Background	A5
	Project/Task Description	A6
	Quality Objectives and Criteria for Measurement Data	A7
	Special Training Requirements/Certification	A8
	Documentation and Records	A9
Measurement/ Data Aquisition	Sampling Process Design	B1
	Sampling Methods	B2
	Sample Handling and Custody	B3
	Analytical Methods	B4
	Quality Control	B5
	Instrument/Equipment Testing, Inspection, and Maintenance	B6
	Instrument/Equipment Calibration and Frequency	B7
	Non-direct Measurements	B9
	Data Management	B10
Assessment/ Oversight	Assessments and Response Actions	C1
	Reports to Management	C2
Data Validation and Usability	Data Review, Verification and Validation	D1
	Verification and Validation	D2
	Reconciliation with User Requirements	D3

2.0 PROJECT/TASK ORGANIZATION (Element A4)

Figure 2-1 presents a typical project-specific organization. This figure shows key positions along with lines of authority and lines of communication and coordination. Descriptions of the responsibilities and authorities for the key positions as they relate to project QA and QC are provided below. It is essential that all individuals have defined responsibilities for their functional areas and are clearly aware of the entire project organization and interrelationships. As this is a project organization, senior officials, managers, and administrators, whose positions are not functionally involved with data generation, data use, or decision-making, are not included. Also to be noted that to some degree, one person may fulfill multiple positions described herein.

QA personnel have sufficient authority, access to work areas, and organizational freedom to identify quality problems; to initiate, recommend or provide solutions to problems through established channels; and to verify solution implementation. Such personnel ensure that all work, including any processing of information, delivery of products, and installation or use of equipment, is reviewed in accordance with QC objectives and that all deficiencies and nonconformances are corrected. QA personnel have direct access to senior management, so that the required authority is provided where needed, to carry out QA duties.

2.1 EPA SITE ASSESSMENT MANAGER

The EPA-assigned Site Assessment Manager (SAM) is responsible for coordinating all project-related activities on behalf of the EPA. A major component of this position involves coordinating with the CDPHE Project Leader in the execution of the work and the submission of deliverables as scheduled, in accordance with the project assignment. Specific responsibilities of the SAM are as follows:

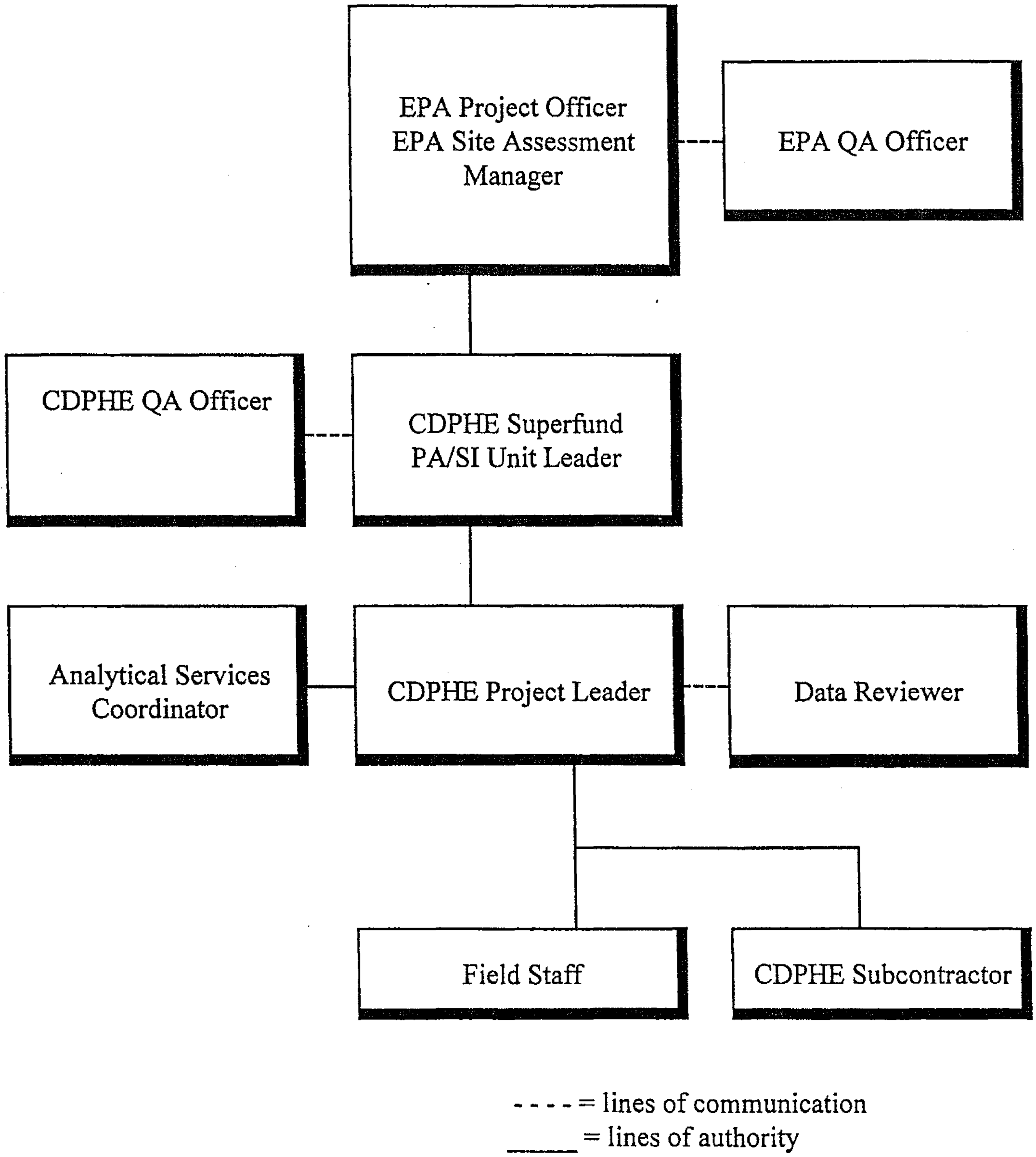
- Provide oversight of all project activities;
- Review and approve project plans (including SAPs) and coordinate review within EPA as necessary. Initiate the Data Quality Objective (DQO) process as appropriate, providing DQO framework;
- Review and approve the QAPP;
- Ensure that the QAPP and associated reports are transmitted to the EPA Quality Assurance Officer (QAO);
- Transmit comments on QA from the EPA to the Project Leader regarding QA plans and laboratory performance;
- Ensure that the Project Leader addresses EPA review comments and takes appropriate action;
- Transmit program-wide quality issues to EPA QAO; and
- Initiate conductance of field and laboratory audits and management system reviews.

2.2 EPA QUALITY ASSURANCE OFFICER

The EPA QAO or designee is responsible for ensuring that the project has an appropriate QA program. Specific responsibilities of this position are as follows:

- Support the EPA SAM on QA issues.

FIGURE 2-1
QA Project Organization



2.3 CDPHE QUALITY ASSURANCE OFFICER

The QAO is responsible for the development, implementation and maintenance of the comprehensive Quality System. Responsibilities of this position include communicating with all levels of program and project management to ensure that a quality product is produced for delivery. Project-specific responsibilities of the QAO or designee are as follows:

- Serve as the official contact with EPA for all QA matters;
- Respond to QA needs, resolve problems, and answer requests for guidance or assistance;
- Prepare the QAPP, and revise as necessary; provide guidance to the Project Leaders in the development of project-specific SAPs;
- Review and approve the project-specific SAPs;
- Assign competent, qualified independent reviewers to review the technical adequacy of deliverables;
- Track the progress and completion of the review and approval process;
- Ensure that EPA protocols and procedures, as well as CDPHE SOPs, are being followed;
- Review the implementation of selected SAPs and the adequacy of the data or products generated based on quality objectives;
- Initiate conductance of field and laboratory audits and management system reviews, as appropriate;
- Maintain a current list of all approved QAPPs, SAPs, and SOPs to be used for auditing purposes;
- Authorize, coordinate, and conduct internal and subcontractor audits of selected projects for adherence to the project plans.
- Submit notice of any laboratory and field systems audits prior to their occurrence and in a timely manner to the EPA QAO who has the option to attend;
- Review audit and nonconformance reports to determine areas of poor quality or failure to adhere to established procedures;
- Confer with the audited entity on the steps to be taken for corrective actions and track nonconformance until it has been corrected; evaluate the adequacy and completeness of the action taken; confer with the Project Leader to resolve an inadequate corrective action; confirm the adequacy and the implementation of the response action;

- Suspend or stop work with the concurrence of the Unit Leader and EPA, upon detection and identification of an immediate adverse condition affecting the quality of results;
- Provide training on QA policies, procedures, and methodology;

2.4 CDPHE SUPERFUND PA/SI UNIT LEADER

The Superfund PA/SI Unit Leader (SUL) is responsible for providing senior leadership and expertise to individual Project Leaders, and for maintaining a broad perspective of EPA and CDPHE priorities. Responsibilities of the SUL are to:

- Identify the need and expectations of services to be provided and when necessary, negotiate acceptable scopes of work;
- Provide senior level input and technical expertise to Project Leaders on developing or establishing project objectives, data quality objectives, sampling rationale, regulatory requirements, and data assessment methods;
- Ensure that the best available technology is being applied to reduce potential waste and inefficiencies, and that the best known processes are in use;
- Provide senior level coordination, review, and approval of project documents;
- Assess completion of work in accordance with EPA and regulatory requirements; and
- Provide full assistance to the QAO and audit team during the planning, scheduling, and management of project-specific QA audits and surveillances; review assessment findings; and ensure that required corrective actions are completed.

2.5 CDPHE PROJECT LEADER

The Project Leaders report to and obtain technical direction and assistance from the EPA SAM and the CDPHE SUL and are responsible for monitoring and documenting the quality of all work produced by the project team, which includes the field staff and subcontractors. The fundamental goal of this position is to produce a quality work product within the allotted schedule and budget. Duties include executing all phases of the project and efficiently applying the full resources of the project team in accordance with the project plans. The Project Leader is responsible for managing any project task involving the specialized chemical expertise and the assessment and reporting of related analytical data. Specific responsibilities of a Project Leader are as follows:

- Assist the SAM in determining DQOs;
- Prepare and implement the project SAPs (which incorporate applicable QAPP elements) and reports for each project, as appropriate;

- Ensure that SOPs are available and in use for activities that affect product quality and that assigned staff have been trained in their implementation;

- Inspect and accept supplies and consumables;

- Ensure that appropriate sampling, testing and analysis procedures are followed and that correct lab QC checks are implemented;

- Monitor sample preservation, handling, transport and custody throughout the project;

- Coordinate the appropriate disposition of investigation-derived waste;

- Ensure that the proper number and type of environmental and control samples are collected, identified, tracked, and sent to the laboratory for analysis;

- Coordinate and schedule sample shipment to analytical laboratories to meet holding times and analytical procedures specifications;

- Monitor subcontractors for compliance with both project and data quality requirements records, costs, and progress of the work; replan and reschedule work tasks as appropriate;

- Review and approve calculations to ensure that data reduction is performed in a manner that produces quality products;

- Verify data quality, test results, equipment calibrations, and QC documentation; maintain and regularly review all QC records;

- Ensure that all project deliverables are subjected to independent technical review by qualified personnel within the time frame of the project schedule;

- Plan and schedule assessments in conjunction with the QAO;

- Provide full assistance to the audit team during the conduct of project-specific QA audits.

- Review and respond to assessment findings; determine the root cause for the non-conformance; confer with the QAO on the steps to be taken for correction; and ensure that procedures are modified to reflect the corrective action and that they are distributed to all field personnel, including subcontractors;

- Report QA problems to the QAO;

- Prepare and send notice of sampling to the Region VIII Sample Broker.

- Qualify and procure laboratories for analysis of samples for projects not handled by the Region VIII Sample Broker;

- Coordinate data collection activities to be consistent with information requirements;

- Oversee evaluation of data received from the laboratory in accordance with the project requirements;

- Coordinate the assessment of data based upon criteria established in DQOs;

- Supervise the compilation of field data and laboratory analytical results;

- Assure that data are correctly reported; and

- Prepare or oversee the preparation of portions of the final report that summarize data results and present conclusions.

2.6 FIELD STAFF

Under the direction of the Project Leader, the Field Staff are responsible for the planning, coordinating, performing, and reporting of specific technical tasks. Responsibilities of the Field Staff are as follows:

- Implement the QAPP and project-specific SAP;
- Develop and maintain technical activity files and log books; and
- Implement technical procedures applicable to tasks.

2.7 SUBCONTRACTORS

CDPHE personnel may delegate to others the responsibility of planning and executing certain portions of the project activities. When subcontractors are involved in activities covered by the requirements of the QAPP, the responsibility and authority of each subcontractor must be clearly established and documented. Project Leaders are responsible for monitoring subcontractors for compliance with both project and data quality requirements.

3.0 PROBLEM DEFINITION/BACKGROUND (Element A5)

The problem definition and background are included in the project-specific SAP. The problem definition and background address the following points:

- Contamination problem to be solved or decision to be made; why this investigation is being conducted;

- Site location and description;

- Source and location of contamination, including any physical or chemical characteristics of the site that could cause a release, historical information or existing data that provided this information, and data gaps that exist and will be filled during this investigation;

- Maps of the project vicinity and areal extent of the contamination problem;

- Regulatory objectives and basis for the sampling effort;

- Action levels for contaminants, including levels used for data evaluation;
- The intended use and users of the data, including decisions/decision makers.

4.0 PROJECT/TASK DESCRIPTION (Element A6)

The project or task description is included in the project-specific SAP. The project or task description addresses the following points:

- Description of the work involved and how the planned activities will resolve the problem or question;
- Applicable technical, regulatory, or project-specific quality objectives that must be met;
- Project schedule and task durations, including audits;
- Project constraints such as time, access or funding;
- Expected measurements and field and analytical data that will be collected;
- Project records required, including reports and field records;
- Special personnel, equipment, or analytical requirements commensurate with the complexity of the project;
- QA Assessment tools as required by the QAPP that will be implemented during the course of the project (e.g., technical reviews, peer reviews, and technical audits).

5.0 QUALITY OBJECTIVES AND CRITERA FOR MEASUREMENT DATA (Element A7)

Project-specific quality objectives and measurement performance criteria are included in each project SAP. It is the goal of EPA and the regulated community to collect data of sufficient quantity and quality to support defensible decision making. At the same time, it is necessary to minimize expenditures related to data collection by eliminating unnecessary, duplicative, or overly precise data. The most efficient way to accomplish both of these goals is to begin each project by defining project quality objectives and measurement performance criteria.

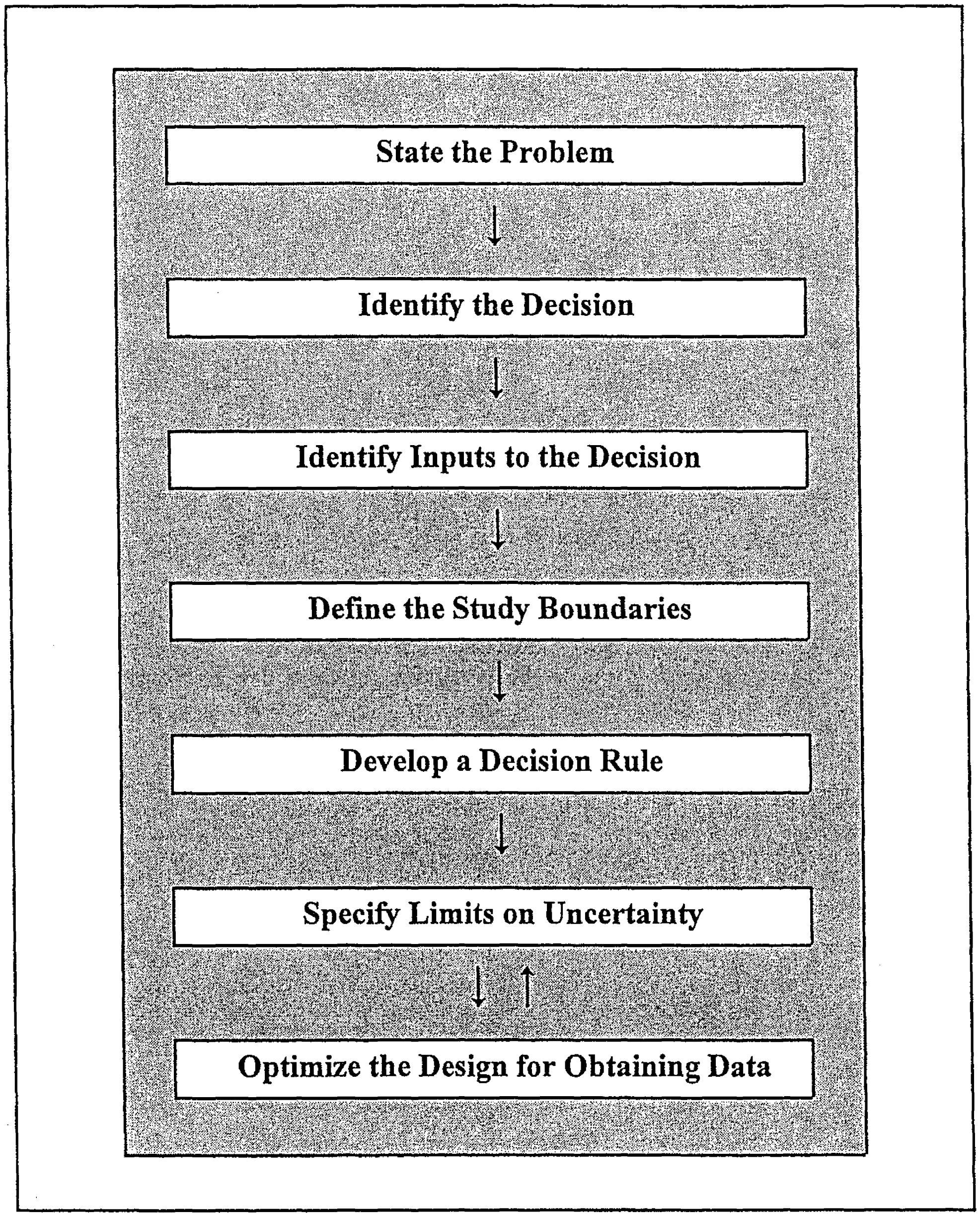
The EPA supports the implementation of the DQO Process to ascertain the type, quality, and quantity of data necessary to address site-specific problems ("Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4HW," EPA 2000). It is the responsibility of the Project Leader, in conjunction with the QAO, to implement the DQO process as part of the project planning activities. In those cases in which the DQO process is not used, it is still necessary to state the project quality objectives and measurement performance criteria in the project-specific SAP.

The QA requirements, identified as a result of the DQO Process, will be used at three stages in a project, as follows:

- Project inception - to present the plans for project execution from a QA viewpoint.
- During the project - to act as a guide for QA implementation, review and audits, and as the specifications for assessing the quality of data generated.
- Project completion - to serve as a basis for determining whether the project has attained established goals.

Figure 5-1 summarizes the DQO Process.

FIGURE 5-1
The Data Quality Objectives Process



5.1 DATA CATEGORIES

Descriptive data categories (definitive data and screening data with definitive confirmation) have been developed by the Superfund program. According to EPA "Data Quality Objectives Process for Superfund, Interim Final Guidance," these two categories are associated with specific QA and QC elements, and may be generated using a wide range of analytical methods (EPA 1993). The goal is to ensure that all data produced by field activities are of known quality and can thus be used for more general purposes than originally intended.

Table 5-1 describes data categories from both references and provides general descriptions of the QA levels and specific QA/QC requirements for various common analyses. The particular type of data to be generated depends on the qualitative and quantitative DQOs developed during application of the DQO process. The data categories, as excerpted from the EPA documents, are:

5.1.1 Screening Data

Screening data are generated by rapid, less precise methods of analysis and less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, instead of elaborate extraction/digestion and cleanup. Screening data provide analyte identification and quantification, although the quantification may be relatively imprecise. Screening data without associated confirmation data are not considered to be data of known quality. QA/QC elements for screening data are:

- Sample documentation (location, date and time collected, batch, etc.);
- Chain of custody (when appropriate);
- Sampling design approach (systematic, simple or stratified random, judgmental, etc.);
- Initial and continuing calibration; and
- Determination and documentation of detection limits.

5.1.2 Screening Data with 10% Definitive Confirmation

This category requires that at least 10% of the screening data be confirmed using analytical methods and QA/QC procedures and criteria associated with definitive data. As a minimum, at least three screening samples reported above the action level (if any) and three screening samples reported below the action level (or as non-detects) should be randomly selected from the appropriate group and confirmed. Analytical error determination (i.e., screening sample replicates) is required unless total measurement error (collocated samples) is determined during the confirmation analyses. Analytical error is the measurement of the precision of the analytical method; total measurement error is the measurement of overall precision of the measurement system from sample acquisition through analysis. QA/QC elements for screening data with 10% definitive confirmation are:

- Sample documentation (location, date and time collected, batch, etc.);
- Chain of custody (when appropriate);
- Sampling design approach (systematic, simple or stratified random, judgmental, etc.);
- Initial and continuing calibration;
- Determination and documentation of detection limits;
- Analyte(s) identification;
- Analyte(s) quantification;
- Analytical error determination (This procedure measures the precision of the analytical method, and is required when total measurement error is not determined under the confirmation step. Refer to Section 5.2); and
- Definitive confirmation: at least 10% of the screening data must be confirmed with definitive data as described below. As a minimum, at least three screening samples reported above the action level (if any) and three screening samples reported below the action level (or as non-detects) should be randomly selected from the appropriate group and confirmed.

5.1.3 Definitive Data

Definitive data are generated using rigorous analytical methods, such as approved EPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce tangible raw data (e.g., chromatograms, spectra, digital values) in the form of paper printouts or computer-generated electronic files. Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. For the data to be definitive, either analytical or total measurement error must be determined. QA/QC elements for definitive data are:

- Sample documentation (location, date and time collected, batch, etc.);
- Chain of custody (when appropriate);
- Sampling design approach (systematic, simple or stratified random, judgmental, etc.);
- Initial and continuing calibration;
- Determination and documentation of detection limits;
- Analyte(s) identification;
- Analyte(s) quantification;
- QC blanks (trip, method, rinsate);
- Matrix spike recoveries;
- Performance Evaluation (PE) samples (when specified); and
- Analytical error determination or total measurement error determination. (Refer to Section 5.2.)

TABLE 5-1
Superfund Data Categories

QA/QC Levels	Screening	Screening Data with 10% Definitive Confirmation	Definitive
Data Uses	Data useful only for immediate situation; and to afford a quick, preliminary assessment of site contamination.	Data useful for site assessment and decision making at SAM discretion	Data useful for enforcement, litigation, risk assessment, and most other uses
Typical Uses	• Preliminary health and safety assessment • Preliminary identification and quantitation of pollutants • Non-critical decisions • Emergency situations • Waste profiling	• Site characterization • Waste characterization • Clean-up confirmation • Verification of health and safety assessment • Verification of critical samples	• Enforcement • Litigation • Risk assessment
Quality Assurance Type	Data of unknown quality	Data of known quality	Data of known quality
Quality Assurance Elements	• Logged quality control checks provided in methods or SOPs • Qualified analyst	• Identification • Quantification • Confirmation of 10% of the samples by a definitive method • Error determination[1]	• Definitive identification • Definitive quantification • Error determination
Validation	None	QC Review[2]	Validation of 10% of the results in each of the samples, calibrations, and QC analyses
Quality Control Elements	• Instrument QC • Field QC (Field blanks and collocated samples are optional) • Analyst training • Document DLs	• Instrument QC • Field QC • Analyst training • QC within method parameters • Document DLs	• Instrument QC • Field QC • Analyst training • QC within method parameters • Document DLs

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[1] Error determination: screening data with 10% definitive confirmation requires measurement of analytical error (screening sample replicates) unless total measurement error (collocated samples) is determined during the confirmation analyses. The site-specific SAP may state that error determination is not necessary if it can be qualitatively shown that the DQOs do not require it, e.g., concentrations in the percent range are expected to be found, yet the action level is in the parts per billion (ppb) range.

[2] QC review is required for all samples analyzed under screening data with 10% definitive confirmation. Data validation is required for 10% of the results in each of the samples, calibrations, and QC analyses for the definitive confirmation data.

TABLE 5-1
Superfund Data Categories
(continued)

QA/QC Levels[1]	Screening	Screening Data with 10% Definitive Confirmation	Definitive
Sampling Plan	Optional	Mandatory	Mandatory
Typical Volatile Analyses	• Field GC (e.g., Sentex field GC with single column and detector)	• Field GC with 10% of samples being confirmed by GC/MS with full QA/QC deliverables; duplicates and blanks.	• EPA Method 8240 or 8260; data report; replicates; blanks and spikes
		• GC method with 10% of samples being confirmed by GC/MS with full QA/QC deliverables; duplicates and blanks.	• EPA Method 8010/ 8020 with second column confirmation; data report replicate, blanks, and spikes.
Typical Non-volatile Analyses	• Immunoassay kits	• Immunoassay with 10% of samples being confirmed by GC/MS with full QA/QC deliverables; duplicates and blanks.	• EPA Method 8270; data report; replicates, blanks, and spikes.
		• GC method with 10% of samples being confirmed by GC/MS with full QA/QC deliverables; duplicates and blanks.	• EPA Method 8100/ 8120 with second column confirmation; data report; replicate, blanks, and spikes.
Typical Metal Analyses	• Field XRF	• Field XRF with 10% of samples being confirmed by ICP or AA with full QA/QC deliverables; duplicates and blanks.	• EPA Method 6010; data report; replicates, blanks, and spikes.
		• AA, ICP, IC, or wet chemistry methods with 10% of samples being confirmed by ICP or AA with full QA/QC deliverables; duplicates and blanks.	• EPA methods for AA (7000s); data report; replicate, blanks, and spikes.

TABLE 5-1
Superfund Data Categories
(continued)

QA/QC Levels[1]	Screening	Screening Data with 10% Definitive Confirmation	Definitive
Typical PCB/ Pesticide Analyses	• Immunoassay Kits	• Immunoassay kits with 10% of samples being confirmed by GC/MS with full QA/QC deliverables; duplicates and blanks.	• EPA Method 8140-Pesticides; data report; replicates, blanks, and spikes.
		• GC method with 10% of samples being confirmed by GC on a second column with full QA/QC deliverables; duplicates and blanks.	• EPA Method 8080 with second column confirmation; data report; replicate, blanks, and spikes.
Typical Petroleum Hydrocarbon Analyses	• Immunoassay kits • Chem test kits (HANBY) • IR (EPA 413 and 418) methods	• Immunoassay[3] IR, and chemical analysis with 10% of samples being confirmed by GC/MS or EPA Method 8015 (modified) with second column confirmation with full QA/QC deliverables; duplicates and blanks.	• EPA Method 8015 (modified) with second column confirmation; data report; replicate, blanks, and spikes.
		• GC method with 10% of samples being confirmed by GC/MS or GC on two columns with full QA/QC deliverables; duplicates and blanks.	
Testing for physical parameters is not analyte specific. Therefore, by strict definition, any physical test would have to be considered non-definitive. However, the testing methods may be definitive if approved methodology is followed.			
Physical Parameters (pH, flash point, etc.)	• Field testing equipment	• Testing equipment with QC samples, duplicates, and blanks.	• Testing equipment; data report; and QC samples, duplicates, and blanks.

GC = Gas chromatograph
GC/MS = Gas chromatography/mass spectrometry
ICP = Inductively coupled plasma
AA = Atomic absorption
IC = Ion chromatography
XRF = X-ray fluorescence
IR = Infrared spectroscopy
DLs = Detection Limits

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[3] Immunoassay kits used to generate data must be capable of generating calibration, blank, duplicate, and estimation of error data.

5.2 DATA ASSESSMENT PARAMETERS

Data acceptance criteria are established in the project-specific SAP for each of the five data assessment parameters identified by the EPA. These objectives are expressed as quantitative and qualitative statements concerning the type of data needed to support a decision, based on a specified level of uncertainty. Table 3 in Appendix A, or an equivalent table, is used in the SAP to present three of the five data assessment parameters (precision, accuracy, completeness). Criteria for comparability and representativeness are described below. Table 3 also defines the required analytical detection limits.

Data are reconciled in the Analytical Results Report (ARR) with stated DQOs by determination of precision (analytical and/or total measurement error determination), accuracy, and completeness, and statements on representativeness and comparability.

The data assessment parameters are:

Precision is a measure of agreement among replicate (or between duplicate) or collocated sample measurements of the same analyte. The closer the numerical values of the measurements are to each other, the more precise the measurement. Precision is determined through calculation of analytical and/or total measurement error.

Analytical error (required for screening with 10% definitive confirmation data unless total measurement error is determined during confirmation analyses) is determined by taking an appropriate number of replicate aliquots from one thoroughly homogenized screening sample. The replicate samples are analyzed and standard laboratory QC parameters (such as variance, mean, and coefficient of variation) are calculated and compared to method-specific performance criteria. Total measurement error (required for definitive confirmation data if analytical error is not determined) is calculated using an appropriate number of collocated samples for each matrix under investigation, independently collected from the same location and analyzed. Standard laboratory QC parameters such as variance, mean, and coefficient of variation are calculated and compared to established measurement error goals. For data to be definitive, either analytical or total measurement error must be determined. (EPA 1993).

For some sampling events, determination of precision may not be required. For example, when it is expected that all sample analyte concentrations will be far greater than site action levels, rigorous error determination may not be necessary. When this is the case, the site-specific SAP QC requirements should reflect the program needs.

Accuracy is a measure of bias in a measurement system. The closer the value of the measurement agrees with the true value, the more accurate the measurement. Accuracy is expressed as the percent recovery of the surrogate or spike analyte from a sample or standard. Accuracy is dependent on traceability of instrumentation, standards, samples, and data; methodology; reference or spiked samples; performance samples; and equipment calibration.

Completeness is a measure of the number of valid measurements obtained in relation to the total number of measurements planned. The closer the numbers are, the more complete the measurement process. Completeness is expressed as the percentage of valid-to-planned measurements. A sufficient volume of sample material is collected to complete the required analyses, so that samples represent all possible contaminant situations under investigation as well as background and control areas. Completeness is influenced by environmental conditions, potential for change with respect to time and location, equipment maintenance, data records, sampling location, sample volume, QC samples, and sample representativeness. In general, a completeness greater than 90% will fulfill the data quality objectives.

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. The comparability goal is achieved through the use of SOPs to collect and analyze representative samples, by reporting analytical results in appropriate and consistent units and by maintaining consistency in sampling conditions, selection of sampling procedures, sample preservation methods, and analytical methods.

Representativeness is a qualitative parameter that expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. The design of and rationale for the sampling program (in terms of the purpose for sampling, selection of sampling locations, the number of samples to be collected, the ambient conditions for sample collection, the frequencies and timing for sampling, and the sampling techniques) ensure that environmental conditions have been sufficiently represented.

6.0 SAMPLING PROCESS DESIGN (Element B1)

The project-specific SAP describes the sampling design by presenting project objectives in terms of specific operational parameters. The design identifies sampling locations, sample types and matrices, frequency of collection and sample numbers, measurement/text parameters and sensitivity needed for decision making. The sampling design should also generate data that are representative of the conditions at the site within resource limitations.

The project-specific SAP presents the rationale for sample selection, including justification for the frequency of collection of each sample matrix at each sample collection site. Elimination of unnecessary, duplicative or overly precise data minimizes expenditures and response time related to sample collection and analysis. However, sufficient data must be collected to support defensible decision making.

When field screening and/or field analyses are to be used, the SAP describes the criteria for sample selection and the required quality objectives. The SAP may also include other information such as specific selection criteria, techniques, rationale or guidelines used to establish sample point locations, measurement criticality, well installation design, selection of sample collection equipment, etc. Examples of the types of site-specific factors that may be discussed in the SAP include: site accessibility, climate, potential hazards, media of concern, and site heterogeneity. Information that can be used to support the design often includes site maps, geological information, disposal records, and historical data. Method validation for unusual sample matrices and situations may also be included to support the decision for their inclusion in the design.

Table 1 in Appendix A, or a table containing equivalent information, is used in the SAP to present the quantities of both environmental and QC samples to be collected and analyzed for each matrix to be investigated. Each type of QC sample is described in detail in Section 10.0 of this plan.

7.0 SAMPLING METHODS (Element B2)

The quality of data collected in an environmental study depends on the quality and thoroughness of field sampling activities. Due to the sensitivity of analytical methods and the extremely low levels of detection specified for sample analysis, the sampling process becomes integral to the integrity of data generated. As a result, general field operations and practices and specific sample collection and inventory must be well planned and carefully implemented.

The project-specific SAP provides detailed descriptions of the sampling program and sampling procedures. The sampling-related topics described in the SAP include the following:

- Identification of all methods used, including method number, date and regulatory citation, when available;
- Procedures for sample collection;
- Required sampling equipment;
- Required support facilities;
- Performance requirements for sampling methods;
- Use of field screening;
- Field measurements;
- Field preparation of samples including filtration and preservation procedures;
- Required sample containers, sample volumes, and sample holding times;
- Corrective action to be taken when sampling or measurement systems fail; appropriate alternative methods;
- Decontamination procedures and materials; and
- Disposal of investigation-derived wastes.

The Project Leader at times is required to adjust the field program and deviate from the project-specific SAP to accommodate site-specific needs, for example, adding or deleting a sampling location, using less inert sampling devices, or collecting smaller sample volumes. When it becomes necessary to modify a program, the Project Leader documents and implements the necessary changes. The designated EPA official is notified if the change is determined to be a significant one.

7.1 STANDARD OPERATING PROCEDURES

SOPs have been developed for use on sampling and related data-gathering activities The purpose of these procedures is to obtain samples that represent the environment and contamination under investigation. These SOPs provide consistency in data collection activities and decrease the time needed for SAP preparation and review. Proposed project-specific modifications to the SOPs along with their justification are clearly documented in the project SAP and in the project reports. SOPs are included in the project-specific SAP as attachments or by reference.

For non-standard operations, unusual sample matrices or unusual sampling conditions, validation of procedures may be required to confirm that project quality criteria can be met. These validations must be developed before project sampling begins and must be documented in the project reports.

SOPs (SOPs) for sample collection are briefly described below.

- SOP 1 - General Field Operation - describes the overall field organization in support of sample collection, sample identification, record keeping, field measurements, and data collection.
- SOP 2 - Sample Containers, Preservation and Maximum Holding Times - describes the methods used to place samples in appropriate containers to preserve specific samples, and the maximum time a sample can be held before it is analyzed.
- SOP 3 - Chain of Custody - outlines the documentation necessary to trace sample possession.
- SOP 4 - Sample Identification, Labeling, and Packaging - specifies the methods for sample identification and labeling. Sample packing and shipment methods are also outlined.
- SOP 5 - Sample Location Documentation - outlines the methods for documentation of all sample locations.
- SOP 6 - Use and Maintenance of Field Log Books - outlines the proper documentation of information in field log books during data collection activities.
- SOP 7 - Hazardous Waste Characterization - outlines the methods for characterization of unknown materials for disposal, bulking, recycling, grouping and classification purposes.
- SOP 8 - Investigation Derived Waste Management - outlines the management of wastes generated during environmental field operations.
- SOP 9 - Monitor Well Installation - describes the methods for monitoring well installation, including design, construction procedures, and materials.
- SOP 10 - Monitor Well Development - describes the methods for monitoring well development, including data recording formats.
- SOP 11 - Equipment Decontamination - describes the techniques used to decontaminate equipment prior to sample collection or data measurement.

- SOP 12 - Groundwater Sampling - establishes the methods for monitoring well purging, sample collection, and equipment use when sampling.

- SOP 12A - Groundwater Sampling for Low Flow Purge - describes equipment and operations for sampling groundwater monitor wells using a pump to obtain samples with a minimum of turbidity.

- SOP 13 - Water Level Measurement - describes the methods used to record water levels at surface water locations and in groundwater monitoring wells.

- SOP 14 - Water Sample Field Measurements - describes the measurement techniques and data requirements associated with the collection of either a groundwater or surface water sample.

- SOP 15 - Flow Measurements - describes the methods for conducting flow measurements during surface water sampling.

- SOP 16 - Surface and Shallow Depth Soil Sampling - establishes the methods for sample collection using a variety of sampling devices. Techniques for avoiding sample and equipment cross-contamination are also discussed.

- SOP 17 - Sediment Sampling - establishes the methods for sample collection using a variety of sampling devices. Techniques for avoiding sample and equipment cross-contamination are also discussed.

- SOP 18 - Surface Water Sampling - establishes the methods for sample collection and equipment use at a variety of surface water locations. Techniques for avoiding water body and sample cross-contamination are also discussed.

- SOP 19 - Soil Gas Sampling - outlines the methods for decontamination and soil gas sampling for routine field operations.

- SOP 20 - Drum and Container Sampling - describes methods for safe and effective sampling of drums and containers less than 120 gallons.

- SOP 21 - Tank Sampling - describes the measurement techniques used in sampling aboveground storage tanks.

- SOP 22 - Aquifer Slug Testing - establishes the methods and data recording formats for conducting slug tests in groundwater monitoring wells.

- SOP 23 - Aquifer Pump Testing - establishes the methods and data recording formats for conducting pump tests in groundwater extraction and monitoring wells.

- SOP 24 - Geological Borehole Logging - describes the information and observations to be recorded for the identification, logging, and sampling of a borehole. Sampling methods and data collection formats are also presented.

- SOP 25 - Residential Dust Sampling - describes the methods for collecting composite dust samples in a residential community.

- SOP 26 - Chip, Wipe and Sweep Sampling - describes the equipment and methods required for obtaining a representative chip, wipe or sweep sample to monitor potential surface contamination.

7.2 RECORD KEEPING AND DOCUMENT CONTROL

Project activities are documented in the project plans and project reports and are supported by field activities records and laboratory data reports. Applicable field forms as described in SOPs may be included as attachments to the project-specific SAP. When references are used in project documents, or when attachments are added to these documents, they must be specific so that the reviewer can readily find the appropriate sections and pages containing the pertinent information. Laboratory documentation requirements are delineated in the laboratory contracts and include specifications for data report composition, report format, turnaround time, and records retention. Laboratory data are recorded in a format that includes sample identification, analysis date, parameter values, and detection limits. Both laboratory and field data are combined and summarized in final tables and graphs that are appropriate to the type of data and convey information to support the findings of the data collection program. In all cases, data are clearly tabulated and presented in a consistent manner to support comparison of common sets of data. Finally, data are presented so as to logically lead to and substantiate the conclusions and recommendations provided by the final report.

8.0 SAMPLE HANDLING AND CUSTODY (Element B3)

Written documentation of sample custody from the time of sample collection through the generation of data by analysis of that sample is recognized as a vital aspect of an environmental study. The chain of custody of the physical sample and its corresponding documentation are maintained throughout the handling of the sample. All samples must be identified, labeled, logged onto a Chain-of-Custody form, and recorded in a sample tracking log or field log book as a part of the procedure to ensure the integrity of the resulting data. The record of the physical sample (location and time of sampling) is joined with the analytical results through accurate accounting of the sample custody. Sample custody applies to both field and laboratory operations.

SOPs and data collection forms have been developed for sample custody, sample labeling, analysis requests, and shipping and tracking procedures. These SOPs are included in the project-specific SAP by reference. Analytical laboratory sample custody procedures are included in the laboratory QA plan, which identifies the roles of both the sample custodian and the laboratory coordinator.

SOPs for sample handling are briefly described below.

- SOP 3 - Chain of Custody - describes the EPA forms, forms completion instructions, and the record keeping requirements and formats associated with sample custody. Additionally, this SOP outlines the steps to be followed in order to maintain a continuous chain of custody from sample collection to data generation and the communications and information transfer that will occur between field personnel, sample coordinators, and EPA personnel;

- SOP 4 - Sample Identification, Labeling and Packaging - outlines the steps involved with sample labeling and packing at the point of collection for distribution to the analytical laboratory; and
- SOP 5 - Sample Location Documentation - outlines the necessary descriptions and information to be recorded for each physical location where sampling is conducted.

9.0 ANALYTICAL METHODS (Element B4)

To ensure that the DQOs established in the project-specific SAP can be achieved, the analytical criteria that are to be used for data generation by laboratory analysis must be clearly identified. Analytical methods for sample analyses are selected on the basis of the required detection limits, known contaminants existing in the study area, and the range of analytes to be determined. The project-specific SAP identifies the analytical methods for the samples collected during the project activities. Table 2 provided in Appendix A, Table 4 provided in Appendix A, or a table containing equivalent information, is used in the SAP to present method numbers, reference guidance, sample container, sample volume requirements, sample preservatives, sample holding times, and contaminant specific benchmarks for each sample matrix and analyte.

Analysis of samples collected at CDPHE are performed by laboratories that have established laboratory QA plans in compliance with the EPA's QA guidance for sampling and chemical analysis. Prior to sample analysis, the laboratory is provided with the following directions.

- Number and matrices of the samples to be analyzed;
- Required analysis turnaround time;
- Identification of analytical methods and equipment;
- Description of sample preparation procedures;
- Identification of digestion/extraction methods;
- Frequency and type of QC analyses;
- Precision and accuracy criteria;
- Data reporting limits and units; and
- Laboratory documentation and reporting requirements.

If the Project Leader, in conjunction with the Analytical Services Coordinator and the Quality Assurance Officer find the analytical data to be unreliable or incomplete, the laboratory is responsible for correcting the errors. If the laboratory can not provide data of adequate accuracy and precision, the samples may need to be recollected.

10.0 QUALITY CONTROL (Element B5)

The project-specific SAP identifies the QC procedures needed for each sampling, analysis or measurement technique applicable to the project and states or references the required control limits for each QC check. The number and type of QC samples collected are determined by the type of data to be collected as identified during the DQO process. QC checks of both field sampling and laboratory sample analysis are used to assess and document data quality and to identify discrepancies in the measurement process that need correction. QC samples are used to determine the representativeness of the environmental samples, the precision of sample collection and handling procedures, the thoroughness of the field decontamination procedures, and the accuracy of the laboratory analysis.

Table 1 in Appendix A, or a table containing equivalent information, is used in the SAP to present the quantities of field and laboratory QC samples to be collected and analyzed for each matrix to be investigated.

10.1 FIELD QUALITY CONTROL

The following sections describe the types of field QC samples that are collected:

Field blanks are used to indicate the presence of external contaminants that may have been introduced into the samples during collection. These blanks may also become contaminated during transport, but this condition is assessed by the use of trip blanks, as discussed below. Field blanks are prepared on site during the sampling event by pouring ASTM Type I organic-free water into randomly selected sample containers.

Trip blanks are used to assess contamination introduced into the sample containers by volatile organics through diffusion during sample transport and storage. One trip blank is prepared off-site and is included in each shipping container with samples scheduled only for analysis of volatile organic compounds regardless of environmental medium. When sample bottles are provided by the laboratory, trip blanks are prepared at the laboratory using ASTM Type I organic-free water, transported to the sampling site with the other sample containers, and returned to the testing laboratory for analysis along with the samples collected during the sampling event. The trip blanks remain unopened throughout the transportation and storage processes and are analyzed along with the associated environmental samples. Trip blanks are analyzed and reported as water samples even though the associated environmental samples may be from a medium such as soil, tissue, product, etc.

Equipment blanks (equipment decontamination rinsates) are used to assess the adequacy of practices to prevent cross-contamination between sampling locations and samples. Rinsate samples are collected daily only for sampling equipment used repetitively to collect environmental samples and not for dedicated sampling equipment or drilling equipment. Rinsate water is collected following the final decontamination rinse of sampling equipment (such as a bailer, sampling pump, or mixing bowl) and then dispensed into sample containers. Specified sample containers and sample volumes are collected for each type of analysis to be conducted by the laboratory. The equipment decontamination rinsates are handled and analyzed in the same manner as all environmental samples.

Field replicates (or duplicates) are collected at selected locations to provide estimates of the total sampling and analytical precision. At least one replicate sample is analyzed from each group of 20 samples of a similar matrix type and concentration. The field replicates are handled and analyzed in the same manner as all environmental samples.

Standard reference samples are used to assess the accuracy of the analytical methods specified and to assess the performance of the laboratory sample analysis. These samples are prepared with a known composition and analyte concentration by an independent laboratory and submitted to the analytical laboratory as unknown samples. The samples contain specific analytes at concentrations anticipated to be measured in the various environmental media and are analyzed in the same manner as all environmental samples.

10.2 LABORATORY QUALITY CONTROL

The analytical laboratory uses a series of QC samples specified in each standard analytical method to assess laboratory performance. Analyses of laboratory QC samples are performed for samples of similar matrix type and concentration and for each sample batch. The types of laboratory QC samples are method blank, laboratory control standard, duplicate, matrix spike and matrix spike duplicate. Other technical QC requirements may be project-specific, for example second column confirmation for a gas chromatography analysis of pesticides.

The analytical laboratory will also report out-of-control occurrences such as poor analysis replication, poor spike recovery, instrument calibration problems, blank contamination, etc. Corrective action is taken at any time during the analytical process when deemed necessary based on analytical judgment or when QC data indicate a need for action. Corrective actions include, but are not limited to:

- Re-analysis;
- Re-calculation;
- Instrument recalibration;
- Preparation of new standards/blanks;
- Re-extraction/digestion;
- Dilution;
- Application of another analysis method; and
- Additional training of analysts.

Out-of-control incidents are documented so that corrective action may be taken to set the system back “in control.” These incidents constitute a corrective action report, and are signed by the laboratory director and the laboratory QA contact:

- Where the out-of-control incident occurred;
- When the incident occurred and was corrected;
- Who discovered the out-of-control incident;
- Who verified the incident;
- Who corrected the problem; and
- Who verified the correction.

11.0 <u>INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY (Element B7)</u>

11.1 CALIBRATION PROCEDURES

The project-specific SAP identifies the field sampling, measuring and testing equipment to be used for data collection activities. All equipment used on the project is calibrated and adjusted to operate within manufacturers' specifications. Equipment and instrumentation calibration ensures that accurate and reliable measurements are obtained. The procedures for calibration and maintenance used by the analytical laboratories are included in their laboratory QA Plans and analytical methods. All calibration standards are traceable to the National Institute of Standards and Technology or other primary standards. Methods and intervals of calibration are based on the type of equipment, stability characteristics, required accuracy, intended use, and environmental conditions.

11.2 PREVENTIVE MAINTENANCE

Preventive maintenance is implemented on a scheduled basis to minimize downtime and to ensure accurate measurements from both field and laboratory equipment. This program is designed to achieve results commensurate with the specified capabilities of equipment operation, thus generating data of known quality. Maintenance is conducted by trained technicians using service manuals or through service agreements with qualified maintenance contractors. In addition, backup equipment and critical spare parts are maintained to quickly correct equipment malfunction.

11.3 CALIBRATION AND MAINTENANCE RECORDS

Calibration and maintenance records are maintained for equipment in project specific logbooks.

12.0 ASSESSMENT AND RESPONSE ACTIONS (Element C1)

Assessments are utilized to increase the user's understanding of the activity being assessed and to provide a basis for improving that activity. Assessments may be conducted by CDPHE staff or independent subcontractors. All assessments are planned and documented based on the project requirements. Both self-assessments and independent assessments utilize one or more assessment tools such as reviews, surveillances, formal audits and technical documentation reviews. The project-specific SAP identifies the number, frequency, and type of assessment activities needed for the project. Assessment responsibilities, planning, tools and responses are summarized below.

12.1 RESPONSIBILITY FOR ASSESSMENTS

QA/R-5 requires that assessments be conducted by personnel who have sufficient authority, access to work areas, and organizational freedom to:

- Identify quality problems;
- Identify and cite practices that may be shared with others to improve the quality of their operations and products;
- Propose recommendations for resolving quality problems;
- Independently confirm implementation and effectiveness of solutions;
- Provide documented assurance to line management that, when problems are identified, further work performed is monitored carefully until the problems are suitably resolved; and
- Suspend or stop work with the concurrence of the SUL and EPA, upon detection and identification of an immediate adverse condition affecting the quality of results.

12.2 IMPLEMENTATION OF ASSESSMENTS

Approaches used for the assessments vary with the objectives of the assessment and the status of the project, but are of two basic types:

- Management and technical self-assessment: the qualitative assessment of a management or technical system by those immediately responsible for overseeing and/or performing the work.
- Management and technical independent assessment: the qualitative assessment of management or technical system by someone other than the group performing the work.

Assessments are scheduled by the QAO in consultation with the Project Leader but may be requested by the SUL or EPA. The schedule for either management or technical assessments is based on the status, risk, and activities in progress and is documented in project-specific plans. In addition to scheduled assessments, technical personnel conduct routine, informal assessments of their work and may request a formal assessment to clarify or document unusual or complex activities.

The planning process for assessments includes one or more of the following:

- Reviewing project-specific requirements identified within project plans;
- Defining acceptance criteria;
- Developing an outline or check list of critical technical functions and procedural requirements;
- Defining the responsibility and authority of the person(s) conducting the assessment; and
- Assuring that the personnel scheduled to conduct the assessment have adequate training and experience. The capability of personnel conducting assessments is determined by review of their training, certification, and experience with the program, project, or system being assessed. Assessor qualifications must be equivalent to or higher than the individual whose activity is to be assessed. Independent assessments must have no real or perceived conflict of interest.

Assessment findings, recommendations, and corrective actions are documented in reports that contain some or all of the following:

- Names of the parties responsible for the assessment;
- A copy of guidelines developed for the assessment;
- Brief description of the activity assessed;
- Description of any quality problems;
- Recommendations for resolving any quality problems; and
- Suggestions for sharing and noteworthy practices.

12.3 MECHANISMS FOR ASSESSMENT

The tools for assessment include:

- Management system reviews;
- Audits and surveillances;
- Independent technical reviews and peer reviews;
- Readiness reviews;
- Data reduction assessment; and
- Data quality assessments.

12.3.1 Management System Review

Management system reviews evaluate the ability of project management to meet programmatic requirements or to meet specified data and information collection DQOs. Normally this type of review will not be scheduled. However, if substantial nonconformances are identified from the other scheduled audits or the quality of data and related documentation are of project concern, this form of review will be employed under the direction of the QAO.

The management system is reviewed to ensure:

- Effectiveness of the system of management controls that are established to achieve and ensure quality;

- Adequacy of resources and personnel provided to achieve and ensure quality in all activities;

- The effectiveness of training and audits; and

- Applicability of DQOs and software.

12.3.2 Audits and surveillances

Systems and performance audits and surveillances are conducted as the principal means to determine compliance with the project-specific documents. Audits and surveillances are used to formally review individual projects during their course and across all levels of management. The QAO has the primary responsibility for conducting audits and surveillances, portions of which may be delegated to an auditing team comprised of senior technical specialists.

Copies of the audit reports and surveillance memoranda are maintained in the QA administrative files and in the project files and are transmitted to the EPA with the final report for a project, or when requested by the EPA. Technical specialists must be familiar with the technical and procedural requirements of both field and laboratory operations, and the associated QA plans. In addition, auditors may not be directly involved with the actual tasks themselves, so as not to introduce bias in the auditing process. Several factors are taken into consideration for determining the scope and frequency for audits and surveillances as follows:

- Complexity of the task order;
- Applicable regulations;
- Program guidance;
- Project or task scope and duration;
- Data quality objectives;
- Deliverable requirements;
- Subcontractor participation;
- Emergency conditions;
- Criticality of data collection; and
- Potential for or frequency of nonconformances.

Surveillances are less formal than audits, but generally they follow the same procedures as an audit. Surveillances may be initiated by line management or the QAO when a need for such is determined.

An audit or surveillance may be initiated prior to the award of a subcontract to determine the capability of a potential subcontractor; when reorganization or major revision has been made to the project-specific SAP; when scheduled audits are established by the project planning documents; at any time a nonconformance is suspected; or to verify that corrective actions for nonconformance have been implemented.

The QAO submits notice of any laboratory or field system audits prior to their occurrence and in a timely manner to EPA. Audits are scheduled such that an EPA representative may attend and observe the audit. Two types of audits are as follows:

Performance Audits are used to determine the status and effectiveness of both field and laboratory measurement systems and provide a quantitative measure of the quality of data generated. For laboratories, this involves the use of standard reference samples or performance evaluation samples. These samples have known concentrations of constituents that are analyzed as unknowns in the laboratory. Results of the laboratory analyses are calculated and compared for accuracy against the known concentrations of the samples and evaluated in relation to the project DQOs. Field performance is evaluated using field blanks, trip blanks, equipment decontamination rinsates, field replicates, and collocated samples.

Technical System Audits are used to confirm the adequacy of the data collection (field operation) and data generation (laboratory operation) systems. The on-site audits are conducted to determine whether the QAPP, project-specific SAP, and field and laboratory SOPs are being properly implemented.

- A systems audit of field procedures assesses and documents at a minimum, prefield activities, sampling methods (including collection, containers, and preservation), equipment decontamination, chain of custody, sample tracking and shipment documentation, sample labeling, QC methodology, equipment maintenance and calibration, sampling documentation and other field activity logs, field team debriefing, post-field activities, and equipment check-in and recalibration.

- A systems audit of laboratory procedures assesses and documents at a minimum, methods for data qualification, analytical data generation, chain-of-custody documentation and protocol, instrument calibration and maintenance, data reporting, QC methods and QC criteria, and nonconformance corrective action procedures.

12.3.3 Independent Technical Review and Peer Review

An independent technical review is a documented critical review of work of a substantive nature or identified as a deliverable. A peer review is a documented critical review of work, generally beyond the state of the art or characterized by the existence of potential uncertainty. These reviews are conducted by experienced and qualified personnel to ensure the quality and integrity of tasks and products by allowing the work and/or deliverable to undergo objective, critical scrutiny. The QAO, SUL, and Project Leader are responsible for ensuring that reviewers are independent from actual work or decision-making on the tasks or activities being reviewed, and possess technical qualifications sufficient for conducting the in-depth review. A written record of the review and resolution of the review findings is incorporated into the project files.

The independent technical review and peer review process is used as a management tool to assess the following:

- Soundness of a technical approach or result;
- Application of complicated problem-solving techniques;
- Changes in the scope of a project;
- Transition between phases of a sampling event;
- Problems identified in a project or report;
- Major decisions made at the planning stage or during the course of a project;
- Potential for erroneous assumptions, data, calculations, methods, or conclusions; and
- Basis of design criteria and calculations.

Independent technical reviews and peer reviews are conducted for (but are not limited to) all:

- Work Plans;
- SAPs;
- Reports of site inspections;
- Draft and final project reports; and
- SOPs.

As needed, based on project DQOs, independent technical reviews and peer reviews may be conducted for:

- Technical approaches;

- Technical memoranda;
- Studies and investigations;
- Cost estimates;
- Plans and specifications; and
- Subcontract scopes of work.

12.3.4 Readiness Review

A readiness review is a systematic, documented review of the readiness for the start up or continued use of a facility, process, or activity. Readiness reviews are typically conducted before proceeding beyond project milestones and prior to initiation of a major phase of work. Readiness reviews are performed by the SUL as needed during key successive phases of a project.

12.3.5 Data Reduction Assessment

The following section outlines the procedures for verifying the accuracy of the data reduction process, the methods used to ensure that data transfer is error-free (or has an admissible error rate), that no information is lost in the transfer process, and that the output is completely recoverable from the input. In order to reduce the risks associated with data transfer, this process is kept to a minimum. Data are reduced either manually on calculation sheets or by computer on formatted print-outs. The following responsibilities are delegated in the data reduction process:

- Technical personnel document and review their own work and are accountable for its correctness;

- Major calculations receive both a method and an arithmetic check by an independent checker. The checker is accountable for the correctness of the checking process;

- An Independent Technical Review is conducted to ensure the consistency and defensibility of the concepts, methods, assumptions, calculations, etc., as scheduled by the Project Leader; and

- The Project Leader is responsible for ensuring that data reduction is performed in a manner that produces quality data through review and approval of calculations.

Hand Calculations must be legibly recorded on calculation sheets and in logical progression with sufficient descriptions. Major calculations are checked by a staff member. After completing the check, the checker signs and dates the calculation sheet immediately below the originator. Both the originator and checker are responsible for the correctness of calculations. A calculation sheet contains the following, at a minimum:

- Project title and brief description of the task;
- Task number and date performed;
- Signature of person who performed the calculation;

- Basis for calculation;
- Assumptions made or inherent in the calculation;
- Complete reference for each source of input data;
- Methods used for calculations; and
- Results of calculations, clearly annotated.

Computer Analysis includes the use of models, programs, data management systems, etc. For published software with existing documentation, test case runs are periodically performed to verify that the software is performing correctly. Both systematic and random error analysis are investigated and appropriate corrective action measures taken.

Documentation for project specific in-house developed models and programs is reviewed by the SUL prior to use. This documentation is prepared in accordance with computer program verification procedures and contains at a minimum:

- Description of methodology and engineering basis;
- Major mathematical operations;
- Flow chart presenting the organization of the model or program; and
- Test case(s), sufficiently comprehensive to test all model or program operations.

QC procedures for checking models (or programs) involves reviewing the documentation, running the test case, and manually checking selected mathematical operations. Each computer run has a unique number, date, and time associated with it appearing on the printout. All QC measures are documented as referenced in applicable procedures.

12.3.6 Data Quality Assessment

Data Quality Assessments are prepared to document the overall quality of data collected in terms of the established DQOs. The data assessment parameters calculated from the results of the field measurements and laboratory analyses are reviewed to ensure that all data used in subsequent evaluations are scientifically valid, of known and documented quality, and, where appropriate, legally defensible. In addition, the performance of the overall measurement system is evaluated in terms of the completeness of the project plans, effectiveness of field measurement and data collection procedures, and relevance of laboratory analytical methods used to generate data as planned. Finally, the goal of the data quality assessment is to present the findings in terms of data usability.

The major components of a data quality assessment are presented below and show the logical progression of the assessment leading to determination of data usability:

- Summary of the individual data validation reports for all sample delivery groups by analytical method. Systematic problems, data generation trends, general conditions of the data, and reasons for data qualification are presented;

- Description of the procedures used to further qualify data caused by dilution, reanalysis, and duplicate analysis of samples. Examples of the decision logic are provided to illustrate the methods by which qualifiers are applied;

- Evaluation of QC samples such as, field blanks, trip blanks, equipment rinsates, field replicates and laboratory control samples to assess the quality of the field activities and laboratory procedures;

- Assessment of the quality of data measured and generated in terms of accuracy, precision, and completeness through the examination of laboratory and field control samples in relation to objectives established and correct application of statistical methods. A further discussion of the evaluation of DQOs is presented in Section 14.0.

- Summary of the usability of data, based upon the assessment of data conducted during the previous four steps. Sample results for each analytical method are qualified as acceptable, rejected, estimated, biased high, or biased low.

12.4 RESPONSE TO ASSESSMENTS

The SUL and Project Leaders review and respond to assessment findings in a timely manner. This response will depend upon the potential impact and/or time-critical nature of the quality problem. In all cases, it is the responsibility of the QAO to confirm the implementation and effectiveness of the response action.

- **Time-Critical, Significant Impact.** Example: A field audit finds that a subcontractor is using an inappropriate analytical procedure. The assessor notifies the Project Leader and QAO from the field, discusses alternatives; attempts to take immediate corrective action; and, if necessary, stops work with concurrence of the Project Leader, SUL and EPA.

- **Time-Critical, Minor Impact.** Example: A field audit finds that sample labels are messy but information is useable. The assessor notifies the Project Leader and documents the finding.

- **Not Time-Critical, Possible Major Impact.** Example: A management assessment determines that a procedure for sampling is in error. The assessor incorporates a description and recommendation into a report to the SUL, and QAO. The SUL establishes a schedule for corrective action, designates a responsible person, and determines what documentation of the corrective action is required; the QAO follows up to confirm that the corrective action has been implemented.

- **Not Time-Critical, Minor Impact.** Example: A management assessment determines that the numbering system for the procedures is obsolete. The assessor describes the problem; discusses a solution with the responsible person; and reports to the Project Leader that the issue has been resolved; the QAO follows up to confirm that the corrective action has been implemented.

12.5 NON-CONFORMANCE AND CORRECTIVE ACTION

Management and technical staff follow project plans, supplementary procedures, SOPs, and training plans and procedures during the course of any CDPHE activity, however, on occasion, non-conformances do occur. Each nonconformance is documented by CDPHE personnel or a subcontractor employee observing the nonconformance. Examples of nonconforming work include:

- Items that do not meet the contractual requirements by a subcontractor supplier;
- Errors made in following work instruction or improper work instruction;
- Unforeseen or unplanned circumstances that result in services that do not meet quality/contractual/technical requirements;
- Unapproved or unwarranted deviations from established procedures;
- Errors in craftsmanship or trade skills;
- Non-validated or verified computer programs;
- Sample Chain-of-Custody missing or deficient; and
- Data falling outside established DQO criteria.

Results of QA reviews and audits typically identify the requirement for a corrective action. The QAO is responsible for reviewing all audit and nonconformance reports to determine areas of poor quality or failure to adhere to established procedures. Nonconformances are formally reported by the QAO to the Project Leader. The Project Leader is responsible for evaluating all reported nonconformances, determining the root cause, conferring with the QAO on the steps to be taken for correction, and executing the corrective action as developed and scheduled. Corrective action measures are selected to prevent or reduce the likelihood of future occurrences and address the root causes to the extent identifiable. Selected measures are appropriate to the seriousness of the nonconformance and are realistic in terms of the resources required for implementation.

In summary, corrective action involves the following steps:

- Discovery of a nonconformance;
- Identification of the responsible party;
- Determination of root causes;
- Plan and schedule of corrective/preventive action;
- Review of the corrective action taken; and
- Confirmation that the desired results were produced.

Upon completion of the corrective action, the QAO evaluates the adequacy and completeness of the action taken. If the action is found to be inadequate, the QAO and Project Leader confer to resolve the problem and determine any further actions. Implementation of any further action is scheduled by the Project Leader. The QAO will issue a suspend or stop work notice with the concurrence of the SUL and EPA in cases where significant problems continue to occur or a critical situation requires work to prevent further discrepancies, loss of data, or other problems. When the corrective action is found to be adequate, the QAO notifies the Project Leader of the completion of the audit.

The QAO maintains a log of nonconformances in order to track their disposition until correction and for trend analysis as necessary. All documentation associated with a nonconformance is entered into the project files and QA administrative files.

13.0 DATA REVIEW, VERIFICATION AND VALIDATION (Elements D1 and D2)

At a minimum, all analytical data are reviewed. The SAP indicates if data validation is also required based on the project DQOs. When applicable, the SAP presents project-specific criteria used to accept, reject or qualify data.

The purpose of the validation process is to eliminate unacceptable analytical data and to designate a data qualifier for any data quality limitation discovered. In some instances, the analytical data may be used only for approximation purposes. Data validation criteria are discussed below for both field and laboratory data.

13.1 FIELD DATA VALIDATION

Field Data Validation is conducted to eliminate data that are not collected or documented in accordance with specified protocols outlined in the QAPP and SAP and listed below. In some instances, the field data are used only for approximation purposes and do not require validation. In all cases, validation of field data is performed on two separate levels. First, all field data are validated at the time of collection reviewing the procedures outlined in the SOPs. Second, the Project Leader reviews the field data documentation to identify discrepancies or unclear entries. Field data documentation are validated against the following criteria:

- Sample location and adherence to the plan;
- Field instrumentation calibration;
- Sample collection protocol;
- Sample volume;
- Sample preservation;
- Blanks collected and submitted with each respective sample set;
- Duplicates collected and submitted with each respective sample set;
- Sample documentation protocols;
- Chain-of-Custody protocol; and
- Sample handling and shipment.

13.2 QC REVIEW AND ANALYTICAL DATA VALIDATION

13.2.1 QC Review

QC Review consists of a review of the data summary forms that are generated for a set of data. At a minimum, Chain-of-Custody records, the case narrative, and the summary results for samples and QC analyses are reviewed. The raw data are reviewed for completeness only. The Reviewer assumes that the information presented in the data summary forms is correct as presented. Information that is not contained in the data summary forms is not used in the review process. (Note: Raw data may be reviewed if the data summary forms reveal a discrepancy or error that cannot be resolved through a review of the data summary forms.)

13.2.2 Data Validation

The Site Assessment Program requires that data be validatable but does not require validation of each data set for decision making. Data is routinely validated. Exceptions are at the descretion of the EPA Site Assessment Manager, in consultation with the CDPHE Project Leader.

Analytical Data Validation is conducted by a specialty contractor not involved with the actual generation of data. All data generated are recorded on standard Contract Laboratory Program (CLP) Statement of Work (SOW) forms, or their equivalent. This requirement includes both CLP and non-CLP analyses such as standard EPA analytical methods not specifically covered by the CLP. The data report is then validated in accordance with the criteria contained in EPA guidance documents modified for the analytical method used (EPA 1994a; EPA 1994b). Data validation reports are filed with the data and describe the usability of the data for further technical interpretations.

The validation report provides a list of all samples being validated, a narrative summarizing each validation topic (e.g., calibration, hold times, etc.), flagged form 1s, worksheets, and any data resubmitted by the laboratory at the request of the validator. The requirements for data validation relate to the QA/QC elements summarized in Table 5-1as follows:

Screening Data: Data need only be evaluated for calibration and detection limits criteria.

Screening Data with 10% Definitive Confirmation: Data validation of 10% of the results reported in each of the samples, calibrations, and QC analyses is required for screening data with definitive confirmation (of the definitive confirmation data only). The results are evaluated for all of the QA elements listed in Section 5.1.2 and in Table 5-1.

Definitive Data: Data validation of 10% of the results reported in each of the samples, calibrations, and QC analyses is required for definitive data. The results are evaluated for all of the QA elements listed in Section 5.1.3 and in Table 5-1.

14.0 RECONCILIATION WITH DATA USER REQUIREMENTS (Element D3)

In the final report for each project, all data generated for the project are reconciled with the DQOs presented in the project-specific SAP. The final report describes initial project DQOs and summarizes all changes made to the DQOs as the project progressed. The rationale for the changes is discussed along with any consequences of these changes. The report describes how issues were resolved and limitations on the use of the data. The report also summarizes procedures used to define data usability, i.e., data reviews or validation reports, and the results of these procedures (see also Section 12.3.6).

Analytical data are assessed for accuracy, precision, completeness, representativeness, and comparability. The data assessment criteria for each of these parameters are described in Section 5.2 of this QAPP. This section establishes the methods for calculating accuracy, precision, and completeness and for evaluating representativeness and comparability using the methods described by EPA guidance. Generally, data that do not meet the established acceptance criteria are cause for resampling and reanalysis. However, in some cases data that do not meet acceptance criteria are usable with specified limitations. Data that are indicated as usable with limitations are included in the project reports, but are clearly indicated as having limited usability. Indicators of data limitations include data qualifiers, quantitative evaluations, and narrative statements regarding potential bias.

14.1 PRECISION

Precision examines the spread of data about their mean. The spread presents how different the individual reported values are from the average reported values. Precision is thus a measure of the magnitude of errors and will be expressed as the relative percent difference (RPD) or the relative standard deviation (RSD). The lower these values are, the more precise that data. These quantities are defined as follows:

$$\boldsymbol{RPD}\ (\%) = 100 \times \frac{|S - D|}{(S + D)/2}$$

$$\boldsymbol{RSD}\ (\%) = \frac{100}{\sqrt{2}} \times \frac{2|S - D|}{(S + D)}$$

where S = *Analyte concentration in a sample*
D = *Analyte concentration in a duplicate sample*

or

$$\boldsymbol{RSD}\ (\%) = 100\ (\frac{s}{\bar{X}})$$

where s = *Standard deviation of replicate measurements*
$\bar{X}$ = *Mean of replicate measurements*

14.2 ACCURACY

Accuracy measures the average or systematic error of an analytical method. This measure is defined as the difference between the average of reported values and the actual value. Accuracy will be expressed as the percent bias for standard reference samples. The closer this value is to zero, the more accurate the data. This quantity is defined as follows:

$$\textit{Bias}\ (\%) = \frac{MC - KC}{KC} \times 100$$

where KC = *Known analyte concentration*
MC = *Measured analyte concentration*

In cases where accuracy is determined from spiked samples, accuracy will be expressed as the percent recovery. The closer these values are to 100, the more accurate the data. Surrogate recovery will be calculated as follows:

$$\textit{Recovery}\ (\%) = \frac{MC}{SC} \times 100$$

where SC = *Spiked concentration*
MC = *Measured concentration*

Matrix spike percent recovery will be calculated as follows:

$$\text{Recovery}\ (\%) = \frac{MC - USC}{SC} \times 100$$

where: SC = Spiked concentration
MC = Measured concentration
USC = Unspiked sample concentration

In instances where data can be adjusted to correct for systematic errors before data evaluation, the correction factor and rationale for correction will be fully documented and presented in the report that summarizes the data.

14.3 COMPLETENESS

Completeness establishes whether a sufficient number of valid measurements were obtained. The closer this value is to 100, the more complete the measurement process. This quantity will be calculated as follows:

$$\textit{\textbf{Completeness}}\ (\%) = \frac{V}{P} \times 100$$

where V = *Number of valid measurements*
P = *Number of planned measurements*

14.4 REPRESENTATIVENESS

Representativeness expresses the degree to which data accurately and precisely represent the environmental condition. Following a determination of precision, a statement on representativeness will be prepared noting the degree to which data represent the environmental and contaminant conditions under investigation.

14.5 COMPARABILITY

Comparability expresses the confidence with which one set of data can be compared to another. Following the determination of both precision and accuracy, a statement on comparability will be prepared citing the acceptance criteria established in relation to use of the data sets in further evaluations and modeling of the environmental and contaminant conditions under investigation. A statement on comparability will also be prepared when the data collected are used with data reported from another or previous study.

15.0 LIST OF REFERENCES

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APPENDIX A

Environmental and Quality Control Sample Collection and Laboratory Analysis Specifications

TABLE 1
Environmental and Quality Control Sample Quantities for Environmental Analyses

Sample ID / Location	Analysis					Quality Control Samples							Total Samples
						Lab QA/QC			Field QA/QC				
						Standard Reference Samples	MS/MSD	Other...	Field Replicates	Trip Blanks	Field Blank	Equipment Rinsate	
Total Samples													

TABLE 2
Environmental Sample Collection and Laboratory Analysis Specifications

Analysis	Analytical Method	Reference	Container[a]	Required Volume	Preservation[b]	Holding Time[c]

[a] Container types: AGV = amber glass vial; HDPE = high-density polyethylene bottle and cap; AGB = amber glass bottle.

[b] Sample preservation will be performed by the sampler immediately upon sample collection. Preservatives will be added to filtered samples following filtration. Containers used for volatile organic samples will be completely filled, permitting no head space.

[c] Holding times begin from the time of sample collection in the field. Two holding times indicate the maximum holding time until sample extraction and the maximum holding time.

TABLE 3
Quality Assurance Objectives for Environmental Samples

Analysis (for each matrix)	Analytical Method	Data Type	Units	Required Detection Limits	Accuracy %	Precision ±%

Note: The complete list of analytes determined from laboratory sample analysis is published in each reference document listed for the specified analytical method. Detection limit, accuracy, and precision values are presented in this table as ranges, but are assigned to each individual analyte as published in each reference document.

Data type refers to the following:
S = Screening;
S/D = Screening with 10% Definitive Confirmation;
D = Definitive data

Accuracy is determined by use of field blind QC samples and laboratory matrix spikes.
Precision is determined by use of field duplicates, laboratory duplicates, and laboratory matrix spike duplicates.

Table 4

A Comparison of CLP Detection Limits with Superfund Chemical Data Matrix Benchmarks and ICP / Mass Spec Limits for ULSA Request

Sorted by Alphabetical Order

Substance Name	CLP Limits		ICP/MS Limits		Ground Water Pathway			Drinking Water			Food Chain		Environmental		Soil Pathway	
	Water mg/L	Soil mg/kg	Water mg/l	Soil mg/kg	MCL/MCLG mg/L	Reference Dose Screening Conc. mg/L	Cancer Risk Screen Conc mg/L	MCL/MCLG mg/L	Reference Dose Screening Conc. mg/L	Cancer Risk Screen Conc mg/L	Reference Dose Screening Conc. mg/kg	Cancer Risk Screen Conc mg/kg	AWQC/ AALAC Freshwater mg/L	AWQC/ AALAC Saltwater mg/L	Reference Dose Screening Conc. mg/kg	Cancer Risk Screen Conc mg/kg
Inorganic																
Aluminum	2.0E-01	4.0E+01	5.0E-03	5.0E-01												
Antimony	6.0E-02	1.2E+01	1.0E-04	1.0E-02	6.0E-03	1.5E-02		6.0E-03	1.5E-02		5.4E-01				3.1E+01	
Arsenic	1.0E-02	2.0E+00	5.0E-04	5.0E-02	5.0E-02	1.1E-02	■	5.0E-02	1.1E-02	■	4.1E-01	■			2.3E+01	4.3E-01
Barium	2.0E-01	4.0E+01	1.0E-04	1.0E-02	2.0E+00	2.6E+00		2.0E+00	2.6E+00		9.5E+01				5.5E+03	
Beryllium	5.0E-03	1.0E+00	1.0E-04	1.0E-02	4.0E-03	1.8E-01	■	4.0E-03	1.8E-01	■	6.8E+00	■			3.9E+02	1.5E-01
Cadmium	5.0E-03	1.0E+00	1.0E-04	1.0E-02	5.0E-03	1.8E-02		5.0E-03	1.8E-02		6.8E-01		1.1E-03	1.1E-03	3.9E+01	
Calcium	5.0E+00	1.0E+03	5.0E-03	5.0E-01												
Chromium	1.0E-02	2.0E+00	1.0E-04	1.0E-02	1.0E-01			1.0E-01								
Cobalt	5.0E-02	1.0E+01	1.0E-04	1.0E-02												
Copper	2.5E-02	5.0E+00	1.0E-04	1.0E-02	1.3E+00			1.3E+00					1.2E-02	1.2E-02		
Iron	1.0E-01	2.0E+01	5.0E-03	5.0E-01									1.0E+00	1.0E+00		
Lead	3.0E-03	6.0E-01	1.0E-04	1.0E-02	1.5E-02			1.5E-02					3.2E-03	3.2E-03		
Magnesium	5.0E+00	1.0E+03	5.0E-03	5.0E-01												
Manganese	1.5E-02	3.0E+00	1.0E-04	1.0E-02		1.8E-01			1.8E-01		6.8E+00				3.9E+02	
Mercury *	2.0E-04	4.0E-02	2.0E-04	2.0E-02	2.0E-03	1.1E-02		2.0E-03	1.1E-02		4.1E-01		■	■	2.3E+01	
Molybdenum	na	na	1.0E-04	1.0E-02		1.8E-01			1.8E-01		6.8E+00					
Nickel	4.0E-02	8.0E+00	1.0E-04	1.0E-02		7.3E-01							■	■	1.6E+03	
Potassium	5.0E+00	1.0E+03	5.0E-03	5.0E-01												
Selenium	5.0E-03	1.0E+00	1.0E-03	1.0E-01	5.0E-03	1.8E-01		5.0E-02	1.8E-01		6.8E+00		5.0E-03	5.0E-03	3.9E+02	
Silver	1.0E-02	2.0E+00	1.0E-04	1.0E-02		1.8E-01			1.8E-01		6.8E+00		2.3E-03	2.3E-03	3.9E+02	
Sodium	5.0E+00	1.0E+03	5.0E-03	5.0E-01												
Thallium	1.0E-02	2.0E+00	1.0E-04	1.0E-02	5.0E-04			5.0E-04								
Vanadium	5.0E-02	1.0E+01	1.0E-04	1.0E-02		2.6E-01			2.6E-01		9.5E+00				5.5E+02	
Zinc	2.0E-02	4.0E+00	5.0E-04	5.0E-02		1.1E+01			1.1E+01		4.1E+02		1.2E-01	1.2E-01	2.3E+04	
Cyanide	1.0E-02	2.0E+00			2.0E-01	7.3E-01		2.0E-01	7.3E-01		2.7E+01		5.2E-03	5.2E-03	1.6E+03	

▨ Lower than CLP RAS DL

■ Lower than normal ICP/MS DL

* - Mercury limits are cold vapor atomic absorption limits, not ICP/MS.

Table 4

A Comparison of CLP Detection Limits with Superfund Chemical Data Matrix Benchmarks

Sorted by Alphabetical Order

Substance Name	CLP Limits			Ground Water Pathway			Drinking Water			Food Chain		Environmental		Soil Pathway	
	Low Conc SOW Water ug/L	Water ug/L	Soil ug/kg	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg	AWQC/ AALAC Freshwater ug/L	AWQC/ AALAC Saltwater ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg
Volatile Organic															
Chloromethane	1.0E+00	1.0E+01	1.0E+01			6.6E+00			6.6E+00		2.4E+02				4.9E+04
Bromomethane	1.0E+00	1.0E+01	1.0E+01		5.1E+01			5.1E+01		1.9E+03				1.1E+05	
Vinyl chloride	1.0E+00	1.0E+01	1.0E+01	2.0E+00		4.5E-02	2.0E+00		4.5E-02		1.7E+00				3.4E+02
Chloroethane	1.0E+00	1.0E+01	1.0E+01												
Methylene chloride	2.0E+00	1.0E+01	1.0E+01	5.0E+00	2.2E+03	1.1E+01	5.0E+00	2.2E+03	1.1E+01	8.1E+02	4.2E+02			4.7E+06	8.5E+04
Acetone	5.0E+00	1.0E+01	1.0E+01		3.7E+03			3.7E+03		1.4E+05				7.8E+06	
Carbon disulfide	1.0E+00	1.0E+01	1.0E+01		3.7E+03			3.7E+03		1.4E+05				7.8E+06	
Dichloroethene, 1,1-	1.0E+00	1.0E+01	1.0E+01	7.0E+00	3.3E+02	1.4E-01	7.0E+00	3.3E+02	1.4E-01	1.2E+04	5.3E+00			7.0E+05	1.1E+03
Dichloroethane, 1,1-	1.0E+00	1.0E+01	1.0E+01		3.7E+03			3.7E+03		1.4E+05				7.8E+06	
Dichloroethene, 1,2- cis	1.0E+00	1.0E+01	1.0E+01											7.8E+02	
Dichloroethene, 1,2- trans	1.0E+00	1.0E+01	1.0E+01											1.6E+03	
Chloroform	1.0E+00	1.0E+01	1.0E+01	1.0E+02	3.7E+02	1.4E+01	1.0E+02	3.7E+02	1.4E+01	1.4E+02	5.2E+02			7.8E+05	1.0E+05
Dichloroethane, 1,2-	1.0E+00	1.0E+01	1.0E+01	5.0E+00		9.4E-01	5.0E+00		9.4E-01		3.5E+01				7.0E+03
2-Butanone	5.0E+00	1.0E+01	1.0E+01		2.2E+04			2.2E+04		8.1E+05				4.7E+07	
Bromochloromethane	1.0E+00	na	na												
Trichloroethane, 1,1,1-	1.0E+00	1.0E+01	1.0E+01	2.0E+02											
Carbon tetrachloride	1.0E+00	1.0E+01	1.0E+01	5.0E+00	2.6E+01	6.6E-01	5.0E+00	2.6E+01	6.6E-01	9.5E+02	2.4E+01			5.5E+04	4.9E+03
Bromodichloromethane	1.0E+00	1.0E+01	1.0E+01	1.0E+02	7.3E+02	1.4E+00	1.0E+02	7.3E+02	1.4E+00	2.7E+04	5.1E+01			1.6E+06	1.0E+04
Dichloropropane, 1,2-	1.0E+00	1.0E+01	1.0E+01	5.0E+00		1.3E+00	5.0E+00		1.3E+00		4.6E+01				9.4E+03
Dichloropropene, cis-1,3-	1.0E+00	1.0E+01	1.0E+01												
Trichloroethene	1.0E+00	1.0E+01	1.0E+01	5.0E+00		7.7E+00	5.0E+00		7.7E+00		2.9E+02				5.8E+04
Dibromochloromethane	1.0E+00	1.0E+01	1.0E+01	6.0E+01	7.3E+02	1.0E+00	6.0E+01	7.3E+02	1.0E+00	2.7E+04	3.8E+01			1.6E+06	7.6E+03
Trichloroethane, 1,1,2-	1.1E+01	1.0E+01	1.0E+01	3.0E+00	1.5E+02	1.5E+00	3.0E+00	1.5E+02	1.5E+00	5.4E+03	5.5E+01			3.1E+05	1.1E+04
Benzene	1.0E+00	1.0E+01	1.0E+01	5.0E+00		2.9E+00	5.0E+00		2.9E+00		1.1E+02				2.2E+04
Dichloropropene, trans-1,3	1.0E+00	1.0E+01	1.0E+01												
Bromoform	1.0E+00	1.0E+01	1.0E+01	1.0E+02	7.3E+02	1.1E+01	1.0E+02	7.3E+02	1.1E+01	2.7E+02	4.0E+02			1.6E+06	8.1E+04
4-Methyl-2-pentanone	5.0E+00	1.0E+01	1.0E+01		2.9E+03			2.9E+03		1.1E+05				6.3E+06	
Hexanone, 2-	5.0E+00	1.0E+01	1.0E+01												
Tetrachloroethene	1.0E+00	1.0E+01	1.0E+01	5.0E+00	3.7E+02	1.6E+00	4.5E+00	3.7E+02	1.6E+00	1.4E+04	6.1E+01			7.8E+05	1.2E+04
Tetrachloroethane 1,1,2,2-	1.0E+00	1.0E+01	1.0E+01			4.3E-01			4.3E-01		1.6E+01				3.2E+03
1,2-Dibromoethane	1.0E+00	na	na	5.0E-02		1.0E-03	5.0E-02		1.0E-03		3.7E-02				7.5E+00
Toluene	1.0E+00	1.0E+01	1.0E+01	1.0E+03	7.3E+03		1.0E+03	7.3E+03		2.7E+05				1.6E+07	
Chlorobenzene	1.0E+00	1.0E+01	1.0E+01	1.0E+02	7.3E+02		1.0E+02	7.3E+03		2.7E+04				1.6E+06	
Ethyl benzene	1.0E+00	1.0E+01	1.0E+01	7.0E+02	3.7E+03		7.0E+02	3.7E+03		1.4E+05				7.8E+06	
Styrene	1.0E+00	1.0E+01	1.0E+01	1.0E+02	7.3E+03		1.0E+02	7.3E+03		2.7E+05				1.4E+07	
Xylenes (total)	1.0E+00	1.0E+01	1.0E+01												
1,3-Dichlorobenzene	1.0E+00	na	na	6.0E+02											
1,4-Dichlorobenzene	1.0E+00	na	na	7.5E+01		3.6E+00	7.5E+01		3.6E+00		1.3E+02				2.7E+04
1,2-Dichlorobenzene	1.0E+00	na	na	6.0E+02	3.3E+03		3.3E+03		1.2E+05					7.0E+06	
1,2-Dibromo-3-chloropropane	1.0E+00	na	na	2.0E-01		6.1E-02	2.0E-01		6.1E-02		2.3E+00				4.6E+02

░ CLP multi-media SOW limits are not low enough.

▓ CLP low concentration limits are not low enough.

This table assists in determining whether CLP labs can provide adequate DL's.
It is subject to update as risk-based benchmarks are updated, and as CLP contracts are re-negotiated.

Table 4

A Comparison of CLP Detection Limits with Superfund Chemical Data Matrix Benchmarks

Sorted by Alphabetical Order

Substance Name	CLP Limits			Ground Water Pathway			Drinking Water			Food Chain		Environmental		Soil Pathway	
	Low Conc SOW Water Limits ug/L	Water ug/L	Soil ug/kg	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg	AWQC/ AALAC Freshwater ug/L	AWQC/ AALAC Saltwater ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg
Semivolatile Organic															
Acenaphthene	5.0E+00	1.0E+01	3.3E+02		2.2E+03			2.2E+03		8.1E+04				4.7E+06	
Dinitrophenol, 2,4-	2.0E+01	2.5E+01	8.3E+02		7.3E+01			7.3E+01		2.7E+03				1.6E+05	
Nitrophenol, 4-	2.0E+01	2.5E+01	8.3E+02												
Dibenzofuran	5.0E+00	1.0E+01	3.3E+02												
Dinitrotoluene, 2,4-	5.0E+00	1.0E+01	3.3E+02		7.3E+01			7.3E+01		2.7E+04				1.6E+05	
Diethyl phthalate	5.0E+00	1.0E+01	3.3E+02		2.9E+04			2.9E+04		1.1E+06				6.3E+07	
Chlorophenyl-phenyl ethe	5.0E+00	1.0E+01	3.3E+02												
Flourene	5.0E+00	1.0E+01	3.3E+02		1.5E+03			1.5E+03		5.4E+04				3.1E+06	
4-Nitroaniline	2.0E+01	2.5E+01	8.3E+02												1.1E+05
Dinitro-2-methylephenol,	2.0E+01	2.5E+01	8.3E+02												
Nitrosodiphenylamine, N	5.0E+00	1.0E+01	3.3E+02												
Bromophenyl-phenylethe	5.0E+00	1.0E+01	3.3E+02												
Hexachlorobenzene	5.0E+00	1.0E+01	3.3E+02	■	2.9E+01	■	■	2.9E+01	■	1.1E+03	2.0E+00			6.3E+04	4.0E+02
Pentachlorophenol	5.0E+00	2.5E+01	8.3E+02	■	1.1E+03	■	■	1.1E+03	■	4.1E+04	2.6E+01	1.3E+01	1.3E+01	2.3E+06	5.3E+03
Phenanthrene	5.0E+00	1.0E+01	3.3E+02												
Anthracene	5.0E+00	1.0E+01	3.3E+02		1.1E+01			1.1E+04		4.1E+05				2.3E+07	
Carbazole	na	1.0E+01	3.3E+02			■			■		1.6E+02				3.2E+04
Di-n-butyl phthalate	5.0E+00	1.0E+01	3.3E+02		3.7E+03			3.7E+03		1.4E+05				7.8E+06	
Flouranthene	5.0E+00	1.0E+01	3.3E+02		1.5E+03			1.5E+03		5.4E+04				3.1E+06	
Pyrene	5.0E+00	1.0E+01	3.3E+02		1.1E+03			1.1E+03		4.1E+04				2.3E+06	
Butylbenzyl phthalate	5.0E+00	1.0E+01	3.3E+02		7.3E+03			7.3E+03		2.7E+05				1.6E+07	
Dichlorobenzidine, 3,3-	5.0E+00	1.0E+01	3.3E+02			■			■		7.0E+00				1.4E+03
Benz(a)anthracene	5.0E+00	1.0E+01	3.3E+02			■			■		4.3E+00				8.8E+02
Chrysene	5.0E+00	1.0E+01	3.3E+02			1.2E+01			1.2E+01		4.3E+02				8.8E+04
Bis(2-ethylhexyl) phthala	5.0E+00	1.0E+01	3.3E+02	6.0E+00	7.3E+02	6.1E+00	6.3E+00	7.3E+02	6.1E+00	2.7E+02	2.3E+02			1.6E+06	4.6E+04
Di-n-octyl phthalate	5.0E+00	1.0E+01	3.3E+02		7.3E+02			7.3E+02		2.7E+04				1.6E+06	
Benzo(b)flouranthene	5.0E+00	1.0E+01	3.3E+02			■			■		4.3E+00				8.8E+02
Benzo(k)flouranthene	5.0E+00	1.0E+01	3.3E+02			■			■		4.3E+01				8.8E+03
Benzo(a)pyrene	5.0E+00	1.0E+01	3.3E+02	■		■	■		■		4.0E-01				8.8E+01
Ideno(1,2,3-cd)pyrene	5.0E+00	1.0E+01	3.3E+02			■			■		4.3E+00				8.8E+02
Dibenz(a,h)anthracene	5.0E+00	1.0E+01	3.3E+02			■			■		4.3E-01				8.8E+01
Benzo(g,h,i)perylene	5.0E+00	1.0E+01	3.3E+02												

■ CLP low concentration SOW limits are not low enough

░ CLP multi-media SOW limits are not low enough

Table 4

A Comparison of CLP Detection Limits with Superfund Chemical Data Matrix Benchmarks

Sorted by Alphabetical Order

Substance Name	CLP Limits			Ground Water Pathway			Drinking Water			Food Chain		Environmental		Soil Pathway	
	Low Conc SOW Water Limits ug/L	Water ug/L	Soil ug/kg	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg	AWQC/AALAC Freshwater ug/L	AWQC/AALAC Saltwater ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg
Semivolatile Organic															
Phenol	5.0E+00	1.0E+01	3.3E+02		2.2E+04			2.2E+03		8.1E+05				4.7E+07	
Bis(2-chloroethyl)ether	5.0E+00	1.0E+01	3.3E+02			■			■		■				5.8E+02
Chlorophenol,2-	5.0E+00	1.0E+01	3.3E+02		1.8E+02			1.8E+02		6.8E+03				3.9E+05	
Dichlorobenzene, 1,3-	na	1.0E+01	3.3E+02	6.0E+02											
Dichlorobenzene, 1,4-	na	1.0E+01	3.3E+02	7.5E+01		■	7.5E+01		■		1.3E+02				2.7E+04
Dichlorobenzene, 1,2-	na	1.0E+01	3.3E+02	6.0E+02	3.3E+03		6.0E-01	3.3E+03		1.2E+05				7.0E+06	
2-Methylphenol	5.0E+00	1.0E+01	3.3E+02		1.8E+03			1.8E+03		6.8E+04				3.9E+06	
2,2-Oxybis(1-Chloroprop	5.0E+00	1.0E+01	3.3E+02		1.5E+03	■		1.5E+03	■	5.4E+04	4.5E+01			3.0E+06	9.1E+03
4-Methylphenol	5.0E+00	1.0E+01	3.3E+02		1.8E+02			1.8E+02		6.8E+03				3.9E+05	
N-nitro-di-n-propylamine	5.0E+00	1.0E+01	3.3E+02			■			■		4.5E-01				9.1E+01
Hexachloroethane	5.0E+00	1.0E+01	3.3E+02		3.7E+01	6.1E+00		3.7E+01	6.1E+00	1.4E+03	2.3E+02			7.8E+04	4.6E+04
Nitrobenzene	5.0E+00	1.0E+01	3.3E+02												
Isophorone	5.0E+00	1.0E+01	3.3E+02		7.3E+03	9.0E+01		7.3E+03	9.0E+01	2.7E+05	3.3E+03			1.6E+07	6.7E+05
Nitrophenol, 2-	5.0E+00	1.0E+01	3.3E+02												
Dimethyl phenol, 2,4-	5.0E+00	1.0E+01	3.3E+02		7.3E+02			7.3E+02		2.7E+04				1.6E+06	
Bis(2-chloroethoxy)metha	5.0E+00	1.0E+01	3.3E+02												
Dichlorophenol, 2, 4-	5.0E+00	1.0E+01	3.3E+02		1.0E+02			1.1E+02		4.1E+03				2.3E+05	
Trichlorlobenzene, 1,2,4-	5.0E+00	1.0E+01	3.3E+02	7.0E+01	3.7E+02		7.0E-02	3.7E+02		1.4E+04				7.8E+05	
Napthalene	5.0E+00	1.0E+01	3.3E+02												
Chloroaniline, p-	5.0E+00	1.0E+01	3.3E+02		1.5E+02			1.5E+02		5.4E+03				3.1E+05	
Hexachlorobutadiene	5.0E+00	1.0E+01	3.3E+02		7.3E+00	■		7.3E+00	■	2.7E+02	4.0E+01			1.6E+04	8.2E+03
Chloro-3-methylphenol,4-	5.0E+00	1.0E+01	3.3E+02		7.3E+04			7.3E+04		2.7E+06				1.6E+08	
Methylnapthalene, 2-	5.0E+00	1.0E+01	3.3E+02												
Hexachlorocyclopentadien	5.0E+00	1.0E+01	3.3E+02	5.0E+01	2.6E+02			5.0E+01	2.6E+02	9.5E+03				5.5E+05	
Trichlorophenol, 2,4,6-	5.0E+00	1.0E+01	3.3E+02			7.7E+00			7.7E+00		2.9E+02				5.8E+04
Trichlorophenol, 2,4,5-	2.0E+01	2.5E+01	8.3E+02		3.7E+03			3.7E+03		1.4E+04				7.8E+06	
Chloronapthalene, 2-	5.0E+00	1.0E+01	3.3E+02		2.9E+03			2.9E+03		1.1E+05				6.3E+06	
Nitroaliline, 2-	2.0E+01	2.5E+01	8.3E+02												
Dimethyl phthalate	5.0E+00	1.0E+01	3.3E+02		3.7E+05			3.7E+05		1.4E+07				7.8E+07	
Acenaphthylene	5.0E+00	1.0E+01	3.3E+02												
Dinitrotoluene, 2,6-	5.0E+00	1.0E+01	3.3E+02		3.7E+01			3.7E+01		1.4E+03				7.8E+04	
Nitroaliline, 3-	2.0E+01	2.5E+01	8.3E+02												

Table 4

A Comparison of CLP Detection Limits with Superfund Chemical Data Matrix Benchmarks

Sorted by Alphabetical Order

Substance Name	CLP Limits			Ground Water Pathway			Drinking Water			Food Chain		Environmental		Soil Pathway	
	Low Conc. SOW Water ug/L	Water ug/L	Soil ug/kg	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	MCL/MCLG ug/L	Reference Dose Screening Conc. ug/L	Cancer Risk Screen Conc ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg	AWQC/ AALAC Freshwater ug/L	AWQC/ AALAC Saltwater ug/L	Reference Dose Screening Conc. ug/kg	Cancer Risk Screen Conc ug/kg
Pesticides/Aroclors															
alpha-BHC	1.0E-02	5.0E-02	1.7E+00			1.4E-02			1.4E-02		5.0E-01				1.0E+02
beta-BHC	1.0E-02	5.0E-02	1.7E+00			4.7E-02			4.7E-02		1.8E+00				3.6E+02
delta-BHC	1.0E-02	5.0E-02	1.7E+00												
gamma-BHC (Lindane)	1.0E-02	5.0E-02	1.7E+00	2.0E-01	1.1E-01	6.6E-02	2.0E-01	1.1E+01	6.6E-02	4.1E+02	2.4E+00	8.0E-02	8.0E-02	2.3E+04	4.9E+02
Heptachlor	1.0E-02	5.0E-02	1.7E+00	4.0E-01	1.8E+01	1.9E-02	4.0E-01	1.8E+01	1.9E-02	6.8E+02	7.0E-01	▓	▓	3.9E+04	1.4E+02
Aldrin	1.0E-02	5.0E-02	1.7E+00		1.1E+00	▓		1.1E+00	▓	4.1E+01	1.9E-01	3.0E+00	3.0E+00	2.3E+03	3.8E+01
Heptachlor epoxide	1.0E-02	5.0E-02	1.7E+00	2.0E-01	4.7E-01	▓	2.0E-01	4.7E-01	▓	1.8E+01	3.5E-01	▓	▓	1.0E+03	7.0E+01
Endosulfan I	1.0E-02	5.0E-02	1.7E+00		2.1E+02			2.2E+02		8.1E+03		5.6E-02	5.6E-02	4.7E+05	
Dieldrin	2.0E-02	1.0E-01	3.3E+00		1.8E+00	▓		1.8E+00	▓	6.8E+01	2.0E-01	▓	▓	3.9E+03	4.0E+01
DDE	2.0E-02	1.0E-01	3.3E+00			2.5E-01			2.5E-01		9.3E+00				1.9E+03
Endrin	2.0E-02	1.0E-01	3.3E+00	2.0E+00	1.1E+01		2.0E+00	1.1E+01		4.1E+02		▓	▓	2.3E+04	
Endosulfan II	2.0E-02	1.0E-01	3.3E+00		2.1E+02			2.2E+02		8.1E+03		5.6E-02	5.6E-02	4.7E+05	
DDD	2.0E-02	1.0E-01	3.3E+00			3.6E-01			3.6E-01		1.3E+01				2.7E+03
Endosulfan sulfate	2.0E-02	1.0E-01	3.3E+00												
DDT	2.0E-02	1.0E-01	3.3E+00		1.8E+01	2.5E-01		1.8E+01	2.5E-01	6.8E+02	9.3E+00	▓	▓	3.9E+04	1.9E+03
Methoxychlor	1.0E-01	5.0E-01	1.7E+01	4.0E+01	1.8E+02		4.0E+01	1.8E+02		6.8E+03		▓	▓	3.9E+05	
Endrin ketone	2.0E-02	1.0E-01	3.3E+00												
Endrin aldehyde	2.0E-02	1.0E-01	3.3E+00												
Chlordane, alpha	1.0E-02	5.0E-02	1.7E+00												
Chlordane, gamma	1.0E-02	5.0E-02	1.7E+00												
Toxaphene	1.0E+00	5.0E+00	1.7E+02	3.0E+00		▓	3.0E+00		▓		2.9E+00	▓	▓		5.8E+02
Aroclor 1016	2.0E-01	1.0E+00	3.3E+01	5.0E-01	7.3E-01	▓	5.0E-01	7.3E-01	▓	2.7E+01	4.1E-01	▓	▓	1.6E+00	8.3E+01
Aroclor 1221	4.0E-01	2.0E+00	6.7E+01	5.0E-01	7.3E-01	▓	5.0E-01	7.3E-01	▓	2.7E+01	4.1E-01	▓	▓	1.6E+00	8.3E+01
Aroclor 1232	2.0E-01	1.0E+00	3.3E+01	5.0E-01	7.3E-01	▓	5.0E-01	7.3E-01	▓	2.7E+01	4.1E-01	▓	▓	1.6E+00	8.3E+01
Aroclor 1242	2.0E-01	1.0E+00	3.3E+01	5.0E-01	7.3E-01	▓	5.0E-01	7.3E-01	▓	2.7E+01	4.1E-01	▓	▓	1.6E+00	8.3E+01
Aroclor 1248	2.0E-01	1.0E+00	3.3E+01	5.0E-01	7.3E-01	▓	5.0E-01	7.3E-01	▓	2.7E+01	4.1E-01	▓	▓	1.6E+00	8.3E+01
Aroclor 1254	2.0E-01	1.0E+00	3.3E+01	5.0E-01	7.3E-01	▓	5.0E-01	7.3E-01	▓	2.7E+01	4.1E-01	▓	▓	1.6E+00	8.3E+01
Aroclor 1260	2.0E-01	1.0E+00	3.3E+01	5.0E-01	7.3E-01	▓	5.0E-01	7.3E-01	▓	2.7E+01	4.1E-01	▓	▓	1.6E+00	8.3E+01

▒	CLP multi-media RAS limits are not low enough
▓	CLP low concentration limits are not low enough

COLORADO DEPARTMENT OF PUBLIC HEALTH
AND ENVIRONMENT
HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION

QUALITY ASSURANCE PROJECT PLAN

APPENDIX B

STANDARD OPERATING PROCEDURES

CONTENTS

STANDARD OPERATING PROCEDURE - 1

GENERAL FIELD OPERATION

1.0 PURPOSE

This procedure outlines the general field organization as well as the field structure of sample collection, sample identification, record keeping, field measurements, and data collection. These guidelines are followed to ensure that the activities used to document sampling and field operations provide standardized background information and identifications. Site-specific deviations from the methods presented herein must be approved by the Project Leader (PL) and Quality Assurance Manager (QAM).

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Project Plans: Includes all documents or plans related to an individual site. Project Plans include the Health and Safety Plan, Sampling Plan, and others.

2.2 Abbreviations

ASC	Analytical Services Coordinator
EM	Equipment Manager
PL	Project Leader
PPs	Project Plans
QA	Quality Assurance
QAC	Quality Assurance Coordinator
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QC	Quality Control
SHSC	Site Health and Safety Coordinator
SAM	Site Assessment Manager (EPA employee)
TDMT	Technical Data Management Team
SOP	Standard Operating Procedures

3.0 RESPONSIBILITIES

The PL is the primary point of contact with the SAM or CDPHE Project Manager and, in some cases, the role of PL and CDPHE Project Manager may be filled by one person. The CDPHE Project Manager, when onsite, has the ultimate responsibility for decisions concerning the project/site and if working in conjunction with EPA, may consult the SAM on decision critical matters. If the CDPHE Project Manager or SAM is not on site, the PL has ultimate responsibility for project/site decisions. The PL is responsible for development and completion of the Sampling Quality Assurance/Quality Control (QA/QC) Plan, project team organization, ensuring that appropriate sampling, testing and analysis procedures are followed; coordinating subcontracting and procurement activities; and reporting to the CDPHE Project Manager or SAM on project progress. The CDPHE Project Manager or SAM is responsible for all public relations efforts.

The PL interacts with the field team members to obtain appropriate field equipment, oversee the implementation of the Project Plans (PPs) in the field, and interacts with the OSC on problems relating to instrumentation, sampling, and field methodologies. The PL oversees all equipment calibration and maintenance in the field, and ensures that decontamination procedures are correctly instituted in the field. The PL reviews and signs all field forms before they are routed to the Technical Data Management Team (TDMT), and also assists the project Quality Assurance Coordinator (QAC) in improving existing field methods and developing new methods when necessary.

The QAC ensures the implementation of all QA program requirements for the project. The QAC informs the PL when new or improved technical and QA procedures are needed; provides QA indoctrination and training to project staff; and interacts with the QAM and PL on technical problems related to methods and instrumentation. The QAM ensures that data collection activities are consistent with the information requirements and that data are correctly and completely reported.

The Analytical Services Coordinator (ASC) ensures that the proper sample containers are sent to the field. The ASC maintains close contact with the PL regarding the number of samples and types of analyses to be preformed. The information that the ASC needs pertaining to planned and altered sample shipments is contained in CDPHE Standard Operating Procedure (SOP) 3, Chain of Custody.

The designated Site Health and Safety Coordinator (SHSC) or the PL is responsible for writing the Site Health and Safety Plan prior to mobilization, conducting daily on-site safety meetings, and ensuring project personnel are in compliance with health and safety protocols. The SAM is not required to be in compliance with CDPHE Health and Safety protocols. CDPHE subcontractors will abide by guidelines set forth in the Site Health and Safety Plan unless they opt not to follow the guidelines. If this option is exercised,an alternative Site Health and Safety Plan will be prepared by the respective subcontractor and subsequently reviewed for approval by the SHSC. Instances under these options will be dealt on by a case by case basis. The SHSC will ensure that project personnel are equipped with proper safety equipment. The SHSC interacts with the PL on environmental monitoring programs and decontamination processes.

Field personnel are responsible for performing site duties as instructed by the PL. The PL is also responsible for collecting and organizing the field data entry forms (Exhibits) and reviewing SOPs prior to performing site activities.

4.0 PROCEDURE

4.1 Mobilization/Demobilization

The PL will write applicable PPs, if required, and have them approved by the CDPHE Project Manager or SAM. The PL will then assign personnel to review the plans and field equipment checklist (provided in Exhibit 1-1). Specific items required for field activities will be identified and acquired.

All equipment to be used will be checked by the PL to verify that it is operational and calibrated before leaving the program support office. Calibration will also be performed, as directed by the PL, when the equipment reaches the site.

The PL will obtain copies of the appropriate SOPs and PPs that will be taken into the field. SOPs brought to the field will contain current versions of procedures and respective exhibits used for the applicable field method. These SOPs will be revised and updated by appropriate staff members as needed.

Upon return from the site, all equipment will returned clean and orderly to the equipment room. If any problems occurred on site with any equipment, the problems should be noted in detail in the field log book and any applicable field form (if used). This information will be written down in a note or memo format and attached to the equipment in question. Defective equipment should be repaired as soon as field personnel identify a problem. Immediate repair will assist future PLs with site preparations.

4.2 Shipping

If sensitive field equipment is to be shipped to the site, proper care must be taken to ensure that damage will not be incurred enroute, including the packaging of individual items in separate containers filled with protective packaging material (e.g., foam pellets). If possible, equipment with carrying cases will be packed in the respective case and placed inside a foam pellet-filled container.

Non-sensitive field equipment can be combined in protective pellet-filled boxes.

All boxes containing equipment shall be labeled with the following items:

- Receiving company name, address and telephone;
- Attention (person receiving items in field);
- Return company name, address and telephone; and
- Return attention.

4.3 Serialization

All non-disposable equipment purchased will be permanently labeled with serial numbers. Any equipment purchased by an outside agency for use on a project will be tagged with the agency serial number.

A permanent inventory of equipment will be maintained, and will include at a minimum: serial numbers, types of equipment, initial costs, service records, and warranty information.

All field forms and field log books will be kept in the project files when returned from the field. Log books will be assigned to project personnel for the duration of the field activities.

4.4 Field Organization

4.4.1 Chain-of-Command

Chain-of-Command protocols will be defined by the CDPHE Quality Management Plan and implemented by the PL. These protocols will be strictly followed while performing field tasks. All decisions concerning sampling, equipment problems and changes in strategy will be made by the CDPHE Project Manager and/or the PL or an approved appointee. Public relations problems will be addressed by the CDPHE Project Manager or SAM only. The PL or an approved designee shall conduct a daily "tailgate meeting" prior to field activities, during which individual roles will be delineated and safety issues discussed.

4.4.2 Field Documentation

All project activities will be recorded each day in the field log book. These methods are outlined in CDPHE SOP 6, Use and Maintenance of Field Log Books. On occasion, non-routine field activities will be recorded on special field forms if the CDPHE Quality Assurance Officer (QAO) and PL approve.

4.4.3 Sampling Organization

The PL shall ensure that the sampling design, outlined in the applicable PPs and TSOPs, is followed during all phases of sampling activities at the site. For each sampling activity, field personnel shall record the information required by the applicable SOPs on the Exhibits provided.

Survey personnel shall identify and locate the monitoring and sampling stations described in the applicable PPs. Benchmarks located on the site and nearby shall be located and used as permanent reference markers. All sample locations shall be clearly marked, labeled and photographed according to the methods outlined in CDPHE SOP 5, Sample Location Documentation.

4.5 Review

The PL or an approved designee shall check field log books, daily logs, and all other documents (Exhibits) that result from field operations for completeness and accuracy. Any discrepancies on these documents will be noted and returned to the originator for correction. The reviewer will acknowledge that review comments have been incorporated by signing and dating the applicable reviewed documents.

5.0 REFERENCES

CPDHE. 2000. Standard Operating Procedure 3, “Chain of Custody.” Standard Operating Procedures.

CDPHE. 2000. Standard Operating Procedure 5, “Sample Location Documentation.” Standard Operating Procedures.

CDPHE. 2000. Standard Operating Procedure 6, “Use and Maintenance of Field Log Books.” Standard Operating Procedures.

6.0 EXHIBITS

1-1 Field Equipment Checklist

EXHIBIT 1-1
Field Equipment Checklist

General

___ 1. Health and Safety Plan
___ 2. Site base map
___ 3. Hand calculator
___ 4. Brunton compass
___ 5. Personal clothing and equipment
___ 6. Personal Protective Equipment
___ 7. Field Sample Plan

Environmental Monitoring Equipment

___ 1. Shovels
___ 2. Keys to well caps
___ 3. pH meter (with calibrating solutions)
___ 4. pH paper
___ 5. Thermometer
___ 6. Conductivity meter (with calibrating solution)
___ 7. Organic vapor analyzer or photoionization detector with calibration gas
___ 8. H_2S, O_2, combustible gas indicator

Sampling Equipment

___ 1. Tool box with assorted tools (pipe wrenches, screwdrivers, socket set and driver, open and box end wrenches, hacksaw, hammer, vice grips)
___ 2. Geologic hammer
___ 3. Trowel
___ 4. Stainless steel and/or Teflon® spatula
___ 5. Hand auger
___ 6. Engineer's tape
___ 7. Steel tape
___ 8. Electric water level sounder
___ 9. Petroleum Interface Probe
___ 10. Batteries
___ 11. Bailers (Teflon®, stainless steel, acrylic, PVC)
___ 12. Slug test water displacement tube
___ 13. Vacuum hand pump
___ 14. Electric vacuum pump
___ 15. Displacement hand pump
___ 16. Mechanical pump (centrifugal, submersible, bladder)
___ 17. Portable generator
___ 18. Gasoline for generator
___ 19. Hose
___ 20. Calibrated buckets

EXHIBIT 1-1 (Continued)

__ 21. Stop watch
__ 22. Orifice plate or equivalent flow meter
__ 23. Data logger and pressure transducers
__ 24. Strip chart recorders
__ 25. Sample bottles
__ 26. 0.45-micron filters (prepackaged in holders)
__ 27. Sample preservatives (nitric, hydrochloric, sulfuric acid/sodium hydroxide)
__ 28. Heavy-duty aluminum foil
__ 29. Coolers
__ 30. Ice packs
__ 31. Large "Ziploc" bags
__ 32. Heavy-duty garbage bags
__ 33. Duct tape
__ 34. Strapping tape
__ 35. Paper towels
__ 36. "Bubble" pack, foam pellets, or shredded paper
__ 37. Vermiculite
__ 38. Stainless steel bowls
__ 39. SW scoop
__ 40. Peristaltic pump/tubing
__ 41. Sample tags
__ 42. TSOPs

Decontamination Equipment

-- 1. Non-phosphate detergent (alconox or liquinox)
-- 2. Selected high purity, contaminant free solvents
-- 3. Long-handled brushes
-- 4. Drop cloths (plastic sheeting)
-- 5. Trash container
-- 6. Galvanized tubs or equivalent (e.g., baby pools)
-- 7. Tap Water
-- 8. Contaminant free distilled/deionized water
-- 9. Metal/plastic container for storage and disposal of contaminated wash solutions
-- 10. Pressurized sprayers, H_2O
-- 11. Pressurized sprayers, solvents
-- 12. Aluminum foil
-- 13. Sample containers
-- 14. Emergency eyewash bottle

Documentation Supplies

__ 1. Field Log Books
__ 2. Daily Drilling Report forms

EXHIBIT 1-1 (Continued)

___ 3. Field Borehole Log forms
___ 4. Monitoring Well Installation Log forms
___ 5. Well Development Data forms
___ 6. Groundwater Sampling Log forms
___ 7. Aquifer Test Data forms
___ 8. Sample Chain-of-Custody forms
___ 9. Custody seals
___ 10. Cooler labels ("This Side Up," "Hazardous Material," "Fragile")
___ 11. Federal Express/DHL labels
___ 12. Communication Record forms
___ 13. Documentation of Change forms
___ 14. Camera and film
___ 15. Paper
___ 16. Pens/pencils
___ 17. Felt tip markers (indelible ink)

STANDARD OPERATING PROCEDURE 2

SAMPLE CONTAINERS, PRESERVATION, AND MAXIMUM HOLDING TIMES

1.0 PURPOSE

The purpose of this procedure is to list acceptable sample containers and describe sample preservation and maximum holding times to be used during all hazardous waste investigations for low-, medium-, or high-concentration samples of liquid, sediment and sludge matrices.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods described herein must be approved by the Project Leader (PL), the Colorado Department of Public Health and Environment. (CDPHE) Quality Assurance Officer, and the Analytical Services Coordinator.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Low-Concentration Sample: In general, the contaminant of highest concentration is present at a level less than 10 parts per million (ppm). Examples include background environmental samples, perimeter, and lagoon samples.

Medium-Concentration Sample: In general, the contaminant of highest concentration is present at a level greater than 10 ppm and less than 15 percent by volume (150,000 ppm). Examples include weathered material.

High-Concentration Sample: In general, at least one contaminant is present at a level greater than 15 percent by volume. Samples from drums and tanks are assumed to be high concentration unless information indicates otherwise.

Routine Analytical Services (RAS): Analysis for low concentration soil or water samples using specific methods on a 30- to 45-day turnaround time through the Contract Laboratory Program (CLP).

Unique Laboratory Sample Analyses (ULSA): Analysis of various matrices using a wide variety of U.S. Environmental Protection Agency (EPA) approved methods for low, medium, or high concentration samples on a normal or rush turnaround schedule through the CLP.

2.2 Abbreviations

APHA	American Public Health Association

BOD	Biochemical Oxygen Demand
CDPHE	Colorado Department of Public Health and Environment
CLP	Contract Laboratory Program
EPA	U.S. Environmental Protection Agency
HCl	Hydrochloric acid
ml	milliliter
NaOH	Sodium hydroxide
NWWA	National Water Well Association
PL	Project Leader
ppm	Parts per million
PPs	Project Plans
QC	Quality Control
RAS	Routine Analytical Services
SAS	Special Analytical Services
ULSA	Unique Laboratory Sample Analyses
VOA	Volatile organic analysis
μgl	micrograms per liter
μm	micrometer, micron

3.0 RESPONSIBILITIES

Sampling personnel (samplers) are responsible for performing the applicable tasks outlined in this procedure.

The PL or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance. All activities and data collected shall be recorded in the field log book.

4.0 PROCEDURE

The sampling and analysis program for START assignments must comply with the analytical procedures outlined by the EPA CLP (EPA 1988) or an equivalent procedure acceptable to EPA.

The purpose of sample preservation is to prevent or retard the degradation and modification of chemicals or to retard biological activity in samples during transit and storage. Efforts to preserve the integrity of the samples must be initiated as soon as possible after the time of sampling and continue until analyses are performed. Preservatives must be added to the sample container as soon as possible after the time of sample collection. The recommended procedure is to take pre-measured volumes of the preservatives in sealed ampules to the field.

Complete and unequivocal preservation of samples, domestic sewage, industrial wastes, or natural waters, is impossible in practice. Regardless of the nature of the sample, complete stability for every constituent is not likely to be achieved. At best, preservation techniques can retard the chemical and biological changes that inevitably continue after the sample is removed from the parent source. Degradation of the sample ceases only if it is preserved at a temperature of absolute zero (-273 °C). However, freezing of a sample to extend hold times is not permitted. Therefore, as a general rule, it is best to analyze the samples as soon as possible after collection. This is especially true when the analyte concentration is expected to be in the low microgram per liter (μg/l) range.

Methods of preservation are relatively limited and are intended generally to perform the following:

- Retard biological action;
- Retard hydrolysis of chemical compounds and complexes;
- Reduce volatility of constituents; and
- Reduce absorption effects.

Preservation methods are generally limited to:

- pH control;
- Chemical addition; and
- Refrigeration.

The recommended preservative for various constituents is given in Exhibits 2-2 and 2-3. Preservation techniques for some analyses requiring more than simple refrigeration or filtering are discussed in Section 4.2. Exhibits 2-2 and 2-3 also provide the estimated volume of sample required for the analysis, the suggested type of container, and the maximum recommended holding times for samples to be properly preserved.

When selecting preservation techniques and sample container type, always refer to the guidance provided in the documentation of the analytical methods to be used.

4.1 Sample Containers

Select sample containers based on the analytical parameters of interest. Use containers made of materials that are nonreactive. Glass and polyethylene containers are the most commonly accepted, and both are used when sampling many constituents. When metals are the analytes of interest, however, polyethylene containers with teflon®-lined caps are preferred. When organics are the analytes of interest, use amber glass containers with Teflon®-lined caps.

Refer to Exhibit 2-3 for sample container requirements for common analyses.

4.2 Sample Preservation

Perform appropriate chemical preservation in the field for various analytical parameters as soon as possible after the time of sample collection. When appropriate, cool samples after collection and during shipment. All samples should be kept out of direct sunlight and stored in the dark (e.g., in a cooler). Regardless of the method of preservation, perform analyses as soon after sampling as is possible.

In some instances, the optimal method for sample preservation may be inappropriate due to the restrictions placed on the transport of certain chemicals by shippers. When shipping restrictions prevent the use of some reagents for sample preservation, use the most appropriate and permissible technique.

Refer to Exhibit 2-3 for preservation requirements for common analyses.

4.3 Maximum Holding Time

Complete and unequivocal preservation of a sample for an extended period of time is a practical impossibility. Regardless of the nature of the sample, complete stability for every constituent is not likely to be achieved. Maximum holding times are assigned to each analyte and are designed for quality assurance purposes to minimize degradation effects on the analysis. Therefore, as a rule, it is better to analyze the sample as soon as possible after collection. This is especially true when low contaminant concentrations are expected. Suggested maximum holding times for some of the more common analytes are listed in Exhibits 2-2 and 2-3.

4.4 Review

The Site Manager or an approved designee shall check all sample control documentation to ensure that the samples, transport, and analysis events have met the criteria outlined in this Standard Operating Procedure (SOP). Any discrepancies shall be noted and the documentation will be returned to the originator for correction. The reviewer will acknowledge that corrections have been incorporated by signing and dating each reviewed document.

5.0 REFERENCE

American Public Health Association (APHA). 1983. "Standard Methods for the Examination of Water and Wastewater." 14th ed.

U.S. Environmental Protection Agency (EPA)/National Water Well Association (NWWA). 1981. "Manual of Groundwater Sampling Procedures." EPA/NWWA Series.

U.S. Environmental Protection Agency (EPA). 1983. "Methods for the Chemical Analysis of Water and Wastes." EPA-600./4-79-020. March 1983.

U.S. Environmental Protection Agency (EPA). 1983. "RCRA Permit Writer's Manual: Groundwater Protection" (40 CFR Part 264, Subpart F), Geotrans Inc., EPA Contract No. 68-01-6464.

U.S. Environmental Protection Agency (EPA). 1984. Federal Register Part VIII, 40 CFR Part 136, October 26, 1984.

U.S. Environmental Protection Agency (EPA). 1986. "Test Methods for Evaluating Solid Waste." SW-846.

U.S. Environmental Protection Agency (EPA). 1988. "Users Guide to the Contract Laboratory Program." 9240.0-1, December 1988.

6.0 EXHIBITS

Exhibit 2-1	EPA Sample Container Requirements Including Laboratory QC for CLP Analyses
Exhibit 2-2	Preservation Requirements for RAS Analyses
Exhibit 2-3	Recommended Sample Containers, Preservation, and Maximum Holding Times

EXHIBIT 2-1

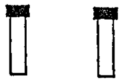
EPA Sample Container Requirements Including Laboratory QC for CLP Analysis

Suggested Sampling Bottles Including Laboratory QC

VOLATILES

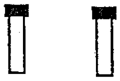
WATER

SAMPLE



2 X 40- ml. Amber Glass Vials

MS/MSD



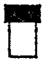
2 X 40- ml. Amber Glass Vials

SOIL

SAMPLE

1 X 4 - oz. Wide Mouth Glass Jar

MS/MSD



1 X 4 - oz. Wide Mouth Glass Jar

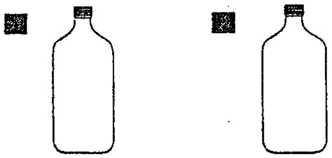
EXHIBIT 2.1 (continued)
EPA Sample Container
Requirements Including Laboratory QC for CLP Analysis

Suggested Sampling Bottles Including Laboratory QC

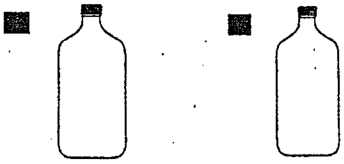
EXTRACTABLE ORGANICS

WATER

SAMPLE **2 x 1-Liter Amber Glass Bottles**

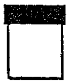


MS/MSD **2 x 1-Liter Amber Glass Bottles**



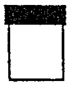
SOIL

SAMPLE



1 x 8 oz. WIDE MOUTH GLASS JAR

MS/MSD



1 x 8 oz. WIDE MOUTH GLASS JAR

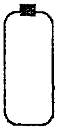
EXHIBIT 2.1 (continued)
EPA Sample Container Requirements Including Laboratory QC for CLP Analysis

Suggested Sampling Bottles Including Laboratory QC

METALS

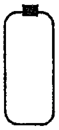
WATER

TOTAL
SAMPLE



1 X 1- Liter
Polyethylene Bottle

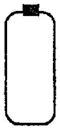
SPIKE/DUPLICATE



1 X 1- Liter
Polyethylene Bottle

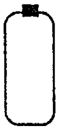
WATER

DISSOLVED
SAMPLE



1 X 1- Liter
Polyethylene Bottle

SPIKE/DUPLICATE



1 X 1- Liter
Polyethylene Bottle

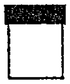
EXHIBIT 2.1 (continued)
EPA Sample Container Requirements Including Laboratory QC for CLP Analysis

Suggested Sampling Bottles Including Laboratory QC
METALS (Cont'd)

SOILS

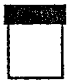
TOTAL

SAMPLE



1 x 8 oz. GLASS WIDEMOUTH JAR

SPIKE/DUPLICATE



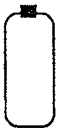
1 x 8 oz. GLASS WIDEMOUTH JAR

EXHIBIT 2.1 (continued)
EPA Sample Container Requirements Including Laboratory QC for CLP Analysis

Suggested Sampling Bottles Including Laboratory QC
CYANIDE

WATER

SAMPLE



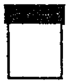
1 X 1- Liter
Polyethylene Bottle

SPIKE/DUPLICATE

1 X 1- Liter
Polyethylene Bottle

SOIL

SAMPLE



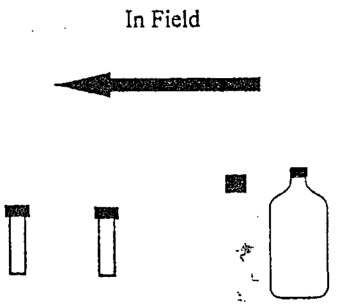
1 x 8 oz. GLASS
WIDEMOUTH JAR

SPIKE/DUPLICATE

1 x 8 oz. GLASS
WIDEMOUTH JAR

EXHIBIT 2.1 (continued)
EPA Sample Container Requirements Including Laboratory QC for CLP Analysis

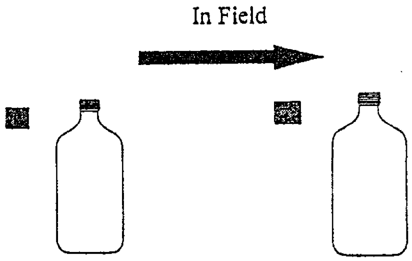
VOLATILE ORGANIC



Empty 40 ml VOA Vials

**ASTM Type
Organic-Free Water**

SEMIVOLATILE ORGANIC
AND/OR INORGANIC

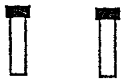


Full

Empty

**ASTM Type
Organic-Free Water**

VOLATILE ORGANICS
Trip Blank



Full 40 ml. VOA Vials (no head space)

ASTM Type Organic Free Water

EXHIBIT 2-2
Preservation Requirements for RAS Analyses

Parameter	Concentration	Preservation
Water Samples		
Volatiles	Low/Medium	Chill to 4°C. Samples must be filled to zero headspace and checked for air bubbles. If acidification causes bubbling, do not acidify.
Semivolatiles	Low/Medium	Chill to 4°C.
Pesticides/PCBs	Low/Medium	Chill to 4°C.
Dissolved Metals	Low/Medium	Filter sample through 0.45 micron filter immediately after sample collection or with in-line filtration when possible. Acidify to pH ≤ 2 with HNO_3 after filtration.
Total Metals	Low/Medium	Includes suspended sediments and particulates. Acidify to pH <2 with HNO_3.
Cyanides	Low/Medium	Preserve all samples with approximately 2 ml. of 10 (Normal) NaOH per liter of sample to pH >12. Chill to 4°C. Treatment for chlorine or other known oxidizing agents may be necessary. Test a drop of the sample with potassium iodide-starch test paper (K-I starch test paper). A blue color indicates the need for treatment. Add ascorbic acid, a few crystals at a time, until a drop of sample produces no color on the indicator paper. Then add an additional 0.6 g. of ascorbic acid for each liter of sample volume.
Soil Samples		
Organics	Low/Medium	Chill to 4°C.
Metals	Low/Medium	None.
Cyanide	Low/Medium	Chill to 4°C.

EXHIBIT 2-2 (continued)
Analytical and Contractual Holding Times for RAS Analyses

Matrix:	Water		Soil	
Analysis	Analytical Holding Times	Contractual Holding Times	Analytical Holding Times	Contractual Holding Times
VOA	14 days	10 days	14 days	10 days
BNA	7 days	5 days	14 days	10 days
Pest./PCB	7 days	5 days	14 days	10 days
Mercury	28 days	26 days	28 days	26 days
Cyanide	14 days	12 days	14 days	12 days
Metals	6 months	35 days	6 months	35 days

EXHIBIT 2-3
Recommended Sample Containers, Preservation Maximum and Holding Times*

Species Type	Measurement/ Analysis	Preservative	Holding Time	Water Sample Volume and Container Type	Solid Sample Volume and Container Type
Physical Properties	Color	Cool, 4°C	48 hours	(1) 4 oz polyethylene	N/A
	Hardness	HNO_3 to pH<2 or H_2SO_4 to pH < 2	6 months	(1) 4 oz polyethylene	N/A
	pH	None Required	ASAP	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Residue, Filterable	Cool, 4°C	7 days	(1) 16 oz polyethylene	N/A
	Residue, Non-Filterable	Cool, 4°C	7 days	(1) 16 oz polyethylene	N/A
	Residue, Total	Cool, 4°C	7 days	(1) 16 oz polyethylene	N/A
	Residue, Volatile	Cool, 4°C	7 days	(1) 16 oz polyethylene	N/A
Metals	Dissolved	Filter on site, HNO_3 to pH<2	6 months [1]	(1) liter polyethylene	(1) 8 oz polyethylene
	Total	HNO_3 to pH<2	6 months	(1) liter polyethylene	(1) 8 oz polyethylene
	Chromium^{+6}	Cool, 4°C	24 hours	(1) 16 oz polyethylene	(1) 4 oz polyethylene
	Mercury, Dissolved	Filter, HNO_3 to pH<2	28 days	(1) liter polyethylene	(1) 8 oz polyethylene
	Mercury, Total	HNO_3 to pH<2	28 days	(1) liter polyethylene	(1) 8 oz polyethylene
Inorganics, Non-Metals	Alkalinity	Cool, 4°C	14 days	(1) 4 oz polyethylene	N/A
	BOD	Cool, 4°C	48 hours	(1) 16 oz polyethylene	N/A
	Bromide	None Required	28 days	(1) 16 oz polyethylene	(1) 8 oz polyethylene
	Chloride	None Required	28 days	(1) 4 oz polyethylene	(1) 8 oz polyethylene
	COD	Cool, 4°C H_2SO_4 to pH<2	28 days	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Cyanide	Cool, 4°C, NaOH to pH>12, 0.6 g ascorbic acid[3]	14 days [2]	(1) liter polyethylene	(1) 8 oz polyethylene
	Fluoride	None Required	28 days	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Nitrogen				
	Ammonia	Cool, 4°C, H_2SO_4 to pH<2	28 days	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Kjeldahl, Total	Cool, 4°C, H_2SO_4 to pH<2	28 days	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Nitrate plus Nitrite	Cool, 4°C, H_2SO_4 to pH<2	28 days	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Nitrate[4]	Cool, 4°C	48 hours	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Nitrite	Cool, 4°C	48 hours	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Oil and Grease	Cool, 4°C H_2SO_4 to pH<2	28 days	(2) 1 liter amber glass	(1) 8 oz glass jars
Inorganics, Non-Metals (continued)	Organic Carbon	Cool, 4°C HCl or H_2SO_4 to pH<2	28 days	(1) 4 oz amber glass	(1) 4 oz glass jars
	Phenolics	Cool, 4°C, H_2SO_4 to pH<2	28 days	(2) 1 liter amber glass	(1) 4 oz glass jar
	Phosphorus				

EXHIBIT 2-3
Recommended Sample Containers, Preservation Maximum and Holding Times* (continued)

Species Type	Measurement/ Analysis	Preservative	Holding Time	Water Sample Volume and Container Type	Solid Sample Volume and Container Type
	Ortho-phosphate	Filter on site, Cool, 4°C	48 hours	(1) 4 oz polyethylene	(1) 8 oz glass jar
	Dissolved	Cool, 4°C	28 days	(1) 4 oz polyethylene	(1) 8 oz glass jar
	Hydrolyzable	Cool, 4°C, H_2SO_4 to pH<2	28 days	(1) 4 oz polyethylene	(1) 8 oz glass jar
	Total	Cool, 4°C, H_2SO_4 to pH<2	28 days	(1) 4 oz polyethylene	(1) 8 oz glass jar
	Total Dissolved	H_2SO_4 to pH<2, Filter on site, Cool, 4°C	24 hours	(1) 4 oz polyethylene	(1) 8 oz glass jar
	Silica	Cool, 4°C	28 days	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Sulfate	Cool, 4°C	28 days	(1) 4 oz polyethylene	(1) 4 oz polyethylene
	Sulfide	Cool, 4°C, add 2 ml Zinc Acetate plus NaOH to pH>9	7 days	(1) 4 oz polyethylene	N/A
	Sulfite	1 ml EDTA	ASAP	(1) 4 oz polyethylene	N/A
Organics	Dioxin/Furan	Cool, 4°C	7 to 14 days	(2) 1 liter amber glass	(1) 8 oz glass jars
	Herbicides	Cool, 4°C	7 to 14 days	(2) 1 liter amber glass	(1) 8 oz glass jars
	Pesticides/PCBs	Cool, 4°C	7 to 14 days	(2) 1 liter amber glass	(1) 8 oz glass jars
	SVOC	Cool, 4°C	7 to 14 days	(2) 1 liter amber glass	(1) 8 oz glass jars
	VOC	Cool, 4°C	7 to 14 days	(2) 40 ml amber glass	(1) 4 oz glass jars

[1] Samples should be filtered on site immediately after collection, then a preservative for dissolved metals should be added.

[2] Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before the pH adjustment in order to determine if sulfide is present. If sulfide is present it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

[3] Should only be used in the presence of residual chloride.

[4] For samples from non-chlorinated drinking water supplies concentrated H_2SO_4 should be added to lower sample pH to less than 2. The sample should be analyzed within 14 days after sampling.

* Adapted from EPA-600-4-82-055 "Technical Additions to Methods for Chemical Analysis of Water and Wastes."

STANDARD OPERATING PROCEDURE - 3

CHAIN OF CUSTODY

1.0 PURPOSE

The purpose of this procedure is to describe the proper chain of custody and tracking methods to be followed for environmental projects. This procedure outlines the documentation necessary to trace sample possession and shipment and provides standardized forms to be used in the field for both the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) and for non-CLP laboratories.

This procedure provides guidance for routine field operations. Site-specific deviations from the methods presented herein must be approved by the Project Leader, the Colorado Department of Public Health and Environment (CDPHE) Quality Assurance Officer, and the Analytical Services Coordinator.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

ASC	Analytical Services Coordinator
BNA	Base/neutral/acid
CLP	Contract Laboratory Program
CLASS	Contract Laboratory Analytical Services Support
EPA	U.S. Environmental Protection Agency
IATA	International Air Transport Association
NEIC	National Enforcement Investigations Center
PCBs	Polychlorinated biphenyls
RAS	Routine Analytical Services
RSCC	EPA Regional Sample Control Coordinator
SCM	UOS Sample Control Manager
TRs	Multi-Sample Traffic Reports/Chain-of-Custody forms
ULSA	Unique Laboratory Sample Analysis
VOCs	Volatile organic compounds

3.0 RESPONSIBILITIES

Field personnel (samplers) are responsible for performing the tasks in accordance with this procedure. These personnel are responsible for the care and custody of the collected samples until the samples are transferred or dispatched properly. All activities and data collected shall be recorded in the field log book.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required in this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced.

4.0 PROCEDURE

4.1 Introduction

Samples are collected as described in the Project Plans.

Written documentation of sample custody from the time of sample collection through the generation of data by analysis of that sample is recognized as a vital aspect of an environmental study. Sample custody consists of three parts: sample collection, laboratory analysis, and final evidence files. The chain of custody of the physical sample and its corresponding documentation will be maintained throughout the handling of the sample. All samples will be identified, labeled, logged onto a Chain-of-Custody form, and recorded in a sample tracking log as a part of the procedure to ensure the integrity of the resulting data. The record of the physical sample (location and time of sampling) will be joined with the analytical results through accurate accounting of the sample custody. As described below, sample custody applies to both field and laboratory operations.

A sample or evidence file is under custody if it is in:

- The possession of the sampler/analyst;
- The view, after being in the possession of, the sampler/analyst;
- The possession of the sampler/analyst and then placed in a secured location; or
- A designated secure area.

Waterproof ink will be used unless prohibited by weather conditions. For example, a log book notation will explain that a pencil was used to fill out the sample tag because the ballpoint pen would not function in freezing weather.

4.1a Samples and Sample Numbers

The CLP Organic and Inorganic Multi-Sample Traffic Reports/Chain-of-Custody Forms (TRs) document samples shipped to CLP laboratories. They also enable Contract Laboratory Analytical Services Support (CLASS) and the Region to track samples and ensure that the samples are shipped to the appropriate contract laboratory. You must use TRs each time you ship Routine Analytical Services (RAS) samples to a CLP laboratory under one Case Number and RAS analytical program.

Please note that the TR includes a chain-of-custody record which is located at the bottom of the form. The form is used as physical evidence of sample custody. According to EPA enforcement requirements, official custody of samples must be maintained from the time of sample collection until the time the samples are introduced as evidence in the event of litigation. You are responsible for the care and custody of the sample until sample shipment.

CLP sample types are defined by the RAS analytical program. There are currently two organic/inorganic programs: Low/medium concentration inorganic, low/medium concentration organic. Low/medium inorganic samples may be analyzed for total metals, dissolved metals, cyanide or all three. Low/medium organics may be analyzed for volatile organic compounds (VOCs), base/neutral/acid (BNAs), pesticide/PCBs, or any combination of these.

A CLP sample is one matrix - water or soil - never both. The CLP sample is further defined as consisting of all the sample aliquots from one station location, for each matrix and RAS analytical program. For example, let's say you were sampling at Pond A. You plan to collect one water sample and one soil/sediment sample, each to be analyzed for VOCs, BNAs, pesticide/PCBs, Total Metals and Cyanide. All the bottles for the organic water analyses at this station - VOC vials, BNA jars, and Pesticide/PCB jars - make up one organic CLP sample, not three. All of the bottles for the organic soil analysis makes up the second organic CLP sample. The bottle for inorganic soil analysis make up the second inorganic CLP sample from Pond A. Even though you have collected a water sample and a soil sample for five different analyses from Pond A, you've collected four CLP samples - an organic water sample, an organic soil sample, an inorganic water sample, and an inorganic soil sample.

The CLP generates unique numbers that must be assigned to each organic and inorganic sample. The unique sample numbers are printed at the CLASS center on adhesive labels and distributed to the EPA Regional Sample Control Coordinator (RSCC) as requested. It is your responsibility to assign this critical sample number correctly and to transcribe it accurately onto the TR.

Organic sample numbers are in the format XX123, and have ten labels per strip: four for extractables, two for VOCs, and four blank (extra). When bottles have been labeled, **DESTROY THE UNUSED LABELS** to prevent duplication of Sample Numbers.

Inorganic sample numbers are in the format MXX123 and have seven labels per strip: two for total metals, two for cyanide and three blank (extra). Remember that the unique sample number must only be used once. **DESTROY THE UNUSED LABELS.**

REMEMBER:

a. TRs must be used for each Case Number with every shipment of samples to each CLP laboratory.

b. Organic samples and inorganic samples are assigned separate, unique sample numbers. Each sample consists of all the sample aliquots from a sample station location for analysis in one of the two analytical programs.

c. A CLP RAS sample will be analyzed as either a water or a soil sample.

d. Prevent accidental duplication of sample numbers by destroying unused labels.

4.2 Transfer of Custody and Sample Tracking Procedures

Samples will be accompanied by a properly completed Chain-of-Custody form. The Chain-of-Custody form for the CLP laboratories is shown in Exhibit 3-3. The Chain-of-Custody form for Unique Laboratory Sample Analysis (ULSA) and non-CLP laboratories is shown in Exhibit 3-1. The sample numbers, locations, and requested analyses will be listed. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to the laboratory, and to or from a secure storage area.

Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis. Shipping containers will be secured with strapping tape. Custody Seals will be placed on the shipping container for shipment to the laboratory. Exhibit 3-5 presents the EPA Custody Seal to be used. The preferred procedure is the attachment of a Custody Seal to the front right and back left of the cooler. The Custody Seals are covered with clear plastic tape. The cooler is strapped shut with strapping tape in at least two locations.

If the samples are sent by common carrier, appropriate federal regulations will be followed (i.e., IATA). Commercial carriers are not required to sign off on the Chain-of-Custody forms as long as the Chain-of-Custody forms are sealed inside the sample cooler and the Custody Seals remain intact.

Exhibit 3-6 describes sample information that must be called in to the Analytical Services Coordinator (ASC) and/or RSCC.

If a sample or sample label is lost during shipment or if a label was never prepared, the following procedure applies (EPA/330/9-78-001-R, "NEIC Policies and Procedures"):

> "A written statement is prepared detailing how the sample was collected, air dispatched, or hand transferred to the laboratory. The statement should include all pertinent information, such as entries in field log books regarding the sample, whether the sample was in the sample collector's physical possession or in a locked compartment until hand-transported to the laboratory, etc."

5.0 REVIEW

The sampler is responsible for the care and custody of the samples until they are transferred or properly dispatched. As few people as possible will handle the samples. The sampler is also responsible for reviewing (or for having a second sampler review) the custody forms for completeness and accuracy before relinquishing custody.

The Project Leader or an approved designee must review all field activities to determine whether proper chain of custody procedures were followed during the field work and to decide if additional samples are required.

The sampler should notify the Project Leader of a breach or irregularity in chain-of-custody procedures. The Project Leader will notify the EPA Remedial Project Manager.

6.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1978. "Policies and Procedures." EPA/330/9-78-00/-R. NEIC.

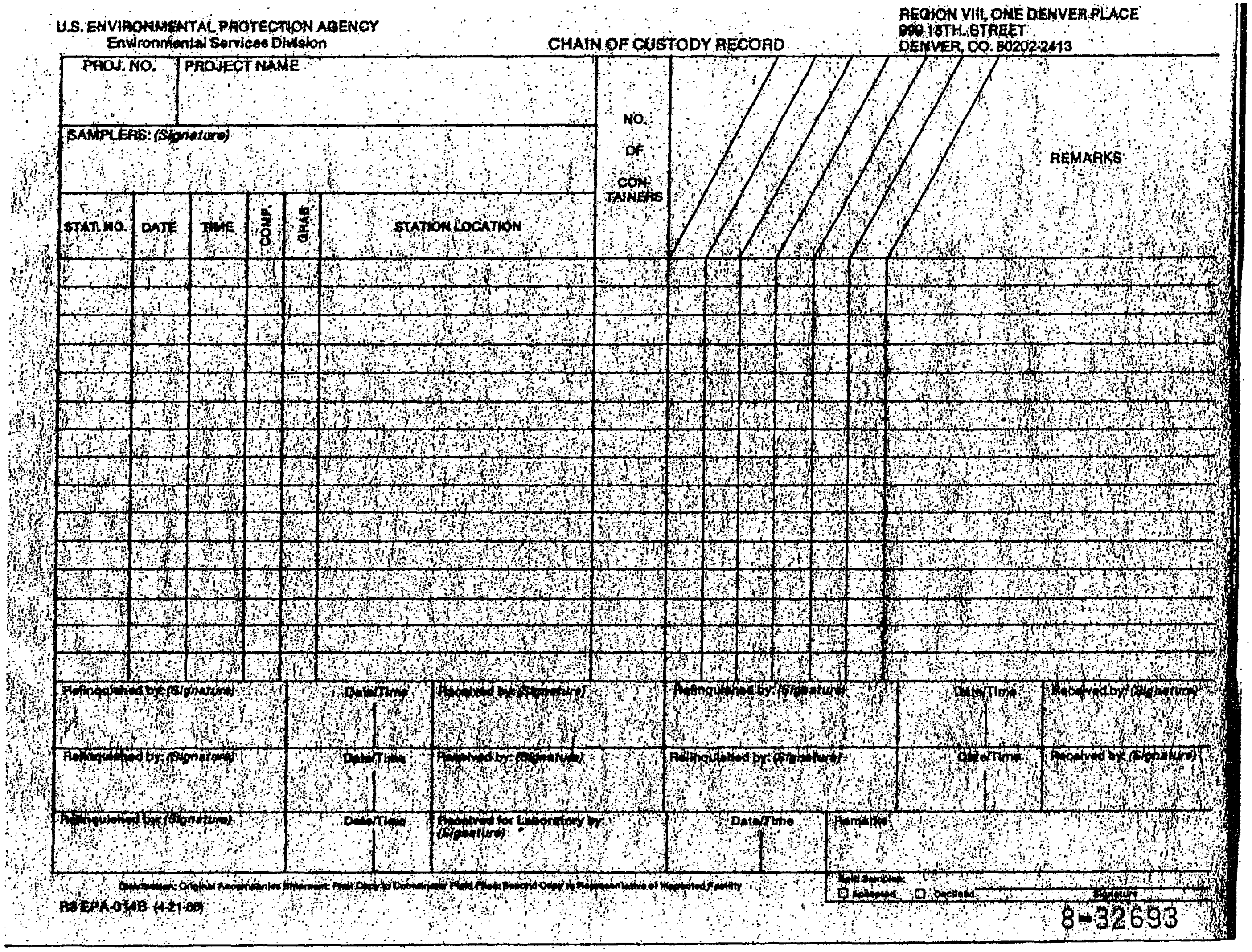
U.S. Environmental Protection Agency (EPA). 1986. "RCRA Groundwater Monitoring Technical Enforcement Guidance Document." (OSWER Directive 9950.1). September 1986.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." EPA/540/P-87/001 (OSWER Directive 9355.01-14). December 1987.

7.0 EXHIBITS

Exhibit 3-1	ULSA and Non-CLP Chain-of-Custody Form
Exhibit 3-2	ULSA and Non-CLP Chain-of-Custody Form Instructions
Exhibit 3-3	CLP RAS Traffic Reports and Chain-of-Custody Record
Exhibit 3-4	CLP RAS Traffic Reports and Chain-of-Custody Record Instructions
Exhibit 3-5	EPA Custody Seal
Exhibit 3-6	Calling in Shipping Information

EXHIBIT 3-1
ULSA and Non-CLP Chain-of-Custody Form



U.S. ENVIRONMENTAL PROTECTION AGENCY
Environmental Services Division

CHAIN OF CUSTODY RECORD

REGION VIII, ONE DENVER PLACE
999 18TH. STREET
DENVER, CO. 80202-2413

PROJ. NO.

PROJECT NAME

SAMPLERS: *(Signature)*

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS							REMARKS

Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date/Time	Received for Laboratory by: *(Signature)*	Date/Time	Remarks	

Distribution: Original Accompanies Shipment; Pink Copy to Coordinator Field Files; Second Copy to Representative of Inspected Facility

Split Samples:
☐ Accepted ☐ Declined ____________ Signature

R8 EPA-014B (4-21-88)

8-32693

EXHIBIT 3-2
UOS ULSA and Non-CLP Chain-of-Custody Form Instructions

In some sampling situations, analyses for compounds or concentrations beyond the scope of the CLP RAS program are required. In these cases, laboratories outside the CLP program must be acquired. This may be accomplished by using the ULSA or by contracting laboratories privately. All sample packing and Custody Seal protocols remain the same as for CLP labs.

1. ULSA and non-CLP Labs

For samples that are to be analyzed by ULSA, the following documentation must be used. In some situations, CDPHE will obtain the labs directly. In these cases, only a Chain-of-Custody form and Computer generated sample label are required. Complete this documentation as described below.

a. ULSA and non-CLP Chain-of-Custody Form

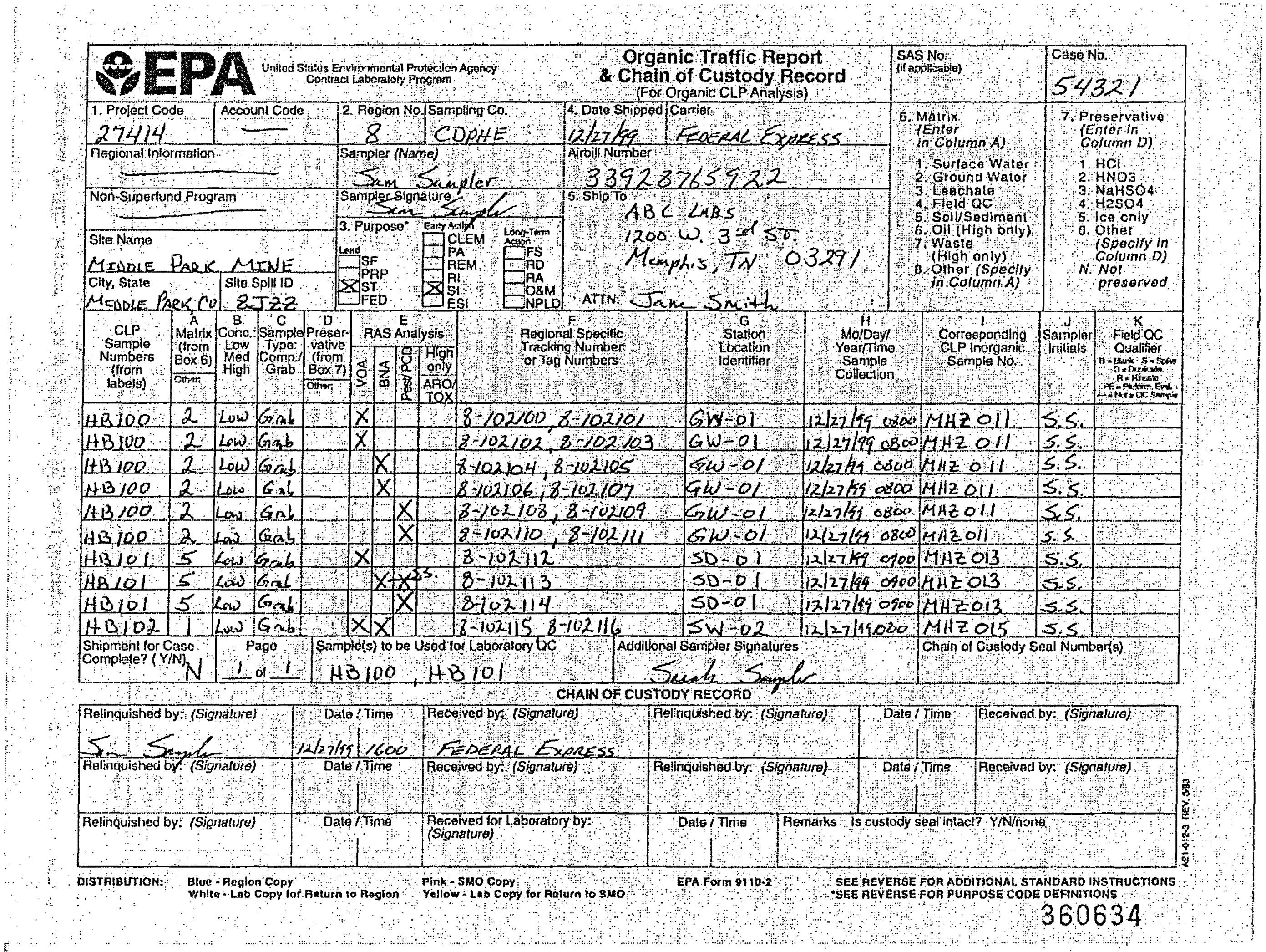
Use this form with all ULSA and non-CLP sample shipments. Do not mix organic and inorganic samples. Chain-of-Custody forms may be obtained from the ASC.

Ship To:	Laboratory name.
Project Name/No.:	project name and project number.
Project Leader:	Project Leader's name.
Samplers:	Sampler(s) sign here.
Station No.:	Appropriate number (consult project plan).
Date and Time:	Both must be included.
Comp/Grab:	Mark if the sample is a composite (a sample composed of more than one discrete sample) or a grab (a discrete sample).
Station Location:	Use the station location abbreviation that was used in the project plan to designate sampling locations on the maps and tables.
Number of Containers:	Write in the number of containers. If necessary, use more more than one row for each sample. For example, one VOC sample includes two containers (40 ml vials).

EXHIBIT 3-2 (continued)
ULSA and non-CLP Chain-of-Custody Form Instructions

Lines:	Write the analyses requested in the boxes next to "Number of Containers," and check the boxes below for the analyses requested on each individual sample.
Remarks:	Write the sample label number on the line corresponding to the sample. For ULSA samples, write the wire tag number here.
Signature Boxes:	The person who turns the samples over to the shipper signs and dates in the first "relinquished by" box. This person's signature must be included in the "Samplers" box. Write in the shipper identification in the first "Received by" box.
Remarks: (bottom right)	Write the airbill number or other shipping identification.
Distribution of Copies:	White - Accompanies sample shipment. Yellow - ASC, CDPHE Pink - Retained in the Field Office, or sent to the CDPHE ASC.

EXHIBIT 3-3
CLP RAS Traffic Reports and Chain-of-Custody Record



EPA United States Environmental Protection Agency
Contract Laboratory Program

Organic Traffic Report & Chain of Custody Record
(For Organic CLP Analysis)

SAS No. (if applicable):
Case No. 54321

1. Project Code: 27414
Account Code: —
2. Region No.: 8
Sampling Co.: CDPHE
4. Date Shipped: 12/27/99
Carrier: FEDERAL EXPRESS
Regional Information: —
Sampler (Name): Sam Sampler
Airbill Number: 3392876592 2
Non-Superfund Program: —
Sampler Signature: Sam Sampler
5. Ship To: ABC LABS
1200 W. 3rd ST.
Memphis, TN 03291
ATTN: Jane Smith
Site Name: MIDDLE PARK MINE
City, State: MIDDLE PARK CO
Site Spill ID: 8J22

3. Purpose*
Lead: ☐ SF ☐ PRP ☒ ST ☐ FED
Early Action: ☐ CLEM ☐ PA ☐ REM ☐ RI ☒ SI ☐ ESI
Long-Term Action: ☐ FS ☐ RD ☐ RA ☐ O&M ☐ NPLD

6. Matrix (Enter in Column A)
1. Surface Water
2. Ground Water
3. Leachate
4. Field QC
5. Soil/Sediment
6. Oil (High only)
7. Waste (High only)
8. Other (Specify in Column A)

7. Preservative (Enter in Column D)
1. HCl
2. HNO3
3. NaHSO4
4. H2SO4
5. Ice only
6. Other (Specify in Column D)
N. Not preserved

CLP Sample Numbers (from labels)	A Matrix (from Box 6) Other:	B Conc.: Low Med High	C Sample Type: Comp./Grab	D Preservative (from Box 7) Other:	E RAS Analysis VOA	BNA	Pest/PCB	High only ARO/TOX	F Regional Specific Tracking Number or Tag Numbers	G Station Location Identifier	H Mo/Day/Year/Time Sample Collection	I Corresponding CLP Inorganic Sample No.	J Sampler Initials	K Field QC Qualifier B = Blank S = Spike D = Duplicate R = Rinsate PE = Perform. Eval. — = Not a QC Sample
HB100	2	Low	Grab		X				8-102100, 8-102101	GW-01	12/27/99 0800	MHZ011	S.S.	
HB100	2	Low	Grab		X				8-102102, 8-102103	GW-01	12/27/99 0800	MHZ011	S.S.	
HB100	2	Low	Grab			X			8-102104, 8-102105	GW-01	12/27/99 0800	MHZ011	S.S.	
HB100	2	Low	Grab			X			8-102106, 8-102107	GW-01	12/27/99 0800	MHZ011	S.S.	
HB100	2	Low	Grab				X		8-102108, 8-102109	GW-01	12/27/99 0800	MHZ011	S.S.	
HB100	2	Low	Grab				X		8-102110, 8-102111	GW-01	12/27/99 0800	MHZ011	S.S.	
HB101	5	Low	Grab		X				8-102112	SD-01	12/27/99 0900	MHZ013	S.S.	
HB101	5	Low	Grab			X	~~X~~ SS.		8-102113	SD-01	12/27/99 0900	MHZ013	S.S.	
HB101	5	Low	Grab				X		8-102114	SD-01	12/27/99 0900	MHZ013	S.S.	
HB102	1	Low	Grab		X	X			8-102115 8-102116	SW-02	12/27/99 1000	MHZ015	S.S.	

Shipment for Case Complete? (Y/N): N
Page 1 of 1
Sample(s) to be Used for Laboratory QC: HB100, HB101
Additional Sampler Signatures: Sarah Sampler
Chain of Custody Seal Number(s):

CHAIN OF CUSTODY RECORD

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Sam Sampler	12/27/99 1600	FEDERAL EXPRESS			
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)

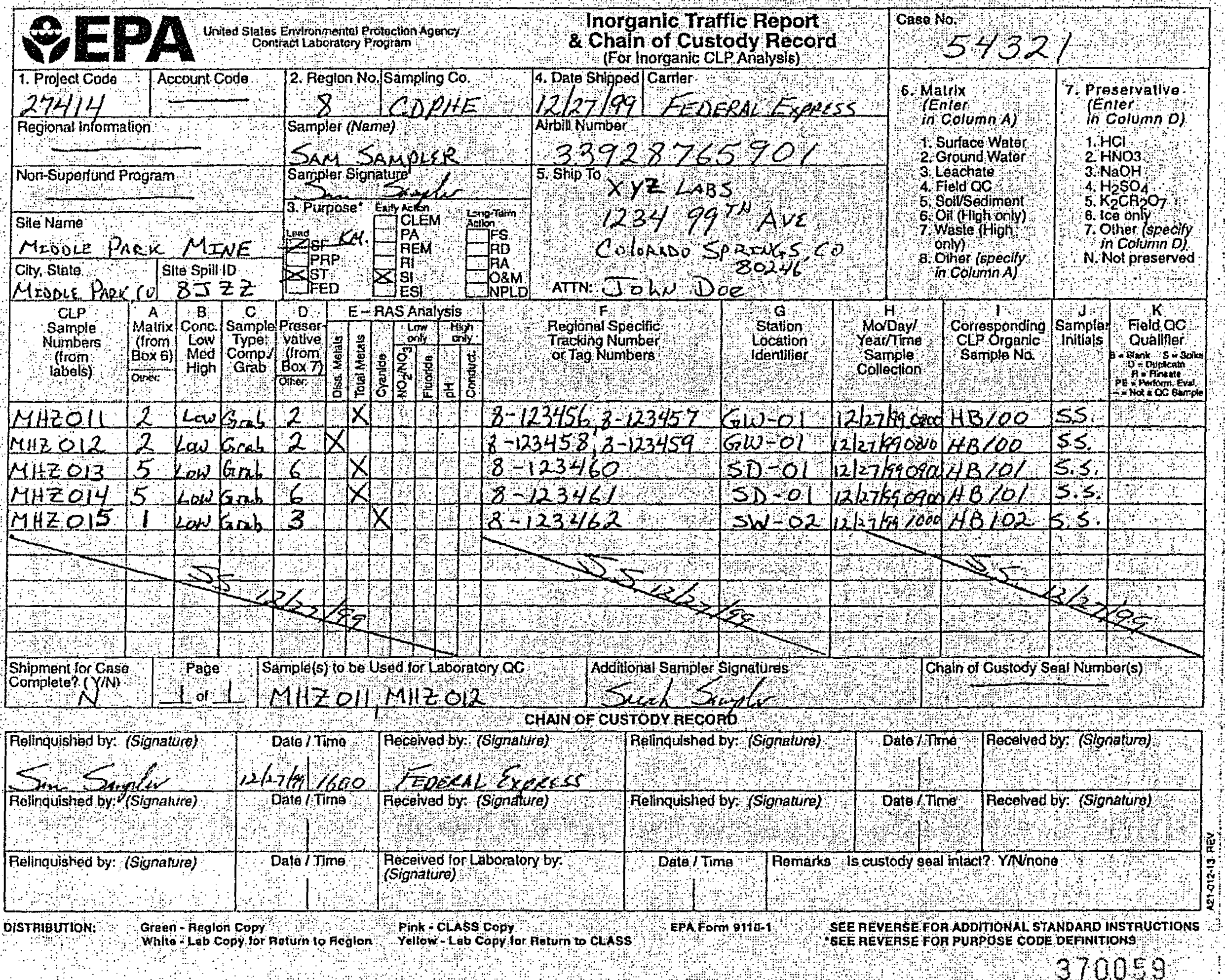
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks Is custody seal intact? Y/N/none

A21-012-3 REV. 3/93

DISTRIBUTION: Blue - Region Copy Pink - SMO Copy
White - Lab Copy for Return to Region Yellow - Lab Copy for Return to SMO
EPA Form 9110-2
SEE REVERSE FOR ADDITIONAL STANDARD INSTRUCTIONS
*SEE REVERSE FOR PURPOSE CODE DEFINITIONS

360634

EXHIBIT 3-3 (continued)
CLP RAS Traffic Reports and Chain-of-Custody Record



EPA United States Environmental Protection Agency
Contract Laboratory Program

Inorganic Traffic Report & Chain of Custody Record
(For Inorganic CLP Analysis)

Case No. 54321

1. Project Code: 27414
Account Code: ——
2. Region No.: 8
Sampling Co.: CDPHE
4. Date Shipped: 12/27/99
Carrier: FEDERAL EXPRESS
Regional Information: ——
Sampler *(Name)*: SAM SAMPLER
Airbill Number: 33928765901
Non-Superfund Program: ——
Sampler Signature: Sam Sampler
5. Ship To: XYZ LABS
1234 99TH AVE
COLORADO SPRINGS, CO
80246
ATTN: John Doe
Site Name: MIDDLE PARK MINE
City, State: MIDDLE PARK CO
Site Spill ID: 8JZZ

3. Purpose*
Lead: ~~☒ SF~~ KM. ☐ PRP ☒ ST ☐ FED
Early Action: ☐ CLEM ☐ PA ☐ REM ☐ RI ☒ SI ☐ ESI
Long-Term Action: ☐ FS ☐ RD ☐ RA ☐ O&M ☐ NPLD

6. Matrix *(Enter in Column A)*
1. Surface Water
2. Ground Water
3. Leachate
4. Field QC
5. Soil/Sediment
6. Oil (High only)
7. Waste (High only)
8. Other *(specify in Column A)*

7. Preservative *(Enter in Column D)*
1. HCl
2. HNO3
3. NaOH
4. H_2SO_4
5. $K_2CR_2O_7$
6. Ice only
7. Other *(specify in Column D)*
N. Not preserved

CLP Sample Numbers (from labels)	A Matrix (from Box 6) Other:	B Conc. Low Med High	C Sample Type: Comp./Grab	D Preservative (from Box 7) Other:	E – RAS Analysis: Diss. Metals	Total Metals	Cyanide	Low only: NO_2/NO_3	Low only: Fluoride	High only: pH	High only: Conduct.	F Regional Specific Tracking Number or Tag Numbers	G Station Location Identifier	H Mo/Day/Year/Time Sample Collection	I Corresponding CLP Organic Sample No.	J Sampler Initials	K Field QC Qualifier B = Blank S = Spike D = Duplicate R = Rinsate PE = Perform. Eval. — = Not a QC Sample
MHZ011	2	Low	Grab	2		X						8-123456, 8-123457	GW-01	12/27/99 0800	HB/00	S.S.	
MHZ012	2	Low	Grab	2	X							8-123458, 8-123459	GW-01	12/27/99 0810	HB/00	S.S.	
MHZ013	5	Low	Grab	6		X						8-123460	SD-01	12/27/99 0900	HB/01	S.S.	
MHZ014	5	Low	Grab	6		X						8-123461	SD-01	12/27/99 0900	HB/01	S.S.	
MHZ015	1	Low	Grab	3			X					8-123462	SW-02	12/27/99 1000	HB/102	S.S.	

SS 12/27/99
SS 12/27/99
SS 12/27/99

Shipment for Case Complete? (Y/N): N
Page 1 of 1
Sample(s) to be Used for Laboratory QC: MHZ011, MHZ012
Additional Sampler Signatures: Sam Sampler
Chain of Custody Seal Number(s): ——

CHAIN OF CUSTODY RECORD

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Sam Sampler	12/27/99 1600	FEDERAL EXPRESS			

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*

Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks Is custody seal intact? Y/N/none

A21-012-13 REV

DISTRIBUTION: Green - Region Copy
White - Lab Copy for Return to Region
Pink - CLASS Copy
Yellow - Lab Copy for Return to CLASS
EPA Form 9110-1
SEE REVERSE FOR ADDITIONAL STANDARD INSTRUCTIONS
*SEE REVERSE FOR PURPOSE CODE DEFINITIONS

370059

EXHIBIT 3-4
CLP RAS Traffic Reports and Chain-of-Custody Record Instructions

Use this form with all RAS or RAS plus ULSA sample CLP shipments. Enclose one form in each cooler being shipped. Do not mix organic and inorganic samples. Organic and inorganic Traffic Report forms and Chain-of-Custody Record forms may be obtained from the UOS ASC.

Top Right: A Case Number is assigned to the sampling project when an CLASS coordinator initiates the lab selection process. The Region VIII RSCC will notify the CDPHE ASC of the Case Number by phone. If the lab will be conducting RAS or RAS+ULSA, the ULSA number must also be recorded on the form.

Box 1: Use a project number. Do <u>not</u> give the actual project name.

Regional information is to be given only by the direction of the ASC.

If sampling is non-Superfund, enter the program name; e.g., RCRA.

Enter the site name, the city, state, and Superfund site spill ID code in the designated spaces. This information does not go through to the lab's copy.

Box 2: Enter Region VIII, the sampling agency (CDPHE), sampler name (printed), and sampler signature.

Box 3: Circle the appropriate Superfund codes.

<u>Funding Leads</u>

SF – Superfund
PRP – Potentially Responsible Party
ST - State
FED – Federal

<u>Types of Activities</u>

Pre-Remedial
PA – Preliminary Assessment
SSI – Screening Site Inspection
LSI – Listing Site Inspection

EXHIBIT 3-4 (continued)
CLP RAS Traffic Reports and Chain-of-Custody Record Instructions

Remedial

RIFS	–	Remedial Investigation Feasibility Study
RD	–	Remedial Design
RA	–	Remedial Action
O&M	–	Operations and Maintenance
NPLD	–	National Priorities List Delete

Removal

CLEM	–	Classic Emergency
REMA	–	Removal Assessment
REM	–	Removal
OIL	–	Oil Response
UST	–	Underground Storage Tank Response

Box 4: Enter the date shipped, the carrier code (e.g., F = Federal Express), and the airbill number.

Box 5: Enter the name, address, and contact person of the CLP lab contracted to perform the analyses. This information is supplied to the sampler by the ASC after the lab contract has been awarded by CLASS.

COLUMNS

Left edge column: Carefully transcribe the CLP Sample Number from the printed sample labels provided. A stack of labels will be provided to the samplers by the ASC. Each sample analysis requires a separate line. All bottle tag numbers for one analysis may be put on one line.

Col. A: Enter the appropriate sample description code from Box 7. Note: Item #6 “Oil,” Item #7 “Waste,” and Item #8 “Other” are for RAS plus ULSA projects only.

Col. B: Organic – If sample is estimated to be low or medium concentration, enter “L.” If sample is high concentration (comprised of more than 15 percent of a compound), it must be sent to a ULSA lab. Notify the CDPHE ASC if you need a ULSA lab for high concentration samples.

Inorganic – Enter the estimated concentration. Low level is less than 10 ppm of a single compound; medium level is between 10 ppm and 15 percent; and high level is above 15 percent.

REMINDER: Ship medium and high concentration organic and inorganic samples in metal paint cans.

EXHIBIT.3-4 (continued)
CLP RAS Traffic Reports and Chain-of-Custody Record Instructions

Col. C:	Mark if the sample is a composite (a sample composed of more than one discrete sample) or a grab (a discrete) sample.
Col. D:	Indicate the appropriate preservative code from Box 6.
Col. E:	Check the appropriate RAS analyses requested for each sample.
Col. F:	List EPA Tag numbers corresponding to CLP sample numbers.
Col. G:	Use the station location abbreviation that was used in the Field Sampling Plan to designate sampling locations on the maps and tables.
Col. H:	Enter the date and military time of sample collection.
Col. I:	Enter the initials of the sampler.
Col. J:	If the sample taken will also be analyzed for organics/inorganics, list the corresponding sample number from the Organic/Inorganic Traffic Report and Chain-of-Custody Record.
Col. K:	Designation of field QC (e.g., rinsates, duplicates) is optional.

BOTTOM OF PAGE

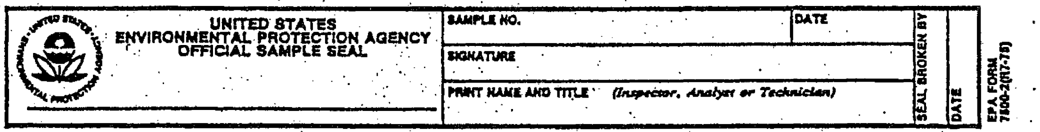
Indicate if this shipment is a portion or the entire sampling for the case number.
Indicate the total number of forms used for the shipment.
Designate lab QC (by CLP sample number).
Provide signatures of all other samplers involved with this sampling event.
Chain-of-Custody Seal number is not applicable in Region VIII.
The person who turns the samples over to the shipper signs and dates in the first "relinquished by" box. This person's signature must be included in a "Samplers" box.

BACK PAGE

Instructions summarizing CLP sample volumes, packaging and reporting requirements are printed on the back of the Organic/Inorganic Traffic Reports and Chain-of-Custody Record.

Distribution of copies:	Green - Region Copy (RSCC). Pink - CLASS copy (Fed Ex overnight). White - Lab copy. Yellow - Lab copy for return to CLASS. Photocopies - ASC, CDPHE and Field Office

EXHIBIT 3-5
EPA Custody Seal



UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
OFFICIAL SAMPLE SEAL

SAMPLE NO.
DATE
SIGNATURE
PRINT NAME AND TITLE *(Inspector, Analyst or Technician)*
SEAL BROKEN BY
DATE
EPA FORM 7500-2(R7-75)

EXHIBIT 3-6
Calling in Shipping Information

Contact (via FAX or telephone) and submit the following information to the ASC on a daily basis:

Case (and/or ULSA) Number;
Date shipped;
Number of samples by concentration (high, medium, low) and sample matrix;
Carrier and airbill number;
EPA Sample Numbers;
Sample destination(s); and
Next planned shipment.

The ASC will notify the RSCC of all shipments. Field personnel must notify the ASC of Saturday sample deliveries in time to contact the RSCC before 12:00 noon on Friday.

Report any delays or changes of scope (i.e., changes in number of samples to be collected, matrix changes, etc.) to the ASC. The ASC will then notify the RSCC.

STANDARD OPERATING PROCEDURE - 4

SAMPLE IDENTIFICATION, LABELING AND PACKAGING

1.0 PURPOSE

The purpose of this procedure is to describe the standard method for sample identification to be used on environmental investigations. This procedure outlines the required information and provides standardized forms and labels.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the Project Leader and CDPHE Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Field Data Records: Field-generated documents including field log books, Exhibits and forms as supplied in the CDPHE Standard Operating Procedures.

2.2 Abbreviations

CLP	Contract Laboratory Program
EPA	U.S. Environmental Protection Agency
ERT	Environmental Response Team
ESD	EPA Environmental Services Division
FDR	Field Data Record
FSP	Field Sampling Plan
PPs	Project Plans
QC	Quality Control
RAS	Routine Analytical Service
RSCC	Regional Sample Control Coordinator
SAP	Sampling and Analysis Plan
ULSA	Unique Laboratory Sample Analysis
VOC	Volatile Organic Compound

3.0 RESPONSIBILITIES

Field personnel (samplers) are responsible for performing the tasks outlined in this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performed and ensuring that the work is conducted in a satisfactory manner. This will be accomplished by reviewing all documents (Exhibits) and data produced.

4.0 SAMPLE IDENTIFICATION PROCEDURES

4.1 Introduction

The coding system described herein will be used to identify each sample taken during the sampling program. This coding system will provide a method for tracking each sample. If the project involves Contract Laboratory Program (CLP) laboratories, U.S. Environmental Protection Agency (EPA) and CDPHE sample numbers will be cross-referenced. Proper sample identification will allow information about a particular sample to be retrieved and will enable the analytical results to be assigned to a specific location. It is imperative that each sample be labeled clearly and concisely and that a consistent and standard identification system be used as described below.

4.2 Method of Sample Identification

The method for identification of a sample depends on the matrix of the sample, and the type of measurement or analysis performed. On-site measurements will be recorded in field log books. The measurements may also be recorded on the Field Data Records (FDRs). Examples of on-site measurements include, but are not limited to: pH, temperature, conductivity, groundwater level, and air sampling.

Sampling during most environmental investigations will include off-site laboratory analysis of samples. The laboratory will be either under contract to the EPA CLP or subcontracted directly by CDPHE.

Within the CLP is the Routine Analytical Services (RAS). Within Region VIII is the Unique Laboratory Sample Analysis (ULSA) program. CLP-RAS samples receive only EPA-issued labels and tags. They do not require CDPHE labels. Samples going to ULSA or non-CLP laboratories receive a CDPHE label (see Exhibit 4-1).

Each sample is identified by a unique code which may include, but is not limited to, the following: site code, sample type, sample point, and sequence number.

4.2.1 Site Code

The site code may be omitted for smaller sites.

4.2.2 Sample Type

A two-letter designation will be used to identify the specific type of sample or the area in which it was collected. To better delineate physical areas within smaller sites, a two-letter designation may be created which represents unique sampling areas as approved by the

Project Leader. Typical designations for sample types which may be collected during the site investigations are:

SW - Surface water grab sample (streams, rivers, lakes, runoff);
SF - Surface water flow (continuous measurement);
MW - Monitor well sample;
GW - Groundwater sampled from various types of wells;
SS - Source sample;
SB - Soil boring sample;
SG - Soil gas;
WQ - Continuous water quality measurement;
SO - Surface samples (beds, surface soil, shallow depth borings);
SE - Sediment samples collected from stream beds, etc.;
LG - Lagoon samples;
TS - Tank samples including aboveground and below ground enclosures;
DM - Drum samples;
AM - Meteorological station;
AG - Gaseous air samples;
AP - Particulate air samples;
AO - Organic air samples;
MS - Trace metal samples;
RS - Rock samples; and
BI - Biological samples.

4.2.3 Sample Point

A number may be used to identify a sample point location. This location can be a soil sample point, borehole, well, drum, tank, surface water sample point, lagoon point, air monitor station, or any other point where a source material, water, soil, core, or air sample will be taken.

The sample type and sample point together represent the unique sample station from which the sample will be taken (e.g., MW-01).

The sample point number may be omitted for smaller sites.

4.2.4 Sequence Number

The final sample identification code will be a sequence identifier. This number will be used to identify separate samples collected at the same sample point. Samplers shall monitor the sequential use of numbers.

The CDPHE sample type, sample point identifier and sequence number codes will be established by the Project Leader for each sample to be collected prior to field activities, and will be identified in the Field Sampling Plan (FSP).

EPA sample numbers will be provided by the Regional Sample Control Coordinator (RSCC) immediately prior to sampling.

5.0 Sample Labeling Procedure

5.1 Sample Label

In order to prevent misidentification of samples, all samples will be temporarily identified with the sample ID and analyses to be preformed on the respective bottle. This will be conducted with the use of an indelible pen, crayon or paint marker. Sample labels can be affixed to the sample jar prior to sampling, but if the label gets wet, the writing on the label may run or the label may fall off. If the sample container is to have labels affixed prior to sampling, each label must be plastic-coated (blank or preprinted) (see Exhibit 4-1). Each label must meet the following criteria:

- Waterproof;
- Will not disintegrate;
- Will retain indelible ink markings when wet; and
- Must be self-adhesive.

Complete all sample labels in legibly printed text with an indelible ink pen. For CLP-RAS samples, the EPA RSCC will provide sample labels. For non-CLP laboratories and for ULSA samples, record the following information on the CDPHE Sample Label:

- Date - A six-digit number indicating the month, day and year of collection;
- Time - Time (24 hour clock) sample was collected;
- Project - Project name (for ULSA samples, do <u>not</u> indicate site location);
- Job No. - CDPHE project number;
- Location - Brief sample location description. This can also be the sample ID. For ULSA samples, do <u>not</u> indicate <u>site</u> location;
- Depth - Depth at which sample was collected (if applicable);
- Sample Number I.D. - EPA ULSA sample number as provided by the EPA RSCC <u>and</u> CDPHE sample number as defined in Section 4.2 of this procedure;
- Preservative - Indicate presence or absence and composition of preservative if present;
- Remarks - Pertinent remarks to help identify sample and analysis to be performed; and
- Signature - Signature of sampler who actually collected the sample.

5.2 EPA Sample Tag (To Be Used for CLP-RAS, ULSA, EPA Environmental Services Division (ESD) or the Environmental Response Team (ERT))

Record the following information on the EPA Sample Tag (Exhibit 4-2):

- Project Code - Record the RSCC-supplied project code;
- Station No. - Record the CDPHE-assigned station number;
- Month/Day/Year - A six-digit number indicating month, day and year of collection;
- Time - Time (24 hour clock) sample was collected;
- Comp. or Grab - Check applicable box for composite or grab sample;
- Station Location - Brief sample location description or sample ID;
- Sampler signature - Signature of sampler(s);
- Preservative - Check the appropriate box and, if preserved, write in the preservative used below the "Yes" box. If sample is preserved to 4°C, check "Yes" box and write 4°C;
- Analyses - Check the appropriate box;
- Remarks - Provide the CLP-RAS sample number (for CLP-RAS samples) on the preprinted label; and
- Lab Sample No. - For laboratory use only.

As each sample is collected, make a record of this in the field log book as specified in CDPHE SOP 4.6, Use and Maintenance of Field Log Books, and place the sample in a labeled container. Bring chests to the decontamination area where, if necessary, the samples can be separated for shipping to the analytical laboratories specified in the Project Plans. Fill out the Chain-of-Custody form for all samples as described in CDPHE SOP 4.3, Chain of Custody.

5.3 Custody Seal

Custody Seals are required on shipping containers.

Fill out Custody Seals (Exhibit 4-3) and sign and date each. Affix the Custody Seals such that any opening of the shipping container or sample will be indicated by a broken seal.

6.0 Sample Packing and Shipping

Pack all samples for shipment following the guidelines outlined below.

6.1 Steps in Packing a Cooler

- Clean the inside and outside of the cooler.
- Line one layer of bubble wrap, bottom side down, in bottom of cooler and line with shredded paper to absorb shock and water.
- Line cooler with one large garbage bag.

6.2 Prepare Samples

- Wrap all glass sample jars one time with bubble wrap. Take note to leave the sample tag out, while making sure that there is bubble wrap coverage on the top and bottom of the sample container.
- Affix bubble wrap in place and put sample in plastic bag of appropriate size as to prevent the bubble wrap from coming unwrapped. Take note to lay the sample tag flat on the outside so it can be read and eliminate air pockets in the ziplock bag.
- Volatile organic compound (VOC) vials are placed in the VOC vial sponge. This is then wrapped loosely in bubble wrap and bagged like other samples.
- Plastic sample bottles are not wrapped in bubble wrap. They are placed in a plastic ziplock baggie with careful attention paid to eliminate air pockets. Make sure that the sample tag is placed face out so it can be read during the final Quality Control (QC) check.
- Check all tags and labels to the corresponding chain of custody. This will complete the final QC check.

6.3 Pack Coolers

- Care must be taken to maximize the number of sample jars placed in the cooler while not overpacking it. Sample jars should fit snugly with little or no movement if shaken lightly prior to filling open spaces with available materials. Do not place sample jars on their sides or on top of one another. Above all, glass should never be touching or capable of touching glass.
- Use available materials to fill any potentially open space in the cooler. Tape jars together, if appropriate, to reduce movement of sample jars during shipment.

- Ice coolers with:
  a. Two to three large ziplock bags with few or no air pockets, or several small bags. These bags then are double bagged to prevent any potential for leaking.
  b. Put ice inside a trash bag below a layer of shredded paper. This will help keep the sample at 4°C. Put paper on top of the ice so it closes very tightly. There should be no inside shifting if the cooler is packed correctly.
- Affix a piece of tape on the top of the cooler with the cooler sequence number, total numbers of coolers for that respective shipment, and the laboratory destination.
- Wrap each cooler a minimum of three times around at each end with strapping or shipping tape. Tape up the drain hole.

6.4 Special Stickers Required On Coolers For Shipment.

- Up (↑↑) labels on the ends under handles
- 8027 label (other regulated substances - environmental samples)
- Hazardous substance code (9 also indicates chilling)
- Typed label stating where shipment is to and who shipment is from
- Two custody seals placed on cooler.

6.5 Completing Shipment

- Use special hazardous waste (Dangerous Goods) Federal Express air bills. Follow directions in Section 6.6 for completing Dangerous Goods Airbill.
- Ice and packing material is considered part of "solids."
- Insure each cooler for $5,000.

6.6 Instructions for Completing a Federal Express Dangerous Goods Airbill

These instructions should be used for non-radioactive environmental samples only. Do not use these instructions to ship chemicals (hexane, methanol, nitric acid, etc.) or radioactive samples. If additional questions arise call Federal Express Special Services at 1-800-238-5355. This number is preprinted at the top of each Dangerous Goods Airbill.

Complete the top portion of the Dangerous Goods Airbill as follows:

Fed Ex Box No.	Instructions
1	This number should be preprinted. If it is not, then fill it in (CDPHE Federal Express government no..
2	Laboratory name and address. If the sample custodian's name is unknown, then simply print "Sample Custodian."
3	Check box number 1 - Bill Sender. A project number is required in the box labeled "your internal billing reference information."
4	Check government overnight <u>only</u>! In the instructions box, check the box that is labeled "Dangerous goods as per attached Shipper's declaration."
4	In the case of Saturday delivery, . . .
4	To be filled in by Federal Express personnel when they weigh the coolers.

Complete the bottom portion of the Dangerous Goods Airbill as follows:

<u>Transport Details</u>

Cross out the boxes that **DO NOT** apply (i.e., most environmental samples can be shipped on passenger aircraft, so cross out the "cargo aircraft only" box).

<u>Shipment Type</u>

Again cross out the boxes that do not apply. Cross out the "Radioactive" box. Remember that these instructions are for non-radioactive environmental samples ONLY!

<u>Shipper's Certification for Restricted Articles/Dangerous Goods</u>

Check the box marked "IATA/ICAO."

<u>Proper Shipping Name</u>

Write in "Other Regulated Substances." Directly below this, write "(Environmental Samples)."

<u>Class or Division</u>

Write "9."

<u>UN or ID Number</u>

Write "8027."

Quantity and Type of Packaging

Write in how many and what kind of coolers are being shipped, as well as the volume and weight of the enclosed media; for example, "1 plastic cooler, 4 liters liquid, 12 kg soil." Weight may be filled in at the Federal Express office after being weighed by the Federal Express personnel.

Packing Instructions

Write "906."

Authorization

Leave this blank.

The Project Leader or an approved designee shall check Exhibit 4-1, Sample Label; Exhibit 4-2, EPA Sample Tag, if applicable; and Exhibit 4-3, Custody Seal for completeness and accuracy. Any discrepancies will be noted and the Exhibits will be returned to the originator for correction.

7.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1986. "RCRA Groundwater Monitoring Technical Enforcement Guidance Document." (OSWER Directive 9950.1). September 1986.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." EPA/540/P-87/001. (OSWER Directive 9355.01-14). December 1987.

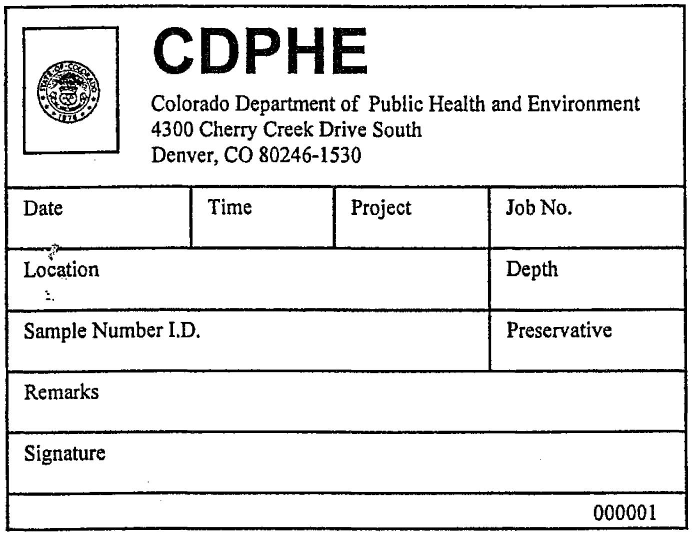
CDPHE. 2000. "Standard Operating Procedure 4.3, Chain of Custody." Technical Standard Operating Procedures.

CDPHE. 2000. "Standard Operating Procedure 4.6, Use and Maintenance of Field Log Books." Technical Standard Operating Procedures.

8.0 EXHIBITS

Exhibit 4-1	Sample Label
Exhibit 4-2	EPA Sample Tag
Exhibit 4-3	EPA Custody Seal
Exhibit 4-4	Sample Packaging Summary
Exhibit 4-5	Required Cooler Labels
Exhibit 4-6	Required Cooler Label Placement
Exhibit 4-7	Federal Express Dangerous Goods Airbill

EXHIBIT 4-1
Sample Label

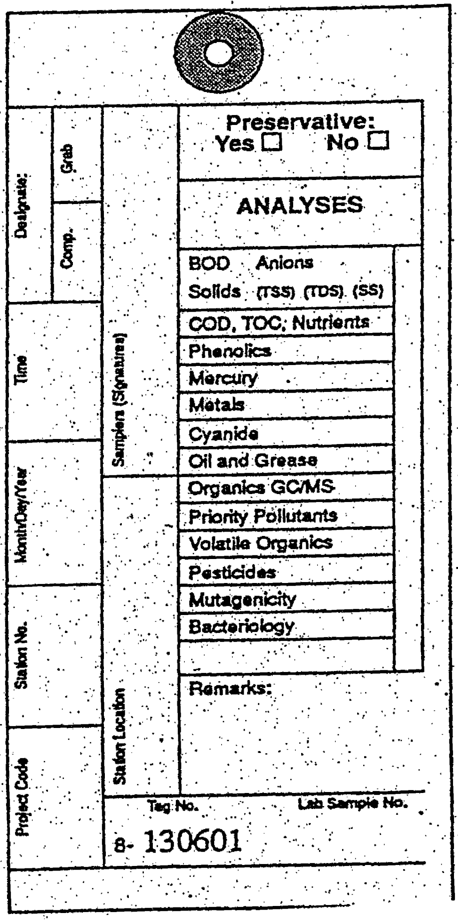


CDPHE

Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80246-1530

Date	Time	Project	Job No.
Location			Depth
Sample Number I.D.			Preservative
Remarks			
Signature			
			000001

EXHIBIT 4-2
EPA Sample Tag



Designate:
Grab
Comp.
Time
Month/Day/Year
Station No.
Project Code
Samplers (Signatures)
Station Location

Preservative:
Yes ☐ No ☐

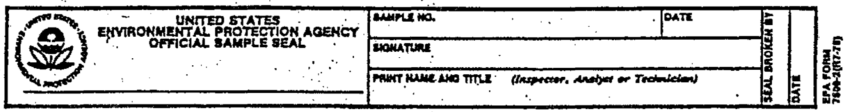
ANALYSES

- BOD Anions
- Solids (TSS) (TDS) (SS)
- COD, TOC, Nutrients
- Phenolics
- Mercury
- Metals
- Cyanide
- Oil and Grease
- Organics GC/MS
- Priority Pollutants
- Volatile Organics
- Pesticides
- Mutagenicity
- Bacteriology

Remarks:

Tag No.
Lab Sample No.
8- 130601

EXHIBIT 4-3
EPA Custody Seal



UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
OFFICIAL SAMPLE SEAL

SAMPLE NO.

DATE

SIGNATURE

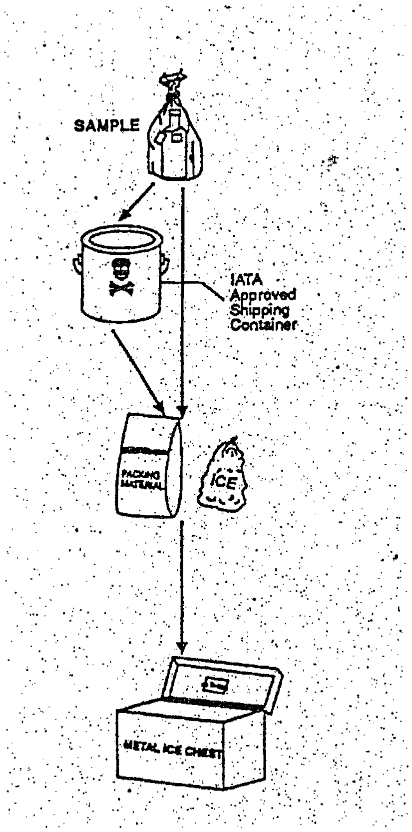
PRINT NAME AND TITLE *(Inspector, Analyst or Technician)*

SEAL BROKEN BY

DATE

EPA FORM 7500-2(R7-75)

EXHIBIT 4-4
Sample Packaging Summary



- Enclose all sample containers in clear plastic bags.
- Pack all medium and high level water and soil samples in metal paint cans.
- Label paint cans with sample number of sample contained inside.
- Surround contents of can with non-combustible absorbent packing material.
- Using freezer packages or ice sealed in plastic bags, cool organic low or medium samples and inorganic samples to be analyzed for cyanide to 4°C.
- Ice is not required in shipping low level soil samples, but may be utilized at the discretion of the sampler.
- Do not cool dioxin, inorganic low level water, inorganic medium/high level water or soil, or organic high level water or soil samples.
- Pack sealed paint cans or plastic-enclosed sample bottles in shipment container.
- Use a metal ice chest for shipment (do not use cardboard or styrofoam containers to ship samples).
- Surround contents with non-combustible absorbent packing material (Do not use earth or ice packing materials).
- Tape paperwork in plastic bags under cooler lid.
- Close cooler and seal with custody seals.

EXHIBIT 4-5
Required Cooler Labels

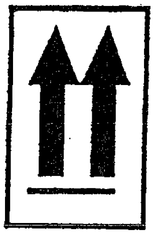
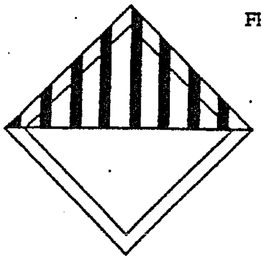
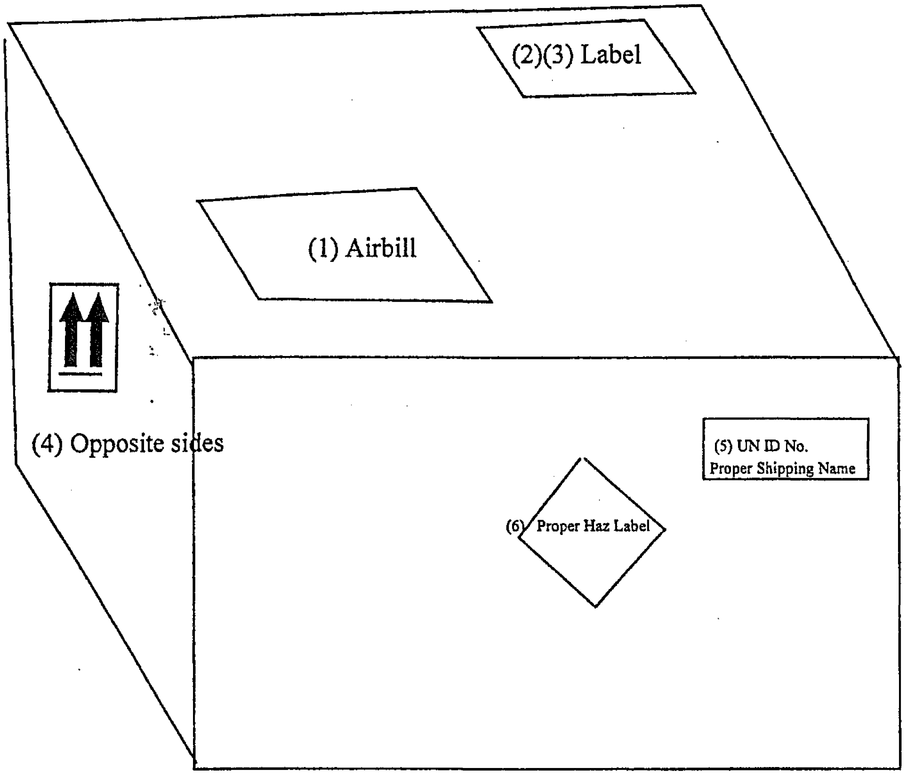
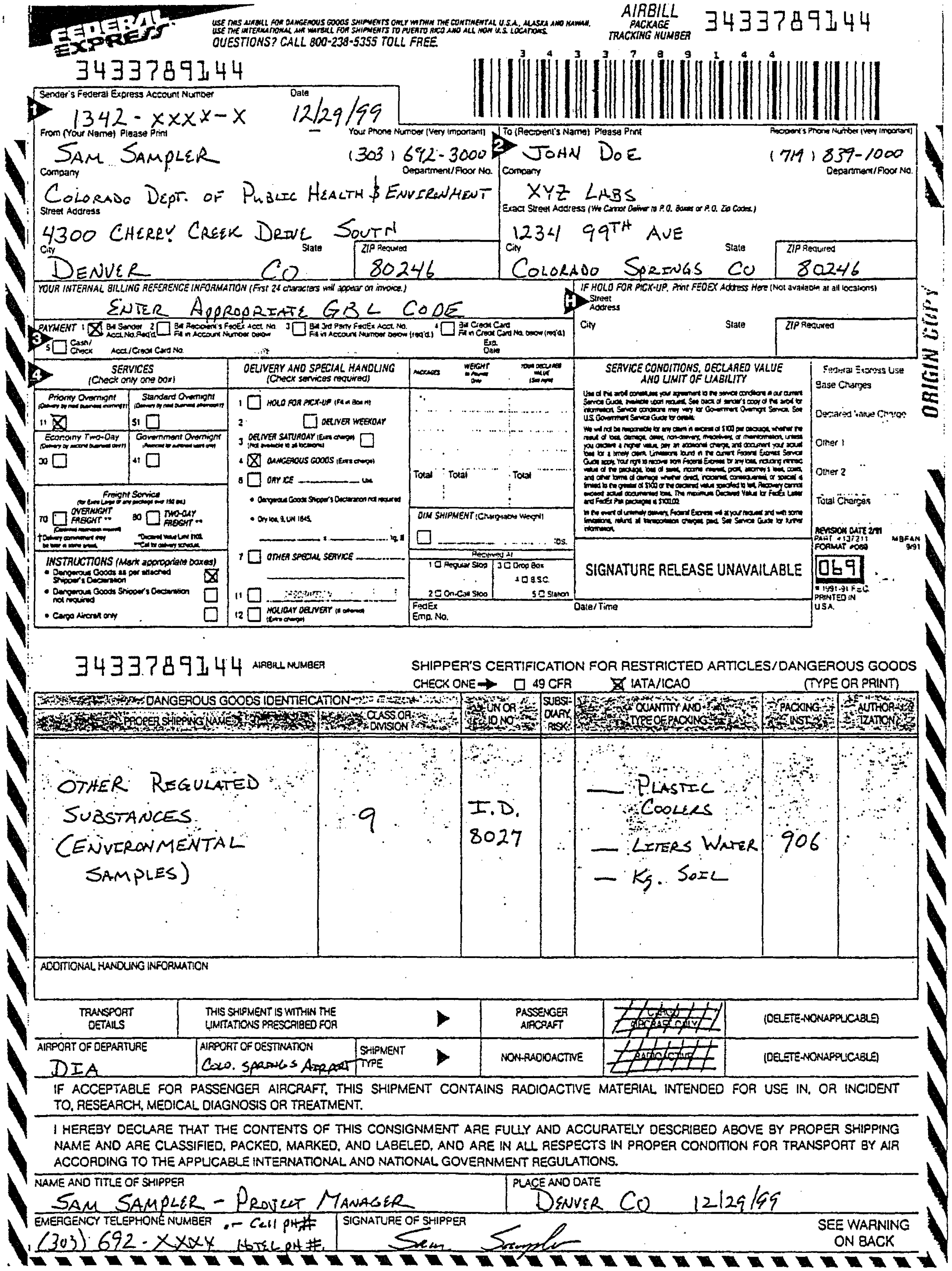
ORIENTATION	HAZARD CLASS
4 - OPPOSITE SIDES 	FRONT 
TOP Colorado Department of Public Health and Environment 4300 Cherry Creek Drive South Denver, CO 80246	FRONT UN ID NO. PROPER SHIPPING NAME NAME
	FRONT **"CONTAINS WET ICE"** (IF APPLICABLE)

EXHIBIT 4-6
Required Cooler Label Placement



(1) Airbill
(2) Recipient Address
(3) Shipper or Consignee Address
(4) Orientation Arrows
(5) UN ID No. and Proper Shipping Name
(6) Label or ORM Marking

EXHIBIT 4-7
Federal Express Dangerous Goods Airbill



FEDERAL EXPRESS

USE THIS AIRBILL FOR DANGEROUS GOODS SHIPMENTS ONLY WITHIN THE CONTINENTAL U.S.A., ALASKA AND HAWAII.
USE THE INTERNATIONAL AIR WAYBILL FOR SHIPMENTS TO PUERTO RICO AND ALL NON U.S. LOCATIONS.
QUESTIONS? CALL 800-238-5355 TOLL FREE.

AIRBILL PACKAGE TRACKING NUMBER 3433789144

3433789144

1 Sender's Federal Express Account Number: 1342-xxxx-x
Date: 12/29/99
From (Your Name) Please Print: SAM SAMPLER
Your Phone Number (Very Important): (303) 692-3000
Company: COLORADO DEPT. OF PUBLIC HEALTH & ENVIRONMENT
Department/Floor No.:
Street Address: 4300 CHERRY CREEK DRIVE SOUTH
City: DENVER
State: CO
ZIP Required: 80246

2 To (Recipient's Name) Please Print: JOHN DOE
Recipient's Phone Number (Very Important): (719) 839-1000
Company: XYZ LABS
Department/Floor No.:
Exact Street Address (We Cannot Deliver to P.O. Boxes or P.O. Zip Codes.): 1234 99TH AVE
City: COLORADO SPRINGS
State: CO
ZIP Required: 80246

YOUR INTERNAL BILLING REFERENCE INFORMATION (First 24 characters will appear on invoice.): ENTER APPROPRIATE GBL CODE

H IF HOLD FOR PICK-UP, Print FEDEX Address Here (Not available at all locations)
Street Address:
City:
State:
ZIP Required:

3 PAYMENT
1 ☒ Bill Sender Acct. No. Req'd.
2 ☐ Bill Recipient's FedEx Acct. No. Fill in Account Number below
3 ☐ Bill 3rd Party FedEx Acct. No. Fill in Account Number below (req'd.)
4 ☐ Bill Credit Card Fill in Credit Card No. below (req'd.)
5 ☐ Cash/Check
Acct./Credit Card No.
Exp. Date

4 SERVICES (Check only one box)
Priority Overnight (Delivery by next business morning†)
11 ☒
Standard Overnight (Delivery by next business afternoon†)
51 ☐
Economy Two-Day (Delivery by second business day†)
30 ☐
Government Overnight (Restricted for authorized users only)
41 ☐

Freight Service (for Extra Large or any package over 150 lbs.)
70 ☐ OVERNIGHT FREIGHT ** (Confirmed reservation required)
80 ☐ TWO-DAY FREIGHT **
† Delivery commitment may be later in some areas.
*Declared Value Limit $100.
**Call for delivery schedule.

INSTRUCTIONS (Mark appropriate boxes)
- Dangerous Goods as per attached Shipper's Declaration ☒
- Dangerous Goods Shipper's Declaration not required ☐
- Cargo Aircraft only ☐

DELIVERY AND SPECIAL HANDLING (Check services required)
1 ☐ HOLD FOR PICK-UP (Fill in Box H)
2 ☐ DELIVER WEEKDAY
3 DELIVER SATURDAY (Extra charge) (Not available to all locations) ☐
4 ☒ DANGEROUS GOODS (Extra charge)
6 ☐ DRY ICE ______ Lbs.
- Dangerous Goods Shipper's Declaration not required
- Dry Ice, 9, UN 1845, ______ x ______ kg. III
7 ☐ OTHER SPECIAL SERVICE ______
11 ☐ ______
12 ☐ HOLIDAY DELIVERY (If offered) (Extra charge)

Packages	Weight In Pounds Only	Your Declared Value (See right)
Total	Total	Total

DIM SHIPMENT (Chargeable Weight)
☐ ______ lbs.

Received At
1 ☐ Regular Stop
2 ☐ On-Call Stop
3 ☐ Drop Box
4 ☐ B.S.C.
5 ☐ Station
FedEx Emp. No.

SERVICE CONDITIONS, DECLARED VALUE AND LIMIT OF LIABILITY

Use of this airbill constitutes your agreement to the service conditions in our current Service Guide, available upon request. See back of sender's copy of this airbill for information. Service conditions may vary for Government Overnight Service. See U.S. Government Service Guide for details.

We will not be responsible for any claim in excess of $100 per package, whether the result of loss, damage, delay, non-delivery, misdelivery, or misinformation, unless you declare a higher value, pay an additional charge, and document your actual loss for a timely claim. Limitations found in the current Federal Express Service Guide apply. Your right to recover from Federal Express for any loss, including intrinsic value of the package, loss of sales, income interest, profit, attorney's fees, costs, and other forms of damage whether direct, incidental, consequential, or special is limited to the greater of $100 or the declared value specified to left. Recovery cannot exceed actual documented loss. The maximum Declared Value for FedEx Letter and FedEx Pak packages is $100.00.

In the event of untimely delivery, Federal Express will at your request and with some limitations, refund all transportation charges paid. See Service Guide for further information.

SIGNATURE RELEASE UNAVAILABLE

Date/Time

Federal Express Use
Base Charges
Declared Value Charge
Other 1
Other 2
Total Charges

REVISION DATE 2/91
PART #137211
FORMAT #069
MBFAN 9/91
069
© 1991-91 FEC
PRINTED IN U.S.A.

ORIGIN COPY

3433789144 AIRBILL NUMBER

SHIPPER'S CERTIFICATION FOR RESTRICTED ARTICLES/DANGEROUS GOODS
CHECK ONE → ☐ 49 CFR ☒ IATA/ICAO (TYPE OR PRINT)

DANGEROUS GOODS IDENTIFICATION						
PROPER SHIPPING NAME	CLASS OR DIVISION	UN OR ID NO.	SUBSIDIARY RISK	QUANTITY AND TYPE OF PACKING	PACKING INST.	AUTHORIZATION
OTHER REGULATED SUBSTANCES (ENVIRONMENTAL SAMPLES)	9	I.D. 8027		— PLASTIC COOLERS — LITERS WATER — KG. SOIL	906	

ADDITIONAL HANDLING INFORMATION

TRANSPORT DETAILS	THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR ▶	PASSENGER AIRCRAFT	~~CARGO AIRCRAFT ONLY~~	(DELETE-NONAPPLICABLE)
AIRPORT OF DEPARTURE DIA	AIRPORT OF DESTINATION COLO. SPRINGS AIRPORT SHIPMENT TYPE ▶	NON-RADIOACTIVE	~~RADIOACTIVE~~	(DELETE-NONAPPLICABLE)

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS OR TREATMENT.

I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT BY AIR ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENT REGULATIONS.

NAME AND TITLE OF SHIPPER: SAM SAMPLER - PROJECT MANAGER
PLACE AND DATE: DENVER CO 12/29/99
EMERGENCY TELEPHONE NUMBER: (303) 692-XXXX ← CELL PH# HOTEL PH #.
SIGNATURE OF SHIPPER: Sam Sampler
SEE WARNING ON BACK

STANDARD OPERATING PROCEDURE - 5

SAMPLE LOCATION DOCUMENTATION

1.0 PURPOSE

The purpose of this procedure is to describe the methods for permanently marking sample points and documenting site conditions. Site-specific deviations from the methods presented herein must be approved by the Project Leader and the CDPHE Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

Not applicable.

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure on environmental projects.

The Project Leader or an approved designee is responsible for checking all work performed and ensuring that the work required by this procedure is performed in a satisfactory manner. This is accomplished by reviewing all documents and data produced.

4.0 PROCEDURE

4.1 Introduction

It is important to adequately document sample locations in environmental investigations because additional sampling events become necessary. An identifiable record of the previous sampling locations prevents replicate sample locations and increases the efficiency of the investigation.

4.2 Sample Point Marking

All sample points should be located by the criteria presented in the Project Plan for the site. When a sample point is located, it will be permanently marked so it can be located by any investigator working on the project. The following practical methods can be used to permanently locate sample points:

- A wooden stake driven securely into the ground (when possible) and identified with a unique site identification code;

- A metal spike or concrete nail driven into asphalt or concrete and the site identification code recorded on an attached tag; and/or

- The location and identification code spray-painted on the ground or ground cover surface. The location of each sample point should be recorded on a site map and referenced, if possible, to a permanent landmark. By using a compass, a bearing from the landmark can be determined and the distance between the landmark and sample point can be measured by pacing or with a tape. Sample points will not be surveyed until they have been sampled, as field operating conditions can dictate the movement of any sample point and a slight change would invalidate a surveyed sample point's location. Massive metal objects may cause interference when a compass is used.

4.3 Photographic Documentation

Identification and documentation of the sample point by photography can also be a useful tool. A photograph of the sample point can be particularly useful when the sample point has been intentionally located near a particular feature, structure, or suspected contamination.

Initially, the camera and lenses that will be used for site pictures shall be recorded in the field log book. Identify the particular picture number and roll number (if more than one roll of film is used) in the field log book to identify which sampling site is recorded in the photograph. Other information which will be recorded in the log book and later transferred to the back of the appropriate photograph includes:

- Name of photographer and any individuals in photograph;
- An accurate description of what the photograph shows, including the name of the facility or site;
- The specific project name and project code;
- Location, weather conditions, date, and time the photograph was taken; and
- Orientation of the photographic view and distance to subject.

Unexposed film will be recorded in the log book as such. The location of film development and the date of processing will be recorded in the log book. The negatives will be supplied uncut, and two sets of prints will be supplied, one for permanent document control and one for investigative use. Each photograph is then identified and labeled on the back with the appropriate information with the use of a photo label Exhibit 5-1. The negatives and one set of prints will be stored in the project files.

4.4 Review

Personnel performing sample location documentation are to record the applicable information on all documents (e.g., field log books, photographs, etc.) as outlined in this procedure.

The Project Leader or an approved designee shall check field log books, daily logs, and photographs for complete and accurate documentation. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the applicable reviewed documents.

5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1986. "Engineering Support Branch. Standard Operating Procedures and Quality Assurance Manual." U.S. EPA Region IV. Environmental Services Division. Athens, Georgia. April 1986.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." EPA/540/P-87/001 (OSWER Directive 9355.0-14). December 1987.

6.0 EXHIBITS

Exhibit 5-1	Photograph Label

EXHIBIT 5-1
Photograph Label

PHOTO NO.: ______________________________
PROJECT NAME:___________________________
PROJECT NO.:____________________________
PHOTOGRAPHER:__________________________
LOCATION:______________________________
DATE/TIME/DIRECTION:____________________
ID OF PERSONS IN PHOTO:_________________
COMMENTS/DESCRIPTION:_________________
____
____
____
____

STANDARD OPERATING PROCEDURE - 6

USE AND MAINTENANCE OF FIELD LOG BOOKS

1.0 PURPOSE

The purpose of this procedure is to describe the methods for use and maintenance of field log books. This procedure outlines methods, lists examples for proper data entry into a field log book, and provides the standardized Colorado Department of Public Health and Environment (CDPHE) format.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the Project Leader and CDPHE Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

QC	Quality Control
DIMP	Data Information Management Plan
SOP	Standard Operating Procedures
CDPHE	Colorado Department of Public Health and Environment

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure when conducting work related to environmental projects. Daily logs will be kept during field activities by a Field Team Member to provide daily records of significant events, observations and measurements taken in the field.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the applicable tasks required by this procedure have been performed. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURE

4.1 Introduction

Field log books provide a means for recording observations and activities at a site. Field log books are intended to provide sufficient data and observation notes to enable participants to reconstruct events which occurred while performing field activities and to refresh the memory of field personnel while writing reports or giving testimony during legal proceedings. As such, all entries will be as factual, detailed and as descriptive as possible so that a particular situation can be reconstructed without reliance on the collector's memory. Field log books are not intended to be used as the sole source of project or sampling information. Sufficient log books will be assigned to a project to ensure that each field team has a logbook with it at all times. If a logbook is not available, field forms should be used until a field log book becomes available.

4.2 Field Log Book Identification

Field log books shall be bound books with consecutively numbered pages. Log books will be permanently assigned to field personnel for the duration of a project, but are to be stored in site project files when not in use. If site activities stop for an extended period of time (i.e., two weeks or more), field log books will be stored in the project files in the CDPHE office. Each log book will be identified by a Site Name either prior to or after the completion of sampling.

The cover of each log book will contain the following information:

- Person or organization to whom the book is assigned;
- Book number;
- Project number (if different than site number); and
- Site name.

4.3 Log Book Entry Procedure

Every field team will have a logbook and each field activity will be recorded in the logbook by a designated field team member to provide daily records of significant events, observations, and measurements during field operations. Beginning on the first blank page and extending through as many pages as necessary, the following list provides examples of useful and pertinent information which may be recorded (optional).

- Serial numbers and model numbers for equipment which will be used for the project duration;
- Formulas, constants, and example calculations;
- Useful phone numbers; and
- County, state, and site address.

Entries into the log book may contain a variety of information. At a minimum, log book entries must include the following information at the beginning of each day:

- Date, initials and signature at top of each page;
- Start time;
- Weather;
- Decontamination methods to be used;
- All field personnel present and directly involved;
- Level of personal protective equipment being used on the site;
- Signature of the person making the entry;
- Equipment used and procedures followed; and
- Any field calculations.

In addition, information recorded in the field log book during the day will include (but is not limited to) the following:

- Sample description including sample numbers, time, depth, volume, containers, preservative, and media sampled;

- Information on field QC samples (i.e., duplicates);

- Observations about site and samples (odors, appearance, etc.);

- Information about any activities, extraneous to sampling activities, that may affect the integrity of the samples;

- Any public involvement, visitors, or press interest;

- Equipment used on site including time and date of calibration;

- Background levels of each instrument and possible background interferences;

- Instrument readings for the borehole, cuttings, or samples in the breathing zone and from the specified depth of the borehole, etc.;

- Field parameters (pH, specific conductivity, etc.);

- Unusual observances, irregularities or problems noted on site or with instrumentation used;

- Maps or photographs acquired or taken at the sampling site, including photograph number and description (CDPHE Standard Operating Procedure (SOP) 4.5, Sample Location Documentation); and

- Forms numbers and any information contained therein used during sampling should be referenced.

All log book entries will be made in indelible black or blue ink. No erasures are permitted. If an incorrect entry is made, the data will be crossed out with a single strike mark and initialed and dated by the originator. Entries will be organized into easily understandable tables if possible.

All log book pages will be initialed and dated at the top of the page. Times will be recorded next to each entry.

No pages or spaces will be left blank. If the last entry for a day is not at the end of the page, a diagonal line will be drawn through the remaining space and the line will be initialed and dated. Logbooks can become contaminated when used in the field. Every effort should be made by the field team to avoid contaminating the logbook. Logbooks can be kept in ziplock plastic bags or temporary plastic covers can be used.

4.4 Review

The Project Leader or an approved designee will check field log books, daily logs, and Exhibits for completeness and accuracy on an appropriate site specific schedule determined by the project leader. Any discrepancies in these documents will be noted and returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the applicable reviewed documents.

5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." EPA/540/P-87/001 (OSWER Directive 9355.0-14). December 1987.

U.S. Environmental Protection Agency (EPA). 1986. "RCRA Groundwater Monitoring Technical Enforcement Guidance Document." September 1986.

CDPHE. 2000. "Standard Operating Procedure 5, Sample Location Documentation." Standard Operating Procedures.

STANDARD OPERATING PROCEDURES - 7

HAZARD CATEGORIZATION (HAZCAT)

1.0 PURPOSE

The purpose of this procedure is to identify the hazardous characteristics of an unknown chemical, mixture or waste. The Hazardous Categorization (HAZcat) kit to be used in this identification process contains supplies and instructions for the ten preliminary chemical categorization tests commonly performed on site. Preliminary categorization tests are to be performed for either liquid or solid matrix in the order they are listed below. For more specific chemical identification, please refer to the manuals provided in the HAZcat Kit.

1. Observation
2. Water Solubility
3. Oxidizer
4. Chlorinated Hydrocarbon/Beilstein Test
5. pH
6. Sulfide
7. Cyanide
8. Flammability
9. Polychlorinated Biphenyls (PCB) Screening
10. Peroxide

By thus classifying the hazardous material, any or all of the following tasks may be performed:

- Assignment of hazardous waste characteristics according to Resource Conservation and Recovery Act (RCRA) (40 CFR, Section 261.20) definitions of ignitability, corrosivity, and reactivity.

- Assignment of Department of Transportation (DOT) hazard class (49 CFR, Sections 171, 172) to permit placarding and manifesting of the material for transportation.

- Rapid assessment of the materials present at a site, and the evaluation of their potential hazards to the populace and environment. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) funds are not accessible for a removal action (40 CFR, Section 300.65) if the materials present are non -hazardous.

- Selection of immediate mitigative measures, such as the segregation of containers of incompatible materials, or the neutralization or containment of a leaking substance with the appropriate material (i.e., soda ash for an acid spill).

- Bulking material into consolidated waste streams for subsequent disposal or treatment, thus reducing disposal/transportation costs.

- Reducing analytical costs by allowing the selection of a limited number of composite samples from each waste stream, instead of submitting many discrete samples to the laboratory.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods described herein must be approved by the Project Leader (PL), CDPHE Quality Assurance Officer (QAO), and Analytical Services Coordinator.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 DEFINITIONS

Waste Stream: A set of materials that have like properties under RCRA definitions and are disposed of together.

Water-Reactive: A material reacts in a way that changes volume or temperature in water. Six reactions include reacts violently; hesitates, fumes, and reacts; boils; becomes hot; effervesces; or becomes cold.

Immiscible: Does not dissolve, rather separates into phases.

Effervescence: Small alka-seltzer size bubbles.

Turbidity: A solution is not transparent, cloudy or opaque.

Oxidizer: Initiates or promotes combustion in other materials. Oxidizers increase the flammability of materials and can cause fire when in contact with combustibles. Chlorine is a common oxidizing gas.

Head-space: The area inside a test tube above the unknown substance.

Support Medium: Cotton swabs or wire loop.

Flammable: A liquid with a flash point from 30° F to 200° F. For HAZcat, a liquid that flashes or continues to burn after the match has been removed.

Ignitable: A liquid having a flash point below 140° F (flammable liquid). This is the temperature that could occur from radiant heat inside a truck in the direct sun light.

2.2 ABBREVIATIONS

$AgNO_3$	Silver nitrate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOT	Department of Transportation
H_2S	Hydrogen sulfide gas
HAZcat	Hazardous Categorization

HCl	Hydrochloric acid
HCN	Hydrogen cyanide gas
HF	Hydrofluoric acid
KI	Potassium iodide
NaOH	Sodium hydroxide
NO_2	Nitric acid
PCB	Polychlorinated biphenyl
PID	Photo ionization detector
PL	Project Leader
PPE	Personal protective equipment
ppm	Parts per million
RCRA	Resource Conservation and Recovery Act
SO_2	Sulfur dioxide
START	Superfund Technical Assistance Response Team
SOP	Standard Operating Procedure
CDPHE QAO	CDPHE Quality Assurance Officer

3.0 RESPONSIBILITIES

Sampling personnel are responsible for performing and documenting the applicable tasks outlined in this procedure on a provided data sheet. The PL or an approved designee is responsible for checking all work performance and approving that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURES

The HAZcat procedure must be performed as outlined by this technical standard operating procedure (SOP) and/or the manual contained in the HAZcat Kit.

4.1 SAMPLE OBSERVATION

Note color, viscosity, turbidity, number and description of phases.

4.2 WATER SOLUBILITY TEST

Add a small quantity of the material to be tested (dime size or 3 drops) to test tube containing 3 mL of distilled water.

Note whether a temperature change occurs, effervescence or fumes/gases/vapors are produced indicating that the sample is **water reactive**.

Note whether the sample completely dissolves in the water, giving NO turbidity AND forming a one-phase solution indicating the sample is **water soluble**.

Note whether sample is **insoluble** or **immiscible**. Indicate sample's **specific gravity**; if it sinks, specific gravity is greater than one, if it floats specific gravity is less than one.

Exhibit 7-1, Water Solubility Test Chart, contains detailed descriptions and explanations for water solubility categorizations.

4.3 OXIDIZER TEST

Conduct on **ALL water soluble** samples.

Add one-half of a pea-sized amount of sample to a watch glass;

-OR-

Add sample liquid to watch dish to form a pool the size of a dime.

Acidify a Potassium Iodide (KI)/Oxidizer test strip with a few drops of 3M hydrochloric acid (HCl).

Touch the test strip to the sample on the watch glass/dish. If the test strip turns **blue** or **black**, the sample is an oxidizer.

Specific observations are contained in Exhibit 7-2, Oxidizer/Acid Test Chart.

4.4 CHLORINATED HYDROCARBONS/BEILSTEIN COPPER WIRE TEST

Conduct on all samples which are **insoluble or** have a **specific gravity greater** than **one**.

WARNING: Do **NOT** put hot copper wire into liquid, especially if the liquid is flammable - quick vaporization of chlorinated solvents may produce **anaesthetic gases**!

Heat copper wire in flame of propane torch until a yellow flame with NO green coloration appears.

Allow wire to air cool (about 15 seconds).

Dip cooled wire into sample and leave for at least 10 seconds.

Put wet wire into torch flame.

- Green flame indicates chlorinated solvents.
- Yellow flame with a green edge indicates an amine. (Must be water-soluble or oily with a high pH test.)
- A green flame may indicate nitrates if the sample is a water-soluble solid with neutral pH and was partially sublimed or auto-ignited during Char Test.

4.5 pH TEST

Use the sample in the test tube from the previous water solubility test.

For a solid sample matrix, probe or strip should be dipped into a solution of sample or into an aqueous extract if partially soluble.

Dip the test strip into the sample solution contained in test tube or watch glass; compare the color with reference colors on the pack. Note color and pH; indicate whether it is base or acid.

- pH is GREATER than 7 indicates basic.
- pH is LESS than 7 indicates acidic.
- pH EQUAL to or LESS than 2 indicates CORROSIVE acid.
- pH EQUAL to or GREATER than 12.5 indicates CORROSIVE base.

4.6 SULFIDE TEST

Perform this test if sample **pH is 7 or GREATER**. Sulfides are not stable in acid solutions. Detection limit of approximately 50 parts per million (ppm) can be obtained.

Add the sample to a watch glass to form a dime-sized pool.

Acidify test strip with about 2 to 3 drops of 3 Molar (3M) (concentrated) Hydrochloric acid (HCl).

Touch moistened lead acetate paper to acidified sample.

If the test strip darkens (brown or black), sulfides are present.

4.7 CYANIDE TEST

Perform this test if sample **pH is GREATER than 7.** Cyanides are not stable in acid solutions. Detection limit of approximately 50 ppm can be obtained. Put 5 mL (about one-half inch) of distilled water in test tube. Dissolve 5 mL of sample in test tube.

Test pH, if not already 11 or GREATER add 2 or 3 drops of 50% sodium hydroxide (NaOH) to adjust the pH to 11.

Add 3 drops of rhodanine solution to test tube and swirl.

Add 1 drop of 0.02M Silver Nitrate ($AgNO_3$) to test tube.

If there is NO color change, cyanide is present.
If there IS color change or precipitate, cyanide is NOT present.

RESPIRATOR MUST BE WORN DURING CYANIDE TEST!

Small amounts of cyanide gas can smell of chlorine.
Large amounts of cyanide gas can smell of almonds.
For an alternate cyanide test method, refer to Exhibit 7-3, HAZcat Chemical Identification System.

4.8 FLAMMABILITY TEST

Use the photo ionization detector (PID) to take a head-space reading from the sample jar. A small amount of sample is applied to a cotton swab (support medium) and exposed to a flame (the BIC/lighter test).

If the sample ignites readily and vigorously on exposure to flame source, and gives a PID reading (10.2eV probe/9.8 span) of **GREATER than 200** units, the flash point is approximately 100° F or LESS and the sample is **FLAMMABLE.**

If the sample ignites and sustains flame on exposure to flame, and gives a PID reading (10.2eV/9.8 span) of **LESS than 200** units, flash point is approximately 200° F or LESS, and the sample is **COMBUSTIBLE.**

If the sample does **NOT ignite OR burn** after sustained exposure to a flame source, the sample is **NON-FLAMMABLE.**

4.9 PCB SCREENING TEST

Commercial test kits are available in the HAZcat Kit.

4.10 PEROXIDE TEST

Wet a Peroxide Test Strip with one drop of distilled water.
Directly touch the wetted peroxide test strip to the sample.
Note color change.

BLUE:	Peroxide or weak chromic acid.
GREEN:	Very strong peroxide, or strip was not wetted, organic peroxides will turn strip green.
BROWN:	Strong chromic acid or very strong peroxide.
YELLOW:	Nitric acid.
ORANGE:	Hypochlorite.
PURPLE:	Silver nitrate.

If Peroxide test strips are unavailable, refer to Exhibit 7-3, HAZcat Chemical Identification System, for an alternate method.

5.0 THE HAZCAT KIT

The HAZcat kit contains the following items:

5.1 REAGENTS AND TEST STRIPS

- ph Test - pH paper
  deionized water
- Oxidizer Test - Potassium Iodide test Strips
  3M Hydrochloric Acid
- Sulfide Test - Lead Acetate/Starch test Strips
- Cyanide Test- 50% sodium hydroxide solution
  Rhodanine solution (20 mg of para-aminobenzalrhodanine in 100 mL of acetone)
  0.02M silver nitrate solution.
- Chlorinated Hydrocarbon Test- Copper wire
  Propane torch
- Peroxide Test - peroxide test strips
- Flammability - PID (photo ionization detector)
  Propane torch
  Support media, such as cotton swabs
- PCB Screening- commercial PCB testing kit.

5.2 EQUIPMENT

- Test tubes
- Test tube rack
- Test tube holder
- Disposable pipets
- Wash bottle of deionized water (250 mL at least)
- Copper wire
- Propane torch
- Strike or matches for ignition
- Garbage bags
- Hand wipes
- Cotton swabs
- Duct tape
- Photo Ionization Detector
- Detector tubes and pump
- Container inventory sheets
- HAZcat data/result sheets

5.3 REAGENTS AND TEST STRIPS

- Rhodanine solution (in acetone) (30 mL)
- 3M hydrochloric Acid (30 mL)
- 50% sodium hydroxide solution (30 mL)
- 0.02M Silver Nitrate solution (30 mL)
- Potassium iodide test strips (2 packs)
- Lead acetate/starch test strips (2 packs)
- pH test strips (2 packs or pH meter)
- Deionized water (250 mL)

6.0 PERSONAL PROTECTIVE EQUIPMENT FOR HAZCAT

6.1 SPECIFIC EQUIPMENT

Personal protective equipment (PPE) that may be required in the identification of hazardous characteristics of an unknown chemical mixture or waste includes:

- Saranex suit or Sijal suit
- Canister respirator with GMC-H organic vapor/acid gas cartridges
- Neoprene boots
- Latex inner & neoprene outer gloves
- Eye protection; goggles or safety glasses
- Hard hat with face shield (optional)
- Acid splash apron (optional)

6.2 GENERAL

If the HAZcat procedure is performed carefully, with attention to detail, little or no contamination of the gloves or other protective clothing should occur.

- **A respirator should be worn when performing HAZcat tests, specifically when conducting cyanide, pesticide, or sulfuric acid tests.**

- The Sijal suit offers the most complete protection against acids, bases, and organics. Saranex is an alternative, offering good protection against acids, bases, some organics and PCB's. However, Saranex offers poor protection against halogenated and aromatic hydrocarbons and has stitched seams which may constitute a penetration pathway.

- Canister respirators are listed in preference to cartridge respirators since the canister is belt-mounted outside the breathing zone and is away from the area of maximum contaminant during sample handling.

- If the samples are known to be principally halogenated and aromatic hydrocarbons, then viton gloves would provide better protection than neoprene. In general, neoprene gloves offer the best compromise when many classes of chemicals are to be handled, although their susceptibility to attack by halogenated hydrocarbons should be noted.

7.0 DATA MANAGEMENT

Field data such as, container markings, size, and HAZcat test results are recorded directly on the data sheets provided in Exhibit 7-4, Hazardous Categorization Data Sheet.

8.0 COMPATIBILITY STUDIES

For a removal action, it is usually desirable to consolidate compatible wastes from different containers in order to generate waste streams for disposal or treatment. Thus, it would be desirable to consolidate all cyanide wastes for one stream. For example, all non-oxidizing acids (liquids) would be put into another container. The qualitative nature of HAZcatting does not completely categorize a given sample since there may be incompatibilities between samples of the same hazard class. Therefore, a bench-top compatibility study MUST first be conducted using small quantities of each sample from a given class, so that any incompatibilities are detected before the materials are mixed bulk.

Composite samples for each hazard class are prepared by taking small quantities (5 to 10 mL) of each sample of that class, and mixing them in an 8 oz. sample jar. The aliquot drawn from each sample should be proportional to the bulk amount of that material present on site. Therefore, the following composite might be prepared from ten containers, each of which was determined to contain liquid cyanide wastes.

Sample #	Container Size (gallon)	% FULL	Aliquot Taken (mL)
1	55	100	5
2	55	50	2.5
3	10	100	1
4	100	100	10
5	25	100	2.5

The composite sample generated approximately reflects the composition of the waste stream obtained when the bulk containers are mixed.

On addition of each constituent to the composite sample, the following observations must be made:

- Is an effervescence observed?
- Is any gas/vapor evolved?
- Is any heat generated?
- Is any solid precipitated?

A positive observation of effervescence, gas/vapor, or heat generation indicates **INCOMPATIBILITY** between the samples; they are probably NOT suitable for bulking into one consolidated waste stream. Perhaps only one sample gives such reactions. In this case, that sample would be disposed of as a separate waste stream (an example is cyanide (reactive)).

During the compositing process, the sample jar should **AT ALL TIMES BE POINTED AWAY** from the person compositing, since adverse reactions can occur, and the solution can erupt out of the jar. Care is essential in this process, as in the HAZcatting procedure itself. During such tests the test tube mouth is always pointed away from the person conducting the tests.

In the open-air environment HAZcatting processes are not dangerous, provided that the specified PPE is used and appropriate safety practices are observed. Remember that the potential for injury always exists.

9.0 ADDITIONAL TESTS

9.1 DETECTOR TUBES

Personal hand pumps along with detector tubes can provide confirmation for ambiguous tests and questionable results. The rhodanine/silver nitrate test for cyanide often proves false negatives. Validation of results can be done by acidifying a small portion (0.5 mL or less) of the sample to a pH of LESS than 5 with a few drops of 3M HCl. Hydrogen cyanide gas (HCN) is liberated and detected with the hydrogen cyanide gas detector tube and pump. ONLY a small quantity of sample can be acidified because HCN is extremely toxic.

Similarly, acidification of a small aliquot of a sulfide-containing sample generates hydrogen sulfide gas (H_2S) which can be detected with a hydrogen sulfide detector tube and pump. It is important that very small quantities (0.5 mL) be acidified for health and safety reasons.

When a site is better categorized and the contaminants present or suspected are known, specific detector tubes can be used to screen for certain hazardous classes. Examples are:

- Flammable liquids: Could be screened for acetone, alcohol, methyl ethyl ketone (MEK) or ethyl acetate.
- Acid Oxidizers: Sulfur dioxide (SO_2) or nitric acid (NO_2).
- Acid Liquids: Hydrofluoric acid (HF) or hydrochloric acid (HCl).

9.2 OTHER TEST STRIPS

Test strips are commercially available to test for metals (nickel, zinc, and chromium) as well as anions (sulfate, chromate, and nitrate) in aqueous solutions. However, these are limited in use due to interferences which may occur when many species are present in the same solution.

9.3 PCB TEST KITS

A variety of PCB kits are available commercially. The CHLOR-N-OIL kit permits the concentration of PCBs in transformer oils to be qualitatively measured. The McGraw Edison kit uses a chloride ion electrode to determine the sodium chloride generated and is therefore a bit more quantitative. Both are easy to use in the field.

9.4 PESTICIDE SCREENING TESTS

A qualitative field test is available for organophosphorus pesticides. Chlorinated pesticides give a positive wire test. ALWAYS wear respirator when performing pesticide tests.

9.5 PHYSICAL APPEARANCE

An unknown material must NEVER be identified solely by supposition based on color or physical appearance. These characteristics provide valuable corroborating evidence, but can be misleading. Similarly, one should never ASSUME that the label on a container is correct.

10.0 AMBIGUOUS RESULTS AND OTHER PROBLEMS

A water soluble sample **CANNOT** be a chlorinated hydrocarbon. If such a sample gives a positive copper wire test, it is a solution containing chloride ions. Hydrochloric acid for example, gives a positive copper wire test but is clearly NOT a chlorinated hydrocarbon.

As commented previously, the cyanide test (in some cases the sulfide and oxidizer test) may give ambiguous results with certain dirty or opaque solutions. In such cases, the test may be repeated with diluted samples (using deionized water for dilution) or in the case of sulfide and cyanide tests, confirmation may be obtained by acidification and use of detector tubes.

Highly colored pure solutions (such as potassium permanganate, which is deep red-purple in color) may also cause difficulty because their color masks that of the pH paper or the oxidizer test strip. Here again the sample can be diluted with deionized water without significantly affecting the pH. Potassium permanganate would be categorized as an oxidizer, and can be acidic or basic depending upon the application in which it was formulated.

Since the pH of a solution is a measure of the hydrogen ion concentration in aqueous solution, organic liquids cannot be tested with pH paper. An aqueous extract must be prepared by mixing the sample with an equal volume of deionized water. The extract is then tested with pH paper. This is an optional test, because of the glassware needed to perform the test.

Some samples may have more than one phase; both an aqueous phase and an organic phase for example.. In this situation, both phases should be HAZcatted separately. Validity of HAZcat tests is dependent upon the skill of the sampler. Without a representative sample, the person HAZcatting cannot properly characterize the material in the container.

11.0 SELECTIVE APPLICATION OF HAZCAT TESTS

In general, most of the preliminary HAZcatting tests do **NOT** need to be conducted on a given sample.

If a liquid is insoluble in water and forms a layer floating on the water surface (it has a specific gravity of less than 1), then it is an organic material and does **NOT** need to be tested for cyanide and sulfide. In addition, since its specific gravity is **LESS than 1** it cannot be chlorinated hydrocarbon; all of which have a specific gravity **GREATER than 1**. Since it could be an organic acid, the pH must be measured by preparing an aqueous extract with deionized water, as the pH of an acid cannot be determined without adding a small quantity of water.

If an insoluble liquid sample has a specific gravity **GREATER than 1**, it is most likely a chlorinated hydrocarbon. In this case, proceed directly to the copper wire test or PCB test kit, if applicable.

If the pH of a sample is **LESS than 7**, the sample cannot contain sulfide or cyanide (neither is stable in an acid solution). Hence neither the sulfide test nor the cyanide test needs to be performed.

If a sample gives a positive oxidizer test, it cannot be sulfide or cyanide (the sulfide would have been oxidized to sulfate and the cyanide to cyanate.

12.0 REFERENCES

Turkington, R. 1995. HAZcat Abridged Manual for Field Use. San Francisco.

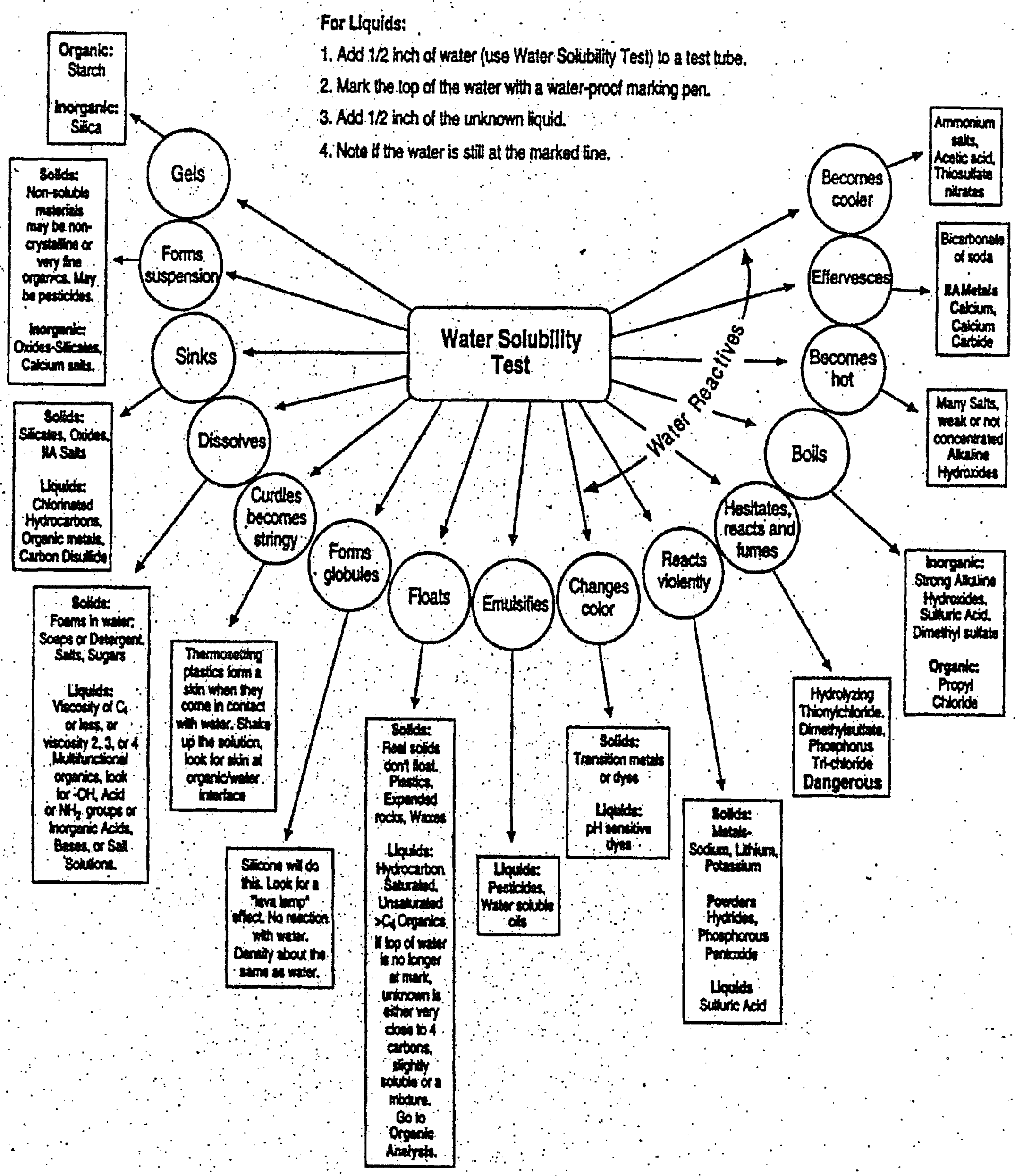
Turkington, R. 1995. HAZcat Chemical identification User's Manual. San Francisco: 1994.

Ecology and Environment. 1988. "Field Chemistry for First Responders."

13.0 EXHIBITS

Exhibit 7-1	Water Solubility Test Chart
Exhibit 7-2	Oxidizer/Acid Test Chart
Exhibit 7-3	HAZcat Chemical Identification System
Exhibit 7-4	Hazardous Categorization Data Sheet

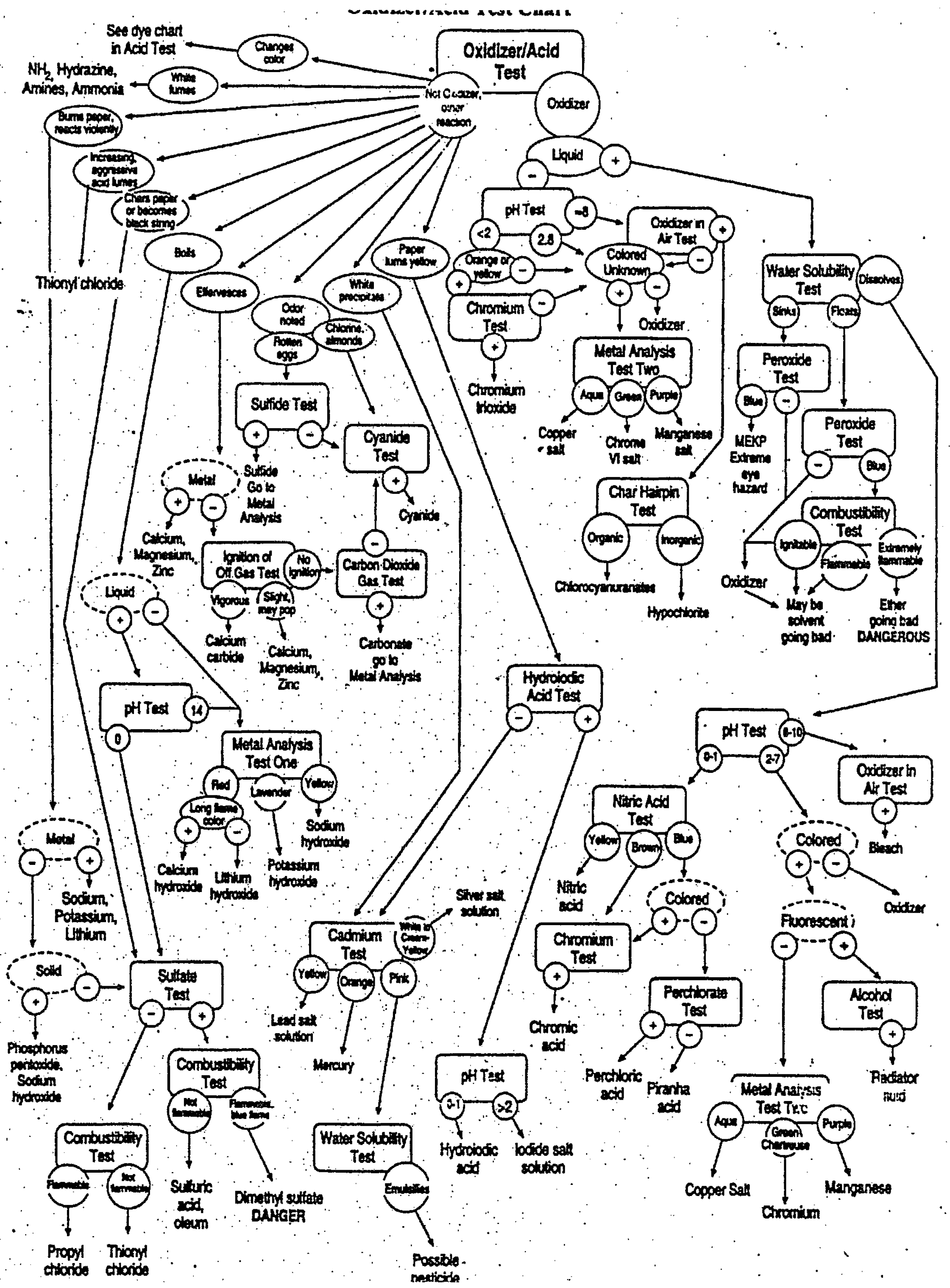
Exhibit 7-1
Water Solubility Test Chart



For Liquids:

1. Add 1/2 inch of water (use Water Solubility Test) to a test tube.
2. Mark the top of the water with a water-proof marking pen.
3. Add 1/2 inch of the unknown liquid.
4. Note if the water is still at the marked line.

Exhibit 7-2
Oxidizer/Acid Test Chart



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SDWA	Safe Drinking Water Act
TCLP	Toxicity Characteristic Leaching Procedure
TDU	Treatment/Disposal Unit
TSCA	Toxic Substances Control Act
SOP	Standard Operating Procedure

3.0 IDENTIFICATION AND CHARACTERIZATION OF INVESTIGATION DERIVED WASTES

To properly deal with IDW, the Project Leader (PL) must identify whether IDW contains Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances, and if so, whether these CERCLA hazardous substances are RCRA hazardous wastes. The PL will estimate the type, quantity and characteristics of any IDW that will be generated during the activity. Additionally, the PL will determine if CDPHE will manage and dispose of the IDW or if a subcontractor will be in charge of the disposal of the IDW (i.e., a hazardous waste broker or a driller disposing of soil cuttings and well development waters after a well has been installed). If a subcontractor is chosen to dispose of IDW, the contractual agreement should clearly indicate all tasks of the work assignment.

3.1 Types of IDW

Typical types of IDW include, but are not limited to, the following:

- Soil cuttings, drill mud and well development waters from soil borings and the installation of monitoring wells;
- Purge water removed from wells before groundwater samples are collected;
- Water, solvents, or other fluids used to decontaminate field equipment and personal protective equipment (PPE); and
- PPE and disposable equipment.

3.2 CERCLA Hazardous Substances and RCRA Hazardous Wastes

The PL must make a professional judgement based on all available information when making a decision whether the IDW contains a CERCLA hazardous substance, and if it does, whether that substance is a RCRA hazardous waste. The PL may consider the IDW hazardous even if there is a limited amount of information available. This is particularly important because the presence of RCRA hazardous IDW invokes special technical considerations and management decisions based on RCRA regulations (i.e., land disposal restrictions (LDR) and discharge to publicly owned treatment works (POTWs)).

CERCLA hazardous substances include, in addition to all RCRA hazardous wastes, elements, compounds, solutions, or mixtures designated as hazardous or toxic under CERCLA or under the authority of other laws such as Toxic Substances Control Act (TSCA), the Clean Water Act (CWA),

STANDARD OPERATING PROCEDURE - 8

INVESTIGATION DERIVED WASTE MANAGEMENT

1.0 PURPOSE

This procedure outlines the management of Investigation Derived Wastes (IDW) generated during environmental field operations. The National Contingency Plan (NCP) requires that management of IDW generated during environmental investigations complies with all applicable or relevant and appropriate requirements (ARARs) to the extent practicable. In addition, other legal and practical considerations may affect the management of IDW.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Container: A portable device in which a material is stored, transported, treated, disposed of or otherwise handled.

Unit: A continuous area of land on or in which hazardous waste (i.e., containers) is placed.

AOC: A single Resource Conservation and Recovery Act (RCRA) land-based unit that can include a non-discrete land area on or in which there is generally dispersed contamination.

2.2 Abbreviations

AOC	Area of Contamination
ARARs	Applicable or Relevant and Appropriate Requirements
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
ERB-OSC	Emergency Response Branch On-Scene Coordinator (EPA employee)
FR	Federal Register
IDW	Investigation Derived Wastes
LDR	Land Disposal Restrictions
NCP	National Contingency Plan
NPDES	National Pollution Discharge Elimination System
PL	Project Leader
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
SAP	Site Assessment Manager (EPA employee)

Exhibit 7-4
Hazardous Categorization Data Sheet

Project Name: ________________________ **Date:** ____________
Project Number: ________________________ **Sample ID No.:** ____________
Notes: ____

OBSERVATIONS:

Container Type:	Vat	Drum	Container	
Material:	Steel	Glass	Poly	Fiber
Top:	Open	Bung		
Size:	______ gallons			
Amount:	Empty	Half Full (____%)		
Sample Matrix:	Solid	Sludge	Liquid	Gas
Viscosity:	Water Like	Coats Surface	Thick Syrup	
Color:	____________________			
# of Phases:	______ Liquid	______ Solid		
Odor:	____________________			

WATER SOLUBILITY TEST: (Add sample to H_2O)

Temperature change:	Yes	No
Effervescence or gases:	Yes	No
Dissolves (soluble)	Won't dissolve (insoluble)	2 or more phases (immiscible)

Specific gravity: sinks (S.G > 1) floats (S.G. < 1)

Oxidizer Test: (Perform on H_2O solubles only)

Color change (oxidizer)	No color change (not oxidizer)

Chlorinated Hydrocarbons:
(Perform only on insolubles or S.G. > 1)

Flame color:	green (chlorinated solvent)	yellow (amines)	clear (none)

TEST:

pH: ___ (Circle Range)

pH > 7	Base
pH > 12.5	Corrosive Base
pH < 7	Acid
pH < 2	Corrosive Acid

Sulfide Test: (Perform if pH > 7)

Test Strip: Darkens (sulfides)	Not Darken (no sulfides)

Cyanide Test: (Perform if pH > 7)

Test Strip: Color change or Precipitate (no cyanide)	No color Change (cyanide)

Flammability Test/BIC Test

PID Reading: ____________

Circle one

Flammable: Sample ignites rapidly and gives PID > 200

Combustible: Sample ignites and sustains flame, PID < 200

Non-flammable: Sample does <u>not</u> ignite or burn

Notes: ____________________
____
____

Peroxide Test: (circle one)

Blue: Peroxide or weak chromic acid
Green: Very strong peroxide
Brown: Strong chromic acid/peroxide
Yellow: Nitric acid
Orange: Hypochlorite
Purple: Silver nitrate

the Clean Air Act (CAA), and the Safe Drinking Water Act (SDWA). A list of these hazardous substances can be located in 40 CFR Part 302.4, Table 302.4. If the IDW contain CERCLA hazardous substances, the determination must be made if these hazardous substances constitute the criteria of a RCRA hazardous waste.

IDW is a RCRA hazardous waste if the IDW contains a listed hazardous waste as defined in Section 3.2.2, RCRA Listed Hazardous Wastes, or if the IDW exhibits any of the hazardous waste characteristics as described in Section 3.2.1, RCRA Characteristic Wastes. Additionally, the contaminants present in the IDW must not be excluded from regulations as a hazardous waste (40 CFR 261.4).

3.2.1 RCRA Characteristic Wastes

IDW is a RCRA characteristic hazardous waste if it exhibits the characteristics of ignitability, corrosivity, reactivity (40 CFR Part 261, Subpart C), or toxicity (toxicity characteristic leaching procedure (TCLP) (55 FR 11796-11877, March 29, 1990)).

IDW exhibits ignitability if:

- It is a liquid, other than an aqueous solution containing less than 24% alcohol by volume, and has a flash point lower than 60°C (140°F);
- It is not a liquid and is capable, under standard temperature and pressure, of causing fire and, when ignited, creating a hazard;
- It is an ignitable compressed gas as defined in 49 CFR 173.300; or
- It is an oxidizer as defined in 49 CFR 173.151.

IDW exhibits corrosivity if:

- It is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5; or
- It is a liquid and corrodes steel at a rate greater than 6.35 mm (0.35 inches) per year at a test temperature of 55°C (133°F).

IDW exhibits reactivity if:

- It is normally unstable and readily undergoes violent change without detonating;
- It reacts violently with water;
- It forms potentially explosive mixtures with water;

- When mixed with water, it generates toxic gases, vapors or fumes that pose danger to human health or the environment;
- It is a cyanide- or sulfide-bearing waste capable (at the pH range of 2 to 12.5) of generating toxic gases that can present a danger to human health or the environment;
- It is capable of detonation or explosive decomposition; or
- It is a forbidden explosive as defined in 49 CFR 173.51.

IDW exhibits TCLP-toxicity when its leachate contains certain contaminants at levels exceeding their regulatory thresholds. The TCLP-toxicity test is designed to determine the mobility of both organic and inorganic contaminants present in liquid, solid and multiphasic wastes.

3.2.2 RCRA Listed Hazardous Wastes

Any type of IDW that contains a listed hazardous waste should be considered a RCRA hazardous waste. A list of RCRA hazardous wastes according to their sources of origin and toxicity is found in 40 CFR Part 261, Subpart D.

- Wastes from nonspecific sources (F-wastes);
- Wastes from specific sources (K-wastes);
- Discarded commercial chemical products, manufacturing intermediates, off-specification (off-spec) chemicals(if they met specification, they would be listed), and container and spill residues that are "acutely hazardous" (P-wastes); and
- Discarded commercial chemical products, manufacturing chemical intermediates, or off-spec commercial chemical products that are "toxic" (U-wastes).

3.3 Waste Characterization

Whenever possible, the nature of the wastes should be assessed by applying the best professional judgement, and using readily available information about the site (observation of contamination, waste manifests, storage records, PAs, SIs, or any other sampling data). The EPA has directed that IDW may not be a "listed" waste under RCRA unless available information about the site suggests otherwise (53 FR 51444, December 21, 1988). RCRA procedures for determining whether a waste exhibits RCRA hazardous characteristics do not require testing if the decision can be made by "applying knowledge of the hazard characteristics in light of the material process used" (40 CFR 262.11(c)).

The fact that extensive resources need not be used in characterizing IDW does not mean that IDW can be assumed to be non-hazardous unless clearly proven otherwise. The PL must make the best informed decision with limited information on whether the wastes are hazardous or not.

When readily available information can not be used, one or more samples will be collected and submitted to a laboratory for characterization. Specific analyses for the characterization of the IDW will be determined by a hazardous waste broker, a subcontractor, or the PL, ASM, and EPA-OSC. Upon receipt of the characterization sample(s), the PL will define disposal options as per the analyses of the waste characterization samples.

4.0 IDW Management Options

TABLE 1
IDW Management Options

Type of IDW	Generation Process	Management Options	
		Non-hazardous	CERCLA or RCRA Hazardous
Soil	Well/test pit installation Borehole drilling Soil sampling	Return to boring, pit or source after generation. Spread around or consolidate in boring, pit or source in the AOC.	Store in a container within the AOC. Send to on-site TDU. Send to off-site TDU.
Sludges/Sediments	Sludge pit/sediment sampling	Return to boring, pit or source after generation. Spread around or consolidate in boring, pit or source in the AOC.	Store in a container within the AOC. Send to on-site TDU. Send to off-site TDU. Store for future treatment and/or disposal.
Aqueous sampling (groundwater, surface water, drilling fluids, other wastewater)	Well installation/development Well purging during sampling Groundwater discharge pump test Surface water sampling	Discharge to surface water. Pour on ground near sampling point. Send to POTW.	Store in a container within the AOC. Send to on-site TDU. Send to off-site TDU. Send to POTW(1). Store for future treatment and/or disposal.
Decontamination Fluids	Decontamination of PPE and equipment	Evaporate (small amounts of low organic fluids). Pour on ground near AOC. Send to POTW.	Store in a container within the AOC. Send to on-site TDU. Send to off-site TDU. Send to POTW(1). Store for future treatment and/or disposal.
Disposable PPE	Sampling procedures or other on-site activities	Place in dumpster at site or at CDPHE.	Store in a container within the AOC. Send to on-site TDU. Send to off-site TDU.

AOC = Area of Contamination
TDU = Treatment/Disposal Unit
POTW(1) = Publicly Owned Treatment Works (see Section 5.3)
PPE = Personal Protective Equipment

4.1 OFF-SITE DISPOSAL OF IDW

IDW should be disposed off-site in the following situations

- They are RCRA hazardous water;
- They are RCRA hazardous soil that may pose a substantial risk if left at the site;
- They are RCRA hazardous PPE and disposable equipment; and/or
- If leaving them on-site would create increased risks at the site.

IDW designated for off-site disposal must be properly containerized, tested, and stored before transport and disposal.

5.0 GUIDELINES FOR MANAGEMENT OPTIONS

When managing IDW, the PL is required to choose an option that is protective of human health and the environment and complies with (or waives) ARARS.

5.1 Protectiveness

In determining if a particular management/disposal option is protective, the PL should consider the following:

- The contaminants, their concentrations, and the total volume of the IDW;
- Media potentially affected (i.e., soil or groundwater) under management options;
- Location of the nearest populations and the likelihood and/or degree of site access;
- Compliance with ARARs to the extent practicable on site;
- Potential exposure to workers if IDW is managed on site; and
- Potential for environmental impacts.

5.2 Compliance With ARARs

This SOP is not designed to guide the PL through the entire disposal process of IDW. Please refer to all applicable ARARs when designing the disposal plan for the IDW.

5.3 Compliance With POTWs

Discharge of any and all (i.e. purge water, decontamination water etc.) derived water to a POTW must comply with both substantive and administrative CWA requirements. These requirements include, but are not limited to water quality criteria, pre-treatment standards, state water quality standards, and National Pollution Discharge Elimination System (NPDES) permit conditions.

6.0 Disposal of IDW

Disposal of IDW will be conducted under direction of the CDPHE PL. When applicable, CERCLA or RCRA hazardous waste disposal options will be conducted in the following order.

6.1 Subcontractor Disposal

When IDW is generated by the activities of a subcontractor (i.e., driller), it should be noted prior to contractual arrangements that the subcontractor will contain, stage, characterize and dispose of all IDW generated for the activity. This needs to be identified in the RFP before the contract goes out to bid.

6.2 Hazardous Waste Broker Disposal

When a subcontractor is not responsible for the generation of the IDW, a hazardous waste broker may be used. Hazardous waste brokers generally collect characterization samples, submit for analyses and delegate the appropriate form of disposal for the IDW as per the characterization results. Details for this process should be clarified prior to the generation of the IDW, as time limits apply for the storage of IDW when it is found to be a RCRA or CERCLA hazardous waste. A general guideline is to allow a maximum of 90 days from the date of IDW collection to the date for disposal or transport off-site. Hazardous waste brokers potentially supply drums and containers for waste storage and sample collection, however, a secured location on-site needs to be procured, as the transportation of RCRA or CERCLA hazardous wastes is regulated by the state and federal Departments of Transportation.

6.3 CDPHE Disposal

When appropriate, CDPHE will be in charge of all sample collection for characterization, laboratory procurement for analyses, analytical interpretation, and disposal options as per ARARs.

7.0 REFERENCES

U.S. Environmental Protection Agency (EPA). June 1989. "Determining When LDRs are Applicable to CERCLA Response Actions. OSWER Directive 9347.3-05FS

U.S. Environmental Protection Agency (EPA). December 1989. "Determining When LDRs Are Relevant and Appropriate to CERCLA Response Actions. OSWER Directive 9347.3-08FS.

U.S. Environmental Protection Agency (EPA) 1991. "Management of Investigation Derived Wastes During Site Inspections." EPA/540/G-91/009, U.S. Environmental Protection Agency. Washington, D.C. May 1991.

U.S. Environmental Protection Agency (EPA). 1992. "Guide to Management of Investigation Derived Wastes." OSWER Directive 9345.3-03FS, April 1992. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response.

STANDARD OPERATING PROCEDURE - 9

MONITOR WELL INSTALLATION

1.0 PURPOSE

The purpose of this procedure is to describe the methods for groundwater monitor well installation. It describes designs, procedures, and materials that will be used to construct a monitor well that will produce accurate groundwater level measurements and representative groundwater samples.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the Colorado Department of Public Health and Environment (CDPHE) Project Leader and the Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Annulus/Annuler Space: The space between the borehole wall and well casing, or the space between a casing pipe and liner pipe.

Bridging: The development of gaps or obstructions in either grout or filter pack materials during emplacement or development.

Conductor Casing: Outer casing used to stabilize or seal off a formation to prevent formation collapse or vertical cross-contamination within the well.

Filter Pack: Sand, gravel, or glass beads that are uniform, clean, and well rounded that are placed in the annulus of the well between the borehole wall and the well intake to prevent formation material from entering through the well intake, and to stabilize the formation.

Grout: A fluid mixture of neat cement and water possibly with various additives or bentonite of a consistency that can be forced through a pipe and emplaced in the annular space between the borehole and casing to form a seal.

Pressure Grouting/Sealing: A process by which a grout is confined within the borehole or casing by the use of plugs or packers and by which sufficient pressure is applied to force the grout slurry into and within the annuler space or zone to be grouted.

Schedule Pipe: The standardization of casing diameters and wall thicknesses where casing wall thickness increases as the schedule number increases.

Screen/Well Intake: A screening device used to keep materials other than formation fluids from entering the well.

Slot Size: The width of the slots machined into a slotted well casing (screen) that allows formation fluids into the well.

2.2 Abbreviations

ANSI	American National Standards Institute
EPA	U.S. Environmental Protection Agency
ID	Inside diameter
PVC	Polyvinyl chloride
SOP	Standard Operating Procedures

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the standards required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and inspecting the actual work. All activities and data collected shall be recorded in the field log book.

4.0 PROCEDURE

4.1 Introduction

Specific Project Plans may have well specifications that differ from the design specifications presented in this procedure. In addition, licensing and/or certification of the driller may be required. Well construction procedures will fulfill all regulatory agency requirements.

The diameter of the exploratory boring is generally a minimum of six inches greater than the outside diameter of the well casing. This is to ensure adequate filter pack settling so that the potential for bridging during well construction is minimized.

Contamination of the water bearing zone by drilling equipment or cross-contamination of wells during the drilling process must be avoided. Vertical seepage of surface water into the monitoring well must also be minimized.

In order to maintain quality control and obtain accurate formation information, a field geologist will be on the site during well installation to log subsurface conditions and construction details for each well.

4.2 Precautions

Use the following precautions during well installation operations:

- All activities will be conducted in conformance with the Site Health and Safety Plan;
- Every attempt should be made to minimize the transfer of potentially contaminated material to downhole equipment and monitoring well materials, or to any equipment and supplies stored on the site; and
- Every attempt should be made to contain contaminated soil and water and prevent further contamination of the environment.

4.2.1 Cutting Containment

Potentially contaminated formation materials brought to the surface during drilling activities will be placed on heavy plastic (12 mm minimum thickness) or plywood, or directly into drums to prevent contamination of the surface area surrounding the borehole. Plastic should be thick enough to prevent puncturing by formation materials, ground surface or removal activities. Materials placed on plastic or plywood for an extended period of time should be covered to provide protection from the elements until they can be disposed of properly.

4.3 Decontamination

All equipment that might potentially spread contamination or that is used directly in the monitoring well installation (i.e., well casing, screen, tremie pipe, centralizers, augers, etc.) must be thoroughly decontaminated prior to use or installation in the well. Decontamination equipment such as steam cleaners and high pressure, hot water cleaners effectively remove potential contaminants left on casings and screens during the manufacturing process. When using polyvinyl chloride (PVC) screen or casing, acid rinse solutions should not be employed for decontamination. All other decontamination procedures will conform with specific protocols outlined in the Field Sampling Plan and CDPHE SOP 4.11, Equipment Decontamination.

Decontaminated materials that are not used immediately after decontamination should be stored under protective cover (e.g., aluminum foil or plastic sheeting) until used.

4.4 Well Installation and Materials

Materials used in the construction of monitor wells will be chemically nonreactive to the contaminants suspected to be in the groundwater. The most commonly used well construction materials are PVC and stainless steel. PVC is the most economical and the easiest material to use. PVC will not decompose when it comes into contact with groundwater containing low concentrations of organic materials. However, over time, high organic contaminant concentrations will react with PVC and cause casing decomposition. Stainless steel provides greater structural strength and its use may prove advantageous for large diameter wells.

Well casing and screen are available in threaded and unthreaded sections, typically in lengths of 5, 10, and 20 feet. Threaded pipe joints will be wrapped with Teflon® tape to facilitate joining and to improve the seal of stainless steel products. Sections of casing and screens will be assembled on the site to allow inspection immediately before installation. PVC connections must be flush threaded or connected by another mechanical method as PVC joint sealant will introduce organic contaminants into the well.

Monitoring well construction commonly requires the use of American National Standards Institute (ANSI) Schedule 40 or Schedule 80 pipe to complete monitoring wells. Schedule 40 pipe is a standard size pipe with a wall thickness of 0.154 inches and an approximate inside diameter (ID) of 2.067 inches. Schedule 80 pipe has a wall thickness of 0.218 inches and an approximate ID of 1.939 inches. Schedule 40 pipe is suitable for most shallow monitoring well applications (total depth less than 100 feet). Schedule 80 pipe is more suitable for wells with depths in excess of 100 feet or in wells to be completed in formations with known swelling properties that could lead to casing collapse.

4.4.1 Well Screen

The purpose of the well screen is to allow sediment-free groundwater to enter the well. The slot size of the well screen is based on filter pack material selection. Both the screen and filter pack material are related to the grain size analysis of the aquifer. Methods for determining appropriate screen slot and filter pack sizes are available in the U.S. Environmental Protection Agency (EPA) Handbook (U.S. Environmental Protection Agency (EPA) 1991) and in "Groundwater and Wells" (Driscoll 1986). Selection of screen slot and filter pack sizes will be determined by industry-wide accepted methods.

For monitoring well construction, two major types of screens are used: continuous slot wire wrap screen, and slotted pipe. Wire wrap provides the greatest open area resulting in higher yields. However, it is significantly more expensive than slotted pipe. Continuous slot wire wrap screen would be most effective when used to sample low yield formations.

Slotted pipe is composed of the same Schedule 40 or Schedule 80 casing pipe, but it has been machined to create uniform openings. Slotted pipe has a smaller effective open area than continuous slot wire wrap screen, but it is usually adequate for wells installed in relatively shallow, permeable formation aquifers. The effective open area should be at least 2.70 square inches per lineal foot for 10-slot, 2-inch slotted pipe, and 4.50 square inches per lineal foot for 20-slot, 2-inch slotted pipe.

Screen length will vary depending on site conditions, but for monitoring well installation, lengths vary from 10 to 20 feet.

4.4.2 Well Filter Pack

The purpose of the well filter pack is to provide lateral support for the well screen, increase yield by improving the hydraulic conductivity in the immediate vicinity of the well, and retain the formation to prevent natural materials from entering the well. Filter packing allows for the use of larger screen slot openings, which in turn increases well recharge rates.

The materials used to construct the filter pack will be chemically inert (e.g., clean quartz sand, silica, or glass beads), well rounded, and dimensionally stable.

Clean and properly packaged silicon sand is the most commonly used pack material and should consist of 90-95% quartz grains. The filter pack should uniformly envelope the well screen with a thickness of no less than three inches or more than eight inches.

Pack size should be such that it retains 90% of the surrounding formation while the screen slot size must retain 90% of the filter pack.

4.4.3 Well Seal

The materials used to seal the annulus between the borehole wall and casing must prevent contaminant migration from ground surface or intermediate zones and must prevent cross-contamination between strata. The materials will be chemically nonreactive to the contaminants found on the site so they do not affect the quality of the groundwater samples. The permeability of the sealants should be one to two orders of magnitude less than the surrounding formation.

The seal material will be bentonite pellets and/or a slurry of bentonite and clean sand. The actual mixture of the materials to be used in any boring will be determined in the field and will be based on drilling and sampling data. Typically, a seal of bentonite pellets with a thickness of at least two feet is installed above the filter pack to more effectively seal the screened section of the well and to prevent the intrusion of overlying cement or cement bentonite grout material into the filter pack.

4.4.4 Annulus Backfill

The annular space above the filter pack and seal is grouted with a bentonite, bentonite/cement mixture or cement grout with shrinkage reducer. Grouting is used to minimize the vertical migration of water to the groundwater intake zone and to increase the integrity and stability of the well casing.

The cement grout will consist of no more than six gallons of potable water per 94-pound bag of cement. If sand aggregate is used, the mixture will be two parts of aggregate by weight to one part cement with no more than six gallons of potable water per 94-pound bag of cement. For bentonite/cement mixture grouts, three-to-five pounds of bentonite should be mixed with 6.5 gallons of water per 94-pound bag of cement. Cement grout should be mixed thoroughly and be free of lumps. After grouting, the well should not be disturbed or be developed for a minimum of 24 hours.

4.5 Well Installation

Monitor well construction will be similar to the diagram in Exhibit 9-1, Monitoring Well Installation Log. Some exploratory borings may require partial backfilling prior to installation of the screen and riser. The field geologist will determine the well depth and the screen setting for each well, as well as the need for partial backfilling prior to well installation. Exhibit 9-1, Monitoring Well Installation Log, will be used to record well construction data.

Backfill materials will consist of bentonite pellets and/or bentonite slurry and clean sand. Due to the high pH and ion exchange capacity of bentonite and the related potential for change in groundwater chemistry, special care must be taken to ensure that the backfill and well screen are not in close proximity. Therefore, construct the well in such a manner that a minimum of one to two feet of filter pack is placed between the backfill and well screen. The actual mix of the materials to be used in any boring will be determined in the field based on drilling and sampling data. The depths of placement of all annulus well materials will be determined by the field geologist, based on the observed subsurface conditions at each well boring location. The drill crew will constantly monitor backfill depths to the satisfaction of the field geologist by means of a weighted steel or plastic measuring tape.

Shallow depth (less than 50 feet deep) exploratory borings and monitor wells are generally drilled and installed with hollow stem auger methods. The well installation is accomplished by placing the riser pipe and screen through the inside of the hollow stem augers. The borehole annulus will then be backfilled through the hollow stem augers with clean filter pack material. The filter pack will be added and the hollow stem auger sections will be sequentially removed from the borehole until the filter pack is a minimum of two feet above the well screen. This process will be performed without the addition of water.

After the depth to filter pack has been confirmed, bentonite pellet seal will be installed directly above the filter pack at a minimum two feet thick. Distilled water will be added and the bentonite pellets will be allowed to hydrate according to the manufacturer's instructions.

The installation procedure for monitor wells greater than 50 feet deep will consist of placing the riser pipe and screen into the completed borehole and backfilling the annulus with clean filter pack material. The borehole annulus will be backfilled to a minimum of two feet above the well screen. The bentonite pellet seal will be installed directly above the filter pack at a minimum two feet thick. Distilled water will be added and the bentonite pellets will be allowed to hydrate according to the manufacturer's instructions.

An accurate record of the quantity of distilled water that was added to the well during construction must be noted on Exhibit 9-1, Monitoring Well Installation Log. The remainder of the boring annulus will be backfilled with a cement/bentonite grout to within three feet of the ground surface.

When necessary, a permanent measuring point reference mark will be placed on the well casings of completed wells. This mark will provide a consistent point from which to collect water level readings. Typically this mark will be made when well elevations and locations are surveyed.

In cases when wells are drilled through a zone of known contamination into deeper water bearing zones, the potential for contamination or downward contaminant transport via drilling activities exists. In these cases, deep wells will be constructed in a manner that seals the upper contaminated aquifer from the lower aquifer of unknown contaminant levels. Methods typically employed for this procedure include the use of pressure grouting and conductor casing to seal zones of known contamination. Once a seal is established, a borehole of smaller diameter may be drilled through the conductor casing into the lower zone of unknown contaminant levels and general well installation procedures may be followed in the lower aquifer.

The exact method for isolating a zone of known contamination may vary depending on site-specific conditions. The field geologist and driller will decide the most appropriate method for aquifer isolation and deep well completion based on site-specific field conditions.

4.5.1 Surface Seal Installation

A concrete surface seal will be placed around the annulus of the well to a minimum depth of one foot or to the top of the bentonite/cement grout seal, whichever is deeper. Protective steel casings (minimum four-inch diameter, four feet in length) equipped with locking caps will be installed around the wells. Alternatively, stainless steel risers equipped with locking caps may be substituted. Where protective casings are employed, two 1/4-inch diameter holes will be drilled at the base of the protective casing at the ground surface to allow water drainage from inside the casing. Three well guards or post protectors may be placed in a radial pattern around each well if the Project Leader determines such protection is necessary to prevent damage to the protective casing. The well guards will be located four feet from the well, driven two-to-three feet below ground surface, and will rise three feet above the ground surface. A concrete pad will be placed around the well on the ground surface. The pad will be formed in such a manner as to direct surface moisture away from the base of the protective steel casing.

Alternatively, if the well is located in an area where frequent vehicular traffic occurs, a commercially supplied traffic rated box will be used as a protective well head or the well may be installed flush with the ground surface. Appropriate locking mechanisms and locks will be used to secure the well and prevent surface runoff from entering the traffic box flush mount or well.

4.6 Review

The Project Leader or an approved designee will check Exhibit 9-1, Monitoring Well Installation Log, for completeness and accuracy. Any discrepancies will be noted and the log will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the "reviewed by" and "date" blanks on Exhibit 9-1, Monitoring Well Installation Log.

5.0 REFERENCES

CDPHE, 2000. Standard Operating Procedure 11, "Equipment Decontamination." Standard Operating Procedures.

Driscoll, F. G. 1986. "Groundwater and Wells." Johnson Division, St. Paul, Minnesota.

U.S. Environmental Protection Agency (EPA). 1986. "RCRA Groundwater Monitoring Technical Enforcement Guidance Document (T.E.G.D.)." OSWER-9950.1.

U.S. Environmental Protection Agency (EPA). 1991. "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells." U.S. Environmental Protection Agency, Washington, D.C.

6.0 EXHIBITS

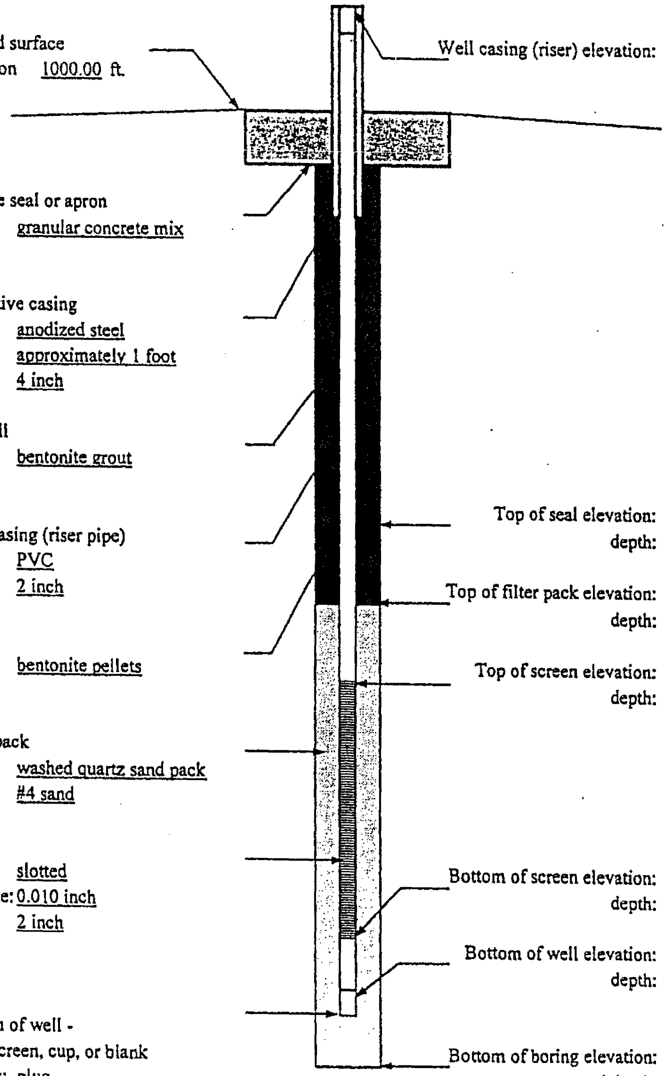
Exhibit 9-1	Monitoring Well Installation Log

EXHIBIT 9-1
Monitoring Well Installation Log

WELL NUMBER:

DATE DRILLED:
LOCATION:
PROJECT:
INSPECTED BY:
COMMENTS:
JOB NO:
INSTALLED BY:

MONITORING WELL CONSTRUCTION DIAGRAM



Ground surface elevation 1000.00 ft.

Well casing (riser) elevation: ft.

Surface seal or apron
type: granular concrete mix

Protective casing
type: anodized steel
length: approximately 1 foot
ID: 4 inch

Backfill
type: bentonite grout

Well casing (riser pipe)
type: PVC
ID: 2 inch

Seal
type: bentonite pellets

Filter pack
type: washed quartz sand pack
size: #4 sand

Screen
type: slotted
slot size: 0.010 inch
ID: 2 inch

Bottom of well -
plug, screen, cup, or blank
specify: plug

Top of seal elevation: 990.00 ft.
depth: 10.0 ft.

Top of filter pack elevation: 988.00 ft.
depth: 12.0 ft.

Top of screen elevation: 986.00 ft.
depth: 14.0 ft.

Bottom of screen elevation: 976.00 ft.
depth: 24.0 ft.

Bottom of well elevation: 976.00 ft.
depth: 24.0 ft.

Bottom of boring elevation: 975.50 ft.
total depth: 24.5 ft.

DATE COMPLETED: 1/1/01
CASING (RISER) ID: 2 inch
SCREEN LENGTH: 10.0 ft.
SCREEN SLOT SIZE: 0.010 inch

ALL ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

STANDARD OPERATING PROCEDURE - 10

MONITOR WELL DEVELOPMENT

1.0 PURPOSE

The purpose of this procedure is to describe the methods used for developing groundwater monitor wells on environmental site investigations. This procedure outlines the methods and advantages and disadvantages of each method. Site-specific deviations from the methods presented herein must be approved by the Colorado Department of Public Health and Environment (CDPHE) Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Hydraulic Conductivity (K): A standardized measure of the flow of a liquid through a porous medium. Hydraulic conductivity is generally expressed in terms of a unit hydraulic gradient so that different rocks (media) can be compared against one another.
Hydraulic Gradient: A pressure gradient. Applied to an aquifer, it is the rate of change in pressure head per unit distance of flow at a given point and in a given direction [Ft/Ft].

Permeability: Capacity of a rock or soil to transmit fluid, such as water, under an hydraulic gradient.

Turbidity: Cloudiness in water due to suspended and colloidal organic and inorganic material.

2.2 Abbreviations

ARARs	Applicable or Relevant and Appropriate Requirements
PID	Photo Ionization Detector

3.0 RESPONSIBILITIES

The personnel developing monitor wells are responsible for performing the applicable tasks outlined in this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance. All activities and data collected shall be recorded in the field log book.

4.0 PROCEDURES

4.1 Introduction

Monitor well development is the process of flushing the formation interface, and cleaning the filter pack and the well screen slots to permit unimpeded flow of groundwater into the monitor well. Water produced from a properly developed monitoring well is representative of formation water and does not contain contaminants introduced during drilling and well construction or formation materials loosened during well installation.

Development is necessary to repair damage done to the formation by drilling so that the natural hydraulic properties are restored; to remove clays, silts, and fine sands (fines) from the filter pack and well screen; and to remove any remnant drilling fluids or drilling-introduced contaminants.

Development of groundwater monitor wells is best accomplished by surging the well. This process agitates the fine grain sediments and moves them into the well so that they may be removed. The use of non-formation water for development is not advised but may be necessary under certain conditions. Extreme care should be taken at all times to avoid damaging the borehole, filter pack and/or well screen. Each well will be considered developed when the groundwater turbidity has diminished to an acceptable level of clarity.

Table 1 presents the four major methods of monitor well development employed by CDPHE. The major consideration for determination of a monitor well development method should be the lithologic characteristics of the interval in which the well is screened. Logistic considerations should be secondary. Methods can also be used in conjunction with any other method.

TABLE 1
Well Development Methods

Method	Best Application	Avoid
Mechanical Surging (Surge Block)	Wells screened in lithologies of medium to high porosities and hydraulic conductivities	Wells screened in lithologies of low permeability; i.e., clay sand silts
Air Lift and Surge (Compressed Air)	Wells screened in lithologies of high hydraulic conductivity	Wells screened in permeable lithologies with clay interbeds
Bailer (Stainless Steel)	Wells screened in low permeable formations	Deep or large purge volume wells
Pumping (Variety of High Volume Pumps)	Deep or large volume wells	Wells screened in a combination of high and low permeability lithologies

During monitor well development, organic vapors will be monitored to evaluate the potential for fire, explosion, and toxic effects on field personnel. The maximum sustainable flow (well yield) will be determined, if required, and recorded on Exhibit 10-1, Well Development Data Summary, for each monitor well. The well yield is the maximum sustainable rate, measured in gallons/minute, that the well can be pumped at before the water level in the well falls below the screened interval. The water level can be measured with the electric tape and the pumping rate can be adjusted until the equilibrium is reached. Groundwater recovery data will be recorded on Exhibit 10-2, Aquifer Test Data.

Temperature, Ph, conductivity and other field parameters can be measured during development, but these have no real bearing on development. The purpose of development is to remove fines from the well and produce clear water. Time spent properly developing a well is usually repaid during sampling when groundwater chemistry stability is required.

4.2 Decontamination

All equipment used for monitor well development will be thoroughly decontaminated to minimize possible cross-contamination of the well. Decontaminate equipment prior to use according to the methods outlined in CDPHE SOP 4.11, Equipment Decontamination.

4.3 Mechanical Surging

A surge block is a round plunger, slightly smaller in diameter than the inside diameter of the well screen. Development by mechanical surging produces good results in formations having medium to high porosities and hydraulic conductivities. Development by this method is as follows:

- Lower the surge block into the well to a point below the static water level;
- Raise and lower the tool alternately with increasing stroke lengths. As water begins to move easily both into and out of the screen, the surge block is lowered and the procedure resumed; and
- Periodically, use a bailer or pump to remove accumulated fines from the well. Development should begin at the static water level and move progressively downward to prevent the surge block from becoming sand locked.

Note: Surging of low-permeability formations can result in a collapsed screen, especially in wells that use plastic screens. Clayey and silty formations in which screen slot sizes are smaller the 0.015 inch are particularly prone to screen collapse.

4.4 Air Lift and Surge

The air lift method involves using compressed air to alternately surge and pump the monitor well. This development method produces best results in formations with high hydraulic conductivities and is implemented as follows:

- Lower an air line a few feet below the static water level to introduce air into the well. The introduced air will blow water and suspended sediments upward and out of the well, and allow formation water to flow into the well. Initial air pressure should be low to minimize the possibility of screen collapse;

- Lower the air line progressively into the well, waiting until the water reaching the surface has clarified enough to indicate that the screened interval is developed before lowering the air line;

- Surging cycles may begin once the flow is established. Apply short pulses of high pressure air into the well to accomplish surging. This has the effect of raising and lowering a column of water within the screen, thus agitating any fine materials within the filter pack; and

- Continue alternating surging and pumping cycles until the desired development is indicated by clean purge water.

Note: Under some conditions, the aquifer or screen may become air locked when a large burst of air is injected into the screened area. Certain formations are more prone to air locking, especially formations which consist of stratified coarse material separated by thin impermeable clay layers. In formations susceptible to air locking, air lifting should be avoided.

Due to the explosive nature of the water exiting the well casing during air lifting operations, care must be taken to contain the discharged water. It is imperative that secondary contamination of surrounding soil, equipment, and personnel does not occur.

4.5 Bailer

A bailer which is heavy enough to sink through the groundwater can be raised and lowered through the water column to produce an agitating action similar to that of a surge block. The bailer has the advantage of being able to remove turbid water and fines each time it is brought to the surface. The bailer method is ideal for formations with low permeabilities as it generally will not produce pressures great enough to cause well screen collapse. Bailing is generally not suitable for deep wells or wells which produce large volumes of water.

4.6 Pumping

Pumping is the simplest method of removing fines from the water-bearing formation, filter pack, and well screen. Pumping is performed at a rate higher than the recharge rate. While this method is relatively simple, development action tends to take place in the most permeable zone or close to the top of the well screen. Once the permeable zone has been developed, water tends to move preferentially through these zones. This results in the rest of the well being poorly developed and contributing only small volumes of water to the total yield. Pumping from low permeability formations may compact the finer sediments around the borehole and restrict flow into the well screen.

4.7 Water Containment

All contaminated waters generated during well development must be contained and stored so as not to pose a health and safety threat. Development water must be stored in approved containers or, in the case of development water containing non-volatile constituents, lined impoundments may be used until water sample results are obtained and proper disposal methods are determined. The presence or absence of volatile constituents will be determined in the field using photo ionization detection (PID) monitoring instruments. Generally, development water must be properly disposed of within 90 days of its generation. Proper storage and disposal methods for development water will be determined based on federal, state, and local regulations (i.e., ARARs) and known or suspected contaminants.

4.8 Review

The Project Leader or designee shall check Exhibit 10-1, Well Development Data Summary and Exhibit 10-2, Aquifer Test Data for completeness and accuracy. Any discrepancies will be noted and the Exhibits will be returned to the originator for correction. The reviewer will acknowledge that review comments have been incorporated by signing and dating the "reviewed by" and "date" blanks on each Exhibit.

5.0 REFERENCES

CDPHE, 2000. "Standard Operating Procedure 11, Equipment Decontamination." Technical Standard Operating Procedures.

Driscoll, G. 1986. "Groundwater and Wells." Johnson Division, St. Paul, Minnesota.

Fetter, C. W. 1988. "Applied Hydrogeology." Merril Publishing Company. Columbus, Ohio. Second Edition. 592p.

U.S. Environmental Protection Agency (EPA). 1987. "Groundwater Handbook." United States Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1988. "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA." United States Environmental Protection Agency, Washington, DC.

6.0 EXHIBITS

Exhibit 10-1	Well Development Data Summary
Exhibit 10-2	Aquifer Test Data

EXHIBIT 10-1
Well Development Data Summary

CDPHE

Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, CO 80246

WELL DEVELOPMENT DATA SUMMARY

Records Management Data

Project Number	Project Name
Well Number	Well Location

Time / Date: ____________ Elevation : ____________

Drilling Method: ____________ Weather: ____________

Development Company: ____________ ____________

Date Development Started: ____________ Date Development Completed: ____________

Screen Intervals Well Diameter: ____________

______ ft. To ______ ft. ______ ft. To ______ ft. ______ ft. To ______ ft. ______ ft. To ______ ft.

Depth of Well (L^w): ____________ ft. Depth to Water Before Development (L'): ____________ ft.

Height of Water Column (L^w - L'): ____________ ft.

Depth to Top of Sediment (L') ____________ ft. Sediment Thickness (L^w - L'): ____________ ft.

Well Volume: ____________ gal.

Total Volume Pumped: ____________ gal.

Number of Well Volumes Pumped (total volume pumped/well volume): ____________

Comments: ____________

Presented By	Date	Checked By	Date

EXHIBIT 10-2
Aquifer Test Data

CDPHE Colorado Dept. of Public Health and Environment	**AQUIFER TEST DATA**	
PROJECT NUMBER:	PROJECT NAME:	PAGE ____ of ____
Well Number:	Well Location:	Static Water Level: ____ ft.

Time	Total Elapsed Time t (min)	Time Since Pumping Stopped t' (min)	Water Level (ft)	Drawdown S (ft)	Corrected Drawdown $S_c'(R)$ (ft)	Recovery S' (ft)	Corrected Recovery S'_c (ft)	Discharge Q gpm
____	____	____	____	____	____	____	____	____
____	____	____	____	____	____	____	____	____
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Recorded By:	Date:	Checked By:	Date:

STANDARD OPERATING PROCEDURE - 11

EQUIPMENT DECONTAMINATION

1.0 PURPOSE

This procedure describes the techniques used to decontaminate sampling and field measurement equipment. Proper decontamination ensures that cross-contamination does not occur.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the Project Leader and the CDPHE Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Potable water: Water suitable for drinking.

10 percent nitric acid: A solution composed of 1 part concentrated nitric acid and 9 parts distilled water (e.g., a 100 ml aliquot of 10 percent nitric acid contains 10 ml concentrated nitric acid and 90 ml distilled water).

2.2 Abbreviations

ml	Milliliter
PPs	Project plans
SOP	Standard Operating Procedures

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks outlined in this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURES

4.1 Methods

Field personnel shall routinely document all equipment decontamination. Decontamination procedures shall be documented in the field log books. All documentation of decontamination procedures shall include the following information:

- Serial number and model number of each piece of equipment (where applicable); and
- Method of decontamination if it deviates from the method described herein.

Specific formatting information for documentation of decontamination procedures in field log books is contained in CDPHE SOP 4.6, "Use and Maintenance of Field Log Books."

Each piece of sampling equipment shall be decontaminated as follows:

- Brush with bristle or steel wire brush to remove gross particulates (as appropriate);
- Scrub thoroughly with a laboratory-grade detergent/potable water solution;
- Rinse thoroughly with potable water;
- Rinse with reagent-grade methanol or nitric acid (as applicable);
- Rinse thoroughly with reagent-grade water; and
- Allow equipment to gravity drain.

Oversized and drilling equipment will be decontaminated using a high pressure water sprayer.

Equipment rinsate samples will be collected according to the specifications in the Project Plans (PPs).

Field measurement equipment such as pH and conductivity meters will be decontaminated by double rinsing with distilled water only and blotting dry. In instances where samples have water insoluble contaminants, additional rinses may be necessary.

4.2 Review

The Project Leader or designee shall check field log books for completeness and accuracy. Any discrepancies in these documents will be noted and returned to the originator for correction. The reviewer will acknowledge that corrections have been incorporated by signing and dating in the appropriate manner.

5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1984. "Standard Operating Safety Guides." Office of Emergency and Remedial Response.

CDPHE. 2000. Standard Operating Procedure 6, "Use and Maintenance of Field Log Books." Technical Standard Operating Procedures.

STANDARD OPERATING PROCEDURE - 12

GROUNDWATER SAMPLING

1.0 PURPOSE

The purpose of this procedure is to describe the equipment and protocols for sampling groundwater monitor wells. This procedure outlines methods for well purging, sample collection, and filtration, when using bailers, submergible pumps and bladder pumps.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Blank: An artificial sample designed to monitor the introduction of contaminants into a process. For aqueous samples, reagent water is used as a blank matrix.

Field Blanks: Blanks used to assess potential contamination resulting from exposure to ambient field conditions.

Trip Blanks: Blanks obtained from the laboratory or prepared by the field sampling team with reagent grade water at a designated clean location prior to sampling activities. Trip blanks are not opened in the field and act as a check for sample contamination originating from sample transport and site conditions.

Rinsate Blanks: Blanks prepared in the field from reagent-grade water that is poured over or passed through the sample collection device after the device has been decontaminated, then collected in a sample container and returned to the laboratory for analysis. Rinsate blanks check the effectiveness of decontamination procedures. Rinsate blanks can also serve as field blanks if they are prepared at the site.

Specific Capacity: The discharge of a well expressed as rate of yield per unit drawdown.

2.2 Abbreviations

FID	Flame ionization detector
PID	Photo ionization detector
POC	Purgeable organic carbon
POX	Purgeable organic halogens

SOP	Standard Operating Procedures
TOC	Total organic carbon
TOX	Total organic halogens
VOC	Volatile organic compound

3.0 RESPONSIBILITIES

Sampling personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents and data produced during work performance.

4.0 PROCEDURES

- Read and follow the specific Manufacturer's Operating Instructions before using any equipment.
- Prior to initiating sampling of a groundwater well, check that all equipment to be used is in good operating condition.
- If possible and where applicable, begin sampling event at those wells that are the least contaminated and proceed to those wells that are the most contaminated.
- Clean all equipment entering the well by methods in CDPHE SOP 4.11, Equipment Decontamination.
- Remove well casing cap, noting in the log book the following: personnel, well number, date, time and weather conditions, as well as any evidence of damage or disturbance to the well. This information may also be recorded on the groundwater sampling data form, Exhibit 12-1, Monitoring Well Sampling Data.
- If required by site specific conditions, monitor headspace of well with a photo ionization detector (PID), a flame ionization detector (FID), or other appropriate monitoring instrument and record in the logbook.
- Check water level as per CDPHE SOP 4.13, Water Level Measurement.
- Purge well.
- Sample well as per Section 4.2, Sampling Procedures.
- Filter and preserve samples as per Section 4.4, Sample Filtration and Preservation.

4.1 Well Purging

In order to obtain a representative sample of groundwater from a monitoring well, the water that has stagnated and/or thermally stratified within the well casing and filter pack must be purged. This procedure allows representative formation water to enter the well. The preferred method of ensuring representative formation water is being sampled is to monitor groundwater parameters during purging.

Measure pH, temperature and specific conductance at regular volumetric intervals (i.e., one-half casing volume) during well purging using the methods outlined in CDPHE SOP 4.14, Water Sample Field Measurements.

The purge volume of static water can be calculated by using the following formula:

$$V = Hr^2(0.163^*)$$

Where: V = Static volume of well in gallons
H = Linear <u>feet</u> of static water in well
r = Inside radius of well casing in inches
0.163* = A constant conversion factor for a 2" diameter well. For a 4" diameter well, use 0.653.

Where possible, the well should be sampled within two hours of purging. Record the results on Exhibit 12-1, Monitoring Well Sampling Data. When parameters vary less than ±10% (pH will vary less than 0.2 pH units) over three consecutive measurements the well may be considered to be adequately purged (stabilized). In wells with poor recovery, purge to near dryness and allow the well to recover prior to sampling. In wells with slow recharge rates, it may be necessary to wait several hours or until the next day to collect the sample.

When well water parameters do not stabilize the well can be sampled after six purge volumes have been removed.

Prior to initiating well purging, record the following groundwater parameters on Exhibit 12-1, Monitoring Well Sampling Data:

- Static water level;
- Depth of well bottom;
- Height of water column;
- Volume of water in borehole;
- Time;
- Temperature;
- Conductivity;
- pH;
- Visual appearance; and
- Monitoring equipment (HNu/OVA) readings.

4.2 Sampling Procedures

After purging the required volume of water from the well, sample within two hours. Do not exceed two hours between purging and sampling, except in cases when a slow recharge rate requires more time between well purging and sample collection. To ensure the groundwater sample is representative of formation water, it is important to minimize the possibility of cross-contamination by performing the following steps:

- Use only Teflon®, stainless steel or disposable sampling devices which have been decontaminated prior to use.

- Use dedicated sampling equipment. If dedicated sampling equipment is not available, thoroughly decontaminate the equipment prior to any sampling and between sampling events according to the methods outlined in CDPHE SOP 4.11, Equipment Decontamination. Collect rinsate blanks as outlined in the Project Plans to verify that cross-contamination has not occurred.

- Specify the order in which the samples are to be collected. Collect samples in the order of volatilization sensitivity. Volatile organics should be collected when flow rate is less than 100 ml/minute. Fill sampling vial(s) completely making sure that there is no head space. The collection order for most common groundwater parameters is as follows:

  - Volatile organic compound (VOC);
  - Purgeable organic carbon (POC);
  - Purgeable organic halogens (POX);
  - Total organic halogens (TOX);
  - Total organic carbon (TOC);
  - Extractable organics;
  - Total metals;
  - Dissolved metals;
  - Phenols;
  - Cyanide;
  - Sulfate and chloride;
  - Turbidity;
  - Nitrate and ammonia; and
  - Radionuclides.

Transfer the groundwater sample to a sample container in such a manner that will minimize agitation and aeration. Samples should also be immediately placed in a cool place out of direct sunlight, such as a cooler. The cooler should be kept at an appropriate temperature for preservation requirements for the applicable analyses.

Immediately after the sample is collected, record applicable information in the field log book. This information may also be recorded on Exhibit 12-1, Monitoring Well Sampling Data..

4.2.1 Sample Containers

The proper sample containers to be used for specific analysis and sample preservation are outlined in CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times.

4.3 Sampling Methods

4.3.1 Bailer Method

Collect groundwater samples with a bailer by lowering the bailer into the well using a disposable nylon line. Avoid contacting the ground or any other surface with the line and bailer. A plastic sheet can be used as an apron. Lower the bailer into the well in a controlled manner to avoid slapping the ground water surface with the bailer as this may cause outgassing of the water from the bailer's impact.

After the desired depth is reached, raise the bailer to the surface and empty it through the bottom by a clamp valve. If the bailer is not equipped with a clamp valve, pour the sample from the bailer into the appropriate container. Empty the bailer at a slow, controlled rate to minimize sample aeration. After all sample containers have been filled, measure sample pH, temperature, and conductivity. Record applicable information on Exhibit 12-1, Monitoring Well Sampling Data.

The advantages to bailers are that they are portable, easily cleaned, and do not require an outside power source. The disadvantage to bailer sampling is that this method is slow when large volumes of water are required or when the well is deep.

4.3.2 Bailer Decontamination

Decontaminate bailers prior to use in each well as per CDPHE SOP 4.11, Equipment Decontamination. In all cases, the bailer cord should be replaced prior to each sampling. Disposable bailers may be used in place of Teflon® or stainless steel bailers. Disposable bailers do not require decontamination.

4.3.3 Bladder Pump Method

The bladder pump consists of a stainless steel housing that encloses a flexible membrane or bladder made of Teflon®. A screen is attached below the bladder to filter any material that may clog the bladder check valves. The pump may be operated by using an air compressor, compressed air, or compressed nitrogen.

The pump is lowered into the well to the desired depth. The air supply line is attached to the controller and the discharge line is placed into a suitable receptacle. When collecting samples for analysis of volatile constituents, do not exceed a pumping rate of 100 milliliters/minute. Higher pumping rates may increase the loss of volatile constituents and may cause fluctuation in pH and pH-sensitive analytes. For non-sensitive analysis, higher pumping rates may be used. Do not allow the sampling flow rate to exceed the flow rate used while purging. Place the samples in sample containers as outlined in CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times. Record applicable sampling information on Exhibit 12-1, Monitoring Well Sampling Data.

The advantages to bladder pumps include ease of operation, ability to pump larger volumes of water. The disadvantages are that a power source is needed, some loss of volatile constituents is possible, and the decontamination process is difficult.

4.3.4 Bladder Pump Decontamination

Decontaminate the bladder pump prior to use in each well. Disassemble and inspect the pump prior to cleaning. Decontamination is completed by the methods outlined in the owner's manual for the specific type of bladder pump, and CDPHE SOP 4.11, Equipment Decontamination.

4.3.5 Submerged Electrical Pump

The electrical pump is constructed of stainless steel. Consult the specific Manufacturer's Operating Instructions before operation. The pump is lowered into the well to the desired depth. The purge volume calculations should be determined prior to placing the pump in the well. Purge rates should not cause drastic drawdown which results in water cascading into the well. When collecting samples for analysis of volatile constituents, do not exceed a pumping rate of 100 milliliters/minute. Higher pumping rates may increase the loss of volatile constituents and may cause fluctuation in pH and pH-sensitive analytes. For non-sensitive analysis, higher pumping rates may be used. Do not allow the sampling flow rate to exceed the flow rate used while purging. Place the samples in sample containers as outlined in CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times. Record applicable sampling information on Exhibit 12-1, Monitoring Well Sampling Data.

4.4 Sample Filtering

Some samples require field filtering within four hours of collection from the well. Filter samples by using a disposable in-line filter housing, or equivalent setup, equipped with a 0.45 micron glass fibre filter. Change filters for each sample. Collect the sample water directly into the sample container.

After the samples have been filtered and placed in appropriate containers, preserve samples as stated in CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times.

4.5 Chain-of-Custody

All samples shall be accompanied by an appropriate Chain-of-Custody form at the time of transfer. The procedures for filling out a Chain-of-Custody form, transporting samples, and transferring custody of samples are outlined in CDPHE SOP 4.3, Chain of Custody.

4.6 Sample Labeling

Label all samples according to the methods outlined in CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging.

4.7 Potable Water Sampling

During certain phases of field investigations, it may be necessary to collect samples from existing domestic or municipal water supply systems.

When samples are collected from domestic wells, the wells should be purged before the sample is collected. Residential wells often have holding tanks which must be evacuated. Evacuation of the holding tank volume helps assure that representative samples are being collected from the aquifer. Information about well construction (casing diameter, depth to water, total depth, screened interval, and holding tank volume) should be obtained, if possible, in order to determine the appropriate volume of water to purge before sampling. If specific well information is not available, a 15-minute evacuation period is the minimum acceptable time. In all cases, temperature pH, conductivity and flow rate should be measured during purging. The well is considered purged when field parameters stabilize.

The name, mailing address, and the resident's home and work telephone numbers are always entered into the sampling log book. This information will assist in informing the owner/operator of the water supply of the results of the sampling program.

Potable water samples must be representative of water quality within a given segment of the distribution network. Taps selected for sampling should be supplied with water from a service pipe connected directly to a water main in the segment of interest and should not be separated from the segment of interest by holding or storage tanks.

All taps should be opened for sufficient time to allow for clearing of the service line. Water samples can then be collected directly from this line into the appropriate sample containers.

4.8 Review

The reviewer shall check Exhibit 12-1, Monitoring Well Sampling Data, for completeness and accuracy. Any discrepancies will be noted and the Exhibits will be returned to the originator for correction. The reviewer will acknowledge that the review comments have been incorporated by signing and dating the "checked by" and "date" blanks on Exhibit 12-1, Monitoring Well Sampling Data.

5.0 REFERENCES

Scalf, R. D. 1980. "Manual of Groundwater Sampling Procedures." National Water Well Association and the U.S. Environmental Protection Agency (EPA) Robert S. Kerr Environmental Research Laboratory.

U.S. Environmental Protection Agency (EPA). 1991. "A Compendium of ERT Groundwater Sampling Procedures." OSWER Directive 9360.4-06, January 1991. U.S. Environmental Protection Agency.

CDPHE, 2000. "Operating Procedure 2, Sample Containers, Preservation, and Maximum Holding Times." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 3, Chain-of-Custody." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4, Sample Identification, Labeling, and Packaging." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 11, Equipment Decontamination." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 13, Water Level Measurement." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 14, Water Sample Field Measurements." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 12-1 Monitoring Well Sampling Data

EXHIBIT 12-1
Monitoring Well Sampling Data

CDPHE	Monitoring Well Sampling Data	
Project Number ______	Project Name:	Page ___ of ____
Well/Borehole Number: ________	Well/Borehole Location:______________________________	Static Water Level:________(ft)

Sample No:_____________________________	Elevation: ____________________________
Sampling Method:______________________	Weather: _____________________________
Bar. Press._____________________	Amb. Temp. ___________________
WATER ELEVATION DATA	
1.) Depth Water Surface:_________________________ (From Casing Top as Marked)	Method of Measurement:___________________
2.) Static Water Level Elevation: ____________ (Casing Top Elevation minus 1)	Product obs: __Yes __No
3.) Depth to Well Bottom: _________________ (From Casing Top as Marked)	Depth to Product:_________________________
4.) Height of Water Column (h):________________ (3 minus1)	Method of Measurement:_________________
Volume of Water in Well:(x) (h) = __________ (gals) (for 2" x= 0.163 gal/ft for 4" x = 0.653 gal/ft)	
Amount of Water Removed From Well:________	Was Well Pumped Dry? __Yes __No
Method of Water Removal: _________________	Total Volume/Time: ______________________

Time	Temp °C	Conductivity	pH	Turbidity	Removed	Flow Rate	Observations

Recorded By:	Date:	Checked By:	Date:

- STANDARD OPERATING PROCEDURE - 12A

GROUNDWATER SAMPLING FOR LOW FLOW PURGE AND SAMPLING

1.0 PURPOSE

The purpose of this procedure is to describe the equipment and operations for sampling groundwater monitor wells using a pump to obtain samples with a minimum of turbidity. This procedure is designed to be used in conjunction with the analyses for the most common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, PCBs, metals and inorganic compounds).

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Blank: An artificial sample designed to monitor the introduction of contaminants into a process. For aqueous samples, reagent water is used as a blank matrix.

Field Blanks: Blanks used to assess potential contamination resulting from exposure to ambient field conditions.

Trip Blanks: Blanks obtained from the laboratory or prepared by the field sampling team with reagent grade water at a designated clean location prior to sampling activities. Trip blanks are not opened in the field and act as a check for sample contamination originating from sample transport and site conditions.

Rinsate Blanks: Blanks prepared in the field from reagent-grade water that is poured over or passed through the sample collection device after the device has been decontaminated, then collected in a sample container and returned to the laboratory for analysis. Rinsate blanks check the effectiveness of decontamination procedures. Rinsate blanks can also serve as field blanks if they are prepared at the site.

Specific Capacity: The discharge of a well expressed as rate of yield per unit drawdown.

2.2 Abbreviations

FID	Flame Ionization Detector
HNu/OVA	HNu/Organic Vapor Analyzer
ID	Inside diameter

NTU	Nephelometric turbidity units
PCBs	Polychlorinated biphenols
PID	Photo Ionization Detector
POC	Purgeable organic carbon
POX	Purgeable organic halogens
PVC	Polyvinyl chloride
TOC	Total organic carbon
TOX	Total organic halogens
VOC	Volatile organic compound

3.0 RESPONSIBILITIES

Sampling personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and assuring that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents and data produced during work performance.

4.0 PROCEDURES

- Read and follow the specific Manufacturer's Operating Instructions before using any equipment.

- Make sure prior to initiating sampling of a groundwater well, that all equipment to be used is in good operating condition.

- If possible and where applicable, start at those wells that are the least contaminated and proceed to those wells that are the most contaminated.

- Decontaminate all equipment entering the well by methods in Section 4.3, Decontamination Methods.

- Remove well casing cap, noting in log book or groundwater sampling data form the following: personnel, well number, type of sampling equipment used, date, time and weather conditions.

- If required by site specific condition, monitor headspace of well with PID, FID or other appropriate monitoring instrument and record readings in logbook or groundwater sampling data form, Exhibit 12A-1, Monitoring Well Sampling Data.

- Check water level as outlined in UOS TSOP 4.13 “Water Level Measurement.” Care should be taken to minimize disturbance of any particulate attached to the sides or the bottom of the well. Measure total depth of well prior to purging or estimate casing volume of well from previous well depth measurements.

- Purge well as per Section 4.1, “Well Purging.”

- Sample well as per Section 4.2, "Sampling Procedures."
- Filter and preserve samples as per Section 4.4, "Sample Filtering."
- Decontaminate equipment as per Section 4.3, "Decontamination Methods."

4.1 Well Purging

In order to obtain a representative sample of groundwater from a monitoring well, an adjustable rate, positive displacement pump (centrifugal or bladder pump constructed of steel or Teflon®) should be used. This low flow procedure allows for a minimization of disturbance of sediments which have accumulated on the sides or in the bottom of the well while allowing a sample to be collected from the representative water formation with a minimum of purging. The preferred method of ensuring representative formation water is being collected is to monitor groundwater parameters every three to five minutes or whatever is appropriate during purging when the pump is placed within the screened interval. Please note that average purge rates are generally from 0.2 to 1.0 liters per minute (l/min).

Measure the water level again with the pump in the well before starting the pump. Start the pump in the well at 0.2 to 0.5 l/min or as appropriate. Ideally, the pump rate should cause little or no water level drawdown in the well. The water level should be monitored every three to five minutes or as appropriate during pumping. Care should be taken not to cause the pump suction to be broken, or entrainment of air into the sample. Record the following for every three to five minute interval or as appropriate in the log book or Exhibit 12A-1, Monitoring Well Sampling Data: pumping rate adjustments, drawdown, depth to water, indicator parameter values, clock time and total volume pumped. Pumping rates, if needed, should be reduced to the minimum capabilities of the pump (e.g., 0.1 to 0.2 l/min) to avoid pumping the well dry and/or to ensure stabilization of indicator parameters.

Measure pH, temperature, specific conductance and turbidity every three to five minutes, every one-half casing volume, or every one to three liters. All indicator parameter measurements will be conducted as per the methods outlined in UOS TSOP 4.14, Water Sample Field Measurements. All measurements should be taken using a flow-through cell or from a clean container (e.g., decontaminated glass beaker).

Record the results in the field log book. Results may also be recorded on Exhibit 12A-1, Monitoring Well Sampling Data. When these parameters vary less than ±10% (pH will vary less than 0.2 pH units) over three consecutive measurements, water in the well has adequately stabilized and the sample should be collected. In wells with slow recharge rates, commence sampling as soon as the well has recharged to a sufficient level to collect the appropriate volume of samples with the pump.

If indicator parameters have stabilized, but the turbidity is not in the range of the goal of five nephelometric turbidity units (NTU), the pump rate should be decreased, and measurements of the parameters should continue every three to five minutes or as appropriate. If indicator parameters do not stabilize within a reasonable time (e.g., three to five casing volumes), sample well and note deviation to sampling procedures.

Prior to initiating well purging, record the following groundwater parameters in the field log book. The parameters may also be recorded on Exhibit 12A-1, Monitoring Well Sampling Data:

- Static water level;
- Check water level as outlined in CDPHE SOP 4.13 "Water Level Measurement." Care should be taken to minimize disturbance of any particulates attached to the sides or the bottom of the well. Measure total depth of well prior to purging or estimate casing volume of well from previous well depth measurements.
- Time;
- Temperature;
- Conductivity;
- pH;
- Visual appearance; and
- Monitoring equipment HNU/Organic Vapor Analyzer (HNu/OVA) readings.

4.1.1 Equipment

An adjustable rate, positive displacement pump (centrifugal or bladder pump constructed of steel or Teflon®) should be used for this method of well purging and sampling on groundwater wells which have a well casing of 2.0-inch inside diameter (ID) or more.

Tubing to be used for low flow type sampling is limited to Teflon® or Teflon® lined polyethylene tubing for organic analyses. For inorganic analyses, Teflon® or Teflon®-lined polyethylene, polyvinyl chloride (PVC), Tygon or polyethylene tubing can be used.

In order to minimize cross-contamination, purge and sample each monitor well with dedicated pumps and tubing. If this is not practical, take extreme care to properly decontaminate all purging and sampling equipment prior to use following the applicable methods as stated in Section 4.3, Decontamination Methods.

Record groundwater parameters as outlined above in the log book. Parameters may also be recorded on Exhibit 12A-1, Monitoring Well Sampling Data.

4.2 Sampling Procedures

After indicator parameters have stabilized in the well, collect the sample immediately. In wells with slow recharge rates, commence sampling as soon as the well has recharged to a sufficient level to collect the appropriate volume of samples with the pump.

Transfer the groundwater sample to a sample container by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Samples should also be placed in a cool place out of direct sunlight, such as an iced cooler.

- Collect samples in the order of volatilization sensitivity. Volatile organics should be collected when the flow rate is less than 100 milliliters per minute (ml/min.). The collection order for most common groundwater parameters is as follows:

  - Volatile organic compound (VOC);
  - Purgeable organic carbon (POC);
  - Purgeable organic halogens (POX);
  - Total organic halogens (TOX);
  - Total organic carbon (TOC);
  - Extractable organics;
  - Total metals;
  - Dissolved metals;
  - Phenols;
  - Cyanide;
  - Sulfate and chloride;
  - Turbidity;
  - Nitrate and ammonia; and
  - Radionuclides.

Immediately after the sample is collected, record applicable information in the field log book as outlined in CDPHE SOP 4.6, Use and Maintenance of Field Log Books. Information may also be recorded on Exhibit 12A-1, Monitoring Well Sampling Data,

After collection of the samples, the pump's tubing may either be dedicated to the well for resampling by hanging the tubing inside the well, decontaminated for use at another site, or properly discarded.

4.2.1 Sample Containers

The proper sample containers to be used for specific analysis and sample preservation are outlined in CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times.

4.2.2 Blanks

A minimum of two types of blanks will be collected to verify the quality of the collected samples. These blank types are as follows:

- Trip Blank: Obtain two volatile organic sample bottles from the laboratory or prepared by the field sampling team with reagent grade distilled water; transport to the site; handle in the same manner as the collected samples; and return to the laboratories for volatile organics analysis. The trip blanks should be kept in the cooler with the VOC samples at all times.

- Rinsate Blank: To ensure that any non-dedicated sampling equipment has been effectively decontaminated, fill sampling device with reagent grade water or pump reagent grade water through the device, transfer to sample bottle(s), and return to the laboratory for analysis. If contamination is found in the rinsate blanks, identify the source of the contamination and take corrective action, such as resampling and/or reviewing decontamination procedures.

- Field Blanks: To assess the possible influence of site-related contaminants entrained in ambient air on sample quality, on-site personnel may collect field blanks during site activities. Field blanks are collected by pouring reagent grade water directly into the appropriate sample container. The sample is then analyzed for site-related contaminants to determine the influence of on-site ambient air on sample results. A rinsate blank can also serve as a field blank if it is prepared at the site.

To determine the frequency of blank collection, refer to the Quality Assurance Project Plan.

4.3 Decontamination Methods

Sampling equipment will be decontaminated prior to use and following sampling of each well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the sample) will be decontaminated by one of the procedures listed below.

4.3.1 Procedure 1

- Steam clean the outside of the submersible pump.
- Pump hot water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.
- Pump five gallons of non-phosphate detergent solution through the inside of the pump.
- Pump tap water through the inside of the pump to remove all of the detergent solution.
- Pump distilled or deionized water through the pump.

4.3.2 Procedure 2

- The decontaminating solutions can either be pumped from buckets through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol used in the decontamination process be used sparingly and water flushing steps be extended to ensure that any sediment trapped in the pump is flushed out. The outside of the pump and the electrical wires must be rinsed with the decontaminating solutions as well. The procedure is as follows:

  - Flush the equipment/pump with potable water.
  - Flush with non-phosphate detergent solution (i.e., five gallons).
  - Flush with tap water to remove all of the detergent solution.
  - Flush with distilled or deionized water.
  - Flush with isopropyl alcohol.
  - Flush with distilled or deionized water.

4.4 Sample Filtering

Some samples require field filtering within four hours of collection from the well. Filter samples by using a disposable in-line filter housing equipped with a 0.45 micron glass fibre filter. Change filters at each sampling location. Collect the sample water directly into the sample container. It is not necessary to change the filter when collecting duplicate or replicate samples unless the sampling media has a high turbidity and has impaired the flow through the filter.

After the samples have been filtered and placed in appropriate containers, preserve samples as outlined in CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times.

4.5 Chain of Custody

All samples shall be accompanied by an appropriate Chain-of-Custody form at the time of transfer. The procedures for filling out a Chain-of-Custody form, transporting samples, and transferring custody of samples is outlined in CDPHE SOP 4.3, Chain of Custody.

4.6 Sample Labeling

Label all samples according to the methods outlined in CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging.

4.7 Review

The reviewer shall check Exhibits 12A-1, Monitoring Well Sampling Data, for completeness and accuracy. Any discrepancies will be noted and the Exhibits will be returned to the originator for correction. The reviewer will acknowledge that the review comments have been incorporated by signing and dating the "checked by" and "date" blanks on Exhibit 12A-1, Monitoring Well Sampling Data.

5.0 REFERENCES

Scalf, R.D. 1980. "Manual of Groundwater Sampling Procedures." National Water Well Association and the U.S. Environmental Protection Agency (EPA) Robert S. Kerr Environmental Research Laboratory.

U.S. Environmental Protection Agency (EPA). 1991. "A Compendium of ERT Groundwater Sampling Procedures." OSWER Directive 9360.4-06, January 1991. U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency (EPA). 1994. "Groundwater Flow Sampling Procedure for Low Flow Purge and Sampling." U.S. EPA SOP #GW 0001; Region I, August 10, 1994. U.S. Environmental Protection Agency.

CDPHE, 2000. "Quality Assurance Project Plan."

CDPHE, 2000. "Standard Operating Procedure 2, Sample Containers, Preservation, and Maximum Holding Times." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 3, Chain of Custody." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4, Sample Identification, Labeling, and Packaging." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 6, Use and Maintenance of Field Log Books." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 7, Bladder Pump." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 13, Water Level Measurement." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 14, Water Sample Field Measurements." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 12A-1 Monitoring Well Sampling Data

EXHIBIT 12A-1
Monitoring Well Sampling Data

CDPHE	Monitoring Well Sampling Data	
Project Number ______	Project Name:	Page ___ of ___
Well/Borehole Number:_________	Well/Borehole Location:__________________________	Static Water Level:________(ft)

Sample No:____________________________	Elevation: ____________________________
Sampling Method:_______________________	Weather: ______________________________
Bar. Press.______________________	Amb. Temp. ____________________
WATER ELEVATION DATA	
1.) Depth Water Surface:________________________ (From Casing Top as Marked)	Method of Measurement:__________________
2.) Static Water Level Elevation: ____________ (Casing Top Elevation minus 1)	Product obs: ___Yes ___No
3.) Depth to Well Bottom: _________________ (From Casing Top as Marked)	Depth to Product:_________________________
4.) Height of Water Column (h):________________ (3 minus1)	Method of Measurement:_________________
Volume of Water in Well:(x) (h) = __________ (gals) (for 2" x= 0.163 gal/ft for 4" x = 0.653 gal/ft)	
Amount of Water Removed From Well:_________	Was Well Pumped Dry? ___Yes ___No
Method of Water Removal: __________________	Total Volume/Time: ______________________

Time	Temp °C	Conductivity	pH	Turbidity	Removed	Flow Rate	Observations

Recorded By:	Date:	Checked By:	Date:

TECHNICAL STANDARD OPERATING PROCEDURE - 13

WATER LEVEL MEASUREMENT

1.0 PURPOSE

The purpose of this procedure is to describe the methods used for obtaining accurate water level measurements from groundwater monitor wells. This procedure outlines the equipment available for water level measurement and its operation. Site-specific deviations from the methods presented in this procedure must be approved by the CDPHE Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

DNAPL	Dense Non-Aqueous Phase Liquid
LNAPL	Light Non-Aqueous Phase Liquid

3.0 RESPONSIBILITIES

Personnel obtaining water level measurements are responsible for performing the applicable tasks outlined in this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents and data produced during work performance.

4.0 PROCEDURE

4.1 Introduction

Accurate groundwater level measurements are a fundamental requirement of any groundwater characterization study. Groundwater level measurements are used to construct water table maps, to determine gradient, to provide basic data during aquifer testing, to determine permeability and hydrologic conductivity, and to determine purge volume for well development and sampling. Static water levels should be measured before the wells are disturbed by any other sampling or monitoring activities. Water levels, for a group of wells, should be taken within as short a time span as possible to ensure compatible readings. If there is a rush of air in or out of the well when the well cap is removed, take water level readings every two minutes until the water level stabilizes with three consecutive readings within 0.1 foot.

A measuring point is marked on each well casing stickup, either by an impressed mark or paint mark. All measurements should be taken from this measuring point. If a measuring point is not marked, then the water levels should be taken from the north side of the casing stickup. The measuring point used to obtain the water level reading (mark or north side of casing) should be noted in the field log book.

The depth to water and the depth to the bottom of the well, to the nearest 0.1 foot, should be recorded on both the appropriate field form and in the field log book, along with any observation such as field monitoring reading, sediment on bottom, damage to well stickup, etc. Exhibit 13-2, the Water Level Form, is used when the groundwater well is not sampled. Exhibit 13-1, Monitor Well Sample Data, is used when water levels are measured during groundwater sampling activities.

All groundwater level measurements will be taken with an optical/electronic interface probe or electrical water level indicator. Read and follow the specific Manufacturer's Operating Instructions before using any equipment.

4.2 Interface Probe

The following describes an ORS brand interface probe. Read and follow the specific Manufacturer's Operating Instructions before using any type of interface probe.

The interface probe consists of a dual sensing probe utilizing an optical liquid sensor and electrical conductivity probe to distinguish between water and immiscible non-conducting liquids. A coated steel measuring tape graduated in fractions of feet or meters transmits the sensor's signals to a reel assembly, where an audible alarm sounds a continuous tone when the sensor is immersed in immiscible non-conducting liquids and an intermittent tone when immersed in water. The interface probe is accurate to within 0.1 of a foot.

When using the interface probe to measure water levels in wells or sumps containing a floating (LNAPL) or sinking (DNAPL) layer of product, it is necessary to compensate for the effects of differing densities of the product and water. This is accomplished by using the following calculation:

(Immiscible Layer Thickness) (Product Density) + (Water Elevation) = Corrected Water Elevation

Note: An averaged product density for petroleum hydrocarbons (LNAPL) is 0.8.

After the interface probe has been decontaminated as described in Section 4.4, Inspection and Decontamination, it is lowered into the well or sump until an audible alarm is heard. The depth is read from the tape by comparing it with the measuring point. The probe is then lowered until a second alarm is heard (if applicable) indicating the interface level within the well. The probe can then be lowered until it touches the bottom of the well, to determine the height of the water column, and to detect any possible DNAPL. When the product/water interface is reached, the probe should be "jiggled" slightly to ensure that any adhering fluids are removed from the probe to provide the most accurate measurement of the interface. Record these depths in the field log book. Depths may also be recorded in Exhibit 13-2, Water Level Form, or Exhibit 13-1, Monitoring Well Sampling Data.

4.3 Electrical Water Level Indicator

An electrical water level indicator consists of a metallic probe on the end of a steel or plastic tape graduated in fractions of feet or meters. The tape contains wires that transmit the probe's signals to a reel containing an audible alarm or light. The electrical probe is not capable of indicating the presence of an immiscible non-conducting liquid.

The probe is used by lowering it into the well or sump until the alarm activates. The alarm should be tested prior to use. The depth on the tape is then compared with the measuring point and the depth is recorded on Exhibit 13-2, Water Level Form, or Exhibit 13-1, Monitoring Well Sampling Data, and the field logbook. The probe can then be lowered until it touches the bottom of the well to determine the height of the water column.

4.4 Inspection and Decontamination

It is important to check the condition of electrical lines for nicks or breaks before each use. Breaks must be repaired before attempting to use the equipment. Periodically, the scale on the instrument tape should be compared to a tape of known accuracy as stretching of the instrument tape may occur after prolonged use. Personnel using the equipment will perform periodic tape calibration.

All probes and tapes must be decontaminated after each use. The tape will be decontaminated at the beginning of each day and after each use. This is best accomplished as described below:

- Wipe tape with laboratory-grade detergent solution saturated cloth;
- Wipe with distilled water saturated cloth;
- Wipe with methanol saturated cloth; and
- Wipe with distilled water saturated cloth.

Special considerations for the water level indicators are the connections between the tape and probe, which are often "jiggled" up and down at the water surface and LNAPL/water and DNAPL/water interfaces, as well as in sediment on the well bottom. Particles and fluids can lodge in the connections, so special efforts must be made to invasively clean these areas.

Measure water levels in monitoring wells in order of increasing contaminant level, where levels of contamination can be determined. Wells containing immiscible liquids should be measured last.

4.5 Review

The Project Leader or an approved designee shall check Exhibit 13-2, Water Level Form, or Exhibit 13-1, Monitoring Well Sampling Data and/or logbooks, for completeness and accuracy. Any discrepancies will be noted and the Exhibits will be returned to the originator for correction. The reviewer will acknowledge that review comments have been incorporated by signing and dating the "reviewer" and "date" blanks on each Exhibit.

5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1989. Superfund Ground Accuracy of Depth to Water Measurements.

U.S. Environmental Protection Agency (EPA). 1991. "A Compendium of ERT Groundwater Sampling Procedures." OSWER Directive 9360.4-06, January 1991. U.S. Environmental Protection Agency.

CDPHE , 2000. "Standard Operating Procedure 11, Equipment Decontamination." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 13-1	Monitoring Well Sampling Data
Exhibit 13-2	Water Level Form

EXHIBIT 13-1
Monitoring Well Sampling Data

CDPHE	Monitoring Well Sampling Data	
Project Number ______	Project Name:	Page ___ of ____
Well/Borehole Number:___ ___	Well/Borehole Location:____________________	Static Water Level:________(ft)

Sample No:____________________	Elevation: ____________________
Sampling Method:________________	Weather: ____________________
Bar. Press.________________	Amb. Temp. ______________
WATER ELEVATION DATA	
1.) Depth Water Surface:________________ (From Casing Top as Marked)	Method of Measurement:______________
2.) Static Water Level Elevation: __________ (Casing Top Elevation minus 1)	Product obs: ___Yes ___No
3.) Depth to Well Bottom: ______________ (From Casing Top as Marked)	Depth to Product:__________________
4.) Height of Water Column (h):____________ (3 minus1)	Method of Measurement:______________
Volume of Water in Well:(x) (h) = __________ (gals) (for 2" x= 0.163 gal/ft for 4" x = 0.653 gal/ft)	
Amount of Water Removed From Well:________	Was Well Pumped Dry? __Yes __No
Method of Water Removal: ______________	Total Volume/Time: __________________

Time	Temp °C	Conductivity	pH	Turbidity	Removed	Flow Rate	Observations

Recorded By:	Date:	Checked By:	Date:

EXHIBIT 13-2
Water Level Form

Project Number	Project Name		Page ___ of ___
Well	Location		
Ground Elevation (ft.) (msl)	Measuring Point Elevation (ft.) (msl)	Stickup (ft.)	

Date								
OVA/OVM (headspace)								
Elevation of Measuring Point (ft.msl)(+)								
Depth to Product, (ft.)(+)								
Depth to Water (ft.)(-)								
Water Table Elevation (ft.msl)(=)								
Depth to Bottom (ft.)(+)								
Comment								
Recorded By								

Reviewed By	Date	Checked By	Date

STANDARD OPERATING PROCEDURE - 14

WATER SAMPLE FIELD MEASUREMENTS

1.0 PURPOSE

This procedure outlines the types of measurements and data requirements associated with the collection of either groundwater or surface water samples. Accurate measurement of water parameters is required when collecting water samples so that baseline conditions can be established, thus allowing later evaluations of how these parameters may have affected the sample results.

Site-specific deviations from the methods presented in this procedure must be approved by the Project Leader and the CDPHE Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

Not applicable.

3.0 RESPONSIBILITIES

Sampling personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURE

Read and follow the specific Manufacturer's Operating Instructions before using any equipment.

Calibrate all equipment as specified below. Additionally, calibrate all equipment prior to and at the commencement of sampling activities to ensure proper equipment operation. Record these measurements in the field log book or in an instrument log book.

4.1 Temperature

- Decontaminate the thermometer according to CDPHE Standard Operating Procedure (SOP) 4.11, Equipment Decontamination. Calibrate electronic thermometers (if applicable) according to their manufacturer's specifications.

- Collect the sample in a clean flask or beaker and insert the temperature probe into the water as per the manufacturer's specifications.

- Read the temperature from the meter and record it in the field log book and on either Exhibit 14-1, Monitoring Well Sampling Data, or Exhibit 14-2, Surface Water Sampling Data.

- Discard the sample and rinse the probe with distilled water.

4.2 pH

- The pH probe must be thoroughly decontaminated prior to use according to CDPHE SOP 4.11, Equipment Decontamination. Calibrate the pH meter according to the manufacturer's specifications.

- Collect the sample in a clean flask or beaker and insert the pH probe into the water according to the manufacturer's specifications.

- Read the pH measurement from the meter approximately one minute from the time the sample was collected and record it in the field log book and on either Exhibit 14-1, Monitoring Well Sampling Data, or Exhibit 14-2, Surface Water Sampling Data.

- Discard the sample and decontaminate the probe.

4.3 Conductivity

- The conductivity probe must be thoroughly decontaminated prior to use according to CDPHE SOP 4.11, Equipment Decontamination. Calibrate the conductivity meter according to the manufacturer's specifications.

- Collect the water sample in a clean flask or beaker and insert the conductivity probe into the water according to the manufacturer's specifications.

- Wait for the reading to stabilize and record the conductivity reading from the meter in the field log book or on either Exhibit 14-1, Monitoring Well Sampling Data or Exhibit 14-2, Surface Water Sampling Data. Check the conductivity meter settings to be sure the desired scale is being used.

- Discard the sample and decontaminate the electrode.

4.4 Dissolved Oxygen Measurement

- Decontaminate the dissolved oxygen meter according to the manufacturer's specifications. Because the probe membrane is very fragile and susceptible to dryness, keep it moist at all times.

- Calibrate the dissolved oxygen meter according to the manufacturer's specifications. At a minimum, calibrate twice daily to correct for instrument drift.

- Collect the water sample as close to the source as possible and place it in a clean flask or beaker.

- Insert the dissolved oxygen probe into the sample so that the membrane is fully submerged. Very gently stir the probe through the sample. Do not agitate the probe as air bubbles cause erroneous measurements.

- When the reading stabilizes, record it in the field log book and on either Exhibit 14-1, Monitoring Well Sampling Data, or Exhibit 14-2, Surface Water Sampling Data.

- Discard sample and decontaminate the probe.

4.5 Review

The Project Leader or an approved designee shall check the field log book as well as Exhibit 14-1, Monitoring Well Sampling Data, or Exhibit 14-2, Surface Water Sampling Data, for completeness and accuracy. Any discrepancies will be noted and the data will be returned to the originator for correction. The reviewer will acknowledge that review comments have been incorporated by signing and dating the "checked by" and "date" blanks on Exhibit 14-1, Monitoring Well Sampling Data, or Exhibit 14-2, Surface Water Sampling Data.

5.0 REFERENCES

U.S. Geological Survey (USGS). 1984. National Handbook of Recommended Methods for Water-Data Acquisition.

CDPHE, 2000. "Standard Operating Procedure 4.11, Equipment Decontamination." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 14-1	Monitoring Well Sampling Data
Exhibit 14-2	Surface Water Sampling Data

EXHIBIT 14-1
Monitoring Well Sampling Data

CDPHE	**Monitoring Well Sampling Data**	
Project Number ______	Project Name:	Page ___ of ___
Well/Borehole Number:_________	Well/Borehole Location:_____________________________	Static Water Level:_________(ft)

Sample No:______________________________	Elevation: ______________________________
Sampling Method:_________________________	Weather: _______________________________
Bar. Press.______________________	Amb. Temp. ____________________
WATER ELEVATION DATA	
1.) Depth Water Surface:__________________________ (From Casing Top as Marked)	Method of Measurement:___________________
2.) Static Water Level Elevation: _____________ (Casing Top Elevation minus 1)	Product obs: __Yes __No
3.) Depth to Well Bottom: __________________ (From Casing Top as Marked)	Depth to Product:__________________________
4.) Height of Water Column (h):__________________ (3 minus1)	Method of Measurement:________________
Volume of Water in Well:(x) (h) = __________ (gals) (for 2" x= 0.163 gal/ft for 4" x = 0.653 gal/ft)	
Amount of Water Removed From Well:_________	Was Well Pumped Dry? __Yes __No
Method of Water Removal: __________________	Total Volume/Time: ________________________

Time	Temp °C	Conductivity	pH	Turbidity	Removed	Flow Rate	Observations

Recorded By:	Date:	Checked By:	Date:

EXHIBIT 14-2
Surface Water Sampling Data

CDPHE	**Surface Water Sampling Data**	
Project Number ______	Project Name:	Page ___ of ____

Sample No:______________________________	Elevation: ______________________________
Sampling Method:_________________________	Weather: _______________________________
Bar. Press._______________________	Amb. Temp. __________________
WATER SAMPLE DATA	
Water Temp: ______oC	Method of Measurement: __________________
Specific Conductance:	Method of Measurement: __________________
pH:	Method of Measurement:__________________

Containers Used (VOA Vial, 1 liter jar etc...): ____

Physical Appearance: ____

Contamination Observed: ____

Remarks: ____

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Recorded By:	Date:	Checked By:	Date:

STANDARD OPERATING PROCEDURE - 15

FLOW MEASUREMENT

1.0 PURPOSE

This procedure provides general guidance for the planning, method selection, and implementation of surface flow measurements for environmental field investigations that require information on flows for streams, rivers, or surface impoundments.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Flow (or Volumetric Flow Rate): The volume of water that passes through a cross-sectional plane of a channel in some unit of time.

Flow Measurement: The act or process of quantifying a flow rate.

2.2 Abbreviations

CFS	Cubic feet per second
gpm	Gallons per minute
SOP	Standard Operating Procedures
USGS	U.S. Geological Survey

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and procedures.

4.0 PROCEDURES

4.1 General Considerations

The planning and implementation of flow measurements requires consideration of the data collection requirements. The accuracy and precision required of the flow measurement will determine the methodology employed in the field. Local site conditions, i.e., site access, stream bed geometry and apparent flow rate, will determine how field procedures must be modified to obtain accurate and precise data.

The two major variables that are determined during flow measurements are:

- The geometry of the cross-sectional plane through which the fluid passes; and
- The velocity at which the fluid is moving through a particular cross section.

These variables are discussed in Section 4.2, General Methods and Applications.

The two major factors that cause variance in flow measurements are:

- The variations in technical procedures introduced by the operator; and
- The variations in fluid flow introduced by turbulence.

The variations in technical procedures introduced by the operator can be minimized by carefully following the procedures outlined in this Standard Operating Procedure (SOP).

The variance in flow measurement caused by fluid turbulence can be reduced by applying the following procedures. The more turbulent the flow the less accurate and reproducible the flow results.

- Do not stand upstream or beside the flow measuring device and stand far enough downstream of the device so that no turbulence affects the device.
- Avoid areas just downstream of a waterfalls, rapids, weir, sluice, dam, or any other structure that creates flow turbulence.
- Avoid areas of the stream that have rocky bottoms, stepping stones, wetlands vegetation in the stream bed or braided channels caused by sandbars.

The more turbulent the flow the less accurate and reproducible the flow results. The ideal location has easy access, with uniform stream banks that are not obstructed by vegetation or debris and a uniform stream bed that is that is also free of vegetation and debris.

Health and safety considerations are also important factors to be considered in planning and execution of flow measurements. Some of these considerations are:

- Accessibility of the site, i.e., bank steepness or obstacles;
- Depth of the fluid to be measured;
- Apparent flow rate of the fluid to be measured;

- Condition of the steam bed, i.e., slipperiness, obstructions, debris, vegetation, etc.; and

- Proximity of downstream structures such as dams, weirs, sluices, rapids and waterfalls.

4.2 General Methods and Applications

Selection and implementation of flow measurement practices require that consideration be given to the following issues which are common to all surface flow measurements at or near environmental sites:

- Preventing the spread of contamination;
- Minimizing the risk to health and safety;
- Maintaining a high level of accuracy in measuring flows;
- Causing the least possible disruption to on-site activities; and
- Reducing, where possible, any additional long- and short-term impacts.

Flow measurements are made in open channels that consist of a bed, two banks or sides, and a free or open water surface.

Most flow measurements are based on determining two key variables cited in Subsection 4.1: cross-sectional area and velocity across that area. For open channels, especially smaller ones, the cross section is often best measured directly using a tape. Care must be taken to find a location where the dimensions are constant during the time period in which flow measurements will be taken. Width and depth are expressed in terms of meters or feet, and the cross-sectional area is expressed as square meters or square feet.

Velocity is determined using one of the methods that follows, either directly or by calculation. Units are commonly given in meters per second or feet per second for most flow velocities. When cross-sectional area and flow velocity are multiplied, their product is the volumetric flow rate expressed as cubic meters per second or cubic feet per second (CFS) for large flows, and as liters per second or gallons per minute for small flows.

4.3 Direct Measurement

At times, the flow in a small stream can be caught in a collector of known volume, such as a 5-gallon can or 55-gallon drum. By clocking the amount of time needed to fill the vessel, one may obtain a direct measurement of volumetric flow rate without resorting to cross-sectional area and velocity measurements. A minimum of 10 seconds to fill the container is recommended. Several fill-ups should be timed, and the results should be averaged to improve the quality of this measurement. Other means of flow measurement will be used more often than this direct estimate, which is valid only for flows between 0.06 liter per second (one gallon per minute (gpm)) and about 6.3 liters per second (100 gpm).

4.4 Current Meter

A current meter can be a mechanical device with a rotating element that, when submerged in a flowing stream, rotates at a speed proportional to the velocity of the flow at that point below the surface. The rotating element may be either a vertical shaft or a horizontal shaft. Meter manufacturers usually provide the user with calibration tables to translate rotation into linear speed in meters per second or feet per second.

Current meters can also be electromagnetic sensors where the passage of fluids between two electrodes in a bulb-shaped probe causes a disturbance of the electromagnetic field surrounding the electrodes. This disturbance generates a small voltage that can be made proportional to fluid velocity by internal electronic circuitry. A direct readout of velocity in meters per second or feet per second is provided for the user (Marsh-McBirney undated).

4.4.1 Applicability

Vertical axis meters are more commonly used because they are simpler, more rugged, and easier to maintain than horizontal shaft meters. They also have a lower threshold velocity of 0.03 meters/sec (0.1 feet/sec). The electromagnetic current meters can be used in making measurements in situations where mechanical meters cannot function, such as weedy streams where mechanical rotating elements would foul. However, the electromagnetic meters must always be carefully aligned to be normal to the stream cross section, since the meter measures only one velocity vector (the one parallel to the probe's longitudinal axis). Current meters will operate at depths ranging from 0.1 meter (0.3 foot) to any depth where the meter can be held rigidly in place using cables or extension poles. For most environmental investigations, depths rarely exceed two or three meters (6.5 to 10 feet). Since current meters provide readings at a single point, the mean velocity must be based on multiple readings along a vertical line, or on a single reading that can be converted to an estimated mean velocity using standard coefficients.

In many areas, the flow of waterways is monitored by local agencies. An effort should be made to incorporate flow readings from established gauge stations. At many locations, readings will be accurate and easy to obtain.

Methods for estimating mean velocity include the following:

- Six-tenths Depth Method - Uses the observed velocity at a point 0.6 of the total depth below the surface as the mean velocity for the vertical. Flow is calculated for each subsection defined by the verticals and is the product of the depth times the mean velocity for that subsection. Total discharge flow is the sum of all individual subsection flows, while the average stream velocity is that sum (total discharge) divided by the total cross-sectional area. The number of readings to be taken to increase accuracy will depend on the width of the stream, from 2 or 3 readings for streams less than 5 feet across to 15 to 25 readings for streams wider than 50 feet across. Ideally, the stream should be partitioned into sections small enough so that less than 10 percent of the total stream flow passes through each section. In this manner, individual measurements that may be in error will have less impact on the overall average velocity determination. However, practical consideration, such as a rapidly changing stage or limited time available to conduct measurements, often may preclude the use of the ideal number of partial sections. Users must recognize the potential impact on the overall accuracy of velocity measurements from an inadequate number of verticals within a given cross section. This method works best at depths between 0.09 and 0.16 meters (0.3 to 2.5 feet) and is the method of choice when measurements must be made quickly.

- Two-point Method - Measures velocities at 0.2 and 0.8 of the total depth below the surface. The average of the two readings is considered to be the average for the vertical. Several different verticals are averaged across the cross section. This method is more accurate than the six-tenths depth method, but it cannot be used at depths less than 0.76 meters (2.5 feet) because the observation points would be too near the surface and the streambed.

- Three-point Method - Measures velocities at 0.2, 0.6, and 0.8 of the total depth below the surface. Readings at 0.2 and 0.8 are averaged; then that result is averaged with the reading at 0.6. This method provides a better mean value when velocities in the vertical are abnormally distributed, but it should not be used at depths less than 0.76 meters (2.5 feet).

- Vertical-velocity Method - Primarily for deep channels, this method measures velocities at 0.1 depth increments between 0.1 and 0.9 of the total depth for several verticals. Because of the multiplicity of readings, this method is rarely used.

4.4.2 Current Meter Methods

A step-by-step summary of a typical flow or discharge measurement is as follows:

- Assemble current meter and test for proper operation in accordance with the manufacturer's instructions. Collect data form or notebook, pencil, stopwatch, 50-foot tape, etc.

- Partition stream into sections (with tag line or bridge railing), visually observing the velocity and general flow of the stream. An adequate number of stations should be established to prevent more than 10 percent of the total discharge from passing through any individual partial section. Note that the partial section in question is<u>not</u> the same as the interval between two successive stations. Mark stations appropriately. A check of measurements may indicate the need for readjustment of the partitioned sections to upgrade the quality of the readings.

- Record stream stage as indicated by one of the staff gauges, and record this value on the water level recorder chart at the point of pen contact.

- Record the following items and other data as appropriate in the field log book and on Exhibit 15-1, Surface Water Flow Measurement:
  - Project;
  - Site;
  - Date;
  - Time at start of measurements;
  - Stream stage at start of measurements;
  - Approximate wind direction and speed;
  - General stream condition (e.g., turbid, clear, low level, floating debris, water temperature, type of streambed material, etc.);
  - Other factors having a bearing on discharge measurements;
  - Location of initial point;
  - Total width of stream to be measured;
  - Type of current meter and conversion factor, if applicable; and
  - Name of investigator taking the readings.
- Determine the depth and mean velocity at the first station or "initial point," if appropriate, and record this information.
- Measure depth at the second station from initial point and record. Determine whether the velocity should be measured at the 0.6 depth from the surface (six-tenths depth method), at the 0.2 and 0.8 depths (two-point method), or by either of the other methods available. Calculate respective depths from the surface, measure the velocity at each point, and record these values.
- Follow the same method at each successive station and proceed as quickly as possible.
- Determine the depth and mean velocity at the last station, or endpoint, and record in the field log book and on Exhibit 15-1, Surface Water Flow Measurement.

- Record in the field log book and on Exhibit 15-1, Surface Water Flow Measurement, the ending time of this series of measurements and the stage, since the stage may have been changing during the measurements.

- Enter the ending stage value on the recorder chart at the point of pen contact. This information will illustrate the interval of time and stage variations during the cross-sectional measurements. also enter the date in the field log book and on Exhibit 15-1, Surface Water Flow Measurement, and indicate that a calibration has taken place over this interval.

- Remove the tag line (if used); rinse the current meter in clean water, if necessary; allow the current meter to dry; then pack it in its carrying case.

Other issues of concern regarding stream discharge calibrations include:

- Where practical, make the measurements with the investigator standing behind (downstream) and well to the side of the meter;

- Avoid disturbing or standing along the streambed beneath the cross-sectional measuring points. This location is part of the control area and should remain constant, if possible, from calibration to calibration of the stream. This step is especially important if soft, mucky sediment is encountered somewhere along the cross section;

- Where possible, attempt to use the same cross section (location) throughout the study period and during all of the stream calibrations. However, the number and position of stations within the cross section may be changed, if necessary, to accommodate changing flow conditions;

- Hold the wading rod vertically if it becomes necessary to switch meters during a calibration, and ascertain how V_{NORM} is determined with each of the various types of meters;

- Repeat the stream calibration at regular intervals throughout the study period to account for seasonal changes in stream bank vegetation and streambed alterations that may affect measurements.

Once the mean velocity for each stream subsection is determined, that value is multiplied by the area of the subsection; the product is the volumetric flow through the subsection per unit of time. The total discharge rate is the sum of all volumetric flows for each subsection across the entire cross section of the stream. Refer to U.S. Geological Survey (USGS) Water Supply Paper 2175 for additional information (U.S. Geological Survey (USGS) 1982). Customary units are CFS for large flows and liters per second (gallons per minute) for small flows.

4.5 Current Meters and Stage Gauges

Where repeated measurements of a volumetric flow rate at a certain cross-sectional area are required, install a permanent stage gauge along the stream's back or side wall to facilitate measurement of the depth. The gauge will be a rigid rod or board, precisely graduated and firmly mounted with the streambed serving as a possible reference point. Where stream characteristics are such that significant bed erosion from scouring may be expected, it is best not to set the streambed as a zero point. This could lead to confusion from generation of negative numbers for gauge height readings. An arbitrary datum plume should be selected that is below the elevation of zero flow expected for the stream site. Gauges may be mounted vertically (perpendicular to the stream surface) or may incline along the slope of the stream bank. Vertical gauges are simpler to construct and calibrate, while inclined gauges provide more accurate readings and are less likely to be damaged by material floating by. The gauge provides one of the measurements needed to estimate area. Width is fixed for channels with vertical sides and are readily determined for other configurations. Velocity is determined using a current meter as described above.

Discharge rating curves are used to define the relationship between stage and stream discharge, and to allow conversion of stage hydrographs to discharge hydrographs. The discharge calibration points are hand or machine plotted onto a log-log paper graph of stage versus stream discharge. Stream stage is plotted on the vertical Y axis, and stream discharge is plotted on the horizontal X axis. Ideally, adequate calibrations are conducted over the full range of stage variations to allow a smooth curve to be hand drawn through these points on the graph.

The slope and rate of change of slope may vary significantly over the length of this curve. At certain gauging stations, the slope of this curve may break sharply, or the distribution of points may require the construction of two partial curves rather than one continuous curve. These latter two situations apply to more complex stage discharge relationships. It is the task of the investigator to derive a mathematical relationship that describes this curve as closely as possible (i.e., an equation). The development of an equation allows calculation of discharge flow by simply plugging in the stream elevation. This equation allows computerization of the process of converting stage records into discharge and eventually allows conversion to volume by noting the time interval on the recorder chart at which this rate of flow applies.

More complicated rating relationships may be required at a particular gauging station. Discharge may be not only a function of stage but also a function of slope, rate of change of stage, or other variables specific to each site. Additionally, stage-discharge relationships are rarely permanent, and discharge calibrations are carried out at periodic intervals to define the effects of various factors including the following:

- Scouring and deposition of sediment;
- Alteration of streambed roughness as a result of the creation and dissemination of dunes, anti-dunes, ripples, and standing-wave features in sandy bottoms; the deposition of leaves and other debris during different seasons; and the seasonal variation in the growth of macrophytes;

- Ice effects that may cause additional resistance to flow (if monitoring is carried out during the colder months, a complete ice-over and additional freeze will tend to constrict the stream channel with time and may increase the stage, when in fact the flow may not be increasing at all); and

- Human-related activities, such as upstream construction, recreation, etc.

4.5.1 Applicability

This method applies to sites where many flow measurements will be made over a long period of time. Care must be taken to maintain a known zero reference point elevation. The point does not have to be the stream's bottom. Where bed erosion over the course of flow measurements may become a problem, provisions must be made to recalibrate the gauge at regular intervals (e.g., weekly). The gauge is lowered or raised as necessary to conform with changing bed conditions. Calculation of flow rate is the same as in the preceding subsection for current meters alone.

4.6 Review

The Project Leader or an approved designee shall check Exhibit 15-1, Surface Water Flow Measurement, for completeness and accuracy. Any discrepancies in the data will be noted and the Exhibits will be returned to the originator for correction. The reviewer will acknowledge that review comments have been incorporated by signing and dating the "Checked By" and "Date" blanks on Exhibit 15-1, Surface Water Flow Measurement.

5.0 REFERENCES

Marsh-McBirney, Inc. "Instruction Manual, Model 201 Portable Water Current Meter." Gaithersburg, Maryland: Marsh-McBirney, Inc. Undated.

U.S. Department of Interior. "Measurement and Computations of Streamflow: Volumes 1 and 2." Geological Survey Water Supply Paper 2175. Washington, DC: USDA. 1982.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." EPA/540/P-87/001. (OSWER Directive 9355.0-14.) December 1987.

U.S. Geological Survey (USGS). 1982. Water Supply Paper 2175.

6.0 EXHIBITS

Exhibit 15-1	Surface Water Flow Measurement

EXHIBIT 15-1
Surface Water Flow Measurement

CDPHE Colorado Dept of Public Health and Environment	Surface Water Flow Measurement	Records Management Data

Date	Project Name:	Site:

Flow Measurement Method
Flow Meter

Gauging/Sample Location:
Channel Description:
Stream Width:
Measurement Filtering Method: Fixed Point Averaging (FPA)
FDA Interval: ___ seconds
Logbook Pages:

Distance from Initial Point (ft.)	Meter Height (%)	Width of Measurement Interval (ft.)	Depth of Water (ft.)	Area (ft^2)	Velocity (ft/sec)	Discharge (CFS)

Recorded By:	Date:	Checked By:	Date:

STANDARD OPERATING PROCEDURE - 16

SURFACE AND SHALLOW DEPTH SOIL SAMPLING

1.0 PURPOSE

The purpose of this procedure is to describe the equipment and operations used for sampling surface and shallow depth soils. This procedure outlines the methods for soil sampling with routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the Project Leader and the CDPHE Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Soil: All unconsolidated materials above bedrock.

Surface Soils: Soils located zero to six inches below ground surface.

Shallow Depth Soils: Soils located above the bedrock surface and from six inches to six feet below ground surface.

2.2 Abbreviations

POC	Purgeable organic compound
POX	Purgeable organic halogens
PRP	Potentially Responsible Party
SVOC	Semivolatile organic compounds
TOC	Total organic carbon
TOX	Total organic halogens
SOP	Standard Operating Procedure
CDPHE	Colorado Department of Public Health and Environment
VOC	Volatile organic compound

3.0 RESPONSIBILITIES

Sampling personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for ensuring that performance standards specified by this SOP are achieved. This will be accomplished by reviewing all documents, exhibits and field procedures.

4.0 PROCEDURES

4.1 Introduction

The objective of surface and shallow depth soil sampling is to ascertain the type, degree, and extent of soil contamination at a site. The data can be used to evaluate potential threats to human health or the environment, to evaluate potential exposure pathways, or to calculate environmental risks.

4.2 Sampling Equipment

Surface and shallow soil sampling equipment includes:

- Stainless steel mixing bowl;
- Stainless steel trowels or spoons;
- Stainless steel hand auger;
- Stainless steel core sampler which uses stainless steel or Lexan® liners (optional);
- Stainless steel shovel; and
- Appropriate sample containers.

4.3 Decontamination

Before initial use, and after each subsequent use, all sampling equipment must be decontaminated using the procedures outlined in CDPHE Standard Operating Procedure (SOP) 4.11, Equipment Decontamination.

4.4 Sampling Location/Site Selection

Follow the sample design criteria outlined in the Project Plan for each sampling event. Relocate the sample sites when conditions dictate - such as natural or artificial obstructions at the proposed sample location (e.g., boulders, asphalt, etc.). Document the actual sample locations on a topographic map or site sketch and photograph all sample locations.

4.5 Sampling Approaches

It is important to select an appropriate sampling approach for accurate characterization of site conditions. Prior to undertaking any soil sampling program, it is necessary to establish appropriate measurement and system Data Quality Objectives. Refer to the U.S. Environmental Protection Agency (EPA) Soil Sampling Quality Assurance User's Guide (listed in Section 5.0, References) for guidance in establishing Data Quality Objectives, statistical sampling methodologies and protocols for each of the sampling approaches. Each approach is defined below.

4.5.1 Judgmental or Biased Sampling

Judgmental or Biased sampling is used primarily for documenting an observed release to either the groundwater, surface water, air or soil exposure pathways. This form of sampling is based on the subjective selection of sampling locations where contamination is most likely to occur. Locations are based on relative historical site information and on-site investigation (site walk-over) where contamination is most likely to occur.

There is no randomization associated with this sampling approach because samples are primarily collected at areas of suspected highest contaminant concentrations. Any statistical calculations based on the results of this sampling technique will be biased.

4.5.2 Random Sampling

Random sampling, used for the characterization of a heterogeneous non-stratified waste, involves arbitrary collection of samples within a defined area. This method is most effective and accurate if the chemical heterogeneity of the waste remains constant from batch to batch. The easiest method for Random Sampling is to divide the area for sampling into an imaginary grid, assign a series of numbers to the units of the grid, and select the numbers or units to be sampled through the use of a random-numbers table which can be found in the text of any basic statistics book. Note that haphazardly selecting sample numbers or units is not a suitable substitute for a randomly selected sample. Refer to Exhibit 16-1, Figure 1 for the random sampling approach.

4.5.3 Stratified Random Sampling

Stratified random sampling, used for the characterization of a heterogeneous stratified waste, involves arbitrary collection of samples within a defined area and strata. This method is most effective and accurate if the chemical heterogeneity of the waste remains constant from batch to batch. The easiest method for stratified random sampling is to divide the area for sampling into an imaginary grid, assign a series of numbers to the units of the grid, and select the numbers or units to be sampled through the use of a random-numbers table which can be found in the text of any basic statistics book. A random sample is then collected from each strata at the selected numbers or units on the grid. Note that haphazardly selecting sample numbers or units is not a suitable substitute for a randomly selected sample. Refer to Exhibit 16-1, Figure 1 for the random sampling approach. Exhibit 16-1, Figure 2 illustrates a stratified random sampling approach.

4.5.4 Systematic Grid Sampling

Systematic grid sampling involves dividing the area of concern into smaller sampling areas using a square or triangular grid. Samples are then collected from the intersection of the grid lines or "Nodes." The origin and direction for placement of the grid should be selected by using an initial random point. The distance between nodes is dependent upon the size of the site or area of concern and the number of samples to be collected. Generally, a larger distance is used for a large area of concern. Refer to Exhibit 16-1, Figure 3 for the systematic grid sampling approach.

4.5.5 Systematic Random Sampling

Systematic random sampling involves dividing the area of concern into smaller sampling areas. Samples are collected within each individual grid cell using random selection procedures. Exhibit 16-1, Figure 4 illustrates a systematic random sampling approach.

4.5.6 Search Sampling

Search sampling utilizes a systematic grid or systematic random sampling approach to define areas where contaminants exceed clean-up criteria. The distance between the grid lines and number of samples to be collected are dependent upon the acceptable level of error (i.e., the chance of missing a hot spot). This sampling approach requires that assumptions be made regarding the size, shape, and depth of hot spots. Exhibit 16-1, Figure 5 illustrates a search sampling approach.

4.5.7 Transect Sampling

Transect sampling involves establishing one or more transect lines, parallel or non-parallel, across the area of concern. If the lines are parallel, this sampling approach is similar to systematic grid sampling, The advantage of transect sampling over systematic grid sampling is the relative ease of establishing and relocation transect lines versus an entire grid. Samples are collected at regular intervals along the transect line at the surface and/or at a specified depth(s). The distance between the sample locations is determined by the length of the line and the number of samples to be collected. Refer to Exhibit 16-1, Figure 6 for the transect sampling approach.

4.6 General

All boreholes and pits will be filled in with the material removed during sampling unless otherwise specified in the Project Plan. Where a vegetative turf has been established, fill in with native soil or potting soil and replace the turf if practical in all holes or trenches when sampling is completed.

4.6.1 Homogenizing Samples

Homogenizing is the mixing of a sample to provide a uniform distribution of the contaminants. Proper homogenization ensures that the containerized samples are representative of the total soil sample collected. All samples to be composited or split should be homogenized after all aliquots have been combined. **DO NOT HOMOGENIZE (MIX OR STIR) SAMPLES FOR VOLATILE COMPOUND ANALYSIS.**

4.6.2 Compositing Samples

Compositing is the process of physically combining and homogenizing several individual soil aliquot of the same volume or weight. Compositing samples provides an average concentration of contaminants over a certain number of sampling points.

4.6.3 Splitting Samples

Splitting samples (after preparation) is performed when multiple portions of the same samples are required to be analyzed separately. Fill the sample containers for the same analyses one after another in a consistent manner (i.e., fill EPA volatile organic compound (VOC) container, fill Potentially Responsible Party's (PRP) VOC container, fill EPA semivolatile organic compounds (SVOC) container, fill PRP SVOC container).

4.7 Surface Soil Sampling

Perform the following steps for surface soil sampling:

- Prior to sampling, remove leaves, grass, and surface debris using decontaminated stainless steel trowel;

- Label the lid of the sample container with an indelible pen or affix the sample label to the side of the jar and tape as to make it impervious to water prior to filling the container with soil.

- Collect surface soil samples with a decontaminated stainless steel trowel, spoon or hand auger and transfer to a decontaminated stainless steel bowl for homogenizing. If VOC analyses are to be conducted, fill the appropriate VOC sample containers and then proceed to transfer the appropriate aliquot of soil to the decontaminated stainless steel bowl for homogenizing;

- Collect samples in the order of volatilization sensitivity. The most common collection order is as follows:

  - Volatile organic compounds (VOC);
  - Purgeable organic carbon (POC);
  - Purgeable organic halogens (POX);
  - Total organic halogens (TOX);
  - Total organic carbon (TOC);
  - Extractable organics;
  - Total metals;
  - Dissolved metals;
  - Phenols;
  - Cyanide;
  - Sulfate and chloride;

    - Turbidity;
    - Nitrate and ammonia; and
    - Radionuclides.

- Immediately transfer the sample into a container appropriate to the analysis being performed (CDPHE SOP 4.2, Sample Preservation, Containers and Maximum Holding Times);

- Place the samples in a cooler with ice which must be maintained at approximately 4°C (if appropriate for analyses) for transport to an analytical laboratory;

- Immediately after the sample is collected, record applicable information in the field log book as outlined in CDPHE SOP 4.6, Use and Maintenance of Field Log Books. This information may also be entered on Exhibit 16-2, Surface/Shallow Soil Sampling Log.

- Excess soil sample media shall be placed in the soil boring or pit and filled to grade with native soil or potting soil.

- Decontaminate all sampling equipment (CDPHE SOP 4.11, Equipment Decontamination); and

- Complete the Chain-of-Custody Record and associated documentation (CDPHE SOP 4.3, Chain of Custody).

4.8 Surface Soil Sampling (Composite Samples Only)

Perform the following steps for surface soil (composite) sampling:

- Prior to sampling, remove leaves, grass, and surface debris using decontaminated stainless steel trowel;

- Collect surface soil aliquots with a decontaminated stainless steel spoon, trowel or hand auger and add to a stainless steel bowl and homogenize. Prior to homogenizing, remove an aliquot for VOC analysis (if appropriate) and then homogenize;

- Samples will be identified and label as per CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging;

- Samples will be preserved and held as per CDPHE SOP 4.2, Sample Containers, Preservation and Maximum Holding Times;

- Complete the Chain-of-Custody Record and associated documentation (CDPHE SOP 4.3, Chain of Custody).

- Record applicable information in the field log book as outlined in CDPHE SOP 4.6, Use and Maintenance of Field Log Books. This information may also be entered on Exhibit 16-2, Surface/Shallow Soil Sampling Log.

- Decontaminate all sampling equipment (CDPHE SOP 4.11, Equipment Decontamination).

4.9 Shallow Depth Soil Sampling

Perform the following steps to collect shallow depth soil samples:

- Use a decontaminated stainless steel shovel to remove the top layer of soil.

- Remove leaves, grass, and surface debris that may have contacted the shovel using a decontaminated stainless steel trowel;

- Excavate soil to the pre-determined sampling depth by using a decontaminated hand auger. Periodically, remove the cuttings from the auger;

- When the proper sample depth is reached, remove the hand auger and all cuttings from the hole;

- Lower the decontaminated core sampler or hand auger to the bottom of the hole. When using a core sampler, it must contain a decontaminated liner appropriate for the constituents to be analyzed;

- Mark the sample interval (i.e., one foot above ground level) on the hammer stem or auger;

- Operate the slide hammer on the core sampler to drive the sampler head into the soil, or advance the auger until it is flush with the interval mark at ground level;

- Record weight of hammer, length of slide, blow counts and geologic soil data for all samples collected with a core sampler in the field log book as outlined in CDPHE SOP 4.6, Use and Maintenance of Field Log Books. This information may also be entered on Exhibit 16-2, Surface/Shallow Soil Sampling Log;

- When the core sampler liner or auger has been advanced the total depth of the required sample, remove it from the bottom of the hole;

- Immediately remove the liner from the core sampler and transfer the sample into a container or stainless steel bowl for compositing and homogenizing as specified in the project-specific Field Sampling Plan appropriate to the analysis being performed using a stainless steel spoon or trowel. Prior to compositing and homogenizing, fill the appropriate aliquot for VOC analysis (if conducted) and then composite and homogenize;

- Samples will be identified and label as per CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging;

- Samples will be preserved and held as per CDPHE SOP 4.2, Sample Containers, Preservation and Maximum Holding Times;

- Complete the Chain-of-Custody Record and associated documentation (CDPHE SOP 4.3, Chain of Custody).

- Record applicable information in the field log book as outlined in CDPHE SOP 4.6, Use and Maintenance of Field Log Books. This information can also be entered on Exhibit 16-2, Surface/Shallow Soil Sampling Log.

- Decontaminate all sampling equipment (CDPHE SOP 4.11, Equipment Decontamination).

4.10 Abandonment Procedures

Abandon boreholes and fill to grade by filling in with the material removed for sampling or clean fill (i.e., potting soil).

4.11 Review

The Project Leader or an approved designee shall check all Exhibits and field log books used to record information during sampling for completeness and accuracy. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the "checked by" and "date" blanks on the Exhibits and at the applicable places in the log book.

5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1989. "Soil Sampling Quality Assurance User's Guide." EPA/600/8-89/046, U.S. Environmental Protection Agency, Washington, DC.

CDPHE. 2000. "Standard Operating Procedure 1, Use and Maintenance of Field Log Books." Standard Operating Procedures.

CDPHE. 2000. "Standard Operating Procedure 2, Sample Preservation, Containers, and Maximum Holding Times." Standard Operating Procedures.

CDPHE. 2000. "Standard Operating Procedure 3, Chain of Custody." Standard Operating Procedures.

CDPHE. 2000. "Standard Operating Procedure 4, Sample Identification, Labeling, and Packaging." Standard Operating Procedures.

CDPHE. 2000. " Standard Operating Procedure 5, Sample Location Documentation." Standard Operating Procedures.

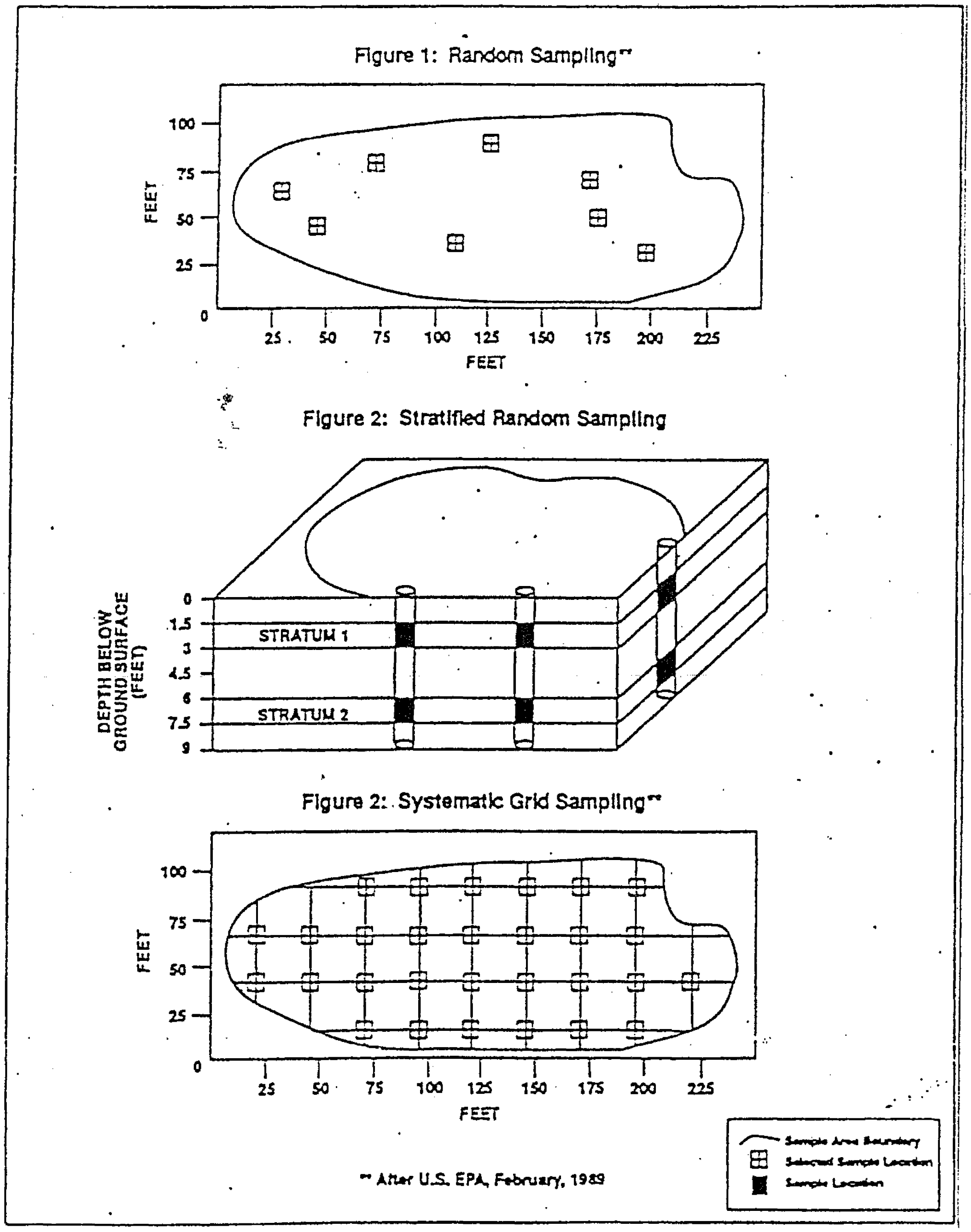
CDPHE. 2000. "Standard Operating Procedure 6, Use and Maintenance of Field Log Books." Standard Operating Procedures.

CDPHE. 2000. "Standard Operating Procedure 11, Equipment Decontamination." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 16-1	Figures for Different Forms of Grid Sampling
Exhibit 16-2	Surface/Shallow Soil Sampling Log

EXHIBIT 16-1
Figures For Different Forms of Grid Sampling



** After U.S. EPA, February, 1989

EXHIBIT 4.16-1 (Continued)
Figures For Different Forms of Grid Sampling

Figure 4: Systematic Random Sampling

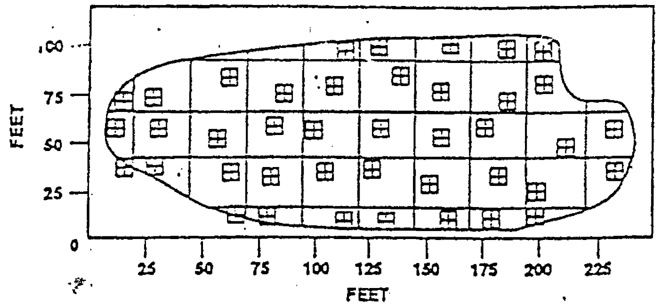


Figure 5: Search Sampling

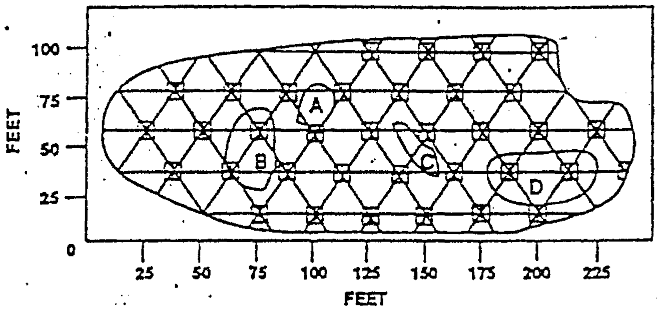
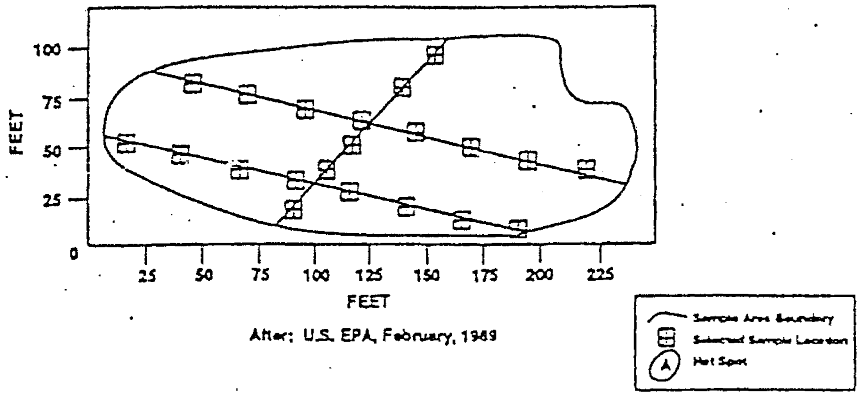
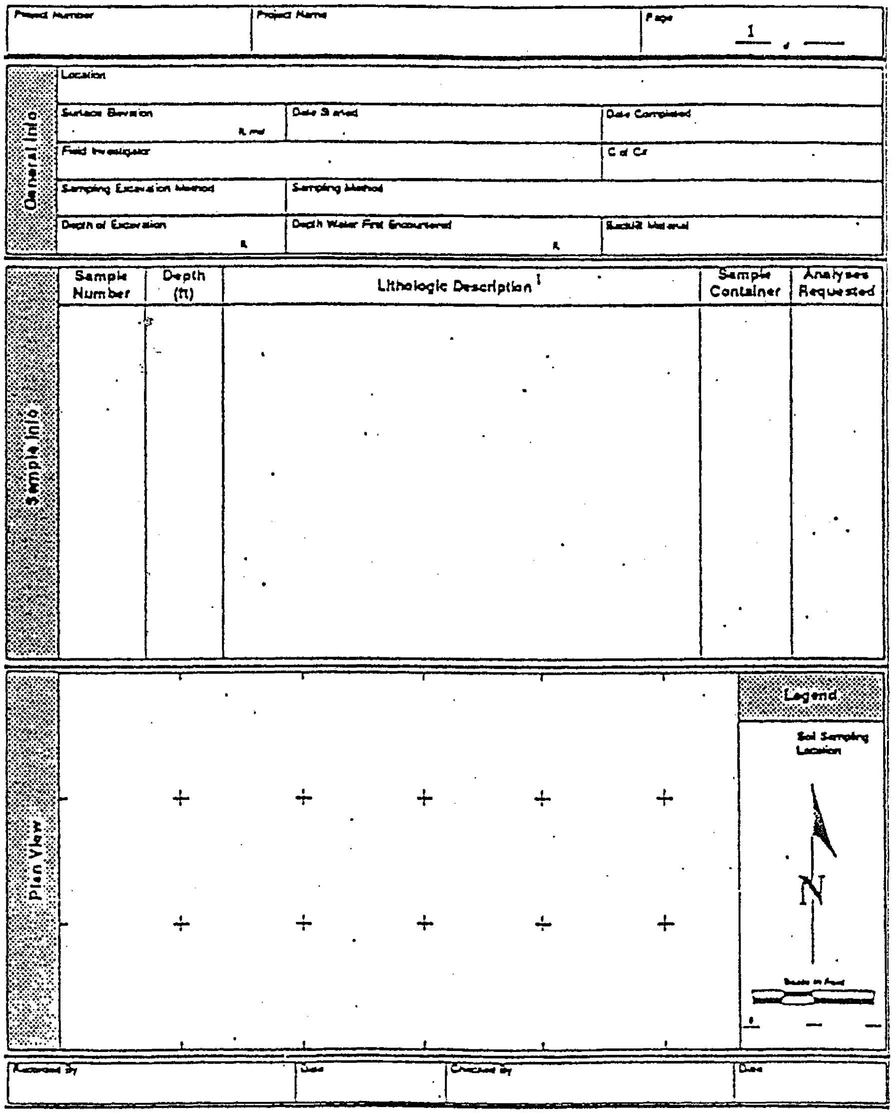


Figure 6: Transect Sampling



After: U.S. EPA, February, 1989

EXHIBIT 16-2
Surface/Shallow Soil Sampling Log



Project Number
Project Name
Page 1 of

General Info

Location
Surface Elevation ft msl
Date Started
Date Completed
Field Investigator
C of C
Sampling Excavation Method
Sampling Method
Depth of Excavation ft
Depth Water First Encountered ft
Backfill Material

Sample Info

Sample Number	Depth (ft)	Lithologic Description [1]	Sample Container	Analyses Requested

Plan View

Legend
Soil Sampling Location
N
Scale in Feet
0

Recorded By
Date
Checked By
Date

STANDARD OPERATING PROCEDURE - 17

SEDIMENT SAMPLING

1.0 PURPOSE

This procedure establishes the guidelines for sediment sampling using a variety of sampling devices. Methods for preventing sample and equipment cross-contamination are included. Proper sediment sampling ensures that any evaluations of sediment contamination are based on actual contaminant levels and are not based on improper sampling techniques.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

VOC	Volatile Organic Compounds

3.0 RESPONSIBILITIES

Field personnel collecting sediment samples are responsible for performing the applicable tasks outlined in this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURES

4.1 Non-Subaqueous Sediment Sampling

Non-subaqueous sediment sampling will consist of the following:

- Field personnel will record all data in the field log books as described in UOS Technical Standard Operating Procedure (TSOP) 4.5, Sample Location Documentation;

- Insert a decontaminated Teflon® or stainless steel spoon, scoop or trowel into sediment surface and remove sample; or rotate auger into the sediment and remove sample;

- Collect samples for volatile organic compounds (VOC) analysis from the sampling device or from unmixed sediment placed into a stainless steel bowl;

- Place the sample in a decontaminated stainless steel bowl. Stir sample thoroughly (non-VOC samples only) with a decontaminated stainless steel spoon or spatula to provide a homogeneous mixture prior to filling sampling containers;

- Fill the appropriate sample containers as specified in CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times;

- Identify or label samples according to CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging;

- Samples will be preserved and held as per CDPHE SOP 4.2, Sample Containers, Preservation and Maximum Holding Times;

- Decontaminate the sampling equipment as described in CDPHE SOP 4.11, Equipment Decontamination.

4.2 Subaqueous Sediment Sampling

Subaqueous sediment sampling will consist of the following:

- Specific sediment sampling devices are described in Exhibit 17-1, Sampling Equipment and Techniques;

- Decontaminate all sampling equipment according to CDPHE SOP 11, Equipment Decontamination;

- If sampling from a boat, attempt to collect the sample with the boat engine off or attempt to ensure that all exhaust fumes are directed away from the sample collection area until the sample has been collected;

- Lower the sampler at a controlled descent of approximately one foot per second (ft/sec.), until the sampler reaches the bottom as indicated by a slackening of the cable. Slowly retrieve the sampler and raise it at a controlled speed. When the sampler is at the water surface, attach a tag line(s) to steady and pull the sampler back into the boat. If large samplers are used, a motorized winch will be required for retrieval;

- Open and tie back any vent flaps on the sampler and carefully siphon off any overlying water over the side of the boat;

- Visually inspect the sample for acceptability (e.g., determine if an undisturbed surface layer is evident, the overlying water is not excessively turbid, and adequate penetration is achieved); if the sample is not acceptable, discard it and collect another sample from an adjacent location;

- Carefully extrude the sediment from the sampler by slowly lifting on the winch cable and sliding the sample out the bottom of the sampler. If using core liners, remove the front face of the core liner to expose the side of the core;

- Visually inspect the side of the sample to identify any obvious stratification (e.g., different sediment types, sizes or colors), and if no patterns are evident, collect a sample from the surface and mid-core depth. During some investigations, it may be necessary to collect separate samples from the surface and mid-core depths. This may best be accomplished by gently scraping the side of the core with a decontaminated stainless steel scraper or knife. Scrape from the bottom to the top of the core only. If the sediment is unconsolidated, do not scrape;

- Remove a sample from the upper two centimeters (cm) of the sample using a decontaminated Teflon® or stainless steel scoop and place it in the sample container. From an undisturbed area of the sample surface, scoop a two-cm sample only if grain size analysis is required. After grain size analysis samples are collected, scrape off the upper sediment layer and discard overboard. Collect samples from the mid-section of the sediment. Sediment must be removed with caution to avoid contaminating the sample (i.e., from exposure to engine exhaust, rust, or grease);

- Nonrepresentative materials such as twigs or debris should not be included in the sample. Sediments contacting the side of the sampler or core liner should not be included for analysis. Aliquot size (i.e., mass), container type, storage conditions, and holding times will follow guidelines in the project plans and CDPHE SOP 4.2, Sample Containers, Preservation, and Maximum Holding Times; and

- Identify or label samples as outlined in CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging.

4.3 Stream Sediment Sampling

Stream sediment sampling will include the following:

- The sample should be collected in an area of sediment accumulation, such as the inside of stream meanders, quiet shallow areas, and low velocity zones. Avoid areas of net erosion, such as high velocity, turbulent flow zones;

- If possible, remain on the stream bank. If the sample cannot be obtained from the bank, enter the stream from a point downstream of the sediment sampling location. Entering a river may be hazardous, hence, consult the Site Health and Safety Plan for specific safety procedures. Collect the sediment sample by reaching into the stream with a decontaminated stainless steel spoon or Teflon® scoop and scooping a sample in an upstream direction. Attempt to minimize the loss of fine material;

- Place sample in a stainless steel beaker or bowl and gently mix with a stainless steel spoon (non VOC samples only). Transfer the sediment samples to the appropriate sample containers using the stainless steel spoon. Do not mix samples for volatile organic analysis. If duplicate or split samples are to be obtained, transfer the sediment directly from the stainless steel bowl into the sample containers in the same manner as standard samples;

- Identify or label sample containers in accordance with CDPHE TSOP 4.4, Sample Identification, Labeling, and Packaging, and store as specified in CDPHE TSOP 44.2, Sample Containers, Preservation and Maximum Holding times;

- Decontaminate sampling equipment as outlined in CDPHE SOP 4.11, Equipment Decontamination; and

- Record all data in field log books.

4.4 Review

The Project Leader or an approved designee shall check all documents (Exhibits) generated during sampling operations for completeness and accuracy. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the applicable reviewed documents.

5.0 REFERENCES

CDPHE, 2000. “Standard Operating Procedure 1, General Field Operation.” Standard Operating Procedures.

CDPHE, 2000. “Standard Operating Procedure 2, Sample Containers, Preservation, and Maximum Holding Times.” Standard Operating Procedures.

CDPHE, 2000. “Standard Operating Procedure 4, Sample Identification, Labeling, and Packaging.” Standard Operating Procedures.

CDPHE, 2000. “Standard Operating Procedure 11, Equipment Decontamination.” Standard Operating Procedures.

CDPHE, 2000. “Standard Operating Procedure 18, Surface Water Sampling.” Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 17-1 Sampling Equipment and Techniques

EXHIBIT 17-1

Sampling Equipment and Techniques

Sediment samples may be obtained using on-shore or off-shore techniques. Sediment sampling equipment and techniques must be designed to minimize the risk of dilution or loss of material as the sample is moved through the water column. For situations where boats are required for sampling, extra precautionary measures must be employed. At a minimum, life preservers must be provided and two individuals will undertake the sampling and an additional person will remain in visual contact on-shore to observe the operations.

Sediment sampling is described below.

Dip Sampler

A dip sampler consists of a pole with a jar or scoop attached. The pole may be made of bamboo, wood, Teflon®, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is attached by a clamp.

The dip sampler is operated by submerging the jar or scoop and pulling it through the sediments to be sampled. The samples retrieved are then transferred into the appropriate sample container after decanting the liquid. Further decanting can occur while the sample is present in the sample jar. Avoid contact with sampler's gloves. Transferring the sample may require the use of a stainless steel or Teflon® spoon/spatula.

Hand Operated Core Samplers

Hand operated sediment core samplers are used to obtain sediment samples in shallow water (less than three feet). These samplers operate in a manner similar to soil core samplers. However because of the saturated conditions of most sediments, provisions must be made to retain the sample within the core. Core samplers are generally constructed of a rigid metal outer tube into which a two-inch plastic core sleeve fits with minimum clearance. The cutting edge of the core sampler has a recessed lip on which the plastic sleeve rests and which accommodates a core retainer. This retainer is oriented such that when the sampler is pressed into the sediment, the core is free to move past the retainer. Due to construction of the retainer, the core will not fall through the retainer upon removal of the sampler from the sediment.

When the sampler is removed from the sediment, the plastic sleeve is removed. The sediment is removed from the sleeve and placed in the appropriate sample container. Chlorinated organics will not be collected using core samplers because core sleeves and retainers are generally made of plastic. The hand operated core sampler will not be useful for obtaining samples of gravelly, stony or consolidated sediments.

Gravity Core Samplers

Gravity core samplers are used to obtain sediment samples in water bodies or lagoons with depths of greater than three to five feet. These types of samplers can be used for collecting one- to two-foot cores of surface sediments at depths of up to 100 feet beneath the water surface.

As with all core type samplers, gravity core samplers are not suitable for obtaining samples of coarse, gravelly, stony, or consolidated deposits. They are, however, useful for fine grained inorganic sediment sampling.

The gravity core sampler operates in a manner similar to the hand operated core in that a two-inch plastic sleeve fits within a metal core housing fitted with a cutting edge. Plastic nests are used to retain the core within the plastic sleeve. An opening exists above the core sleeve to allow free flow of water into and through the core as it moves vertically downward to the sediment. The sampler has a messenger-activated valve assembly which seals the opening above the plastic sleeve following sediment penetration. This valve is activated by the messenger creating a partial vacuum to assist in sample retention during retrieval.

Samples are obtained by allowing the sampler, which is attached to approximately 100 feet of aircraft cable, to drop to the benthic deposits. The weight of the sampler drives the core into the sediment to varying depths depending on the characteristics of the sediments. The messenger is then dropped on the taut aircraft cable to seal the opening above the plastic sleeve. The sampler is then carefully retrieved.

Upon retrieval of the sampler, the plastic core sleeve is removed and the sample placed in the appropriate sample container. Care should be exercised in labeling in order to properly identify sample orientation.

Dredges

Dredges are generally used to sample sediments which cannot easily be obtained using coring devices or when large quantities of materials are required. Various dredge designs are available for sampling in deep or turbulent waters and for obtaining samples from gravelly, stony or dense deposits.

Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a messenger. Dredges are commonly quite heavy and therefore require use of a winch and crane assembly for sample retrieval.

Upon retrieval of the dredge, the sample can either be sieved or transferred directly to a sample container for labeling and storage. Dredge types which could be used for sampling include Ponar, Petersen and Ekman dredges.

Hand Auger

Sediment samples may be collected using a hand auger. When using a hand auger, provisions must be made to ensure that sediment samples remain in the auger. Hand augers are best utilized when sampling non-subaqueous sediments.

STANDARD OPERATING PROCEDURE - 18

SURFACE WATER SAMPLING

1.0 PURPOSE

The purpose of this procedure is to describe the methods for surface water sampling. It describes the procedures and equipment to be used to obtain representative surface water samples that are capable of producing accurate quantification of water quality.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Aliquot: Fractional amount.

Composite Samples: Samples composed of more than one aliquot collected at various sampling sites and/or at different times.

Epilimnetic zone: The uppermost layer of water in a lake, characterized by an essentially uniform temperature that is generally warmer than elsewhere in the lake and by a relatively uniform mixing caused by wind and wave action. Specifically, the light (less dense), oxygen-rich layer of water in a thermally stratified lake.

Grab Samples: Samples that are collected at one particular point and time.

Hypolimnetic zone: The lowermost layer of water in a lake, characterized by an essentially uniform temperature (except during turnover) that is generally colder than elsewhere in the lake and often characterized by relatively stagnant or oxygen-deficient water.

Rinsate: Waste water generated as a result of rinsing sampling equipment during decontamination procedures.

Surface water samples: Samples of water collected from streams, ponds, rivers, lakes, or other impoundments open to the atmosphere.

2.2 Abbreviations

PA	Preliminary Assessment

SI	Site Inspection
SOP	Standard Operating Procedures

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURE

4.1 Introduction

The objective of surface water sampling is to evaluate the surface water quality entering and/or leaving a site. It is also used to obtain data on waste loads, water quality and characteristics that will permit prediction or modeling of the water system (to describe probable water quality), and effects on uses under a variety of conditions.

4.2 Sampling Equipment

There is a variety of equipment available for surface water sampling. Because each site may contain varied surface water conditions, collection of a representative sample may be difficult. In general, a sampling device will include the following characteristics:

- Be constructed of disposable or non-reactive material (Teflon® or stainless steel); and

- Have a minimum capacity of 500 ml to minimize sample disturbance.

All surface water sampling equipment will be designed to maintain sample integrity and to provide the desired level of quality in achieving desired analytical results.

Sampling equipment includes all sampling devices and containers that are used to collect or contain a sample prior to final sample analysis.

4.3 Decontamination

Prior to and after each sampling event, all sampling equipment must be thoroughly decontaminated following the methods outlined in CDPHE Standard Operating Procedure (SOP) 4.11, Equipment Decontamination. The primary purpose of equipment decontamination is to prevent the potential of cross-contamination within the samples collected.

4.4 Sampling Location/Site Selection

Prior to sampling, consideration must be given to the specific sampling locations in order to provide a representative sample. This and other considerations are detailed in the Project Plans.

The general determining factors in the selection of a sampling device for sampling liquids in lakes, ponds, lagoons, and surface impoundments are listed below:

- Accessibility:
  - Boat: If the water is navigable, any sampling location is accessible by boat.
  - Bridges: Provide ready access, are readily identifiable, and permit water sampling at any point across the width of the water body.
  - Wading: Personnel safety must be paramount. Wading is not recommended in areas where bottom deposits are easily disturbed, thereby increasing the possibility of increased sediment in the samples.
- Rivers, streams, and creeks:
  - Sampling stations will be located wherever a marked physical change occurs in the stream channel. For example, between a rapids/deep water transition, as well as at both ends of the reach (only applicable for PA/SI, not ERB).
  - Sampling stations will be located short distances above and below dams and weirs, to determine the artificial increase in dissolved oxygen (only applicable for PA/SI, not ERB).
  - A minimum of three sampling locations will be established between any two points of major change in a stream (only applicable for PA/SI, not ERB).
  - Sampling stations will be located upstream and downstream of any waste discharge site. Since the inflow frequently hugs the stream bank with very little lateral mixing, care must be taken to establish the sampling station after complete mixing with the main stream.
  - A tributary sampling station will be established near the mouth and upstream of any effects from the main stream. The station on the main stream will be just upstream from the confluence.
  - Sample as close as is practical to areas or points of important water uses.

  - At stations where wastes and tributary waters are well-mixed, one sampling point near mid-channel is usually adequate. At stations where mixing is inadequate, the station will be sampled at quarter points across the width of the station.

- Lakes, ponds, and impoundments:

  - A single station at the deepest point may be sufficient for naturally-formed ponds (near the center) and for impoundments (near the dam or spillway).

  - A sampling grid is the most representative for lakes and large impoundments.

  - In lakes with irregular shapes and with several bays and coves that are protected from the wind, sampling stations should be established in these areas.

  - A control station above a waste source is usually necessary to compare background water quality. It should be carefully selected and it may be necessary to have two or three control stations to establish the rate at which unstable material is changing. The time of travel between stations should be sufficient to permit accurate measurement of the change in the constituents under consideration.

4.5 Sampling Methods

4.5.1 General

The specific sampling method utilized will depend on the accessibility to, the size, and the depth of the water body, as well as the type of samples being collected.

In most ambient water quality studies, grab samples will be collected. However, the objectives of the study will dictate the sampling method.

For rivers, streams and creeks, the type of samples collected will be dependent upon the size and the amount of turbulence in the water body. Approximate the depth and location of samples in order to assure consistency. Flow rates will be measured using an appropriate method as described in UOS SOP 4.15, Flow Measurement.

- With small streams less than 20 feet wide, a single grab sample collected at mid-depth in the center of the channel is usually adequate to represent the entire cross-section. In small streams and creeks less than 10 feet wide, a single grab sample can be collected by immersing the bottle directly under the surface of the water as close to the center of the channel as possible. This method reduces the potential for cross contamination as it does not require the decontamination of equipment. Clean non-reactive surgical or nitrile gloves are worn while the sample jar is immersed and filled in the sample media.

- For slightly larger streams, a vertical composite sample in the center of the channel may be required. The composite sample consists of samples taken just below the surface, at mid-depth and just above the bottom.

- For rivers, several vertical composite samples are collected across the water body. The vertical composite samples will be collected at points in the cross-section approximately proportional to flow. The number of vertical composites required and the number of depths sampled for each are usually determined in the field. This determination is based on a reasonable balance between two considerations:

    - The larger the number of subsamples, the more nearly the composite sample will represent the water body; but

    - Taking many subsamples is time-consuming and increases the chance of cross-contamination.

- For lakes, ponds and impoundments, the greater tendency to stratify and the relative lack of adequate mixing usually requires that more subsamples be collected. The flow rate of impoundments will be measured as described in CDPHE SOP 4.15, Flow Measurement.

    - In ponds and small impoundments, a single vertical composite sample at the deepest point is usually adequate.

    - In lakes and larger impoundments, several vertical composites should be combined into a single sample. In some cases, it may be useful to form several composites of the epilimnetic and hypolimnetic zones. Normally, however, a composite consists of several verticals with subsamples collected at various depths.

4.5.2 Weighted Bottle Sampler

Collecting a representative sample from a larger body of water requires the gathering of samples from various depths and locations. For this type of sampling a weighted bottle sampler is used. The sampler consists of a Teflon® bottle, a weighted sinker, a bottle stopper and a wire cord used to raise, lower and open the samples. This type of sampler can be fabricated or purchased. The following procedures will be followed when sampling with a weighted bottle sampler (Exhibit 18-1, Weighted Bottle Sampler):

- Decontaminate all equipment in accordance with the procedures described in CDPHE SOP 4.11, Equipment Decontamination;

- Assemble the weighted bottle sampler in accordance with the sampler instruction manual;
- Gently lower the sampler to the desired depth so as not to remove the stopper prematurely. Do not let sampler disturb bottom sediments;
- Pull out the stopper with a sharp jerk of the sampler line;
- Allow the bottle to fill completely, as evidenced by the cessation of air bubbles;
- Raise the sampler, seal, wipe clean, label or identify and prepare the bottle for transport in accordance with project guidelines;
- Record the applicable information in the field log book. The information may also be recorded on Exhibit 18-6, Surface Water Sampling Data; and
- Mark sample location and approximate depth, if possible, and note on maps and in field log book in accordance with CDPHE SOP 4.6, Use and Maintenance of Field Log Books.

One additional grab sample from each location will be collected and described in terms of pH, conductivity, temperature, turbidity, odors and other significant characteristics. This sample will not be used for laboratory analysis.

4.5.3 Pond Sampler

The pond or dip sampler (Exhibit 18-2, Pond Sampler) consists of a scoop or container attached to the end of a telescoping or solid pole. The sampler will be of non-reactive material such as wood, plastic, or metal. The sample will be collected in a jar or beaker made of stainless steel or Teflon®. Preferably, a disposable beaker that can be replaced prior to each sampling will be used at each station. Liquid wastes from water courses, ponds, pits, lagoons or open vessels will be "ladled" into a sample container.

Perform the following procedures when sampling with a pond sampler:

- Decontaminate all sampling equipment in accordance with the procedures described in CDPHE SOP 4.11, Equipment Decontamination;
- Assemble pond sampler in accordance with manufacturer's instructions;
- Extend pole to length that will allow safe access to desired sample location;

- Submerge pond sampler to desired sample depth. Submerge the sampler very slowly to minimize surface disturbance;
- Allow the sampler to fill very slowly;
- Retrieve the sampling device with minimal surface water disturbance;
- Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the sampler edge;
- Empty the sampler slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence. Fill sample bottle to appropriate head space, if any;
- Seal sample bottle, wipe clean, label or identify and prepare for transport in accordance with project guidelines;
- Collect additional grab samples to acquire field measurements such as temperature, pH, conductivity, turbidity and other significant characteristics;
- Record applicable data in the field log book. The data may also be recorded on Exhibit 18-6, Surface Water Sampling Data;
- Mark sample location and approximate depth, if possible, and note location on maps and in field log book in accordance with CDPHE SOP 4.6, Use and Maintenance of Field Log Books; and
- Decontaminate equipment in accordance with procedures described in CDPHE SOP 4.11, Equipment Decontamination.

4.5.4 Manual Hand Pumps

Manual pumps are available in various sizes and configurations. Manual hand pumps are commonly operated by peristaltic, bellows or diaphragm, and siphon action. Manual hand pumps that operate by a bellows or diaphragm, and siphon action should not be used to collect samples that will be analyzed for volatile organics (4.18-3, Manual Hand Pump). These types of pumps should be constructed out of inert materials; i.e., Teflon® or stainless steel.

Perform the following procedures when collecting surface water samples with a manual hand pump:

- Assemble and operate the pump in accordance with the manufacturer's instructions;

- The inlet hose and any surface of the pump used for sampling will be constructed of materials that are operable and non-reactive;
- To avoid agitation, insert the sampling tube into the liquid sample prior to pump activation;
- Insert a liquid trap (preferably the sample container) into the sample inlet hose to collect the sample and to prevent pump contamination;
- Sample bottles will be sealed, wiped clean, labeled or identified and prepared for transport in accordance with appropriate SOPs;
- Record applicable data in the field log book. Data may also be recorded on .18-6, Surface Water Sampling Data;
- Decontaminate equipment in accordance with procedures described in CDPHE SOP 4.11, Equipment Decontamination; and
- Mark sample locations and approximate depth, where possible, and note location on map and in field log book in accordance with CDPHE SOP 4.6, Use and Maintenance of Field Log Books.

4.5.5 Peristaltic Pump

Gathering surface water samples with the assistance of a peristaltic pump is another commonly used sampling technique. In this method the sample is drawn through heavy-walled tubing and pumped directly into the sample container. This system allows the operator to extend into the liquid body to sample from depth, or sweep the width of narrow streams. Medical-grade silicon tubing is often used in the peristaltic pump and the system is suitable for sampling almost any parameter, including most organics (Exhibit 18-4, Peristaltic Pump).

Peristaltic pumps are available with a range of power sources. For field use the battery operated units have proven most convenient and very reliable.

Perform the following procedures when sampling with a peristaltic pump:

- Prepare the peristaltic pump in accordance with manufacturer's instructions. When using a battery-operated pump, be sure battery is fully charged prior to entering the field.
- In most situations, it is necessary to change the Teflon® suction line and the silicon pump tubing between sample locations to avoid cross-contamination. This action requires maintaining a sufficiently large stock of tubing material to avoid having to decontaminate the tubing in the field.

- Gently lower the pump intake tube to the desired sample depth. Avoid unnecessary agitation (aeration) of the liquid to be sampled and bottom sediments.

- Prior to activating the pump, note in which direction the pump will be rotating. (Most peristaltic pumps are capable of rotating in two directions.) Accidental reverse rotation of the pump will cause aeration of the liquid to be sampled.

- Run the pump until no air bubbles are noted in the discharge.

- Discharge water shall be released down stream from sampling area during sampling event.

- To prevent excess agitation and/or aeration of the sampler, fill the sample containers by tilting the container and flow the sample water down the side of sampling container.

- Record applicable data in the field log book (i.e. color, turbidity, pH, degree of turbulence, and weather conditions). Data may also be recorded on Exhibit 18-6, Surface Water Sampling Data.

- In most cases, no specific decontamination procedures are required due to the use of disposable tubing. However, site-specific sample procedures may require additional decontamination. Check with the Project Leader prior to commencing field operations.

- Mark sample location and approximate depth, if possible, and note location on map and in field log book in accordance with CDPHE SOP 4.6, Use and Maintenance of Field Log Books.

When medical grade silicon tubing is not available for analytical requirements, the system can be altered as illustrated in Exhibit 18-5, Peristaltic Pump - Modified. In this configuration, the sample volume accumulates in the vacuum flask and does not enter the pump. This system will provide excellent sample integrity for most analyses; however, the potential for losing volatile fractions to the reduced pressure of the vacuum flask renders this method unacceptable for sampling of volatiles.

It may sometimes be necessary to sample large bodies of water where a near-surface sample will not sufficiently characterize the body as a whole. In this instance, the above-mentioned pump is appropriate. It is capable of lifting water from slightly deeper than six meters. It should be noted that this lift ability decreases somewhat with higher density fluids and with increased wear on the silicone pump tubing. Similarly, increases in altitude will decrease the pump's ability to lift from depth.

When sampling a liquid stream that exhibits a considerable flow rate, it may be necessary to weight the bottom of the suction line.

4.5.6 Optional Sampling Methods

The above-mentioned methods of surface water sampling will be used most often on CDPHE environmental projects; however, choice of sampling equipment depends on site specific conditions. Additional types of samplers available are:

- Kemmerer sampler;
- Wheaton sampler;
- Bacon Bomb sampler;
- Open tube sampler;
- D.O. Punker sampler; and
- Bailer.

Prior to any field work, the Project Leader will review the available sampling equipment and choose the sampler that will best suit the project requirements.

4.6 Sample Collection Records

All surface water samples gathered in the field will be labeled, shipped and documented in accordance with the site-specific requirements set forth in the Project Plans and in the following:

- Samples will be transported in accordance with the procedures outlined in the CDPHE SOP 4.3, Chain-of-Custody;

- All samples will be labeled or identified in accordance with procedures outlined in the CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging;

- Quality assurance and quality control procedures outlined in the site-specific Project Plan;

- The Surface Water Sampling Data form contained in Exhibit 18-6 must be filled out for each surface water sample collected; and

- Detailed Field Log Books documenting the sampling event must be kept. All field notes will be in accordance with procedures outlined in the CDPHE SOP 4.6, Use and Maintenance of Field Log Books.

4.7 Review

The Project Leader and an approved designee shall check all Exhibits and field log books used to record information during sampling for completeness and accuracy. Any discrepancies will be noted and and the documents will be returned to the originator for correction.

The reviewer will acknowledge that these review comments have been incorporated by signing and dating the "checked by" and "date" blanks on the Exhibits and at the applicable places in the log books.

5.0 REFERENCES

CDPHE, 2000. "Standard Operating Procedure 3, Chain-of-Custody." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4, Sample Identification, Labeling, and Packaging." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 6, Use and Maintenance of Field Log Books." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 11, Equipment Decontamination." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 15, Flow Measurement." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 18-1	Weighted Bottle Sampler
Exhibit 18-2	Pond Sampler
Exhibit 18-3	Manual Hand Pump
Exhibit 18-4	Peristaltic Pump
Exhibit 18-5	Peristaltic Pump - Modified
Exhibit 18-6	Surface Water Sampling Data

EXHIBIT 18-1
Weighted Bottle Sampler

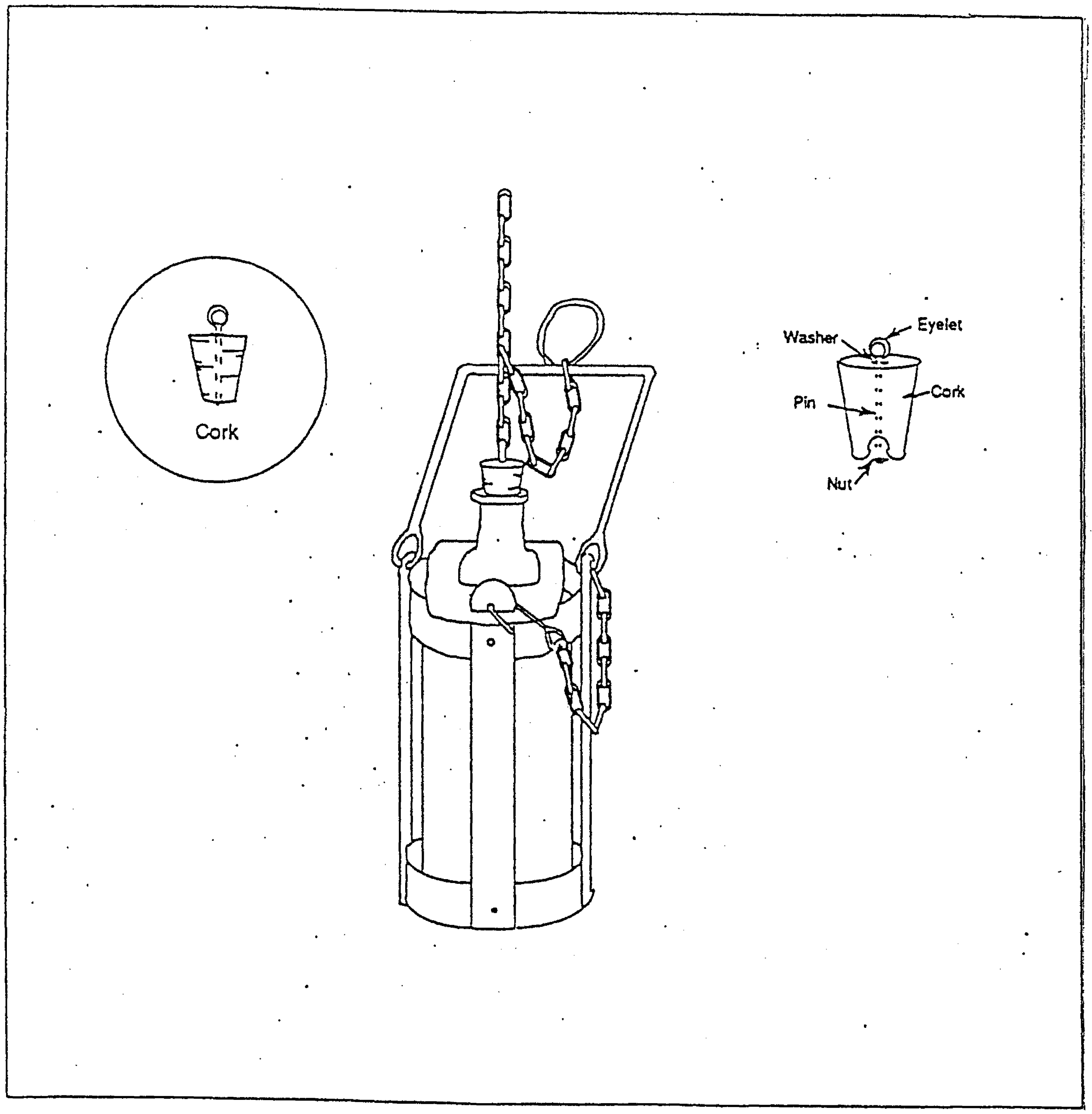


EXHIBIT 18-2
Pond Sampler

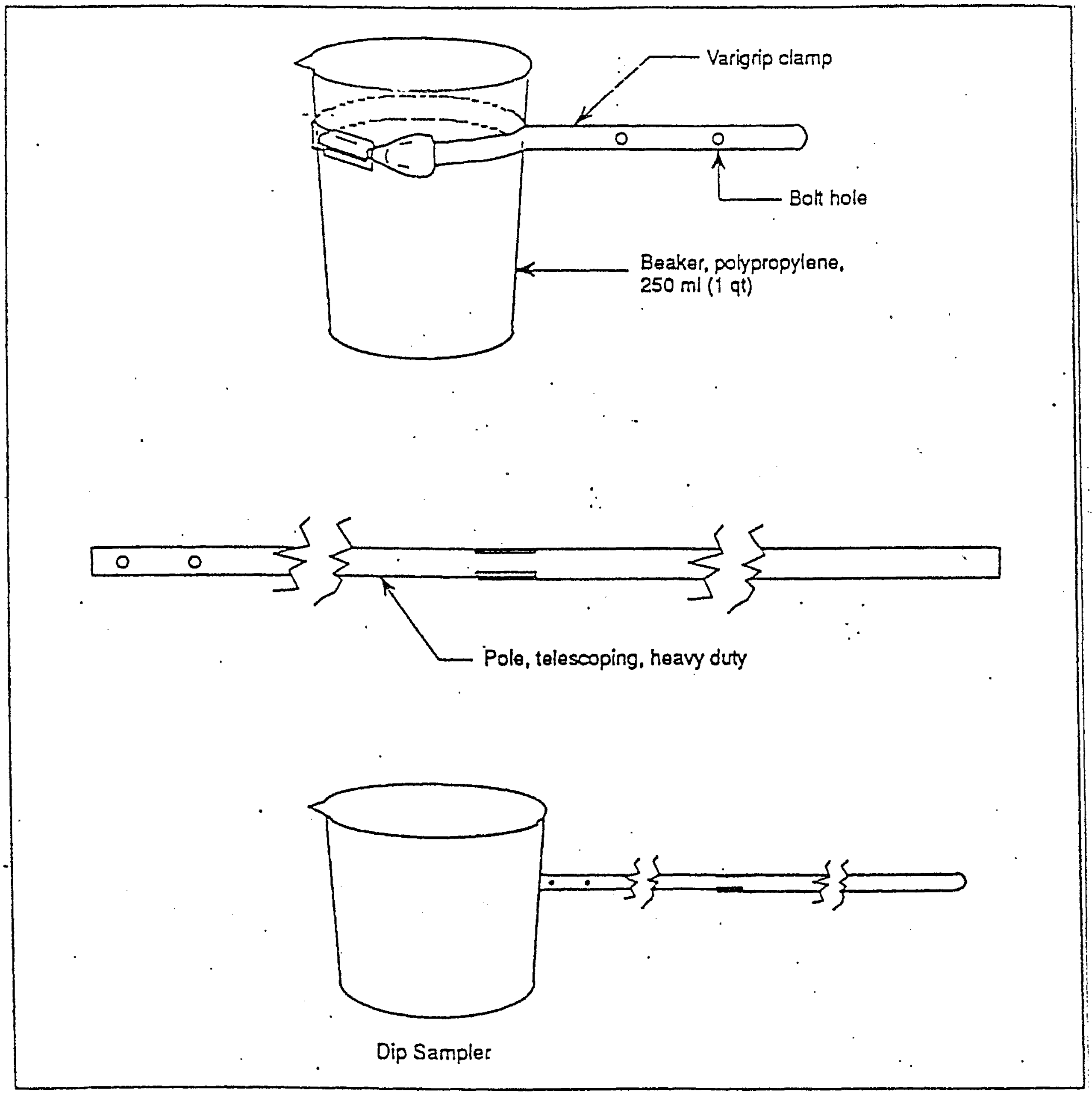


EXHIBIT 18-3
Manual Hand Pump

EXHIBIT 18-4
Peristaltic Pump

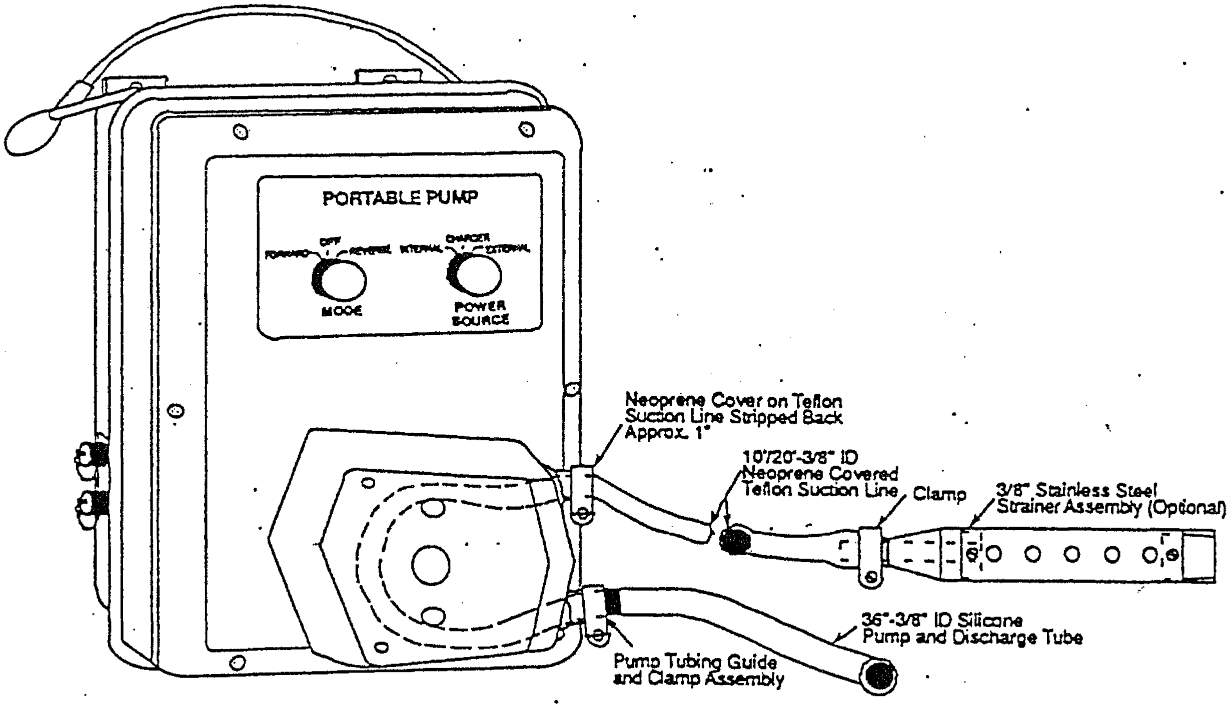


EXHIBIT 18-5
Peristaltic Pump - Modified

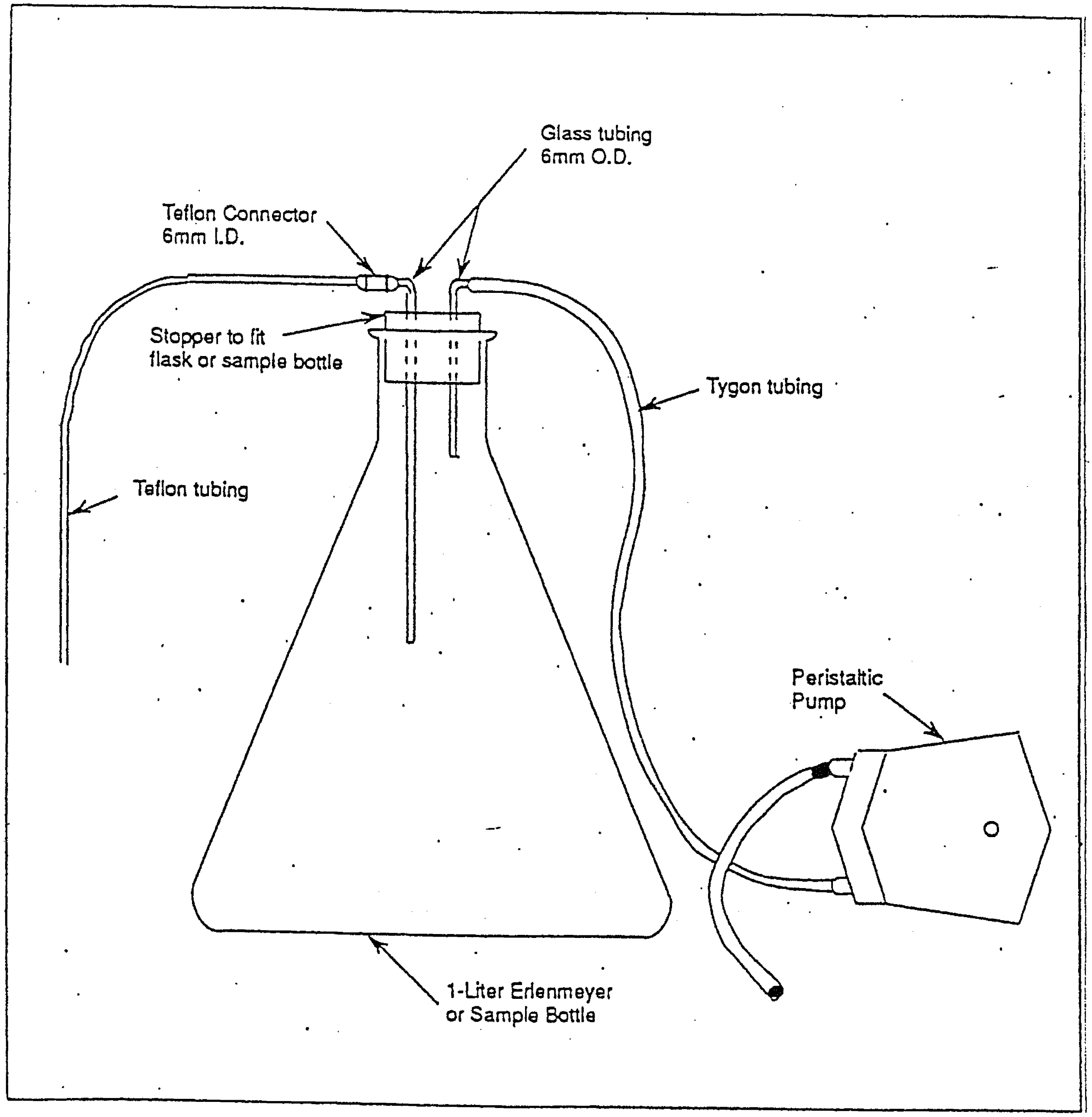


EXHIBIT 18-6
Surface Water Sampling Data

CDPHE	Surface Water Sampling Data	
Project Number ______	Project Name:	Page ___ of ____

Sample No:______________________	Elevation: ______________________
Sampling Method:__________________	Weather: ______________________
Bar. Press._________________	Amb. Temp. _______________
WATER SAMPLE DATA	
Water Temp: ______oC	Method of Measurement: ______________
Specific Conductance:	Method of Measurement: ______________
pH:	Method of Measurement:______________

Containers Used (VOA Vial, 1 liter jar etc...): ____

Physical Appearance: ____

Contamination Observed: ____

Remarks: ____

Recorded By:	Date:	Checked By:	Date:

STANDARD OPERATING PROCEDURE - 19

SOIL GAS SAMPLING

1.0 PURPOSE

The purpose of this procedure is to describe the equipment and operations used for sampling surface and shallow depth soil gas. This procedure outlines the methods for decontamination and soil gas sampling for routine field operations on environmental projects. The purpose of this document is to present alternative procedures that may be chosen on a case-by-case basis. Regardless of application, any soil gas sampling program should include a review of the following items: sampling program development, sample documentation techniques, analytical instrumentation, sample analysis, and final data interpretation. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Soil: All unconsolidated materials above bedrock.

Surface Soils: Soils located zero to six inches below ground surface.

Shallow Soils: Soils located six inches to six feet below ground surface.

2.2 Abbreviations

EPA	U.S. Environmental Protection Agency
FID	Flame ionization detector
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
PID	Photo ionization detector
SOP	Standard Operating Procedure
VOCs	Volatile organic compounds

3.0 RESPONSIBILITIES

Sampling personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURES

4.1 Introduction

The objective of surface and shallow depth soil gas sampling to assess potential contamination problems arising from active transport of volatile organic compounds (VOCs) by groundwater or localized vadose zone diffusion due to point sources, such as leaking underground storage tanks. Soil gas surveys may be used to define:

- Source location(s) by systematically sampling toward higher concentrations;
- Plume boundaries, utilizing the more sensitive analytical procedures;
- Relative concentration gradients through grid sampling; or
- Simply defining the presence/absence of vadose zone contamination without rigorous quantification.

Soil gas sampling is most often utilized as a screening technique to identify trends of contamination, and is not to be used as a definitive quantitative procedure.

4.2 Sampling Equipment

Shallow soil sampling equipment includes:

- Borehole equipment - slam bars, soil corers, Geoprobe, hollow stem augers;
- Sampling pumps to evacuate chambers or pull gas sample;
- Tedlar® bags or applicable sample storage media
- Analytical equipment to read volatile organic vapors (photo ionization detector (PID), flame ionization detector (FID), Syntex Gas Chromatography (GC), Gas Chromatography/Mass Spectrometry (GC/MS)).

4.3 Decontamination

Before initial use, and after each subsequent use, all sampling equipment must be decontaminated using procedures outlined inCDPHE Standard Operating Procedure (SOP) 4.11, Equipment Decontamination.

4.4 Sampling Location/Site Selection

Follow the sample design criteria outlined in the Sampling and Analysis Plan for each sampling event. Relocate the sample sites as conditions dictate - such as natural or artificial obstructions at the proposed sample location (e.g., boulders, asphalt, etc.). Document the actual sample locations, photographically or on a sketched site map.

4.5 Sampling Approaches

It is important to select an appropriate sampling approach for accurate characterization of site conditions. Each approach is defined below.

4.5.1 Borehole Method

Soil gas may be obtained directly from augured or driven holes. This technique requires construction of a hole, and collection of gas into a container at the bottom of the hole, or through a tube to a container at the top of the hole. Sample containers may be gas-tight syringes, Tedlar® bags, glass sample bulbs or other gas-holding containers.

The fastest and cheapest borehole construction method should be attempted first (slam bar, soil core, or Geoprobe). Specialized soil gas probe tips and shafts are available on the Geoprobe for this technique (Exhibit 19-2, Probe Tip and Probe Shaft; and Exhibit 19-3, Insertion and Extraction Tools). The use of a hollow stem auger can be more expensive, but it can assist in volatilizing contaminants, and has shown a twofold increase in sensitivity over static methods.

Samples may be collected from the bottom of an augured or driven hole by using a small, gas-tight syringe with the cylinder and plunger attached to separate extension rods. An alternative method is to lower a small diameter Teflon® tube, connected at the surface to a sample container (e.g., gas-tight syringe or Tedlar® bag) and pump to the bottom of the borehole. A sample can then be extracted using the sampling pump. Care should be taken to maintain positive pressure in the sample container and to quickly seal the container to avoid contact with the atmosphere. If hollow stem augers are used, the augers should be raised slightly from the bottom of the borehole to create a void space. The soil gas sample should then be collected while the augers are in place in the borehole to minimize loss of VOCs while extracting the augers.

The advantages of using the borehole method are that it provides inexpensive subsurface sampling, uses minimum apparatus, and provides quick collection. The disadvantages are that the technique is not controlled, it is not effective for surface soils, there may be potential variability of results, and representativeness is difficult to achieve and impossible to document.

4.5.2 Soil Headspace

A viable alternative to collecting a gas sample is to collect a soil sample that contains contaminants adsorbed onto soil particles, dissolved within soil water, and existing in associated pore spaces. Physical soil properties may dictate this as the only practical method.

Soil samples with low concentration VOCs should be collected so as to be as undisturbed as possible and then sealed from atmospheric contact. Various tube-type samplers have been employed, including split spoons and shelby tubes with inner sleeves. The sleeves are sealed with caps and later placed directly into sample containers (2-4 oz septa jars, or 40 ml vials). A gas-tight syringe is inserted into the septa liner and the headspace gas collected and analyzed. A field laboratory equipped with the Syntex GC, Photovac GC, or the GC/MS can read the VOC content in the headspace by heating and agitation (sonication) of the sample.

The advantages of this method include higher sensitivity, and samples are collected quickly. The disadvantages are that soil type may prevent collection, and sample preparation may be required.

For rapid field screening purposes the following procedure can be used. Soil samples can be placed in glass containers, covered with aluminum foil, heated (preferably in a warm water bath) and agitated. The aluminum foil can then be pierced with a PID or FID and a VOC concentration determined.

4.6 General

All boreholes will be filled in with the material removed during sampling unless otherwise specified in the project-specific Field Sampling Plan. Where a vegetative turf has been established, fill in and replace the turf if practical in all holes or trenches when sampling is completed.

4.7 Review

The Project Leader or an approved designee shall check all Exhibits and field log books used to record information during sampling for completeness and accuracy. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the "checked by" and "date" blanks on the Exhibits and at the applicable places in the log book.

5.0 REFERENCES

CDPHE, 2000. " Standard Operating Procedure 4.1, Use and Maintenance of Field Log Books." Technical Standard Operating Procedures.

CDPHE, 1999. "Standard Operating Procedure 4.3, Chain of Custody." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4.4, Sample Identification, Labeling, and Packaging." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4.5, Sample Location Documentation." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4.6, Use and Maintenance of Field Log Books." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 19-1	Soil Sampling
Exhibit 19-2	Probe Tip and Probe Shaft
Exhibit 19-3	Insertion and Extraction Tools

EXHIBIT 19-1
Soil Sampling

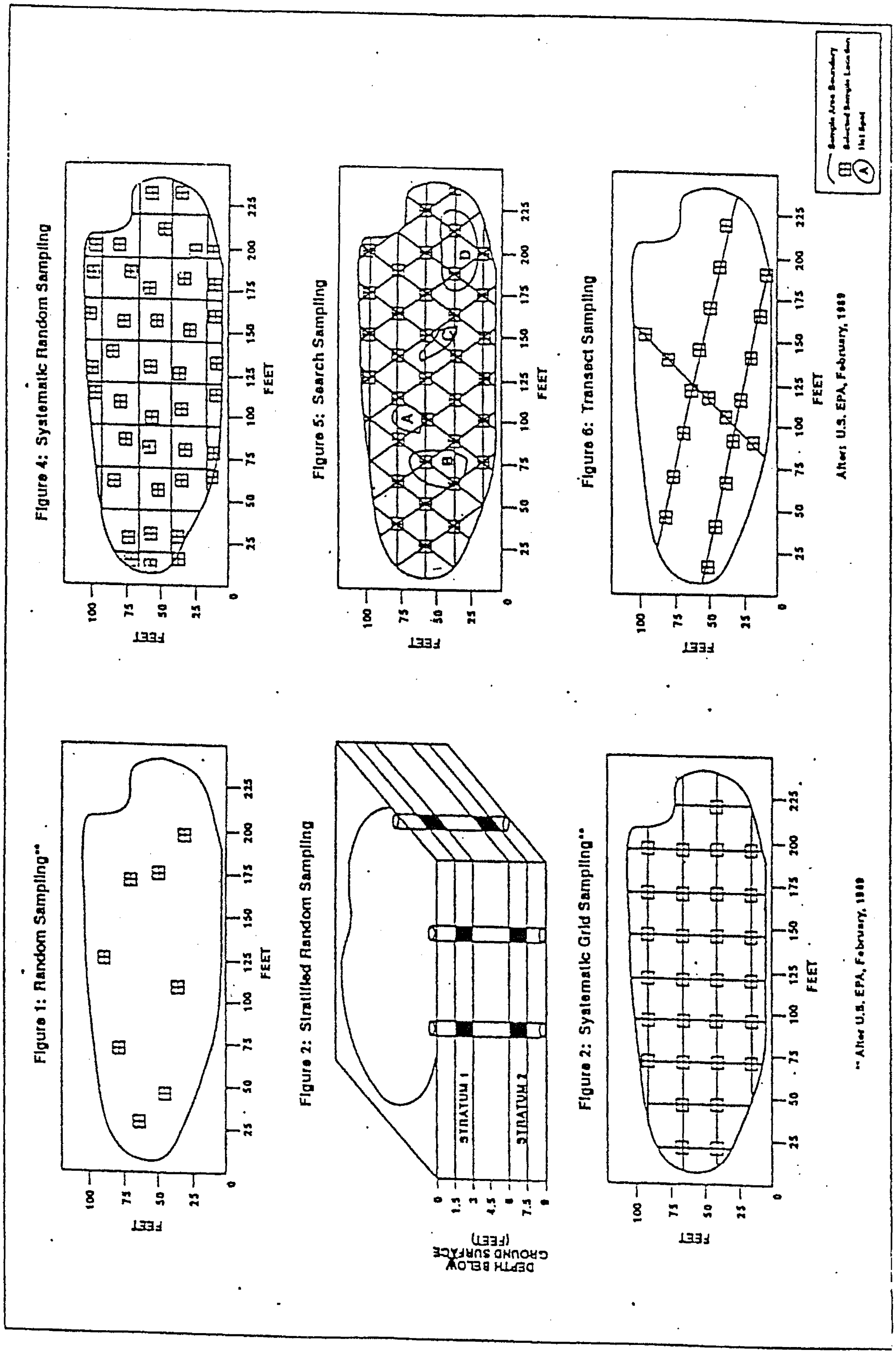


EXHIBIT 19-2
Probe Tip and Probe Shaft

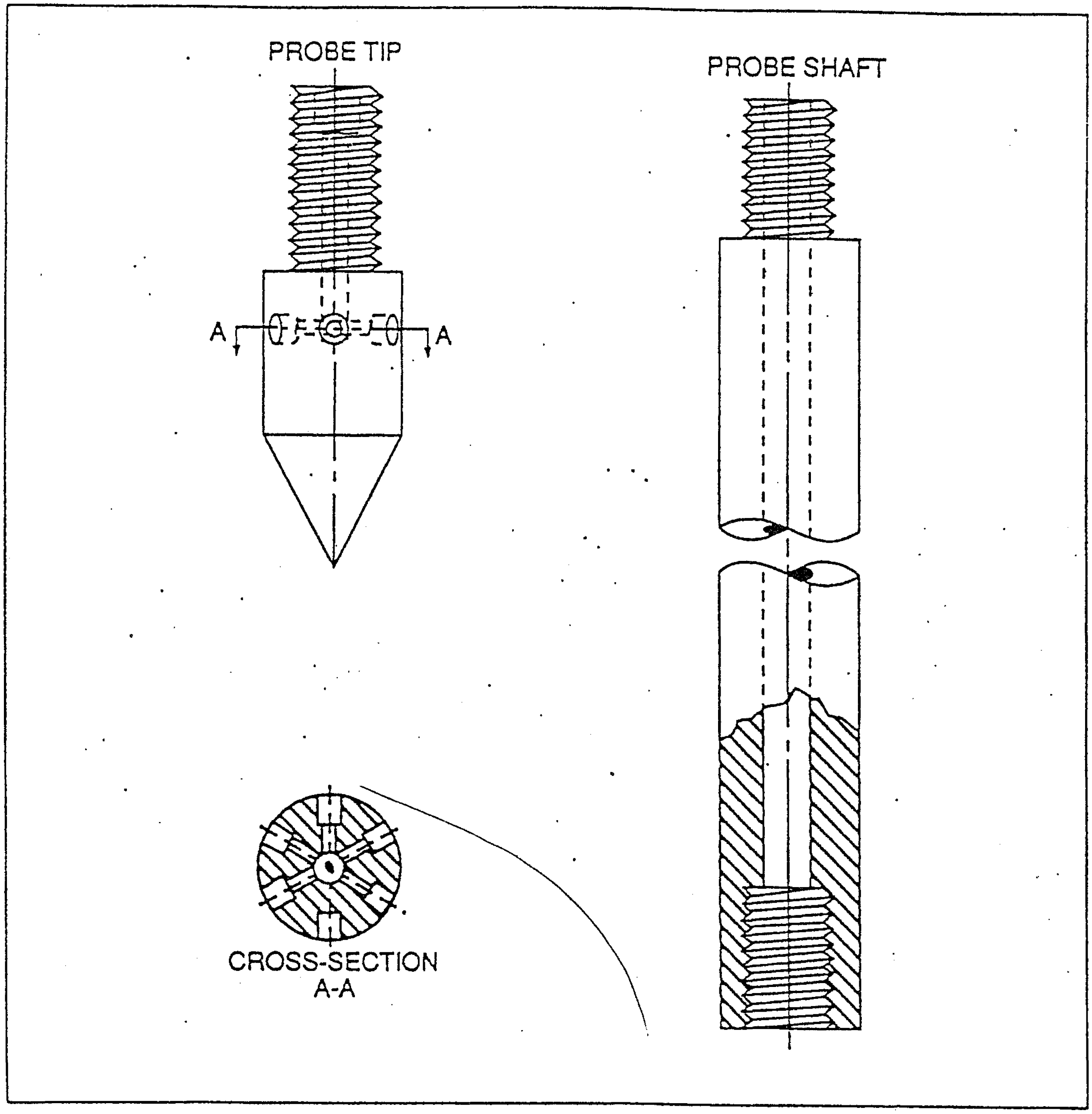
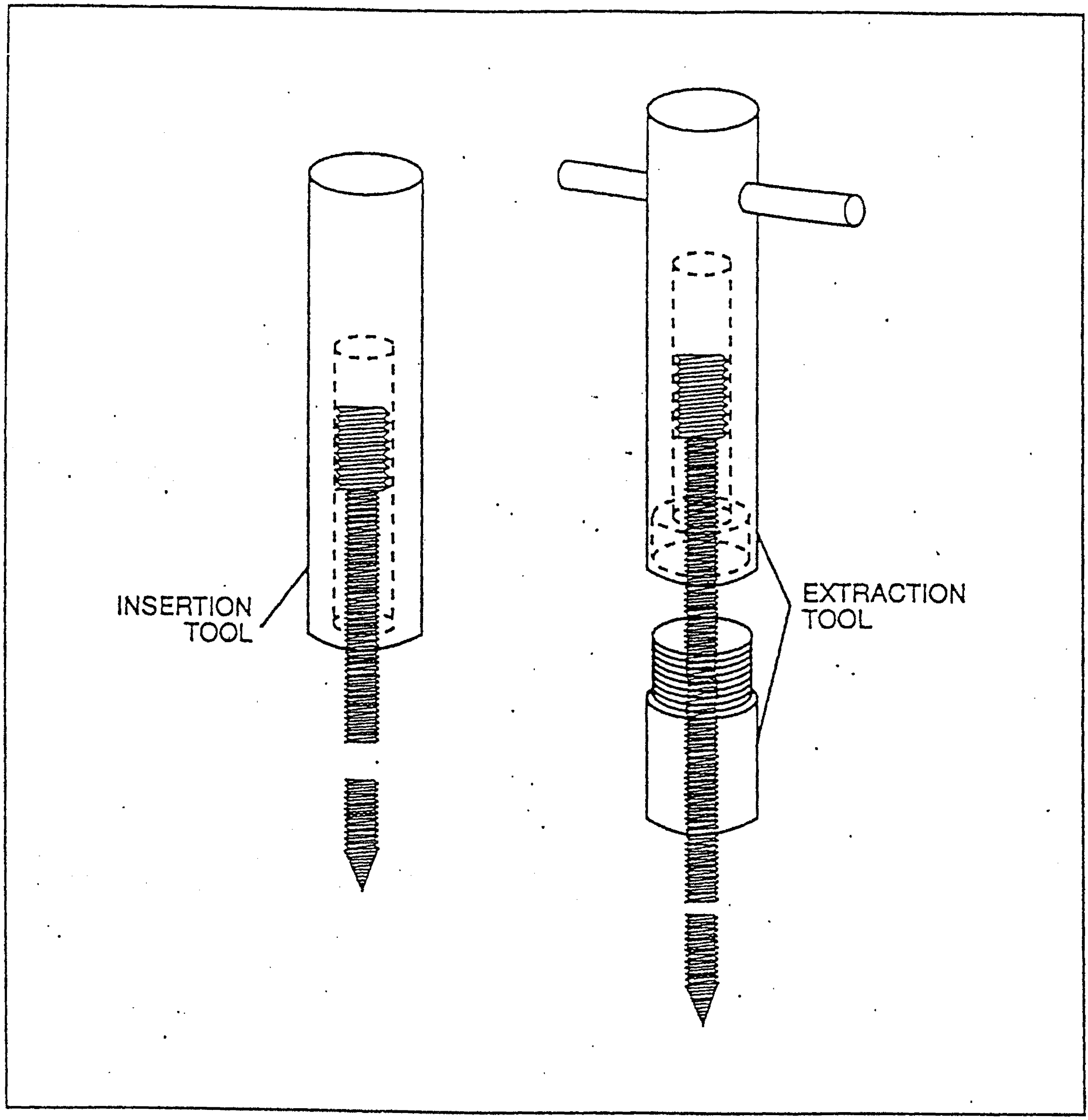


EXHIBIT 19-3
Insertion and Extraction Tools



STANDARD OPERATING PROCEDURE - 20

DRUM AND CONTAINER OPENING AND SAMPLING

1.0 PURPOSE

The purpose of this document is to provide recommended procedures for implementing safe and effective opening and sampling of drums and containers less than 120 gallons. Container contents are sampled and characterized for disposal, bulking, recycling, grouping, and classification purposes.

This procedure provides guidance for field operations associated with all types of drum and container opening and sampling. Deviations from the methods presented herein must be approved by the Project Leader and (CDPHE) Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Tanks: Any container with a capacity of 120 gallons or greater. Tanks can be aboveground, free standing, below ground, or mobile. Tanks can be constructed of plastic, steel or concrete and can include tank trucks, rail cars and even boats.

Drums: 55-gallon steel or plastic containers. Generally the top can be removed. Steel drums tend to corrode with use and can sometimes rupture as a result of freezing. Plastic drums tend to be corrosion resistant but are more susceptible to rupturing as a result of freezing. Drums can also be smaller than 55-gallons. Overpacks are large drums that damaged/leaking drums are totally enclosed in.

Containers: Any bottle, can, bag and the like with a capacity of 120 gallons or less.

Bung: The opening on the lid of a holding drum which is designed for liquids to enter and exit the drum.

Chime: The metal ring which is bolted tightly to the top of the drum, sealing the lid to the drum.

2.2 Abbreviations

CLP	Contract Laboratory Program
COLIWASA	Composite Liquid Waste Sampler
FID	Flame ionization detector
IATA	International Air Transport Association
ID	Inside diameter
OSHA	Occupational Safety and Health Administration
PID	Photo ionization detector

PPE	Personal Protective Equipment
PPs	Project Plans
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
SCBA	Self-Contained Breathing Apparatus
SHSP	Site Health and Safety Plan
TSA	Temporary Storage Area

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure when performing work related to drum and container opening and sampling.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by the procedure. This will be accomplished by reviewing all documents (Exhibits) and reviewing procedures during work performance. All activities and data collected shall be recorded in the field log book.

4.0 PROCEDURE

4.1 Drum Sampling

Prior to sampling, drums must be inventoried, staged, and opened. Inventory entails recording visual qualities of each drum and any characteristics pertinent to the contents' classification. Staging involves the organization, and sometimes consolidation of drums that have similar wastes or characteristics. Opening of closed drums can be performed manually or remotely. Remote drum opening is recommended for worker safety. The most widely used method of sampling a drum involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and requires no decontamination.

4.1.1 Sample Preservation, Containers, Handling, and Storage

These guidelines must be followed when taking samples from a drum:

- No preservatives shall be added to the sample;
- Read International Air Transport Association (IATA) regulations for shipping your particular sample and follow the specific requirements;
- Place each sample container in two ziplock bags;
- Place each bagged container in a one-gallon covered can containing absorbent packing material. Place lid on can. (Drum samples are considered to be high concentration.);

- Mark the sample identification number on the outside of the can;
- Place the marked cans in a cooler and fill remaining space with absorbent packing material;
- Fill out a chain-of-custody record for each cooler, place in plastic, and affix to the inside lid of the cooler;
- Secure and custody seal the lid of the cooler; and
- Arrange for the appropriate transportation mode consistent with the type of hazardous waste involved.

4.2 Potential Problems

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used if the drums are visually overpressurized or if shock-sensitive materials are suspected.

Drums that have been overpressurized to the extent that the head is swollen above the level of the chime should not be moved. A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (three meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted into the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum and the gas vents along the grooves. The venting should be done from behind a wall or barricade. This device can be designed cheaply and easily and constructed where needed. Once the pressure has been relieved, the bung can be removed and the drum sampled.

4.3 Equipment

The following are standard materials and equipment required for sampling:

- Health and Safety Plan;
- Personal Protective Equipment (PPE);
- Wide-mouthed glass jars with Teflon® cap liner (approximately 500-ml volume);
- Uniquely numbered sample identification labels with corresponding data sheets;
- Chain-of-Custody sheets;
- Decontamination plan and materials;
- Glass thieving tubes or Composite Liquid Waste Sampler (COLIWASA); and

- Drum opening devices.

4.3.1 Bung Wrench

A common method for opening drums manually is using a universal bung wrench (Exhibit 20-1, Universal Bung Wrench). These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium nonsparking alloy formulated to reduce the likelihood of sparks. The use of a nonsparking wrench does not completely eliminate the possibility of sparks being produced.

Manual drum opening with bung wrenches should not be performed unless the drums are structurally sound (no evidence of bulging or deformation), and their contents are known. If opening the drum with a bung wrench is deemed safe and cost-effective, then certain procedures should be implemented to minimize the hazard:

- Field personnel should be fully outfitted with protective gear;
- Drums should be positioned upright with the bung up, or, for drums with bungs on the side, laid on their sides with the bung plugs up;
- The wrenching motion should be a slow, steady pull across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, a "cheater bar" can be attached to the handle to improve leverage.

4.3.2 Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader (Exhibit 20-2, Drum Deheader). This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part-way off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed-head drums. Drums with removable heads must be opened by other means.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off if so desired. If the top chime of a drum has been damaged or badly dented it may not be possible to cut the entire top off. Because there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built up pressure. The safest technique would be to employ a remote method prior to using the deheader.

Self-propelled drum openers which are either electrically or pneumatically driven are available, and can be used for quicker and more efficient deheading.

4.3.3 Hand Pick, Pickaxe, and Hand Spike

These tools are usually constructed of brass or a nonsparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung (Exhibit 20-3, Hand Pick, Pickaxe, and Hand Spike). The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated four-foot-long poles with a pointed end.

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or hand spike. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. Because of this, the potential for splash or spraying is greater than with other opening methods; therefore, this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums, some of which may be under pressure, cannot be opened slowly with these tools, spray from drums is common and appropriate safety measures must be taken. The pick or spike should be decontaminated after each drum is opened to avoid cross-contamination and adverse chemical reaction from incompatible materials.

4.3.4 Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket (Exhibit 20-4, Backhoe Spike). In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

Drums should be "staged" or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with a spike.

The spike should be decontaminated after each drum is opened to prevent cross-contamination. Even though some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This combined with the normal personal protection gear should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with supplied air.

4.3.5 Hydraulic Drum Opener

Recently, hydraulic devices have been fabricated to open drums remotely (Exhibit 20-5, Hydraulic Drum Opener). One such device uses hydraulic pressure to pierce through the wall of a drum. The device consists of a manually operated pump which pressurizes oil through a length of hydraulic line. The pressurized oil advances a piercing device through the drum to allow an access point for subsequent sampling.

4.3.6 Pneumatic Devices

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-staged regulator (Exhibit 20-6, Pneumatic Bung Remover). A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This remote bung opener does not permit the slow venting of the container, and therefore, appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

4.4 Decontamination

All sampling equipment and the exterior of the sample jars will be decontaminated as described in the following section.

These decontamination procedures will be used on all pieces of equipment to maintain sample integrity and eliminate the cross-contamination of samples.

4.4.1 Decontamination of Sampling Equipment

All sampling equipment, jars, and containers will be decontaminated after each sample has been obtained. The decontamination procedure will follow the procedures listed in the Technical Standard Operating Procedure 4.11, Equipment Decontamination.

4.4.3 Decontamination of Field Personnel

All on-site personnel will wear personal protective equipment (PPE) as described in the Site Health and Safety Plan (SHSP). Personnel decontamination procedures are also described in the SHSP and will be implemented at each sampling location.

4.5 Methods

4.5.1 Drum Staging

Prior to sampling, the drums should be staged to allow easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum should explode or catch fire when opened.

During staging, the drums should be physically separated (if potential contents are known from drum type or existing labels) into the following categories: Those containing solids, those containing liquid, and those which are empty. This is done because the strategy for sampling and handling drums or containers in these categories will be different. Separation may be achieved by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open-top drums. Closed-head drums with a bung opening generally contain liquid; and
- Visual inspection of the contents of the drum during sampling, followed by restaging, if needed.

Once a drum has been staged and sampled, and any immediate hazard has been eliminated by overpacking or transferring the drum's contents, the drum is affixed with a numbered tag and/or transferred to a secondary staging area, if necessary. Color-coded tags, labels, or bands should be used to mark similar waste types. Considering that such labels can be lost, it may be appropriate to paint-number each container. A description of each drum, its condition, any unusual markings, and the location where it was buried or stored are recorded on a drum data sheet. This data sheet becomes the principal record-keeping tool for tracking the drum on site.

Where there is good reason to suspect that drums containing radioactive, explosive, and shock-sensitive materials are present, these materials should be staged in a separate, isolated area. Placement of explosives and shock-sensitive materials in diked and fenced areas will minimize the hazard and the adverse effects of any premature detonation of explosives.

Where space allows, the drum opening area should be physically separated from the drum removal and drum staging operations. Drums are moved from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grapplers or barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

4.5.2 Drum Opening

There are three basic techniques available for opening drums at hazardous waste sites:

- Manual opening with nonsparking bung wrenches;

- Drum deheading; and
- Remote drum puncturing or bung removal.

The choice of drum opening techniques and accessories depends on the number of drums to be opened, their waste contents, and physical condition. Remote drum opening equipment should always be considered in order to protect worker safety. Under OSHA 1910.120, manual drum opening with bung wrenches or deheaders may be performed ONLY when drums are structurally sound, drum contents are known, and the contents are NOT shock sensitive, reactive, explosive, or flammable in nature.

4.6 Drum Sampling

After the drum has been opened, preliminary monitoring of headspace gases should be performed using an explosimeter and flame ionization detector (FID) or photo ionization detector (PID).

In most cases, it is impossible to observe the contents of sealed or partially sealed vessels. Since some layering of stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the vessel.

When sampling a previously sealed vessel, check for the presence of bottom sludges. This is easily accomplished by measuring the depth to the apparent bottom then comparing this value to the interior depth.

4.6.1 Glass Thief Sampler

The most widely used implement for sampling a drum or similar vessel is a glass tube (glass thief, 6- to 16-mm inside diameter (ID) x 48-inch length). This tool is simple, cost effective, quick, and collects a sample without having to be decontaminated.

The standard operating procedure for using a drum thief is as follows:

- Remove cover from sample container;
- Insert glass tubing almost to the bottom of the drum or until a solid layer is encountered. About one foot of tubing should extend above the drum;
- Allow the waste in the drum to reach its natural level in the tube;
- Cap the top of the sampling tube with a tapered stopper or gloved thumb, ensuring liquid does not come into contact with the stopper;
- Carefully remove the capped tube from the drum and insert the uncapped end of the tube into the sample container;

- Release the stopper and allow the glass thief to drain completely into the sample container. Fill the container to about 2/3 capacity;
- Remove the tube from the sample container, break it into pieces and place the pieces in the drum;
- Cap the sample container tightly and place the prelabeled sample container into the carrier;
- Replace the bung or place plastic over the drum; and
- Transport the sample to the decontamination area for preparation for transport to the analytical laboratory.

In many instances, a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sample tube down into this layer and then gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by using a stainless steel lab spoon.

It should be noted that in some instances, disposal of the tube by breaking it into the drum may interfere with eventual plans for the removal of the contents. The use of this technique, or other disposal techniques evaluated, should be cleared with the Project Leader for compatibility with planned disposal techniques.

4.6.2 COLIWASA

Designs exist for equipment that will collect a sample from the full depth of a drum and maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the COLIWASA and modifications thereof. The COLIWASA is a much cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. One configuration consists of a 152 cm by 4 cm inside diameter (ID) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

- Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block;
- Slowly lower the sampler into the liquid waste;
- When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

- Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the discharge end of the sampler is positioned in a sample container.

- Cap the sample container with a Teflon®-lined cap; attach label; seal; and record on the sample data sheet; and

- Unscrew the T-handle of the sampler and disengage the locking block. Clean the sampler.

4.7 Health and Safety

The opening of closed containers is one of the most hazardous site activities. Maximum effort should be made to ensure the safety of the sampling team. Please refer to Health and Safety Standard Operating Procedure 3.9, Container Handling, for guidelines for safely working in and around drums.

Proper protective equipment and general awareness of the possible dangers will minimize the risk inherent to sampling operations. Employing proper drum opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

Most drum sampling activities are performed in level B PPE with additional splash protection, including the following:

- Protective coverall (saranex, Tyvek, polyvinyl chloride (PVC), acid suit, etc.);
- Hard hat;
- Self-Contained Breathing Apparatus (SCBA);
- Steel toe, steel shank boot (or booties covering steel toe work boots);
- Surgical gloves;
- Solvent and acid resistant gloves;
- Splash apron; and
- Face splash shield.

5.0 REFERENCES

National Institute for Occupational Safety and Health (NIOSH), U.S. Coast Guard, and U.S. Environmental Protection Agency (EPA). 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. U.S. Government Printing Office, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1985. (OSWER Directive 9380.0-3.) “Guidance Document for Cleanup of Surface Tank and Drum Sites.” U.S. Environmental Protection Agency. Washington, DC.

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CDPHE. 2000. "Standard Operating Procedure 4.11, Equipment Decontamination." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 20-1	Universal Bung Wrench
Exhibit 20-2	Drum Deheader
Exhibit 20-3	Hand Pick, Pickaxe, and Hand Spike
Exhibit 20-4	Backhoe Spike
Exhibit 20-5	Hydraulic Drum Opener
Exhibit 20-6	Pneumatic Bung Remover
Exhibit 20-7	COLIWASA Sampler

Exhibit 20-1
Universal Bung Wrench

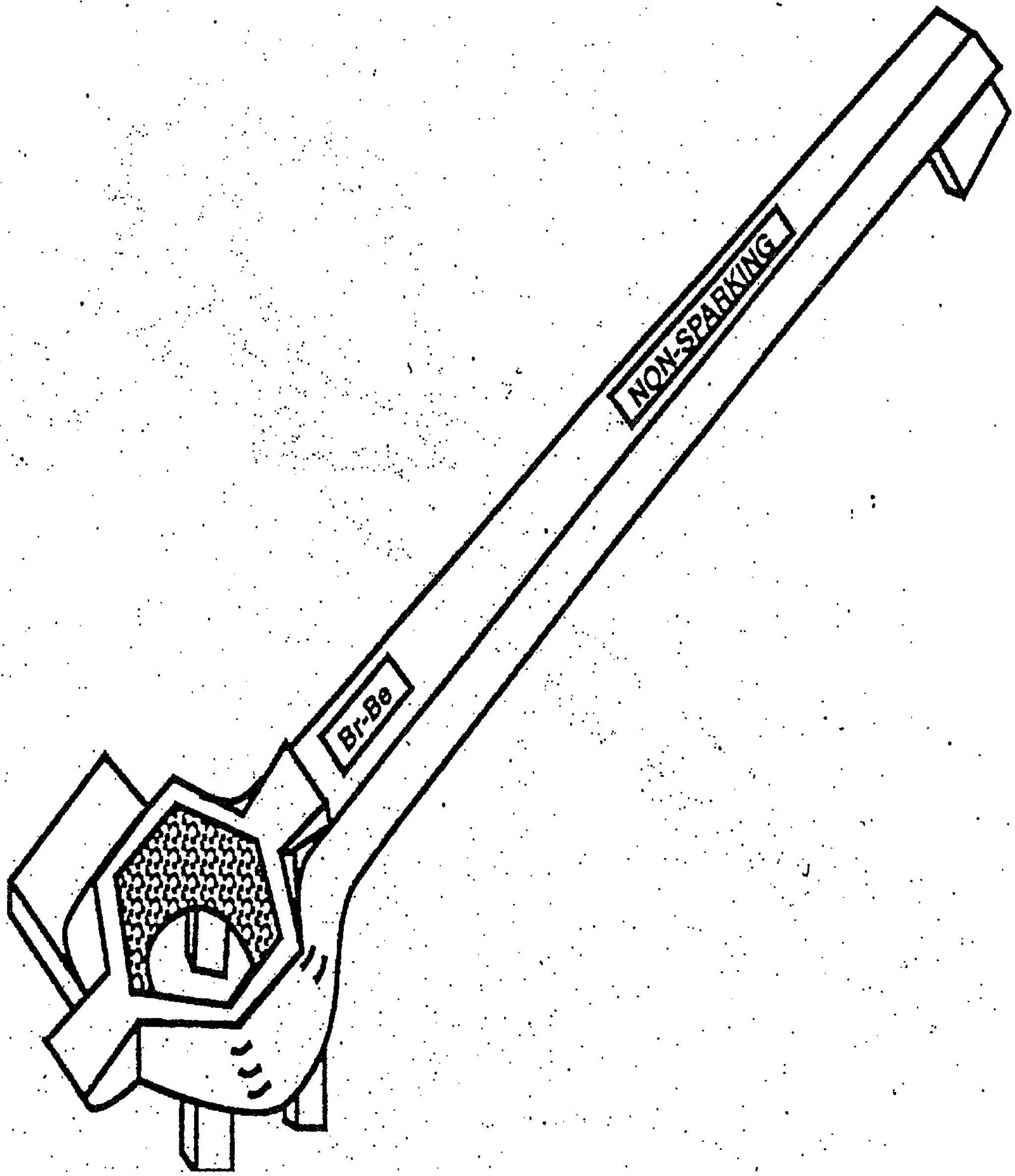


Exhibit 20-2
Drum Deheader

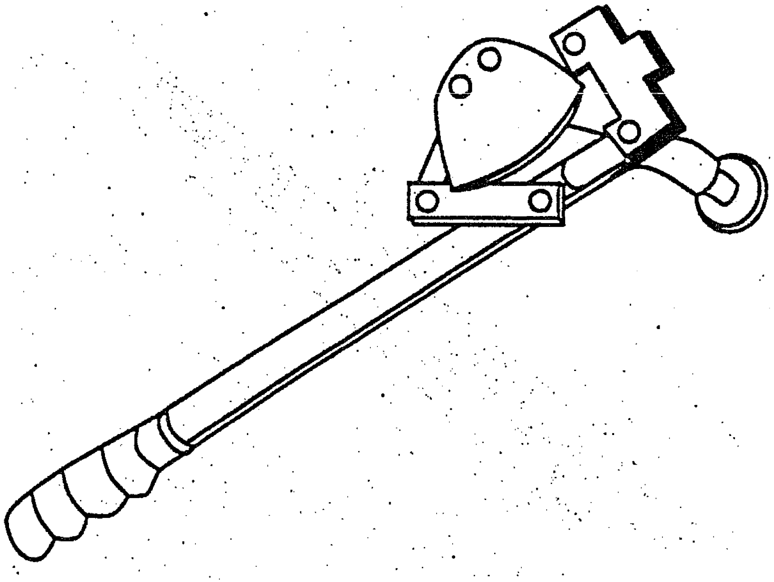


Exhibit 20-3
Hand Pick, Pickaxe, and Hand Spike

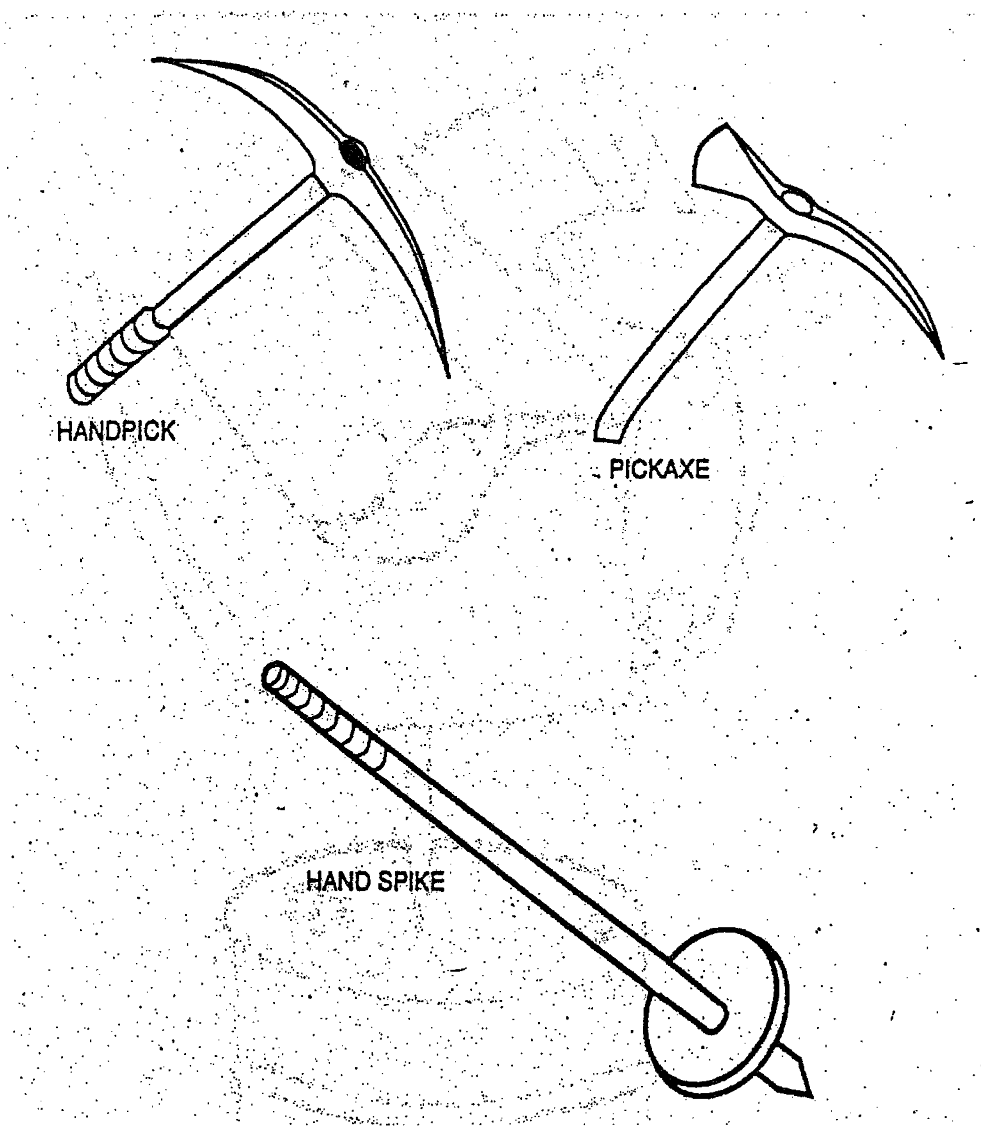


Exhibit 20-4
Backhoe Spike

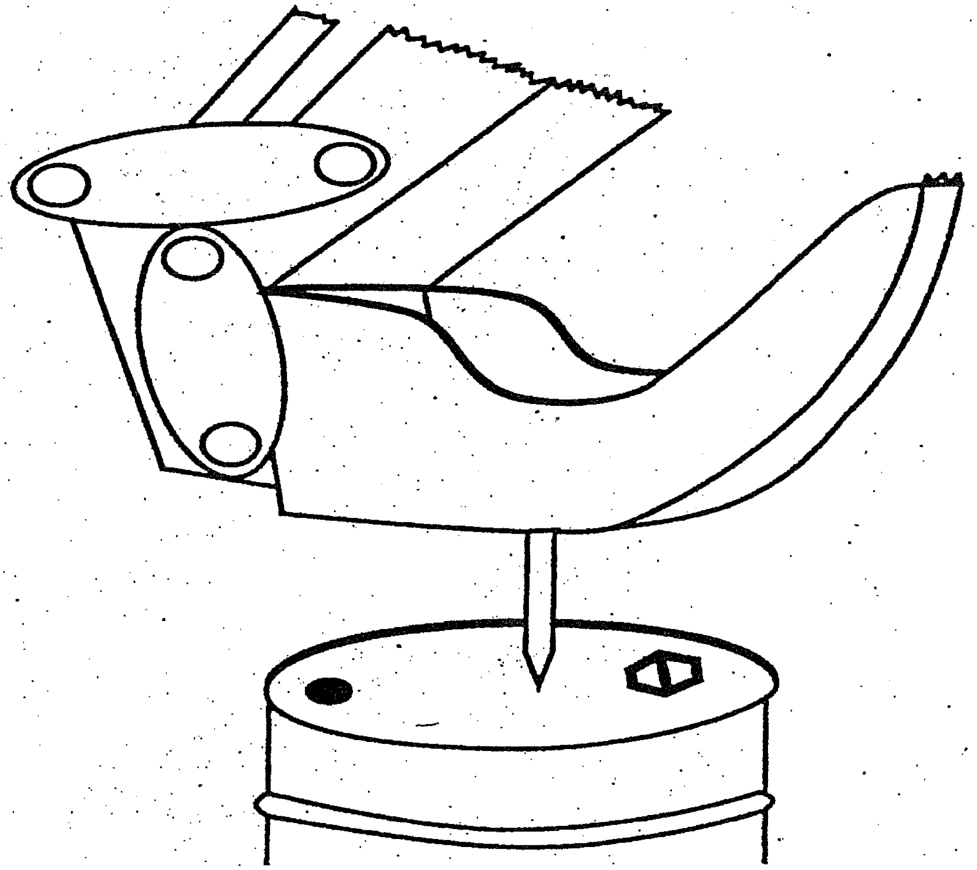


Exhibit 20-5
Hydraulic Drum Opener

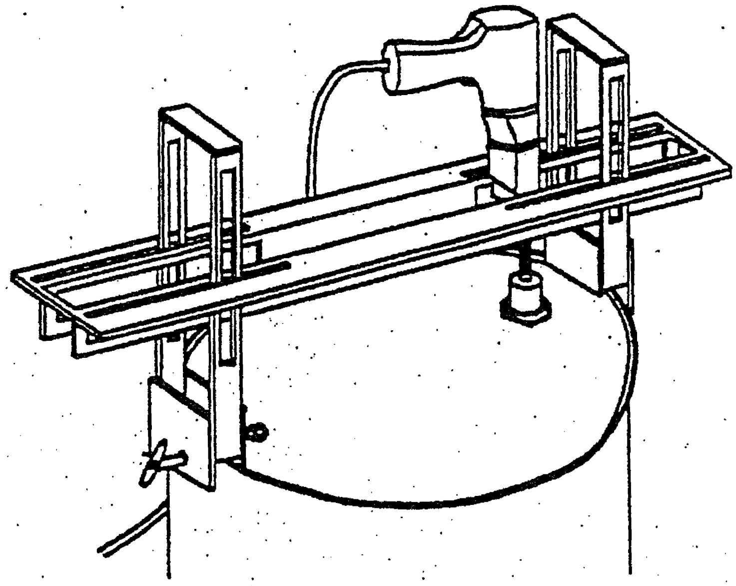


Exhibit 20-6
Pneumatic Bung Remover

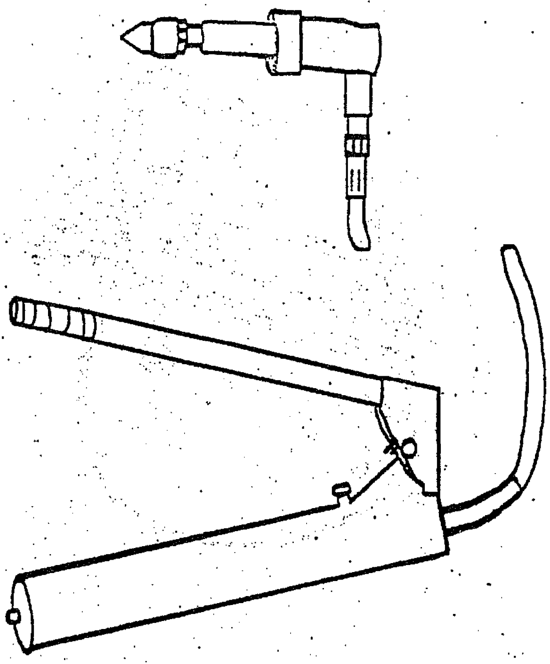
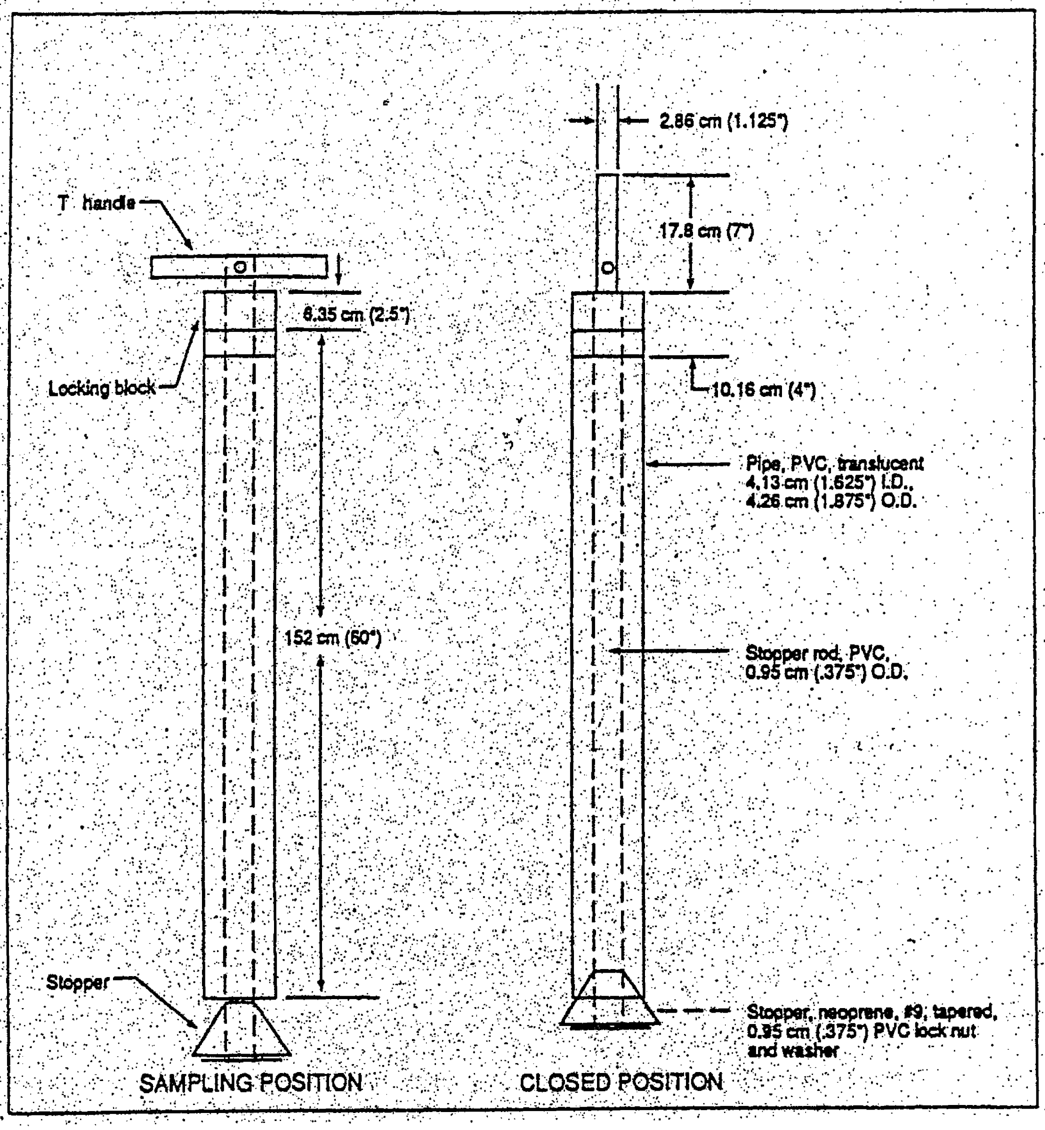


Exhibit 20-7
COLIWASA Sampler



STANDARD OPERATING PROCEDURE - 21

TANK SAMPLING

1.0 PURPOSE

The purpose of this Procedure is to describe the equipment and methods used for tank sampling. This procedure outlines the methods for equipment operation with a variety of tank sampling devices, techniques for routine tank sampling at environmental sites and equipment decontamination procedures. Site-specific deviations from the methods presented herein must be approved by the Project Leader and CDPHE Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Tank: Any bulk container with a capacity of more than 120 gallons, such as railroad tank cars, large above- and below-ground storage containers and tank trailers.

2.2 Abbreviations

COLIWASA	Composite Liquid Waste Sampler
ID	Inside diameter

3.0 RESPONSIBILITIES

Sampling personnel are responsible for performing the applicable tasks and procedures outlined herein when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced.

4.0 PROCEDURES

4.1 Introduction

The objective of tank sampling is to ascertain the type, degree and amount of hazardous materials contained in a tank and/or the extent of contamination of the tank. The data collected from tank sampling is used to evaluate potential exposure pathways, to calculate environmental risks and to provide data which serves as a basis for design and implementation of an efficient, cost-effective site remediation system.

4.2 Sampling Equipment

4.2.1 Introduction

Before sampling any tank or other large container, first try to determine as much as possible about the contents. A measuring tape, an oil/water interface probe or dip sticks can be used to answer questions such as:

- What is the volume of the tank?
- What is the volume of the material in the tank?
- Does the tank contain both solid and liquid phases; and
- Does the tank contain two or more separate liquid layers?

Once some basic physical properties of the tank contents have been determined, an appropriate sampling method can be selected. Some basic methods and their best application are:

• Homogenous liquid:	dip sampler, bailer, pump, spigot
• Multi-layered liquids:	weighted bottle, COLIWASA, Bacon Bomb
• Solid and liquid:	dip sampler, sediment sampler

4.2.2 Weighted Bottle Sampler

Collecting a representative liquid sample from a large tank or from a tank where the contents have separated into layers is facilitated by the use of a weighted bottle sampler, which enables samples to be collected from various depths. The weighted bottle sampler consists of a glass or Teflon® bottle, a weighted sinker, a bottle stopper, and a wire or cord to raise, lower, and open the sampler. This type of sampler can be fabricated or purchased dependant upon time and expected usage demands. The following procedures will be followed when sampling with a weighted bottle sampler.

- Decontaminate all equipment in accordance with SOP 4.11, Equipment Decontamination;

- Assemble the weighted bottle sampler in accordance with the manufacturer's instructions;

- Gently lower the sampler to the desired depth so the stopper is not removed prematurely (do not let the sampler disturb bottom sediments);

- Pull the stopper out with a sharp jerk of the sampler line;

- Allow the bottle to fill completely, as evidenced by the cessation of air bubbles in the tank liquid;

- Raise the sampler, seal, decontaminate, label or identify, and prepare the bottle for transport in accordance with project guidelines;
- Record all pertinent information in the field log book and on appropriate field forms;
- Decontaminate equipment in accordance with SOP 4.11, Equipment Decontamination.

4.2.3 Dip Sampler

A dip sampler consists of a container attached (by an adjustable clamp) to the end of a telescoping pole. The pole is of a non-reactive material such as wood, plastic, or metal. The sample is collected in a jar or beaker made of stainless steel, glass or Teflon®. Liquid waste from the tank is "ladled" into the appropriate sample container. The following procedures are performed while sampling with a dip sampler:

- Decontaminate all sampling equipment in accordance with the procedures in SOP 4.11, Equipment Decontamination;
- Assemble dip sampler in accordance with manufacturer's instructions;
- Extend pole to a length which will allow safe access to tank contents;
- Submerge the dip sampler to the desired sample depth slowly to minimize surface disturbance;
- Allow the sampler container to fill very slowly;
- Retrieve the dip sampler with minimum disturbance of liquid surface;
- Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the sampler container edge;
- Empty the dip sampler slowly, allowing the sample stream to flow gently down the inside of the bottle with minimal entry turbulence;
- Seal and label or identify the sample bottle; and
- Decontaminate the equipment according to SOP 4.11, Equipment Decontamination.

4.2.4 COLIWASA

Designs exist for equipment that will collect a sample from the full depth of a drum or tank and maintain it in the transfer tube until delivery to the sample bottle. These designs include primarily the Composite Liquid Waste Sampler (Exhibit 21-1, COLIWASA Sampler) and modifications thereof. The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. One configuration consists of a 152 cm by 4 cm inside diameter (ID) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. The major drawbacks associated with using a COLIWASA concern decontamination and cost. The sampler is difficult if not impossible to decontaminate in the field and it is a high cost method in relation to alternative procedures (e.g., glass tubes). It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary. The following procedures are performed while sampling with a COLIWASA.

- Read the operation manual and familiarize yourself with equipment parts and function.

- Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

- Slowly lower the sampler into the liquid waste. (lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same height. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a nonrepresentative sample.

- When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

- Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.

- Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

- Cap the sample container with a Teflon-lined cap; attach label and seal; and record on sample data sheet.

- Unscrew the T-handle of the sampler and disengage the locking block. Clean the sampler.

4.2.5 Bacon Bomb Sampler

The bacon bomb sampler (Exhibit 21-2), is designed to collect material from various levels within a storage tank. It consists of a cylindrical body, usually made of chrome-plated brass and bronze with an internal tapered plunger that acts as a valve to admit the sample. A line is attached to the top of the plunger opens and closes the valve. A line is attached to the removable top cover which has a locking mechanism to keep the plunger closed after sampling. The following procedures are performed while sampling with a bacon bomb sampler.

- Attach the sample line and the plunger line to the sampler.
- Measure and then mark the sampling line at the desired depth.
- Gradually lower the bacon bomb sampler by the sample line until the desired level is reached.
- When the desired level is reached, pull up on the plunger line and allow the sampler to fill before releasing the plunger line to seal off the sampler.
- Retrieve the sampler by the sample line. Be careful not to pull up on the plunger line and thereby prevent accidental opening of the bottom valve.
- Rinse or wipe off the exterior of the sampler body.
- Position the sampler over the sample container and release its contents by pulling up on the plunger line.
- Cap the sample container tightly and place the prelabeled sample container in a carrier.
- Replace the bung or place plastic over the tank.
- Log all samples in the site log book and label all samples. Samples may also be logged on field data sheets.
- Package samples and complete necessary paperwork.
- Transport sample to decontamination zone to prepare it for transport to the analytical laboratory.

4.3 Decontamination

Before initial use, all sampling equipment that may contribute to cross-contamination must be thoroughly decontaminated following the methods outlined in SOP 4.11, Equipment Decontamination.

Place all rinsate and unsampled material in 55-gallon drums and store temporarily on the site. Follow all applicable state and federal transportation and disposal regulations. Document decontamination operations in the field log book.

4.4 Sampling Documentation

Proper documentation of sampling procedures and sample control are accomplished by following SOP 4.4, Sample Identification, SOP 4.3, Chain of Custody and Sample Tracking, and SOP 4.5, Sample Location Documentation. Photographic documentation (SOP 4.5) of tank location, tank condition and tank contents are particularly important in a tank sampling program. The Aboveground Storage Tank Characterization and Sampling Form (Exhibit 21-3) should be completed for each tank examined and sampled.

4.5 Sampling Methods

Containers will be opened according to the specifications presented in the Project Plans and Site Health and Safety Plan. Open the tank cover or access port with non-sparking tools. Care should be taken not to agitate and homogenize liquids and sludges or to unnecessarily mix stratified layers of liquid in the tank.

Field personnel will monitor the surrounding air and the head space of the tank for fumes and vapors according to the Site Health and Safety Plan. Sampling may proceed once the area has been determined to be safe and/or the appropriate precautions have been taken.

Check for the presence of sludge in the tank by measuring the apparent depth and comparing this number with the known tank depth. Bottom sludges can be sampled using a sediment sampling device, such as those outlined in SOP 4.17, Sediment Sampling.

4.6 Review

The Project Leader or an approved designee shall check Exhibit 21-3, Aboveground Storage Tank Characterization and Sampling Form, for completeness and accuracy. Any discrepancies in the data will be noted and the form will be returned to the originator for correction. The reviewer will acknowledge that review comments have been incorporated by signing and dating the "Checked By" and "Date" blanks on Exhibit 21-3, Aboveground Storage Tank Characterization and Sampling Form.

5.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1985. (OSWER Directive 9380.0-3.) "Guidance Document for Cleanup of Surface Tank and Drum Sites." U.S. Environmental Protection Agency. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." EPA/540/P-87/001, U.S. Environmental Protection Agency. Washington, DC.

CDPHE, 2000. "Standard Operating Procedure 1, General Field Operation." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 3, Chain of Custody." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4, Sample Location Documentation." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 5, Sample Location Decontamination." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 6, Use and Maintenance of Field Log Books." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 11, Equipment Decontamination." Standard Operating Procedures.

CDPHE , 2000. "Standard Operating Procedure 17, Sediment Sampling." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 18, Surface Water Sampling." Standard Operating Procedures.

6.0 EXHIBITS

Exhibit 21-1	COLIWASA Sampler
Exhibit 21-2	Bacon Bomb Sampler
Exhibit 21-3	Aboveground Storage Tank Characterization and Sampling Form

EXHIBIT 21-1
COLIWASA Sampler

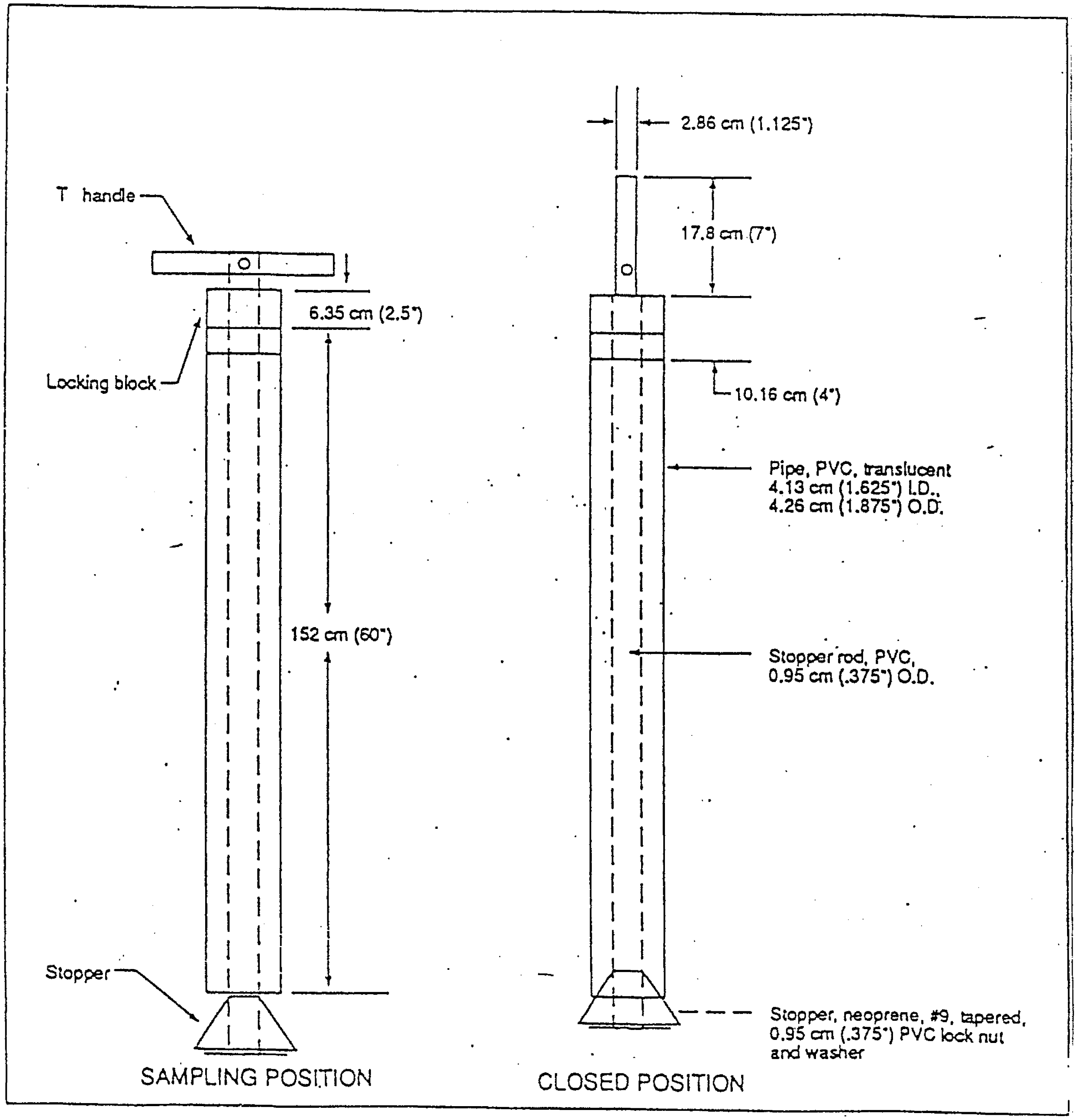


EXHIBIT 21-2
Bacon Bomb Sampler

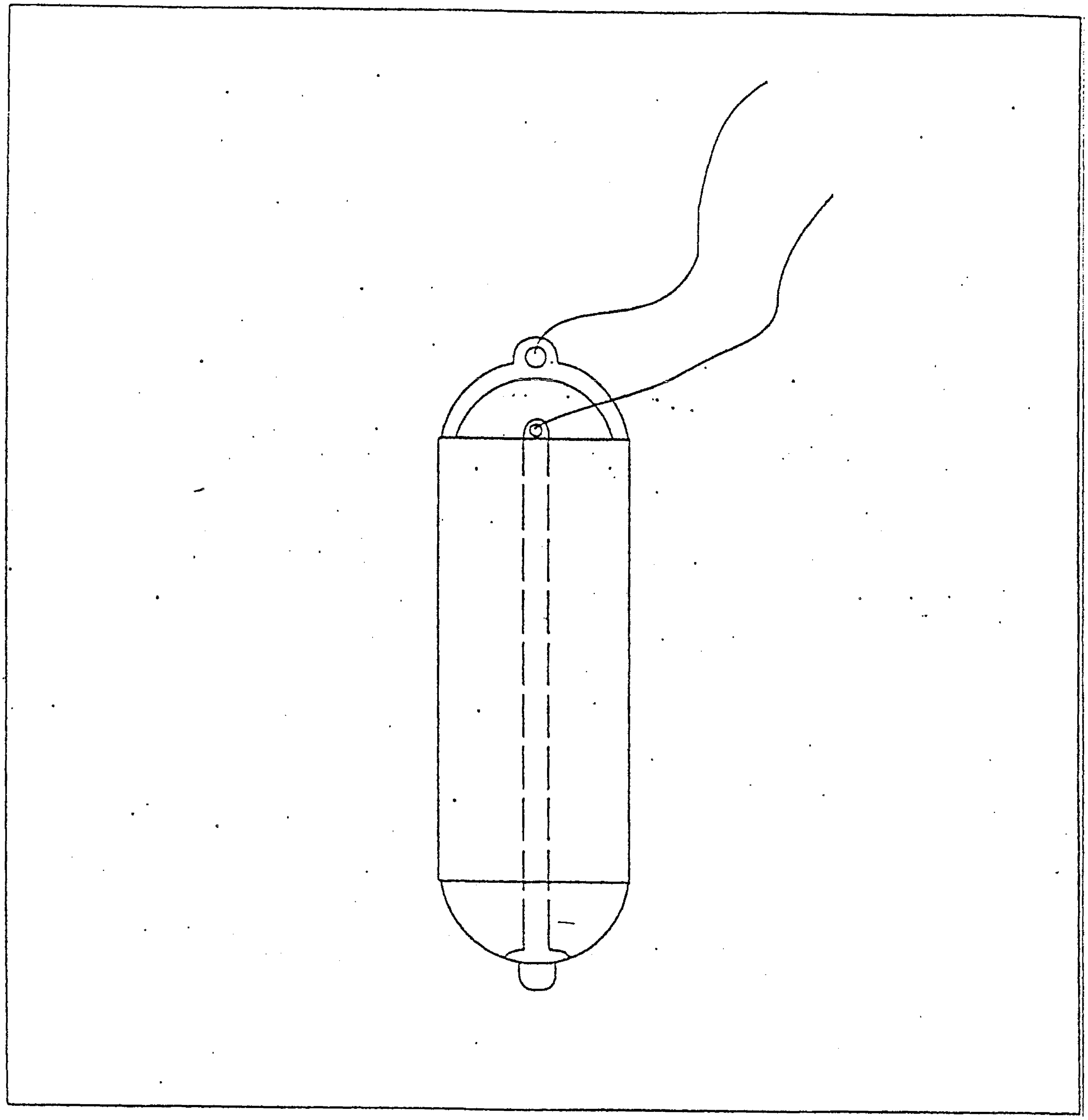


EXHIBIT 21-3
Aboveground Storage Tank Characterization and Sampling Form

Project Number	Project Name	Site
Tank Identification	Tank Location (use back of form for sketch if necessary)	

EXTERIOR INSPECTION

Circumference ________________
Height of Tank ________________
Location of Manholes/Portholes ________________

Pipes, Hoses, Valves or Other Fittings ________________

Labeling on Tank ________________
Physical Condition of Tank ________________
(rust, holes, etc.) ________________
Evidence of Spill or Leaking ________________
to the Environment ________________
General Conditions Around Tank ________________

TANK CONTENTS

Monitoring Data: PID ____________ Oxygen Meter ____________ Explosimeter ____________

Depth of Liquid Contents ________________
Measured by ________________

Description of Contents ________________

Contents Layered? Yes____ No____ How? ________________

Sampling Method ________________

SAMPLE INFORMATION

TAG #	ANALYSIS	CONTAINER	AMOUNT OF SAMPLE	PRESERVATIVE	COC#

Recorded By:	Date:	Checked By:	Date:

STANDARD OPERATING PROCEDURE - 22

AQUIFER SLUG TESTING

1.0 PURPOSE

The purpose of this procedure is to provide technical guidance and methods for performing slug tests on piezometers and monitor wells. It outlines methods and provides for documentation of field data.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Aquifer: A geologic formation capable of yielding significant quantities of water to wells.

Electronic Data Logger: An electronic instrument capable of recording electrical impulses and converting them to data usable for scientific analysis. This instrument, when connected to a transducer probe, can record rapid changes in water levels over short time intervals.

Hydraulic Conductivity: A measure of the ability of a porous medium to transmit fluids. It is dependent on both the fluid and the medium. The hydraulic conductivity is generally defined as a rate of flow through a unit cross-sectional area under a unit hydraulic gradient. English units for hydraulic conductivity are commonly expressed either in gal/day/ft^2 or ft/day. SI metric units are often expressed in cm/s.

Hydraulic Gradient: It is defined for any fluid as dh/dl, which is the ratio of the change in total hydraulic head (dh) per length (dl) of flow. It dimensionally has the units of (ft/ft).

Measuring Point: A survey mark on a well casing from which all measurements are taken.

Piezometer: A well designed for groundwater level measurements. Typically, a piezometer consists of a small diameter pipe screened over the aquifer interval.

Slug: Sealed pipe or other object which is used to produce an instantaneous head change in a well by displacement. The head change can be produced by either quickly lowering the slug into the water or, after submerging the slug and allowing the water level to equilibrate, by quickly raising the slug above water.

Transducer Probe: The pressure transducer responds to pressure changes caused by groundwater level fluctuations. Pressure changes are converted to an electrical impulse and sent to an electronic data logger.

2.2 Abbreviations

cm/s	Centimeters per second
dh	Total hydraulic head
dl	Length of flow
ft/d	Feet per day
gal/day/ft^2	Gallons per day per square foot
SI	International System of Units

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This is accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURES

4.1 Introduction

A slug test is conducted by measuring water level responses over time to an "instantaneous" withdrawal or addition of a "slug" of water. The addition of water is generally referred to as a falling head slug test whereas the removal of water is commonly called a rising head slug test. The rising head slug test is usually performed by lowering a solid slug below the water table and allowing the water level to equilibrate to static conditions. The slug is quickly withdrawn from the well and the subsequent rise in water levels is measured. The falling head slug test is performed by adding a slug and measuring the fall in water levels subsequent to the initial instantaneous rise.

Both types of tests can usually be performed at a monitoring well site. Although procedures described below are for a rising head slug test they can be considered applicable to both types of tests.

Do not perform slug tests simultaneously in adjacent monitor wells (i.e., within 50 feet of each other vertically or horizontally). Typically, use a 5- to 10-foot long slug of appropriate diameter to fit the well casing to provide the "instantaneous" head change.

4.2 Decontamination

Prior to lowering the equipment into any well or boring, decontaminate each item using the procedure outlined in TSOP 4.11, Equipment Decontamination.

4.3 Pre-Test Data Recording

Complete Exhibit 22-1, Slug-Test Data prior to conducting each slug test. Obtain the following information from existing well logs prior to the slug test and record on Exhibit 22-1:

- Casing diameter;
- Borehole diameter;
- Location of surveyed measuring point;
- Total casing depth;
- Static water level (prior to introducing slug);
- Screen depth and interval;
- Location of filter pack;
- Lithology of screened interval; and
- Volume of slug.

4.4 Field Methods

4.4.1 Setup

- Measure the static water level from the surveyed location measuring point on the well head with an electronic water level indicator. Record water levels to the nearest 0.01 foot. Determine the total monitor well depth with a weighted measuring tape from the measuring point.

- Measure water levels during the slug test with either an electronic data logger or an electronic water level indicator. Refer to the equipment operations manual for any instructions needed. Using the manufacturer's operations manual, select the appropriate transducer probe for the monitor well to be tested.

- Set the transducer probe in the monitor well at the appropriate depth as determined by the sensitivity of the transducer, height of the water column in the well, and length of the slug. Secure the probe cable so that it will not move during the test. If using an electronic data logger follow the manufacturer's operating instructions to complete the test setup and verify that the equipment is working correctly.

- After completion of the initial test setup and pre-run check, lower the solid slug into the monitor well so that the top of the slug is approximately two to three feet below the initial static water level. If there is insufficient water in the monitor well to allow complete submergence of the slug, immerse the slug as fully as possible without disturbing the transducer probe. Allow the water level in the monitor well to equilibrate to static water level conditions.

4.4.2 Testing

- Prior to slug removal, start the electronic data logger. Then quickly remove the slug from the monitor well. The transducer probe must remain stationary during the entire test. Continue the test until the water level returns to within 10 percent of the static water level or until 24 hours have elapsed.

  Set recording intervals on the data logger using either default time intervals or the intervals presented below as appropriate for test conditions.

Elapsed Time (After removing slug)	Water Level Measurement Interval
0-30 sec.	1.0 sec.
30-120 sec.	3.0 sec.
2-10 min.	5.0 sec.
10-100 min.	2 min.
100-1,000 min.	10 min.
1,000-10,000 min.	100 min.

- Measure the water level in the monitor well periodically with the water level indicator to verify that the data logger is functioning properly. Record the data on Exhibit 22-1, Slug Test Data. The required test completion time will depend upon the hydraulic conductivity of the surrounding formation. Slug tests may vary in duration from several minutes to more than a day.

- If available, print out all logger data in the field using a compatible printer. Otherwise, periodically download data from the data logger onto the appropriate forms. Staple the printout of the slug test data to the corresponding Exhibit 22-1, Slug Test Data.

- Slug tests performed in monitor wells, that are anticipated to exhibit slow water level response (as indicated by monitor well development records), may be measured with an electronic water level indicator.

4.5 Analysis Methods

Analyze slug test data using an analytical method appropriate for the monitor well and local aquifer conditions. Methods may include: Hvorslev (1951); Cooper and others, (1967); Cooper and Jacob (1946); Bouwer and Rice (1976); and Bouwer (1989). Refer to the reference list in Section 5.0, References, for actual analytical methods.

In the field, an estimate of the hydraulic conductivity may be made by using Hvorslev's method (1951), where the hydraulic conductivity K is estimated by the following equation:

$$K = \frac{r^2 \ln (L/R)}{2LT_o}$$

where:
K = hydraulic permeability
r = radius of the well casing
L = length of the well screen
R = radius of the well screen
T_o = the time it takes for the water level to rise or fall to 37 percent of the initial change

4.6 Review

Personnel performing slug tests will record the applicable field data in the field log book and on Exhibit 22-1, Slug Test Data, as determined by the Project Leader. Staple electronic data logger printouts to the appropriate Exhibit for each monitor well. The personnel performing slug tests must sign and date Exhibit 22-1, Slug Test Data, in the "measured by" and "date" blanks. These personnel must also sign and date electronic data logger printouts and all calculations prepared during slug test analyses.

The Project Leader or designee will check the slug test data, electronic data logger printouts, and calculations prepared during slug test analyses for completeness and accuracy. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating Exhibit 22-1, Slug Test Data, and the applicable reviewed documents.

5.0 REFERENCES

Bower, H. 1989. "The Bower and Rice Slug Test - An Update." Groundwater, 27: 3: 304-309.

Bower, H. and R. C. Rice. 1976. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells." Water Resources Research, 12: 423-428.

CDPHE, 2000. "Standard Operating Procedure 4.11, Equipment Decontamination." Standard Operating Procedures.

Cooper, H. H., Jr., J. D. Bredehoeft, and I. S. Papadopulos. 1967. "Response of a Finite Diameter Well to an Instantaneous Change of Water." Water Resources Research. 3: 1: 263-269.

Cooper, H. H., Jr., and C. E. Jacob. 1946. "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History." Transcripts of the American Geophysical Union. 27: 4.

Hvorslev, M. J. 1951. "Time Log and Soil Permeability in Groundwater Observations." Bulletin 36. Waterways Experiment Station. U.S. Army Corps of Engineers, Vicksburg, Miss.

6.0 EXHIBITS

Exhibit 22-1	Slug Test Data

EXHIBIT 22-1
Slug Test Data

CDPHE Colorado Department of Public Health and Environment 4300 Cherry Creek Drive South Denver, CO 80246	Slug Test Data	Records Management Data
Project Number	Project Name	Page _____ of _____
Location		

Actual Time	Elapsed Time (min.)	Depth to Water from Top of Casing (ft)	H Excess Head (ft)	H/Ho	Comments

Presented By	Date	Checked By	Date

STANDARD OPERATING PROCEDURE - 23

AQUIFER PUMP TESTS

1.0 PURPOSE

The purpose of this procedure is to provide technical guidance for performing aquifer tests that utilize both pumping and observation wells. This procedure outlines methods for conducting step-drawdown/recovery and constant discharge/recovery tests and providing documentation of this data.

This procedure does not discuss analysis of the data collected during aquifer pumping tests. Numerous analytical methods are available. Each method includes unique assumptions and limitations; hence, the particular analytical method must be tailored to site-specific conditions under which the aquifer test was conducted. Consult Section 5.0 of this procedure for specific sources on aquifer analysis.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Aquifer: A geologic formation capable of yielding significant quantities of water to wells.

Electronic Data Logger: An electronic instrument capable of recording electrical impulses and converting them into data usable for scientific analysis. This instrument, when connected to a transducer probe, can record rapid changes in water levels over short time intervals.

Hydraulic Conductivity: A measure of the ability of a porous medium to transmit fluids. It is dependent on both the fluid and the medium. The hydraulic conductivity is generally defined as a rate of flow through a unit cross-sectional area under a unit hydraulic gradient. English units for hydraulic conductivity are commonly expressed either in gallons per day per square foot (gal/day/ft^2) or feet per day (ft/day). International System of Units (SI) metric units are often expressed in centimeters per second (cm/s).

Hydraulic Gradient: It is defined as dh/dl, which is the ratio of the change in total hydraulic head per length of flow. It dimensionally has the units of (ft/ft).

Piezometer: A well designed for groundwater level measurements. Typically, a piezometer consists of a small diameter pipe screened over the aquifer interval.

Slug: Sealed pipe or other object which is used to produce an instantaneous head change in a well. The head change can be produced by either quickly lowering the slug into the water or, after submerging the slug and allowing the water level to equilibrate, by quickly raising the slug above water.

Specific Capacity: The discharge from a well expressed as a rate of yield per unit drawdown (gpm/ft).

Storage Coefficient: The volume of water that an aquifer releases from storage per unit surface area of aquifer per unit decline in the component of hydraulic head normal to that surface (dimensionless).

Transmissivity: It is expressed as Kb where K is the hydraulic conductivity and b is the saturated thickness of the aquifer. The transmissivity is defined as a rate of flow through a unit width of aquifer thickness b under a unit hydraulic gradient. English units for transmissivity are commonly expressed either in gal/day/ft or ft^2/day. SI metric units are often expressed in square meters per second (m^2/s).

Transducer Probe: The pressure transducer responds to pressure changes caused by groundwater level fluctuations. Pressure changes are converted to an electrical impulse and sent to an electronic data logger.

2.2 Abbreviations

cm/s	Centimeters per second
dh	Total hydraulic head
dl	Length of flow
ft/d	Feet per day
ft^2/d	Feet squared per day
gal/day/ft	Gallons per day per foot
gal/day/ft^2	Gallons per day per square foot
gpm/ft	Gallons per minute per foot of drawdown
m^2/s	Meters squared per second
SI	International System of Units
SOP	Standard Operating Procedures

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This is accomplished by reviewing all documents (Exhibits) and data produced during work performance. All activities and data collected shall be recorded in the field log book.

4.0 PROCEDURES

4.1 Introduction

The assessment of aquifer characteristics is vital to any investigation of groundwater contamination. Pump tests are one of the primary methods to quantitatively estimate aquifer characteristics. Depending upon the duration of the test, pump testing may also simulate actual pumping during groundwater remediation and provide valuable information for future recovery systems.

Drawdown pump tests may be conducted to determine both the performance characteristics of a well and the hydraulic parameters of an aquifer. In a well performance test, well yield and drawdown are measured so that the specific capacity can be calculated. These data, taken under controlled conditions, give a measure of the productive capacity of the completed well and also provide information needed for the selection of pump equipment.

Aquifer pump tests also provide data from which the principal aquifer properties, transmissivity and storage coefficient, can be calculated. These properties are essential in determining not only the radius of influence for individual or multiple pumping wells but also are necessary in establishing groundwater flow velocities.

An aquifer test consists of pumping a well at either constant or variable pumping rates and measuring the drawdown in the pumping well and in any nearby observation wells. There are generally two types of aquifer tests; one is a constant rate test and the other is a step-drawdown test. In a constant rate test, pumping is sustained at a constant discharge rate for the duration of the test, whereas in a step-drawdown test a constant discharge rate is maintained for relatively short periods of time, after which time the rate is usually increased. Although data from both types of aquifer pumping tests can be utilized for aquifer analyses, step-drawdown data tend to be more difficult to interpret. Step-drawdown data from this type of test do not easily lend themselves to conventional analysis and require a special analytical method. In addition, as pumping rates are increased, fluctuations in step-drawdowns may occur as the well experiences the effects of well development concurrent with pumping. If possible, a constant rate pump test should be conducted to determine aquifer properties.

Data requirements for aquifer tests include static water level measurements made prior to commencement of the test, discharge rate(s) and time of change in discharge rates; drawdown measurements made during preestablished time intervals, and the time pumping stopped. A recovery test should also be conducted following a step-drawdown pump test to assure the precision and validity of all resulting data. Recovery water levels should be measured at preset time intervals after the pump is stopped.

For well performance tests, well yield and drawdown are measured usually near the end of the test. Although aquifer testing is more involved than well testing, the following methods for determining well yields and drawdowns are similar in both types of tests. These methods and procedures apply primarily to constant discharge, step-drawdown aquifer and recovery tests.

4.2 Decontamination

Prior to lowering the equipment into any well, decontaminate each item using the procedure outlined in Standard Operating Procedure (SOP) 4.11, Equipment Decontamination.

4.3 Pre-Test Data Recording

Complete the applicable portions of Exhibit 23-1, Aquifer Test Data, prior to conducting the aquifer test. Use a separate Exhibit page for each well. Also, obtain the following information (from existing logs) for each well to be used in the test prior to performing the test:

- Casing diameter;
- Borehole diameter;
- Location of surveyed measuring point;
- Total casing depth;
- Static water level of each monitor well;
- Screen depth and interval;
- Filter pack depth and interval; and
- Lithology of screened interval.

Assemble the equipment necessary to conduct the aquifer pumping test. A list of useful equipment is presented in Exhibit 23-2, Aquifer Testing Equipment List.

4.4 Pumping Test Design

Aquifer testing and analysis methods are generally based upon the following assumptions:

- The aquifer is homogenous and isotropic;

- The aquifer is infinite in extent in the horizontal direction from the well and has a constant thickness;

- The well screen interval fully penetrates the aquifer;

- Groundwater flow within the aquifer and pumped well is laminar; and

- The initial static water level is horizontal.

Typically, these assumptions may be invalidated by the nature of the subsurface geologic conditions and materials that comprise the aquifer. However, under many hydrogeologic conditions, conventional pump test analyses are appropriate to use. (Under conditions where the above assumptions may be invalidated, there is a variety of specific analytical techniques that can accommodate them.) In these situations, it is recommended that these highly specific methods of analyses be utilized.

Prior to the start of the pump test, a pretest should be conducted to determine the general characteristics and anticipated response of the aquifer. Data to be obtained from this test include the following:

- The maximum sustained discharge rate that will effectively stress the aquifer but will not dewater the test well;
- The maximum anticipated drawdown. For most pumping tests, a major portion of the drawdown will occur in the first few hours of pumping; and
- An estimate of the total volume of water to be produced from the pumping test. Appropriate disposal methods must be considered before any pumping can occur.

The actual pump test should not be started until water levels in the aquifer have returned to (pre-test) static levels.

The accuracy of drawdown data taken during a pumping test depends upon the following:

- Maintaining a constant yield during the test (only for a constant rate test);
- Measuring the drawdown carefully in the pumping well and observation wells;
- Recording drawdown readings at appropriate time intervals;
- Evaluating how changes in barometric pressures, stream levels, and tidal oscillations affect drawdown data;
- Comparing recovery data with drawdown data taken during the pumping portion of the test; and
- If possible and conditions allow, continue the pumping test for at least 8 hours for a confined aquifer and 24 hours for an unconfined aquifer during constant discharge. For step-drawdown tests, 24 hours is usually sufficient for either type of aquifer.

The accuracy of data taken from a pumping well is usually less reliable than data obtained from an observation well because of turbulence created by the pump. Therefore, if possible, drawdown measurements should be obtained from several observation wells within the expected radius of influence. Also select and monitor drawdown in an observation well that is located at a sufficient distance to be unaffected by the pumping well. Data from this well may provide an important understanding of the effects of not only evapotranspiration but other external stresses that may cause groundwater levels to fluctuate.

Drawdown data from an observation well are necessary to calculate the storage coefficient accurately, whereas transmissivity values may be calculated from either a pumping or an observation well.

Generally, in unconfined aquifers, observation wells should be less than 100 feet from the pumped well. For thick, confined aquifers that are considerably stratified, observation wells should be within 300 to 700 feet from the pumped well.

If drawdown measurements are obtained with an electronic data logger, refer to SOP 4.22, Aquifer Slug Testing, Section 4.4.1 for verification procedures prior to testing. Measurement intervals are discussed in Section 4.4.2 of SOP 4.22, Aquifer Slug Testing.

4.5 Background Water Level Measurements

The objective of background measurements is to identify any naturally-occurring temporal and diurnal changes to the groundwater system. When these observed fluctuations occur, drawdown data should be adjusted to reflect background fluctuations. Perform the following steps during the pump test to record background water levels:

- Measure water levels in at least one well not expected to be influenced by the pumping well. Continue monitoring for the duration of the test;
- Use an electronic water level indicator to measure water levels in background wells; and
- Measure all water levels to within 0.01 foot.

4.6 Drawdown/Recovery Test

Perform the following steps to conduct a drawdown test:

- Measure static water levels in the pumping well and all selected monitor wells and piezometers. Record all measurements in the field log book and on Exhibit 23-1, Aquifer Test Data. Use a separate Exhibit page for each well;
- Prior to installing the pump, measure the static water level in the pumping well. Depending on site restraints, place the pump above the bottom of the well to avoid pumping fines that have accumulated on the bottom of the well. This will prolong the operating life of the pump. Keep the pump intake at least two feet above the bottom of the well, if possible;
- If measurements are to be obtained with an electric logger, install the transducer probe in the well so that it will not move during the test; carefully secure the transducer cable to the top of the well casing;
- Program the data logger for logarithmic cycle measurements so that water-level measurements are recorded at the times shown in Exhibit 23-3, Time Intervals for Drawdown Measurements in a Pumped Well;
- Measure and record water levels in all wells with an electronic water level indicator;

- Start the electronic data logger;

- Start the pump at the discharge rate determined in the pretest;

- Measure water levels in all wells after pumping starts. Record times in the field log book and on Exhibit 23-1, Aquifer Test Data. Exhibit 23-3, Time Intervals for Drawdown Measurements in a Pumped Well, and Exhibit 23-4, Time Intervals for Drawdown Measurements in Observation Wells, provide suggested time measurement intervals. Always record these measurements in a log book or on appropriate field forms in case the electronic data logger fails;

- Calculate drawdown during the test;

- Do not change water level measurement devices during a test; and

- Plot all data on semilog graph paper in the field, where the X-axis is time (minutes) since pumping began on the log scale and the Y-axis is drawdown (feet) in the arithmetic scale.

4.7 Step-Drawdown/Recovery Test

Follow steps described in Section 4.5 on drawdown test procedures. Incorporate the following changes to the above procedures:

- Maintain constant discharge rates for each step. Discharge measurements can be made with a totalizing flow meter or by timing flow into a five-gallon bucket. These measurements should be performed at regular intervals of approximately 15 minutes.

- On Exhibit 23-1, Aquifer Test Data and in the field log book, note the actual time that the discharge rate in the pumped well is increased and note the time the pump is shut off. Also note any other unusual and routine occurrences.

- Ideally, the step-drawdown test will employ several different discharge rates with each subsequent flow rate greater than the previous flow rate.

- Consider the water level in the pumping well when selecting the next pumping step. In low permeability sediments, it is recommended that the flow rate be increased by approximately 1.5 times. This conservative approach tends to preclude dewatering the well. Refer to Exhibit 23-5, Pumping Test Discharge Rate Criteria, for optimum pumping rates during the step-drawdown test.

- Maintain the current flow rate if no increase in the flow rate can be sustained by the well beyond the first step. Continue the test as a constant rate test and analyze the data accordingly. Prior to dewatering, shut off the pump and perform a recovery test.

- The duration of a step depends on the observed water level in the pumping well. The target duration of each step is at least 60 minutes. If the water level in the test does not change by more than 0.1 foot after 10 minutes of pumping for a particular step, increase the discharge to the next step. If the water level in the test well comes within a foot of the top of the pump, then pumping should be eased to prevent dewatering and possible pump damage. If within a step, the pumping level reaches equilibrium (maintains a steady level), maintain the flow rate for at least 30 minutes. Usually such cases indicate a large transmissivity or recharge.

4.7.1 Well Recovery Test

The recovery portion of the drawdown pumping test is the same as it is for a step-drawdown test. It begins immediately after pumping ceases. Perform the following steps for recovery testing:

- Measure water levels in all wells;
- Before the pump is shut off, prepare the electronic data logger for restart of the logarithmic cycle;
- When the pump is shut off, immediately re-start the electronic data logger and begin water level measurements per the intervals outlined in Exhibit 23-3, Time Intervals for Drawdown Measurements in a Pumped Well, and Exhibit 23-4, Time Intervals for Drawdown Measurements in Observation Wells;
- Continue monitoring water level recovery until water levels in all wells return to their static level (within 0.1 foot); and
- Terminate recovery measurements if the water level returns to the static level. (Do not remove the pump from the well until the recovery test is complete).

4.8 Review

Personnel performing aquifer pumping tests will record the applicable field data in the field log book and on Exhibit 23-1, Aquifer Test Data, and will sign and date the "measured by" and "date" blanks. Electronic data logger printouts will be stapled to the appropriate Exhibit for each monitor well. These personnel will also sign and date electronic data logger printouts and all calculations prepared during aquifer pumping test analyses.

The Project Leader or designee will check Exhibit 23-1, Aquifer Test Data, electronic data logger printouts and calculations prepared during aquifer test analyses for completeness and accuracy. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the applicable reviewed documents.

5.0 REFERENCES

CDPHE, 2000. Standard Operating Procedure 4.11, Equipment Decontamination. Standard Operating Procedures

CDPHE, 2000. Standard Operating Procedure 4.22, Aquifer Slug Testing. Standard Operating Procedures

Driscoll, F. G. 1986. "Groundwater and Wells." Johnson Division. St. Paul, Minnesota.

Fetter, C. W. 1988. "Applied Hydrogeology." Merrill Publishing Company. Columbus, Ohio. 592p.

Freeze, R. A. and Cherry, J. A. 1979. "Groundwater." Prentice-Hall, Inc. 604p.

Headquarters, Dept. of Army, Air Force and Navy. 1983. "Dewatering and Groundwater Control." Army TM 5-818-5/AFM 88-5, Chapter 6/NAVFACP-418. U.S. Government Printing Office. Washington, DC.

Heath, R. C. 1984. "Basic Groundwater Hydrology." U.S. Geological Survey Water Supply Paper 2220. U.S. Government Printing Office. Washington, DC. 84p.

Todd, D. K. 1980. "Groundwater Hydrology." John Wiley & Sons. 535p.

6.0 EXHIBITS

Exhibit 23-1	Aquifer Test Data
Exhibit 23-2	Aquifer Testing Equipment List
Exhibit 23-3	Time Intervals for Drawdown Measurements in a Pumped Well
Exhibit 23-4	Time Intervals for Drawdown Measurements in Observation Wells
Exhibit 23-5	Pumping Test Discharge Rate Criteria

EXHIBIT 23-1
Aquifer Test Data

CDPHE
Colorado Dept. of Public Health and Environment

AQUIFER TEST DATA

PROJECT NUMBER:

PROJECT NAME:

PAGE ____ of ____

Well Number:

Well Location:

Static Water Level: ____ ft.

Time	Total Elapsed Time t (min)	Time Since Pumping Stopped t' (min)	Water Level (ft)	Drawdown S (ft)	Corrected Drawdown S_c'(R) (ft)	Recovery S' (ft)	Corrected Recovery S'_c (ft)	Discharge Q gpm

EXHIBIT 23-2
Aquifer Testing Equipment List

The following list represents field equipment necessary to successfully conduct a proper pump test:

Field Log Book
Pickup truck with hitch and trailer
Submersible pump and control box
Pump discharge pipe or hose (with quick connect fittings)
Manifold system with flowmeters (with quick connect fittings)
Discharge hose (with quick connect fittings)
5 KW or 10 KW generator with compatible AC plug system
Support boom with swing arm (to support pump in extraction well)
Five-gallon fuel cans and funnel
Electric sounders (plus extra batteries)
Duct tape
Teflon® tape
Work gloves
Tools (especially pipe wrenches)
Tape measures (with increments in 0.01 ft)
Rinse bottle and extra deionized water (prevents cross-contaminating wells)
Mirror
Flashlight
Stopwatch
Five-gallon bucket
Rubber gloves
Aquifer test data (Exhibit 23-1)
Four-cycle semilog graph paper
Clipboard
Project site map, well logs, well detail sheets
Checklist
Keys to well locking devices
Pencils, rulers, calculator
Buckets with extra fittings, etc. (spare parts)
Appropriate safety equipment
Technical Standard Operating Procedure 4.23, Aquifer Pump Tests

EXHIBIT 23-2 (continued)

Optional equipment may be required for the following reasons: (1) a long-duration test is required (24 hours or longer), (2) groundwater sampling is required, or (3) climatic conditions.

Optional Equipment

Lantern with extra fuel
Foul weather gear
Sampling equipment
Folding chair
Hat
Sunscreen
Drinking water (many sites do not have this available)
One-inch PVC discharge line (as needed)
Toilet facilities

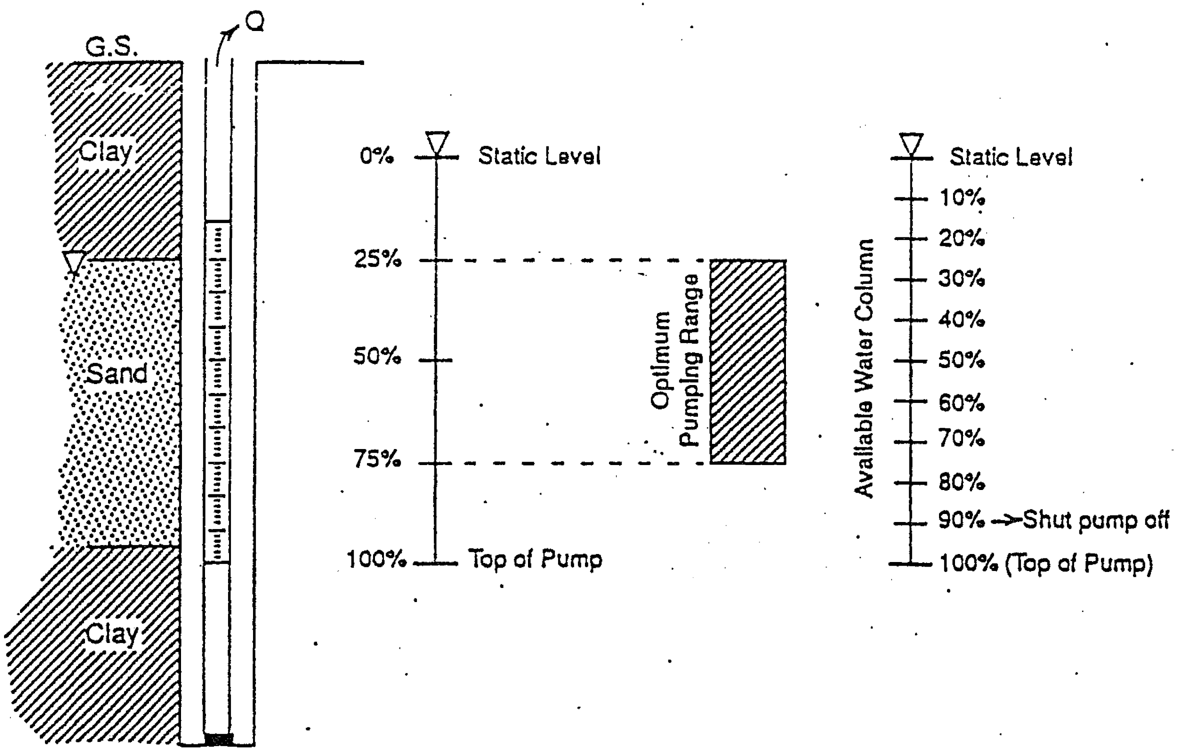
EXHIBIT 23-3
Time Intervals for Drawdown Measurements in a Pumped Well

Time Since Pumping Started (or Stopped) Time Intervals Between Measurement (in minutes)	(in minutes)
0 - 10	0.5 - 1
10 - 15	1
15 - 60	5
60 - 300	30
300 - 1440	60
1440 - termination of test	480 (8 hr)

EXHIBIT 23-4
Time Intervals for Drawdown Measurements in Observation Wells

Time Since Pumping Started (or Stopped) (in minutes)	Time Intervals Between Measurements (in minutes)
0 - 60	2
60 - 120	5
120 - 240	10
240 - 360	30
360 - 1,440	60
1,440 - termination of test	480 (8 hours)

EXHIBIT 23-5
Pumping Test Discharge Rate Criteria



Conduct step-test accordingly through 75% of the available water column. Beyond 75%, monitor drawdown very carefully. Shut pump off at ≤ 90% of water column.

G.S. = Ground surface
Q = Discharge rate

- STANDARD OPERATING PROCEDURE - 24

GEOLOGIC BOREHOLE LOGGING

1.0 PURPOSE

The purpose of this procedure is to describe the methods for geological borehole logging of soil and data collection.

This procedure provides guidance for routine field operations on environmental projects. Site-specific deviations from the methods presented herein must be approved by the CDPHE Project Leader and Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Plasticity: The property of permanently changing shape without movement on any visible fractures

2.2 Abbreviations

AGI	American Geologic Institute
PID/OVA	Photo Ionization Detector/Organic Vapor Analyzer
SPT	Standard Penetration Test
USCS	Unified Soil Classification System

3.0 RESPONSIBILITIES

Personnel conducting exploratory soil boring and monitoring well borehole logging are responsible for performing the applicable tasks outlined in this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced during work performance.

4.0 PROCEDURE

4.1 Introduction

A major portion of the work produced at an environmental site is geologic in nature and is concerned with characterizing the physical subsurface and the geologic and hydrologic processes operating at the site. A properly prepared borehole log serves as an essential tool in making environmental assessments. This

Technical Standard Operating Procedure (TSOP) defines the methodology of collecting pertinent data so that all borehole logs made at a site can create a consistent, uniform database from which interpretations can be made. Inferences such as vertical and horizontal extent of strata, facies changes, attitude of bedding or layering, structural features (faults, folds, fractures, dikes, etc.), location of the water table, lithologic characterizations, and the extent of subsurface contamination are made from observations recorded on the borehole log. These observations include bedding, grain size, degree of sorting, shape of grains, color, hardness, organic vapor levels, and other observable physical characteristics including visible evidence of contamination.

Logging should document both general and specific lithologic information about the borehole. In all cases, the lithologic log should be identified by the specific site number; well/boring number; drilling method; location; date of drilling; individual logger (geologist); drilling contractor; significant organic vapor reading; visible evidence of contamination; depth to water first encountered; final depth of water level; well/boring elevation (if data is available); total depth in feet; graphic log; and lithologic description.

Lithologic descriptions for unconsolidated materials often use the Unified Soil Classification System (USCS) or standard geologic field description methods, Compton 1962. Descriptions of bedrock should follow applicable U.S. Geologic Survey standards.

Lithologic descriptions of unconsolidated material should contain the following characteristics when possible:

- Soil or formation name;
- Gradation degree of sorting;
- Principal constituent;
- Specific descriptors for principal constituents (e.g., plasticity, grain size, and shape);
- Firmness/hardness;
- Minor constituents;
- Moisture content;
- Color;
- Particle morphology; and
- Other descriptors (i.e., visual evidence of contamination, specific monitoring equipment readings including PID/OVA readings).

4.2 Classification System

Sections 4.24-1 through 4.24-2 will describe in detail the parameters and descriptive terminology used to classify each sample for the bore log.

4.2.1 Soil or Formation Name

The soil or formation name will include the major constituent(s) and may be preceded by a single-word modifier indicating the subordinate constituent. Percentages of each constituent will be used to classify the material without actually recording constituent percentage. The textural terms used to classify a soil are shown in Exhibit 24-1, Triangular Diagram Showing Percentage of Sand, Silt, and Clay in Each Textural Class.

4.2.2 Gradation (Degree of Sorting)

Size sorting describes the extent to which grain size is uniform. The comparison chart listed in Exhibit 24-2, "Comparison Chart for Estimating Degree of Sorting," will be used to describe soils being logged from a borehole.

4.2.3 Principal Constituent

Principal constituents recorded during borehole logging include an identification of the following unconsolidated material types:

- Clay;
- Silt;
- Sand;
- Cobbles;
- Gravel; and
- Boulders.

If known, an identification of the potential source of the material should be made (i.e., alluvium, colluvium, artificial fill, or residual material).

4.2.4 Principal Constituent Descriptors

Additional descriptors for the principal material constituents may be added to the log in order to further delineate or accurately record subtle changes in the lithologic structure. Modifiers such as grain size, shape, and plasticity of materials (i.e., high, medium, and low plasticity).

4.2.5 Consistency/Density/Rock Hardness

The characteristics of unconsolidated material are often determined by the Standard Penetration Test (SPT). The SPT involves driving a split spoon sampler into the material by dropping a 140 pound weight from a height of 30 inches. The resistance of the material is reported in the number of blows of the weight required to drive the spoon one foot and translates into the following descriptors:

# of Blows/Foot	Cohesive Consistency (Clay)
0-2	Very soft
2-4	Soft
4-8	Medium
8-15	Stiff
15-30	Very stiff
30+	Hard

# of Blows/Foot	Cohesive Consistency (Gravel)
0-4	Very loose
4-10	Loose
10-30	Medium dense
30-50	Dense
50+	Very Dense

# of Blows/Foot	Rock Hardness
<20	Weathered
20-30	Firm
30-50	Medium Hard
50-80	Hard
80+	Very Hard

4.2.6 Minor Constituents

Constituents not previously described in the principal constituent description may be described as a percentage or by weight. Typically, modifiers for minor constituents conform to the following standards:

- No modifier < 5%
- Slightly 5-12%
- Moderately (i.e. add (y) or (ey) such as silty clay) 12-40%
- Very 40-50%

4.2.7 Moisture Content

Terms ranging from dry to saturated, are used to describe the relative moisture content of a field soil sample. These terms are described as follows:

- Dry - The sample is completely without moisture. Dry, silty sands, for example, will produce suspended particles when dropped by hand.
- Damp - Samples containing a very slight amount of water.
- Moist - Soils in this range are near the maximum water content for their maximum compactibility or density. Moist soils will form a ball when compressed in the hand.
- Wet - The soil samples are wet enough to produce free water upon shaking but still contain unoccupied air voids. Fine-grained soils close to the liquid limit would be termed wet.
- Saturated - Soils with zero air voids. Samples placed in sample jars or bags will probably have standing water after a short period of time.

4.2.8 Color

The color of soil and associated materials will be recorded on the borehole log. Color descriptors should include but are not limited to the following descriptors: black, grey-black, brown, olive, mottled, streaked, etc. Color charts should be used to provide general logging guidance but specific use is not necessary for adequately describing lithology.

4.2.9 Particle Morphology

The key elements of particle morphology are roundness and sphericity. Roundness is a measure of the curvature of grain corners. Sphericity is a measure of how equal the three axial lengths (x, y, z) of an object are. Determination of both properties is facilitated by the use of a hand lens. Estimate grain roundness and sphericity by using the American Geologic Institute (AGI) Data Sheet (Exhibit 24-4).

4.2.10 Other Descriptors

Field screening data collected during the drilling process may help further characterize site conditions during subsurface investigations. Readings from on-site monitoring equipment such as PIDs, OVAs and Oxygen/Explosimeters should be recorded at each sample interval. Other useful information includes the organic content and the presence or absence of waste material in samples.

4.2.11 Particle Size Distribution

An estimate of particle sorting by grain size is often useful for borehole logging purposes. Precise estimates of percent composition of the sample is not necessary.

USCS Grain Size Categories

Exact Size Limits	Approximate Inch Equivalents	Name of Loose Aggregate
>256 mm	>10 in.	Boulder gravel
64 – 256 mm	2.5 – 10 in.	Cobble gravel
32 – 64 mm	1.2 – 2.5 in.	Very coarse pebble gravel
16 – 32 mm	0.6 – 1.2 in.	Coarse pebble gravel
8 – 16 mm	0.3 – 0.6 in.	Medium pebble gravel
4 – 8 mm	0.15 – 0.3 in.	Fine pebble gravel
2 – 4 mm	0.08 – 0.15 in.	Granule (or very fine pebble) gravel
1 – 2 mm	0.04 – 0.08 in.	Very coarse sand
1/2 – 1 mm	0.02 – 0.04 in.	Coarse sand
1/4 – 1/2 mm	0.01 – 0.02 in.	Medium sand
1/8 – 1/4 mm	0.005 – 0.01 in.	Fine sand
1/16 – 1/8 mm	0.002 – 0.005 in.	Very fine sand
1/256 – 1/16 mm	0.00015 – 0.002 in.	Silt
<1/256 mm	<0.00015 in.	Clay (clay-size materials)

From Wentworth Scale, Compton 1962.

The Comparison Chart for Estimating Percentage Composition (Exhibit 24-3) can be used to estimate the percentage of various grain sizes present in a sample. However, visual estimates usually provide sufficient information for characterizing site lithology.

4.3 Borehole Logs

Record data collected during exploratory boring soil logging in the field log book and on Exhibit 24-5, Borehole Log. Use this Exhibit on all applicable field drilling and subsurface sampling operations.

Geologic correlation and aquifer properties prediction are dependent on good exploratory boring sample descriptions. Rotary drilling with fluids is generally unacceptable since the drilling fluids may potentially contaminate the aquifer under investigation. High quality borehole data are generally acquired with a split-spoon or pitcher core barrel. This method of sampling provides detailed logging. The lithofacies interpreted from cuttings logs may lack the accuracy necessary for detailed correlation. Where possible, techniques such as geophysical borehole logging will be used to supplement cuttings descriptions. Note on the log any geologic description determined from borehole cuttings. The cuttings are often mixed over the entire length of the boring.

In bedrock formations, cuttings may be acquired from a reverse circulation, air rotary or from a dual wall rotary boring. These cuttings do not provide information on the in situ properties of the materials, but do provide adequate sample description information.

In summary, close sample spacing or continuous sampling in a boring provide the best material for descriptive geology. Use traditional geologic terminology and supplement with the USCS descriptive system when appropriate. Provide sufficient data on layering and other sedimentary structures and undisturbed textures. Sample numbers, depths, and analytes should be included in each description. The applicable field methods described by Compton (1962) and AGI (1982) are recommended. These methods are fully referenced in Section 5.0.

4.4 Review

Personnel conducting borehole logging of soil will record field data on Exhibit 24-5, Borehole Log, and will record a chronological summary in the project log book. The applicable methods outlined in this procedure shall be used to record the data on this Exhibit. The personnel conducting these operations will sign and date the "logged by" and "date" blanks on Exhibit 24-5, Borehole Log.

The Project Leader or designee shall check all field generated data and Exhibit 24-5, Borehole Log, for completeness and accuracy. Any discrepancies will be noted and the Exhibits will be returned to the originator for correction. The reviewer will acknowledge that corrections have been incorporated by signing and dating the "reviewed by" and "date" blanks on Exhibit 24-5, Borehole Log.

5.0 REFERENCES

American Geological Institute. 1982. "AGI Data Sheets." Falls Church, Virginia.

ASTM 1984. "ASTM D1586, Description and Identification of Soils, Visual-Manual Procedure" in "Annual Book of ASTM Standards." V.04.08

Compton, R. R. 1962. "Manual of Field Geology." John Wiley and Sons, Inc., New York, New York, 378p.

Munsell. 1988. "Munsell Soil Color Charts." Macbeth Division, Kollmorgen Instruments Corporation, Baltimore, Maryland, 1988 edition.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." EPA/540/P-87/001 (OSWER Directive 9355.0-14). December 1987.

6.0 EXHIBITS

Exhibit 24-1	Triangular Diagram Showing Percentage of Sand, Silt and Clay in Each Textural Class
Exhibit 24-2	Comparison Chart for Estimating Degree of Sorting
Exhibit 24-3	Comparison Chart for Estimating Percentage Composition
Exhibit 24-4	Comparison Chart for Estimating Roundness and Sphericity
Exhibit 24-5	Borehole Log

EXHIBIT 24-1

Triangular Diagram Showing Percentage of Sand, Silt and Clay in Each Textural Class

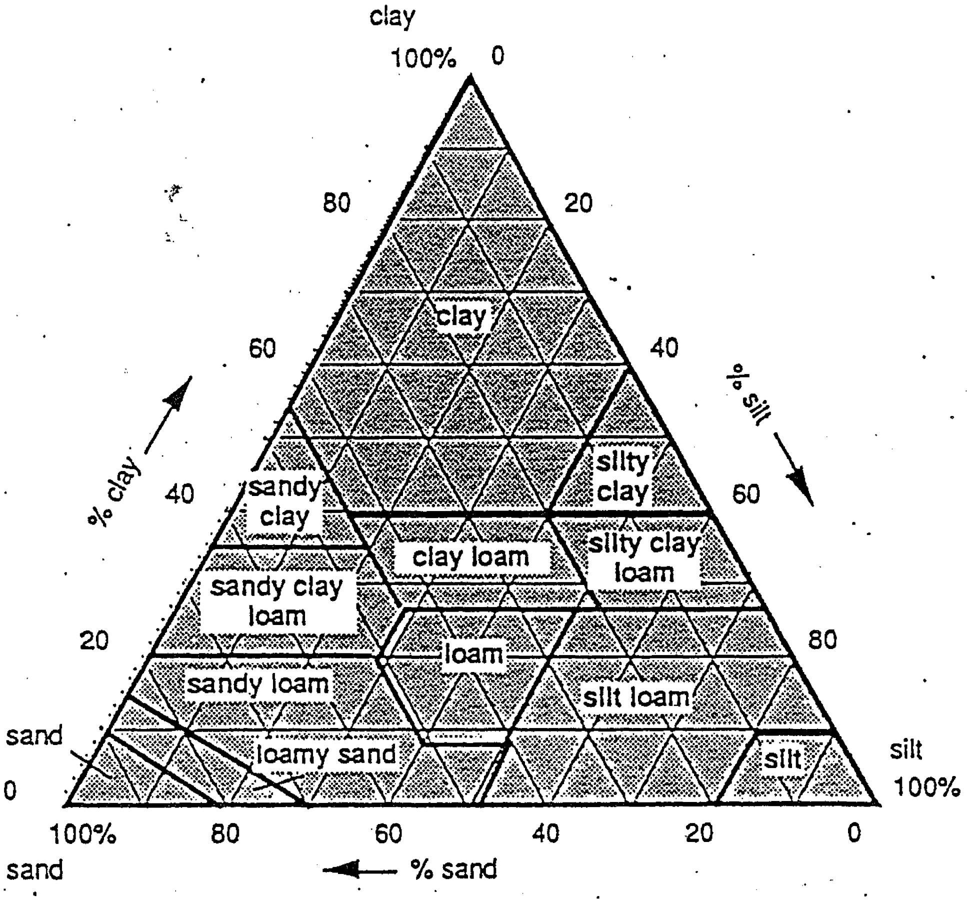
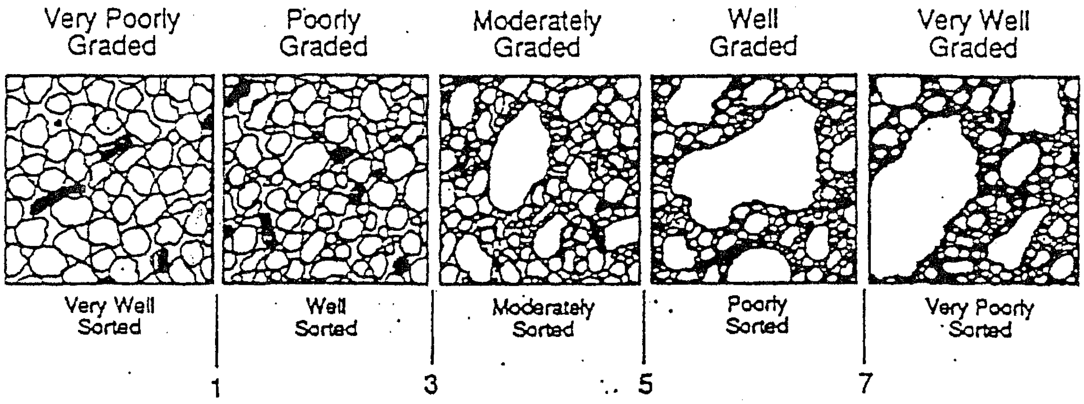


EXHIBIT 24-2

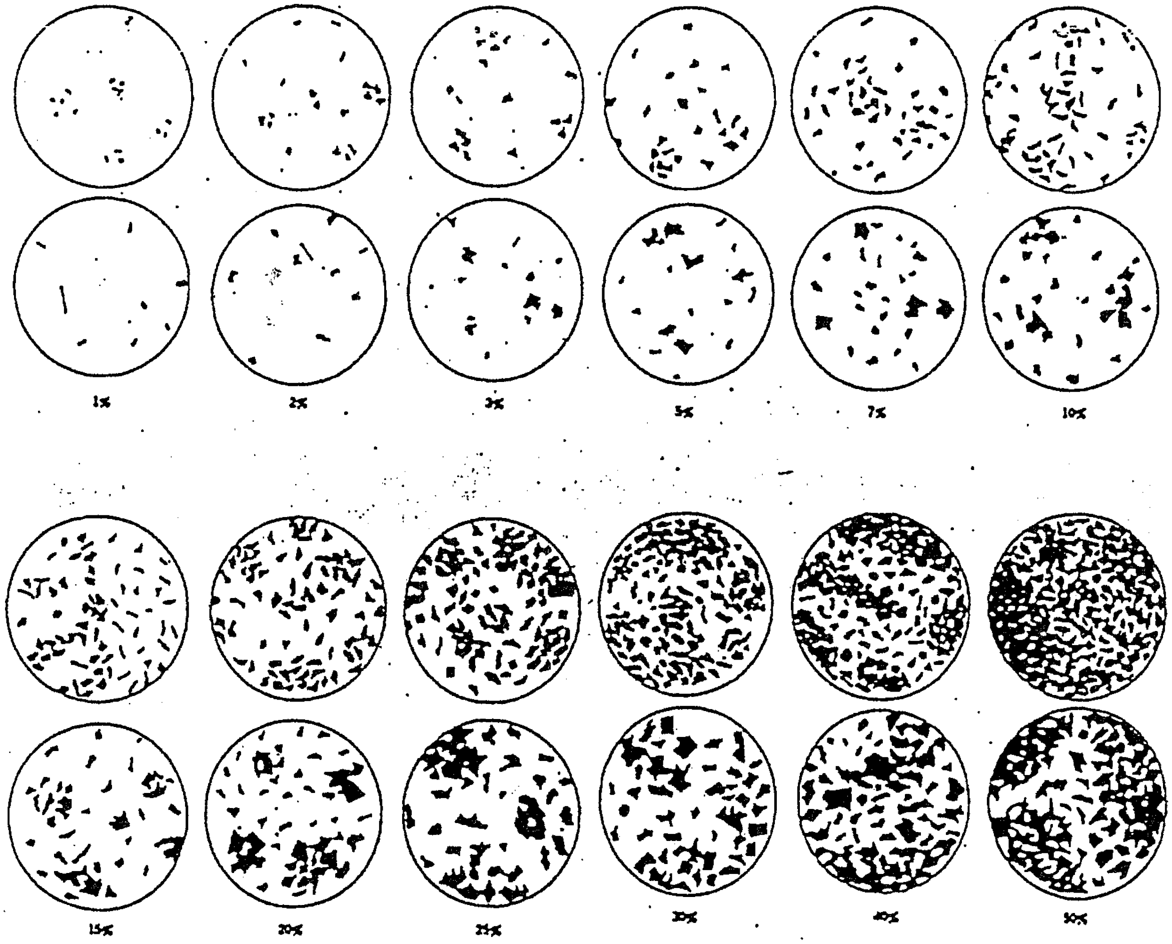
Comparison Chart for Estimating Degree of Sorting



Terms for degrees of sorting. The numbers indicate the number of size-classes included by the bulk (80 percent) of the material. The drawings represent sandstones as seen with a hand lens. Silt and clay-size materials are shown diagrammatically by the fine stipple.

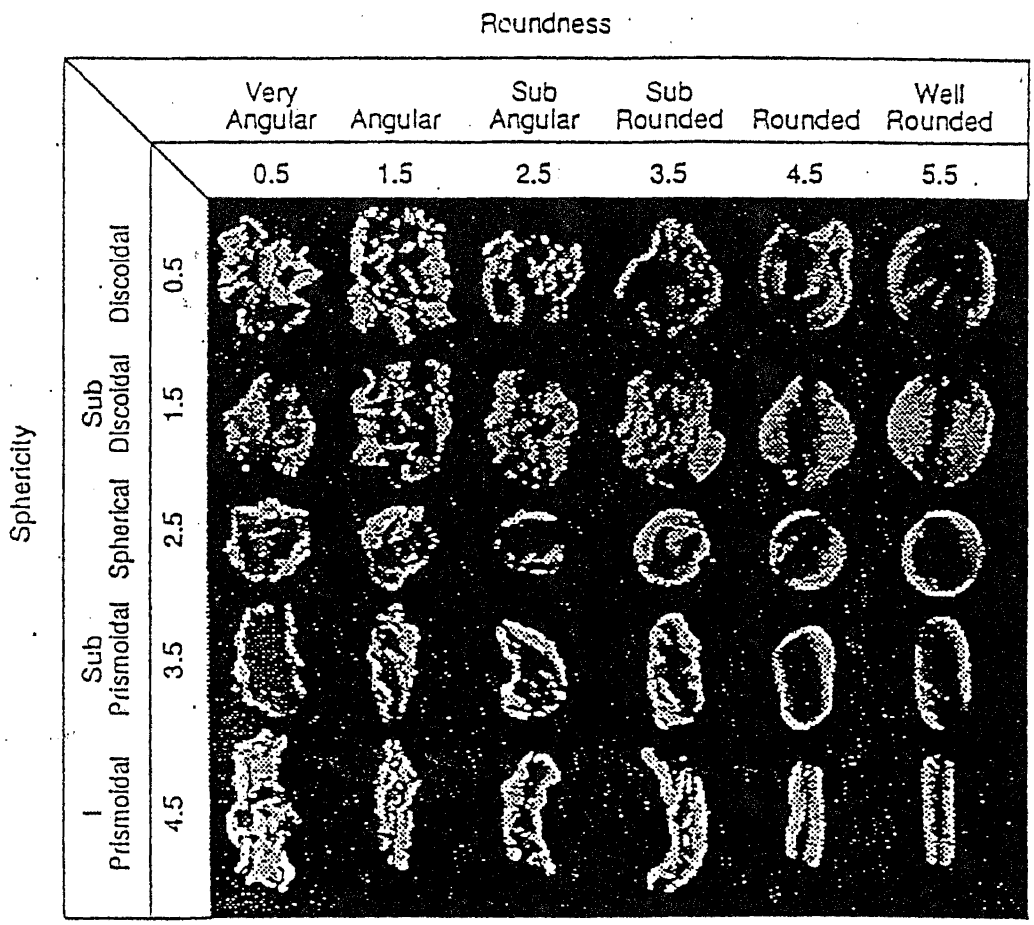
Reference: Compton, R.R. 1962. *Manual of Geology*. John Wiley & Sons, Inc. New York, N p. 214

EXHIBIT 24-3
Comparison Chart for Estimating Percentage Composition



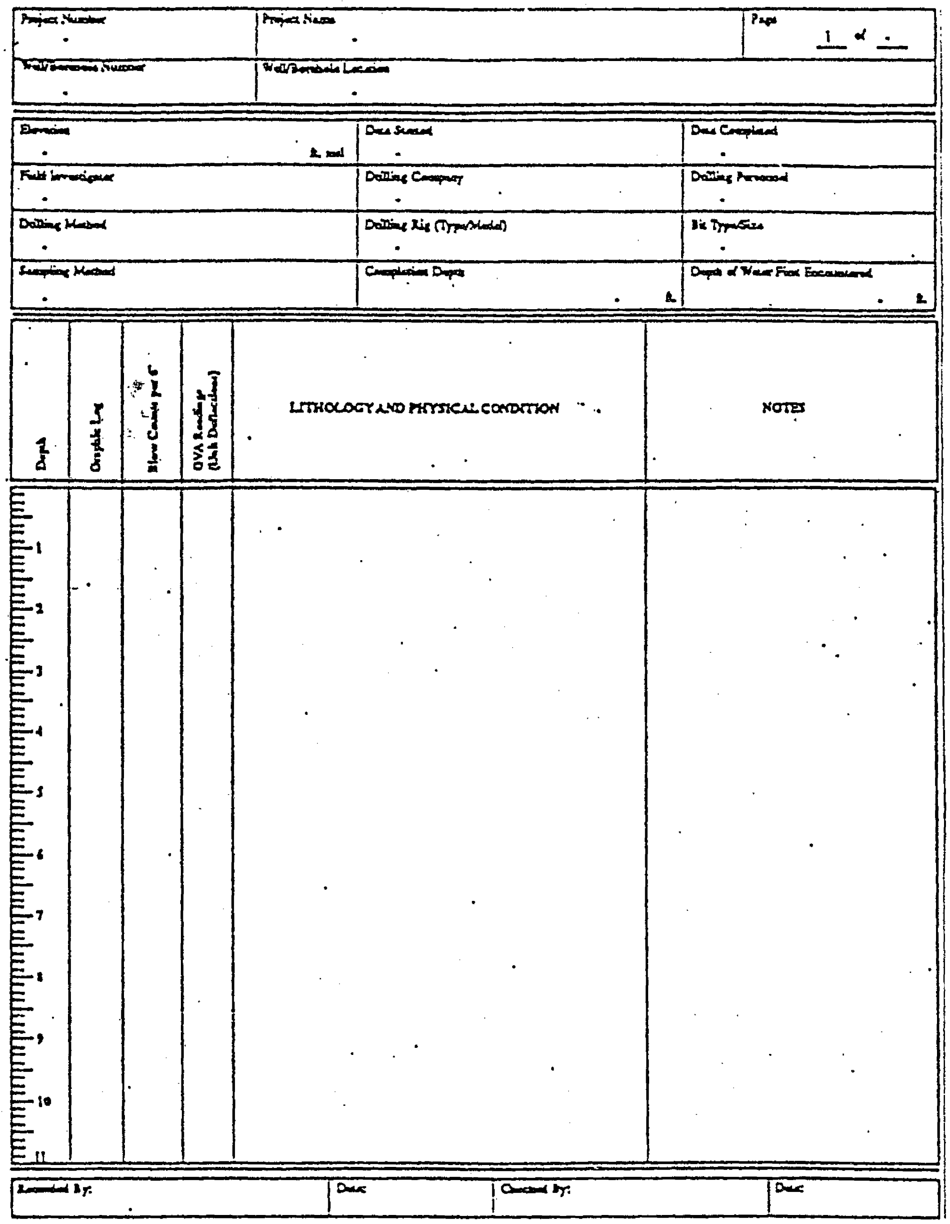
Reference: Compton, R.R. 1962. *Manual of Geology.* John Wiley & Sons, Inc. New York, NY p. 332-333

EXHIBIT 24-4
Comparison Chart for Estimating Roundness and Sphericity



Reference:American Geological Institute. 1982. "AGI Data Sheet 18.1" in *AGI Data Sheets.* Fall Church, VA

EXHIBIT 24-5
Borehole Log



Project Number	Project Name	Page 1 of _
Well/Borehole Number	Well/Borehole Location	

Elevation ft. msl	Date Started	Date Completed
Field Investigator	Drilling Company	Drilling Personnel
Drilling Method	Drilling Rig (Type/Model)	Bit Type/Size
Sampling Method	Completion Depth ft.	Depth of Water First Encountered ft.

Depth	Graphic Log	Blow Counts per 6"	OVA Readings (Unit Deflections)	LITHOLOGY AND PHYSICAL CONDITION	NOTES
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					

Recorded By:	Date:	Checked By:	Date:

EXHIBIT 24-5 (Continued)

Project Number	Project Name	Page 2 of
Well/Borehole Number	Well/Borehole Location	

Depth	Graphic Log	Blow Counts per 6"	OVA Readings (Unit Deflections)	LITHOLOGY AND PHYSICAL CONDITION	NOTES
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Recorded By:	Date:	Checked By:	Date:

STANDARD OPERATING PROCEDURE - 25

RESIDENTIAL DUST SAMPLING

1.0 PURPOSE

The purpose of this procedure is to describe the equipment and operations used for residential dust sampling. This procedure provides guidance for routine operations during residential dust sampling. Site-specific deviations from the methods presented herein must be approved by the Project Leader and the Colorado Department of Public Health and Environment (CDPHE) Quality Assurance Officer.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

EPA	U.S. Environmental Protection Agency
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
SOP	Standard Operating Procedure

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the applicable tasks in accordance with this procedure when conducting work related to environmental projects.

The Project Leader or an approved designee is responsible for checking all work performance and verifying that the work satisfies the applicable tasks required by this procedure. This will be accomplished by reviewing all documents (Exhibits) and data produced by work performance.

4.0 PROCEDURES

4.1 Introduction

Residential dust samples will be collected in conjunction with specific surface/shallow depth soil samples to determine if there is a direct relationship between airborne contamination and soil contamination. Residential dust samples will be collected from residences that are within or near the corresponding soil sampling locations.

4.2 Equipment

Residential dust sampling will be conducted using the following equipment:

- Portable personal sampling pump (similar to the Dupont Alpha-1®);
- Tygon® tubing and stainless steel sampling nozzle (with an approximate aperture of 1.5 cm x 3 mm); and
- A 37 mm (diameter) three-piece Aerosol Analysis Monitor Cassette fitted with a thin cellulose support pad and 0.8 micron mixed cellulose ester filter will commonly be utilized. Sampling media may vary according to the contaminants present. In addition, sampling will be conducted in accordance with the U.S. Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), or the National Institute of Occupational Safety and Health (NIOSH) methods where applicable.

4.3 Calibration

Calibration (in accordance with EPA, OSHA, or NIOSH methods) will be implemented using the mini-Buck Calibrator or equivalent. All calibrations will be completed according to manufacturer's specifications, and recorded in the field log book. Calibrations may also be recorded in the equipment calibration logs.

4.4 Method

Residential dust sampling will be conducted as follows:

- Set up pump and sampling apparatus in the area to be sampled. The sampling media should be placed at least four feet off the ground in an area that accurately represents contamination concentrations, i.e., away from exhausts and fans;
- Start the pump and record the start time in the field log book;
- Check the pump periodically to ensure proper functioning for the duration of sampling;
- After the appropriate sampling interval has elapsed, stop the pump and record the stop time in the field log book.

4.5 Decontamination

Decontamination procedure for residential dust sampling equipment will include the following:

- Remove the cassette;
- Replace the cassette stoppers;

- Label the cassette following guidelines identified in CDPHE Standard Operating Procedure (SOP) 4.4, Sample Identification, Labeling, and Packaging; and

- After each sample is collected, replace the Tygon® tubing and sampling nozzle.

4.6 Background Samples

Background samples will be collected as specified in the Sampling and Analysis Plan.

4.7 Review

The Project Leader or an approved designee shall check all documents (Exhibits) generated during sampling operations for completeness and accuracy. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the applicable reviewed documents.

5.0 REFERENCES

CDPHE, 2000. " Standard Operating Procedure 4, Sample Identification, Labeling, and Packaging." Standard Operating Procedures.

6.0 EXHIBITS

Not applicable.

STANDARD OPERATING PROCEDURE - 26

CHIP, WIPE AND SWEEP SAMPLING

1.0 PURPOSE

The purpose of this procedure is to describe the equipment and methods required for obtaining a representative chip, wipe or sweep sample to monitor potential surficial contamination.

These methods of sampling are appropriate for surfaces contaminated with non-volatile species of analytes (i.e., polychlorinated biphenyls (PCB), polychlorinated dibenzodioxin (PCDD), polychlorinated dibenzofuran (PCDF), metals, cyanide, etc.). Detection limits are analyte specific. Sample size should be determined based on the detection limit desired and the amount of a sample requested by the analytical laboratory. A typical sample area is one square foot; however, based upon sample location, the area may be modified due to area configuration. Site-specific deviations from the methods presented herein must be approved by the Project Leader and the CDPHE (CDPHE) Quality Assurance Officer.

Chip sampling is appropriate for porous surfaces and is generally accomplished with either a hammer and chisel, or an electric hammer. The sampling device should be decontaminated as outlined in CDPHE Standard Operating Procedure (SOP) 4.11, Equipment Decontamination. To collect the sample, a measured and marked off area is chipped both horizontally and vertically to an even depth of 1/8 inch. The sample is then transferred to the appropriate container.

Wipe samples are best collected from smooth surfaces and help to indicate surficial contamination. A sample location is delineated. Sampling is conducted using a sterile gauze pad soaked with a predesignated solvent. The gauze pad is then stroked firmly over the sample surface, first vertically, then horizontally, to ensure complete coverage. The gauze pad is then transferred to the sample container.

Sweep sampling is an effective method for the collection of dust or residue on porous or non-porous surfaces. To collect such a sample, an appropriate area is delineated. Sampling is conducted by using a dedicated brush to transfer the sample to a dedicated dust pan for placement of the sample into the appropriate sample container.

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Not applicable.

2.2 Abbreviations

HPLC	High Performance Liquid Chromatography
NIOSH	National Institute of Occupational Safety and Health
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzodioxin
PCDF	Polychlorinated dibenzofuran
PPs	Project Plans

3.0 RESPONSIBILITIES

Field personnel are responsible for performing the actual sampling, maintaining sample integrity and preparing the proper chain-of-custody forms.

The Project Leader or an approved designee is responsible for deciding when chip, wipe, and sweep sampling is needed, for checking all work performance, and for verifying the resulting data.

4.0 EQUIPMENT

The following equipment is needed for chip, wipe or sweep sampling:

- Disposable chemical-protective gloves that are appropriate for the solvent, contaminant, and analysis involved;

- Sterile wrapped gauze pad (3 in. X 3 in.) (wipe sampling);

- Appropriate High Performance Liquid Chromatography (HPLC) grade solvent (wipe sampling);

- Medium sized decontaminated paint brush and dust pan (sweep sampling);

- Medium sized decontaminated chisel and hammer (chip sampling);

5.0 SAMPLING LOCATION/SITE SELECTION

Follow the sample design criteria outlined in the applicable Project Plan for each sampling event. Sampling sites can be relocated when conditions dictate, such as when natural or artificial obstructions prevent access to the proposed sample location. Document the actual sample locations, using a camera or sketched site map.

6.0 PROCEDURES

6.1 Preparation

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.

- Obtain necessary sampling and monitoring equipment.
- Decontaminate or preclean equipment, and ensure that it is in proper working order.
- Mark all sampling locations, record in log book, and photo document prior to sampling.

6.2 Sampling Steps

6.2.1 Chip Sampling

- Chip the sample area horizontally and then vertically to an even depth of approximately 1/8 inch.
- Place the sample in a clean jar appropriate for the intended analysis, as described in CDPHE SOP 4.2, Sample Containers, Preservation and Maximum Holding Times. The sample jar should be labeled in accordance with CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging. The proper chain-of-custody procedures should be followed, as outlined in CDPHE SOP 4.3, Chain of Custody.
- Dispose of the sampling device as outlined in CDPHE SOP 4.8, Investigation Derived Waste Management, or decontaminate as outlined in CDPHE SOP 4.11, Equipment Decontamination, if practical.

6.2.2 Wipe Sampling

- Moisten the filter with a solvent selected to dissolve the contaminants of concern as specified in the Project Plan. The filter should be wet but not dripping.
- Thoroughly wipe a predetermined area with the moistened filter using firm strokes. Wipe vertically and then horizontally to ensure complete coverage. A stencil can help judge the size of the wipe area. If a larger or smaller area is wiped, record the change in the field logbook. If the surface is not flat, be sure to wipe any crevices or depressions. If the surface is so rough that the filter would be ripped and torn during wiping, press the filter firmly on the surface and lift with a slight sideways motion.
- Without allowing the filter to contact any other surface, fold it in half with the exposed side in, and then fold it in half a second time to form a 90 degree angle in the center of the filter.
- Place the filter (angle first) into a clean jar appropriate for the intended analysis, as described in CDPHE SOP 4.2, Sample Containers, Preservation and Maximum Holding Times. Label the sample jar in accordance with CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging. The proper chain of custody procedures should be followed, as outlined in CDPHE SOP 4.3, Chain of Custody. The sample

jars should be placed in a container appropriate for the intended analysis (e.g., cooler or sturdy box) and sent to the laboratory as provided for in the project Sampling and Analysis Plan.

- Follow decontamination procedures as outlined in CDPHE SOP 4.11, Equipment Decontamination.

6.2.3 Sweep Sampling

- Sweep the measured area using a dedicated sweeping or paint style brush. Continue to sweep the dust with the brush into a dedicated dust pan which has been placed firmly on the outside of the premeasured sampling area.
- Transfer the sample from the dust pan to a clean jar appropriate for the intended analysis, as described in CDPHE SOP 4.2, Sample Containers, Preservation and Maximum Holding Times. The sample jar should be labeled in accordance with CDPHE SOP 4.4, Sample Identification, Labeling, and Packaging. The proper chain-of-custody procedures should be followed, as outlined in CDPHE SOP 4.3, Chain of Custody.
- Leave contaminated sampling brush and dust pan in sample media or dispose of as outlined in CDPHE SOP 4.8, Investigation Derived Waste Management.
- Follow decontamination procedures as outlined in CDPHE SOP 4.11, Equipment Decontamination.

7.0 DOCUMENTATION

All chip, wipe or sweep sampling procedures should be fully documented in the field logbook. In addition to the information listed in CDPHE SOP 4.6, Use and Maintenance of Field Log Books, include the following:

- Time of collection of each chip, wipe or sweep sample;
- Predominant wind direction (if sampling outdoors);
- Sketch map(s) and/or photographs showing sampling area; and
- Description of item(s) being sampled.

8.0 REVIEW

The Project Leader or an approved designee shall check all documents (Exhibits) generated during sampling operations for completeness and accuracy. Any discrepancies will be noted and the documents will be returned to the originator for correction. The reviewer will acknowledge that these review comments have been incorporated by signing and dating the applicable reviewed documents.

9.0 REFERENCES

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operation Methods." EPA/540/P-87/001, U.S. Environmental Protection Agency. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1991. "A Compendium of ERT Waste Sampling Procedures." OSWER Directive 9360.4-07, January 1991. Office of Emergency and Remedial response, U.S. Environmental Protection Agency.

CDPHE, 2000. "Standard Operating Procedure 2,Sample Containers, Preservation, and Maximum Holding Times." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 3, Chain of Custody." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 4, Sample Identification, Labeling, and Packaging." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 6, Use and Maintenance of Field Log Books." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 8, Investigation Derived Waste Management." Standard Operating Procedures.

CDPHE, 2000. "Standard Operating Procedure 11, Equipment Decontamination." Standard Operating Procedures.

10.0 EXHIBITS

Not applicable.

Attachment 2

August 31, 2012 letter from the EPA to the Pueblo City Council

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

AUG 31 2012

Ref: 8EPR-AR

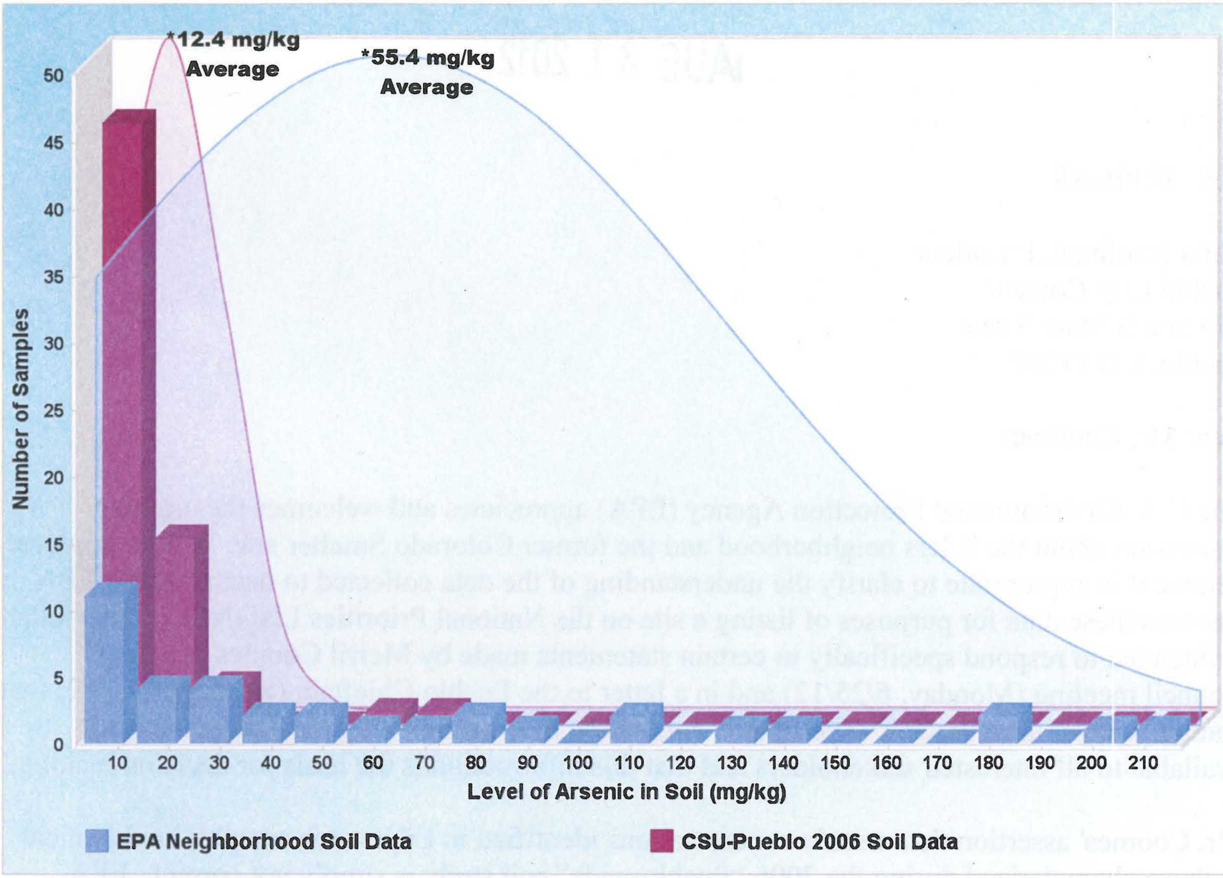
Chris Kaufman, President
Pueblo City Council
200 South Main Street
Pueblo, CO 81003

Dear Mr. Kaufman:

The U.S. Environmental Protection Agency (EPA) appreciates and welcomes the ongoing discussion about the Eilers neighborhood and the former Colorado Smelter site. We do however believe it is appropriate to clarify the understanding of the data collected to date and how EPA assesses these data for purposes of listing a site on the National Priorities List (NPL). This letter is intended to respond specifically to certain statements made by Merril Coomes at a City Council meeting (Monday, 6/25/12) and in a letter to the Pueblo Chieftain (Sunday, 8/12/12) that contain several inaccuracies. The EPA is committed to assuring that factual information is available to all interested stakeholders and that this information is the basis for decision making.

Mr. Coomes' assertion that arsenic concentrations identified in Eilers area samples are identical to those characterized during the 2006 "Pueblo-wide" soil study is simply not correct. EPA technical staff including Charles Partridge, PhD, EPA toxicologist, and Robert Edgar, PhD, EPA statistician, reviewed the data from the 2006 Colorado State University-Pueblo (CSU-Pueblo) - "Pueblo-wide" soil study and compared it to the data collected in the Eilers neighborhood in support of listing the Colorado Smelter site. Based on rigorous analysis using five different statistical tests, EPA determined that the soil arsenic data collected from the Eilers neighborhood are indeed statistically significantly higher when compared to the soil arsenic data from the 2006 CSU-Pueblo study.

The following figure shows a comparison of the levels of arsenic in the soil from the 2006 CSU-Pueblo study versus the levels of arsenic found in the soils of the Eilers neighborhood. On the vertical axis are the numbers of samples at those concentrations. You can see that the average concentration of 12.4 milligrams per kilogram (mg/kg) for the CSU-Pueblo samples is much lower than the EPA/CDPHE study's average concentration of 55.4 mg/kg samples. Additionally all 66 of the CSU-Pueblo samples contained less than 70 mg/kg arsenic and approximately 92 percent of the CSU-Pueblo samples contained 20 mg/kg or less of arsenic. None of the CSU-Pueblo samples contained greater than 70 mg/kg of arsenic; whereas there were samples with arsenic concentrations exceeding 70 mg/kg and as high as 210 mg/kg in the EPA/CDPHE study's samples. This figure dramatically illustrates the increased levels of arsenic in the soils surrounding the Colorado Smelter site when compared to those levels of arsenic found in soils across the City of Pueblo.



Regarding Mr. Coomes' assertions that lead and arsenic in the Eilers neighborhood may be from other sources, site history and factual information clearly link contaminants from the smelter to the area of concern. The notion that lead from historic smelting may also be mixed with lead from old paint in residential yards does not make the concern about inhalation, ingestion and public health less compelling.

The EPA and Colorado Department of Public Health and Environment sampling results clearly indicate a need to more fully investigate smelter related contamination and potential associated health risks. A key part of the Superfund process that occurs *after* listing on the NPL is a comprehensive scientific assessment of the nature and extent of contamination, exposure, and risk.

The EPA is committed to providing accurate information as we move forward and to answering questions in a timely manner. Ultimately, decisions about any cleanup activity will be made based on science and a continuing consultation with the community. We hope Pueblo residents will take the opportunity to discuss and learn more about these concerns at upcoming public meetings and other forums. We are open to and would welcome continued City involvement in this dialogue. These are important issues and we are eager to engage with the community and to work with all stakeholders to find a long-term solution that benefits the community.

Please feel free to contact me or my staff should you have questions or concerns going forward. I can be reached at (303) 312-6827.

Sincerely,

David Ostrander, Acting Director
Assessment & Revitalization Program

Cc:
Amy Nawrocki, District 1 Representative
    Pueblo City Council
Eva Montoya, District 2 Representative
    Pueblo City Council
Leroy Garcia, District 3 Representative
    Pueblo City Council
Sandy Daff, District 4 Representative
    Pueblo City Council
Steve Nawrocki, Vice President
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Chris Nicoll, Representative at Large
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Tom Florczak, City Attorney
Dr. Christine Nevin-Woods, Director
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Moussa Diawara, PhD
    Colorado State University - Pueblo
Dr. Chris Urbina, MD, MPH, Executive Director and Chief Medical Officer
    CDPHE
Dan Scheppers, Remediation Program Manager
    CDPHE

Attachment 3

Excerpt of USGW Open File Report 81-197

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

CHEMICAL ANALYSES OF SOILS AND OTHER SURFICIAL MATERIALS OF THE CONTERMINOUS UNITED STATES

By

Josephine G. Boerngen and Hansford T. Shacklette

Open-File Report 81-197

1981

This report is preliminary and has not been
edited or reviewed for conformity with U.S.
Geological Survey standards or nomenclature.

Contents

Introduction

A sampling program was begun in 1961 that was designed to give estimates of the abundance of elements in soils and other surficial materials and in associated plants from sites selected along routes of travel, and in study areas, of U.S. Geological Survey scientists. The sampling plan was kept simple. The proposed sampling intensity consisted of one sample of soil and one of plants collected at sites about 50 mi. (81 km) along routes of travel to areas of other types of field study. Sampling sites were selected, insofar as possible, that represented soil in its natural condition. This program resulted in the sampling of 863 sites. The results of the soil analyses were published for 35 elements by plotting their concentrations, in two to five frequency classes, on maps (Shacklette, Hamilton, Boerngen, and Bowles, 1971).

Soon after this publication, interest in environmental geochemistry, particularly the application to problems of industrial and vehicular pollution, increased greatly. At the same time, advances in analytical techniques made the analysis of additional elements practical. Therefore, the samples from the first study, with some additional samples, were analyzed and reported as follows: mercury by Shacklette, Boerngen, and Turner (1971); lithium and cadmium by Shacklette, Boerngen, Cahill, and Rahill (1973); and selenium, fluorine, and arsenic by Shacklette, Boerngen, and Keith (1974).

Sampling according to this plan continued, as opportunities arose, until autumn, 1975, resulting in the sampling of 355 additional sites that were selected to give a more uniform geographical coverage of the conterminous United States. These samples were analyzed and the data were merged with those of the original samples to produce the results given in this report.

The elemental composition of only the surficial materials were given in all reports; the data on analysis of the plant samples are held in files of the U.S. Geological Survey.

This study was made possible by the cooperation of many persons in the U.S. Geological Survey. We express our appreciation to those who collected samples, as follows: Jessie M. Bowles, F. A. Branson, R. A. Cadigan, F. C. Canney, H. L. Cannon, F. W. Cater, Jr., M. A. Chaffey, Todd Church, J. J. Connor, Dwight Crowder, R. J. Ebens, R. N. Eicher, J. A. Erdman, R. F. Gantner, G. B. Gott, W. R. Griffitts, T. P. Hill, E. K. Jenne, M. I. Kaufman, J. R. Keith, Frank Kleinhampl, A. T. Miesch, R. F. Miller, R. C. Pearson, E. V. Post, Douglas Richman, James Scott, D. E. Seeland, R. C. Severson, M. H. Staatz, T. A. Steven, M. H. Strobell, V. E. Swanson, R. R. Tidball, H. A. Tourtelot, J. D. Vine, and R. W. White.

We thank the following members of the U.S. Department of Agriculture, Soil Conservation Service for providing soil samples from areas in Minnesota: Donald D. Barron, Carroll R. Carlson, Donald E. DeMartelaire, Royce R. Lewis, Charles Sutton, and Paul Nyberg.

We acknowledge the analytical support provided by the following U.S. Geological Survey chemists: Lowell Artis, Philip Aruscavage, A. J. Bartel, S. D. Botts, L. A. Bradley, J. W. Budinsky, Alice Caemmerer, J. P. Cahill, E. Y. Campbell, G. W. Chloe, Don Cole, E. F. Cooley, N. M. Conklin, W. B. Crandell, Maurice Devalliere, P. L. D. Elmore, E. J. Finlay, Johnnie Gardner, J. L. Glenn, T. F. Harms, R. C. Haven, R. H. Heidel, M. B. Hinkle, Claude Huffman, Jr., L. B. Jenkins, R. J. Knight, B. W. Lanthorn, L. M. Lee, K. W. Leong, J. B. McHugh, J. D. Mensik, V. M. Merrit, H. T. Millard, Jr., Wayne Mountjoy, H. M. Nakagawa, H. G. Neiman, Uteana Oda, C. S. E. Papp, R. L. Rahill, V. E. Shaw, G. D. Shipley, Hezekiah Smith, A. J. Sutton, Jr., J. A. Thomas, Barbara Tobin, J. E. Troxel, J. H. Turner, and G. H. VanSickle.

We were assisted in computer programming for the data by J. B. Fife and George VanTrump, Jr.

Sample collection, preparation, and analysis

The sampling sites were selected, if possible, to represent surficial materials that were altered very little from their natural condition and that supported native or cultivated plants suitable for sampling. In practice, this site selection necessitated sampling away from roadcuts and fills, but in some areas only cultivated fields were available for sampling. The materials sampled included soil as defined by soil scientists, beach and dune sands, very stony lithosols, and organic deposits generally considered to be peat instead of soil. Most samples were collected at a depth of about 8 in. (20 cm), which reduced or avoided the effects of surface contamination. In zonal soils, this depth commonly is within the range of the B soil horizon (zone of element accumulation). Some lithosols over near-surface bedrock did not extend downward to 8 in. (20 cm); they were sampled at the bottom of soil development in the profile.

Areas of field studies commonly were sampled more intensively than at intervals of 50 miles (81 km). Samples used from these studies were selected to represent about the same geographical coverage as did those along roads.

The soil samples were dried in the laboratory, pulverized and sieved, and the minus-2mm fractions were used for analysis. The methods of analysis used for some elements were changed during the course of the study as new techniques and instruments became available. The results published in the first report (Shacklette, Hamilton, Boerngen, and Bowles, 1971) were obtained for most elements by use of a semiquantitative six-step emission spectrographic method (Neiman, 1976). Other methods were used for the following elements: atomic absorption, with flame (Huffman and Dinnin, 1976) for mercury, lithium, magnesium, sodium, rubidium, and zinc; atomic absorption, flameless (Vaughn, 1967) for mercury; X-ray fluorescence spectrometry (Wahlberg, 1976) for calcium, germanium, iron, potassium, selenium, silver, sulfur, and titanium; combustion (Huffman and Dinnin, 1976), total carbon; and neutron activation (Millard, 1975, 1976) for thorium and uranium.

Table 1.--Location, description, and concentration of elements for samples of surficial materials--continued

Sample No.	State	County	Latitude	Longitude	Date Colln.	Site and Soil Descriptions
GC066550	CO	MESA	39 11	109 3	72 9	US 50-6 REST STOP .5 MI E STATE LINE; GRAY-BROWN SOIL ON SILTSTONE
GC066650	CO	MESA	39 11	108 17	72 9	JCT I-70 & RT 65; LIGHT BROWN SILT
GC262150	CO	MINERAL	37 28	106 47	68 5	US 160 AT SUMMIT WOLF CREEK PASS; SHALLOW SOIL OVER BEDROCK
GC033450	CO	MOFFAT	40 32	107 27	65 8	US 40 4 MI E CRAIG; BROWN SILTY LOAM
GC033550	CO	MOFFAT	40 26	108 16	65 8	US 40 12 MI W MAYBELL; BROWN SANDY B HORIZON
GC033650	CO	MOFFAT	40 16	109 2	65 8	US 40 1 MI E COLO-UTAH LINE; RED BROWN SAND
GC185450	CO	MOFFAT	40 15	108 40	65 6	US 40 5 MI E MASSADONA; BROWN CLAYEY SILT 8-IN. DEPTH
GC015550	CO	MONTEZUMA	37 28	108 39	62 5	US 160 9 MI NW CORTEZ; LOESS SOIL ON DAKOTA SANDSTONE
GC073250	CO	MONTEZUMA	37 21	108 30	73 3	US 160 4 MI E CORTEZ; SANDY LOAM
GC016250	CO	MONTROSE	38 31	107 56	62 5	SITE AND SOIL DESCRIPTION NOT RECORDED
GC027850	CO	MONTROSE	38 15	108 21	72 8	NUCLA RD OFF RT 90 AT W LIMIT UNCOMPAGRE NAT FOREST; COLLUVIUM & SILT
GC028050	CO	MONTROSE	38 26	107 35	72 8	US 50 2 MI W CIMARRON; LIGHT BROWN LOAM OVER SHALE
GC044450	CO	MORGAN	40 15	103 45	66 10	RT 71 1 MI N BRUSH; BROWN SANDY LOAM
GC085450	CO	OTERO	37 45	103 30	75 6	RT 109 15 MI S LA JUNTA; SANDY LOAM, MODERATELY WELL DEVELOPED
GC085850	CO	OTERO	37 40	104 0	75 6	US 350 1 MI N DELHI; ARIDISOL FROM SANDSTONE AND SHALE
GC016350	CO	OURAY	37 57	107 40	62 5	SITE AND SOIL DESCRIPTION NOT RECORDED
GC027950	CO	OURAY	38 9	107 49	72 8	RT 62 3 MI W RIDGEWAY; SILT OVER SHALE
GC033350	CO	PARK	40 24	106 38	65 8	US 40 ON RABBIT EARS PASS; SANDY B HORIZON ON HORNBLENDE SCHIST
GC155050	CO	PARK	39 27	105 42	63 7	US 285 AT KENOSHA PASS SUMMIT; DARK LOAM, FROM GRUS
GC181450	CO	PARK	39 13	106 0	64 7	US 285 4 MI S FAIRPLAY; SOIL NOT DESCRIBED
GC156750	CO	PROWERS	38 0	102 7	63 10	US 50 1 MI W HOLLY; IRRIGATED CALCIMORPHIC SOIL
GC277650	CO	PROWERS	37 45	102 35	69 1	US 385 9 MI N COUNTY LINE; LIGHT YELLOW SAND OVER SANDSTONE BUTTES
GC086050	CO	PUEBLO	38 25	104 11	75 6	BOONE RD 12 MI N BOONE; WINDBLOWN SAND
GC170150	CO	PUEBLO	37 58	104 47	64 5	I-25 20 MI S PUEBLO; ARID LIGHT SOIL
GC185250	CO	ROUTT	40 29	107 2	65 6	US 40 2 MI E STEAMBOAT SPRINGS; BROWN SILTY CLAY 8-IN. DEPTH
GC181350	CO	SAGUACHE	38 14	105 55	64 7	US 285 .5 MI N VILLA GROVE; SAN LUIS VALLEY LOAM
GC010351	CO	SAN MIGUEL	38 2	108 40	64 9	18 MI SW NUCLA; SOIL ON ALLUVIAL FILL
GC027750	CO	SAN MIGUEL	38 8	108 23	72 8	BLM RD AT BURN CANYON 7 MI W NORWOOD; SOIL DERIVED FROM SANDSTONE
GC066950	CO	SUMMIT	39 33	106 9	72 9	US 6 .5 MI E OFFICERS GULCH CAMPGROUND; BROWN GRAVELLY SOIL ON TILL
GC016850	CO	TELLER	38 57	105 17	62 5	US 24 E EDGE FLORISSANT; BLACK SOIL
GC000250	CO	WASHINGTON	39 45	103 14	62 5	US 36 1 MI W ANTON; MEDIUM BROWN SILTY LOAM
GC263250	CO	WELD	40 53	104 47	68 8	US 85 2 MI S ROCKPORT AND .5 MI E ON GROVER RD; B HORIZON CALICHE VEIN
GC268750	CO	WELD	40 59	103 42	68 8	RT 71 26 MI N STONEHAM; LOESS AND SAND CAP OVER FISSILE LIMESTONE
GC268850	CO	WELD	40 38	104 5	68 8	RT 14 18 MI W JCT RT 52; SANDY SILT TOPSOIL CALCAREOUS SANDY SUBSOIL
GC000350	CO	YUMA	39 42	102 23	62 5	US 36 1 MI W IDALIA; BROWN SILTY LOAM
GC006250	CT	NEW HAVEN	41 16	72 50	62 10	CONN TPK 2 MI E EXIT 52; YELLOWISH-ORANGE SANDY CLAY
GC006150	CT	NEW LONDON	41 35	72 4	62 10	CONN TPK 3 MI NE EXIT 81; YELLOW-BROWN B HORIZON
GC032450	DE	NEW CASTLE	39 19	75 37	72 9	RT 13 2 MI N SMYRNA; LIGHT BROWN SAND
GC032250	DE	SUSSEX	38 43	75 9	72 9	RT 24 2 MI SW MIDWAY; SANDY PEBBLY SOIL
GC278150	FL	ALACHUA	29 30	82 18	69 1	US 441 1 MI S MICANOPY; UPLAND HUMIC SAND
GC025850	FL	BREVARD	28 10	80 37	71 7	I-95 12 MI N JCT WITH US 192; ORGANIC SOIL AND SAND
GC026650	FL	BROWARD	26 9	80 29	71 7	JCT US 27 & RT 84 NEAR ANDYTOWN; ORGANIC & SANDY SOIL
GC278550	FL	CHARLOTTE	27 0	82 10	69 1	US 41 5 MI W MURDOCK; FINE SAND
GC070450	FL	CITRUS	28 48	82 24	73 2	US 19 3 MI N HOMOSASSA; YELLOW SANDY SOIL
GC025450	FL	CLAY	31 50	82 5	71 7	JCT RT 218 & US 301 8 MI N LAWTEY; MUCK
GC026550	FL	COLLIER	25 50	80 59	71 7	US 41 AT PAOLITA STATION; MUCK WITH SAND & SHELLS
GC026750	FL	COLLIER	26 10	80 57	71 7	RT 84 W OF SEMINOLE RESERVATION; ORGANIC & SANDY SOIL
GC278750	FL	COLLIER	25 55	81 45	69 1	RT 92 ON BEACH RIDGE OF MARCO ISLAND; CALCAREOUS SAND
GC278850	FL	COLLIER	26 8	81 30	69 1	RT 838 10 MI W JCT RT 29; HUMIC SAND OVER MARL, NON-CALCAREOUS
GC026450	FL	DIXIE	29 38	83 8	71 7	US 19-98 AT CROSS CITY; ORGANIC & SANDY SOIL

Table 1.--Location, description, and concentration of elements for samples of surficial materials--continued

Sample No.	Al %	As ppm	B ppm	Ba ppm	Be ppm	Br ppm	C %	Ca %	Ce ppm	Co ppm	Cr ppm	Cu ppm
GC066550	3.00	8.3	50	300	1.5	<.5	1.4	4.09	<150	N	30.0	10.0
GC066650	10.00	5.5	30	1,000	1.5	<.5	1.3	2.53	<150	5	50.0	20.0
GC262150	>10.00	4.9	30	700	1.0	--	--	1.00	N	7	30.0	30.0
GC033450	7.00	7.2	30	700	N	--	--	1.00	150	15	100.0	20.0
GC033550	5.00	4.2	30	500	N	--	--	.60	N	N	15.0	10.0
GC033650	5.00	5.3	50	500	N	--	--	1.80	N	N	15.0	15.0
GC185450	3.00	10.0	70	300	N	--	--	7.43	--	3	30.0	30.0
GC015550	7.00	--	30	500	2.0	--	--	.60	N	7	50.0	30.0
GC073250	3.00	5.4	30	300	N	<.5	1.6	1.40	N	<3	20.0	10.0
GC016250	7.00	--	70	500	2.0	--	--	4.20	--	7	100.0	50.0
GC027850	3.00	3.5	30	300	N	<.5	.7	.33	N	5	100.0	20.0
GC028050	7.00	10.1	20	700	1.5	.9	2.2	5.42	--	5	70.0	20.0
GC044450	3.00	4.9	20	700	1.0	--	--	.50	N	5	30.0	15.0
GC085450	5.00	9.6	<20	700	1.0	.9	1.4	3.62	N	7	30.0	15.0
GC085850	10.00	8.8	30	1,000	1.0	1.2	3.3	8.45	N	7	70.0	30.0
GC016350	>10.00	--	N	700	2.0	--	--	.65	N	20	30.0	70.0
GC027950	10.00	10.8	30	500	N	1.2	5.9	14.49	--	7	70.0	50.0
GC033350	>10.00	3.3	N	700	N	--	--	1.20	N	15	50.0	30.0
GC155050	3.00	4.0	N	500	N	--	--	1.50	N	N	50.0	30.0
GC181450	7.00	--	30	500	N	--	--	1.10	--	7	50.0	10.0
GC156750	7.00	8.8	50	700	N	--	--	3.80	N	10	50.0	20.0
GC277650	1.00	3.9	<20	100	N	--	--	.09	N	3	3.0	5.0
GC086050	5.00	2.3	N	1,000	N	<.5	.3	.28	N	5	15.0	7.0
GC170150	5.00	8.5	30	500	N	--	--	8.40	--	7	50.0	15.0
GC185250	5.00	8.2	30	700	N	--	--	.58	150	15	70.0	30.0
GC181350	>10.00	--	20	700	N	--	--	1.40	N	15	50.0	20.0
GC010351	5.00	7.2	30	300	N	--	--	8.40	N	N	70.0	20.0
GC027750	5.00	6.7	30	500	N	<.5	1.6	1.68	<150	5	50.0	20.0
GC066950	7.00	4.9	<20	500	1.5	.9	1.2	1.07	<150	10	50.0	20.0
GC016850	>10.00	--	N	1,500	2.0	--	--	1.80	N	10	70.0	30.0
GC000250	5.00	5.0	30	700	N	--	--	.79	150	15	30.0	30.0
GC263250	5.00	9.1	20	700	N	--	--	.55	N	3	20.0	15.0
GC268750	1.50	5.0	N	700	N	--	--	32.00	N	3	10.0	15.0
GC268850	10.00	4.5	20	300	1.5	--	--	4.90	N	3	30.0	15.0
GC000350	3.00	5.4	30	700	N	--	--	1.00	150	7	30.0	20.0
GC006250	7.00	3.7	N	300	N	--	--	.70	N	10	30.0	20.0
GC006150	>10.00	4.5	N	500	N	--	--	.98	N	5	50.0	10.0
GC032450	3.00	2.7	20	500	N	2.3	2.1	.17	N	5	50.0	7.0
GC032250	1.50	<.1	<20	300	N	.7	1.5	.15	N	N	10.0	3.0
GC278150	2.00	1.5	20	200	1.5	--	--	.95	N	N	50.0	3.0
GC025850	.20	.2	<20	30	N	<.5	.2	.11	N	N	1.0	N
GC026650	1.00	2.5	N	30	N	4.1	6.9	2.03	--	N	20.0	7.0
GC278550	.20	2.9	20	30	N	--	--	.04	N	N	2.0	2.0
GC070450	.30	.5	<20	20	N	<.5	.4	--	N	N	5.0	N
GC025450	5.00	3.9	N	20	N	2.5	29.9	--	N	N	10.0	5.0
GC026550	3.00	3.3	<20	30	N	--	9.4	14.79	N	N	30.0	2.0
GC026750	.30	.3	<20	50	N	<.5	3.0	.25	N	N	2.0	1.0
GC278750	.20	1.3	20	50	N	--	--	1.80	N	N	3.0	3.0
GC278850	.70	1.0	30	50	N	--	--	.14	N	N	5.0	1.0
GC026450	.20	7.0	<20	10	N	<.5	1.0	.95	N	N	2.0	1.0

Table 1.--Location, description, and concentration of elements for samples of surficial materials--continued

Sample No.	F %	Fe %	Ga ppm	Ge ppm	Hg ppm	I ppm	K %	La ppm	Li ppm	Mg %	Mn ppm	Mo ppm
GC066550	.070	1.50	10	1.48	.02	1.4	1.27	50	30	.500	100	N
GC066650	--	2.00	20	1.25	.02	<.5	1.80	<30	15	1.000	200	N
GC262150	.046	3.00	30	--	.24	--	2.50	50	20	1.000	1,500	N
GC033450	.037	2.00	20	--	.02	--	1.70	70	21	.700	700	N
GC033550	.011	.70	10	--	.01	--	1.70	N	12	.200	200	N
GC033650	.025	.70	7	--	.02	--	1.80	N	17	.500	300	N
GC185450	.057	1.50	30	--	.05	--	1.70	30	35	1.500	300	N
GC015550	--	2.00	20	--	--	--	2.10	30	--	.700	300	N
GC073250	--	1.00	7	1.27	.02	.8	.74	N	15	.700	100	N
GC016250	--	2.00	30	--	--	--	2.10	30	--	2.000	300	N
GC027850	--	2.00	10	.92	.03	<.5	1.10	50	15	.200	150	N
GC028050	.050	3.00	20	1.18	.05	.7	1.80	<30	30	1.000	300	N
GC044450	.055	1.50	20	--	.05	--	2.70	30	22	.300	300	N
GC085450	.070	2.00	15	1.47	.04	1.0	1.60	50	32	1.000	200	N
GC085850	--	1.50	20	1.03	.05	1.5	1.83	N	35	.700	100	5
GC016350	--	7.00	30	--	--	--	1.90	50	--	1.000	1,500	N
GC027950	.070	3.00	20	.94	.02	2.1	1.46	50	24	1.000	300	7
GC033350	.027	3.00	30	--	.04	--	2.50	50	40	1.000	500	N
GC155050	.045	1.50	15	--	1.30	--	2.00	50	37	.500	300	N
GC181450	--	2.00	20	--	--	--	2.50	70	--	.500	300	N
GC156750	.051	3.00	30	--	.20	--	2.20	50	29	1.000	500	N
GC277650	.007	.70	N	--	.08	--	.19	N	9	.050	70	N
GC086050	--	1.50	20	1.42	.03	.5	2.88	50	15	.300	200	N
GC170150	.044	2.00	20	--	.06	--	1.70	30	22	.700	300	N
GC185250	.041	2.00	20	--	.14	--	2.13	70	28	.700	700	N
GC181350	--	3.00	20	--	--	--	2.70	70	--	.500	1,000	N
GC010351	.110	1.50	15	--	.06	--	2.00	N	42	1.000	150	N
GC027750	--	2.00	15	1.69	.03	1.0	1.16	<30	30	.500	150	N
GC066950	--	3.00	15	1.44	.04	.6	1.76	50	20	.700	500	N
GC016850	--	3.00	30	--	--	--	2.20	50	--	.700	700	N
GC000250	.053	1.50	30	--	.08	--	2.21	70	25	.700	700	N
GC263250	.021	2.00	20	--	.02	--	2.90	30	12	.300	300	N
GC268750	.056	.70	5	--	.03	--	.85	N	9	.700	70	N
GC268850	.073	2.00	20	--	.01	--	2.50	50	28	1.500	300	N
GC000350	.044	1.50	20	--	.07	--	2.27	70	19	.700	500	N
GC006250	.005	1.50	10	--	.22	--	1.30	N	31	.500	700	N
GC006150	.028	2.00	20	--	.39	--	1.80	30	23	.500	200	7
GC032450	--	1.00	10	1.22	.05	1.5	1.71	<30	15	.100	100	N
GC032250	--	.50	5	.55	.03	<.5	1.21	N	7	.050	70	N
GC278150	.130	.70	<5	--	.06	--	.24	N	14	.300	150	N
GC025850	--	.03	N	.98	.01	<.5	.12	N	--	.007	N	N
GC026650	--	.30	N	.39	.04	2.1	1.47	N	5	.150	30	N
GC278550	.024	.07	N	--	.11	--	.02	N	<5	.010	2	N
GC070450	--	.10	N	.97	.01	<.5	.11	N	<5	.007	10	N
GC025450	--	.15	N	.60	.14	2.3	--	N	<5	.010	10	N
GC026550	--	1.00	5	.62	.03	--	.06	N	20	.150	100	N
GC026750	--	.20	N	.77	.03	.7	.14	N	<5	.015	20	N
GC278750	<.001	.10	N	--	.10	--	.02	N	<5	.020	20	N
GC278850	<.001	.15	N	--	.03	--	.04	30	7	.020	20	N
GC026450	--	.20	N	.74	.02	<.5	.04	N	<5	.015	10	N

Table 1.--Location, description, and concentration of elements for samples of surficial materials--continued

Sample No.	Na %	Nb ppm	Nd ppm	Ni ppm	P %	Pb ppm	Rb ppm	S %	Sb ppm	Sc ppm	Se ppm	Si %
GC066550	.50	<10	N	5	--	15	50	<.08	1	5	.3	32
GC066650	2.00	<10	N	10	--	15	85	<.08	<1	5	1.0	31
GC262150	3.00	10	100	7	.040	20	--	--	--	7	.5	--
GC033450	1.00	20	N	20	.024	30	--	--	--	7	.3	--
GC033550	.70	N	N	5	.012	15	--	--	--	5	<.1	--
GC033650	.70	N	N	7	.016	20	--	--	--	N	.2	--
GC185450	.70	N	N	15	.096	30	--	--	--	7	2.6	--
GC015550	1.00	20	N	20	.008	30	--	--	--	7	--	--
GC073250	.20	N	--	7	--	N	35	<.08	<1	<5	.3	36
GC016250	2.00	15	N	30	.060	100	--	--	--	10	--	--
GC027850	.30	<10	N	7	--	10	40	<.08	<1	5	.2	37
GC028050	1.00	<10	N	10	--	20	50	<.08	<1	7	.4	25
GC044450	.70	15	70	15	.030	20	--	--	--	7	.3	--
GC085450	1.00	10	N	10	--	20	70	<.08	3	7	.3	32
GC085850	.50	N	--	20	--	15	60	.72	<1	10	.3	21
GC016350	1.50	20	70	20	.090	100	--	--	--	15	--	--
GC027950	1.00	<10	N	20	--	15	80	<.08	2	7	.3	19
GC033350	2.00	15	N	20	.016	50	--	--	--	10	.1	--
GC155050	2.00	15	N	7	.120	30	--	--	--	7	.5	--
GC181450	1.00	10	N	15	.030	70	--	--	--	15	--	--
GC156750	1.50	15	N	30	.044	30	--	--	--	10	1.4	--
GC277650	.05	N	--	5	.004	N	--	--	--	N	.3	--
GC086050	2.00	10	N	5	--	20	125	<.08	<1	<5	.2	38
GC170150	1.50	10	N	20	.044	30	--	--	--	10	.8	--
GC185250	.70	15	70	15	.087	30	--	--	--	15	.3	--
GC181350	1.00	10	N	15	.060	50	--	--	--	7	--	--
GC010351	1.00	N	--	20	.040	N	--	--	--	5	2.3	--
GC027750	.50	<10	N	10	--	15	40	<.08	2	7	<.1	33
GC066950	1.50	<10	N	15	--	30	85	<.08	<1	10	.3	31
GC016850	3.00	15	70	15	.060	30	--	--	--	10	--	--
GC000250	.70	15	70	15	.039	20	--	--	--	15	.5	--
GC263250	1.00	10	N	7	.016	20	--	--	--	7	.2	--
GC268750	.70	N	--	7	.016	10	--	--	--	N	.5	--
GC268850	1.00	10	N	10	.024	15	--	--	--	7	.4	--
GC000350	.70	15	N	10	.048	20	--	--	--	10	.3	--
GC006250	1.50	N	N	15	.020	N	--	--	--	7	.5	--
GC006150	1.50	10	N	10	.020	N	--	--	--	10	1.2	--
GC032450	.50	<10	N	7	--	20	60	<.08	<1	5	.5	37
GC032250	.20	<10	--	<5	--	10	40	<.08	<1	N	<.1	38
GC278150	<.05	10	--	7	.600	N	--	--	--	7	.2	--
GC025850	N	N	--	N	--	N	<20	<.08	<1	N	<.1	42
GC026650	.10	N	--	5	--	100	<20	<.08	8	N	.2	33
GC278550	N	N	--	N	.004	N	--	--	--	N	.1	--
GC070450	N	<10	--	N	--	N	<20	<.08	<1	N	.2	36
GC025450	N	N	--	5	--	10	<20	<.08	<1	N	.5	17
GC026550	.05	N	--	5	--	10	<20	<.08	<1	5	.2	22
GC026750	<.05	N	--	N	--	N	<20	<.08	<1	N	<.1	42
GC278750	<.05	15	--	N	.030	N	--	--	--	N	.3	--
GC278850	<.05	N	70	N	.004	N	--	--	--	N	.3	--
GC026450	N	N	--	N	--	N	<20	<.08	<1	N	.3	41

Table 1.--Location, description, and concentration of elements for samples of surficial materials--continued

Sample No.	Sn ppm	Sr ppm	Ti %	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn %	Zr ppm
GC066550	2.28	150	.150	10.13	3.87	70	20	2.0	32	150
GC066650	1.38	150	.200	9.41	4.32	150	20	2.0	82	150
GC262150	--	700	.300	--	--	70	20	5.0	85	300
GC033450	--	200	.300	--	--	70	30	5.0	40	300
GC033550	--	100	.070	--	--	20	10	1.5	--	100
GC033650	--	70	.100	--	--	20	10	1.5	20	100
GC185450	--	150	.150	--	--	150	30	3.0	180	70
GC015550	--	150	.300	--	--	70	30	5.0	35	300
GC073250	.91	50	.150	--	2.35	30	10	1.5	34	200
GC016250	--	300	.200	--	--	150	20	3.0	140	70
GC027850	.44	70	.200	7.00	2.55	30	10	2.0	28	300
GC028050	.96	200	.300	8.55	3.10	150	20	2.0	97	70
GC044450	--	150	.150	--	--	50	30	3.0	60	150
GC085450	1.79	200	.200	13.30	3.24	70	20	3.0	66	150
GC085850	2.65	1,000	.150	15.28	5.98	100	15	1.5	50	70
GC016350	--	300	.500	--	--	100	30	--	155	150
GC027950	1.27	300	.200	13.60	4.89	200	20	3.0	110	100
GC033350	--	300	.300	--	--	70	20	3.0	60	150
GC155050	--	200	.100	--	--	50	30	2.0	250	150
GC181450	--	100	.100	--	--	70	20	3.0	100	100
GC156750	--	300	.300	--	--	150	30	5.0	100	150
GC277650	--	10	.070	--	--	15	N	1.0	15	70
GC086050	2.18	150	.150	6.41	2.74	50	20	3.0	38	200
GC170150	--	500	.150	--	--	150	30	3.0	50	200
GC185250	--	150	.300	--	--	70	30	5.0	79	300
GC181350	--	300	.500	--	--	100	50	5.0	125	200
GC010351	--	200	.070	--	--	70	15	1.5	70	50
GC027750	2.01	100	.200	11.03	2.74	70	20	3.0	37	500
GC066950	1.02	150	.200	14.17	2.88	70	20	3.0	2,080	150
GC016850	--	1,000	.300	--	--	100	30	3.0	65	150
GC000250	--	150	.300	--	--	70	70	7.0	70	300
GC263250	--	200	.150	--	--	50	30	3.0	30	200
GC268750	--	500	.050	--	--	20	N	1.0	20	30
GC268850	--	300	.150	--	--	50	20	2.0	35	100
GC000350	--	100	.150	--	--	30	30	3.0	60	300
GC006250	--	100	.200	--	--	50	20	3.0	45	150
GC006150	--	150	.300	--	--	70	30	3.0	35	200
GC032450	.40	100	.200	6.98	2.12	30	20	3.0	29	300
GC032250	.17	30	.150	2.76	.95	10	10	1.0	17	300
GC278150	--	70	.200	--	--	30	50	3.0	20	300
GC025850	.23	N	.030	--	.47	N	N	N	<5	70
GC026650	7.88	200	.020	--	1.68	20	N	N	40	N
GC278550	--	<5	.070	--	--	N	N	N	--	70
GC070450	<.10	5	.100	--	.62	<7	N	1.0	<5	300
GC025450	<.10	N	.100	6.05	2.47	7	10	1.0	8	200
GC026550	.61	150	.100	3.16	1.32	30	<10	1.0	14	50
GC026750	<.10	5	.070	--	.57	N	N	N	<5	50
GC278750	--	30	.100	--	--	7	<10	1.0	35	500
GC278850	--	7	.070	--	--	7	20	1.5	--	500
GC026450	1.92	N	.010	--	.33	N	N	N	8	20

Attachment 4

Wilcoxon Rank-Sum Test Calculations

SAS Output:

```
    Descriptive Statistics of Arsenic data: BKGRD (Diawara) vs. INVEST (ARR) sets                          1
                                                                            09:25 Monday, September 22, 2014

Obs    Set        n      mean        std     median      min     max      q1       q3

 1     BKGRD     68    12.5912    10.8881      10.3      1.8     66.5     6.2    14.25
 2     INVEST    93    40.1183    32.5366      33.0     10.0    195.0    24.0    41.00
```

SAS Output:

```
                                                              Expected        Std Dev           Mean
Wilcoxon-Rank-Sum comparison of Arsenic data: BKGRD (Diawara) vs. INVEST (ARR) sets
                                          N         Scores    Under H0       Under H0          Score

                                         68         2810.0      5508.0     292.153425      41.323529
                                         93        10231.0      7533.0     292.153425     110.010753



                                                                       2810.0000

Set

Wilcoxon Scores (Rank Sums) for Variable As                             -9.2332
BKGRD                                                         Z          <.0001
INVEST                                                                   <.0001

The NPAR1WAY Procedure

Classified by Variable Set                                    Z          <.0001
                                                                         <.0001
Sum of



Average scores were used for ties.

                                                                        85.2829
                                                                              1
                                                                         <.0001
Wilcoxon Two-Sample Test
Statistic


Normal Approximation
02:25
Z
One-Sided Pr <
```

NCSS Output:

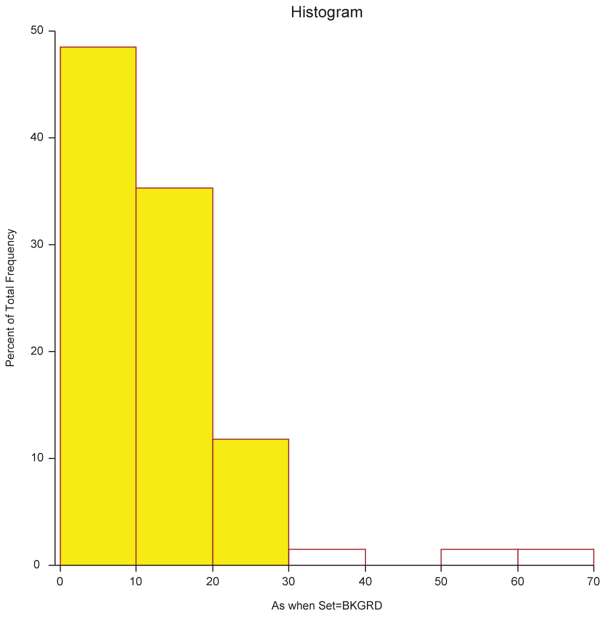
```
                                             Two-Sample Test Report
Dataset            C:\myfiles\hrs\as_compare.xls
Variable           As

Descriptive Statistics
                                            Standard      Standard      95.0% LCL     95.0% UCL
Variable              Count   Mean          Deviation     Error         of Mean       of Mean
Set=BKGRD             68      12.59118      10.8881       1.320376      9.955695      15.22666
Set=INVEST            93      40.11828      32.53655      3.373883      33.41746      46.8191
Note: T* (Set=BKGRD) = 1.9960,   T* (Set=INVEST) = 1.9861


Descriptive Statistics for the Median
                                                  95.0% LCL     95.0% UCL
Variable              Count         Median        of Median     of Median
Set=BKGRD             68            10.3          7.6           11.4
Set=INVEST            93            33            30            36


Mann-Whitney U or Wilcoxon Rank-Sum Test for Difference in Location

                      Mann           W             Mean          Std Dev
Variable              Whitney U      Sum Ranks     of W          of W
Set=BKGRD             464            2810          5508          292.1534
Set=INVEST            5860           10231         7533          292.1534
Number Sets of Ties = 34,   Multiplicity Factor = 996

                   Exact Probability*        Approx. Without Correction          Approx. With Correction
Alternative   Prob          Reject H0                  Prob          Reject H0                  Prob          Reject H0
Hypothesis    Level         (α = 0.010)   Z-Value      Level         (α = 0.010)   Z-Value      Level         (α = 0.010)
Diff < 0                                  -9.2349      0.000000      Yes           -9.2332      0.000000      Yes

(Diff = BKGRD median - INVEST median, i.e., testing that Diff<0 is same as testing that BKGRD Median < INVEST Median)

*Exact probabilities are given only when there are no ties and the sample sizes in both groups are ≤ 20.
```

NCSS Output:

Two-Sample Test Report

Dataset C:\myfiles\hrs\as_compare.xls
Variable As

Plots Section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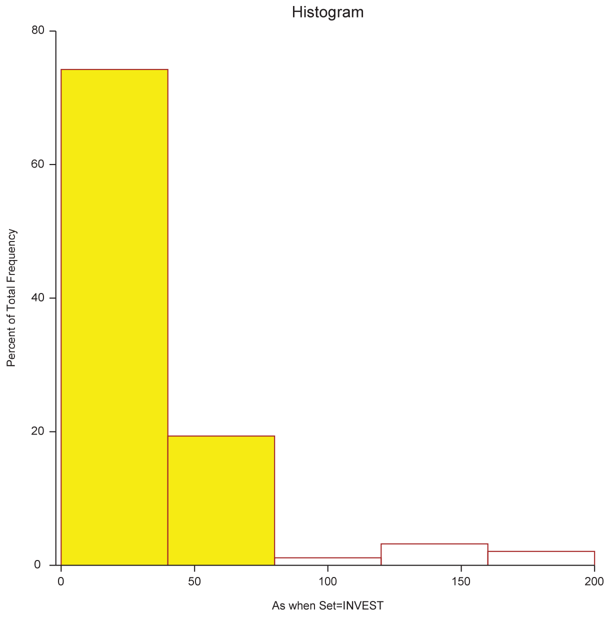
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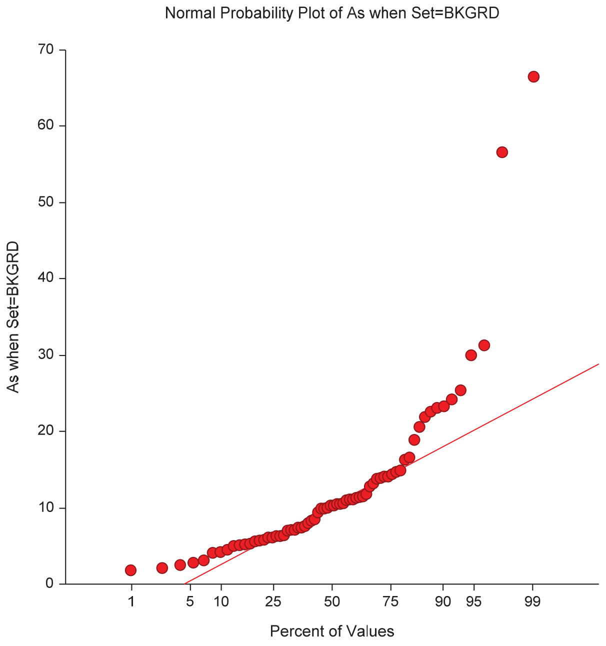
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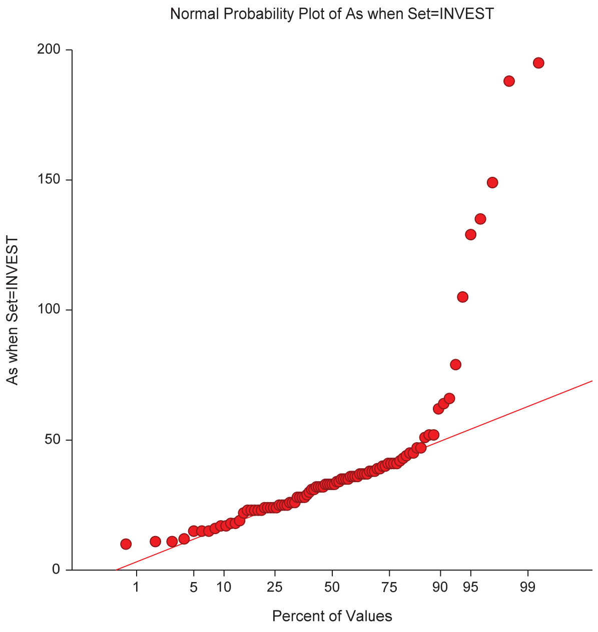
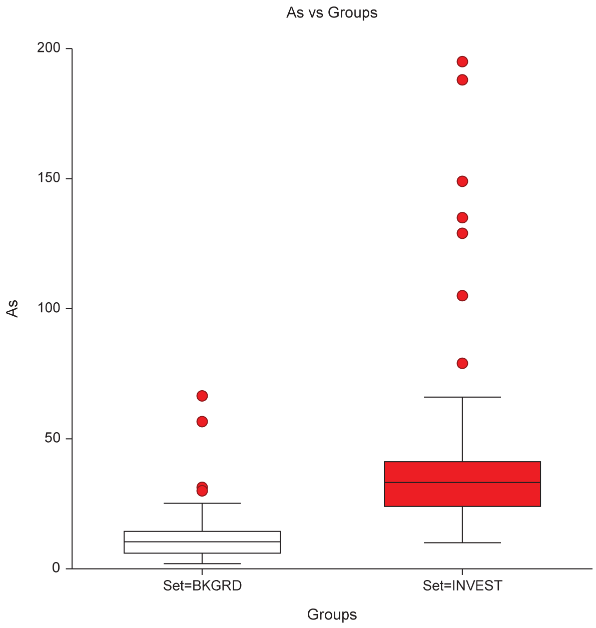

Normal Probability Plot of As when Set=INVEST

NCSS Output:

Two-Sample Test Report

Dataset C:\myfiles\hrs\as_compare.xls
Variable As



Attachment 5

Colorado Smelter Outreach Timeline

Colorado Smelter Outreach Timeline

2007 – EPA and CDPHE reviewed Moussa Diawara Pueblo soils study and the CDPHE Pueblo Discovery effort and saw the need for more soil sampling in populated areas.

June 2010 – CDPHE requested access from 100 property owners/residents to sample residential yards. CDPHE sampled 47 out of 100 yards where access was requested.

June 2011 – CDPHE sent soil sampling results letters to residents.

October 2011 – EPA/CDPHE met with Pueblo City-County Health Department to share findings, discuss recent EPA Removal Action at Blende Smelter, and that the Colorado Smelter site was too large and complex for a Removal Action.

March 15 – 16, 2012 – Meetings with locals, including recognized community leaders and Sandy Daff, District 4 Representative, about how best to do our outreach.

March 28, 2012 – Presentation to Pueblo Board of Health.

April 30, 2012 – Presentation to Pueblo City Council.

May 17, 2012 – Meeting with Pueblo City Attorney. Separate meeting with about 14 Bessemer/Eilers residents including Representative Daff.

June 1, 2012 – Mailings to 1000 residents living within ¼ mile of the Colorado Smelter site including the Site Fact Sheet, "This is Superfund" Community Guide Booklet, and Frequently Asked Questions and Answers.

June 11-12, 2012 – Larger Community Meetings at NeighborWorks; two city council representatives present at each meeting.

June 25, 2012 – Meeting before City Council to discuss the Colorado Smelter contamination and possible addition to the National Priorities List to get resources for clean up.

August 2012 – Meeting with CDOT about their project area that overlaps the Colorado Smelter site.

September 2012 – Door-to-door survey of residents in Eilers and Bessemer neighborhoods. We had 175 respondents to the questionnaire regarding the Superfund listing, risks posed by the site, and best ways to keep residents informed during the site listing and Superfund process.

November 2012 – Results sent to City Council; Follow up calls made and had brief discussions with two City Council members who stated they would defer to Sandy Daff on this matter. No other calls returned from other City Council Members.

January 26, 2013 – Attended Council woman Sandy Daff's Neighborhood meeting to give site update and let residents know about February Outreach meeting. At this meeting it was stated that previous blood lead studies showed some elevated blood lead levels in children from the Eilers/Bessemer neighborhood.

February 21, 2013 – Two public availability sessions: EPA/CDPHE/ATSDR presented on previous sample data collected, risks of arsenic and lead, the Superfund process, sampling and cleanup methods in a residential cleanup, and property values and institutional controls at Superfund sites. The two availability sessions were attended by approximately 80 people.

March-April 2013 – Following Pueblo City Council members visit/meeting to EPA headquarters in Washington DC, EPA Region 8 staff committed to reviewing the 2010 sampling data with one to two city council members per their request. To date City Council has not been able to schedule a meeting with EPA.

April 25, 2013 – Two outreach meetings/availability sessions (afternoon session was a public meeting and evening session was an availability session): EPA/CDPHE/ATSDR discussed health effects of arsenic and lead, the benefits and challenges of Superfund, the data collection process, and how EPA determined that this smelter and neighborhood are part of a NPL-caliber site. Neighborhood participants in the meetings ranged from supportive to non-supportive of Superfund; however, those supportive of cleanup were more vocal than in previous outreach sessions. Of particular concern to some community members is how institutional controls or deed restrictions might impact their properties. These two meetings were attended by approximately 35 people. Prior to these meetings, the EPA met with the Pueblo Chieftain Editorial Board.

June 3, 2013 – CDPHE met with State legislators, city council members, PCCHD and the public to listen to their local environmental and public health concerns. These meetings resulted in a commitment by the state to follow up with a larger meeting on July 23, 2013.

July 23, 2013 – EPA, CDPHE, ATSDR, and Pueblo City-County Health met with local residents and elected officials including Pueblo City Council, Pueblo County Commissioners, and State Representatives to listen and discuss the Colorado Smelter site data, public health concerns, and using the Superfund program to address the health risks. EPA reiterated that we have worked through funding, property values, and community impact concerns at many sites. Also, EPA discussed that their policy is not to move forward until the community supports the project.

July 31, 2013 – EPA, CDPHE, ATSDR, and Pueblo City-County Health presentation for County Commissioners MacFadyen and Hart.

August 26, 2013 – EPA staff met with Sierra Club and attended Eilers Neighborhood meeting to answer residents' questions, get input about how best to conduct outreach, and get residents' participation in outreach. EPA has committed to developing a fact sheet regarding the Pros and Cons of Superfund (similar to a poster that has already been developed for community meetings) for the door-to-door work. The Eilers meeting participants were excited about the pending ATSDR health study and will likely be able to assist in outreach so that as many people participate in the study as possible.

August 27, 2013 – Outreach to Rocky Mountain Head Start, Bessemer Academy, Central High School, Patient Advocate for the area schools' nurses. The team shared our English and Spanish outreach materials with Bessemer Academy and Rocky Mountain Head Start – these contacts should be able to help maximize participation in the ATSDR health study.

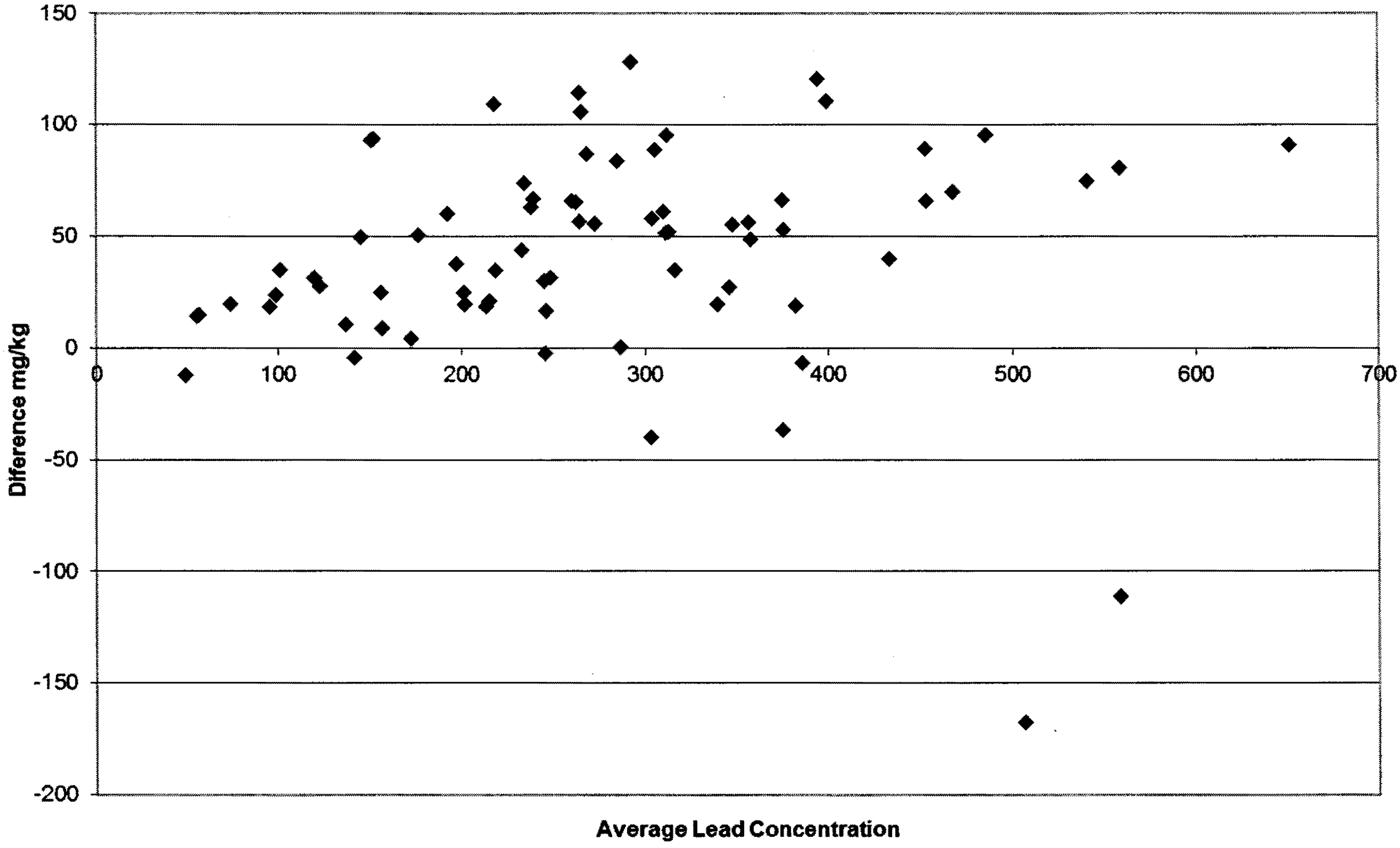
April – July 2014 – Neutral facilitator funded to assist with Community Advisory Group (CAG development).

September 9, 2014 – First official CAG meeting held.

Attachment 6

Figure 4 of Mr. Coomes’ Comment Submittal

Figure 4. Difference Equals Composite Value Minus Average Value For the Aliquots



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