CSMRI Creekside Site
Final Site Characterization Work Plan

Prepared for:

Colorado School of Mines
Golden, Colorado

Prepared by:

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Lafayette, Colorado

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Approvals		
Date: May 12, 2006		
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List of Acronyms

AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ATV	all-terrain vehicle
CDPHE	Colorado Department of Public Health and Environment
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CSMRI	Colorado School of Mines Research Institute
cy	cubic yard
DAC	derived air concentration
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
EPA	U.S. Environmental Protection Agency
FGS	field gamma scintillator
FSL	field screening level
GIS	geographical information system
GPERS-II	Global Positioning Environmental Radiological Surveyor
GPS	global positioning system
HSO	health and safety officer
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LOD	limit of detection
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCA	multi-channel analyzer
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDL	method detection limit
MS/MSD	matrix spike/matrix spike duplicate
NCP	National Contingency Plan
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
NVLAP	National Voluntary Laboratory Accreditation Program
OSHA	Occupational Safety and Health Administration
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
PEL	permissible exposure limit
PPE	personal protective equipment
ppm	parts per million
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RDL	required detection limit
RI/FS	Remedial Investigation/Feasibility Study

ROD	Record of Decision
RPD	relative percent difference
RSO	Radiation Safety Officer
SAP	sampling and analysis plan
School	Colorado School of Mines
SSHSP	site-specific health and safety plan
TCLP	Toxicity Characteristic Leaching Procedure
VSP	Visual Sampling Plan
XRF	x-ray fluorescence

1. Introduction

The S.M. Stoller Corporation (Stoller) on behalf of Colorado School of Mines (School) prepared this work plan. This plan will serve as the controlling work document for characterization of the CSMRI Creekside Site (Site). This work plan will be submitted to the Colorado Department of Public Health and Environment (CDPHE) for approval prior to conducting the Site characterization described in this work plan.

The work plan is designed to evaluate the Site as it currently exists using a combination of existing data and newly collected data. The work plan details how the nature and extent of impacted material at the Site will be determined using tentative clean-up goals. Other goals of the work plan are to fill data gaps and potentially revise the Remedial Investigation and Feasibility Study (RI/FS) and Record of Decision (ROD) for the Site, as necessary.

The CSMRI Site has a Radioactive Materials License (Number 617-01). The CSMRI site characterization work will be completed under the Stoller Radioactive Materials License (Number 1094-01) and the Stoller Radiation Safety Officer (RSO), Patrice McEahern.

1.1 Site Location and Description

The Site is located near the School's baseball field and is defined by the fenced area north of the intersection of Birch and 12th Streets in Golden, Colorado (Figure 1-1). The Site is demarcated by the fenced area on Figure 1-1, although a temporary fence has been added to the Site southern boundary as a staging area for certain containerized soils. Historically, the Site included the Clay Pits Area located south of that same intersection, but for this project, the Site is defined as the fenced area. No contamination of the Clay Pits Area has been identified in the previously conducted investigation work. Therefore, the Clay Pits Area is not a part of the continuing investigation.

The Site is located on the south side of Clear Creek, east of U.S. Highway 6, in the northeast quarter of the northwest quarter of Section 33, Township 3 South, Range 70 West as shown in Figure 1-1. The main entrance to the Site is located approximately 475 feet northwest of the intersection of Birch and 12th Streets. An 8-foot chain-link fence restricts access to the Site. The Site includes an area that was the location of a former settling pond. The pond was remediated and closed by the U.S. Environmental Protection Agency (EPA) and CDPHE in 1992 as part of an emergency removal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the pond area is not part of the continuing Site characterization.

The Site covers an area of about six acres and is currently defined by the shaded area shown in Figure 1-1. In accordance with CERCLA and the National Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Parts 300.5 and 300.400(e), the term "on-site" refers to the areal extent of contamination and all suitable areas in very close proximity to the contamination. Consequently, the Site boundary may be modified or expanded to address the needs of the remedial action.

1.2 Site History

Numerous industrial mineral research projects involving materials that contained natural radionuclides and metals were conducted on the Site from 1912 until about 1987. Sixteen buildings once occupied the six-acre Site. The CDPHE has issued a Radioactive Materials License to CSMRI for the Site. The License authorizes storage of "naturally occurring, source, and byproduct radionuclides."

In 1992, a City of Golden water main broke and released water into an inactive settling pond on the Site. This prompted the EPA to undertake an emergency removal action pursuant to CERCLA. This activity involved the excavation of 22,000 cubic yards (cy) of soil from the vicinity of the pond. The material was later disposed as "solid waste" at a local solid waste landfill. The EPA removal action ended in 1997.

All of the aboveground structures on the Site have been removed, including concrete slabs, asphalt-paved areas, and most subsurface footers for the buildings.

Numerous environmental assessments of the Site that identified the contaminants of concern (COCs) released into the soil have been completed. The COCs include the radium radionuclides Ra-226 and Ra-228; the thorium radionuclides Th-228, Th-230, and Th-232; the uranium radionuclides U-234, U-235, and U-238; and metals arsenic (As), lead (Pb), mercury (Hg), molybdenum (Mo), and vanadium (V). Where radionuclides are present, they are part of naturally occurring decay chains and minerals. The metals generally occur together with the radionuclide COCs. Toxicity Characteristic Leaching Procedure (TCLP) results indicate that the affected material is not hazardous waste pursuant to the Resource Conservation and Recovery Act (RCRA).

All of these COCs occur naturally in the bedrock formations and in the surficial deposits that comprise the Site. The following three background studies were completed between 2000 and 2004.

- *Background Characterization Report,* prepared for Colorado School of Mines Environmental Health and Safety, prepared by URS Greiner Woodward Clyde International-Americas, Inc., July 7, 2000 (URS 2000)
- *Colorado School of Mines Research Institute Supplementary Background Characterization draft final report*, prepared by URS Corporation, January 28, 2002 (URS 2002)
- *Remedial Investigation/Feasibility Study and Proposed Plan, prepared for Colorado School of Mines Research Institute Site,* prepared by New Horizons Environmental Consultants, Inc., January 21, 2004 (New Horizons 2004)

In 2002, the School contracted with New Horizons Environmental Consultants, Inc. to provide surface and subsurface sampling and analysis of the Site and to generate an RI/FS report. New Horizons performed the Site characterization work and prepared an RI/FS dated January 21, 2004. The RI/FS outlined several alternative remedial options, with the School preferring one as the proposed remedial action plan for the Site. After public comment, a ROD was signed on March 31, 2004. The ROD selected the remedial alternative of excavation of soils and offsite

disposal at landfills. This work constituted Phase I of the environmental assessment and response work.

In the RI/FS, New Horizons divided up the affected soils into two classes. "Class I soil" was described as soil that required disposal at a U.S. Ecology facility in Idaho because the radionuclide concentrations would exceed that allowed at a local landfill. New Horizons estimated that the amount of Class I soil that would be excavated during the remedial action would be approximately 500 cy. "Class II soil" was described as soil that could be disposed of at the local landfill. New Horizons estimated that the amount of Class II soil that would be excavated during the remedial action would be approximately 9,500 cy.

In 2004, New Horizons was selected to identify, excavate, and dispose of contaminated soils at the Site. Field work began in April 2004. This field work constituted Phase II of the environmental assessment and response. New Horizons began its field work by first excavating all of the Class I soil and placing the Class I soil into bags for shipment to the U.S. Ecology facility in Idaho. By May 2004, less than half of the Site had been excavated. However, the volume of excavated Class I soil reached approximately 1,870 cy, which exceeded the 500-cy volume estimated in the RI/FS. It therefore became apparent that the extent of contamination at the Site was not fully understood by New Horizons. Therefore, remedial work was halted by the School and the Site was stabilized. Approximately 1,870 cy of soil had been excavated, bagged, and staged on the Site as Class I soil by New Horizons during the 2004 remediation work. The contract with New Horizons was terminated by the School in the fall of 2004. At the time of the contract termination, an estimated 100 cy of the bagged soil had been shipped from the Site for disposal leaving an estimated 1,776 cy remaining for transport and disposal. CDPHE also stated that additional Site characterization should be performed before accurate clean-up options and cost estimates can be developed.

Bagged soil staged at the Site by New Horizons had been initially slated for disposal at a U.S. Ecology facility in Idaho. In December 2004, Stoller collected representative soil samples from a portion of the 455 super-sack containers staged at the Site to evaluate potential alternative disposal options of the containerized material. Results were submitted to the CDPHE for review in the April 2005 report, *Dose Assessment for the Emplacement of the CSMRI Site Containerized and Remaining Subsurface Soil into a RCRA Subtitle D Solid Waste Landfill* (Stoller 2005). After review of the dose assessment report, the CDPHE approved shipment of the Class I soil bagged material and up to 30,000 cy of similar yet-to-be-excavated soils to a local solid waste landfill (the BFI Foothills Landfill on Highway 93 in Jefferson County) in a letter dated August 26, 2005. The bagged material was shipped from the Site to the BFI Foothills Landfill in December, 2005.

1.3 Site Geology

The Site is located along the front range of the Rocky Mountains adjacent to Clear Creek as shown in Figure 1-1. The bedrock underlying the Site consists of four steeply dipping formations overlain by four surficial geologic units. The bedrock Formations are the Pierre Shale, the Fox Hills Sandstone, the Laramie Formation, and the Arapaho Formation.

A geologic map of the bedrock formations is provided as Figure 1-2. These formations range from fine-grained shales and coal beds to coarse-grained sandstones and conglomerates. The coal bed within the Laramie Formation was mined. A plaque near the site commemorates the loss of life that took place in the mineshaft that underlies a portion of the site. Each of the four bedrock formations has a different chemical composition and can be expected to have different background concentrations of metals and radionuclides.

Four younger surficial deposits in the vicinity of the Site overlie the bedrock formations. These surficial deposits are most impacted by activities at the Site, with minor impacts to the underlying bedrock formations. These younger deposits are Louviers Alluvium, Post Piney Creek Alluvium, Colluvium, and artificial fill.

Detailed lithologic descriptions of these units are contained in the RI/FS. A geologic map showing the extent of these four deposits is presented as Figure 1-3. Each of these four deposits has different chemical composition and can be expected to have different background concentrations of metals and radionuclides.

Determination of background concentrations for Site contaminants would ideally consider the background activity of the four bedrock formations as well as the four surficial deposits, if technical and practical issues may be resolved. However, blending of different geologic units most likely occurred during development and demolition of the Site buildings, and research and maintenance operations over the decades, complicating the geologic picture and background determination. The School's effort to generally increase background concentrations for the Site to account for these complexities was not accepted by CPDHE. The School therefore proposes below a different approach that addresses the complexities at this Site and CPDHE's comments, while allowing for a method to account for the different formations and deposits at the Site in a pragmatic and cost-effective manner.

1.4 Site Licensing History

The Site licensing and regulatory history is described in the RI/FS (pp. 4-12 through 4-44). Additional licensing information and history is provided in Appendix A. Previously excavated soils from the Site have been disposed offsite as solid waste at solid waste landfills. These activities were completed under the Radioactive Materials License of the contractor performing the work.

1.5 Current Site Conditions

The Site is currently overgrown with vegetation and littered with some metal debris, piping, crushed empty drums, etc. Soil erosion controls are in place, and the entire Site is fenced. The terrain is uneven and the Site contains numerous test pits, identified during previous New Horizons activities as "BFI" pits. A review of existing data indicated that the bulk soil samples taken from these locations were analyzed in the laboratory only for TCLP lead concentrations. These test pits are, in general, only 2 to 3 feet deep and were located across the entire Site. Each pit has a soil stockpile associated with it. In addition to the BFI pits, six larger excavations (Hole K, Hole J, Hole I1, and Holes H1, H2, and H3) and six test pits remain open (TP1, TP2, TP3, TP8, TP9, and TP10) from the previous investigative/remedial efforts. Four test pits cannot be

located (TP4, TP5, TP6, and TP7); they were presumably removed during excavation of the six holes that encompassed these test pits.

Since January 2005, Stoller personnel have been contracted by the School to perform weekly Site inspections and Site maintenance, monthly air sampling, and quarterly groundwater and surface water data collection. On a weekly basis, Stoller personnel perform a Site walk-down. Site inspections include verifying that air monitoring stations are working properly, visually inspecting soil stockpiles and the condition of the geotextile liner over bagged materials, and verifying that erosion controls are in place. Stoller has placed two continuous high-volume air samplers on the Site, one each in the prevailing upwind and downwind directions. The filters in the air monitoring stations are replaced each month with new filters and the exposed filters are removed and sent to a laboratory for analysis. Four groundwater monitoring wells and two surface water locations are sampled on a quarterly basis. These monitoring programs will remain in place during the characterization activities described in this work plan. The Site is currently stabilized.

1.6 Project Organization

Figure 1-4 presents the project organization chart, which identifies key management roles and diagrams areas of responsibility for the scope of work outlined in this work plan. The management structure should not be confused with the project lines of communication. It is Stoller's and the School's intent to maintain open communication among all entities involved in this work plan. Stoller recognizes that the oversight role of the CDPHE may require open access to the field activities, laboratory activities, community relations activities, and project quality assurance/quality control (QA/QC) information. Stoller will work with CDPHE to keep them informed of the ongoing activities.

Primary responsibility for the achievement of the work plan objectives lies jointly between Linn Havelick, the School Principal Representative and Stephen Brinkman, Stoller Project Manager. The Stoller Project Manager will be on the Site at the commencement of the project activities and periodically thereafter. Stoller's Project Lead, Michael (Harry) Bolton has the responsibility of ensuring that all field activities conducted by Stoller and its subcontractors are performed in conformance with the approved work plans. Various Stoller employees will act in technical support capacities and perform those portions of the Site characterization that fall within their individual areas of expertise.

Radiation safety is the responsibility of the RSO. Patrice McEahern is the primary RSO, and Joseph Gordon is the alternate RSO.

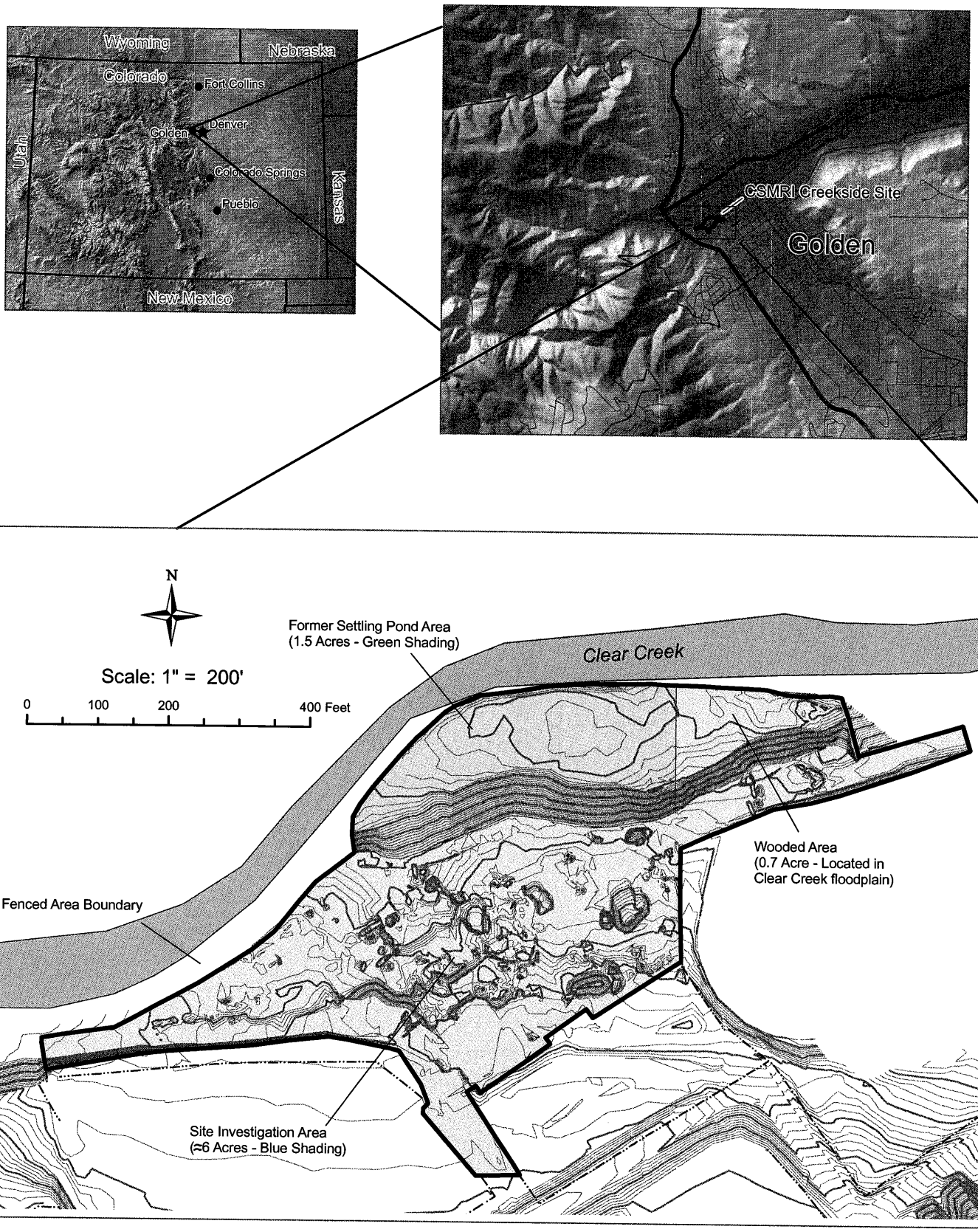

Figure 1-1

CSMRI Creekside Site
Site Location Map

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)

CSMRI
Site Characterization Workplan

Stoller

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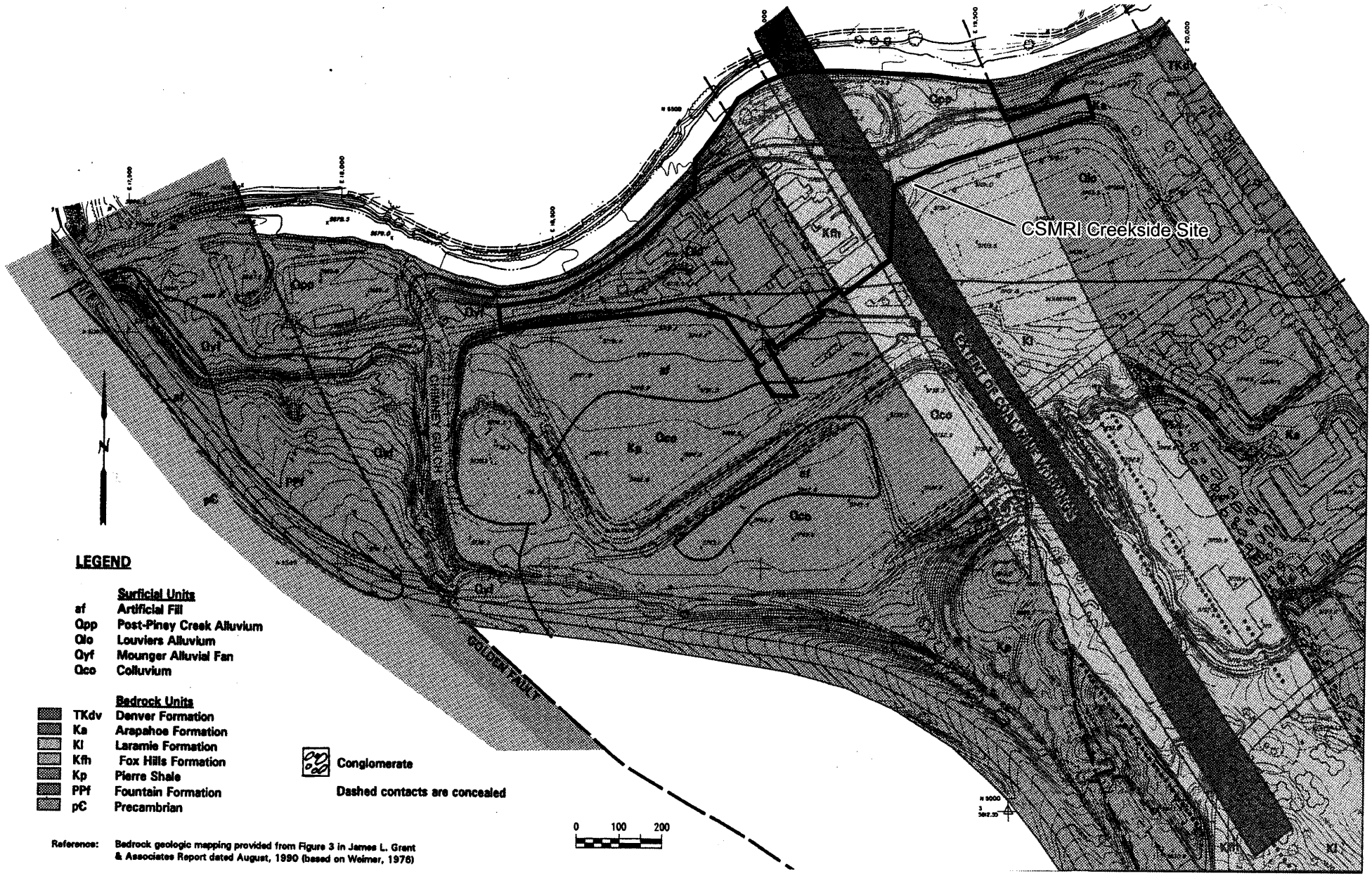

Figure 1-2

CSMRI Creekside Site
Bedrock Geologic Map

CSMRI
Site Characterization Workplan

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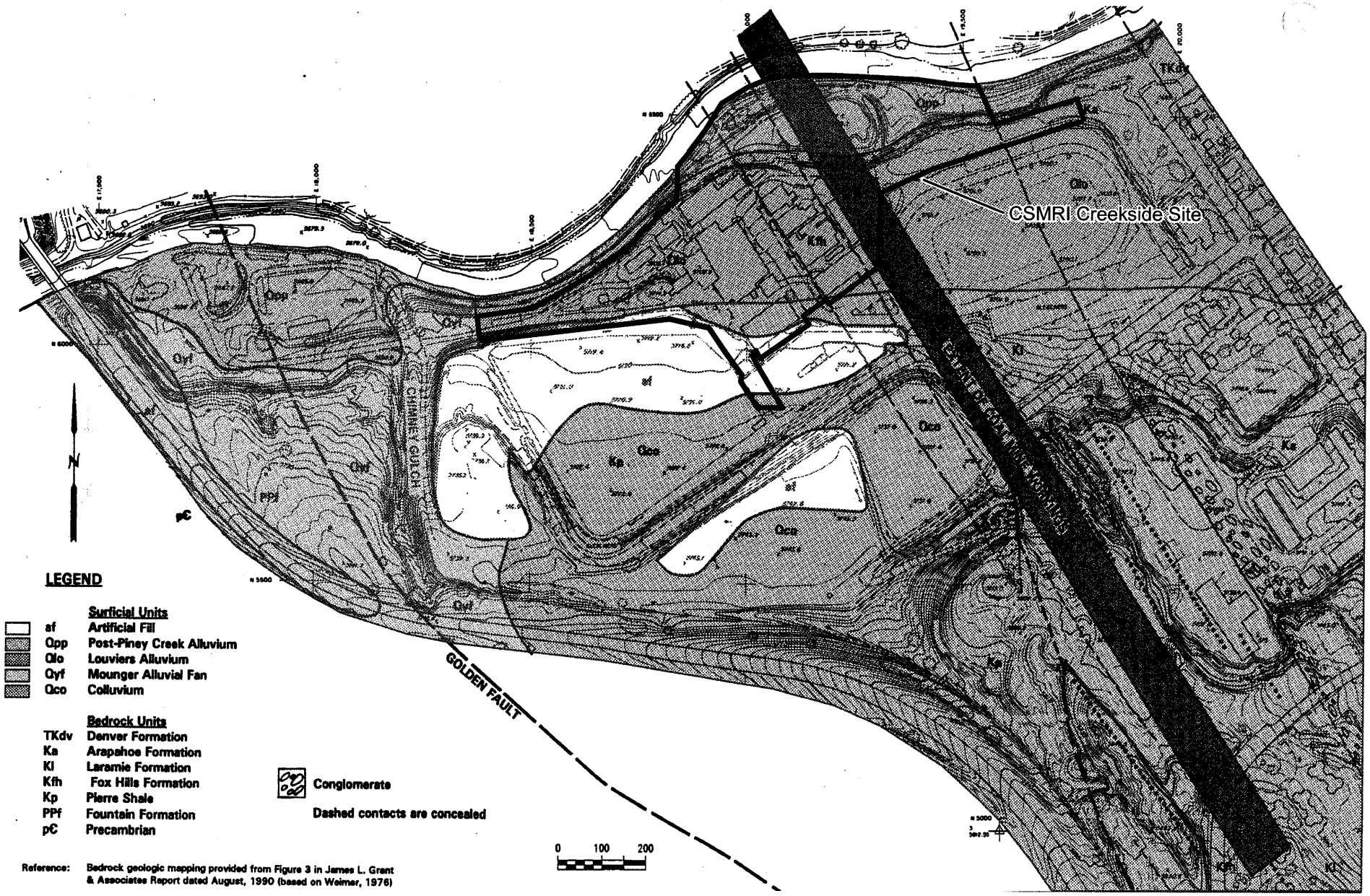

Figure 1-3

CSMRI Creekside Site
Surface Geologic Map

CSMRI
Site Characterization Workplan

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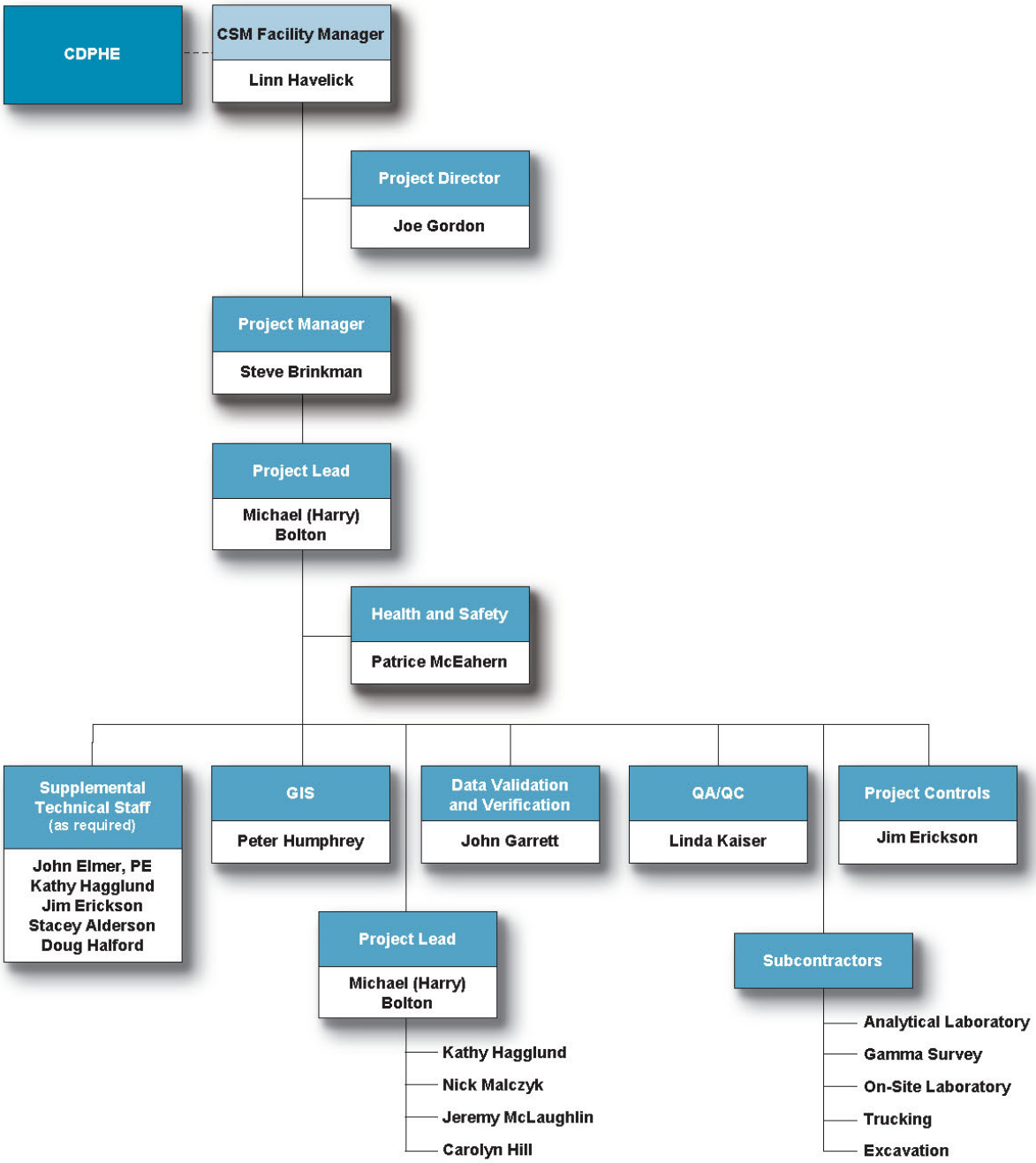
CSMRI Creekside Site Characterization Project Organizational Chart
Figure 1-4



2. Site Characterization Objectives and Approach

The objectives of this Site characterization are to efficiently and accurately evaluate the Site using a combination of existing data and newly collected data, facilitate the use of appropriate clean-up goals, and determine the nature and extent of impacted material at the Site. Although this work plan is limited to Site characterization activities, the ultimate goal of the School's environmental assessment and response work is to properly manage and address the risks at the Site. After the additional Site characterization is completed, the RI/FS and the ROD, including the previously selected remedy, will be re-evaluated. This work plan is designed to meet the immediate objectives and the ultimate goal. This will be accomplished consistently with CERCLA and the NCP.

Key tasks described in this work plan include:

- Prepare locations to store stockpiled soils based on known contaminant extent.
- Excavate areas of known contamination based on existing data.
- Calibrate, determine any bias(es), and correlate field instruments to each other and to laboratory data when possible.
- Conduct a radiological land survey to identify remaining areas of surficial contamination of gamma-emitting radionuclides.
- Determine vertical and lateral extent of soil exceeding the tentative clean-up goals , using a combination of *in-situ* field measurements in excavated areas, field laboratory analyses on collected *in-situ* samples, and excavate additional contaminated soil.
- Collect verification samples for field laboratory and offsite laboratory confirmatory analyses.
- Estimate volume of stockpiled soil exceeding the tentative clean-up goals.
- Characterize impacted stockpiled soil for use in determining appropriate remedial alternative.

Each of these tasks is described in further detail in separate sections of this work plan. Section 3 summarizes the existing Site Assessment data and identifies data needs. Section 4 presents the tasks to be completed to prepare for the field work. Section 5 details the field activities, including performing the baseline gamma survey, initial soil excavation, soil stockpiling, and *in-situ* measurements. Sampling and analysis information is provided in Section 6, Sampling and Analysis Plan (SAP). The Quality Assurance Project Plan (QAPP) is provided in Section 7.

The tentative schedule for the activities covered by this work plan is provided in Appendix B. The schedule includes all major work activities that Stoller will perform through the completion of the Site characterization.

The tentative clean-up goals for this Site characterization are presented in Table 2-1. The concentrations in Table 2-1 include background levels within the clean-up goal. For the most part, these are the levels agreed upon by the CDPHE and presented in the ROD. Two metal compounds have had their clean-up goals adjusted from the ROD: mercury and arsenic. Mercury was adjusted to meet the ability of the laboratory to test for the compound, and a clean-up goal of 23 parts per million (ppm) total mercury has been established. Arsenic was adjusted due to elevated background levels in the Front Range area. A background concentration of 38

ppm is used with a target of 1 ppm above background to arrive at a clean-up goal of 39 ppm. (The previously proposed clean-up goal for arsenic was 13 ppm.)

Table 2-1
Tentative Site Clean-up Goals

Compound	Tentative Site Clean-up Goal
Metals	**mg/kg**
Arsenic	39
Barium	5,277
Cadmium	76.1
Chromium	223
Lead	400
Mercury (total)	23
Molybdenum	390
Selenium	380
Silver	380
Vanadium	550
Zinc	22,825
Radioisotopes	**picoCuries/gram**
Radium 226	4.14
Radium 228	4.6
Thorium 228	6.47
Thorium 230	11.53
Thorium 232	3.88
Uranium 234	254.9
Uranium 235	4.97
Uranium 238	21.8

Based on previous sampling efforts on the Site, five of the metals listed above (arsenic, lead, mercury, molybdenum, and vanadium) are present at levels above these action levels; therefore, these metals are considered COCs. Levels of the other metals onsite are already below the action levels and no further analysis will be conducted.

3. Existing Site Assessment Data

Existing Site data generated during the RI/FS and the implementation of the remedial action were assessed and compared against the clean-up goals from the past consultant and newly derived clean-up goals for arsenic and mercury. Additional details of this assessment are presented in Section 5 of this document. A brief summary of this assessment follows.

Data collected during the original RI/FS were used to evaluate the extent of gamma-emitting radionuclides, alpha-emitting radionuclides, and metal COCs. Surface samples, test pit samples, and samples from borings were analyzed to determine the extent of impacts to the Site. Surface samples were collected from the entire Site in a uniform grid. Test pits and borings were focused in areas suspected of containing the highest concentration of contaminants. The contaminants at the Site were determined to be the alpha-emitting radioisotopes Th-228, Th-230, Th-232, U-235, and U-238; the gamma-emitting radioisotopes Ra-226 and Ra-228; and the metals As, Pb, Hg, Mo, and V.

New Horizons calculated the nature and extent of these contaminants in the RI/FS using traditional methods of Site investigation (surface samples, borings, and test pits). However, after New Horizons commenced the field work to excavate the Class I soil, it became apparent to New Horizons that it had underestimated the nature and extent of the Class I soils and the Class II soils. In the field, New Horizons reported encountering soils that exhibited higher concentrations of contaminants than previously calculated and it reported finding a greater volume of impacted soils than it had expected to find. When asked to re-calculate the nature and extent of contamination based on existing data, New Horizons stated that it could not do so without further Site characterization field investigations. CDPHE concurred with this conclusion.

Due to the very heterogeneous nature of Site contaminants generated by the numerous research projects conducted at this Site, which is unlike many other sites contaminated with radionuclides and metals, a large amount of additional data would be needed to accurately determine the nature and extent of contamination within a confidence range to enable remedial cost estimates to be developed within the +50% to -30% range in the RI/FS stage and +15% to -10% range for the remedial design and remedial action stage of the remedial action. Estimating a volume of impacted soil based on the current data in the RI/FS and the data from the New Horizons excavation of Class I soils would not be possible with the requisite degree of confidence.

Therefore, the question becomes what method to use for additional Site characterization. To attempt to determine the volume of impacted material onsite using traditional methods of Site investigation would be comparable in cost to the technique proposed herein but provide less certainty in volume estimates. Further, if the currently selected remedial alternative remains valid, implementation of the remedial alternative will be less costly.

The investigative method proposed herein is to excavate the impacted soil and then stockpile it on the Site to determine the nature and extent of contamination. This excavation method is analogous to the method used by EPA to address the former settling pond at the Site. EPA had excavated the former settling pond down to clean-up goals and then stockpiled the soil at another location on the Site for further characterization work for disposal purposes. The New Horizons'

baseline risk assessment has already demonstrated that remedial action is necessary at the Site for the remaining contaminated soils. New Horizons' excavation of the Class I soil shows that the nature and extent of contamination is greater than previously estimated. Accordingly, it is clear that the "no action" alternative must still be rejected because the "no action" alternative cannot be found now to be protective of the human health and the environment when the scope of the problem is believed to be greater than before.

Therefore, excavation of the contaminated soils is very likely to be inevitable to implement the eligible alternative remedies (Alternatives 2-5) considered in the RI/FS and selected in the ROD. Only Alternative #2 did not involve excavation of the contaminated soils, but that alternative was less likely to be selected than the other remedies that met more of the NCP remedy selection criteria.

The estimated cost of using this excavation investigative method is comparable to the cost for using the traditional method of Site investigation. In addition, the excavation method simultaneously performs the likely inevitable task of soil excavation and guarantees the requisite degree of confidence to determine the nature and extent of the contamination to reliably estimate remediation costs, unlike the traditional investigation method. It is as cost effective as the traditional method, but it will produce more reliable results than the traditional method.

Therefore, to maintain fiscal responsibility and attain the requisite degree of confidence to estimate nature and extent of contamination, this plan adopts and describes the Site characterization technique of excavating and stockpiling impacted material. Data from the RI/FS will be used to guide initial soil removal activity. Field screening tools will be used to guide additional excavation. Laboratory analyses will be used to confirm that tentative clean-up goals are met and to determine the nature and extent of contamination.

4. Field Preparation

This section describes the mobilization efforts and Site preparation activities that are necessary prior to initiation of field activities. These efforts consist of the following administrative and field activities:

- Project mobilization
- Erosion control
- Site preparation
- Set up positional surveying equipment
- Installation of air monitors
- Training
- Site organization

4.1 Project Mobilization

This section describes mobilization of personnel, equipment, and material to the Site and administrative activities associated with operations on the Site.

Stoller will provide a temporary field office for onsite personnel. The field office will be located near the fence northeast of the bagged soil staging area on an existing asphalt slab. The field laboratory operations will be located in the field office. A project identification sign will be erected in front of the field office. Mobile telephones will be provided at the field office and/or carried by designated field personnel. The trailer will be equipped with bottled drinking water and fire extinguishers. Temporary sanitary facilities will be established at the field office and within the work area.

A decontamination area will be designated in an area of the Site that will be included in the subsequent Site remediation activities (i.e., near the contaminated soil stockpile location).

4.1.1 Administrative Activities

Stoller will be responsible for Site security throughout the project. The gate will be locked when the Site is unattended. It will be unlocked during working hours; however, all visitors will be required to check in at the project office. Visitors shall be escorted while onsite. Stoller and subcontractor personnel will produce proper identification upon request. All visitors will be required to read and sign the Site-Specific Health and Safety Plan (SSHSP) and attend a safety briefing prior to access to the Site.

Administrative activities related to Site preparation and field investigation activities are listed in Table 4-1.

Table 4-1
Administrative Activities Related to Field Work

Activity	Requirements
Notifications	Notify CDPHE at start of project
Utility Clearance	After site preparation, but prior to excavation activities
Health and Safety	General Health and Safety requirements are provided in the Stoller Environmental, Safety and Health Program Manual. In addition, a SSHSP has been developed (Appendix C).
Stormwater Control	Prepare and submit a Stormwater Management Plan, including maps showing the locations of silt fencing and erosion control logs.
Site Access	A log will be maintained for all personnel and equipment entering and leaving the site. A list of authorized personnel will be provided to the School prior to initiation of mobilization activities. Visitors will not be allowed onsite without School approval. Approved visitors will be required to be escorted while onsite and will be required to read the SSHSP and attend a safety briefing.
XRF License	The portable XRF will be registered with the state of Colorado in accordance with Hazardous Materials and Waste Management Division, Radiation Control, 6 CCR 1007-1 Part 8.
Postings	Copies of the following documents must be posted or available onsite: • CDPHE Rules and Regulations Pertaining to Radiation Control, Part 10: Notices, Instructions, and Reports to Workers: Inspections (6 CCR 1007-1 Part 10) • CDPHE Rules and Regulations Pertaining to Radiation Control, Part 4: Standards for Protection against Radiation (6 CCR 1007-1 Part 4) • The CSMRI site Radioactive Materials License (No. 617-01) • The Stoller Radioactive Materials License (No. 1094-01) • The operating procedures applicable to activities under the license • The approved site-specific work plan • A list of all persons who have completed safety training for the site • State, federal, and OSHA jobsite postings

4.1.2 Site Boundaries and Staging/Stockpile Locations

The Site boundaries are described in Section 1. Intrusive activities outside of these boundaries, except for the collection of background soil samples, require prior approval from the Project Manager and the School Principal Representative.

During characterization activities, three stockpiles of excavated soil will be generated. These stockpiles are described in more detail in Section 5.7. The tentative locations of these stockpiles are shown on Figure 4-1.

Equipment and material laydown and storage areas will be established at the Site. All materials and equipment will be stored in accordance with manufacturer's specifications to prevent damage, disfigurement, etc.

4.1.3 Materials and Equipment

The following is a list of equipment that will be mobilized to the Site:

- Temporary Facilities

  - Office/laboratory trailer
  - Mobile storage unit - secured storage container for tools and equipment used during the project
  - Portable toilets
- Heavy Equipment
  - Track excavator
  - Backhoe
  - Articulated wheel loader
  - Dump trucks
  - Bulldozer
- Field Instruments
  - Gamma scintillation (NaI) probe with appropriate survey meter
  - Field portable xray fluorescence (XRF)
  - Eberline gamma survey instrument (GPERS-II)
  - Global positioning system (GPS) survey station
  - Handheld GPS
- Field Laboratory Instruments/Equipment
  - NaI detector with multi-channel analyzer (MCA) (New Millennium)
- Sampling Equipment and Supplies
  - Hi-Vol ambient air samplers (4)
  - E-Perm radon samplers
  - Nitrile gloves
  - Decontamination solution
  - 4-gallon plastic buckets
  - Tool box
  - Disposable soil scoops
  - Stainless steel mixing bowl
  - Bowl liners
  - Field logbooks
  - Sample containers
  - Sample labels
  - Chain-of-custody forms and tape
  - Plastic bags
  - Coolers for shipping samples
- Radiological Control Instrumentation and Supplies
  - Alpha/beta swipe counter
  - Alpha/beta scintillation probe with appropriate survey meter
  - Radiation dose rate survey meter
  - Swipes
- Erosion Control Materials
  - Silt fencing
  - Erosion control logs
  - Stakes
  - Hand tools
- Miscellaneous
  - Water meter and fire hose

- Diesel-fueled generator (35 kW)
- Gas generator(s) for hand tools and air monitors
- Fire extinguishers
- Hand tools
- Emergency eyewash station
- Absorbent pads (fueling)
- Air horns
- First aid equipment
- Mobile telephones/Nextel walkie-talkies
- Personal protective equipment (PPE)
- Designated vehicle with emergency supplies - designated Stoller vehicle supplied with first aid equipment, to be used only in the event of an emergency
- Trash bags, trash dumpster, and recycling containers

4.1.4 Training

Prior to any field work, all project personnel will be trained in accordance with the SSHSP. This document is provided in Appendix C of this work plan.

4.2 Site Preparation

The metal debris, piping, drums, etc littering the surface of the Site were removed during the Bagged Soil Removal. Any additional debris shall be stockpiled and applicable radiological surveys will be performed as described in Section 6.5, prior to release of this material from the Site, unless the materials are being transferred to a disposal location where a free release is not required.

Two additional air monitors will be set up to compliment the two existing air monitors. The two new air monitors will be located adjacent to areas where soil disturbance activities are being conducted as described in Section 6.5.3.

Twenty test pits, identified as "BFI" test pits, were dug during previous remediation activities. A review of existing data indicated that the samples taken from these locations were analyzed only for TCLP lead concentrations. These test pits are, in general, only 2 to 3 feet deep and a review of RI/FS data indicates that the pits are not in impacted locations. The material removed from each test pit was stockpiled adjacent to the excavation. These test pits will be left open at the request of the CDPHE. The locations of these test pits are shown in Figure 4-2.

The fenced area, minus the former settling pond area, will be cleared and grubbed, as necessary, to provide sufficient clearance for operation of the gamma survey instrumentation. In the event that uneven land surface(s) in the work area to be surveyed requires grading, a bulldozer or similar piece of heavy equipment will be used to level the surface.

4.3 Positional Surveying Equipment

Ground control for the survey will be provided by an onsite differential GPS. The GPS will consist of a base station and one or more backpack-type mobile receivers. The GPS will be capable of locating positions within 10-mm horizontal and 15-mm vertical.

The base station will be placed in a location where its transmitter can "see" the entire survey area and which provides clear signal reception from at least one GPS satellite. The base station location will be established using conventional land survey methods from an established benchmark. The location of the base station will be identified by a Colorado-registered land surveyor.

The GPS shall require coordinants in the following projection:

- Projection UTM
- Zone 13
- Datum NAD83

4.4 Erosion Control

Stormwater management and erosion control are detailed in the Stormwater Management Plan provided in Appendix D. Erosion control measures specified in this plan that are not already in place at the Site will be installed. These may include silt fencing and erosion control logs.

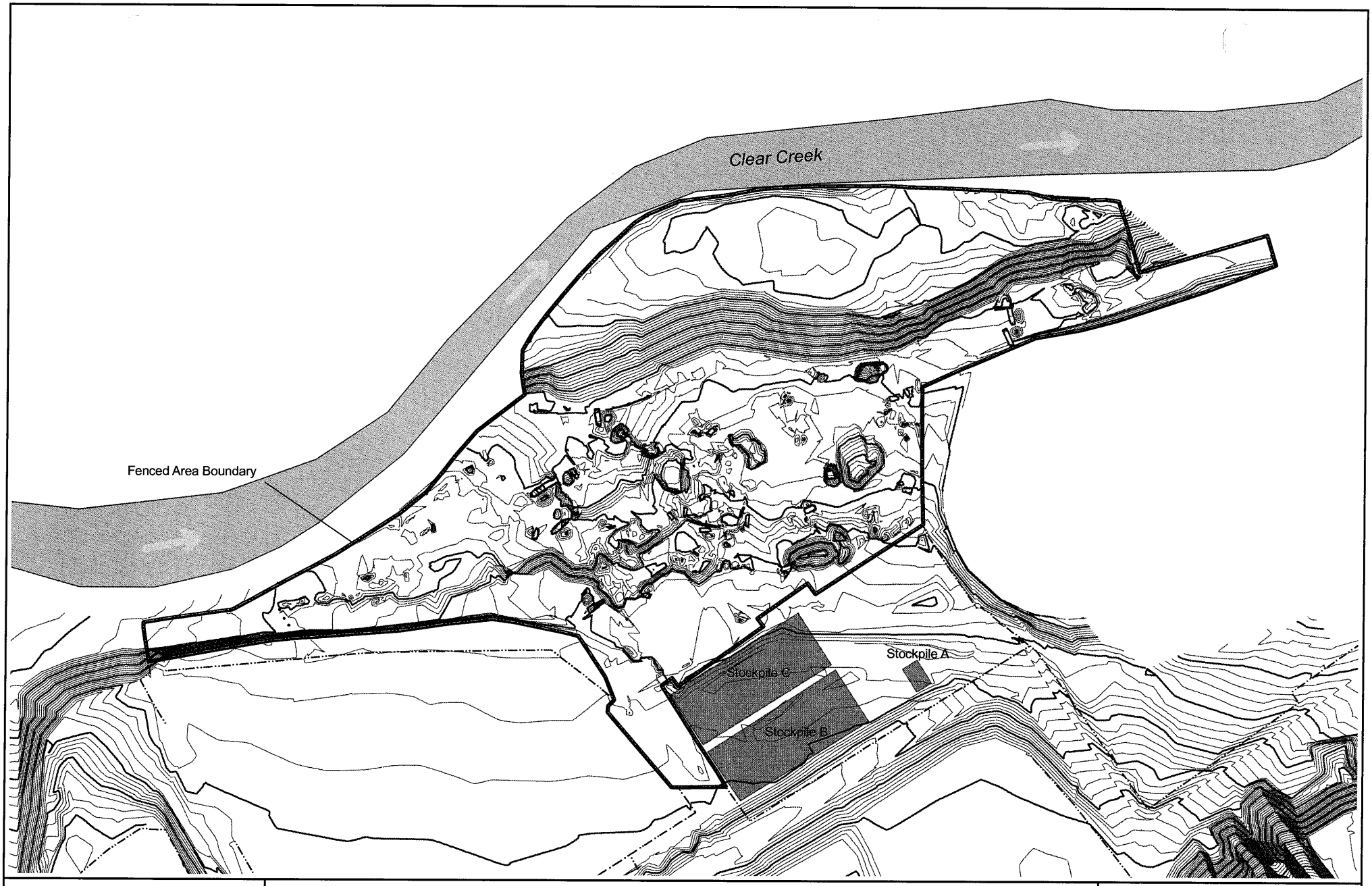


Figure 4-1

CSMRI
Area of Construction Map

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Proposed Stockpile

N

Scale: 1" = 150'

0 75 150 300 Feet

CSMRI
Site Characterization Workplan

Stoller

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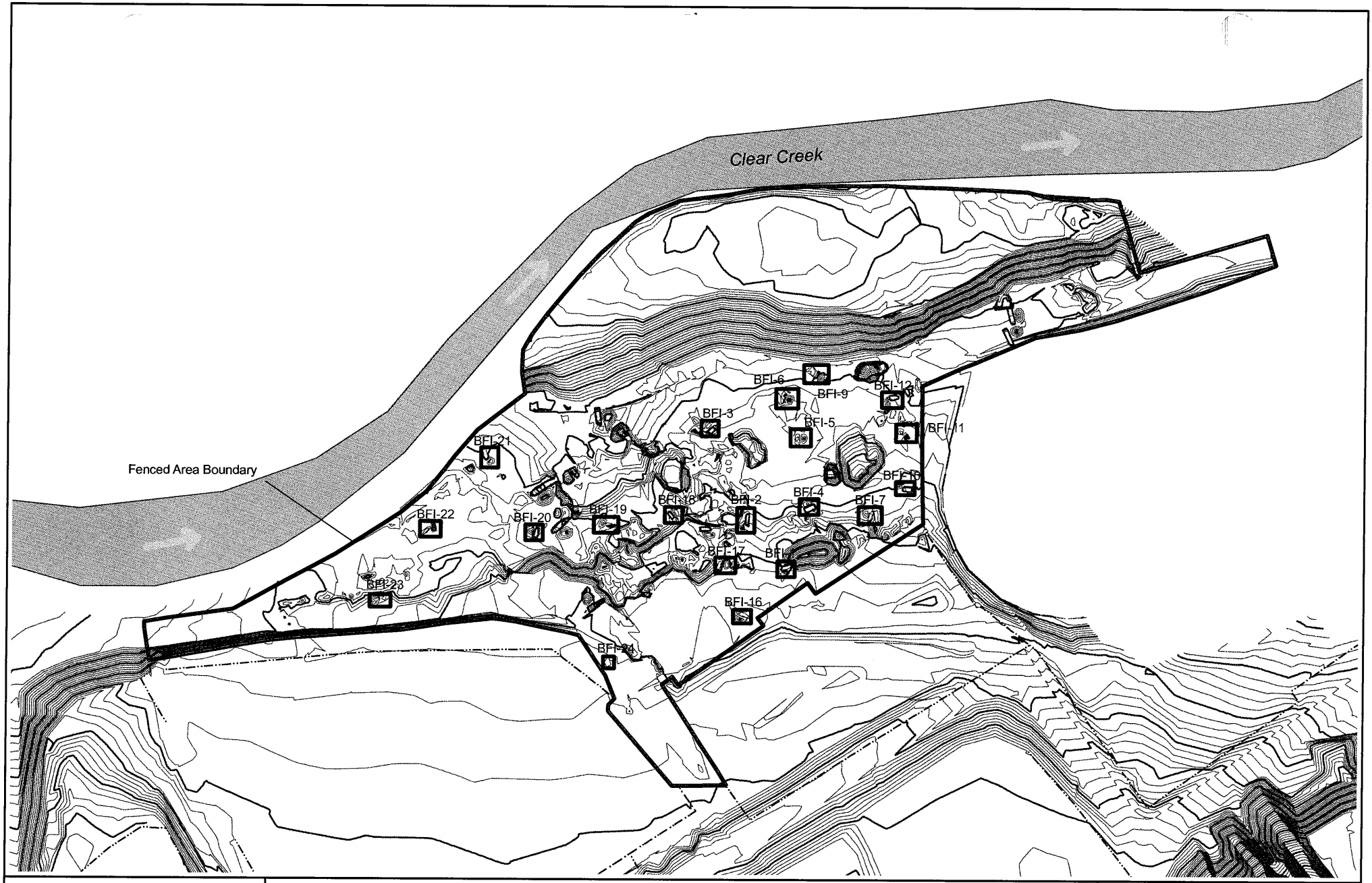

Figure 4-2

BFI Test Pit Locations
CSMRI Creekside Site

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- BFI Test Pit Locations

Note: Missing BFI Pits removed during past remedial activities.

N

Scale: 1" = 150'

0 75 150 300 Feet

CSMRI
Site Characterization Workplan

Stoller

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5. Site Characterization

Characterizing the nature and extent of contaminated soil remaining onsite is complicated by the previous incomplete remediation and the heterogeneous nature of Site soils. The past effort to characterize the Site through the use of bore holes and test pits was not successful in delineating the extent of impacts or understanding the volume of impacted soil at the Site. The heterogeneity of contaminant distribution at the Site led to the lack of understanding. Because of the heterogeneity of the soil onsite, a vast number of borings would be required to accurately define the extent of contamination and determine the volume of impacted soils.

Based upon historical information and current Site conditions, it has been determined that characterization of this Site warrants a different approach. Section 3 of this work plan explains the Site investigation techniques considered and adopted for this work plan. The investigation method that will be used to characterize the extent of contamination remaining on the Site consists of starting from the surface and excavating successive vertical layers of impacted material until non-impacted material is encountered.

The first phase of this project will involve excavation of materials that were previously identified by New Horizons as impacted. After these materials have been excavated and stockpiled on Site, a radiological land survey will be performed to identify remaining surficial contaminated areas. Using the data from this land survey as a starting point, sampling, excavation, and segregation of impacted material (guided by field screening instruments) will be performed until the extent of the impacted material has been identified, excavated, and stockpiled. Upon completion of excavation activities, samples will be taken in the remaining areas to confirm that the impacted material has been excavated. This sampling may also serve as a final status survey of the entire Site. In addition, samples will be taken of the stockpiled soils to help evaluate remedial options. The relationship of these tasks to each other are depicted on Figure 5-1.

A hand-held gamma scintillator, a field portable XRF, and a sodium iodide (NaI) detector located in the field laboratory will be used to guide excavation activities. Prior to using data from these instruments for field activity decisions, bulk samples will be collected to establish correlations between field screening data and laboratory data.

The heterogeneity of contamination at the Site is expected to complicate efforts to determine highly accurate correlations between field screening data and laboratory data. However, the use of reasonably accurate correlations will allow for the use of field screening methods and instrumentation that are critical to allow timely determination of excavation end points. The co-location of many of the COCs along with overlapping use of the different field instruments will help to ensure that the correlations used will be effective.

5.1 Initial Soil Excavation of Known Impacted Soil

Analytical data generated from samples collected during the RI/FS focused on surface soil sampling of the entire Site and soil borings and test pits directed at areas of suspected releases. The surface characterization consisted of collecting 150 samples from the surface of the entire Site. These samples were sent to an analytical laboratory and analyzed for radionuclides (Ra-226, Ra-228, Th-228, Th-230, and Th-232) and metals (Ag, As, Ba, Cd, Cr, Hg, Mo, Pb, Se, V, and Zn). These data were used to determine the extent of COCs in surface soil at the Site.

The soil borings and test pits were placed at selected locations to preferentially detect contamination resulting from releases. This sampling scheme led to the identification of areas exhibiting high levels of contamination.

Analytical data generated for and presented in the RI/FS were re-evaluated, plotted on a series of maps, and presented below. Maps showing the extent of radioisotopes and metals as well as areas to be excavated during the initial soil removal process are provided in this document and are described below. As indicated on the maps, the uppermost layer of contaminated soil is already delineated by existing data, and this soil can be excavated and placed into an impacted stockpile without further field screening work. Existing data also delineate contaminated soil at depth.

The below-listed figures depict the extent of contaminants as delineated by these data and inferred by the data. Stoller used a different method to delineate the contamination than New Horizons used. New Horizons used krieging to infer the extent of contamination. Stoller used a geologist to meticulously evaluate each data point and determine whether the extent was successfully delineated. Stoller's method determined a known volume of impacted soil of approximately half of the total impacted volume estimated by New Horizons. However, it is important to clarify that Stoller is only using this method to delineate the known areas of contamination for the purpose of performing the initial excavations without further field screening for cost efficiency purposes. Unlike New Horizons, Stoller is not trying to estimate the full nature and extent of Site contamination during this initial excavation process. The limited purpose here is to excavate the known areas of contamination to allow for further Site characterization to take place. For each of these figures, dashed lines indicate areas where the lateral and vertical extent is not known but inferred. Additionally, the figures and following tables do not account for any soil previously removed by New Horizons.

- Figure 5-2 shows the extent of alpha-emitting radionuclides (Th, U) above the tentative clean-up goals.
- Figure 5-3 shows the extent of gamma-emitting radionuclides (Ra) above the tentative clean-up goals.
- Figure 5-4 shows those areas identified as containing material that may limit remedial options. This was determined to be material in excess of 100 picoCuries per gram (pCi/g) of total activity. This material totals approximately 141 cy. Table 5-1 details each planned excavation.
- Figure 5-5 shows the extent of metals (As, Hg, Pb, Mo, and V) above the tentative clean-up goals.
- Figure 5-6 shows a combined extent of all the COCs and depicts the extent of the initial soil removal activity. This removal totals 4,330 cy. Table 5-2 details each planned excavation.

Prior to further Site characterization activities, these materials will be excavated and stockpiled. During this excavation process, soils with activity levels greater than 100 pCi/g of total activity will be segregated from materials with lower levels of activity, as described in Section 5.7, Material Handling.

Tables 5-1 and 5-2 depict the depth and planned quantity for each excavation.

Table 5-1
Depth and Planned Excavation Quantity for Material above 100 pCi/g of total activity (See Figure 5-4)

Excavation Location ID	Intervals to be Excavated (feet)	Volume (cubic yards)
#1	0 to 1	3
#2	0 to 1 6 to 8	3 6
#3	0 to 1	3
#4	0 to 1	13
#5	0 to 1	44
#6	0 to 1	3
#7	0 to 2	6
#8	0 to 1	23
#9	0 to 1 1 to 2	**11** 6
#10	0 to 2	6
#11	0 to 2	11
#12	0 to 1	3
Total		141

Table 5-2
Depth and Planned Excavation Quantity for Initial Soil Removal (See Figure 5-6)

Removal Location ID	Depth (feet)	Cubic Yards
#1	0 to 1	601
#2	0 to 1	3
#3	0 to 1 1-3 west 1-3 east	2,834 298 16
#4	0 to 1	3
#5	0 to 1	3
#6	0 to 1	13
#7	0 to 1	8
#8	0 to 3	39
#9	0 to 1	3
#10	0 to 1 10-12	34
#11*	0 to 3	132
#12	0 to 1	21
#13*	0 to 1	55
Total		4,330

* Areas may have been addressed by New Horizons

5.2 Identification of Background Areas for Instrument Calibration

Contemporaneous with the initial soil excavation, areas located in similar geologic settings will be identified for use as background areas. These areas will be unimpacted areas as close to the site as possible and with as similar geology as possible. These areas will be used to calibrate instrumentation to background prior to use on Site.

5.3 Radiological Land Survey

After completion of the initial soil excavation, radiological survey of the surface of the entire Site will be performed by Eberline personnel using Global Positioning Environmental Radiological Surveyor (GPERS-II), as described in Section 6.2. This survey will produce a real-time picture of the relative intensity of gamma emitters in the surface soil at the Site. The purpose of the land survey is to provide a new baseline of areas that may be considered impacted and areas that may be considered non-impacted, after known impacted soils have been excavated. To successfully complete this survey, the instrument will require calibration to background gamma intensity. The background data will be collected prior to the survey activities and will consist of operating the instrument in an area known to represent non-impacted, background conditions for the Site as described above. The area selected to represent background will be in the vicinity of the Site, in location(s) with similar materials as the Site. Determining an appropriate area for establishing instrument background will directly impact the effectiveness of the instrument for providing valuable data.

5.4 Instrument Bias/Correlation Sampling

During Site characterization activities, field and laboratory screening instruments and visual observations will be used to guide excavations. These instruments include a hand-held gamma scintillator, a field XRF, and a NaI counting system located in an onsite laboratory. To confirm the effectiveness of these instruments for detecting contaminants above the tentative clean-up goals, samples will be taken for radiochemical and metals analyses by an approved offsite laboratory. Data generated using different field techniques will be cross-correlated, as well as compared to laboratory data. After the data have been compiled, a thorough data review and comparison will be made to determine if any biases exist and, if so, whether there is a correlation between the different measurement results. If correction factors are necessary and appropriate, the basis for determining the factors will be documented in Laboratory and Field Logs, as applicable for the instrument.

Sample collection and analysis information to evaluate these correlations is presented in Section 6. The flow chart presented as Figure 5-7 demonstrates how each screening instrument will be evaluated for bias when compared to laboratory data and how correlations between the different instruments will be made. If results of this study indicate the screening instruments will allow reliable semi-quantitative assessment of contaminant levels, the correlations and biases for each instrument will be documented and the field work will continue. If, after this step, it has been determined the field screening instruments will not provide a reliable, semi-quantitative tool for determining the extent of COCs at the Site, the field work will stop and a re-evaluation of the screening instruments will be made.

5.4.1 Gamma Detector Method Correlation

When sufficient data have been accumulated from the gamma characterization survey, a minimum of 20 grab samples (total) will be taken from three types of areas: areas identified as being contaminated (count rate greater than two times background), "gray areas" (count rate between background and two times background), and potentially non-impacted areas (approximately background count rate). The potentially non-impacted areas will be located onsite in areas adjacent to impacted areas. The samples will be collected using the technique described in Section 6.8, Sample Acquisition – Initial Gamma Characterization Survey Sampling.

Prior to collection of each sample, *in-situ* gamma measurements using a hand-held field gamma scintillator (FGS) will be taken. The collected samples will be analyzed in the field laboratory using the NaI detector. The samples will also be submitted to an offsite laboratory for radionuclide analyses. Radium 226/228 analyses performed for correlation purposes will use the EPA 901.0M screening to achieve a 2-day turnaround. Data generated from these measurements will be used to establish correlations between characterization gamma survey data, *in-situ* hand-held gamma survey meter readings, and data obtained with the NaI detector in the field laboratory. Whenever possible, these locations will be co-located with the samples taken for the Metals XRF Bias Determination to evaluate the potential for using *in-situ* metals data as a surrogate for identifying locations of radiological contamination.

5.4.2 Metals XRF Bias Determination

In-situ metals analyses will be performed using a field portable XRF. *In-situ* XRF measurements may differ from, but have the ability to be directly correlated to laboratory results. The magnitude of this bias is dependent on Site/sample conditions. To quantify this bias for the materials on this Site, soil will be evaluated by the field XRF and also submitted to an offsite laboratory for metals analyses, as described in Section 6.7, Sample Acquisition – Metals Correlation Initial Sampling. A minimum of 20 sampling locations representing a range of field readings will be selected based on historical data and field XRF readings. After the laboratory data have been obtained, a correlation curve will be generated for each element in question and *in-situ* measurements will be corrected using the applicable correlation factor. If the correlation is not well defined, a conservative correction factor will be used. Whenever possible, these locations will be co-located with the samples taken for the Gamma Detector Method Correlation to evaluate the potential for using *in-situ* metals data as a surrogate for identifying locations of radiological contamination.

5.5 Lateral and Vertical Extent Determination

Extent determination will commence only after necessary adjustments to field operations and field screening instruments are made, based upon data collected during the instrument bias/ correlation sampling event.

Results of the radiological land survey described in Section 5.3 will guide further soil excavation. Areas of elevated gamma activity and metals concentration will be assessed using a hand-held FGS and a hand-held XRF, respectively. Data generated with these field instruments will guide further testing as depicted in Figure 5-8.

The FGS will be used, in both ratemeter and scaler modes, to measure gamma count rates. The FGS will initially be used to scan the excavation area in approximately 10-foot by 10-foot areas at a rate of 0.5 meters per second. Newly exposed 1-foot side wall will be scanned in 5-foot sections. The observed count rate will be evaluated against the Field Screening Level (FSL) (Section 6.1). If the observed count rates are less than the FSL and constant (within the expected variability of background count rate) over the survey area, a 1-minute static count will be recorded in approximately the center of the survey area. If count rates greater than the FSL are observed, scanning will continue until the edge of the contaminated area has been identified. Static counts will be made at sufficient locations to define and document the boundaries of the contaminated area. One static count will also be made at the location with the highest count rate within the contaminated area to document the highest contamination level. GPS coordinants of the measurement locations as well as the data logger number associated with the static gamma count will be made on the Waypoint/ID Log, Form Number ST-RAD-GEN-007. The result of the reading will be displayed on the ground by a circle of spray paint using the following scheme: red for above the tentative clean-up goals, yellow for near the tentative clean-up goals, and green for below the tentative clean-up goals. The XRF technician will then enter the excavation and evaluate the yellow and green circles left by the FGS. The XRF reading will be made in the open center of the paint circle, so that any metals in the paint will not affect the reading. The XRF technician will record the XRF measurement point ID on the same Waypoint/ID Log as the FGS data and modify any color dots to indicate if metals exist above the tentative clean-up goals using the same color scheme. If it is determined during the method correlation phase of this project that one or more metals can be used as a surrogate indicator of radionuclide contamination, then the surrogate action levels will be used in place of the metals tentative clean-up goals in this step. Visual observations of impacted material, whether corroborated with FGS and/or XRF data or not, shall be documented on the Excavation Drawing/Notes Log.

Sample locations identified by yellow dots will have samples collected for analysis using the NaI detector in the field laboratory as described in Section 6.9, Sample Acquisition – Continuing Characterization Survey Sampling. In addition, random samples from red and green color-coded areas will also be collected and analyzed using the NaI detector in the field laboratory to provide ongoing checks of field screening instrumentation accuracy.

Soils that are confirmed to be above the tentative clean-up goals as shown on the flow chart in Figure 5-8 will be excavated and placed in the appropriate stockpile as described in Section 5.7. Overburden requiring removal to access soils exceeding the tentative clean-up goals will also be placed in the appropriate stockpile.

This process will be repeated until all contaminated soil has been identified and excavated to a stockpile.

5.6 Confirmation Sampling and Final Status Survey

At the conclusion of characterization activities, confirmation sampling will be performed that may later serve as the final status survey. Aspects of the confirmation sampling and the final status survey include selecting and verifying the survey unit classification, demonstrating that the potential risk from residual elevated areas is below the release criteria for each survey unit.

The final survey for radionuclides will be performed in accordance with the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). Based on data generated by the Site characterization, MARSSIM-defined Class 1 and Class 2 areas were identified. After removal of the Class 1 soils, the entire Site, except for the stockpiled soils, will be classified as a Class 2 area. The maximum size of a Class 2 survey unit is 10,000 square meters. Therefore, the Site will be divided into a minimum of three survey units. Visual Sampling Plan (VSP) software will be used to select sampling locations. Decisions regarding whether or not the Site has achieved the clean-up goals will be made in accordance with *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media* (EPA 1989).

The final survey for metals will be performed in accordance with the *Superfund Lead-Contaminated Residential Sites Handbook* (EPA 2003).

The sampling design for the final status survey is provided in Section 6.10.

5.7 Material Handling

Three soil stockpiles will be made during implementation of the CSMRI Site Characterization Work Plan. These three stockpiles will manage soils removed from the site with varying levels of contamination as describe below. The stockpiles will be managed with the goal being zero releases from the stockpiled material as described in the Management section below.

Stockpile A will be created from soil that has analytical results totaling more than 100 pCi/g total activity. Stockpile A will contain approximately 150 cu yds of soil and will be made during the first several days of field activities. Once made, it will be sealed with a tackifier or suitable surfacting agent.

Stockpile B will contain all material removed from the site, except the material managed in Stockpile A, with activities or metals concentrations above the Tentative DCGLs. This stockpile will contain the 4,330 cu yds removed during the initial soil removal and all other soil characterized as being above the site tentative DCGLs and removed form the site. This stockpile will be made during the first days of fieldwork and will continue to have soil added to it as characterization proceeds.

Stockpile C will contain soil below the tentative DCGLs, including overburden and other "clean" soil needing temporary removal from the site.

Each stockpile will be managed with the goal being zero releases due to either wind or precipitation. Management protocols are described below.

5.7.1 Daily Management of Stockpile

The stockpiles will have water applied to them to provide dust suppression during each day soil is added to the pile and sufficient water at the end of each day to create a crust.

5.7.2 Break Management of Stockpile

If a break in the work is taken (weekends, holidays, etc), a heavy crust will be established on each stockpile. If the break is more than two days, a qualified technician will check the piles to ensure adequate crust and apply additional water as deemed necessary.

5.7.3 Remedial Alternatives Analysis Period Management

During the time period when CSM is conducting public meetings and selecting a final remedial alternative, which may last a couple of months, the stockpiles will be stabilized with a surfactant or other application that will effectively eliminate the potential for releases. Erosion controls will be installed around the perimeter of the stockpiles and will consist of either silt fence or straw waddles. Drainage will be established that is protective of the waters of the State, and the site will be checked weekly to ensure proper controls remain effective and functional.

Upon completion of the excavation activities, the three soil stockpiles will be sampled and analyzed to characterize these materials for further assessment of the RI/FS and ROD, and possibly additional remedial alternative analysis. Stockpile sampling and analysis activities are described in Section 6.11, Sample Acquisition – Stockpile Samples.

5.8 Health and Safety Control

The SSHSP is provided in Appendix C. The engineering controls and personnel protection and monitoring practices to ensure worker safety during the characterization activities are detailed in the following subsections.

5.8.1 Work Area Air Monitoring

Perimeter air samples will be collected to determine if air quality standards for radionuclides are maintained during the field operations. These air monitors will be operated on a continuous basis to monitor air quality in the vicinity of the Site. Details on the use of these samplers are provided in Section 6.5.

Engineering controls will be used to minimize dust generation during field excavation activities. Water from fire hydrants will be used as a dust suppressant during all excavation work. Wind speed and direction will be monitored, and when windy conditions are creating visible dust that cannot be adequately controlled using water, the Project Lead will shut down field activities.

Based on the maximum Site metals concentrations presented in the RI/FS, calculations (provided in the SSHSP) show that air concentrations of metals will not exceed permissible exposure limits (PELs) published by the Occupational Safety and Health Administration (OSHA), assuming adequate dust suppression water is used. No perimeter or personal air samples will be analyzed for metals based on this determination.

The need for personnel radiological air sampling was evaluated by calculating the required soil concentration for each isotope of interest that, if resuspended, would equate to a 40 derived air concentration (DAC)-hr exposure during the expected time period that a worker would be on the project. The time required to receive a committed effective dose equivalent (CEDE) of 25 mrem (assuming member of the public) for each of the radionuclides, using their maximum concentrations and assuming complete resuspension, was calculated. This calculation is

conservative, as Site personnel are subject to the Stoller occupational dose as low as reasonably achievable (ALARA) guideline of 100 mrem. Based on this calculation (provided in the SSHSP), personnel air monitoring is not required for these radionuclides.

Air monitoring for radon will be conducted using E-Perm electret ion chambers, which are passive monitoring devices that are useful for measuring radon flux from the ground and for measuring radium in soil. These monitors will be placed in several excavated areas prior to the start of active field work to determine background radon concentrations in the work area. Further evaluation will be required for radon readings over 25 picoCuries per liter (pCi/L) (25 percent of the OSHA exposure limit, adopted from the 1971 version of 10 CFR Part 20 Appendix B).

5.8.2 Work Area Dose Rate Monitoring

Work areas will be monitored daily for ionizing radiation. Monitoring will be performed using a Ludlum Model 19 MicroR or a Bicron MicroRem meter. Occupational exposure monitoring for external radiation is required if a worker is likely to exceed 500 mrem per year from sources external to the body, per 6 CCR 1007-1, Part 4. Stoller has established an ALARA guideline of 100 mrem per year in accordance with the company Radiation Protection Program. These limits are not anticipated to be exceeded on this Site; therefore, personal dosimetry will not be required. If area dose surveys indicate that personnel may receive a dose greater than 100 mrem/year, a dosimetry program will be implemented. Additional details are provided in Section 6.5.

5.8.3 Radiological Contamination Control Procedures

All vehicles entering and leaving the Site will be surveyed to verify that they are free of radioactive contamination. If a vehicle has excessive dirt on the outside, it may be cleaned and dried prior to the survey being performed. A Ludlum 43-89 alpha/beta scintillation probe will be used to survey exterior surfaces (e.g., tires, cab floors, and excavation attachments) for total (fixed plus removable) contamination. Smears will also be taken from the surfaces and counted for alpha and beta activity if the total measured activity, or minimum detectable activity for the survey instrument, is greater than the limit for removable contamination. Table 5-3 shows the maximum total and removable contamination limits.

Table 5-3
Total and Removable Contamination Limits

Contamination Type	Removable (dpm/100 cm^2)	Total (fixed + removable) (dpm/100 cm^2)
Gross alpha	20	100 avg, 300 max
Gross beta	1,000	5,000 avg, 15,000 max

From U.S. Nuclear Regulatory Commission Regulatory Guide 1.86, based on most restrictive alpha limits (Ra-226, Th-228, Th-230)

All personnel and equipment leaving the contaminated area of the work site will be thoroughly surveyed for contamination. Levels of contamination listed in Table 5-3 must be met prior to being released from the area. Personnel frisking will be performed after removal of protective clothing. Personal items, such as notebooks, papers, and pens, will be subject to the same frisking requirements. Instructions for personnel frisking will be posted adjacent to frisking instruments. Personnel found with detectable contamination on their skin or clothing will be

promptly decontaminated. Contaminated equipment may be decontaminated or disposed. Details are provided in Section 6.5.2.

Instrument calibration and performance testing requirements for the survey instruments are provided in Section 6.1 of this plan. Equations to calculate detection limits and convert these limits to count rates are also provided in the standard operating procedures for the instrument.

All radiological surveys shall be documented on radiological survey form, ST-RAD-GEN-005, or equivalent. The following information shall be recorded, at a minimum:

- Equipment identification in sufficient detail to make the record unique (i.e., description, serial number, license plate number, etc.)
- Model and serial numbers of survey instrument(s)
- Name of person performing the survey
- A sketch of the equipment showing survey and/or smear locations, as applicable
- Date and time of the survey

If surveys indicate that vehicle or equipment is contaminated greater than the limits, it shall be decontaminated and resurveyed. The repeat survey shall be recorded on a separate survey form. Personnel shall be frisked after leaving the excavation area prior to entering the field office or leaving the Site.

5.8.4 Personal Protective Equipment

Personnel working on the Site, outside of the trailers, will wear sturdy over-the-ankle leather boots, a high-visibility safety vest, and safety glasses (level D). In addition, personnel working on the ground in the excavation areas will wear Tyvek, boot covers, and gloves (nitrile, latex, or equivalent) (level C). Contamination control PPE will be doffed prior to entering the office trailer.

5.8.5 Decontamination Procedures

Prior to release from the Site, heavy equipment will be cleaned using a dry and/or wet decontamination procedures. Excessively dirty equipment will be cleaned by brushing or scraping excess soil from the equipment. This technique should be used only when the soil is wet or damp to prevent an airborne dust hazard. Following initial cleaning, site water (fire hydrant) may be used for wet decontamination. Equipment will be positioned in the designated decontamination area during the cleaning process. Radiological surveys will be performed on the equipment as described in Section 5.8.3. All sampling equipment will be disposable; therefore, decontamination of these items will not be required.

5.9 Waste Management

The majority or all of the Site-generated or investigation-derived waste (excluding the three stockpiles) is expected to be stored in an onsite dumpster that is emptied weekly, the contents of which will go to a solid waste landfill. Any materials identified as recyclable will be evaluated to determine if recycling is the most effective option for their final disposition. Recyclers have been identified that are capable of receiving scrap metal and concrete; however, depending on the condition of these materials, disposal may be the preferred option.

5.9.1 Sanitary Waste

Site-generated wastes that are not directly associated with sampling or remediation efforts will be collected in trash bags as routine sanitary wastes. These wastes may include packaging, water bottles, food waste, and office waste. Recyclable materials such as cardboard, plastic, and paper will be segregated when practicable from the sanitary waste and taken to a local recycling facility. Other wastes that are associated with Site sampling or remediation efforts will also be managed as sanitary wastes, as described below, but will have additional handling controls.

5.9.2 Personal Protective Equipment and Disposable Sampling Equipment

Used PPE and disposable sampling equipment will be collected in plastic bags and managed as sanitary waste. The bags will be securely closed prior to disposal. This waste includes used Tyvek suits, gloves, booties, sample scoops, smear papers, and other wastes generated in the onsite field laboratory. Damp materials, such as towels with decon solution used to wipe down sample bottles, will be packaged with sufficient dry material so that no free liquids are present in the waste. The PPE and sampling equipment will not contain appreciable quantities of soil. Based on the levels of radioactivity on this Site, the levels of radionuclides on this material will be well below the U.S. Department of Transportation (DOT) levels that would require transportation as radioactive material, both in terms of total activity in the consignment and the activity concentration.

5.9.3 Sample Disposal

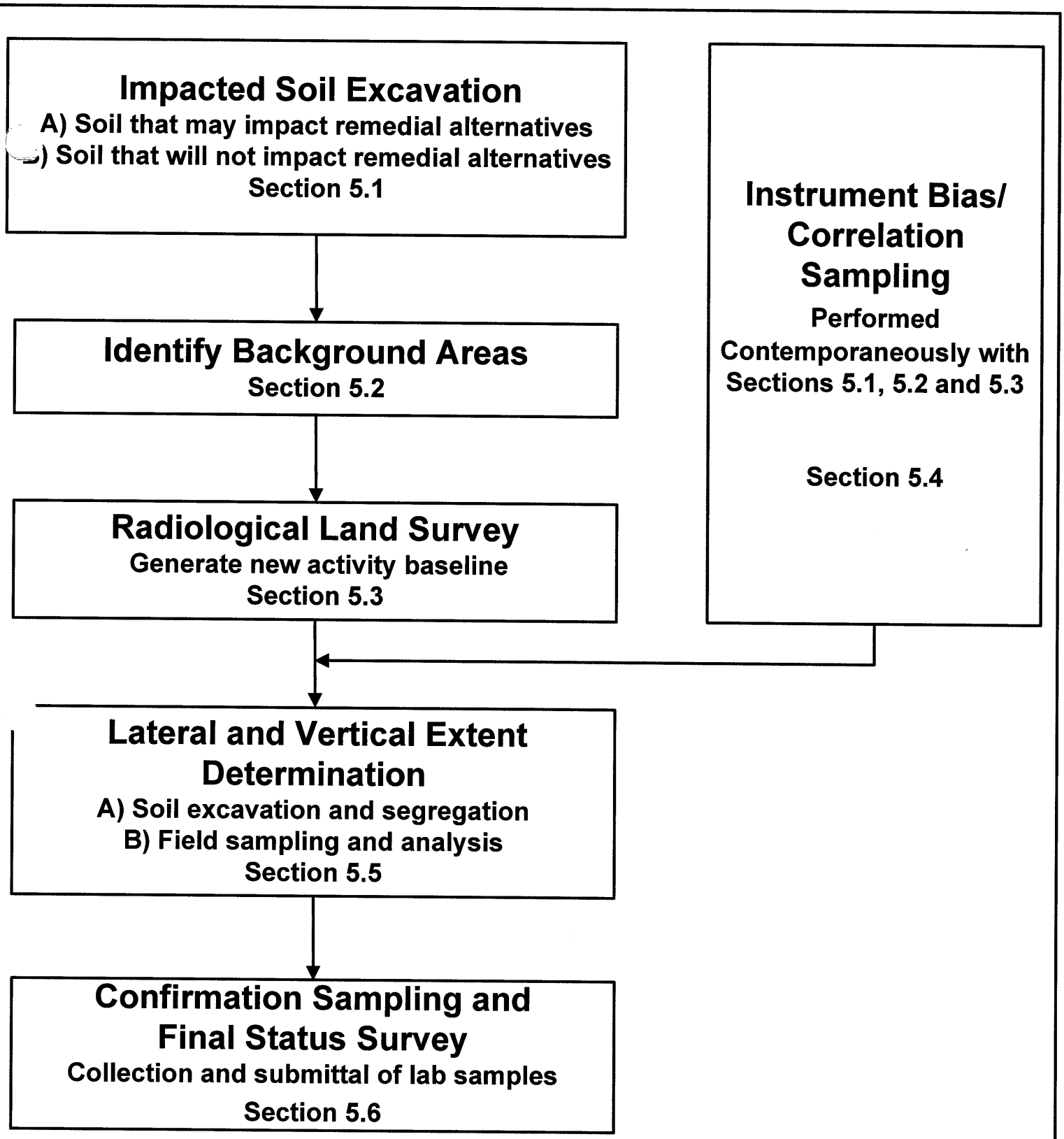
Excess samples will be stored onsite for as long as they might reasonably be useful for Site characterization. Samples that are to be discarded will be added to one of the soil stockpiles onsite, depending on the levels of contaminants in the sample. Empty sample containers will be disposed of as sanitary waste.

5.9.4 Miscellaneous Waste

Site-generated wastes that do not fit in one of the above categories will be characterized and managed appropriately. Liquid waste streams are not anticipated at the Site. Dust suppression water will be applied as a mist and will not be used in quantities that require collection or treatment. Equipment clean-up will be performed in an area of the site that will require future remediation activities, such as the contaminated soil stockpile locations. The application rate and quantity of water that will be used for decontamination will be limited to the quantity that will be absorbed by the soil in the stockpile location. The water will not be permitted to "run" to other parts of the site.

5.9.5 Waste Minimization

As described above, recyclable materials such as cardboard, paper, and plastic will be segregated from the sanitary waste stream where practicable. However, sanitary waste from field sampling or characterization activities that may be contaminated with low levels of metals and/or radionuclides will not be recycled but will be managed as sanitary waste. Large-volume waste streams that are recyclable but potentially contaminated will be evaluated to determine if conducting free release surveys (with possible decontamination) would be feasible and cost effective. This might include scrap metal recovered from excavations onsite.



CSMRI

Site Characterization Flow Chart

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Proj # 4060 January 2006 Figure 5-1

Figure 5-2

Extent of Alpha-emitting Radionuclides (Th, U)
Above the Tentative Cleanup Goals
CSMRI Creekside Site

Explanation

Surface Samples
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Borings
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Test Pits
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Known Extent
- Inferred Extent

Tentative Cleanup Goals

Thorium 228	6.47 PCi/g
Thorium 230	11.53 PCi/g
Thorium 232	3.88 PCi/g
Uranium 234	254.9 PCi/g
Uranium 235	4.97 PCi/g
Uranium 238	21.8 PCi/g

N W E S

Scale: 1" = 75'

Feet
0 50 100 200

CSMRI
Site Characterization Workplan

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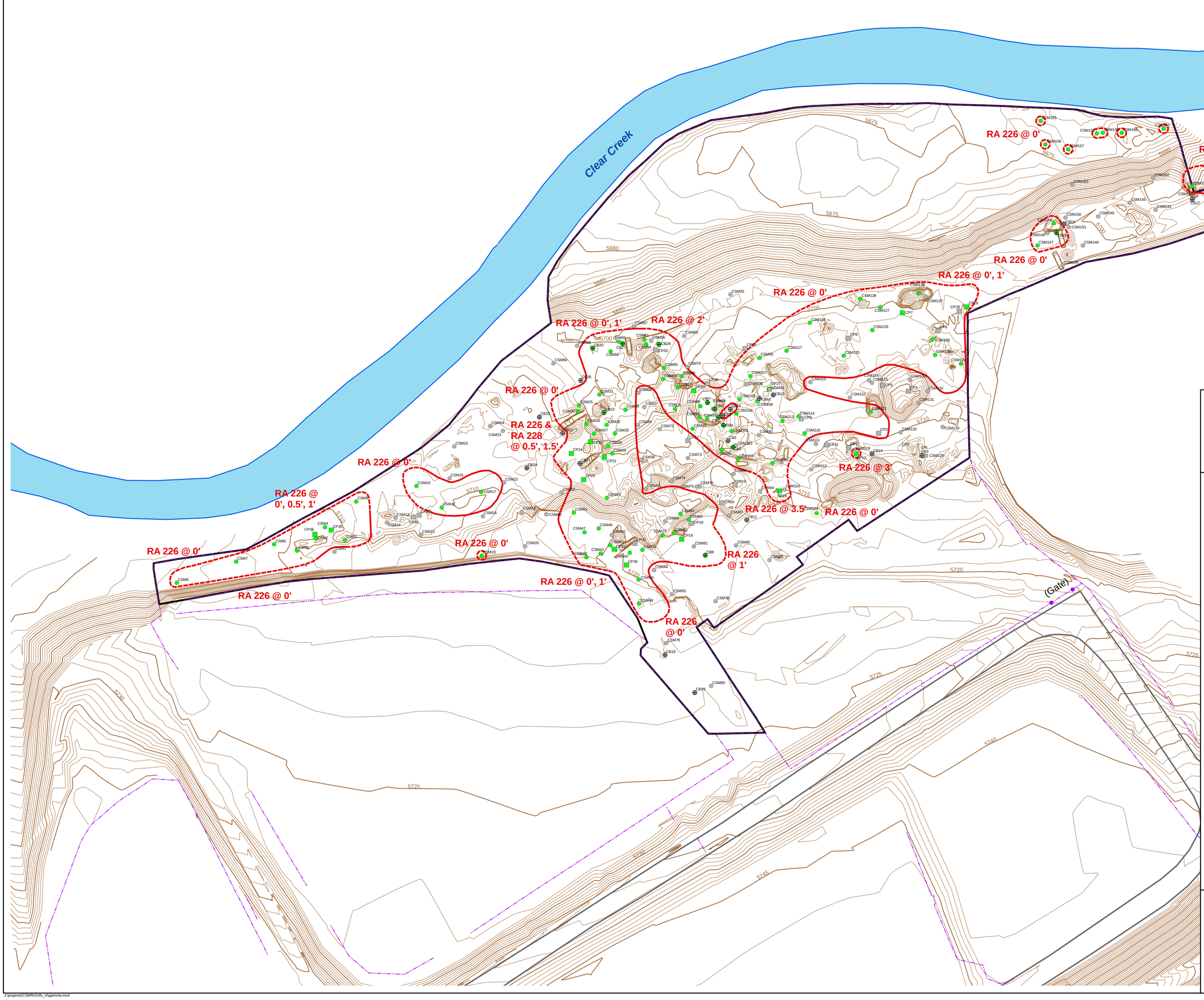

Figure 5-3

Extent of Gamma-emitting Radionuclides (Ra) Above the Tentative Cleanup Goals CSMRI Creekside Site

Explanation

Surface Samples
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Borings
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Test Pits
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Known Extent
- Inferred Extent

Tentative Cleanup Goals

Radium 226 4.14 PCi/g
Radium 228 4.6 PCi/g

N W E S

Scale: 1" = 75'

Feet
0 50 100 200

CSMRI
Site Characterization Workplan

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Figure 5-4
Areas Containing Material Above
100 PicoCuries per Gram Total Activity
CSMRI Creekside Site

Explanation

Surface Samples
- Sampled - All Results Below DCGL
- Sampled - Some Results Exceed DCGL

Borings
- Sampled - All Results Below DCGL
- Sampled - Some Results Exceed DCGL

Test Pits
- Sampled - All Results Below DCGL
- Sampled - Some Results Exceed DCGL

- Hot Spot
- Fences
- Old Building Footprints
- Topography (1 Foot Contour Interval)

Note: The hot spot numbers correspond to details on table 5-1

N

Scale: 1" = 75'

0 100 Feet

CSMRI
Site Characterization Workplan

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Clear Creek

AS, HG @ 0'

AS, HG @ 0'

AS, HG @ 0'

AS, HG @ 0', 1'

AS, HG @ 0'

AS, HG @ 0', 1'

AS, HG @ 0', 1'

AS, HG, PB @ 1'

AS, HG @ 0'

AS @ 0'

AS, HG, PB @ 0'

AS, HG @ 0'

AS, HG @ 0'

AS @ 0'

AS @ 0'

AS @ 0'

AS, HG @ 0'

AS, HG, PB @ 0'

AS, HG @ 0'

AS @ 0'

AS, HG, PB @ 0'

AS, HG, PB @ 0'

(Gate)

12th Street

Figure 5-5

Extent of Metals (As, Hg, Pb, Mo, V) Above the Tentative Cleanup Goals CSMRI Creekside Site

Explanation

Surface Samples
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Borings
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

Test Pits
- Not Sampled
- Sampled - All Results Below Tentative Cleanup Goal
- Sampled - Some Results Exceed Tentative Cleanup Goal

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Roads
- Known Extent
- Inferred Extent

Tentative Cleanup Goals

Arsenic	39 mg/kg	Molybdenum	390 mg/kg
Barium	5277 mg/kg	Selenium	380 mg/kg
Cadmium	76.1 mg/kg	Silver	380 mg/kg
Chromium	223 mg/kg	Vanadium	550 mg/kg
Lead	400 mg/kg	Zinc	22825 mg/kg
Mercury (total)	23 mg/kg		

N W E S

Scale: 1" = 75'

Feet

0 50 100 200

CSMRI
Site Characterization Workplan

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Figure 5-6

Combined Extent of all COCs and Extent of the Initial Soil Excavation CSMRI Creekside Site

Explanation

- Surface Samples
- Borings
- Test Pits
- Gamma Extent
- Metal Extent
- Alpha Extent
- Combined Extent - 1' Depth
- Combined Extent - 3' Depth
- Fences
- Old Building Footprints
- Topography (1 Foot Contour Interval)

N
W E
S

Scale 1" = 75'

0 50 100 200 Feet

CSMRI
Site Characterization Workplan

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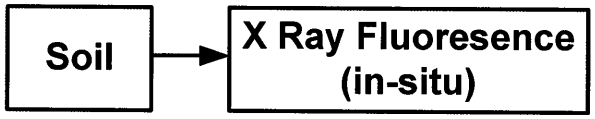
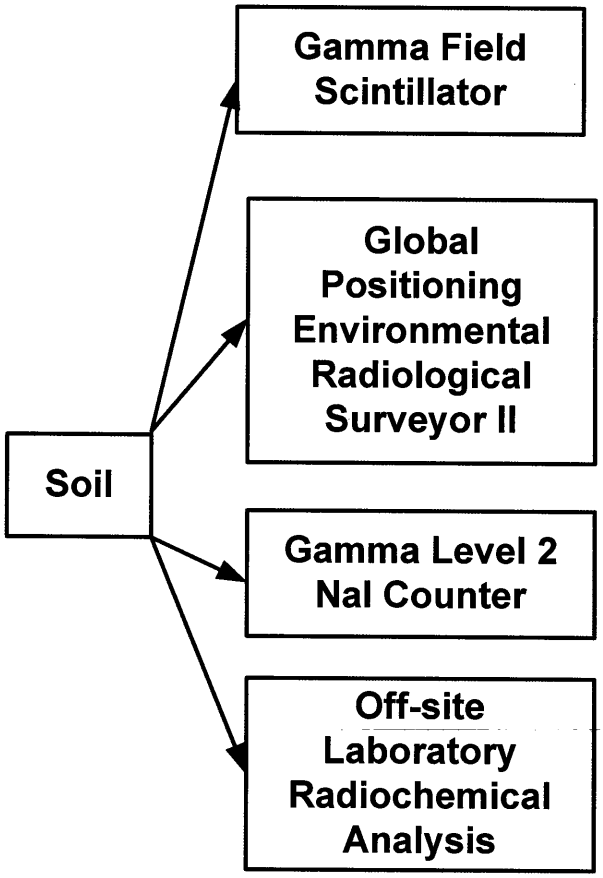
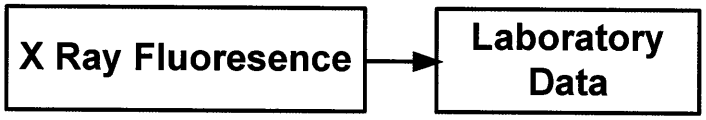
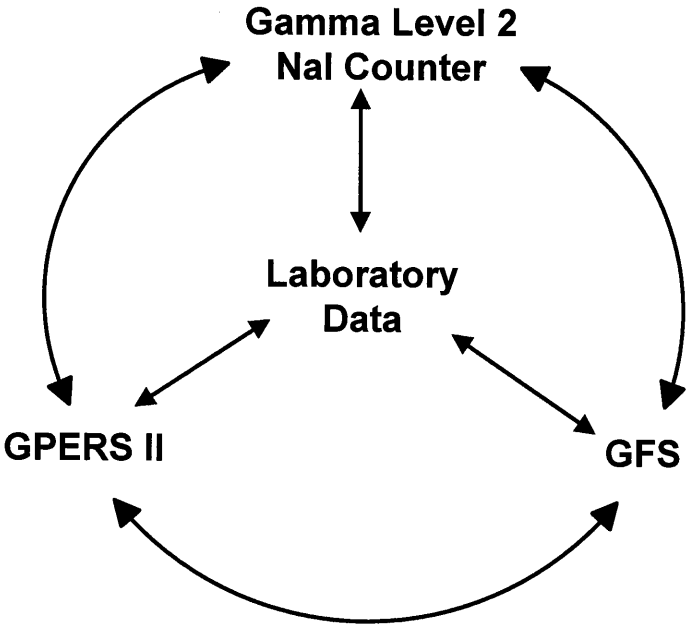
Soil Sampling





Data Comparision





CSMRI

Field Screening Bias Correlation

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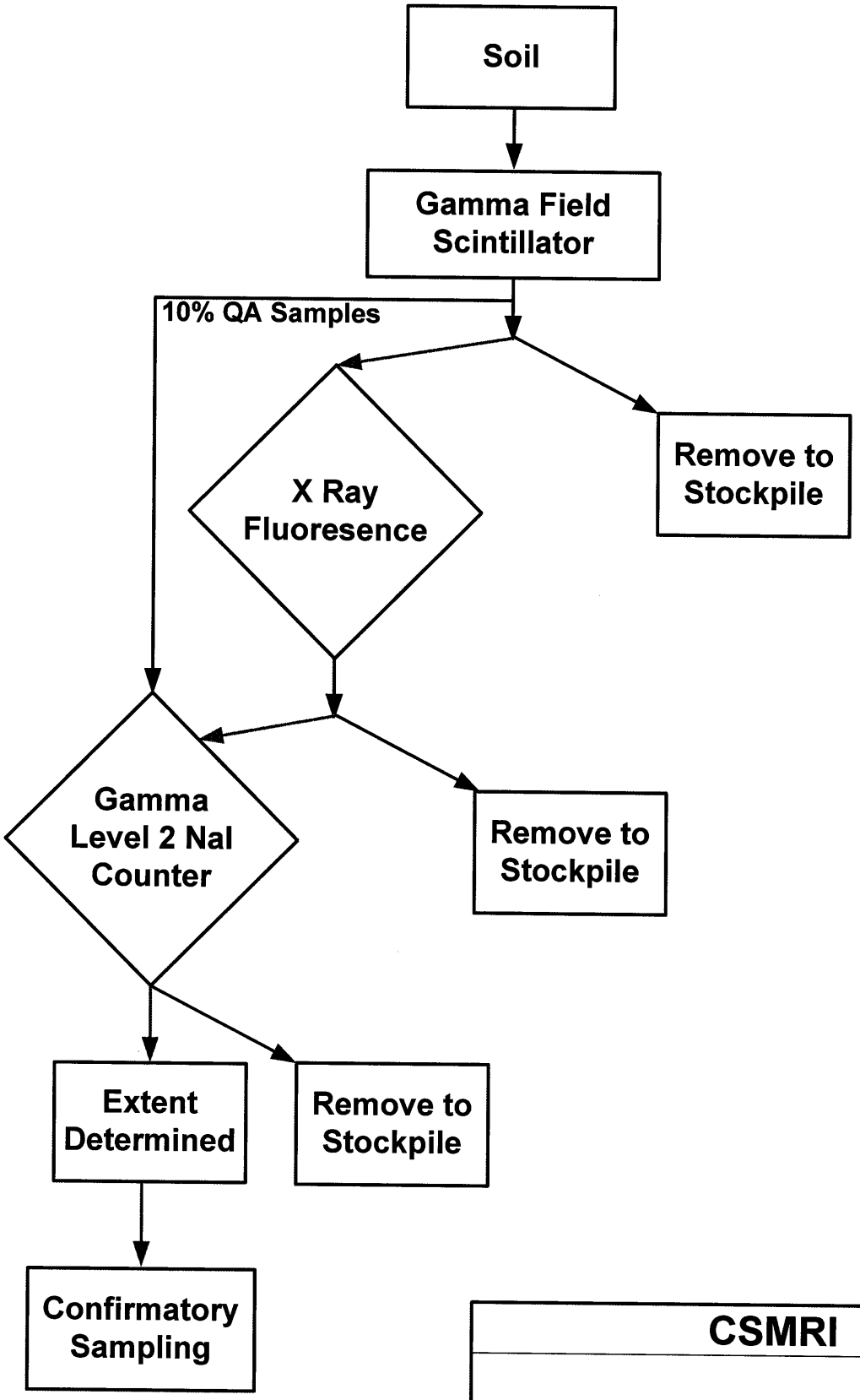
Proj # 4060 January 2006 Figure 5-7



Legend

Below DCGL

At DCGL

Above DCGL

CSMRI

Field Screening Flow Chart

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Proj # 4060 January 2006 Figure 5-8

6. Sampling and Analysis Plan

The sampling and analysis activities associated with the characterization project at the Site will be a combination of *in-situ* measurements, field laboratory analyses, and samples submitted to an approved (offsite) analytical chemistry laboratory. The SAP describes field instrumentation requirements; describes techniques for identifying sampling locations; specifies sample collection methodologies, including types and frequencies of field QC samples; describes sample labeling, control, packaging, and shipping requirements; and defines sample analysis requirements for measurements performed both in the field laboratory and the offsite laboratory. The purpose of this SAP is to provide the necessary guidance to control excavation by properly identifying soils that exceed the tentative clean-up goals, to perform the final status survey using portable survey meters, and to collect and analyze verification samples. Support activities for radiological control of the Site and worker protection are also covered in this SAP.

Characterization data that were generated during the RI/FS indicate that two types of impacted materials (primarily soils) were present on the Site. The RI/FS showed that some of these materials contained radionuclide concentrations above background levels. This impacted material has been designated Class 1 area material as defined by MARSSIM (2000). The Site also includes areas with elevated concentrations of metals (As, Pb, Hg, Mo, and V), which are solid waste but not hazardous waste. The metals-impacted areas are in general also contaminated with small concentrations of radionuclides. Because of the potential for radionuclide activity, it has been designated as Class 2 material under MARSSIM. Much of the Class 1 material and some of the Class 2 materials appear to have been removed in previous remedial efforts at the Site by New Horizons.

As discussed previously, the first step in field operations will be to excavate soil in areas that are known to exceed the tentative clean-up goals. After areas of known contamination have been excavated and stockpiled, and the Site has been prepared for additional characterization activities, a radiological land survey (gamma) will be performed by Eberline Services personnel using their GPERS-II instrument. A correlation study will then be performed to correlate the field instruments with each other and offsite laboratory data. Data from the land survey and the correlation study will be used to guide additional subsurface Site characterization activities. A hand-held gamma scintillator and a portable field XRF instrument will be used to guide the excavations. Details regarding use of these instruments are provided in Section 5, Site Characterization. Specifications, calibration requirements, and performance check requirements for these instruments are described in this SAP and Section 7 (QAPP).

After the land gamma survey is performed but before additional subsurface excavation is performed, samples will be collected and submitted to both the onsite field laboratory and an approved offsite laboratory. *In-situ* measurements for both gamma and metals will be taken at each sampling location prior to collecting the sample. *In-situ* gamma readings and field laboratory data generated with the NaI detector will be compared to each other and to offsite laboratory radiochemical data. *In-situ* metals results will be correlated with the offsite laboratory metals data. The quality of the correlations and the magnitude of the bias(es), if present, will be evaluated to validate the effectiveness of using the *in-situ* measurement techniques to guide excavation activities. The correlations that will be made are shown in Figure 5-7. The correlation study will be completed contemporaneously with the initial soil excavation and land

survey. If the data do not correlate well, the proposed SAP scheme will be re-evaluated and redesigned, if necessary.

During the additional subsurface characterization activities, *in-situ* gamma readings and/or XRF readings will be taken as described in Section 5 and in the applicable Sample Acquisition section of this SAP. When the *in-situ* measurements (corrected for any identified bias) indicate that the area is contaminated above the tentative clean-up goals for metals or radionuclides, the contaminated material will be removed to the applicable stockpile. However, when the *in-situ* gamma count rates are close to the tentative clean-up goals or the data are inconclusive due to extreme variability, samples will be taken for analysis by the field laboratory. Samples are not anticipated to be taken for offsite laboratory analyses during excavation activities. However, if additional laboratory data are deemed to be necessary to define the extent of contamination, the Project Lead may direct additional sampling.

Upon completion of excavation activities, verification sampling will be performed in accordance with MARSSIM for radionuclides and *The Superfund Lead-Contaminated Residential Sites Handbook* (EPA 2003) for metals contamination. *In-situ* measurements for gamma and metals will be taken at the sampling locations. In addition to the verification samples, which will be submitted to an offsite laboratory, samples will be taken for analysis in the field laboratory, and up to 10% of samples will have a duplicate collected for the CDPHE. The *in-situ* and field laboratory data will be used to increase the confidence that the contamination has been excavated and the remaining soils are not contaminated prior to submitting the samples to the offsite laboratory. Offsite laboratory data of verification samples will be used to demonstrate that all materials that exceed the tentative clean-up goals have been removed and stockpiled and that the extent of contamination has been identified.

The characterization activities will result in three stockpiles of material. The stockpiles will be sampled and analyzed by the offsite laboratory for parameters required to evaluate remedial options. *In-situ* and field laboratory measurements will be used to ensure that the composite samples generated from sampling the stockpiles accurately represent the stockpiled materials. However, these field data will not be used to evaluate remedial options. Offsite laboratory data will be used to evaluate remedial options.

Samples taken for each of these different purposes will have different acquisition guidelines, as described in the applicable section of this SAP. In addition to the measurements described above, support activities will be necessary to maintain radiological control of the Site and provide worker protection. Requirements for these measurements are also included in the applicable section of the SAP.

6.1 Field Radiation Detection Instrumentation

A variety of radiation detection instruments will be used on this project. A hand-held FGS will be used during excavation activities as an initial screening tool to identify areas of elevated activity and assist in the determination of the limits of excavation. A NaI gamma scintillation detector such as the Ludlum Model 44-10 coupled with a Ludlum model 2221 or 2350-1 scaler/ratemeter will be used for these surveys. A hand-held alpha/beta scintillator probe such as a Ludlum Model 43-89 in conjunction with a Ludlum Model 2224 or 2360 alpha/beta

scaler/ratemeter will be used for frisking and general surveys. A dual alpha/beta scintillation counter, such as a Ludlum Model 2929 with a Model 43-10-1 detector, will be used onsite to count swipes and air-monitoring samples. A Ludlum Model 19 MicroR meter, or equivalent, will be used for dose rate surveys. Radiation detectors will be purchased or leased from certified vendors and will have current calibrations. Documentation of the calibration will be maintained onsite.

Ten background locations will be identified as detailed in Section 5.3. The soils must be in areas with a minimal probability of being impacted, while also representing the different geologic formations that are on the Site, when possible. The locations of the background soils shall be documented with GPS coordinants. The basis for the site selection shall also be documented. These soils will be used to determine the FSL of the gamma scintillator for the remainder of the project. The instrument-specific FSL shall be established daily by measuring background at each location, for a total of 10 background counts. The count time used for these measurements will be the same count time as will be used in the field for static measurements. The FSL will be calculated as the average plus two standard deviations of the dataset. It will be documented in the applicable radiological survey instrument logbook. It will also be recorded on the instrument. Count rates below the FSL are not statistically different from background. Count rates between the FSL and the count rate that has been determined to correlate with the tentative clean-up goals, as determined during the Initial Gamma Characterization Survey Sampling (Sections 5.3 and 6.8) will identify areas that require additional sampling and testing.

Performance checks will be performed on all detectors prior to use in accordance with the applicable operating procedure(s) as indicated in Table 6-1.

Table 6-1
Portable Field Radiation Instrument Procedures

Instrument	Procedure
Ludlum 2221 or 2350-1 with Ludlum 44-10 NaI detector	SOP-RAD-001, *Portable Radiation Survey Instrument Operation*
Ludlum 2224 or 2360 with Ludlum 43-89 alpha/beta scintillation detector	SOP-RAD-001, *Portable Radiation Survey Instrument Operation*
Ludlum Model 19 MicroR meter or Bicron MicroRem meter	SOP-RAD-001, *Portable Radiation Survey Instrument Operation*
Ludlum 2929 alpha/beta sample counter with Model 43-10-1 detector	SOP-RAD-031, *Counting Systems Operation*

6.2 Global Positioning Environmental Radiological Surveyor System

The GPERS-II, which is supplied and operated by Eberline Services, will be used to perform the initial surficial gamma survey after areas of known contamination have been excavated. This instrument is an integrated system of several modular components. The core electronics are the GPS receiver (sub-meter accuracy), RF radio modem, display monitor, NaI detectors and associated signal processing electronics, and a computer that runs customized software. Instrument quality control and calibration is conducted in accordance with ANSI N323, *Radiation Protection Instrumentation Test and Calibration*. Two NaI detectors will be mounted on a custom cart specifically designed to traverse rough terrain. This cart will be pulled over the

Site with an all-terrain vehicle (ATV) or a small tractor. In areas of the Site that will not be accessible by the ATV, one of the NaI detectors will be mounted on a backpack or an "excavation sled," as appropriate for the terrain.

This instrument will be operated in accordance with Eberline Services, Field Screening Procedure 2.11, *Portable Environmental Survey Instrument Operation*, and Eberline Services-RC-06 Environmental Radiological Instruction 4.8, *Operation of the Global Positioning Environmental Radiological Surveyor (GPERS-II)*. The observed count rate from each detector will be logged on a point-per-second by positional coordinant. The field files will then be downloaded and processed with geographical information system (GIS) software to produce a color-coded radiological survey map. Data will also be downloaded into the project database.

GPERS-II will be operated using stationary counting intervals (operated in count rate mode) over areas where the contamination levels are expected to be less than the tentative clean-up goals. The survey rate will be established to achieve a detection limit sufficiently lower than the tentative clean-up goal for Ra-226. A radiological set point will be used to cue the operator to elevated activity readings. If the elevated reading appears to be due to an anomalous reading or a small localized area of contamination, the operator will perform a real time "resurvey" to provide additional data. If the elevated reading is due to a large contaminated area as evidenced by continuing elevated count rates as the survey continues, a slow survey rate is not warranted. In these situations, the survey rate will be increased to most efficiently utilize this instrument until the edge of the contaminated area has been located.

6.3 Field Laboratory Sodium Iodide (NaI) Detector

The field laboratory will be equipped with a NaI detector system, which will be used to analyze soil samples collected during Site characterization. Data from these analyses will be used to define extent of contamination. This instrument will be operated by qualified New Millennium personnel, using their standard operating procedures provided in Appendix E. This instrument will be used to generate semi-quantitative results for gamma-emitting nuclides on selected samples, as described in Sections 5.5 and 6.9 of this plan. The count time will be adjusted to meet a minimum detectable activity (MDA) sufficiently lower than the tentative clean-up goal for Ra-226. If the measured Ra-226 activity in the sample exceeds two times the MDA, the MDA is not relevant and the count times may be shortened to increase sample throughput. If the results from the NaI detector are determined during the correlation activities described in Sections 5.4 and 6.8 to be biased relative to laboratory results, the measured activities will be corrected for the bias. Thorough documentation on generation and use of bias correction factors shall be maintained in the Field Laboratory Logbook.

6.4 Field Portable XRF

The metals of primary concern on this Site are As, Hg, Mo, Pb, and V. An Innov-X-Systems field portable XRF, or equivalent, will be used to make *in-situ* measurements of metals during characterization activities to delineate extent of metals contamination during excavation activities. The XRF is supplied with a current calibration from Innov-X-Systems. It will be operated, in accordance with the instrument operating procedure, by factory-trained field personnel. A QC check is required daily prior to operation and every four hours during operation, thereafter. The instrument has built-in software that prompts the operator to perform

the required performance checks, as required. The QC check data are captured by the Innov-X software.

Due to matrix interferences, *in-situ* XRF data may be biased low when compared to analytical results of the same sample from laboratory testing. The magnitude of this bias is dependent on the Site and sample conditions. To evaluate and quantify the potential bias for the materials on this Site, samples will be collected both in areas of known metals contamination and in non-impacted areas. These areas will be identified by a combination of *in-situ* measurements and historical data. Collected samples will be submitted to the offsite laboratory for metals analyses. When the laboratory data have been obtained, a correlation curve will be generated for each element of concern. Subsequent *in-situ* measurements will be corrected using the applicable correlation factor. If the correlation is not well defined (correlation coefficient less than 0.80), a conservative correction factor will be used. The samples used to generate the correlation data will be collected using the technique described in Section 6.7, Sample Acquisition – Metals Correlation Initial Sampling.

This analysis method complies with EPA Method 6200 for metals in soils, with the exception that except for the correlation samples taken at the beginning of the field activities, additional samples will not be submitted to the laboratory for confirmation. This step is not necessary, as all soil stockpile and verification samples will be submitted to the laboratory for analysis. Estimated limits of detection (LOD) for the elements of concern are summarized in Table 6-2.

Table 6-2
Field Portable XRF Estimated Limits of Detection

Element	Limits of Detection in ppm [1]
As	13
Hg	14
Mo	20
Pb	16
V	20

[1] LOD based on a 2-minute count time

6.5 Contamination Control and Radiological Protection Instrumentation

Radiological surveys will be performed during Site characterization and sampling activities to ensure that fugitive radiologically impacted material is not dispersed beyond the Site and to provide worker protection and monitoring.

6.5.1 Swipe Sampling and Counting

Swipe samples will be taken to monitor for removable alpha and beta contamination prior to release of samples, equipment, and vehicles that were in areas of potential radiological contamination. Swipe samples will be collected in accordance with procedure SOP-RAD-002, *Swipe Sample Collection.* These swipes will be counted on a Ludlum Model 2929 alpha/beta scaler with a Model 43-10-1 detector in accordance with procedure SOP-RAD-031, *Counting Systems Operation*. Release limits for removable contamination are presented in Table 5-3.

6.5.2 Personnel and Equipment Survey Requirements

All personnel and equipment leaving the contaminated area of the work site will be thoroughly surveyed for contamination. These surveys will utilize a Ludlum Model 2224 or 2360 alpha/beta scaler/ratemeter with a Model 43-89 alpha/beta scintillation probe (or equivalent). Unrestricted release criteria provided in Table 5-3 must be met prior to personnel or equipment being released from the area.

Personnel shall be trained on the use of frisking instruments prior to use. Instructions for personnel frisking will be posted adjacent to frisking instruments. Personnel found with detectable contamination on their skin or clothing will be promptly decontaminated. Contaminated equipment may be decontaminated or disposed.

Surveys for the release of equipment will be documented on a Radiological Survey Form, ST-RAD-GEN-005, or similar form that identifies, at a minimum, the released equipment, survey instrument used, survey results, background at the time of the survey, and name of the surveyor. If radon potentially causes elevated removable alpha readings, the equipment will not be released until the swipes have been allowed to decay and a recount meets the unrestricted release limit.

6.5.3 Perimeter Air Monitoring

Air monitoring will be conducted in accordance with SOP-RAD-018, *Long-Lived Airborne Radioparticulate Surveys*. Airborne radioactivity samples will be obtained on a 2-inch diameter glass fiber filter at a sampling rate of 60 to 80 liters per minute. Four air monitoring stations will be used. The monitoring stations will be located surrounding the work area to ensure adequate monitoring in the event of directional wind changes. Placement of the monitoring stations will be directed by the Health and Safety Officer (HSO). The proposed sampling locations are shown in Figure 6-1. These locations may be modified, if necessary, by the HSO.

The samplers will be labeled as PM-*n*; where *n* is the sampler number as shown in Figure 6-1. The filters will be identified using the sampler number, date the filter was deployed (On Date), and date the filter was removed from the sampler (Off Date). Samplers will be run continuously during the characterization field work. Operational hours of the samplers will be recorded for use in calculating air volume. Filters will be changed and analyzed on a weekly basis when active soil sampling/excavation is being conducted. During inactive periods, filters will be changed monthly.

Samples will be counted in the field laboratory using a Ludlum Model 2929 alpha/beta scaler with a Model 43-10-1 detector in accordance with procedure SOP-RAD-031, *Counting Systems Operation*. Measured count rates (counts per minute) will be converted to disintegrations per minute (dpm) using the efficiency of the detector. The measured dpm values will be converted to microcuries and divided by the total volume of air sampled in milliliters for comparison to the effluent concentration standard. Table 6-3 shows the Colorado effluent concentration limits for the radionuclides of concern on the Site, along with a calculated effluent concentration limit for the mixture. The chemical form of the radionuclides on the Site is unknown; therefore, the limits for Class W compounds, which are the most restrictive, are shown in the table.

The concentration limit for the mixture was derived from the following equation:

$$\text{Concentration limit for mixture} = \frac{1}{\sum_i \frac{f(i)}{C(i)}}$$

Where:

f(i) is the fraction of activity of nuclide *i* in the mixture (using mean plus 95% UCL data from bagged soil data), and
C(i) is the effluent concentration limit for nuclide *i*.

Table 6-3
Effluent Concentration Standards[1]

Isotope (Class W)	Concentration (microcuries per milliliter)
Ra-226	9 E-13
Ra-228	2 E-12
Th-228	3 E-14
Th-230	2 E-14
Th-232	4 E-15
U-234	3 E-10
U-235	3 E-10
U-238	1 E-12
Limit for mixture	4.8 E-14

[1] 6 CCR 1007-1 Part 4, Appendix 4B, Standards for Protection Against Radiation

Samples with elevated alpha readings will be held for a minimum of 72 hours and recounted to allow the radon and progeny to decay. If the gross alpha activity from the recount indicates that an effluent standard could have been exceeded, the sample will be submitted for laboratory analysis of specific isotopes. All air samples will be archived until data from laboratory analyses are received and evaluated to ensure that any of the archived samples do not require additional analyses.

6.5.4 Personnel Dose Monitoring

Occupational exposure monitoring for external radiation is required if a worker is likely to exceed 500 millirem per year from sources external to the body, per 6 CCR 1007-1, Part 4. Stoller has established an ALARA guideline of 100 mrem per year in accordance with the company Radiation Protection Program. These limits are not anticipated to be exceeded on this Site. Area dose rate surveys will be performed using a Ludlum Model 19 MicroR meter, or equivalent instrument, in accordance with procedure SOP-RAD-033, *External Dose Rate Tracking*. If an area dose greater than 50 microrem/hr above background is observed, the planned work activities will be evaluated and every effort will be made to limit personnel time in the area. If this evaluation indicates that the external dose to any worker could exceed 100 mrem per calendar year, dosimeters will be issued in accordance with procedure SOP-RAD-027, *Personnel Monitoring for External Radiation Exposure.* The dosimeters will be issued by a company that holds personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST)

and is approved in the accreditation process for beta and gamma radiation detection. The dosimetry program, if required, will be administered in accordance with procedure SOP-RAD-029, *Control and Handling of External Dosimetry Devices.*

6.6 Sample Acquisition – General Guidelines

Samples will be taken for a variety of purposes during this project. General guidelines for sample collection of all sample types are provided in this section. Specific information on each sample type is provided in the following sections. All samples must be collected, handled, documented, analyzed, and reported in a defensible manner. The information provided in the following sections will properly address these issues.

Samples will be collected using disposable soil scoops or if necessary, gloved hands. The samplers shall ensure that a representative proportion of each type of soil is present in the sampling location and that different types of soils are not over or under represented. Rocks and cobbles larger than 3-cm and other extraneous material such as vegetation and roots will be excluded and/or manually removed from samples. Samples may be grab samples or composite samples, as specified in the sample acquisition guidelines for the specific type of sample being collected. All sampling equipment will be disposable. Mixing containers will be disposable or non-disposable containers will be lined with a disposable liner. If compositing is required, the procedure used to generate the composite will be included in the applicable Sample Acquisition section.

All sampling events will be documented on three data sheets:

- Waypoint/ID Log, Form ST-RAD-GEN-007
- Sample Collection Log, Form ST-RAD-GEN-002
- Excavation Drawing/Notes Log, Form ST-RAD-GEN-003

Copies of these forms are provided in Appendix F. A more detailed description of these data sheets is given in Section 6.9.2. In addition to recording information on these forms, samples that will be analyzed onsite will be documented in a logbook that will remain in the field laboratory. Samples that will be submitted to the offsite laboratory will be recorded on a chain of custody.

Certified clean sample containers shall be used for all samples submitted to the offsite laboratory. These containers will be supplied by the laboratory. The sizes and types of sample containers are specified in the sample acquisition guidelines for the specific type of sample being collected. New sample containers will be used for samples collected for field laboratory use. Certified clean containers are not required for these samples.

Field QC samples will be used to assess sample variability and evaluate potential sources of contamination. Field duplicates are the only type of QC sample that will be collected for this project. Field duplicate samples will be samples collected at the same time and from the same source and placed in separate sample containers. Duplicate frequencies are specified in the following sections for each type of sampling. These samples will be submitted to the field laboratory and/or offsite laboratory for the same analysis(es) as those requested for the original

sample. Duplicate data will be used to measure the precision of the entire sampling and analysis procedure. Samples will be assigned unique numbers and will not be identified as duplicates to the laboratory. Equipment rinsates will not be required, as all sampling equipment will be disposable.

A split sample is taken in the same way as a duplicate sample, with the material thoroughly blended and split between two containers. Split samples will be collected and analyzed in a variety of situations, as described in the following sections. Data from split samples will be used to compare and correlate data from different methods.

6.7 Sample Acquisition – Metals Correlation Initial Sampling

A portable field XRF will be used to take *in-situ* measurements of metals during excavation activities. Due to matrix interferences, *in-situ* XRF measurements have the potential to be biased when compared to laboratory results. The correlation of the data from the two measurement methods must be evaluated and the magnitude of the bias(es) quantified. Prior to the beginning of field activities, a minimum of 20 samples will be collected and submitted to the offsite laboratory for metals analyses. *In-situ* measurement data will be correlated to the analytical data for each element of concern, and, if applicable, a correction factor will be applied to *in-situ* measured values.

6.7.1 Sampling Locations

Samples will be taken in three types of areas: areas that are known to be impacted, areas that are slightly impacted (close to the action level), and areas that are believed to be non-impacted. Sample locations will be biased to collect most of the samples close to the action level, as this is the main area of concern for good correlation between field and laboratory results. The sampling locations will be selected based upon historical RI/FS data and field XRF measurements. Water will be used to control dust during actual field operations; therefore, water will be applied to the sampling site prior to performing the *in-situ* measurement. Sufficient water should be applied to mimic anticipated dust-control conditions. In addition to collecting the samples in areas with a range of metals contamination, samples will be taken in areas with different soil types, so that the diversity of this Site will be well represented in the correlation data. Sampling locations will be selected by the Project Lead. The basis for determining the sampling locations shall be documented.

6.7.2 Sample Collection

Prior to collecting each soil sample, a GPS reading and an *in-situ* XRF measurement will be taken and the sample ID and sampling location will be documented on the Waypoint/ID Log, Sample Collection Log, and Excavation Drawing/Notes Log. A 2-minute count will be used for areas where the concentration of the COC is at or below the tentative clean-up goal. In areas of significant metals contamination, shorter count times may be used. The soil will be placed into a container and homogenized thoroughly before filling individual sample containers. Sufficient soil will be collected for the samples listed in Table 6-4 using a grab sampling technique. If a duplicate will be taken, sufficient soil will be collected to fill the original and duplicate sample containers. Each sample container will be labeled as described in Section 6.12 and custody seals will be applied to the containers. The samples will be recorded on a chain of custody for the offsite laboratory. Samples will be placed in a cooler with ice.

Table 6-4
Metals Correlation Samples

EPA Method	Laboratory Method	Sample Container	Preservation	Holding Time
EPA 3050/6010B and 7471A	ICP metals (As, Hg, Pb, Mo, V) (ICP/CVAA)	Poly container, 4-ounce wide mouth	4°C	28 days

6.7.3 Field QC

A field duplicate will be collected for two sampling locations (assuming ≤ 20 samples are collected).

6.8 Sample Acquisition – Initial Gamma Characterization Survey Sampling

A combination of the characterization gamma survey (GPERS-II), *in-situ* gamma measurements using a hand-held gamma scintillator, and samples analyzed in the field laboratory using a NaI detector will be used to help guide excavation of radionuclide-impacted material during the characterization activities. These methods range from qualitative to semi-quantitative; therefore, for information from these measurements to be useful, the data need to be correlated to laboratory data.

A minimum of 20 samples will be collected for this purpose. These samples will be submitted to the offsite laboratory for radiochemical analyses. Data generated with GPERS-II, *in-situ* measurement data collected with the gamma scintillator, and data generated using the NaI detector will be correlated to the analytical data. Correction factors will be applied to *in-situ* measured values and NaI detector data, if applicable.

Laboratory data will be reported on a dry-weight basis. Therefore, to assist in correlating these data to *in-situ* measurements, a percent moisture analysis will also be requested.

6.8.1 Sampling Locations

Samples will be taken in areas that are known to be impacted, areas that are slightly impacted (close to the action level), and areas that are believed to be non-impacted. Sample locations will be biased to collect most of the samples close to the action level, as this is the main area of concern for good correlation between field and laboratory results. The sampling locations will be selected based upon historical data and field gamma measurements. In addition to collecting the samples in areas with a range of radionuclide contamination, samples will be taken in areas with different soil types, so that the diversity of this Site will be well represented in the correlation data. Sampling locations will be selected by the Project Lead. The basis for determining the sampling locations shall be documented.

6.8.2 Sample Collection

Prior to collection of each soil sample, a GPS reading and an *in-situ* gamma measurement, based on a 1-minute static count, will be taken and the results documented on the Waypoint/ID Log, Sample Collection Log, and Excavation Drawing/Notes Log. The collected material will be thoroughly mixed before filling the sample containers. Sufficient sample will be collected into the mixing container to fill the sample bottles listed in Table 6-5. Each sample container will be

labeled as described in Section 6.12 and custody seals will be applied to the sample containers. Samples going to the offsite laboratory will be recorded on a chain-of-custody form.

The gamma screen sample will be submitted to the field laboratory for a NaI analysis. If the field laboratory is not in operation at the time these samples are collected, the samples will be placed in a custody-sealed cooler or a locked sample storage cabinet.

Table 6-5
Radiometric Correlation Samples

EPA Method	Laboratory Method	Sample Container	Preservation	Holding Time
N/A	Field Laboratory Gamma Screen	Poly container, 8-ounce wide mouth	None	N/A
ASTM D3972-90M	Isotopic Thorium (228, 230, 232)	Poly container, 16-ounce wide mouth [2]	None	180 days
ASTM D3972-90M	Isotopic Uranium (234, 235, 238)			
EPA 901.0M	Radium (Screening) [1] (226/228)			
EPA 901.0M	Radium (Bi/Pb-214) [1] (226/228)			
ASTM 2216-96	Percent Moisture			

[1] Preparation of sample will be done using in-growth method. Prepared samples will initially be analyzed by gamma spectroscopy using the 186 keV line from Ra-226. After sufficient in-growth, the sample will be recounted using the Bi/Pb-214 gamma rays.
[2] The samples for Ra, Th, U and percent moisture can be submitted in a single sample container.

6.8.3 Field QC

Field duplicates will be collected for two sampling locations (assuming 20 or fewer samples are collected). The duplicates will be submitted to both the field laboratory and the offsite laboratory.

6.9 Sample Acquisition – Continuing Characterization Survey Sampling

Samples taken during the characterization activities will be analyzed by the field laboratory using the NaI detector. The data generated by this analysis will be used to guide decisions about whether the impacted soil has been sufficiently removed or if further excavation is required.

As the field laboratory generates data, the results may indicate the necessity of collecting additional samples to further define extent or direction of contamination. On the contrary, if samples taken from a particular excavation indicate that contamination above the tentative clean-up goals is still present, not all of the previously collected samples may be analyzed. If a sample will not be analyzed, documentation of this decision and the basis for the decision will be made in the Field Laboratory Logbook.

6.9.1 Sampling Locations

The locations and frequency of samples collected during characterization activities will be based on *in-situ* gamma and/or XRF measurements, as well as visual indicators.

If the *in-situ* measurements for both gamma and XRF are less than the FSL and tentative clean-up goals , respectively, and there are no visual indications that any impacted areas remain, samples will be collected in a systematic fashion in the excavation, as described in Section 5.5. The information from these analyses will be used for confirmatory measurements to verify that the impacted material has been removed and that the area is ready for the final status survey. If impacted material is visually indicated, despite the lack of *in-situ* measurement evidence, additional biased samples may be collected around the suspect location.

If the gamma *in-situ* measurement is greater than the FSL, a systematic set of samples generally will not be collected. Samples will be taken periodically in these areas to strengthen the dataset used to establish the correlation between *in-situ* measurements and the NaI results. A minimum of 20 samples will be taken for this purpose during the first week of the project. These samples shall include both samples from identified contaminated areas and areas where the field measurements indicate that remediation is complete. In subsequent weeks, the number of samples taken will be dependent on the quality of the correlation of the data that already exist. The frequency that these samples are taken is expected to diminish as the project progresses. The Project Lead will specify the number of this type of samples that will be taken each day. The decision will be based on the quality of the correlation of the data between the two analysis methods.

If the *in-situ* gamma count rates or the XRF data are inconclusive due to extreme variability or are close to the FSL or tentative clean-up goals, samples will be collected, as necessary, to adequately characterize the excavation.

6.9.2 Sample Collection

Samples will be collected in areas identified during the extent determination activities described in Section 5.5. Prior to collection of each soil sample, an XRF measurement and a static 1-minute gamma count will be performed using the gamma scintillation detector at the sampling location. All *in-situ* gamma measurements will be located with the GPS.

Characterization samples will be collected using a grab sampling technique using a disposable soil scoop or gloved hand. Sufficient sample will be collected into the mixing container to fill the sample bottles listed in Table 6-6.

Table 6-6
Continuing Characterization Survey Samples

EPA Method	Laboratory Method	Sample Container	Preservation	Holding Time
N/A	Field Laboratory Gamma Screen	Poly container, 16-ounce wide mouth	None	None

Each sample container will be labeled as described in Section 6.12 and custody sealed. Field notes and photographs will be used, as necessary, to document all sampling activities and any deviations from this plan. Three different data sheets will be used to document sample collection information. The Waypoint/ID Log will be used to record GPS waypoints, gamma meter data point ID numbers, XRF data point ID numbers, times, and color code. Actual GPS coordinants, gamma meter readings, and XRF readings will not be recorded on any of the data sheets. These

data will be stored in the corresponding meters with either waypoints or ID numbers as the reference point. These data will be downloaded daily into a database. The Waypoint/ID Log will document each *in-situ* measurement and sample location. The Sample Collection Log will be used to record all samples collected onsite, including sample ID numbers, dates and times for all samples collected, the waypoints, and gamma and XRF data point ID numbers, as applicable for the sample type. The Excavation Drawing/Notes Log will be used to sketch pictures of the excavation, record field notes, and document locations of photographs.

6.9.3 Field QC

Duplicate samples for analysis by the field laboratory will be collected at a rate of 10 percent.

6.10 Sample Acquisition – Verification Samples

After the extent of contamination has been delineated and the excavated materials stockpiled, the underlying soil must be evaluated to verify absence of COCs above the tentative clean-up goals. This sampling will be part of the Final Status Survey.

At the end of the excavation activities, all Class 1 material will have been moved to either stockpile A or B and the remainder of the Site will be classified as a Class 2 area. The maximum size of a Class 2 area is 10,000 square meters. Therefore, the Site will be divided into a minimum of three survey units.

6.10.1 Sampling Locations

VSP software will be used to develop the sampling requirements for the Class 2 areas. Only the radionuclide portion of the SAP will be addressed with VSP. The following assumptions will be used for the Class 2 survey units:

- the Site is assumed to be dirty
- a 5-percent false rejection rate
- a 10-percent false acceptance rate
- an action level (tentative clean-up goal) as presented in Section 7.3.5.5
- width of the gray region (delta) of 0.5 (half of the tentative clean-up goal)
- a standard deviation calculated from data generated characterization survey

The number of samples will be calculated for each COC (radionuclide) and the maximum number of samples will be taken. Prior to sample collection, the sampling locations will be identified using a random start triangular grid.

The Superfund Lead-Contaminated Residential Sites Handbook (EPA 2003) recommends that each quarter acre be sampled using a five-point composite sample. To determine the metals sample locations, the Site will be divided into one-quarter-acre plots. Locations of the samples will be selected by laying an imaginary grid over the site, assigning consecutive numbers to units of the grid, and selecting locations to be sampled using a random number table. One composite sample will be taken from each plot for a total of 24 metals samples collected for verification.

6.10.2 Sample Collection

Samples for the Class 2 area final status survey will be obtained from the uppermost 15-cm of surface soil at each location. If the location is in an excavation, the sample will be taken at the exposed surface. The sample should be approximately cylindrical in cross-section so that all horizontal components are equally represented in the sample. Samples will be collected with a scoop or gloved hand. Soil at the selected sample location will be composited with four additional samples (equal volume) collected randomly within a radius of 2 meters of the designated sampling location. The location of each sample (subsample) shall be documented. The five aliquots will be composited into the mixing container and homogenized before being transferred into the sample containers as listed in Table 6-7. Prior to collecting each soil sample, a GPS reading and gamma measurement of the sampling location will be made and recorded on the Waypoint/ID Log and Sample Collection Log.

Metals samples will be generated in the same manner as described above except that the locations for the five composite aliquots will be randomly selected from the quarter-acre-plot area. Each sampling area shall be identified in the Waypoint/ID Log and Sample Collection Log. Once the composite has been generated, and before the sample bottles are filled, an XRF measurement will be made on the composited material. All metal samples will be placed on ice (4°C) until delivered to the laboratory, due to preservation requirements for mercury.

Each sample container will be labeled as described in Section 6.12 and custody seals will be applied to the sample containers. Samples going to the offsite laboratory will be recorded on a chain-of-custody form.

Table 6-7
Verification Samples

EPA Method	Laboratory Method	Sample Container	Preservation	Holding Time
ASTM D3972-90M	Isotopic Thorium (228, 230, 232)	Poly container, 16-ounce wide mouth [1]	None	None
ASTM D3972-90M	Isotopic Uranium (234, 235, 238)			
EPA 901.0M	Radium (Bi/Pb-214) (226/228)			
ASTM 2216-96	Percent Moisture			
EPA 3050/6010B and 7471A (Hg)	ICP metals (As, Hg, Pb, Mo, V) (ICP/CVAA)	Poly container, 4-ounce wide mouth	4°C	28 days
N/A	Field Laboratory Gamma Screen	Poly container, 8-ounce wide mouth	None	N/A

[1]The samples for Ra, Th, U and percent moisture can be submitted in a single sample container.

6.10.3 Field QC

Duplicate samples will be taken for 10 percent of the sampling locations and submitted to both the field laboratory and the offsite laboratory.

6.11 Sample Acquisition – Stockpile Samples

Samples taken from stockpiles A and B will be analyzed for radionuclides and TCLP metals to characterize the material placed in the stockpiles and to evaluate remedial options for the stockpiled materials. Samples taken from Stockpile C will be analyzed for radionuclides and total metals to verify that the soil can be used for backfill. These samples may be analyzed by the field laboratory prior to submitting the samples to the laboratory; however, only data generated by the offsite laboratory will be used in disposition decisions. Data from the field laboratory will be used to confirm that the stockpiles were adequately sampled and that the samples are representative of the material in the stockpile.

6.11.1 Sampling Locations

Upon completion of the characterization activities, the excavated soil will be in three stockpiles. These stockpiles were generated based upon segregation criteria used during excavation activities. Stockpile A will consist of materials that contain greater than 100 pCi/g of combined radionuclide activity as measured *in-situ* and documented in the RI/FS. Stockpile B will consist of all other contaminated material. Stockpile C will consist of material that is expected to remain on the Site for use as backfill.

The number of composite samples necessary to characterize each stockpile will be calculated according to the requirements in SW-846 using a simple random sampling scheme. Locations of the samples will be selected by laying an imaginary grid over the stockpile, assigning consecutive numbers to the units of the grid, and selecting the locations to be sampled using a random number table. Exact positional information for these samples is not required; however, a sketch of sampling locations shall be made on an Excavation Drawing/Notes Log.

Section 7.3 provides details on how to calculate the number of samples that need to be collected.

6.11.2 Sample Collection

Within each selected grid location, composite samples will be generated by collecting five aliquots of approximately 500 cubic centimeters each into a disposable plastic container or a stainless steel bowl that has been lined with a disposable liner. The locations of the five sampling areas will be randomly placed within the identified grid location for each sample. The composite shall be thoroughly mixed. If the material is extremely heterogeneous, this may require quartering the sample, mixing each quarter separately, and combining the quarters. This process shall be repeated, as necessary, until a homogeneous mixture has been achieved. After the sample has been homogenized, an XRF measurement will be taken on the composite. The sample thickness at the point of measurement must be greater than 1-cm so that the sample container does not interfere with the XRF measurement. The composite shall be used to fill the applicable sample container(s), as listed in Table 6-8. Each sample container will be labeled as described in Section 6.12 and custody sealed. Excess composited material shall be discarded back into the stockpile. Sample collection will be documented on a Sample Collection Log and chain-of-custody forms.

Table 6-8
Stockpile Samples

EPA Method	Laboratory Method	Sample Container	Preservation	Holding Time
ASTM D3972-90M	Isotopic Thorium (228, 230, 232)	Poly container, 16-ounce wide mouth	None	180 days
ASTM D3972-90M	Isotopic Uranium (234, 235, 238)			
EPA 901.0M	Radium (Bi/Pb-214) (226/228)			
EPA 3050/6010B and 7471A (Hg)	ICP metals (As, Hg, Pb, Mo, V) (ICP/CVAA)	Poly container, 4-ounce wide mouth	4°C	28 days
EPA 1311	TCLP 8 RCRA metals	Poly container, 4-ounce wide mouth	4°C	28 days
N/A	Field Laboratory Gamma Screen	Poly container, 8-ounce wide mouth	None	N/A

6.11.3 Field QC

Duplicate samples will be collected for a minimum of 10 percent of all the stockpile samples.

6.12 Sample Identification and Labeling Requirements

Samples shall be labeled using the following numbering scheme: mmddyy-nn; where mm is the two-digit month, dd is the two-digit day, yy is the two-digit year, and nn is the sequential number beginning with 01 for the first sample collected that day.

Sample labels will be used to prevent misidentification of samples. Labels will be pre-printed whenever possible. Labels will include, at a minimum, the following information:

- Sample number using the methodology described above
- Name of the sample collector
- Date and time of sample collection
- Client (Stoller)
- Location (CSMRI)
- Analysis(es)
- Preservative, if applicable

6.13 Sample Handling and Custody Requirements

The possession and handling of all samples collected will be traceable from the time of collection, through analysis, until final disposition. Documentation of the sample history is referred to as "chain of custody." Components of the chain of custody include sample labels, sample seals, chain of custody, field logbook, and sample collection logs. Samples are in custody if they are in the custodian's view, stored in a secure place with restricted access, or placed in a container secured with custody seals. For samples that will be sent offsite, a chain-of-custody record will be signed by each person who has custody of the samples and will accompany the samples at all times. Samples that are to be analyzed by the field laboratory will not use a chain of custody but will instead be relinquished to a logbook that will remain in the

field laboratory at all times. The logbook will contain the same information as the chain of custody.
At minimum, the chain-of-custody form will include the following information:

- Site name
- Signature and initials of sample collector
- Date and time of sample collection
- Sample ID
- Sample matrix
- Sampling type (e.g., composite or grab)
- Sampling location
- Number of sample containers shipped
- Requested analysis(es)
- Sample preservation information
- Method of shipment/name of carrier
- Signatures of persons in the chain of custody
- Date and time of each change in sample custody
- Name of laboratory

Chain of custody will begin once the samples are collected. To ensure proper traceability, all samples will be properly labeled at the time of acquisition. Samples that are not directly transferred to field laboratory personnel will be placed in the onsite sample locker with the corresponding chain of custody. Samples requiring laboratory analysis may be stored up to one week prior to shipment. Metals samples will be stored in coolers packed with ice and shipped to the laboratory within one day of collection.

Samples will be shipped to the laboratory in coolers sealed with custody seals. Each cooler will have three seals: one on the front of the cooler and one on each side. The laboratory sample custodian will establish the integrity of the seals at the laboratory.

The original chain-of-custody form will be transported with the samples to the laboratory. Upon receipt of the samples by the laboratory, the laboratory sample custodian will inventory the samples by comparing sample labels to those on the chain-of-custody forms. The laboratory shall maintain documented chain of custody through the laboratory analytical process.

6.14 Sample Packaging and Shipment

Prior to packaging for shipment, sample bottles shall be smeared to verify absence of external removable radiological contamination in accordance with procedure SOP-RAD-002, *Swipe Sample Collection.* The DOT release criteria for removable contamination are shown in Table 6-9. Bottles with contamination above this level will be decontaminated using wet wipes until they are below this level.

Table 6-9
DOT Removable External Contamination Limits

Contaminant	Maximum Limit* (dpm/cm^2)	Maximum Limit ($dpm/100\ cm^2$)
Alpha-emitting radionuclides	2.2	220
Beta and gamma emitters	22	2,200

*From 6 CCR 1007-1 Part 17, Section 17.15.18.1 Table 3. Equivalent to DOT limits in 49 CFR Part 173.443 when the 0.10 swiping efficiency is included.

Sample bottles will also be surveyed using a dose ratemeter such as a Ludlum Model 19 MicroR meter. Limited quantity radioactive materials must have a surface dose rate that does not exceed 0.5 mrem/hr at any point on the external surface of the package.

Individual sample containers will be placed into a sealed plastic bag. Samples will then be packed in a cooler lined with a large plastic bag. The chain-of-custody form will be placed into a zip-locked bag and taped on the inside lid of the cooler. Each cooler will be sealed with three chain-of-custody seals. The following labels will be applied to the coolers: "This End Up" arrow labels will be placed on each side of the cooler, and "Fragile," "Environmental samples," and waybill labels will be placed on the top of the cooler. The cooler will be taped shut with at least three wraps of tape around each side.

Samples will be packaged and shipped in accordance with DOT regulations as specified in 49 CFR Parts 172 and 173 and State of Colorado regulations in 6 CCR 1007-1 Part 17.

Verification samples and Stockpile C samples are expected to have levels of radionuclides exempt from DOT classification as radioactive material based on the Site tentative clean-up goals; therefore, these samples will be shipped as general freight with no special shipping provisions.

Initial samples for metals and gamma characterization and stockpile A and B samples will be shipped as limited quantity class 7 radioactive materials. The outside of these packages will be marked with "UN2910," and the outside of the inner packaging (sample containers) will be marked "Radioactive." The proper shipping name is "Samples – Radioactive material, excepted package-limited quantity of material."

Coolers may be transported to the laboratory by courier or overnight shipping service, or hand-delivered to the analytical laboratory. The coolers will be clearly labeled with sufficient information on the waybill to ensure positive identification.

Figure 6-1

Air Monitoring Station Placement
CSMRI Creekside Site

Explanation

- Existing Monthly Air Monitoring Locations
- New Weekly Air Monitoring Locations
- 1 Foot Contours
- 5 Foot Index Contour
- Property Boundary
- Fences
- Clear Creek

N

Scale: 1" = 150'

0 50 100 150 200 Feet

CSMRI
Site Characterization Workplan

Stoller

7. Quality Assurance Project Plan

The purpose of this QAPP is to document the procedures required for QA, QC, data verification and validation, and data quality assessment for sampling and analysis activities related to the CSMRI Site project, as described in this work plan. The goal of the QAPP is to identify and implement the QA/QC practices associated with sampling and analytical methodologies that limit the introduction of error into analytical data. The QAPP provides the methodology to ensure that project data will be of adequate quantity, quality, and usability for their intended purpose, and further ensures that such data are authentic, appropriately documented, and technically defensible.

Quality assurance elements are the procedures used to control those immeasurable components of a project such as using the proper sampling techniques, collecting a representative sample, specifying the proper analysis, etc. Although not measurable, quality assurance procedures are essential to produce quality information.

Quality control data are the data generated to estimate the magnitude of bias and variability in the processes for obtaining the environmental data. These processes include both the field processes for obtaining the data and the laboratory analyses.

Data quality assessment is the overall process of assessing the quality of the environmental data by reviewing the application of the QA elements, the analysis of the QC data, and results of the data verification and validation. Quality assessment encompasses both the measurable and immeasurable factors affecting the quality of the environmental data. Assessment of these factors may identify limitations that require modifications to procedures or protocols for sample collection and analysis or affect the desired interpretation and use of the data.

This QAPP was developed in accordance with the requirements in *Guidance for Quality Assurance Project Plans* (EPA 2002). This QAPP augments the information and requirements described in other sections of this work plan.

7.1 Project Management

A description of the project management and a project organization chart are provided in Section 1.6 of this work plan.

7.2 Project Description

A complete description of this project and project goals is provided in sections 1 and 2 of this work plan. A schedule of project activities is provided in Appendix B.

The objective of this project is to evaluate the Site, using a combination of existing data and newly collected data, and determine the extent of impacted material at the Site. In the course of determining extent, the impacted materials will be excavated. The long-term goal is termination of the Radioactive Materials License for the Site and release of the property for development by the School. Although completion of these two objectives is not within the scope of this work plan, the work covered by this plan will be designed with these ultimate objectives in mind. Upon completion of characterization/excavation activities, a final status survey will be performed. To accomplish these objectives, data will be collected to:

- Direct and control excavation of materials that exceed the tentative clean-up goals
- Characterize the stockpiled soil to evaluate disposal options for excavated materials
- Verify that sufficient material has been removed to support proposed future use of the property and termination of the Radioactive Materials License for the Site
- Provide radiological monitoring and control

Data necessary to support these objectives include field measurements for gamma-emitting isotopes and metals contamination, field laboratory data for semi-quantitative analysis of gamma-emitting radionuclides, analytical laboratory data for radionuclides and metals, sample and excavation positional information, and health and safety monitoring data.

When the extent of contamination has been identified and the contaminated material removed, verification sampling will be performed in accordance with the following documents:

- Radionuclides:
  - *Consolidated NMSS Decommissioning Guidance, Volume 2, Characterization, Survey, and Determination of Radiological Criteria* (NRC 2003)
  - *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM 2000)
- Metals:
  - *The Superfund Lead-Contaminated Residential Sites Handbook* (EPA 2003)

In addition to these guidance documents, the following software will be used to assist in determining characterization and verification sampling requirements:

- *RESRAD*, Version 6.21, U.S. DOE and U.S. Nuclear Regulatory Commission (NRC), developed by the Environmental Assessment Division of Argonne National Laboratory, September 2002 (ANL 2002)
- *Visual Sampling Plan (VSP),* Version 2, Pacific Northwest Laboratory, Contract DE-AC06-76RL01830

Specific procedures necessary to accomplish these objectives are provided in this QAPP and are integrated throughout this work plan. Copies of all standard operating procedures identified in this work plan are provided in Appendix E.

7.3 Data Quality Objectives

The overall data quality objective is to develop and implement procedures for field measurements, sampling, laboratory analysis, and data analysis and reporting that will provide results that are technically sound, capable of supporting Site characterization and soil disposition decisions, and legally defensible in a court of law. The data quality objectives to achieve the primary objective were determined using the systematic planning process as outlined in the EPA guidance document *Guidance for the Data Quality Objectives Process* (EPA 2000).

7.3.1 Problem

Data generated during the RI/FS documented that the Site was contaminated with elevated levels of radionuclides and metals. Remediation efforts to excavate impacted soils (started in April 2004 by New Horizons Environmental Consultants) were halted when it became apparent, due to

the volume of soil being excavated, that data generated during the RI/FS were not adequate to establish extent of contamination on the Site. Based upon these lessons learned, a different approach has been proposed to complete the Site characterization and determine the volume of impacted soil on the Site. These characterization activities are described in previous sections of this work plan. In the course of characterization activities, the impacted materials will be excavated and stockpiled. Following excavation of the impacted materials, a final status survey will be performed to confirm that materials exceeding the tentative clean-up goals have been excavated. In addition, soil stockpiles that were generated during characterization activities will be sampled and analyzed for parameters necessary to evaluate potential remedial options.

7.3.2 Decisions

During the course of field activities, data necessary to answer the following questions must be generated.

- Was sufficient material excavated to define the nature and extent of impacted material?
- Was the stockpiled material adequately characterized to determine disposition options?
- Does the Site (excluding the stockpiled material) meet the release criteria for termination of the Radioactive Materials License?
- Were adequate work practices employed to protect the onsite worker and surrounding community during the Site characterization activities?

The final survey and verification samples must demonstrate that the tentative clean-up goals are met during area averaging (over small areas, as allowed by MARSSIM) (exclusive of the stockpiles). Clean-up goals for metals must also be met.

7.3.3 Inputs to the Decision

The tentative clean-up goals for the Site were determined using RESRAD 6.21. The receptors evaluated included a recreational user who played soccer on the field 4 hours per day, 365 days a year and consumed fish from Clear Creek, and an urban resident who was on City water and bought all food at the local grocery store, but also enjoyed fishing and consumed her catch.

The following sources of information will be used during the course of characterization activities:

- Data generated during the RI/FS will be used to identify known contaminated material that will be excavated at the inception of the field activities.
- The radiological land survey data (GPERS-II) will be used to identify remaining areas of surficially contaminated soil.
- Air monitoring data will be used to ensure that appropriate dust control practices are used and to monitor worker internal radiation dose.
- Area dose surveys (and dosimetry data, if found to be necessary) will be used to monitor and control worker exposure to external radiation.
- Field radiation surveys will be used for excavation control and the final status survey.
- Field portable XRF, used to quantify metals contaminations, will be used for excavation control.
- Field laboratory data generated with the NaI detector will be used for excavation control.

- Laboratory analytical data will be used to quantify method bias and determine bias correction factors (field gamma methods and *in-situ* metals analyses), if necessary, generate data for the final status survey, and characterize the soil stockpiles.
- GPS and survey data will provide positional information for excavation, sampling, and the final status survey.

7.3.4 Boundaries

Spatial boundaries for the characterization activities are limited to the Site as described in Section 1 of this work plan. The horizontal surface boundary is the perimeter of the six-acre Site excluding the former settling pond area. The entire Site surface will be surveyed. The vertical boundary will be delineated using the existing soil borings and test pits, followed by field sampling and excavating the known extent of contaminated materials.

The contaminants to be evaluated include the COCs identified during data evaluation. These include eight radioisotopes (Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238) and five metals (As, Pb, Hg, Mo, and V).

7.3.5 Decision Rules

A number of decision rules will be used to guide characterization activities, protect the health and safety of Site workers and the surrounding community, and perform the final status survey.

7.3.5.1 Occupational Health Requirements

Occupational exposure monitoring for ionizing radiation is required if a worker is likely to exceed 500 mrem per year from sources external to the body, per 6 CCR 1007-1, Part 4. Stoller has established an ALARA guideline of 100 mrem per year in accordance with the company Radiation Protection Program. These limits are not anticipated to be exceeded on this Site; therefore, personal dosimetry will not be required. Dose rate surveys will be conducted daily, in accordance with procedure SOP-RAD-033, *External Dose Rate Tracking,* to monitor external employee exposure, using Ludlum Model 19 MicroR meter, or equivalent. If dose rates greater than 50 microrem/hr above background (based upon a 2,000-hour work year) are observed, steps will be taken to limit personnel time in the area. In the event that this is not possible, and extrapolation of the dose rate indicates that the 100 mrem per year limit may be exceeded, the dosimetry program will be implemented.

The potential for internal exposure has been estimated based on maximum activity concentrations of radionuclides located on the Site, and the results show that personnel air monitoring (breathing zone monitoring) is not required for Site workers. For metals, employee exposures must be below the PELs published by OSHA for the metal COCs. Calculations based on the maximum metals concentrations in Site soils demonstrate that dust concentrations will be below PELs for all metals of concern, assuming effective dust suppression is provided. Air monitoring for metals will not be conducted based on this analysis. Documentation of these assessments is attached to the SSHSP.

Exposures to the public must be maintained in accordance with 6 CCR 1007-1, Part 4. Fugitive dust will be controlled by using dust suppression during all activities that have the potential to generate dust. Four air samplers will be deployed at the Site boundary. Filters from these

samplers will be exchanged weekly. The boundary air monitoring results will be used to monitor public exposures. These filters will be counted (after allowing decay of radon and thoron progeny) using the alpha/beta counter in the field laboratory. The observed activity for the filter (converted to air concentration) will be compared to the calculated effluent concentration limit for the site isotope mixture of 4.8×10^{-14} microcurie per milliliter as described in Section 6.5.3. If the activity exceeds this limit, the filter will be submitted to the offsite laboratory for isotope-specific analyses. The laboratory data will be compared to the individual isotope effluent concentration standards provided in Table 6-3. If the standards are exceeded, excavation work will be suspended until adequate dust control practices have been implemented.

7.3.5.2 Radiological Land Survey (GPERS-II)

The GPERS-II survey system will be used to map surficial gamma radiation levels after areas of known contamination have been removed. Results from this survey will be used to direct additional excavation activities.

7.3.5.3 Gamma Scintillator Field Measurements

A hand-held gamma scintillation detector will be used to guide excavation activities. An FSL will be established daily for this instrument, as described in Section 6.1. Additionally, the count rate that has been determined to correlate with the tentative clean-up goals will be determined during the Initial Gamma Characterization Survey Sampling (Sections 5.3 and 6.8). Count rates below the FSL are not statistically different from background. Count rates between the FSL and the tentative clean-up goal equivalent count rate will identify areas that will require additional sampling and testing.

7.3.5.4 Field Portable XRF

The field portable XRF will be used to measure metals concentrations, *in-situ*. Results from these measurements will be compared to the site-specific action levels for metals. Count times will be established based on field data that allow a detection limit sufficiently below the action levels. Soil that is contaminated above these levels will be excavated.

7.3.5.5 Derived Concentration Guidelines for Radionuclides

The Site has been divided into Class 1 and Class 2 areas according to MARSSIM guidance. The Class 1 areas were evaluated using VSP software "hotspot" assumptions to determine the number of samples required to verify excavation of the material during characterization activities. Upon completion of excavation of Class 1 material, the entire Site will become a Class 2 area. Analytical data from the verification samples will be compared to the agreed upon tentative clean-up goals. The Site-specific tentative clean-up goals (which include background levels) are summarized in Table 7-1.

Table 7-1
Radionuclide-Specific Tentative Clean-up Goals

Isotope	Activity (pCi/g)
Ra-226	4.14
Ra-228	4.6
Th-228	6.47
Th-230	11.53
Th-232	3.88
U-234	254.9
U-235	4.97
U-238	21.8

7.3.5.6 Site-Specific Metals Clean-up Standards

Metals concentration in the soil will be determined from samples composited from one-quarter-acre parcels in accordance with *Superfund Lead-Contaminated Residential Sites Handbook* (EPA 2003). Metals of concern for the Site include As, Hg, Mo, Pb, and V. Metals concentrations will be compared to the proposed Tier 2 soil standards, with the exception of arsenic for which a Site-specific standard has been calculated due to elevated levels of arsenic in the background materials of this Site. The applicable standards are summarized in Table 7-2.

Table 7-2
Site-Specific Metals Tentative Clean-up Standards

Metal	Concentration (ppm)
As	39
Pb	400
Hg (Total)	23
Mo	390
V	550

7.3.5.7 Soil Stockpile Sampling Requirements

Stockpiles A and B may be disposed in a solid waste landfill, or consistent with another remedial alternative if a decision is made to change the previously selected remedy. The material in Stockpile C is expected to remain onsite and be used as backfill. Sampling these stockpiles is included in the scope of this work plan; however, disposition of the material is not. The soil stockpiles will be sampled and analyzed to provide information for future disposition decisions. During characterization activities, approximate levels of contaminants in the material added to stockpiles A and B will be generated from the screening data.

The number of samples necessary to characterize each stockpile will be determined using the guidance in SW-846. To determine the number of samples that must be taken to adequately characterize each stockpile, the average and standard deviations for the COCs will be determined using data generated during the characterization activities. If insufficient data are available to evaluate the material in Stockpile C, data may be obtained using the portable XRF and samples collected for analysis in the field laboratory. Samples will be collected from each stockpile and submitted for analysis by the offsite laboratory. The regulatory thresholds used for these

calculations will depend upon the remedial option being considered. The regulatory thresholds for Stockpile C will be the tentative clean-up goals.

7.3.5.8 ALARA Assessment

Guidance in NUREG-1757 requires that in addition to dose/risk based clean-up standards, the residual radioactivity levels be reduced to ALARA. The method to determine whether the levels of residual radioactivity specified by the tentative clean-up goals are ALARA is described in Appendix N of NUREG-1757 (NRC 2003). The ALARA assessment for this project is provided in Appendix G.

7.3.6 Limits on Decision Errors

7.3.6.1 Occupational Health Requirements

An alpha/beta counter will be used to count swipes and air filters. The count time will be adjusted to achieve an MDA (95% confidence limit) that is adequate for the intended use of the data. The MDA is calculated as follows:

$$MDA\,(dpm) = \frac{\frac{2.71}{T_S} + 3.29\sqrt{\frac{C_B}{T_S} + \frac{C_B}{T_B}}}{Eff}$$

Where:

T_S – Count time for sample filter (minutes)
T_B – Count time for background (minutes)
C_B – Background count rate (cpm)
Eff – Efficiency of detector

Air Filters

Assuming a 1-week filter exposure time with the pump running at 60 liters per minute, the action level would be approximately 3 dpm. The estimated count time to achieve an MDA of 1.5 dpm is 20 minutes. The actual MDA based on field conditions will be calculated for the proposed count time using the equation presented above. The count time may also be adjusted if higher volume pumps are used for sample collection. These filters will be submitted to the offsite laboratory for radiochemical analyses if the field laboratory data indicate that an effluent standard may have been exceeded. The required detection limits (RDLs) will be 0.25 pCi/filter for Th isotopes and 1 pCi/filter for Ra-226 and the U isotopes.

Swipes

Swipes used to monitor for removable contamination will be counted for alpha and beta activities. The most restrictive swipe release limits are 20 dpm/100 cm^2 alpha and 100 dpm/100 cm^2 beta. If the area swiped is not equal to 100 cm^2, these values will be adjusted proportionally. The estimated count time to achieve an MDA of 5 dpm alpha (the most restrictive) is 1 minute. The actual MDA based on actual field conditions will be calculated for the proposed count time using the equation presented above. MDAs will be recorded along with the count data. Count times may be adjusted, as necessary.

Survey Meter

The alpha/beta survey meter will be used for monitoring for total contamination (fixed plus removable) on personnel and equipment. The Ludlum 43-89 probe used for these surveys has an alpha scanning detection limit of 100 dpm/100 cm^2 at a distance of one-quarter inch and a rate of ≤ 0.5 inch per second. The static alpha detection limit is 85 dpm/100 cm^2. The beta scanning detection limit is 2,500 dpm/100 cm^2 using the same scanning parameters with a static beta detection limit of 800 dpm/100 cm^2. These detection limits are adequate to demonstrate compliance with the release criteria of 100 dpm/100 cm^2 alpha and 5,000 dpm/100 cm^2 beta specified in NRC Regulation 1.86. When an audible response is observed, the probe should be placed in a static location over the area where the initial response was heard for 5 to 10 seconds to provide adequate time for instrument response.

7.3.6.2 Radiological Land Survey (GPERS-II)

The survey rate will be controlled to achieve a survey detection limit sufficiently below the tentative clean-up goals for Ra-226.

7.3.6.3 Gamma Scintillator Field Measurements

The gamma scintillator will be used in both scanning survey mode and static count mode. The minimum detectable concentration (MDC) for this instrument is a function of detector efficiency, background count rate, and count time or scanning rate. The scanning rate will be controlled to achieve a detection limit sufficiently below the tentative clean-up goal for Ra-226. The scanning MDC that will actually be achieved in the field will be evaluated once the instrument is in the field and instrument background is known, using the equations provided in Section 6 of MARSSIM, and also using data generated during the Initial Gamma Characterization Survey Sampling (Sections 5.3 and 6.8).

The MDC for this instrument in static count mode using a 1-minute count time is estimated to be less than 2 pCi/g Ra-226. The actual correlation of count rate versus radioactivity levels in the soil will be determined during the Initial Gamma Characterization Survey Sampling (Sections 5.3 and 6.8). These data will be evaluated to verify that a 1-minute static count will provide adequate data. Documentation of this assessment will be added to the project files. In areas of high count rates, the count time may be shortened, as directed by the Project Lead, to improve efficiency of field operations.

7.3.6.4 Metals

The laboratory method detection limits (MDL) for the metals of concern were verified to be acceptable and well below the action levels (5 times or greater) using the specified analytical method. The laboratory MDLs are given in Table 7-3.

Table 7-3
Laboratory Analyses Required Detection Limits

Analyte	Method Description	Specific Method	Matrix	RDL
Ra-226/Ra-228	Gamma Screening	EPA 901.0	Soil	2 pCi/g
	Gamma (Bi/Pb-214 Ingrowth)	EPA 901.0	Soil	0.2 pCi/g
	Radon emanation	EPA 903.1	Air Filter	1 pCi/filter
Th-228, Th-230, Th-232	Alpha Spectroscopy	ASTM D3972-90	Soil	0.1 pCi/g
			Air Filter	0.25 pCi/filter
U-234, U-235, U-238	Alpha Spectroscopy	ASTM D3972-90	Soil	0.1 pCi/g
			Air Filter	1.0 pCi/filter
ICP Metals (Total) As, Pb, Mo, V	Inductively Coupled Plasma-Atomic Emission	EPA 3052 (Acid Digest Total) EPA 6010B	Soil	0.1 ppm
Metals (Total) - Hg	Cold Vapor Atomic Adsorption	EPA 7471A	Soil	0.1 ppm
TCLP Metals (As, Pb, Hg)	ICP-AES/CVAA	EPA 1311	Soil	0.1 ppm

The detection limits for the field XRF data are also less than the action levels for the metals of concern, although not significantly so. The potential bias in the field XRF data will be evaluated during Metals Correlation Initial Sampling described in Section 6.7. Data corrections will be applied as necessary and applicable. Interference in As measurements from Pb is possible if the As/Pb ratio is greater than 10. This will also be evaluated during the correlation sampling event. The data from the field XRF are considered screening level measurements; therefore, these data will be used only for excavation control.

7.3.6.5 Final Status Survey

For the final status survey, the Site will be assumed dirty with decision errors for the final status survey of 5 percent for the false rejection rate (alpha) and 10 percent for the false acceptance rate (beta).

7.3.6.6 Soil Stockpile Sampling Requirements

The probability level (confidence interval) for sampling the stockpiles is 80 percent. However, since the upper limit of the confidence interval is compared to the regulatory threshold, only one side (tail) of the distribution curve is relevant. Therefore, the effective confidence is 90 percent.

7.3.6.7 ALARA Assessment

An ALARA assessment was completed to determine if the tentative clean-up goals met the intent of the ALARA guidelines. The results of this assessment indicated that the Site-specific tentative clean-up goals are more conservative than the tentative clean-up goals derived using the NUREG-1727: *Consolidated NMSS Decommissioning Guidance,* Volume 2, Appendix D. This assessment is provided in Appendix G.

7.3.7 Optimize Project Design

The final status surveys for radionuclides and metals will be designed using the computer models listed in Section 7.2. These programs will select the optimal sample size that satisfies the data quality objectives.

The final soil stockpile sampling will be designed based on the size and expected range of contaminants of the three stockpiles to adequately characterize the stockpiles for evaluation of disposal options.

7.4 Measurement Data Acquisition and Performance Criteria

The data quality indicators that will be used to assess the laboratory data include precision, accuracy, representativeness, completeness, and comparability.

7.4.1 Precision

Precision measures the degree of agreement among repeated measurements of the same characteristic (EPA 1986). It may be determined by calculating the standard deviation (for three or more determinations or relative percent difference [RPD] for two samples) for samples taken from the same place at the same time. The EPA National Functional Guidelines set RPD as one of the required measurements of laboratory precision. Generally, precision is calculated for compounds positively detected in both the original and duplicate samples. For two samples, the following formula is used:

$$RPD = |(original-duplicate)/((original + duplicate)/2)|$$

Precision can be measured in laboratory analyses by evaluating matrix spike and matrix spike duplicate (MS/MSD) pairs and pairs of "unspiked" samples and the corresponding duplicates, as specified in each analytical report. The acceptable RPD range, called "advisory limits" is given on the Form III for each analytical report (EPA 1999). Analytical results in which the RPD is above those limits, is qualified, usually with an asterisk (*) or a "P".

7.4.2 Accuracy

Accuracy measures how close results are to the true value and is determined by comparing analysis of standard or reference samples to their actual value (EPA 1986). In practice, accuracy is determined by measuring the level of contamination in method and equipment rinsate blanks; evaluating performance against known laboratory control samples (LCS); evaluating surrogate recovery; and validated MS/MSD samples. Evaluation of each of these quality controls is described below.

Results for blanks agree with values generally obtained in field investigations. The affected samples have been qualified and the detection limits have been appropriately corrected to reflect the accuracy of laboratory analyses.

EPA protocols tightly control LCS and LCS duplicate (LCSD) failures. The LCS percent recovery must be within the QC limits for the sample data to be accepted (EPA 1999). When an analytical run has LCS or LCSD failures that directly impact the analytes requested, the samples

must be re-analyzed. Due to these tight controls, LCS and LCSD samples demonstrate that accuracy was met for each analytical run.

7.4.3 Representativeness

Representativeness is a qualitative measure that evaluates whether samples and measurements are collected in a manner such that the resulting data appropriately reflect the property to be measured (EPA 1998). Representativeness can be affected by the collection of the sample or by the analysis. Problems with representativeness arise if the samples collected do not extract the material from its natural setting in a way that accurately captures the qualities to be measured or if a subsample is not representative of the sample because the subsample was collected from the most accessible portion of a non-homogenized sample (EPA 1998). Representativeness is most commonly addressed by defining protocols based on standard techniques and adhering to them throughout a study (EPA 1991). These standard techniques are most commonly addressed by using standard sample collection techniques (from SW-846 and other EPA guidance) and homogenizing samples prior to subsampling. The standard techniques to be used in this study are detailed in this work plan and will be implemented during field sampling activities.

7.4.4 Completeness

Completeness is the comparison between the amount of valid or usable data originally planned to be collected and the amount of data actually collected (EPA 1986). Because Stoller's plan is investigative in nature and the extent of the impacts are not known, the quantity of data to be collected during this plan is unable to be determined. The final survey will collect data that will strive for an excess of 90 percent completeness.

7.4.5 Comparability

Comparability measures the extent that data can be compared between sample locations and periods of time within a project or between projects (EPA 1986). Data collected for the current CSMRI field work should be comparable with data collected from previous CSMRI field work, as long as past consultants followed the procedures outlined by the EPA (chemical data were obtained using EPA SW-846 methods [EPA 1986] and standard sampling techniques [from SW-846 and other EPA guidance]). Approved laboratories performed all analyses.

7.5 Special Training and Certifications

All field personnel are required to read the SSHSP, this work plan, and applicable procedures and attend a safety briefing prior to commencement of work activities. Completion of required reading will be documented using a required reading checklist or equivalent. Morning safety meeting attendance will be documented on the safety form.

A Colorado-licensed professional land surveyor will perform all required surveys. Personnel using GPS equipment will be given instrument-specific training prior to using the equipment in the field. This training will be recorded using a training roster or equivalent form.

New Millennium personnel trained in the operation of the gamma spectrometer will operate the NaI detector in the field laboratory.

Eberline personnel, trained in the operation of the GPERS-II, will operate the radiological land survey equipment.

Field personnel will be trained on the proper use of the frisker. This training will be recorded using a training roster or equivalent form.

7.6 Documentation and Records

Field-generated documentation will consist of field logbooks, instrument calibration and operation logs, field survey and excavation documentation sheets, and sample collection logs. Standardized field forms are provided in Appendix F.

Requirements for documentation include the following:

- Logbooks will be bound, with consecutively numbered pages.
- Removal of any logbook pages, even if illegible, is prohibited.
- Entries will be made legibly with black (or dark) waterproof ink.
- Entries will be made while activities are in progress or as soon afterward as possible.
- Name of person making the entry will be recorded.
- Each consecutive day's first entry will be made on a new, blank page.
- At the conclusion of the field activities for the day, any unused space on the field logbook page will be "Z'd out" to prevent later entries.
- Unused portions of field forms and chains of custody will be "Z'd out" to prevent later entries.
- The date and time, based on a 24-hour clock (e.g., 0900 for 9 a.m. and 2100 for 9 p.m.) will appear on each page.
- Any photographs taken at the sampling location will be noted on the field sheets.

Documentation will be reviewed for discrepancies, missing information, missing signatures, etc. on a weekly basis (minimum frequency), by the Project Lead, or designee, as evidenced by a review signature in the logbook or on the record sheet. Documentation deficiencies will be directed to the appropriate personnel as soon as possible for correction or augmentation.

Corrections to any document will be made by drawing a single line through the original entry allowing the original entry to be read. The corrected entry will be written alongside the original. Corrections will be initialed and dated and may require a footnote for explanation.

All documentation generated during this project will become part of the project record files.

7.6.1 Field Logbook

All field activities and observations that are not noted on other types of field-generated paperwork will be noted in a field logbook during fieldwork by the Project Lead. The field logbook will be a bound document containing the following information, at a minimum:

- Date and time of each entry
- Personnel onsite, including documentation of any visitors

- Area(s) being worked and types of samples collected
- General observations
- Any changes that occur at the site (e.g., personnel, responsibilities, deviations from this work plan) and the reasons for these changes

The Project Lead is responsible for ensuring that the field logbook and all field data forms are correct and complete. The descriptions will be clearly written with enough detail so that participants can reconstruct events later, if necessary.

In addition to the preceding requirements, the person recording the information must initial and date each page of the field logbook. If more than one individual makes entries on the same page, each recorder must initial and date each entry. The bottom of the page must be signed and dated by the individual who made the last entry.

7.6.2 Waypoint/ID Log

The Waypoint/ID Log will be used to document the unique sample IDs assigned by the data logger and/or XRF at each waypoint assigned by the GPS. This log also will be used to record the color-coded indicator that was applied to the ground for excavation control.

7.6.3 Sample Collection Log

The Sample Collection Log will be used to document sample collection of all soil samples. Other types of samples, such as health and safety related samples are recorded on chains of custody. Chains of custody will be used for these samples in the event that the screening measurements performed in the field laboratory indicate that the samples need to be submitted to the offsite laboratory.

7.6.4 Excavation Drawing/Notes Log

A sketch of the excavation with any field observations will made at each iteration in the excavation. If photographs are taken, the location and description of where the picture was taken shall be documented.

7.7 Sample Handling Requirements and Controls

All samples will be collected and handled in accordance with the requirements in Section 6, SAP. After collection, samples will be placed in the onsite sample staging locker or in a custody-sealed cooler with the corresponding chain of custody, until they are shipped to the offsite laboratory. Metals samples will be stored in coolers on ice (4°C preservation requirement for mercury) and shipped to the laboratory within one day of collection. Samples that are being submitted to the field laboratory will remain under chain of custody until relinquished to field laboratory personnel.

7.7.1 Field Procedures

The following steps must be taken by field personnel to ensure chain of custody on field samples:

- Use only approved containers for acquiring samples.
- Properly label all sample containers at the time of sample acquisition.

- Record all required sampling information in field logs and/or sample collection logs, as applicable.
- Ensure that labels are legible and intact after sampling or write information directly on sample container.
- Immediately place samples in a designated container (cooler, etc.) that accompanies the sampling personnel until custody of the samples is transferred.
- Place the sample in a secure location if not transferring to another individual.
- Document all changes of sample custody such as transfer to the onsite laboratory or the offsite laboratory.
- Use an appropriate custody seal on the sample container during shipment to ensure no tampering in route to the laboratory.
- Fill out the applicable chain of custody form.

7.7.2 Approved Sample Containers

Samples will be placed and transported in containers appropriate to the sample matrix and analytical parameters. Sample containers for samples submitted to the offsite laboratory are supplied by the laboratory. The bottles are required to be pre-cleaned and certified. Sample containers for samples submitted to the onsite laboratory are not required to be certified. The appropriate size and type of sample containers for the analytes being collected are specified in the applicable Sample Acquisition section of the SAP.

7.7.3 Sample Label Requirements

Sample labels will be pre-printed whenever possible. Specific sample collection information, such as collection time, will be written on the sample labels at the time of sampling. Sample labels will be filled out with indelible ink. Samples will be labeled with the following information, at a minimum:

- Date and time sample was collected
- Unique sample number
- Name of sampler
- Requested analysis(es)
- Preservative, if applicable
- Client (Stoller) – Only required for offsite samples

7.7.4 Sample Documentation

Sampling activity is documented on a Sample Collection Log.

7.7.5 Preservatives

Metals samples shall be preserved with ice (4 ± 2°C). There are no preservation requirements for the other sample types.

7.8 Analytical Methods Requirements

Samples collected for method correlation, verification sampling, and some occupational health samples, will be analyzed at a CDPHE-certified environmental/radionuclides laboratory. Samples designated for laboratory analysis will be analyzed in accordance with laboratory-

specific internal procedures for the specified analytical method. The laboratory methods used for this project and the required detection limits are listed in Table 7-3.
The NaI detector system will be operated in accordance with New Millennium standard operating procedures. The RDL for Ra-226 is 2 pCi/g.

The field portable XRF will be operated by personnel who have received instrument-specific training on its use. The estimated limits of detection for this instrument are listed in Table 7-4. The actual detection limits obtained with this instrument will be affected by field conditions and will be determined during use.

Table 7-4
Field Portable XRF Estimated Limits of Detection

Element	LOD in ppm [1]
As	13
Hg	14
Pb	16
Mo	20
V	20

Radioactivity will be measured with a variety of instruments. A hand-held gamma scintillator will be used for terrestrial (*in-situ)* gamma measurements. A hand-held dual phosphor alpha/beta probe with scaler/ratemeter will be used for general radiological surveys and frisking. A field laboratory dual-channel wipe counter will be used to analyze swipes and air filters. A gamma survey meter will be used for area dose surveys. These instruments will be operated in accordance with standard operating procedures as listed in Table 6-1.

7.9 Quality Control Requirements

The following sections describe the QC requirements for the types of samples required by this project. The samples include ambient air samples, environmental radioactivity survey samples (e.g., equipment wipe samples, area dose monitoring), and soil samples to provide method correlation, characterize stockpiled material, and verify clean-up requirements.

7.9.1 Sampling Quality Control Requirements

Samples must be collected from representative material using clean sampling equipment and the proper sample containers. Collection of the sample must be well documented. The samples must be properly stored and shipped. The Project Lead will supervise sampling personnel to verify sampling, storage, and shipping procedures are followed. If discrepancies are noted, corrective action will be initiated, which may include retraining and/or revising procedures.

Every effort will be made during the soil sample collection to produce well-mixed soil samples free of excessive gravel, pebbles, or organic material. Duplicate soil samples will be collected from a minimum of 10 percent of all sample sites. New sampling equipment or reusable items that have been lined with a disposable liner will be used to collect all samples. Sufficient sample quantity will be provided for internal laboratory QC operations.

7.9.2 Field Portable XRF

Daily performance checks, in accordance with the instrument operating procedure, are required at the beginning of the shift and after every four hours of operation. The operator is prompted to perform the required checks by the instrument software. Evaluation of the performance check data is done automatically by the software. If results of the performance check are not acceptable, the instrument shall be tagged out of service and shall not be used until the problem is resolved.

7.9.3 Field Laboratory NaI Detector Quality Control Requirements

The NaI instrumentation shall be operated in accordance with New Millennium standard operating procedures. The NaI counting system will be performance checked prior to operation. Results of the performance checks shall be documented. At least 10 percent of all of the samples submitted to New Millennium shall be duplicate samples. Instrument duplicate samples shall be run in accordance with internal New Millennium procedures.

7.9.4 Radiation Detection Instrumentation

Daily performance checks shall be completed prior to instrument use each day. Results of the performance checks shall be documented, as specified in the applicable instrument operating procedure.

7.9.5 Laboratory Quality Control Requirements

Laboratory QC shall be performed in accordance with established internal laboratory procedures. Standard QA/QC procedures include initial calibration, continuing calibration, reagent blanks (where applicable), laboratory control samples (for radionuclide samples), laboratory duplicates, serial dilutions (as needed), tracer samples (both chemical and radionuclide), and MS/MSD (i.e., addition of known quantities of chemicals or radionuclides).

All laboratory quality control samples shall be reported along with the standard sample analyses. Problems with laboratory QC shall be reported in the laboratory data package. Analyses that are out of accepted laboratory QC ranges shall be reported to the Project Manager or QA Manager to determine if the samples need to be rerun. Problems with QC shall be corrected as soon as possible and affected samples may require re-analysis. In some instances, technical judgment may be required to determine if flagged data are of adequate quality for project needs.

7.9.6 Survey Data

Positional data will be recorded onsite through the use of GPS. Continual checks of the accuracy of these data will be made by maintaining GIS maps of the accumulated information and checking the locations against adjacent, mapped locations.

7.9.7 Documentation

Significant documentation shall be generated by this project. Documentation will be reviewed for discrepancies, completeness, etc. on a weekly basis, at a minimum by the Project Lead or designee. Documentation deficiencies will be brought to the attention of the appropriate personnel as soon as possible for correction.

7.10 Instrument/Equipment Testing, Inspection, and Maintenance

All instrumentation used for this project requires testing, inspection, and maintenance. Equipment problems will be identified in a timely manner and the instrument will be repaired or replaced as soon as possible. Instrumentation that may be used on this project includes:

- Hand-held radiation survey instruments
- Various air sampling pumps of capacities from 60 liters per minute to 40 cubic feet per minute
- Field portable XRF
- GPERS-II
- Laboratory analytical instruments

Manufacturer- or vendor-specified preventive maintenance procedures and/or consumable item replacement schedules shall be strictly followed for all field instrumentation/equipment. Field instrumentation/equipment will be function checked and/or calibrated before being assigned to the field activity. Function testing and/or calibration in the field will be performed daily or in conformance with the manufacturer's recommendations and recorded on the equipment log sheet. A sufficient inventory of repair items and consumable components will be maintained on the Site to keep the field instruments and equipment in service. Arrangements will be made with offsite vendors and service companies for repair and maintenance of instruments that require specialized equipment or skills.

Maintenance problems shall be brought to the attention of the Project Manager or QA Manager if data quality is affected.

7.11 Instrument Calibration and Frequency

The portable XRF is calibrated by the instrument manufacturer. This calibration is a one-time event unless repairs are performed on the instrument.

The NaI counting system will be calibrated using a NIST-traceable standard. The calibration will be performed prior to the start of the project, after any instrument repairs or modifications are made, or if any results of the performance checks indicate that an instrument shift has occurred. Calibration data will be part of the project files.

Radiation detection instrumentation shall be calibrated annually, according to manufacturer's procedures. The calibrations shall be NIST traceable and documentation of the calibration shall be available in the field laboratory.

7.12 Inspection/Acceptance of Supplies and Consumables

Certified clean containers, supplied by the laboratory, shall be used for all samples submitted to the offsite laboratory.

Receipt of supplies and consumables shall be verified against the purchase order to verify that the order was properly and completely filled. If items were ordered with specification requirements, documentation of specification compliance (i.e., certificates, etc.) shall be reviewed for compliance.

7.13 Data Management

Data for this project will be generated in written and electronic form. Field data will be recorded in field notebooks, sample collection logs, chain-of-custody forms, instrumentation visual output, instrumentation digital output, and software-generated digital output. Laboratory data shall be delivered in electronic form, in addition to the hard-copy report. These data must be accurately recorded and cross-checked to verify quality data are produced. This section of the QAPP addresses the generation and maintenance of manual and electronic data, including sampling and analysis data that will be generated on this project. The objectives for data management on this project are as follows:

- Track and organize all data pertaining to field activities, including surveys, *in-situ* measurements, collection of samples, and data from associated laboratory analyses
- Ensure that the description of each data point is meaningful and complete
- Ensure that large volumes of data can be handled efficiently
- Ensure that each data point is accurate and readily accessible

Data created by the field work activities are described in the following sections and include the following:

- Field measurement data (radiological land survey and *in-situ* gamma and metals data)
- Survey information
- Sample collection and tracking information
- Field laboratory analytical results
- Offsite laboratory analytical results

Data will be managed as shown in Figure 7-1, Data Management System Flow Chart. Surveys will be performed to set the boundaries and depths for each excavation and all confirmatory sample locations. These locations will be surveyed, and coordinant information will be uploaded to the survey database. Surface soil samples will be collected for confirmation of remediation goals. Sampling event forms such as the chain of custody will be completed. This information will be stored in the tracking database. Confirmation samples and stockpile characterization samples will receive Level III analyses and full validation. Analytical results will be uploaded into the test and results database. These data files will be used in a GIS to produce maps that illustrate the success of the characterization.

Data will be entered into the data management system through manual data entry, downloading from data loggers, and electronic files supplied by the laboratories. Data from the sampling event forms will be manually entered into the project database. Hard copies of these data will be generated and scrutinized for errors, omissions, and problems. Identified errors and omissions will be corrected. Problems will be researched and corrected before sampling has terminated. Field personnel will be closely involved in verifying and providing complete information regarding sampling events to ensure that QA/QC sampling objectives are met. Data will initially be entered or uploaded into an interim table. Data quality assurance will consist of a variety of techniques depending on the source of the data. Manually entered data will be randomly verified. Newly entered data from all sources will be evaluated using queries to check for outliers or anomalous data. The data will be transferred into final database tables only after data

quality has been assured by the Project Lead or designee. The database will be backed-up nightly. Hard-copy original data sheets will be maintained in the project files until project completion and closeout at which time project files will be turned over to the client.

7.14 Assessment and Response Actions

Performance and system audits of field activities will be conducted to verify that activities are performed in accordance with the procedures established by or provided in the SAP and this QAPP. Audits of field activities will be conducted by or under the direction of the Site QA Manager. The audit will include a review of applicable records, record-keeping practices, and field operations to ascertain that field activities are conducted in accordance with established procedures.

A field audit will take place at the commencement of the project to determine that personnel are aware of and capable of executing project activities in accordance with the procedures established for those activities. Follow-up audits or surveillances will be conducted to ensure that established procedures continue to be followed. At least one project-wide follow-up audit will be performed. Audits may also be performed to verify the implementation of specified corrective actions.

The Site QA Manager will prepare a written record of any field audits performed. Findings of any such audits, including corrective actions recommended or required, will be included in this record. Corrective actions may be required for either field or laboratory actions. The procedures for initiating a corrective action are similar in both cases. Corrective actions may be required in the field to correct situations or conditions with a negative impact on data or sample quality. These conditions may arise from an instrument or device malfunction or from a failure to follow established procedures. If the corrective action is necessary due to a malfunctioning instrument or piece of equipment, formal corrective action will be implemented as soon as the existence of an equipment or instrument malfunction is brought to the attention of the Site QA Manager.

The Project Manager shall concur with the proposed corrective actions. The Site QA Manager will undertake the following actions:

- Identify the item that is not functioning properly,
- If possible, determine how long the item has been malfunctioning,
- Remove the item from service and order its repair or replacement, and
- Evaluate the effect of the malfunction on current and past operations.

The Site QA Manager will make a written record of the circumstances of the corrective action. If the condition results in the impairment of the quality of data already collected, the Site QA Manager will identify the affected data, evaluate the effect of the equipment malfunction, and take appropriate action to correct the affected data, if this is possible. Corrected data will be noted as such, together with a statement of how the correction was performed. Data that cannot be corrected will be identified. Limitations on the future usability of the data will be noted.

The Site QA Manager will conduct such follow-up investigations as may be required in the event of an equipment malfunction. The effectiveness of any repairs, replacement, or recalibration will be examined and evaluated.

If the corrective action is a result of procedural non-compliance, the Site QA Manager will take the following actions:

- Consult with the Project Manager to identify the situation and define its scope and significance,
- Evaluate the effect on data quality of the failure to follow approved procedures,
- Determine the extent and duration of the procedural breakdown,
- Instruct affected personnel in the proper procedure,
- Conduct follow-up inspections, observations, or audits to ensure that the procedure is being properly utilized, and
- Prepare a written record of the corrective action.

In the event that project personnel discover errors or inconsistencies with laboratory data, the Site QA Manager will initiate an investigation to determine if a corrective action is required. Corrective action may be ordered by the Site QA Manager in the event that any condition or circumstance results in the impairment of laboratory data. The laboratory will be required to inform the Site QA Manager of any laboratory corrective actions undertaken and identify any data whose usefulness may be affected by the condition or circumstance causing the corrective action. This requirement applies for corrective actions initiated by the laboratory as well any corrective actions ordered by the Project Lead.

7.15 Reports to Management

The Site QA Manager will submit the start-up audit report to the Project Manager.

The Project Manager will submit a weekly status report to the client. This report will include status of the progress on the project and any special outstanding issues or problems.

7.16 Data Review, Validation, and Verification Requirements and Methods

Data review and validation will be performed similarly to that completed for the soil sampling performed in December 2004. A copy of this validation is attached in Appendix H.

A summary of QA activities, including conditions or situations affecting data completeness or quality, corrective actions, and outcomes of corrective actions will be prepared as part of the final report. The report will address completeness and reliability of data generated during project activities, quality and completeness of documentation, and identify data and documentation that is incomplete or not in conformance with the project requirements.

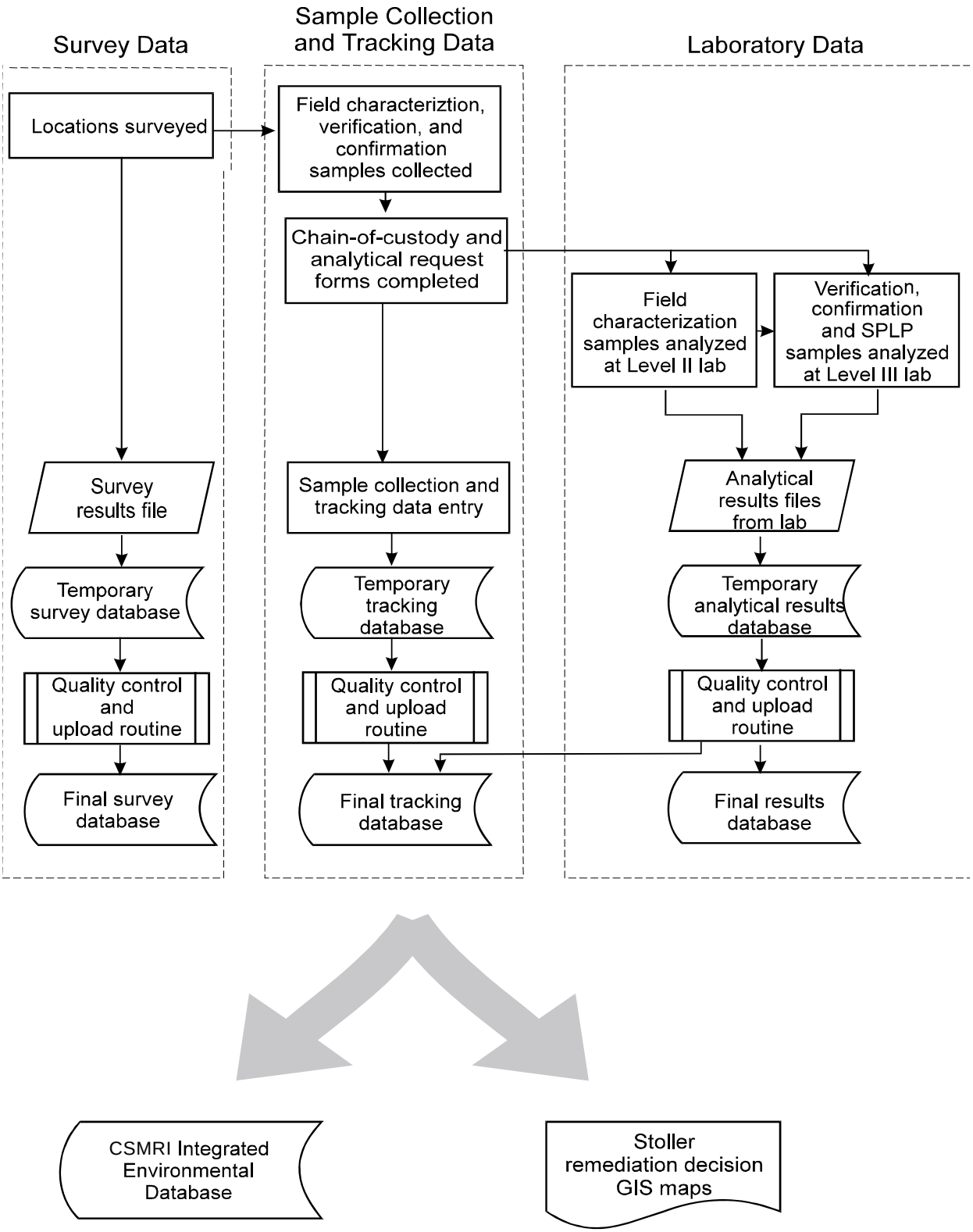

Figure 7-1 – Data Management System Flow Chart

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Appendix A
Site Licensing History

Appendix A
Site Licensing History

The Site licensing and regulatory history is described in the RI/FS (pp. 4-12 through 4-44). Government regulators concluded that the facility would be regulated under the authority of the Solid Waste Disposal Sites and Facilities Act and associated regulations.

Prior to this governmental determination, CSMRI applied for permits under RCRA, Subtitle C, which regulates hazardous waste management, including the permitting for treatment, storage, and disposal facilities of hazardous materials. Obtaining a RCRA hazardous waste permit requires a two-part application process. On November 17, 1980, CSMRI submitted a Part A permit application. On August 24, 1984, EPA requested that CSMRI complete the permitting process by submitting a Part B permit application. In undertaking the more detailed Part B application, it became apparent that original Part A application had been filed in error and that the facility was not subject to RCRA, Subtitle C, hazardous waste regulations. CSMRI submitted a request for exemption from Subtitle C as provided in 40 CFR part 261.4(b)(7). CDPHE reviewed this information and determined the facility was exempt from Subtitle C of RCRA.

Although most of the research at the Site was not related to the study of radioactive materials, CSMRI possessed, and continues to possess, a license for the storage, handling, and possession of Naturally Occurring Radioactive Materials (NORM), source, and byproduct material (Colorado Radioactive Materials License Number 617-01S).

A chronological summary of the U.S. Atomic Energy Commission (AEC) and the State of Colorado licensing actions at the CSMRI Site is provided in Table 1-1.

Summary of State of Colorado Licensing Actions at CSMRI

Time Period	License Details
Terminated 1948	Weinig had License No. R-120 from the AEC for source material, which terminated in 1948. V2731, V2732. Weinig's clients also may have had separate licenses from the AEC for research at the Site. V1436.
1958 – 1967	The State of Colorado has records of AEC licensing actions dating from January 1958 through December 1967.
1958 – 1967	AEC Byproduct Material License Number: 5-4607-1 (including amendment #1 through amendment #23) dated from January 1958 through December 1967 Issued to: Colorado School of Mines Research Foundation, Inc. Authorized uses: laboratory research; teaching of industrial radioisotopic courses; as a component of a neutron generator for activation analysis; calibration of instruments; measurement of specific gravity of slurry in a pipeline; laboratory tracer studies; monitoring of solutions and slurries; metallurgical studies; neutron generator for activation analysis; experimental curing of thin plastic films deposited on ceramics; studies of molybdenum; geochemical research; to measure wear rate of experimental pipelines and machines and similar laboratory studies; and for the determination of solubility constants.
1966	AEC Special Nuclear Materials License Number: SNM -972 (for Plutonium), dated August 1966 Issued to: Colorado School of Mines Research Foundation, Inc. Authorized uses: for use in accordance with the procedures described in the licensee's application dated July 20, 1966. Storage only of soil samples.

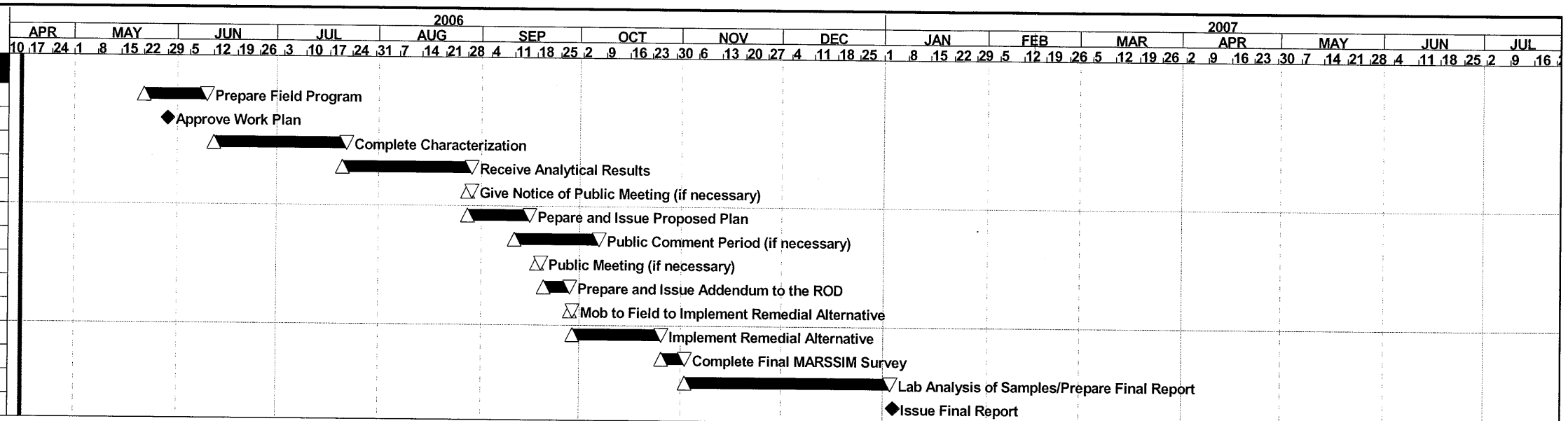
Summary of State of Colorado Licensing Actions at CSMRI

October 24, 1968	Colorado Radioactive Materials License Number: Colo. 08 – 01 (F) Issued to: Colorado School of Mines Research Foundation, Inc. and Colorado School of Mines. Authorized uses: Research, development, and teaching.
March 7, 1969	Amendment No. 2 to License Number: Colo. 08 – 01 (F).
May 25, 1971	Amendment No. 2 to License Number: Colo. 08 – 01 (F).
September 29,1971	Amendment No. 3 to License Number: Colo. 08 – 01 (F).
February 25,1972	Amendment No. 4 to License Number: Colo. 08 – 01 (F).
August 16, 1974	Amendment No. 5 to License Number: Colo. 08 – 01 (F).
Note: The State does not have records of licensing actions between November 1975 and March 1985.	
April 10, 1985	Colorado Radioactive Materials License Number: Colo. 617-01S Issued to: Colorado School of Mines Research Institute. Authorized uses: Possess, use, and store.
March 25, 1986	Amendment No. 1 to License Number: Colo. 617-01S
September 11, 1990	Amendment No. 2 to License Number: Colo. 617-01S. Issued to: Colorado School of Mines Research Institute. Authorized uses: Possess, use, and store.
October 31, 1997	Amendment No. 3 to License No. 617-01S
March 30, 2001	Amendment No. 4 to License No. 617-01S
February 11, 2002	Amendment No. 5 to License No. 617-01S. Issued to: Colorado School of Mines Research Institute. Authorized uses: Possess and store naturally occurring, source and byproduct.

Both the AEC and the State of Colorado licensed the Site over several decades for numerous types of radioactive materials. The current license includes NORM, source material, and byproduct material. Previous licenses authorized possession and use of any radioactive materials having atomic numbers 3 through 88 inclusive, americium, and plutonium. The licenses authorizing the use of americium state that americium was for the calibration of instruments and for gauges. The amounts of americium maintained onsite for these instruments must have been minute. No records are related to the disposal of americium.

Appendix B
Project Schedule

Activity ID	Activity Description	Orig Dur	Rem Dur	%	Early Start	Early Finish
Colorado School of Mines						
110	Prepare Field Program	15	15	0	22MAY06	09JUN06
120	Approve Work Plan	0	0	0	29MAY06	
120	Complete Characterization	30	30	0	12JUN06	21JUL06
125	Receive Analytical Results	27	27	0	21JUL06	28AUG06
130	Give Notice of Public Meeting (if necessary)	1	1	0	28AUG06	28AUG06
140	Pepare and Issue Proposed Plan	15	15	0	28AUG06	15SEP06
150	Public Comment Period (if necessary)	20	20	0	11SEP06	06OCT06
160	Public Meeting (if necessary)	1	1	0	18SEP06	18SEP06
170	Prepare and Issue Addendum to the ROD	6	6	0	20SEP06	27SEP06
180	Mob to Field to Implement Remedial Alternative	1	1	0	28SEP06	28SEP06
190	Implement Remedial Alternative	19	19	0	29SEP06	25OCT06
200	Complete Final MARSSIM Survey	5	5	0	26OCT06	01NOV06
210	Lab Analysis of Samples/Prepare Final Report	44	44	0	02NOV06	02JAN07
220	Issue Final Report	0	0	0		03JAN07



Start Date	14APR06
Finish Date	
Data Date	15APR06
Run Date	10MAY06 09:45

Early Bar
Progress Bar
Critical Activity

CSM2

Sheet 1 of 1

S.M. Stoller Corporation

Colorado School of Mines

Classic Schedule Layout

Date	Revision	Checked	Approved

Appendix C
Site-Specific Health and Safety Plan

S.M. STOLLER CORPORATION
SITE-SPECIFIC HEALTH AND SAFETY PLAN

Project Location:	Colorado School of Mines Research Institute (CSMRI)
Task Name:	Field characterization
Duration of Activities:	Duration of contract. This HASP will be modified, as necessary, if new tasks are added.

APPROVALS

Title/Organization:	*Printed name:*	*Signature:*	*Date:*
Project Manager	Steve Brinkman		
Health and Safety Supervisor	Harry Bolton		
Health and Safety Manager	Patrice McEahern		

SCOPE OF WORK

Breakdown and description of work activities:

1. Mobilize and establish field office/lab, work zones, and equipment staging areas.
2. Conduct preliminary site leveling and relocate known contaminated soil to stockpile.
3. Conduct field gamma scan (Eberline subcontractor).
4. Obtain initial background soil samples.
5. Obtain verification samples for metals and gamma surveys.
6. Package/ship samples to offsite laboratory.
7. Conduct field measurements using field XRF and gamma survey instruments.
8. Collect soil samples for verification in field laboratory by NaI instrumentation (New Millennium subcontractor)
9. Move soil to stockpiles based on results of field surveys.
10. Apply dust suppression water as required.
11. Collect samples from soil stockpiles upon completion of excavation.
12. Conduct final status survey of site for verification that DCGLs were met.

Should any off-normal event occur, work will immediately stop and will not commence unless the hazards have been addressed and the necessary THA, procedure, or HASP modification completed.

PERSONNEL

Assigned Responsibility:	*Name and Organization:*	*Phone Number:*
Project Manager	Steve Brinkman	303-546-4388 office, 303-994-1883 cell
Assistant Project Manager	Harry Bolton	303-546-4351 office, 303-435-4872 cell
Health and Safety Supervisor	Harry Bolton	303-546-4351 office, 303-435-4872 cell
Radiation Safety Officer (RSO)	Patrice McEahern	303-546-4300 office
Alternate RSO	Joseph Gordon	303-546-4318 office, 303-817-4884 cell

TASK HAZARD ANALYSIS

Task-specific hazard control measures are specified in each Task Hazard Analysis (THA). THAs have been developed for the following activities and are included as attachments. Activities with procedures have hazard abatement incorporated into the procedure and do not have THAs.	
Activities with a THA:	
General Maintenance	
General Site/Visitor	
Field sampling/remediation	

PERMITS

(Required permits must be signed before work commences.)

Permit:	No	Yes	Notes and Comments:
Hot Work	X		Hot work is not anticipated.
Rad Worker	X		Conditions identified onsite do not warrant this permit.
Confined Space	X		This type of work is not anticipated.
Lockout/Tagout	X		Most of the activities anticipated can be controlled by unplugging the cord. Any other electrical activities will be undertaken by a licensed electrician.
Excavation/Intrusive Soil Activity	X		Utilities have previously been identified, and no permit is required.
Other:			

PERSONAL PROTECTIVE EQUIPMENT

The following personal protective equipment (PPE) will be used for the identified activities.

Activity	Head/Face	Foot	Hands	Respiratory	Clothing
Site preparation, general maintenance, and support functions	Safety glasses	Sturdy, over the ankle leather boots	Dedicated leather gloves when using tools	NA	Standard work clothing, high-visibility safety vest when heavy equipment is onsite
Soil sampling, field XRF, and gamma surveys	Safety glasses. Hearing protection as necessary.	Sturdy, over the ankle leather boots. Tyvek or latex boot covers	Synthetic gloves (nitrile) or dedicated leather gloves	NA	Standard work clothing, Tyvek suit, high-visibility safety vest

Dust suppression and decontamination	Safety glasses, face shield when spraying water	Sturdy, over the ankle leather boots. Latex boot covers	Synthetic gloves (nitrile), dedicated leather gloves when using tools	NA	Standard work clothing, coated Tyvek suit or rain suit, high-visibility safety vest
Visitor	Safety glasses	Sturdy, over the ankle leather boots	NA unless touching equipment	NA	Standard work clothing, high-visibility safety vest when heavy equipment is onsite

The following competent person certifies that a hazard assessment for the identified activities has been performed and the selection of PPE is based on best available information.

Printed Name:	Signature:	Date:
Patrice McEahern		September 20, 2005

TASK HAZARD(S) SUMMARY

The potential health and safety hazards of these tasks are summarized below. The potential for encountering these hazards is ranked (high, medium, or low) based on the work to be performed and the hazard control measures to be used.

Summary	*Hazard Potential (High, medium, or low)*	*Description of potential hazards (List each potential hazard)*
☒ Safety *Walking and working surfaces, falls, power and hand tools, materials handling*	Medium	Slips, trips, or falls due to uneven walking surface or wet/snow/icy conditions, hand tool usage
☐ Utilities *Buried, overhead, or in general work area*	Low	
☐ Chemical *Identify chemicals of concern here, and attach MSDSs*	Low	
☒ Physical *Heat, cold, noise, radiological*	Medium	Radiological contamination from inhalation or skin contact. Data results indicate that rad concentrations in soil and air are sufficiently low that the PPE described for each task will eliminate exposure potential. Potential heat stress issues for personnel wearing Tyvek. Potential cold stress due to weather.
☒ Biological *Plants, animals, insects, spiders, infectious waste*	Medium	Spiders/insects may be present, and possibly animals such as raccoons, foxes, coyotes, and squirrels.

☒ Other - Heavy Equipment	Medium	Soil moving equipment will be onsite. All personnel working in vicinity of heavy equipment will wear reflective safety vests and will act as spotters for equipment operators as necessary.

SITE MONITORING

(Task-specific monitoring requirements are identified below.)

Direct Reading Exposure Monitoring (to monitor potential worker exposure)

Activity(s)	*Instrument*	*Action Level(s) and Actions*	*Frequency*
Scanning trucks, equipment, and personnel monitoring	Ludlum Model 19 dose rate survey instrument (or similar) Alpha/beta scintillation probe with rate meter/scaler for contamination surveys	Monitoring to be conducted periodically/as needed to evaluate site conditions and keep personnel exposures as low as reasonably achievable. Dose rates will be tracked hourly and used with personnel work durations to ensure personnel exposure remains below 100 mrem/yr.	All personnel and equipment leaving contamination area must be surveyed.

Integrated Personal Air Monitoring (full-shift worker exposure sampling and/or analysis)

Activity(s)	*Contaminant*	*Method*	*Frequency*
This will be conducted should sample results indicate airborne material is present			
Comments or special instructions:	Metals: lead, arsenic, mercury Radionuclides: radium, thorium, uranium	Using maximum site concentrations of metals and radionuclides from RI/FS, calculations show no personal air monitoring will be required (see attached analyses).	

Perimeter or Work Area Monitoring (ambient work area or fence line monitoring)

Activity(s) /Location	*Contaminant(s)*	*Method*	*Frequency*
Perimeter air monitoring stations will be operated at the site. Two are run throughout the contract period (sampled quarterly) and four additional monitors will be used during soil excavation/sampling (sampled weekly).	Radionuclides	Filters counted for gross alpha/beta onsite. Filters sent to offsite laboratory for isotopic analysis if gross alpha/beta above action level specified in work plan.	Weekly during soil excavation/sampling; monthly during remainder of contract

Comments or special instructions: Operations will be evaluated by the site supervisor when wind speeds exceed 20 mph as determined by an onsite anemometer. If dust cannot be adequately controlled by dust suppression water, activities will be shut down.

SITE CONTROL

(Task-specific site control measures are specified below)

Site Control for General Work Area(s)	
Location	***Site Control Procedure (discuss important elements such as signs, barricades, fencing, briefings, sign-in/out logs, etc)***
	Individual time in the work area will be documented in log books or a sign-in log. A tailgate meeting will be completed for activities conducted at the site on a daily basis. The work area is fenced.
Site Control for Potentially Contaminated Area(s)	
Location	***Site Control Procedure (discuss important elements such as signs, barricades, briefings, qualifications, required supplies and equipment, sign-in/out logs, etc.)***
Support Zone	The work area is fenced and posted.
Contamination Reduction Zone	NA
Exclusion Zone	NA

DECONTAMINATION

(Required decontamination procedures are described below)

Type of decontamination	***Identify activity(s) requiring decontamination and describe decontamination steps, location, required equipment, and collection and disposal of potentially contaminated liquids and solids.***
Personnel decontamination	Proper doffing and disposal of booties, gloves, and Tyvek as sanitary waste.
Equipment decontamination	Soil excavation equipment will be visually inspected to ensure the exterior is free from waste material. Excavation equipment will be decontaminated using water from a hydrant as necessary. Sample bottles and other field equipment that is not disposable will be swipe sampled and decontaminated if necessary using wet wipes to verify that removable contamination is below free release limits.
Other:	Radiological surveys will be conducted on all personnel and equipment leaving the contamination area.

COMMUNICATIONS

(A primary and back-up means of communications for field crews have been established as described below)

Type of communication	**Primary means**	**Back-up means**
Communications with home base	Cell phones 303-546-4300, Stoller Office	
Communications among field crew members	Hand signals or voice communications	
Communications with client	Cell phone 303- 273-3998	

MEDICAL SURVEILLANCE AND QUALIFICATION

The following medical surveillance is required for on-site personnel working in the field.

Required medical surveillance:	Job-specific medical testing:
_____ Hazardous Waste _____ Respirator Use _____ Hearing Conservation _____ Other: **None required**	Describe: NA

HAZARDOUS CHEMICALS

Hazardous chemicals (as defined in 29 CFR 1910.1200) to be brought or used onsite are identified below. This chemical inventory will be maintained and Material Safety Data Sheet(s) shall be maintained on the site.

Chemical Name	Amount	Location	Purpose
NA			

REQUIRED FACILITIES AND EQUIPMENT

The following facilities and equipment are required for safe completion of work.

Facility	*Type:*	*Location:*
_____ Worker Showers/Lockers		
x____ Restrooms		Public or at the school/close proximity. Portable toilet will be onsite during extended field activities.
_____ Supplementary Illumination		
_____ Emergency eyewash/shower		
x____ First Aid Supplies	Eyewash bottle will be included in first aid kit	Vehicle
x____ Fire Extinguishers		Vehicle
_____ Hazardous Materials Storage		
x____ Spill Containment/Clean-up	For solid waste spills: shovels, bags, wipes, decon solution. For liquid waste spills: vermiculite and shovel.	Vehicle
_____ Other:		

TRAINING

(The following training is required for onsite personnel working in the field. Copies of training certificates and training records will be kept onsite)

_____ 40-hour General Site Worker _____ 8-hour Supervisor _____ 3-day On-the-Job _____ 8-hour Refresher _x___ HASP Orientation (for all workers and visitors) _____ Hazard Communication _____ Hearing conservation _*___ Radiation Worker	Please describe: Field personnel and visitors must be trained on the requirements of the health and safety plan and the PPE requirements. *Radiation protection requirements will be covered in site-specific training.

EMERGENCY ACTION AND RESPONSE

Personnel responsible for coordinating emergency situations during site activity are identified below. A site map showing assembly points and directions to the authorized medical facility is attached. Documented rehearsal and critique of this plan is required at least once during the task, or more often as necessary.

Responsibility	***Name***	***Phone Number(s)***
Task Emergency Coordinator	Steve Brinkman	303-546-4388
Client Interface	Linn Havelick	303-273-3998
Type/Frequency of Rehearsal	NA	

If an emergency situation develops that requires evacuation of the work area, the following steps shall be implemented.

Evacuation Step	***Methods and comments:***
Notify affected workers	Cell phones, hand signals, or voice communications
Evacuate to safe location	Parking area, immediately offsite
Assemble and account for workers	At parking area
Notify emergency services	Call 911
Complete incident report	Affected worker and /or supervisor

Potential emergency situations and response actions are identified below:

In case of:	***Response actions:***
Fire or personnel injury	911

ATTACHMENTS

Applicable attachments to the task-specific health and safety plan are identified below:

Attachment Number:	***Title:***
1	Personnel Air Monitoring Calculations
2	Site Map
3	Task Hazard Analysis Forms
4	Tailgate Safety Meeting Forms
5	Map to Hospital

ATTACHMENT 1
PERSONNEL AIR MONITORING CALCULATIONS, CSMRI CREEKSIDE SITE

Permissible Exposure Level (PEL) Calculations

Utilizing the average and maximum values for the metal and radionuclide contaminants of concern from the RI/FS report, a calculation was made for how large a dust cloud would need to be to reach the PEL of any of the contaminants. The results are shown in the following table.

Sample Location	Contaminant	RI/FS data used	Size of dust cloud to reach PEL of any contaminant
Surface Soils	Metals	Maximum contaminant values	Dust Cloud of 0.7 mg/m^3
Surface Soils	Metals	Mean contaminant values	Dust Cloud of 16 mg/m^3
Surface Soils	Th and Uranium Isotopes	Maximum contaminant values	Dust Cloud of 2.5 mg/m^3
Borings	Metals	Maximum contaminant values	Dust cloud of 2.42
Borings	Metals	Mean contaminant values	Dust cloud of 33 mg/m^3
Borings	Th and Uranium Isotopes	Maximum contaminant values	Dust cloud of 2.98 mg/m^3
Test Pits	Th and Uranium Isotopes	Maximum contaminant values	Dust cloud of 5.72 mg/m^3
Test Pits	Metals	Maximum contaminant values	Dust cloud of .9 mg/m^3
Test Pits	Metals	Mean contaminant values	Dust cloud of 17.28 mg/m^3

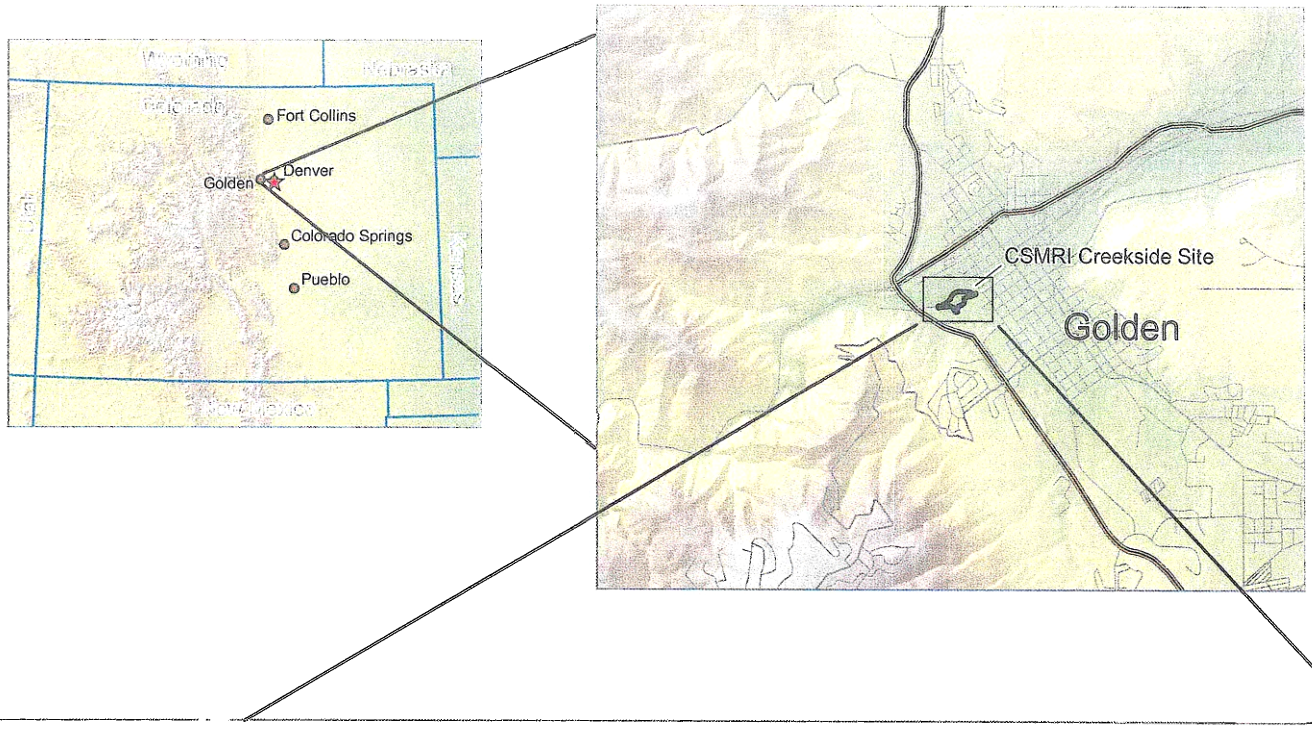
For example, this table shows that for mean metals surface data, a dust cloud with a concentration of 16 mg/m^3 would have to be generated to reach the PEL of any of the contaminants. This type of dust concentration would be seen for miles and would not occur at the site even if dust suppression was not provided. Using the maximum concentration for metals surface sampling, a dust cloud with a concentration of 0.7 mg/m^3 would be required to reach any of the PELs. Good dust suppression will accomplish this. Therefore, adequate dust suppression is achieved, even with the maximum concentrations, respirators will not be required.

Internal and External Radiation Monitoring

The 100 mrem/yr limit is a total effective dose equivalent (TEDE). The TEDE is a summation of the deep dose equivalent (external exposure) and the committed effective dose equivalent (internal exposure). Therefore, the potential exposures from airborne and external radiological sources need to be assessed.

The need for air sampling can be estimated by calculating the required soil concentration for each isotope of interest if resuspended that would equate to a 40 DAC-hr exposure during the expected time period that a worker was to be on the project. We have calculated the time required to receive a CEDE of 25 mrem (assuming member of the public) for each of the radionuclides using their maximum concentrations shown in the RI/FS report and assuming resuspension. Based on this calculation, air monitoring for these radionuclides is not required (note this calculation does not include radon progeny).

The dose rate at a vertical distance of 3 feet from an infinite slab 1 foot thick has also been computed. The slab contains the maximum concentrations of the reported radionuclides. The dose at this distance is approximately 1.1 mrem/hr. If an individual were to work at the site in this average field for 8 hours per day they could potentially receive 8 mrem. Therefore, the dose rates in the work zone will be monitored and stay times will be determined so that individuals cannot exceed the 100 mrem/yr constraint.



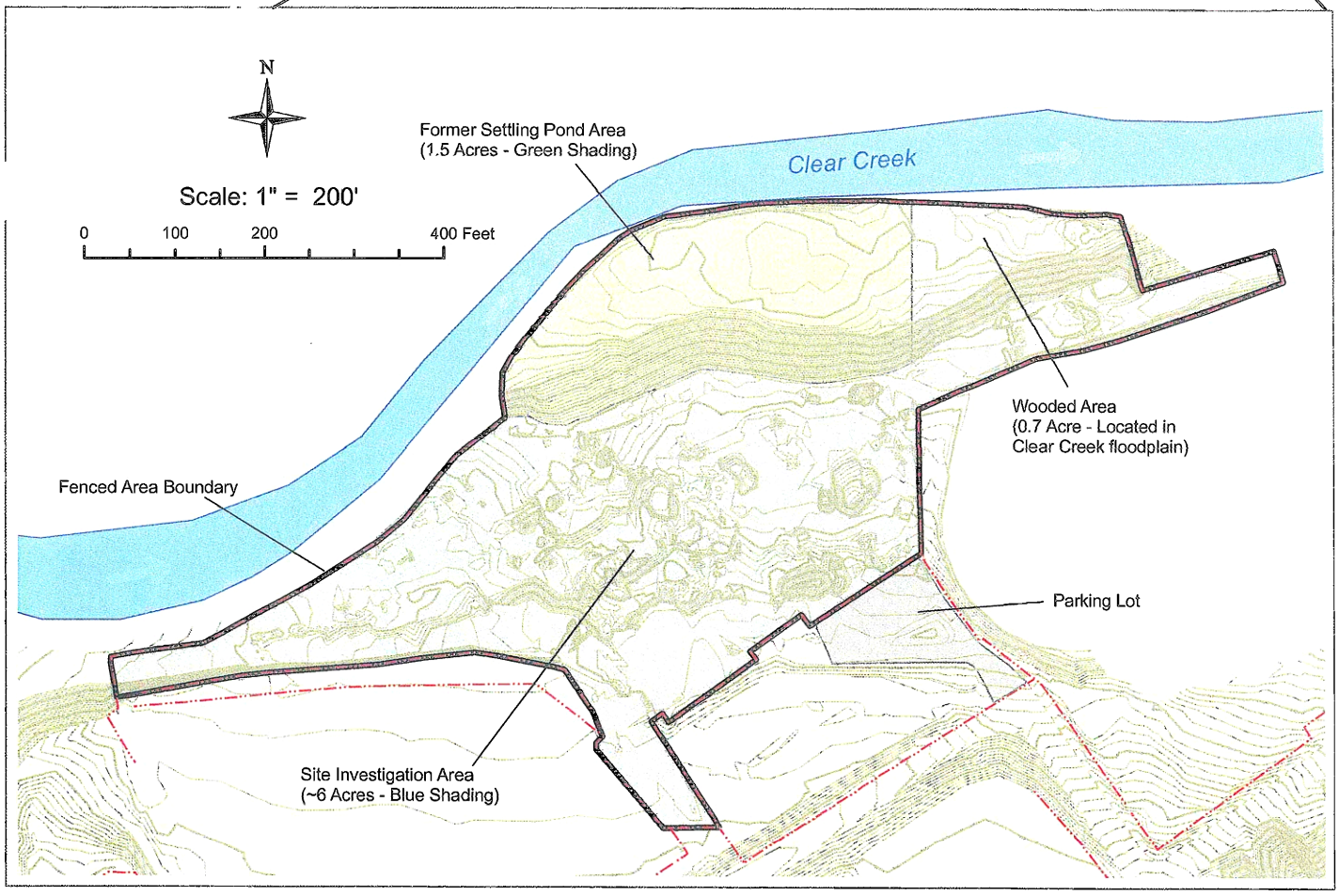


Figure 1

CSMRI
Site Location Map

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Culverts

CSMRI
Health & Safety Plan

Stoller

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TASK HAZARD ANALYSIS FORM

Project & Location **Colorado School of Mines Research Institute** **Visitor THA**	**Health and Safety Manager/Supervisor Approval**	**Date** **8/18/2005**
Description of Job This THA encompasses activities a visitor would conduct on the site (just walking through. No contact with work surfaces)	Page 1 of 2	THA # CSMRI 1
	Title of Person Who Does: Various	
	Required PPE Minimum - Safety glasses, sturdy over the ankle leather boots, safety vest when heavy equipment is onsite	
	THA Completed By Dalene Nickelson	

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
1. Receive THA orientation, sign THA and sign visitor log	Loss of site control	Use buddy system Adhere to requirements of THA
2. Park/walk in designated areas	Loss of site control creating potential spread of contaminants	Stoller will provide direction as to where to walk and/or park
3. Training	Uninformed visitors	Site-specific THA training required No other training No medical surveillance requirements

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
4. No contact rule	Potential for contamination	Do not sample soil Do not touch bags Walk around standing water Do not sit on the ground Wear disposable boot covers as directed
5. Booty disposal	Potential cross contamination	Wear disposable booties when ground is wet/muddy Follow proper doffing techniques Place booties in receptacles provided and as directed
6. Emergency procedures	Visitors not accounted for	Meet in designated assembly area Follow directions provided by Stoller project manager on site

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TASK HAZARD ANALYSIS FORM

Project & Location **CSMRI** **Golden, CO**	**Health and Safety Manager/Supervisor Approval**	**Date** **8/18/2005**
Description of Job Maintenance of Facility	Page 1 of 2	THA # CSMRI 2
	Title of Person Who Does Job: Technician	
	Required PPE: Standard work clothing, safety glasses, leather gloves, sturdy over the ankle leather boots, safety vest when heavy equipment is onsite	
	THA Completed By Dalene Nickelson	

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
Complete Tailgate Meeting Document and necessary Procedure review before work		
1. Trash pick up and removal	Slips, trips and falls on uneven terrain	1. Wear appropriate sturdy over the ankle leather boots
	Cuts	1. Ensure any glass or sharp metal is placed in a separate trash receptacle to reduce possibility of cuts 2. Wear leather gloves
	Wind	1. Wear appropriate clothing and safety glasses, as needed, to reduce the possibility of eye injury 2. Refrain from this duty on windy days, if possible
	Potential cross-contamination	1. Wear disposable boot covers or chemical resistant boots when wet/muddy
2. Fence integrity	Cuts	1. Fence repair will be conducted by contracted Company

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
3. Electrical maintenance	Electrical shock	1. Electrical repair will be conducted by contracted Company
4. Onsite visual survey	Slips, trips and falls	1. Wear appropriate sturdy over the ankle leather boots
	Potential cross contamination	1. Wear disposable boot covers or chemical resistant boots when wet/muddy

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TASK HAZARD ANALYSIS FORM

Project & Location **CSMRI** **Golden, CO**	**Health and Safety Manager/Supervisor Approval**	**Date** **9/20/2005**
Description of Job **Field sampling/remediation**: Conduct preliminary site leveling and relocate known contaminated soil to stockpile. Conduct field gamma scan. Obtain initial background soil samples and correlation samples for metals and gamma surveys. Conduct field measurements using XRF and gamma survey instruments to guide excavation of contaminated soil to stockpiles. Collect soil samples for onsite lab gamma survey. Apply dust suppression water as required. Upon completion of surveys/excavation, sample soil stockpiles and conduct final status survey of site.	Page 1 of 4	THA # CSMRI 4
	Title of Person Who Does Job: Technician	
	Required PPE: Standard work clothing, safety glasses, nitrile gloves or dedicated leather gloves, sturdy over the ankle leather boots, Tyvek or latex boot covers, Tyvek coveralls, high-visibility safety vest when heavy equipment is onsite, face shield when spraying water.	
	THA Completed By Carolyn Hicks	

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
Complete Tailgate Meeting Document and necessary procedure review before work		
1. Collect soil samples, including background, metals and gamma correlation, onsite gamma lab, soil stockpiles, and final survey. Also conduct field XRF and gamma surveys.	Slips, trips, and falls on uneven or slippery terrain	1. Wear appropriate sturdy, over the ankle leather boots. 2. Maintain good housekeeping. 3. Dust suppression water should be applied as a mist and not applied in excessive quantities that would cause muddy conditions. 4. After rain or snow events, extra care should be taken when walking onsite and working in excavations.

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
	Heat stress from wearing Tyvek coveralls	1. Drink plenty of fluids. 2. Take rest breaks as needed 3. Follow heat stress stay times or work/rest regimens as directed by H&S lead.
	Cold stress	1. Drink plenty of fluids. Avoid the use of alcohol, caffeine, and tobacco. 2. Wear appropriate cold weather clothing (hat, gloves, boots, etc.) Dress in layers. Adjust clothing as needed to prevent excessive sweating while working in the cold. Keep clothing dry. 3. Take warm up breaks as needed.
	Soil cave-ins in pits/trenches	1. Excavations will be maintained in accordance with OSHA regulations in 29 CFR Part 1926. Ladders or ramps will be provided for egress if excavations are over 4 feet deep. Excavated or other material will be kept 2 feet from the edge to keep them from falling in. Sloping or benching will be used if excavations are over 5 feet deep. 2. Inspections of excavations and adjacent areas will be conducted daily and after rainstorm events to check for hazardous conditions.
	Radiological hazards	1. Wear appropriate PPE: Tyvek coveralls, boot covers, gloves 2. Follow proper doffing techniques. 3. Do not touch face while working 4. Self-monitor after doffing PPE using alpha/beta frisker 5. Ensure dust suppression water is used adequately
2. Move soil to designated stockpiles	Personnel injured by heavy equipment	1. Maintain a safe distance from the operating equipment and wear high visibility safety vests. 2. All equipment shall be operated per manufacturer's instructions. 3. Only trained and qualified personnel shall operate heavy equipment. 4. Operators to inspect heavy equipment to ensure proper working order. 5. Personnel will not walk to the side or behind heavy equipment without the operator's knowledge. 6. Ground personnel and equipment operator are to maintain communication using hand signals, radios, or voice commands. 7. Loader operator may need assistance in spotting during material moves. 8. At no time shall personnel be under a suspended load.
	Heat stress from wearing Tyvek coveralls	1. Drink plenty of fluids. 2. Take rest breaks as needed 3. Follow heat stress stay times or work/rest regimens as directed by H&S lead.
	Cold stress	1. Drink plenty of fluids. Avoid the use of alcohol, caffeine, and tobacco. 2. Wear appropriate cold weather clothing (hat, gloves, boots, etc.) Dress in layers. Adjust clothing as needed to prevent excessive sweating while working in the cold. Keep clothing dry. 3. Take warm up breaks as needed.

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
	Slips, trips and falls on uneven terrain	1. Wear appropriate sturdy, over the ankle leather boots. 2. Maintain good housekeeping. 3. Dust suppression water should be applied as a mist and not applied in excessive quantities that would cause muddy conditions. 4. After rain or snow events, extra care should be taken when walking onsite and working in excavations.
	Radiological hazards	1. Wear appropriate PPE: Tyvek coveralls, boot covers, gloves 2. Follow proper doffing techniques. 3. Do not touch face while working. 4. Self-monitor after doffing PPE using alpha/beta frisker. 5. Stand upwind of loading operations if windy conditions are present.
	Noise	1. Wear hearing protection in high noise areas (where normal conversation is difficult with other person two feet away).
3. Decontaminate loaders and provide dust suppression with water from hydrant	Personnel injured by heavy equipment	1. Maintain a safe distance from the operating equipment and wear high visibility safety vests. 2. All equipment shall be operated per manufacturer's instructions. 3. Only trained and qualified personnel shall operate heavy equipment. 4. Operators to inspect heavy equipment to ensure proper working order. 5. Personnel will not walk to the side or behind heavy equipment without the operator's knowledge. 6. Ground personnel and equipment operator are to maintain communication using hand signals, radios, or voice commands. 7. Loader operator may need assistance in spotting during material moves. 8. At no time shall personnel be under a suspended load.
	Heat stress from wearing Tyvek coveralls	1. Drink plenty of fluids. 2. Take rest breaks as needed 3. Follow heat stress stay times or work/rest regimens as directed by H&S lead.
	Cold stress	1. Drink plenty of fluids. Avoid the use of alcohol, caffeine, and tobacco. 2. Wear appropriate cold weather clothing (hat, gloves, boots, etc.) Dress in layers. Adjust clothing as needed to prevent excessive sweating while working in the cold. Keep clothing dry. 3. Take warm up breaks as needed.
	Slips, trips, and falls on uneven terrain	1. Wear appropriate sturdy, over the ankle leather boots. 2. Maintain good housekeeping. 3. Dust suppression water should be applied as a mist and not applied in excessive quantities that would cause muddy conditions. 4. After rain or snow events, extra care should be taken when walking onsite and working in excavations.
	Radiological hazards	1. Wear appropriate PPE: Tyvek coveralls, boot covers, gloves 2. Follow proper doffing techniques. 3. Do not touch face while working 4. Self-monitor after doffing PPE using alpha/beta frisker

Sequence Of Basic Job Steps	Potential Hazards	Hazard Control/PPE
	Water spray from hose	1. Wear face shield when spraying water 2. Wear coated Tyvek coveralls or rain suit when individual could contact significant water spray 3. Stand upwind of truck or loader when spraying water.

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TAILGATE MEETING DOCUMENTATION

Tailgate Discussion Topic

Date of Meeting _____

Meeting Conducted by:

Printed Name _____ **Signature** _____

Meeting Attendees: Attach Any Handouts and File in Project Files

DATE	PRINTED NAME	SIGNATURE

SchoolofMines_LuthMedCenter

SchoolofMines_LuthMedCenter

10.4 miles; 15 minutes

9:00 AM	0.0 mi	1 Depart 1500 Illinois St, Golden, CO 80401 on Illinois St (North-West) for 120 yds
9:00 AM	0.1 mi	Turn RIGHT (North-East) onto 14th St for 0.2 mi
9:01 AM	0.3 mi	Turn LEFT (North-West) onto Washington Ave for 0.5 mi
9:02 AM	0.8 mi	Take Ramp (RIGHT) onto SR-58 for 4.6 mi towards CO-58
9:08 AM	5.4 mi	Take Ramp onto I-70 for 3.4 mi towards I-70
9:11 AM	8.7 mi	At exit 269A, turn RIGHT onto Ramp for 0.2 mi towards CO-121 / Wadsworth Blvd
9:11 AM	8.9 mi	Take Ramp (RIGHT) onto SR-121 [Wadsworth Blvd] for 1.1 mi towards Wheat Ridge / Lakewood
9:14 AM	10.0 mi	Turn RIGHT (West) onto W 38th Ave for 0.5 mi
9:15 AM	10.4 mi	2 Arrive 8300 W 38th Ave, Wheat Ridge, CO 80033

Appendix D
Stormwater Management Plan

Appendix D
Stormwater Management Plan

Prepared for:

Colorado School of Mines
Golden, Colorado

Prepared by:

S.M. Stoller Corporation
Lafayette, Colorado

May 12, 2006

Table of Contents

List of Figures

List of Attachments

1. Site Description

The CSMRI Creekside Facility (Facility) is located on the Colorado School of Mines (CSM) campus in Golden, Colorado. It is located on the south bank of Clear Creek approximately 0.5 miles east of the intersection of U.S. Highway 6 and Highway 58 at the western end of 12th Street. It encompasses approximately six acres and includes the former CSMRI mineral processing operations area and the clay pits. The latitude and longitude of the site are 39.753º N, 105.227º W. Clear Creek is the receiving water from this site and the currently permitted outfall is in the west corner of the site. Figure 1 shows the Facility site and the receiving water. The Facility conducted industrial mineral research projects from 1912 until approximately 1986. These projects utilized materials common to the mineral industry: molybdenum, copper, zinc, precious metals, uranium, etc. These projects utilized approximately 16 buildings that have been removed. However, some of the building foundations, footers, and floor slabs remain and residual surface and possible subsurface impacts require remediation by characterization and excavation.

CSM and its contractor(s) are resuming site restoration activities. The current restoration project will include the removal of excavated soil that has been bagged and under cover since 2003. Additionally, contaminated soil will be characterized in the field, stockpiled based on the results of the characterization, and final site restoration composed of limited grading and seeding.

2. Construction Description

2.1 Proposed Construction Activities

- Preparation of work plans, health and safety plans, sampling plans, transportation plans, and stormwater management plans will be completed and approved prior to mobilization to the site.
- Remaining concrete slabs and footers will be staged.
- Soil sampling for characterization and stockpiling purposes will commence.
- Areas of impacted soil will be delineated, excavated, and stockpiled. Any non-impacted soils removed during this process will be stockpiled for later distribution during the grading operation.
- Final grading will be consistent with the current slope of the site, which is gently sloping to the north and northwest.
- The entire area will be reseeded with an appropriate foothills native grass mixture.

2.2 Existing Site Conditions

The entire site (6 acres) is subject to this Stormwater Management Plan although the anticipated area expected to undergo clearing, excavation, and grading is approximately 4 acres. The estimated runoff coefficient "C" value before construction activities begin is 0.1 to 0.3 based on the existing vegetative cover. Upon completion of site restoration and establishment of the vegetative cover, the runoff coefficient is estimated to be 0.10 to 0.30.

Surface soils onsite are generally sand and silt with intermittent rock, cobbles, and slag fragments. Currently, the surface coverings and established vegetation, including trees, shrubs, and grasses adequately stabilize the site. The perimeter of the site is 100% vegetated with grasses and trees, including cottonwood/poplar, pine, and Russian olive. The former tailings

pond area that was remediated in 1992 and is not part of this construction project will act as a temporary sediment basin during this project. It is also 100% vegetated and forms a runoff barrier to Clear Creek. The construction area itself has limited existing vegetation that will be removed during the project. Erosion potential is small although with the proximity to Clear Creek a significant storm event could potentially cause localized flooding along the creek bank below the construction site.

2.3 Previous Stormwater Sampling

CSM has been sampling stormwater discharge under the conditions of its general permit (Permit # COR-020243) for several years. Recent data include oil/grease, pH, total suspended solids (TSS), biological oxygen demand (BOD), and chemical oxygen demand (COD). Results are not significantly elevated indicating good stormwater management.

3. Description of Potential Pollutant Sources

The greatest potential pollution source from this project is sediment, although the risk of sediment from this project impacting the water quality of Clear Creek is considered minimal. The assessment is based on the location of the construction site and the existence of the former tailings pond area between the construction site and the creek. Although the risk is considered minimal, the best management practices (BMPs) described later in this Stormwater Management Plan will be implemented to ensure control of this potential pollution source.

During this project, no chemical storage is anticipated. A service truck that will visit the site one to two times a week will conduct fueling and minor vehicle maintenance. Appropriate procedures for fueling and minor maintenance will limit the potential for spills and leaks from these activities. No significant maintenance of vehicles or equipment will be conducted onsite.

At this time, there are no known non-stormwater components of discharge from this site. This plan will be amended as necessary if such components are identified during the project.

4. Site Map

The site plan is included as Figure 2. The figure presents the following features:

- Construction site boundaries
- Areas of soil disturbance
- Areas for storage of materials, debris, and soil
- Location of erosion control structures
- Surface water bodies

A copy of the Flood Insurance Rate Map (FIRM) published by the Federal Emergency Management Agency for the City of Golden, Colorado is presented as Figure 3. The figure identifies the limits of the 100-year and 500-years flood plain(s).

5. BMPs for Stormwater Pollution Prevention

5.1 Erosion and Sediment Controls

Structural practices shall be implemented to divert flows from exposed soils, temporarily store flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site. Structural practices shall be implemented in a timely manner during the construction process to minimize erosion and sediment runoff.

Straw bales, wattles, or erosion control matting will be placed as necessary along any natural or manmade drainage courses at the site to control sediment runoff. As part of the previous construction activities, silt fences were installed along the northern boundary of the construction site to control sediment runoff over the embankment and into the former tailings pond area. This fencing will be replaced and maintained.

5.2 Stockpile Controls

Berms will be installed around soil stockpiles to prevent run-on and runoff. Excavated soil as part of the previous remediation effort has been covered under a series of tarpaulins that do not allow for any runoff of sediment

5.3 Other Pollution Prevention Controls

The vegetative buffer that exists around the construction site will be preserved to prevent run-on and runoff from the site. Reseeding will be completed at the end of construction activities to establish a vegetative cover over the site. Portions of the site that were disturbed after the initial remediation action were reseeded as indicated by the November 5, 2004 Addendum to the CSMRI Project Stormwater Management Plan. This action was conducted as a BMP to minimize stormwater runoff during the hiatus in remediation activities. A copy of the November 5, 2004 Addendum is presented as Attachment A.

6. Schedule of Activities

Construction activity is anticipated to resume during the summer of 2006. Structural BMPs (straw bales, wattles, silt fences, etc.) will be installed prior to construction excavation activities commencing. As excavation is conducted additional structural controls will be installed as necessary and this Stormwater Management Plan will be amended. It is anticipated that the project will be completed by the autumn of 2006.

7. Material Handling and Spill Prevention

All construction activities and any soil stockpiles will be managed to prevent stormwater impacts. Soil stockpiles will be placed an adequate distance from the creek bank to prevent runoff from immediately entering the creek and allow for the installation of structural controls as necessary between the pile and the creek. Each soil stockpile will be bermed to prevent run-on and runoff. Soil stockpiles will be removed and/or redistributed as expeditiously as possible. No chemicals will be stored or handled onsite. A bermed wash area will be established to decontaminate, if necessary, any vehicle prior to leaving the site. Truck load-out will be conducted on an impervious asphalt surface. Any excavated soil spilled during load-out will be cleaned up immediately prior to loading the subsequent truck in queue.

8. Final Stabilization and Long-Term Stormwater Management

A vegetative cover will be established over the site after the completion of final grading. At the end of the project, the site will be backfilled with native fill and graded to achieve a gentle slope. It will be seeded with a native grass mixture appropriate to the site and as much existing vegetation as possible will be preserved to further enhance the site and prevent stormwater impacts.

9. Inspection and Maintenance

Inspections will be conducted at least once every seven days and within 24 hours after any storm event greater than 0.5 inches of rain per 24-hour period. The project manager or site supervisor will inspect all structural controls, soil stockpiles, truck load-out areas, and surface areas where erosion could occur. Any identified condition that may result in breakdown or failure of the stormwater controls must be identified and corrected. Records shall include the identified condition, how it will be addressed, and the date that it was identified and repaired. Additionally, records should include the dates and duration of significant storm events, implementation of specific BMPs, training sessions, contacts with regulatory agencies, and other items of significance. A sample inspection form is attached as Attachment B to this Stormwater Management Plan.

10. Other

Field vehicles that will be traveling from dirt roads to paved surfaces will have the mud removed from the tires and wheel wells. This action will reduce the amount of soil caking hard surface areas and contributing to sediment during precipitation events.

A separate Stormwater Quality Permit is required by the City of Golden. Forms associated with the city's permit will be completed and submitted for approval a minimum of 30 days prior to initiation of construction activities.

Employee training on this Stormwater Management Plan shall be conducted prior to mobilization at the site. All site employees shall be trained on the objectives and control measures included in this plan. A periodic refresher (every six months) should be given and recorded should the project run longer than six months. Good housekeeping is an integral part of project management and stormwater pollution prevention. During the weekly inspection, the project manager or site supervisor should note any housekeeping discrepancy and follow up to ensure that it is being addressed/resolved. This portion of the inspection should include but not be limited to evidence of spills or leaks, collection and disposal of trash and debris, location and adequacy of posted signs, appropriate storage of spill cleanup equipment and materials, identification of all chemical substances, and appropriate storage, etc.

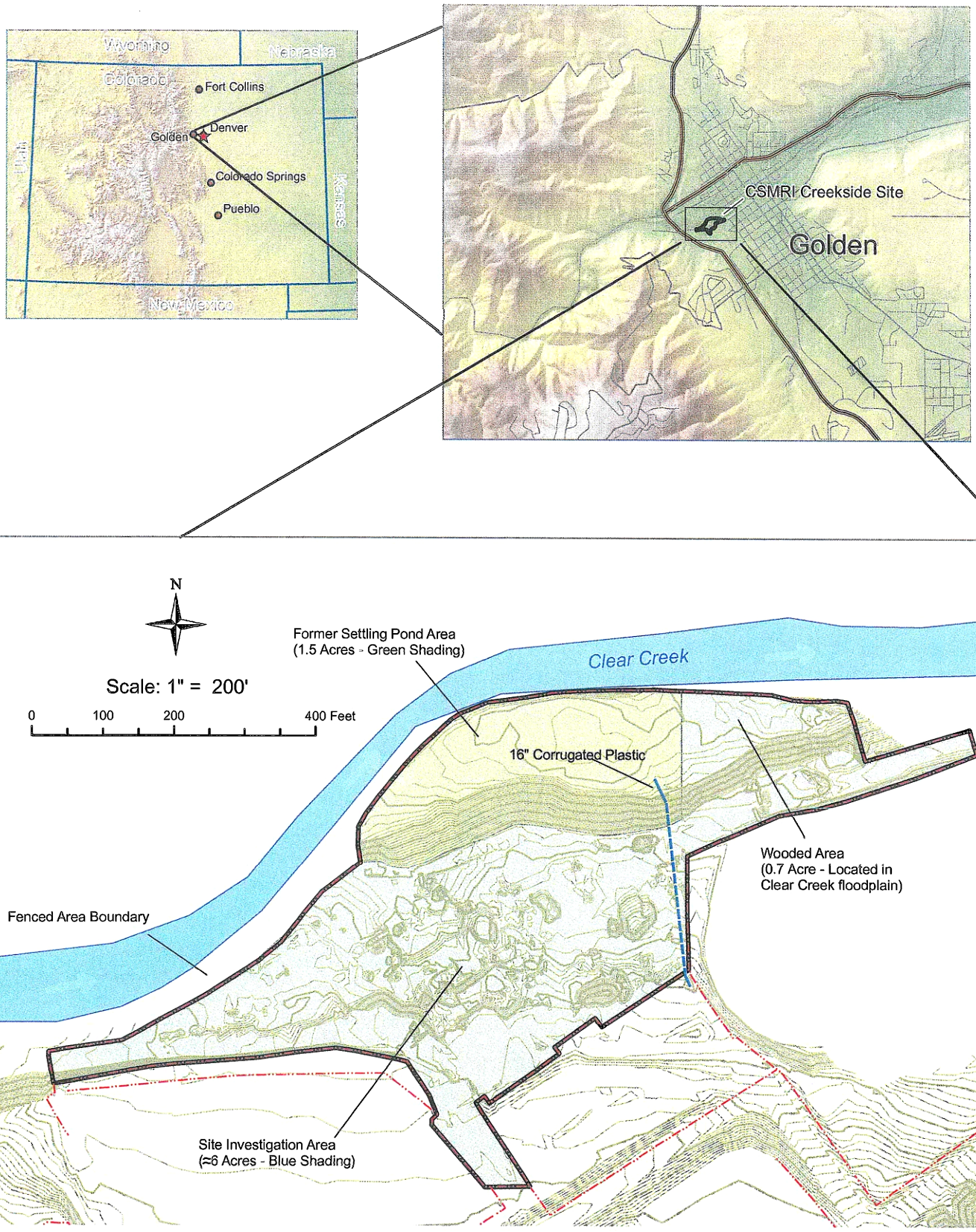

Figure 1

CSMRI
Site Location Map

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Culverts

CSMRI
Stormwater Management Plan

Stoller

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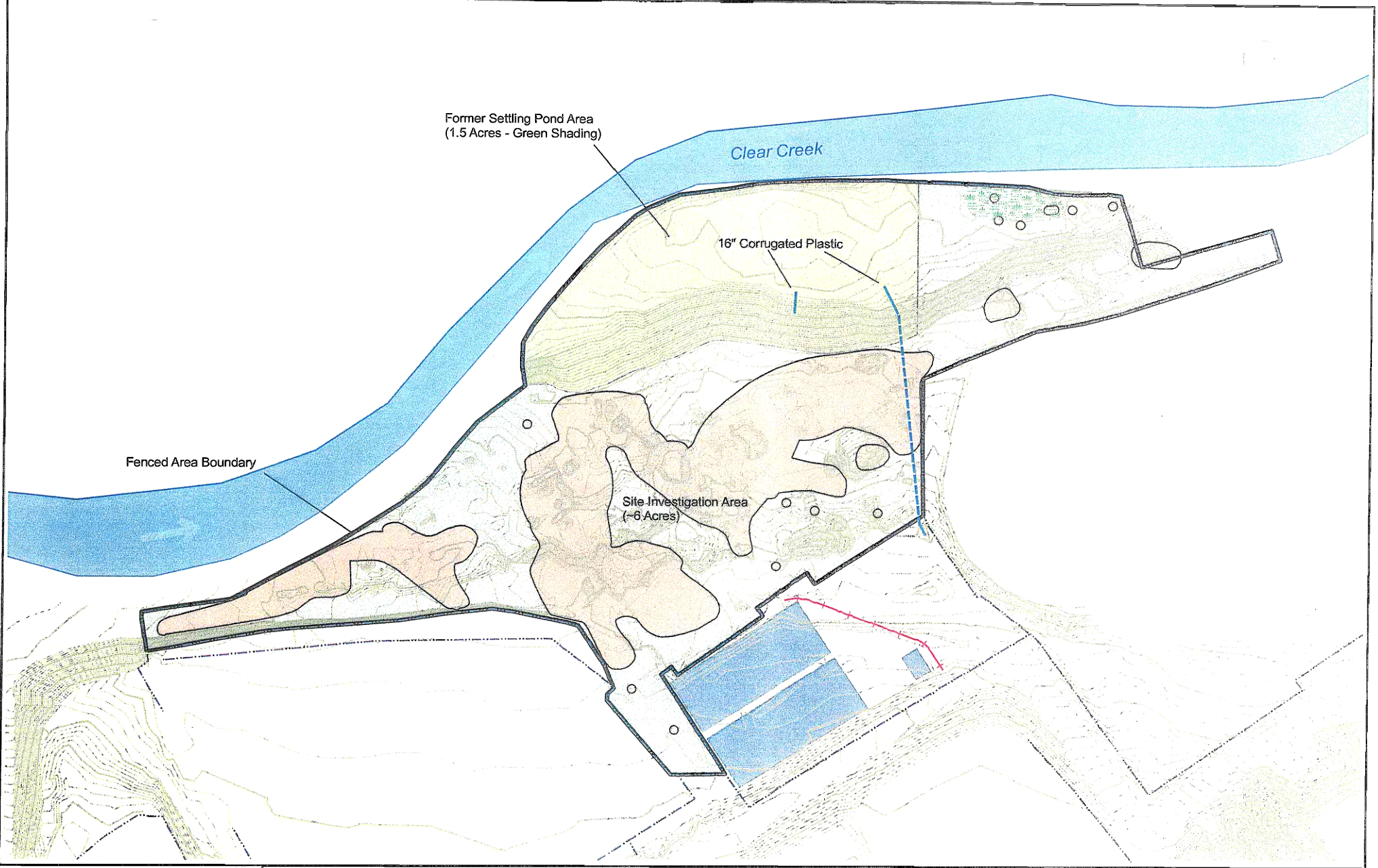

Figure 2

CSMRI
Area of Construction Map

Explanation

- CSMRI Creekside Site
- Fences
- Topography (1 ft Intervals)
- Topography (5 ft Intervals)
- Culverts
- Proposed Excavations
- Wetlands
- Silt Fence
- Proposed Stockpile

N

Scale: 1" = 150'

0 75 150 300 Feet

CSMRI
Stormwater Management Plan

Stoller

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NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

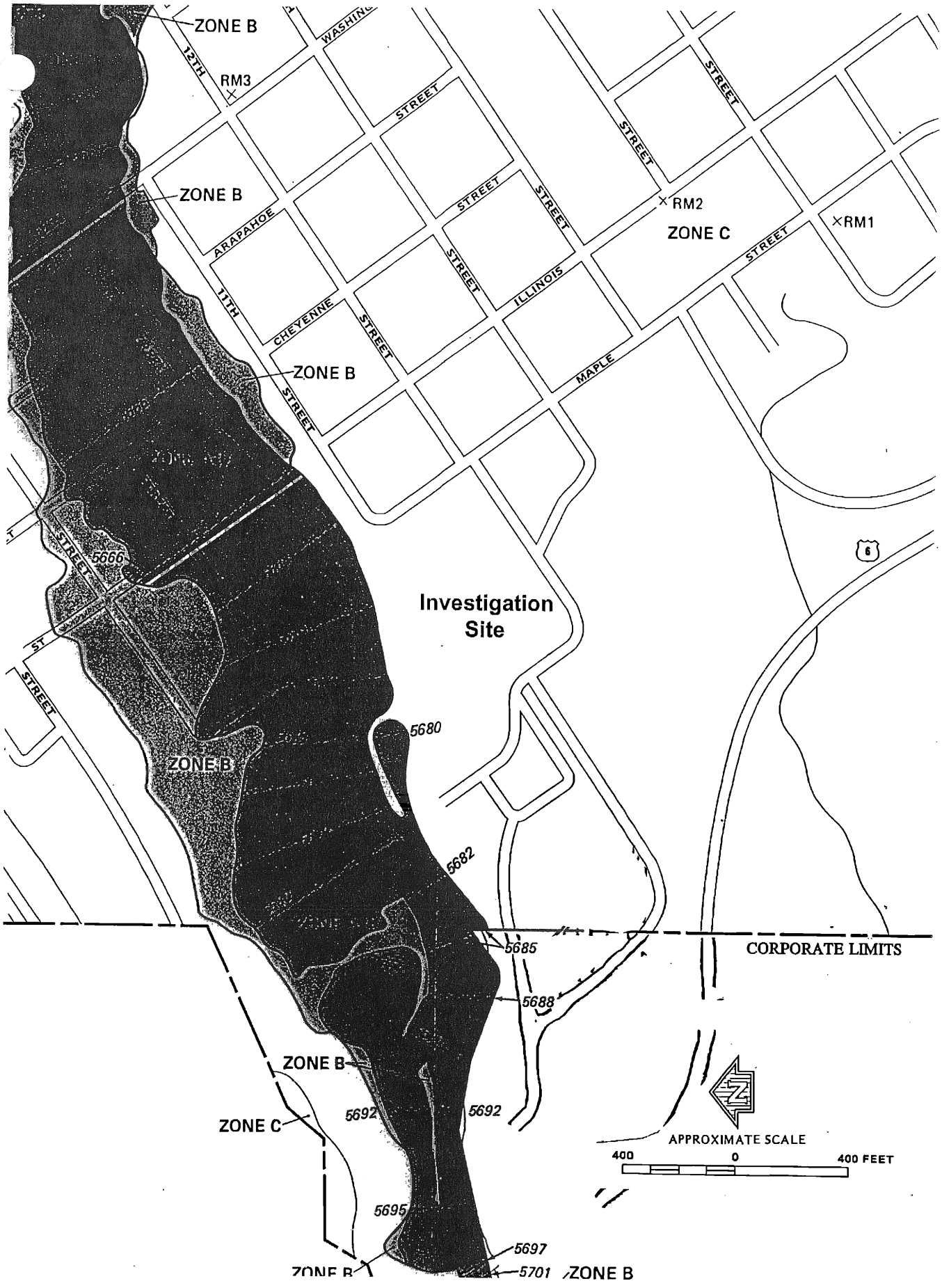
CITY OF
GOLDEN,
COLORADO
JEFFERSON COUNTY

PANEL 3 OF 5
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
080090 0003 A

EFFECTIVE DATE:
MAY 15, 1985

Federal Emergency Management Agency

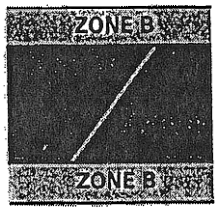

ZONE B
12TH
STREET
RM3
ZONE B
ARAPAHOE
11TH
CHEYENNE
STREET
ZONE B
STREET
STREET
STREET
STREET
STREET
RM2
ZONE C
RM1
STREET
ILLINOIS
MAPLE
STREET
5666
ST
STREET
Investigation Site
6
5680
ZONE B
5682
5685
CORPORATE LIMITS
5688
ZONE B
ZONE C
5692
5692
5695
5697
5701
ZONE B
APPROXIMATE SCALE
400
0
400 FEET

KEY TO MAP

500-Year Flood Boundary

100-Year Flood Boundary

Zone Designations



100-Year Flood Boundary

500-Year Flood Boundary

Base Flood Elevation Line With Elevation In Feet** — 513

Base Flood Elevation in Feet Where Uniform Within Zone** — (EL 987)

Elevation Reference Mark — RM7×

Zone D Boundary

River Mile — •M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
A0	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

For adjoining map panels, see separately printed Index To Map Panels.

INITIAL IDENTIFICATION:
NOVEMBER 5, 1976

Attachment A
November 5, 2004 Addendum to CSMRI Project Stormwater Management Plan

Addendum to the CSMRI Project Stormwater Management Plan

November 5, 2004

The existing Stormwater Management Plan was prepared by New Horizons Environmental Consultants, Inc. New Horizons is no longer providing environmental services at the Site. This addendum updates the existing Plan.

The CSMRI Creekside Facility is located on the Colorado School of Mines campus in Golden, CO. It is located on the south bank of Clear Creek approximately ½ mile east of the intersection of US Highway 6 and Highway 58 at the west end of 12th Street. It encompasses approximately 6 acres and includes the former CSMRI mineral processing operations area. Clear Creek is the receiving water from this site and the currently permitted outfall is in the west corner of the site. Figure 1 shows the Facility site, the receiving water, and the outfall point.

Stormwater quality best management practices shall be implemented to minimize soil erosion, sedimentation, increased pollutant loads and changed water flow characteristics resulting from land disturbing activity, to the maximum extent practicable, so as to minimize pollution of receiving waters.

Excavation work was halted in the summer of 2004. Additional investigation of the Site will occur prior to resumption of excavation work. Excavation is not expected to resume until spring 2005.

Approximately 455 bags of excavated soil are stored at the south end of the Site. These bags are expected to be evaluated to determine appropriate disposal options by January of 2005. The bags are expected to be shipped for disposal following review of the evaluation options.

Disturbed soil areas of the Site (approximately two acres) were seeded with native grasses in October of 2004. Germination and coverage will be evaluated in the spring of 2005.

Improvement of systems for management of surface water entering the Site is expected during the fall and winter of 2004.

Linn D. Havelick, CIH
Director, CSM Environmental Health and Safety

Attachment B
Stormwater Management Plan Inspection Form

Contract No. 4060 S.M. Stoller Corporation	**Inspection and Maintenance** Inspections will be conducted at least once every seven days and within 24-hour after any storm event greater than 0.5 inches of rain per 24-hr period			
Site Name: CSMRI Creekside Golden, CO	Last Inspected (d/m/y):	Storm Event Since Last Inspection: Y / N	If Yes, Provide Detail: Date: Duration: Event Rainfall (In.)	Current Inspection: Date: Time:

Observations:

Pollution Control

Fuel Storage Area:

Soil Staining: ( ) Yes ( ) No
Spills/Leaks: ( ) Yes ( ) No

Type & Qty (gal.) of Material Released:

Location:

Equipment/ Vehicle Inspection

Soil Staining: ( ) Yes ( ) No
Spills/Leaks: ( ) Yes ( ) No

Type & Qty (gal.) of Material Released:

Erosion & Sediment Control

Evidence of Erosion/Sedimentation

( ) Yes ( ) No

Location(s):

Evidence of Off-Site Runoff

( ) Yes ( ) No

Location(s):

Erosion & Sediment Control BMPs Inspections

Erosion Controls

( ) Good ( ) Damaged (tears, bypassing/undercut)

Location(s) and Description of Damage:
Additional Notes:

Additional Notes:

Contract No. 4060 S.M. Stoller Corporation	**Inspection and Maintenance** Inspections will be conducted at least once every seven days and within 24-hour after any storm event greater than 0.5 inches of rain per 24-hr period	
Corrective Actions / Comments (any deficiencies will be repaired/corrected within 7 days of discovery)		
1)	Date Completed:	Inspected by (initial):
2)		
3)		
4)		
5)		
6)		
Inspector Name:	Signature:	Date:

Appendix E
Standard Operating Procedures

Document No: SOP-RAD-001, Rev.1

Title: Portable Radiation Survey Instrument Operation

Approved: _____ Date _____
Stoller Health and Safety Manager/
Radiation Safety Officer

Approved: _____ Date _____
Stoller Quality Assurance

Approved: _____ Date _____
Stoller Project Director and
Alternate Radiation Safety Officer

Revision Number	Date
0	1/17/05
1	10/7/05

UNCONTROLLED WHEN PRINTED

1. Introduction

1.1 Summary

Radiation detection instruments are required to be performance checked prior to use. This procedure includes requirements for establishing control limits and performing required instrument checks for a variety of portable radiation survey instruments. If specific instruments require different or additional performance tests, these will be addressed in instrument-specific standard operating procedures.

1.2 Scope

All portable radiation survey instruments will be calibrated, in accordance with manufacturer's requirements, by a certified vendor. This procedure does not include calibration procedures.

This procedure is applicable to portable radiation survey instrumentation that is used to detect ionizing radiation. It is not applicable to gamma spectroscopy or neutron instrumentation.

2. Definitions

ALARA: As Low As Reasonably Achievable

Location: A new location or site, for the purpose of this procedure, means a location with an altitude that varies by more than 1,000 feet from the altitude at which the control limits were previously measured.

3. Responsibilities and Qualifications

Personnel using this procedure must be qualified to handle radioactive sources and to operate the instrument that is being used. Documentation of qualification and training will be maintained in the project files.

Personnel performing on-site surveys shall have the required training to enter the job site, or be escorted by qualified personnel, as permitted by the Site-Specific Health and Safety Plan.

The Radiation Safety Officer will approve sources other than those listed in Appendix A for use as check sources.

The Project Manager, in conjunction will the project Quality Assurance Officer, will evaluate situations in which an instrument has been taken out of service for failure to meet the acceptance criteria. This evaluation will determine whether or not a Non-conformance Report (NCR) and/or Corrective Action Request (CAR) are required.

4. Safety

Personnel shall understand the potential hazards of the job site and comply with the requirements of the site-specific work plans and the Site-Specific Health and Safety Plan.

Personal protective equipment specified in project-specific work plans shall be used.

Personnel shall use As Low As Reasonably Achievable (ALARA) principles to minimize exposure.

5. Quality Control

Instrument calibrations are performed, in accordance with the manufacturer's recommendations, by a qualified vendor. Frequently, the probe and meter will have separate calibration stickers. However, the probe and meter are required to be calibrated as a unit. Therefore, the calibration dates must be the same for both, and the calibration sticker(s) must have evidence that they were calibrated as a unit.

The check sources shall be manufactured from NIST traceable material. However, they are not required to have current calibrations.

6. Special Equipment

Radiation survey instrument, including the instrument operating manual, if applicable.

Applicable source for the survey meter, as shown in Appendix A. The minimum activity above background that should be used to test a surface contamination survey instrument's response is approximately 150 cpm or 4,000 dpm/100cm^2. Source activities below this value will not yield statistically valid variations within the ±20% acceptance criterion specified in the ANSI standard.

7. Material

Shielding and/or source placement devices necessary to obtain appropriate count rates and repeatable geometries.

8. Instructions

8.1 Instrument Configurations

For analog meters, the instrument should be tested on each scale normally used (or expected to be used) in the performance of radiological surveys. For microprocessor-based digital instruments (which do not have "scales"), the instrument should be tested at least three points over the activity range expected to be measured in the performance of radiological surveys. Selection of a range is not necessary for microprocessor controlled or auto-ranging instruments. For these instruments, check the instrument's response at three points over the anticipated range of radioactivity to be measured in field operations. Indicate "Auto-Ranging" in the "Scale" column.

For each applicable scale or activity range, choose a source-to-detector distance and geometry and any shielding necessary to obtain an instrument response at or near the middle of the scale. If the performance check will be a static count, select the applicable count time. If the performance check is a count rate, the count time will be "N/A". Document the applicable configurations in Instrument Configuration section of the Portable Radiation Survey Instrument Operation Performance Check Data Sheet, Form SOP-RAD-01.1 (Appendix B).

8.2 Instrument Response Control Limits

Note: Control limits should be established promptly upon receipt of an instrument following repair and/or calibration, relocation from another location, or when a new check source will be used. The instrument response control limits used for the Daily Source Checks are valid only at the location (site) where the data used to establish the control limits were collected.

8.2.1 Perform miscellaneous instrument checks as described in Section 8.3.

8.2.2 Select the correct source (in accordance with Appendix A) for the instrument being checked.

8.2.3 Obtain any necessary shielding, as documented in the Instrument Configuration section of form SOP-RAD-01.1.

8.2.4 Record the following information at the top of form SOP-RAD-01.1:

- Project,
- Location (site),
- Instrument manufacturer, model number, and serial number,
- Probe manufacturer, model number, and serial number,
- Instrument and probe calibration and calibration due dates,
- Scaler/Probe efficiency, and
- Radioactive check source identification number and isotope.

8.2.5 Count the source. If the performance check is a static count, count the source for the length of time specified in the configuration. If the performance check is a count rate, count the source long enough to allow the count rate to stabilize (normally approximately 30 seconds).

8.2.6 Record the observed count or count rate.

8.2.7 Repeat steps 8.2.5 and 8.2.6 until five data points have been generated.

8.2.8 Measure the instrument background using the same procedure and record the background count or count rate.

8.2.9 Calculate the average count or count rate as shown in Step 9.1, as applicable, and record on form SOP-RAD-01.

8.2.10 Calculate the control limits as shown in Step 9.2 and record these values in the appropriate locations on form SOP-RAD-01.1. Limits need to be recorded on page 1 and on continuation sheets.

8.2.11 Repeat steps 8.2.2 through 8.2.10 for each type configuration for the instrument being checked. A separate form will be used for each type of radiation (or each different source) that is used to test the instrument.

8.3 Miscellaneous Instrument Checks

8.3.1 Prior to establishing control limits or performing the daily instrument performance checks, the following items shall be checked, as applicable for the instrument.

- Inspect the instrument to verify that the calibration is current. Refer to Section 5 for additional information regarding calibration requirements.
- Check the batteries to ensure that sufficient battery strength is available. Replace the batteries, if necessary.
- Check the physical condition of the instrument to ensure that there is no obvious damage that might impact proper instrument response.
- Check for audible response to a source (as applicable).

8.3.2 If all items checked are acceptable, check (√) the Instrument Check box on form SOP-RAD-01. Add a note in the comments field if the batteries were changed.

8.3.3 If any of the checks are not acceptable, write "No" in the Instrument Check box and describe the problem in the comments field. Tag the instrument out of service.

8.4 Daily Instrument Response Check

8.4.1 Obtain the same source as the one used to establish the control limits.

8.4.2 Perform miscellaneous instrument checks as described in Section 8.3.

8.4.3 Measure the instrument response for each configuration, using the same source to detector distance, geometry, and shielding as listed on form SOP-RAD-01.1.

8.4.4 Record the instrument's response for each configuration.

8.4.5 Measure the instrument background.

8.4.6 Evaluate the results of each test against the applicable control limits. All results must be in control to be acceptable. Note the results of this evaluation (Pass or Fail).

8.4.7 If all of the results are acceptable, the instrument is released for use. If any of the results are not within the applicable control limit range, the performance check may be repeated once. Repeat counts shall be recorded on the next line in the log, and the recount annotated in the comments section. If the performance check fails a second time, tag the instrument "OUT OF SERVICE", provide a brief description of the problem, and notify supervision.

9. Calculations

9.1 Average Calculation

$$AVG = \frac{(y_1 + y_2 + \ldots y_n)}{n}$$

where: y = each individual count or count rate
n = number of counts

9.2 Control Limits

The control limits are established as follows:

Upper Control Limit = 1.2 * AVG
Lower Control Limit = 0.8 * AVG

where:

AVG = The average count or count rate, as applicable, determined in Step 9.1.

10. Records

10.1 Records Generated by this Procedure

Portable Radiation Survey Instrument Operation, Performance Check Data Sheet, Form SOP-RAD-01.1.

10.2 Supervisory Review

Review the completed documentation to ensure completeness, accuracy, legibility, and reproducibility.

Compare the data recorded with data from like instruments and data for the same instrument from previous months to determine if trends are developing or unexpected results were obtained.

Notify the Radiological Safety Officer or Project Manager of any trends or unexpected results.

10.3 Record Disposition

Maintain the documentation generated by this procedure with the project records. Retention of these records will be in accordance with the requirements for the project records.

11. References

ANSI N323 – 1997, Radiation Protection Instrumentation Test and Calibration.

12. Appendices

Appendix A – Instruments and Applicable Check Sources

Appendix B – Portable Radiation Survey Instrument Operation Performance Check Data Sheet, Form SOP-RAD-01.1, Rev. 1

13. Supersession

This procedure supersedes procedure SOP-RAD-01, Rev. 0, January 2005.

Appendix A

Instruments and Applicable Check Sources

Source	Instruments
Sr-90	β/γ Exposure/Dose rate ion chamber survey instruments
Cs-137 or Ra-226	γ Exposure/Dose rate survey instruments
Cl-36 or Tc-99	Contamination Rate meters with β probes
Th-230	Contamination Rate meters with α probes

Note: *Sources not listed above shall be approved for use by the Radiological Safety Officer.*

Appendix B

Portable Radiation Survey Instrument Operation
Performance Check Data Sheet

Project_____
Location _____

Check Source Information
Source ID _____
Isotope(s) _____
Activity/Units _____

Survey Instrument Information
Manufacturer _____
Model _____
Serial Number _____

Detector/Probe Information (if applicable)
Manufacturer _____
Model _____
Serial Number _____

Calibration Information
Scaler Calibration Date _____
Scaler Calibration Due Date_____
Detector/Probe Calibration Date_____
Detector Probe Cal. Due Date_____

Calibration Efficiency_____

Instrument Configuration				
Configuration	Scale	Source/Detector Distance	Shielding	Count Time (minutes)
1				
2				
3				

Check Source Control Limits Check Source Control Limits										
Configuration	Observed Count or Count Rate					Average	Background	LCL	UCL	Units
1										
2										
3										
CL Generated By: _____Date:_____										
CL Reviewed By: _____Date:_____										

Performance Check Data (continuation sheet)			
Established Control Limits (from page 1) by Configuration			
Configuration	**1**	**2**	**3**
Lower Control Limit			
Upper Control Limit			

Date/Time	Observed Gross Count/Count Rate by Configuration			Background	Units	Pass/ Fail	Instrument Checks	Initials	Comments
	1	2	3						

Document No: SOP-RAD-002, Rev.1

Title: Swipe Sample Collection

Approved: _____ Date _____
Stoller Health and Safety Manager/
Radiation Safety Officer

Approved: _____ Date _____
Stoller Quality Assurance

Approved: _____ Date _____
Stoller Project Director and
Alternate Radiation Safety Officer

Revision Number	Date
0	1/17/05
1	10/7/05

UNCONTROLLED WHEN PRINTED

1. Introduction

1.1 Summary

This procedure establishes the requirements and provides instructions to collect swipe samples for the purpose of determining the level of removable contamination on solid surfaces. The objective of the procedure is to establish a uniform method for collecting swipe samples to achieve data comparability.

The techniques described in this procedure are wet and dry swipe sampling, tape press sampling, and large area swipes (LAS). Wet and dry swipe techniques are used to test for removable contamination on hard surfaces. Tape press swipes are used to test for removable contamination on rough or soft surfaces where normal swipe techniques would not be effective. Tape press swipes may also be used when the contamination is believed to be present as "hot particles" as opposed to widely distributed contamination. LASs are used to obtain a gross indication of contamination over large areas or large pieces of equipment. LAS may be used to check normally clean areas or materials not suspected of having contamination.

1.2 Scope

This procedure is limited to the collection of swipes for contaminants that can be sampled using wet or dry swiping techniques or a tape press sampling technique. It was specifically written for surveying of radionuclide contaminants. However, it may be applicable for other contaminants provided that the contaminant(s) of concern can be adequately removed using one of the techniques provided in this procedure.

2. Definitions

Swipe Sample (Smears): A sample collected by wiping a hard surface with an absorbent pad in such a manner that the removable contamination on the swiped surface will be transferred onto the pad.

Tape Press Swipe: A sample collected by pressing a piece of tape onto the survey area in such a manner that the removable contamination on the survey area will be transferred onto the tape.

Removable Contamination: The fraction of the radioactive contamination present on a surface that can be transferred to a swipe or piece of tape by rubbing with moderate pressure.

3. Responsibilities and Qualifications

Sampling personnel shall be trained and qualified on this procedure. This training shall be documented in the project files using training rosters and/or read and sign sheets.

Sampling personnel shall have the required training to enter the job site, or be escorted by qualified personnel, as permitted by the Site-Specific Health and Safety Plan.

The Project Manager, in conjunction with the Radiation Safety Officer, has the responsibility to ensure that the swipe sample collection method/materials are appropriate for the project needs.

4. Safety

Sampling personnel shall understand the potential hazards of the job site and comply with the requirements of the site-specific work plans and the Site-Specific Health and Safety Plan.

Gloves (latex, Nitrile, or equivalent) are the minimum protection required for the collection of swipe samples. In addition to these minimum requirements, personal protective equipment (PPE) specified in project-specific work control documents or posted in the work area shall be worn.

Personnel shall employ "As Low As Reasonably Achievable (ALARA)" principles to minimize exposure.

5. Quality Control

Two blank smears shall be submitted with the samples when smears are collected for low-energy beta-emitting isotopes.

6. Special Equipment

No special equipment is required for this procedure.

7. Material

The materials used to collect swipe samples will vary depending on the surface to be swiped and the contaminant(s) of concern. The project-specific work plan may dictate specific sampling materials. For certain types of contaminants, the laboratory that will perform the swipe analysis may provide the sampling materials. In the event specific guidance is not provided, the Project Manager will specify the sampling methods/materials. The following information can be used as a guideline.

7.1 Alpha and Hi-Energy Beta/Gamma-Emitting Isotopes

- Disc smears, such as Defensap® swipes, or other suitable soft absorbent cloth swipes
- Tape, 2-inch wide, duct tape, or other suitable tape (tape press method only)
- Tape press jig (tape press method only)
- Protective envelope, such as a Glassine envelope (if not provided with swipe)

7.2 Low-Energy Beta-Emitting Isotopes (including tritium)

- Whatman 41 filter paper or polystyrene smear papers (as specified by laboratory)
- Vials for smear
- Wetting solution (glycerin or de-ionized water, for tritium only)

7.3 Large Area Smears

- Masselin cloth, or other absorbent cloth

8. Instructions

8.1 Swipe Sample Collection

Note: This section is applicable to collection of wet or dry swipes from hard surfaces. The physical collection of the sample is the same for wet and dry swipes.

8.1.1 Select sampling locations based on project objectives and the purpose of the swipe samples identified in project-specific work plans. Swipes normally cover an area of approximately 100 cm^2. However, in some instances the survey requirements may be based upon a different survey area. Ensure that the applicable area is surveyed. Some projects may require use of a paper template to control the size of the survey area. When the item to be surveyed has an area less than 100 cm^2, estimate the actual area surveyed.

8.1.2 If the smear will be analyzed for tritium, apply a thin film of de-ionized water or glycerin to the smear, unless the smears come pre-wetted from the laboratory. This may be done by dipping the smear into the container of sorbent, and allowing the excess sorbent to drip back into the container. Care must be taken to keep the forceps or tweezers uncontaminated to ensure that the sorbent remains uncontaminated. In hot or very dry environments, glycerin is the preferred sorbent due to the significant evaporation rate of water.

8.1.3 Collect the swipe by moving the smear paper in an "S-shaped" pattern over the area to be sampled. Apply moderate pressure to the smear paper during swipe collection. The pattern should cover an area approximately 4-inches (one hand-width) wide and 9-inches in length for a 100 cm^2 swipe.

8.1.4 If swipes will be analyzed by liquid scintillation counting (typically low-energy beta emitters), prepare two blank smears, using the same technique except do not swipe anything with the prepared swipes.

8.1.5 Place the swipe in an envelope or in a vial, as applicable. If a vial is used, secure the lid tightly.

Note: If the swipe will be analyzed by liquid scintillation counting, the exterior of the vial may not be written on. A separate label secured with a rubber-band to the top or outside of the vial should be used for these samples.

Note: If the swipes are being taken as part of an area survey or for release of equipment, the description or location of the swipe may be referenced to the survey map or release survey form to satisfy the description requirement listed in the following step.

8.1.6 Record the following information on the envelope or vial:

- Date/time of sample collection
- Name (or initials) of person collecting the swipe
- Description of sampling location in sufficient detail to definitively identify where the swipe was taken
- Size of area surveyed
- Sorbent, if applicable

8.1.7 Submit the swipe for counting or analysis.

8.2 Tape Press Sample Collection

Note: This section is applicable to collection of swipe samples from soft or rough surfaces, or when presence of "hot particles" is suspected.

8.2.1 Place tape over a tape press jig or use a strip of tape approximately 2" x 8".

8.2.2 Place tape press jig (or tape) on the survey area and apply moderate pressure. Do not rotate or "grind" the tape onto the surface.

8.2.3 If the sample will not be immediately counted, place the sample into a protective container, taking care to prevent the tape from adhering to the container.

8.2.4 Submit the sample for counting or analysis.

8.3 Large Area Smears

Note: This type of smear should be used to supplement standard swipe techniques in areas generally assumed not to be contaminated, such as entrances to radiological areas. If an evaluation indicates that an area wiped is contaminated, a thorough contamination swipe survey should be performed (Section 8.1).

8.3.1 Wipe over the area to be surveyed with a masselin or other absorbent cloth.

8.3.2 Count the swipe using a contamination survey instrument capable of detecting the type of contamination suspected.

8.3.3 Calculate the results in dpm using the highest reading observed and the area correction factor (total swipe area/measured area).

8.3.4 Report the results in dpm/LAS. If the data indicate that the contamination level is above the allowable limit, perform a swipe survey as described in Section 8.1.

9. Calculations

If the item smeared is less than 100 cm^2, the results shall be reported as dpm/"estimated size of area smeared" in cm^2 and normalized to dpm/100 cm^2 unless the requirement is based on a different size area.

10. Records

If the smears will be submitted to a laboratory for analysis, complete the required chain of custody form. If the swipes will be counted at the project site, no records are specifically generated by this procedure. Smears are generally taken in support of actions such as release of equipment or materials or area surveys. The documentation associated with these activities will be discussed in the applicable procedure.

11. References

There are no references for this procedure.

12. Appendices

There are no appendices to this procedure.

13. Supersession

This procedure supersedes procedure SOP-RAD-02, Rev. 0, January 2005.

Long-Lived Airborne Radioparticulate Surveys

1.0 Introduction

1.1 Purpose

The purpose of this procedure is to provide instructions for taking breathing zone and general area air samples to determine airborne concentrations of long-lived particulate radionuclides. It also provides instructions on reviewing the results to determine if radiological posting is required.

1.2 Scope

This procedure addresses the requirements for monitoring airborne radioactivity. It includes monitoring methods, documentation, and result analysis. This procedure does not address use of continuous air monitors, how to establish radiological posting, or access control requirements.

1.3 Applicability

This procedure is applicable to monitoring for long-lived airborne radioparticulates. This procedure is not applicable to air sampling for determining radon or radon decay product concentrations, airborne tritium concentrations, or concentrations of non-radiological materials.

2.0 Precautions, Limitations, and Notes

2.1 Precautions

Handle samples with care to prevent cross-contamination.

Do not allow an air sampler to pick up debris from the floor, ground, or other surface.

Do not operate air samplers in explosive atmospheres or where there is >25% oxygen content.

Exhaust air samplers away from workers, contaminated surfaces, and open containers of radioactive (or other hazardous) material.

2.2 Limitations

This procedure only applies to radionuclides with half-lives of 405 days (1.11 years) or longer.

2.3 Definitions

High Volume Air Sampler – Air sampler capable of collecting greater than 3 ft^3/min.

Low Volume Air Sampler – Air sampler capable of collecting greater than 10 L/min but less than 3 ft^3/min.

Personal Air Sampler – Air sampler capable of being worn by personnel and measuring the wearer's breathing zone. These samplers are usually capable of collecting 10 L/min or less.

Breathing Zone – The general volume of air breathed by the worker(s). The breathing zone for a personal air sample is defined as the imaginary globe of a two-foot radius surrounding a person's head. The breathing zone of an area is the general volume of air to which occupants are expected to be exposed—typically at a height of 1 to 2 meters.

Annual Limit on Intake (ALI) – The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue.

Derived Air Concentration (DAC) – For the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2,000 hours (assuming a breathing volume of 2,400 m^3). For the radionuclides listed in Appendix C of 10 CFR 835, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud.

3.0 Prerequisite Actions

Verify air sampling equipment has been calibrated and has not exceeded the calibration due date.

4.0 Monitoring Requirements

4.1 General

1. Air sampling is required in occupied areas when, under typical conditions, an individual's intake is likely to exceed 2% of an ALI. For continuously occupied areas, this is 2% of a DAC, while 50% occupancy is 4% of a DAC, while <20% occupancy is 10% of a DAC. The Radiological Control Manager is responsible for determining the appropriate air sample location and frequency of collection.
2. Evaluate air sample results as quickly as practicable to evaluate the need for respiratory protection, area evacuation, worker intake, and worker relief from respirator use.
3. Air samples do not need to be counted any further when the activity is at or below the detection limits of the instrument counting the sample. For automated scalers with built-in algorithms, this value is calculated for each sample (e.g. Protean, Tennelec). For manual scaler systems such as the Ludlum 2000, Ludlum 2929, and E-600, this corresponds to the default detection limits, which are set at 5% of the applicable DAC.

4.2 Area Sampling

1. Use high volume air samplers (greater than 3 cubic feet per minute) to obtain sensitive and prompt determinations of "instantaneous" (short time duration) air concentrations.
2. Use low volume air samplers when monitoring over an extended time period (i.e., several hours).

4.3 Personal Monitoring

Use lapel air samplers for accurate breathing zone monitoring of personnel.

5.0 Sample Volumes and Collection Time Determination

1. Determine the altitude of the sampling location using the categories in Table 1.
   a. **IF** the location is a major fixed facility,

      THEN, the actual altitude should be used.

   b. **IF** the altitude is not well known,

      THEN, estimate it to the nearest thousand feet using a topographic map or equivalent.

   c. Record the altitude of the sampling location on the Airborne Radioactivity Data Sheet.

      NOTE: *It is recognized that temperatures change during field operations, and that accurate temperature measurements may be difficult. Therefore, a simplified method has been adopted which uses descriptive categories of very cold (<10 ºF), cold (10-35 ºF), cool (35-55 ºF), room temperature (55-80 ºF), and hot (>80 ºF).*

2. Determine the temperature of the sampling location using the categories in Table 1.

   Record the temperature at the sampling location on the Airborne Radioactivity Data Sheet.

3. Select the appropriate pressure and temperature correction factor in Table 1.

   Record the selected pressure and temperature correction factor on the Airborne Radioactivity Data Sheet.

Table 1. Pressure (altitude) and Temperature Correction Factors

Facility	Altitude (ft)	Temperature Range (ºF)				
		<10 very cold	10 - 35 cold	35 - 55 cool	55 - 80 room temp	>80 hot
	0	1.10	1.07	1.04	1.00	0.96
	1,000	1.08	1.05	1.02	0.98	0.95
	2,000	1.06	1.04	1.00	0.96	0.93
	3,000	1.04	1.02	0.98	0.95	0.91
Moab	4,000	1.02	1.00	0.96	0.93	0.90
Grand Jct.	4,565	1.01	0.99	0.95	0.92	0.89
	5,000	1.01	0.98	0.95	0.91	0.88
	6,000	0.99	0.96	0.93	0.89	0.86
MMS[a]	6,900	0.97	0.95	0.91	0.88	0.85
	7,000	0.97	0.94	0.91	0.88	0.85
	8,000	0.95	0.93	0.89	0.86	0.83
	9,000	0.93	0.91	0.88	0.85	0.81
	10,000	0.91	0.89	0.86	0.83	0.80

[a] *Monticello Mill*

4. Select the applicable DAC for the specified work locations or radionuclide type from Table 2.

   a. **IF** the specific work location and radionuclide type are not specified in Table 2,

      THEN contact the health physicist to obtain the appropriate DAC.

   b. Record the applicable DAC on the Airborne Radioactivity Data Sheet.

5. Select the sample volume (mL) from Table 2 (or from the graphs in Appendix A when the work location and radionuclide type are not specified in Table 2), corresponding to the counting instrument planned for use in counting the air sample.

6. Correct the selected sample volume for the altitude and temperature conditions at the sample location.

   Divide the selected sample volume by the pressure and temperature correction factor obtained in step 5.0[3] to obtain the corrected total sample volume.

$$SV_C = \frac{SV_U}{PT_{CF}}$$

where SV_C = Corrected total sample volume (mL)

SV_U = Uncorrected sample volume (from Table 2)

PT_{CF} = Pressure and temperature correction factor (from Table 1).

Table 2. Minimum Flow Rates and Sampling Time Required to Achieve Minimum Sample Volumes[a]

Project Name or Radionuclide	DAC (µCi/mL)	Air Sample Volume (milliliters)			
		Protean / Tennelec	Ludlum 2000	Ludlum 2929	E-600
GJO[b]	5×10^{-11}	6.3×10^{5}	6.3×10^{5}	6.3×10^{5}	Not Available
GJORAP[b]	5×10^{-11}	6.3×10^{5}	6.3×10^{5}	6.3×10^{5}	Not Available
Moab	5×10^{-11}	6.3×10^{5}	6.3×10^{5}	6.3×10^{5}	Not Available
Monticello[b]	5×10^{-11}	6.3×10^{5}	6.3×10^{5}	6.3×10^{5}	Not Available
UMTRA VPs[b]	5×10^{-11}	6.3×10^{5}	6.3×10^{5}	6.3×10^{5}	Not Available
Uranium "yellowcake"	2×10^{-11}	1.6×10^{6}	1.6×10^{6}	1.6×10^{6}	Not Available
TRU[c]	2×10^{-12}	1.6×10^{7}	1.6×10^{7}	1.6×10^{7}	Not Available
Mixed Fission Products and Mixed Activation Products[d]	2×10^{-9}	1.7×10^{4}	Not Applicable	8.3×10^{5}	Not Available

[a]Sample volumes are "uncorrected values" based upon air sampler pump calibration at 70 °F and sea level altitude (29.92 inched of Hg.).
[b]Based on the DAC for uranium mill tailings derived in Stoller Health and Safety Calculation.
[c]Based upon Pu-239, Pu-240, or Pu-242 as the most restrictive radionuclide of this type likely to be encountered.
[d]Based upon Sr-90 as the most restrictive radionuclide of this type likely to be encountered.

6.0 Long-Lived Radioparticulate Air Sampling

6.1 Preparation of Sampling Apparatus

1. **IF** the air sampler used is equipped with a programmable flow totalizer,

   THEN set the flow totalizer to collect the corrected total volume.

2. Determine the necessary sample collection time at the flow rate of interest.

   NOTE: *If the time required to collect the corrected sample volume exceeds the expected work duration, contact the health physicist for guidance.*

3. Disassemble the filter housing apparatus.

4. Inspect all sealing surfaces, gaskets, o-rings, and seals.

   Replace any gaskets, o-rings, or seals, which show evidence of damage or deterioration.

   NOTE*: The Millipore RW 19, 47 mm filters are not identified as to which side is the flow side of the filter. The filters must be removed from the containers with the top of the filter being the side of the filter to be placed facing the atmosphere being sampled.*

5. Place the filter over the support screen in the filter housing apparatus and install the retaining ring securely over the filter.

6. Inspect the assembled filter housing apparatus to ensure that the filter did not buckle or tear during installation and that it is securely seated in the housing to provide a leak-tight seal.

7. Place a clean cover over the filter housing face to protect the filter from physical damage and incidental contamination until ready for use.

8. Attach the filter housing to the air sampler.

6.2 Collecting the Air Sample

1. Locate the air sampler on the person or in the area selected for the collection of the sample and in the breathing zone of the individual/occupants of the area being sampled.

   NOTE: *When conditions warrant the collection of a personal air sample, an area air sample is also required.*

2. Remove the protective cover from the air sample filter apparatus.
3. Turn the air sampler "ON" and collect the desired sample volume.

   Record the start time and date on the Airborne Radioactivity Data Sheet.

4. Turn the air sampler "OFF."

   Record the stop time and date on the Airborne Radioactivity Data Sheet.

5. **IF** the air sample is collected to monitor an area rather than an individual,

   THEN,

   a. Record the location where the air sample was collected on a Radiological Survey Map, or on the Airborne Radioactivity Data Sheet.

   b. Annotate the air sample filter ID number and time of collection in the remarks section of the Radiological Survey Map or on the Airborne Radioactivity Data Sheet.

6.3 Preparing the Sample Filter for Counting

1. Remove the sample filter media from the filter housing apparatus being careful to prevent damage and cross-contamination.
2. Place the filter in a clean filter envelope or sample container.
3. Label the envelope or sample container with a unique sample (filter) ID number.
4. Record the following data on the Airborne Radioactivity Data Sheet at a minimum.
   a. Location, including: site, area, and specific location for area samples
   b. Name and ID number if individual monitored for personal samples
   c. RWP#, if applicable
   d. Sample (filter) ID number
   e. Air sampler type, model, and serial number
   f. Name and signature of technician collecting the sample
   g. Sampler flow rate (in mL/minute)
   h. Pressure and Temperature correction factor
   i. Sample time (in minutes)
   j. Volume sampled (in mL)
   k. Remarks or special conditions pertinent to the sample
5. Transport the filter media with the associated Airborne Radioactivity Data Sheet to the counting room for analysis.

7.0 Sample Analysis

7.1 Counting Samples With Short-Lived Radionuclides Present

NOTE: *If at any time during the counting sequence of an area air sample from a posted Airborne Radioactivity Area, it is determined that occupancy is not necessary, only the count for the record need be performed (step 7.1[5]).*

1. Count the sample and calculate activity concentration within 90 minutes.
   a. **IF** the airborne concentration is <5% of the DAC,

      THEN,

      1. Do not post the area as an Airborne Radioactivity Area.
      2. Proceed to step 7.1[6] of this procedure.

   b. **IF** the airborne concentration is <10% but >5% of the DAC,

      THEN,

      1. Do not post the area as an airborne radioactivity area.
      2. Perform step 7.1[5] of this procedure.

   c. **IF** the airborne concentration is <400% but >10% of the DAC,

      THEN,

      1. Do not post the area as an airborne radioactivity area.
      2. Perform step 7.1[2] of this procedure.

   d. **IF** the airborne concentration is >400% of the DAC,

      THEN,

      1. Notify the Radiological Control Manager and follow his/her instructions for follow-up sampling and posting of the area.
      2. Perform step 7.1[2] of this procedure.

         NOTE: *If an area is posted as an Airborne Radioactivity Area, and follow up area air samples indicate airborne radioactivity concentrations to be < 10% of the DAC, further analysis of the initial air sample(s) need only be completed for count of record (step 7.1[5]).*

2. Recount the sample and calculate activity concentration at least 6 hours after the first count or during the next work shift.
   a. **IF** the airborne concentration is <5% of the DAC,

      THEN,

      1. Do not post the area as an Airborne Radioactivity Area.
      2. **IF** the area was previously posted as an Airborne Radioactivity Area,

         THEN, depost the area.
      3. Proceed to step 7.1[6] of this procedure.

b. **IF** the airborne concentration is <10% but >5% of the DAC,

THEN,

1. Do not post the area as an airborne radioactivity area.
2. **IF** the area was previously posted as an Airborne Radioactivity Area,

   THEN, depost the area.
3. Perform step 7.1[5] of this procedure.

c. **IF** the airborne concentration is <100% but >10% of the DAC,

THEN,

1. **IF** posting was not required by step [1] above,

   THEN do not post the area as an Airborne Radioactivity Area.
2. Perform step 7.1[3] of this procedure.

d. **IF** the airborne concentration is >100% of the DAC,

THEN,

1. Post the area as an Airborne Radioactivity Area.
2. Perform step 7.1[4] of this procedure.
3. Notify the Radiological Control Manager.

3. Recount the sample and calculate activity concentration 72 hours after sample collection (or if more than 72 hours has elapsed, prior to allowing the area to be occupied).

a. **IF** the airborne concentration is <5% of the DAC,

THEN,

1. Do not post the area as an Airborne Radioactivity Area.
2. **IF** the area was previously posted as an Airborne Radioactivity Area,

   THEN, depost the area.
3. Proceed to step 7.1[6] of this procedure.

b. **IF** the airborne concentration is <10% but >5% of the DAC,

THEN,

1. Do not post the area as an Airborne Radioactivity Area.
2. **IF** the area was previously posted as an Airborne Radioactivity Area,

   THEN, depost the area.
3. Proceed to step 7.1[5] of this procedure.

c. **IF** the airborne concentration is <100% but >10% of the DAC,

THEN,

1. **IF** posting was not required by step 7.1[1] or [2] above,

   THEN do not post the area as an Airborne Radioactivity Area.
2. Perform step 7.1[4] of this procedure.

d. **IF** the airborne concentration is >100% of the DAC,

THEN,

1. Post the area as an Airborne Radioactivity Area.
2. Perform step 7.1[4] of this procedure.
3. Notify the Radiological Control Manager.

4. Recount the sample and calculate activity concentration each shift worked.

a. **IF** the airborne concentration is <5% of the DAC,

THEN,

1. Do not post the area as an Airborne Radioactivity Area.
2. **IF** the area was previously posted as an Airborne Radioactivity Area,

THEN, depost the area.

3. Proceed to step 7.1[6] of this procedure.

b. **IF** the airborne concentration is <10% but >5% of the DAC,

THEN,

1. Do not post the area as an Airborne Radioactivity Area.
2. **IF** the area was previously posted as an Airborne Radioactivity Area,

THEN, depost the area.

3. Proceed to step 7.1[5] of this procedure.

c. **IF** the airborne concentration is >10% of the DAC,

THEN,

1. Post the area as an airborne radioactivity area.
2. **IF** continued occupancy is required in the posted Airborne Radioactivity Area,

THEN repeat step 7.1[4] of this procedure for each shift worked.

3. Perform step 7.1[5] of this procedure after 7 days from the time of sample collection.

5. Recount the sample ≥7 days after collection for record.

IF the airborne concentration is >5% of the DAC,

THEN, notify the Radiological Control Manager and Dosimetry.

6. Record sample results on the Airborne Radioactivity Data Sheet.
7. Sign and date the Airborne Radioactivity Data Sheet.

7.2 Counting Personal Samples

1. Count the sample and calculate activity concentration during the next work shift (but not sooner than 6 hours) after sample collection.

a. **IF** the airborne concentration is <5% of the DAC,

THEN perform step 7.2[4] of this procedure.

b. **IF** the airborne concentration is <100% but >5% of the DAC,

THEN perform step 7.2[3] of this procedure.

c. **IF** the airborne concentration is >10% of the DAC,

THEN,

1. Perform step 7.2[2] of this procedure.
2. Notify the Radiological Control Manager.

2. Recount the sample and calculate activity concentration 72 hours after sample collection.

a. **IF** the airborne concentration is <5% of the DAC,

THEN, perform step 7.2[4] of this procedure.

b. **IF** the airborne concentration is >5% of the DAC,

THEN, perform step 7.2[3] of this procedure.

3. Recount the sample >7 days after collection for record.

IF the airborne concentration is >5% of the DAC,

THEN, notify the Radiological Control Manager.

4. Record sample results on the Airborne Radioactivity Data Sheet.
5. Forward the completed Airborne Radioactivity Data Sheet and Radiological Survey Map, if used, for review and signature.

8.0 Records

8.1 Records Generated By This Procedure

Airborne Radioactivity Data Sheet

Radiological Survey Map

Chain of Sample Custody

8.2 Record Review

1. Review the completed sample documentation to ensure completeness, legibility, and reproducibility.
2. Compare the sample data with similar data to determine if trends are developing or unexpected results were obtained.
3. Notify the Radiological Control Manager of any trends or unexpected results.

8.3 Record Disposition

Maintain the documentation generated by this procedure in accordance with the project-specific QAPP.

9.0 References

Title 10, *Code of Federal Regulations*, Part 835, "Occupational Radiation Protection."

DOE 10 CFR 835 Implementation Guide, G-10 CFR 835/E2 - Rev. 1, "Workplace Air Monitoring."

Stoller Radiological Control Manual

Stoller Health and Safety Manual

Control and Handling of External Dosimetry Devices

1.0 Introduction

1.1 Purpose

This procedure describes the process for control and handling of external dosimetry devices issued to individuals performing duties, under the direction of Stoller, which present the potential for external radiation exposure.

1.2 Scope

This procedure describes the requirements for issuing, retrieving, and storing dosimeters used for personnel radiation exposure monitoring and for transmittal receipt of dosimeters from a dosimetry vendor. This procedure does not address criteria for determining dosimetry requirements when monitoring is necessary (addressed in *Personnel Monitoring for External Radiation Exposure*) or for interpretation of radiation exposure.

1.3 Applicability

This procedure is applicable to external radiation monitoring programs implemented at the Stoller facility and at off-site locations where Stoller-controlled dosimeters are used.

1.4 Responsibilities

Line management shall ensure that employees and subcontractors employed by Stoller meet applicable prerequisites identified in the Stoller Health and Safety Manual and in the Stoller Site Radiological Control Manual prior to being issued a dosimeter. Line management shall ensure that all monitored individuals comply with requirements for wearing and storing dosimeters.

Health and Safety is responsible for (1) administering the provisions of this procedure in a manner that ensures compliance with Health and Safety policies and procedures, the State of Colorado Rules and Regulations Pertaining to Radiation Control, requirements in 10 CFR 835, the Stoller Site Radiological Control Manual, and other applicable guidelines, (2) administering contracted dosimetry processing services, and if applicable, (3) ensuring that National Voluntary Laboratory Accreditation Program (NVLAP) criteria are met by dosimetry vendors in accordance with RH 4.17.3 of the State of Colorado Rules and Regulations Pertaining to Radiation Control.

The monitored individual shall ensure the proper wearing, storage, and safekeeping of any assigned dosimetry device in accordance with instructions provided in Radiation Worker Training and by Health and Safety and shall comply with dosimetry requirements contained in Radiological Work Permits (RWPs).

1.5 Definitions

Albedo Dosimeter – A monitoring assembly, usually combined with a whole body beta-gamma monitoring TLD, with an attached element (albedo) for monitoring neutron dose equivalent.

Calendar Quarter – A three consecutive month monitoring period. The quarters are January through March, April through June, July through September, and October through December. For monitoring purposes, quarters shall begin and end as close as possible to the beginning and ending days of the month without skipping or overlapping days.

CR-39 Dosimeter – A neutron monitoring device composed of a special plastic which may be etched to relate neutron tracks to dose equivalent; CR-39 dosimeters are used to measure dose from high energy neutrons which albedo dosimeters are not able to quantify.

Dosimeter – Any of several forms of personnel radiation exposure monitoring devices described in this procedure.

Dosimetry processor – The organization or contractor responsible for providing dosimetry processing services to Stoller.

Electronic dosimeter – A battery-powered dosimeter capable of providing real-time indication of cumulative dose to the wearer (see the Stoller Radiological Control Manual).

Extremity – Hands and arms below the elbow or feet and legs below the knee.

Extremity dosimeter – A dosimeter (usually a TLD) used to monitor shallow radiation dose to the extremities in situations where this dose may be significantly higher than the whole body dose.

Multiple dosimetry – Use of more than one dosimeter to characterize dose to an individual exposed to nonuniform radiation fields.

Self-reading dosimeter – A term applied to dosimeters (usually pocket ion chambers) which allow reading of estimated cumulative dose by the wearer, electronic dosimeters which are used for the same monitoring situations may also be considered self-reading dosimeters.

Supplemental dosimeters – Dosimeters such as pocket ion chambers and electronic dosimeters that provide a real-time indication of cumulative radiation dose to the wearer.

Whole body dosimeter – The primary dosimeter used to determine recordable whole body radiation dose (i.e., deep dose, shallow dose to skin, and when combined with an albedo dosimeter in applicable situations, whole body neutron dose); this dosimeter is normally a TLD with appropriate elements and filters allowing specific measurements of these dose components.

2.0 Precautions, Limitations, and Notes

2.1 Precautions

Failure to comply with provisions of this procedure can result in inadequate or incomplete assessment and recording of radiation doses to occupational radiation workers, as well as noncompliance with regulations in 10 CFR 835 related to personnel exposure monitoring.

2.2 Limitations

Only Health and Safety or individuals authorized by Health and Safety shall be allowed to issue dosimeters.

2.3 Notes

None.

3.0 Prerequisite Actions

Prior to issuing a external dosimetry to an individual, it shall be verified that the individual does not already have a dosimeter issued for the current quarter at that location. If a dosimeter was already issued during the quarter at that location, the individual should use the issued dosimeter for the remainder of the quarter.

Prior to issuance of external dosimetry device(s), completion of an appropriate level of Radiological Worker Training by the monitored individual shall be verified, and pertinent prior exposure information obtained as described in *Personnel Monitoring for External Radiation Exposure*.

3.1 Special Tools, Equipment, Parts, and Supplies

- Vendor supplied dosimeters and shipping cases
- Temporary TLD inserts

- TLD badge opener

4.0 Receipt of Dosimeters From the Dosimetry Processing Facility

Health and Safety shall ensure that receipt of dosimeters from the dosimetry processing facility is performed in a manner to prevent the inadvertent contamination or exposure of the dosimeters.

Health and Safety shall ensure that the dosimeter shipment is not visibly damaged upon receipt.

Health and Safety shall ensure that all requested materials are included in the dosimeter shipment.

5.0 Issuance and Retrieval of Dosimetry Devices

5.1 Issuance of Routine External Dosimeters to Radiological Workers

Appropriate personnel dosimeters shall be assigned to individuals identified in accordance with *Personnel Monitoring for External Radiation Exposure* as needing routine external dosimetry monitoring. Routine personnel dosimeters are considered to be:

- Whole body TLDs for monitoring deep and shallow dose quantities;
- Albedo dosimeters for measuring doses from neutrons with average energies less than 2 MeV;
- Extremity TLDs (e.g., finger rings) for monitoring shallow dose to the extremities; and
- Radon dosimetry to monitor radon dose quantities.

Individuals shall initially be assigned whole body TLDs and albedo dosimeters in accordance with the guidelines of Issuance of Whole Body TLD Badges, Appendix A.

NOTE: *An albedo dosimeter is a unique assembly of two different monitoring devices designed to be used as a single unit. They may not be worn separately or exchanged with other dosimetry devices.*

All personnel assigned to the Radiological Assistance Program (RAP) and all individuals who handle neutron logging sources shall be issued an albedo dosimeter.

Individuals shall be issued extremity TLDs in accordance with the guidelines of Issuance of Extremity TLDs, Appendix B. Only personnel assigned to wear a whole body TLD shall be issued an extremity TLD. Health and Safety shall be informed thoroughly of radiological conditions requiring extremity dose monitoring prior to issuance of extremity TLDs.

For individuals issued routine personnel dosimeters for the first time, adequate instructions in proper wear and handling of the specific dosimeter type issued shall be provided to the individual. Provide the individual with the appropriate handout on instructions for wearing personnel dosimetry.

After initial issuance, routine personnel dosimeters shall be exchanged and processed on a calendar quarter frequency unless a different frequency is determined to be more appropriate for a particular application or operation.

5.2 Issuance of Personnel Dosimeters to Visitors

Visitors requiring monitoring as identified by *Personnel Monitoring for External Radiation Exposure* shall be issued dosimeters according to the guidelines in Issuance of Visitors Dosimeters, Appendix D.

Adequate instructions in proper wear and handling of the specific dosimeter type issued shall be provided by the issuer to the visitor and provided the handout on how to properly wear the dosimeters.

Dosimeters issued to visitors shall be returned and processed promptly after the termination of the visit.

5.3 Issuance of Supplemental Dosimeters

Supplemental dosimeters include electronic dosimeters, pocket dosimeters, other self-reading dosimeters, and alarming dosimeters that are issued to individuals who may receive large doses in a short period of time as identified in *Personnel Monitoring for External Radiation Exposure*. Issuance of supplemental dosimetry shall be in accordance with the guidance in Issuance of Supplemental Dosimeters, Appendix E.

Personnel shall only be issued supplemental dosimeters if they are also assigned and wear a whole body TLD. The supplemental dosimeter shall be worn as near the whole body dosimeter as is feasible.

Prior to issuance and use of supplemental dosimeters, monitored persons shall be briefed individually by the issuer on proper wearing and provided the handout "Instructions for Wearing Supplemental Dosimeters." Briefing should also address handling of the assigned dosimeter and on indicated doses or conditions requiring termination of radiological exposure.

CAUTION*: Radiological exposure of a monitored individual shall be terminated immediately if a supplemental dosimeter malfunctions during the exposure. No further radiological exposure may be authorized for that individual until an initial evaluation of the potential exposure has been performed by Health and Safety.*

Indicated doses recorded from supplemental dosimetry shall be promptly provided to Health and Safety for evaluation at the end of each day during which the dosimetry is used.

5.4 Issuance of Multiple Dosimeters

Multiple dosimeters shall be issued to individuals exposed to nonuniform radiation fields as identified in *Personnel Monitoring for External Radiation Exposure*. They may also be issued at any time to provide more accurate estimates of whole body dose equivalent or at the discretion of radiation protection personnel.

Multiple dosimeters should be placed at locations on the body with the potential of receiving the highest dose equivalent. Multiple dosimetry refers to whole body dosimeters only and does not apply to extremity dosimetry.

The rationale for the placement of multiple dosimeters shall be documented thoroughly, and documentation shall be retained in the personnel radiological exposure file for the monitored individual.

Multiple dosimetry shall be promptly retrieved and processed upon termination of the activity for which monitoring was required.

5.5 Issuance of CR-39 Dosimeters

CR-39 neutron dosimeters shall be issued to individuals who are exposed to high energy (2 MeV or greater average energy) neutrons as identified in *Personnel Monitoring for External Radiation Exposure*.

Management shall notify Health and Safety well in advance of the need for monitoring personnel exposures to high energy neutrons to allow adequate time for dosimeter procurement, since CR-39 dosimeters are not normally maintained at Stoller.

Prior to issuance and use of CR-39 dosimeters, monitored persons shall be briefed individually by the issuer on proper wearing and handling of the assigned dosimeter.

6.0 Storage of Dosimeters

Whole body, albedo, extremity TLDs, radon dosimetry, and CR-39 dosimeters shall be stored in a secure, uncontaminated, low radiation background area and away from sources of heat prior to issuance to individuals.

Dosimeters issued to individuals shall be stored in a location approved by Health and Safety for the facility where they are to be used.

Supplemental dosimeters (e.g., electronic dosimeters, pocket ion chambers) should be stored in a manner consistent with the manufacturer's operating specifications and in a secure, uncontaminated area.

7.0 Lost, Damaged, or Contaminated Dosimeters

7.1 Instructions Regarding Lost or Damaged Dosimeters

A monitored individual whose dosimeter is lost or damaged while performing work in a radiologically controlled area should place work in a safe condition and immediately exit the area.

The loss or damage shall be reported immediately to Health and Safety. An evaluation of the circumstances and radiological conditions of the area shall be documented by Health and Safety.

If Health and Safety determines that a significant exposure has not occurred, the individual may be issued a new dosimeter and allowed to return to work.

If an exposure near or above administrative control levels or dose limits is suspected, or if the magnitude of the exposure is in question, the individual shall not be allowed access to radiological areas where exposure potential exists.

7.2 Instructions Regarding Contaminated Dosimeters

If a person discovers or suspects that their dosimeter has become contaminated while performing work, they should place work in a safe condition and immediately exit the area.

The contamination shall be reported immediately to Health and Safety.

Health and Safety should promptly perform a contamination survey of the dosimeter to confirm whether or not it is contaminated, and shall contact the Radiological Control (RadCon) Manager if contamination above background is detected.

Health and Safety will decontaminate or direct activities to decontaminate the dosimeter in a manner least likely to result in loss of dose monitoring information from the dosimeter. Refer to "TLD Decontamination," Appendix F, for decontamination instructions.

8.0 Shipment of Dosimeters to the Dosimetry Processing Facility

Health and Safety shall ensure that shipment of dosimeters to the dosimetry processing facility is performed in accordance with the shipping requirements of the dosimetry processor and in a manner so as to prevent inadvertent contamination or exposure of the dosimeters. Shipping packages containing dosimeters to be processed shall be identified with clearly visible "DO NOT X-RAY" warning stickers.

Dosimeters that have been used in radiological areas shall be frisked prior to shipment to ensure they are free of contamination. If contamination is detected, the dosimeter(s) affected shall be noted and decontaminated as directed by Appendix F. Processing results of the dosimeter(s) shall be evaluated to determine whether they were affected by the contamination.

Enclose a completed copy of the vendor-supplied dosimeter issue log with the dosimeters to be sent.

9.0 Results Review

WHEN analysis results are received from the vendor,

THEN,

1. Enter the analysis results in the Dosimetry Database.
2. Provide an "External Dosimeter Quarterly Monitoring Report" for review, which summarizes the results of each external dosimetry-monitoring device analyzed, to the RadCon Manager.

9.1 RadCon Manager

Compare the data with past and similar data to determine if trends are developing or unexpected results were obtained.

Document the resolution in the External Dosimeter Quarterly Monitoring Report.

10.0 Accreditation and Quality Control of Dosimetry Devices

For monitoring exposures to radiation fields, which fall within the scope of the DOELAP, only dosimeters provided and processed by a DOELAP accredited processor shall be used. The Radiological Control Manager shall routinely review performance testing results, procedures, and processing algorithms of the processor, shall ensure that anomalous processing results can be readily identified, and shall ensure that periodic blind testing of the processor is periodically performed.

Methods for ensuring the quality of results for dosimeters and dosimetry applications outside the scope of DOELAP shall be documented.

Direct reading instruments used as supplemental dosimeters (e.g., electronic dosimeters or pocket ion chambers) shall be maintained and calibrated in accordance with recommendations of the manufacturer and Stoller Radiological Control Manual.

11.0 Records

11.1 Records Review

1. Review completed documentation to ensure completeness, accuracy, legibility, and reproducibility.
2. Compare the data recorded with specific limits and procedural controls to determine if trends are developing or unexpected results were obtained.
3. Notify the Radiological Control Manager of any trends or unexpected results.

11.2 Record Disposition

All records generated by this procedure shall be maintained in accordance with the project-specific QAPP.

Copies of records generated by this procedure related to TLD issuance, including multiple dosimetry issuance, shall be maintained in each worker's personnel radiation exposure file.

Records supporting DOELAP accreditation are maintained by the dosimetry processing facility.

Calibration and maintenance documentation for supplemental dosimeter instrumentation shall be maintained in an appropriate instrument file associated with the specific instrument.

12.0 References

Stoller Health and Safety Manual

Stoller Radiological Control Manual

Code of Federal Regulations, Title 10, Part 835, "Occupational Radiation Protection."

DOE STD 1111-98 DOE Laboratory Accreditation Program Administration

13.0 Appendices

Appendix A – Issuance of Whole Body TLD Badges

Appendix B – Issuance of Extremity TLDs

Appendix C – Issuance of Radon Dosimeters

Appendix D – Issuance of Visitor TLDs

Appendix E – Issuance of Supplemental Dosimeters

Appendix F – TLD Decontamination

Appendix A

Issuance of Whole Body TLD Badges

1. Obtain an unassigned TLD from the dosimetry storage supply cabinet.

   NOTE: *Assign a whole body TLD with an attached albedo dosimeter to Health & Safety technicians, Radiological Assistance Program (RAP) team members, and individuals with the potential for exposure to neutrons with average energies less than 2 MeV.*

2. Obtain a temporary TLD card and fill in the requested information on the front and back of the card as follows:

   - Employment category ("Emp." for Stoller employees; "Const." is nonapplicable and should not be checked; "Non-emp." is for subcontractor employees.)
   - Name (monitored individual's full name)
   - Company affiliation (Stoller)
   - Employee 'S' number is not applicable (enter "N/A")
   - Issued (enter current date)
   - Expires (enter last day of current calendar quarter)
   - Dosimetry packet no. (enter the 5-digit number on the TLD elements inside the badge)
   - Area visited (enter area where the TLD will be used, e.g., Moab.)
   - Issuing official (name of person issuing the TLD)
   - Social security number (SSN of individual to whom TLD is being issued)
   - Date of birth (birth date of individual to whom TLD is being issued)
   - Sex
   - Mailing address (this information is recorded elsewhere; enter "N/A.")

3. Complete vendor supplied dosimeter issue log, include name, SSN, and issued dosimeter number.
4. Insert the temporary card into the TLD holder with the open area of the card exposing the TLD elements. Close the TLD and holder assembly firmly until the unit snaps shut.
5. Issue the TLD to the individual along with a handout of instructions for proper wear and any other specific instructions necessary.
6. Complete the "Personnel Dosimetry Issue Record" form and file in the monitored individual's personnel radiation exposure file.
7. Update the Dosimeter Database with appropriate information.

Appendix B

Issuance of Extremity TLDs

1. Ensure that the individual to be monitored has a whole body TLD, which is to be worn at all times while the extremity TLD is worn.
2. Fill out the appropriate sections of the Extremity TLD Issue form with the name, social security number, issue date, location of the job, RWP number, and exposure period (leave the end date blank if the job length is not certain and fill it when the dosimeters are returned).
3. Obtain the extremity dosimeters from the storage cabinet and fit the employee/subcontractor with required number of extremity TLDs. Note the TLD number and location of the extremity for all extremity TLDs issued to the individual on the Extremity TLD Issue form.
4. Provide the individual with the handout information on Instructions for Wearing Extremity TLDs and any other instructions on wearing the extremity TLD(s).
5. If the extremity TLD is for a temporary job, issue a control dosimeter with the extremity TLD. If the length of the job is to exceed one day, designate an appropriate low background storage area and note this location on the Extremity TLD Issue form.
6. At the end of the quarter, complete appropriate sections of the Extremity Dosimeter Processing Report, noting the name and social security number of the monitored individual, the exposure period, the extremity on which the TLD(s) were worn, the type of dosimeter, and the TLD identification number for each dosimeter worn. Ensure the top of the form contains the submittal date, company name and location identifier.
7. Return the Extremity Dosimeter Processing Report to the dosimeter processor with the extremity TLDs.
8. File the Extremity TLD Issue Form in the monitored individual's personnel radiation exposure file.
9. Update the Dosimeter database with appropriate information.

Appendix C

Issuance of Radon Dosimeters

1. Obtain an unassigned radon dosimeter from the dosimetry storage supply cabinet.
2. Ensure the radon dosimeter is in its original, sealed packaging.
3. Complete the vendor-supplied issue log, including name, SSN, and issued dosimeter identification number.
4. Remove dosimeter from packaging.
5. Write the individual's name on the existing label of the dosimeter, or attach a label with this information on the dosimeter.
6. Complete the "Personnel Dosimetry Issue Record" form and file in the monitored individual's personnel radiation exposure file.
7. Issue the Radon Dosimeter to the individual along with a handout of instructions for proper wear and any other specific instructions as necessary.
8. Update the Dosimetry Database with appropriate information.

Appendix D

Issuance of Visitor Dosimeters

The Radiological Control Manager shall use input from radiation survey data provided by Health and Safety, along with other information (e.g., length and nature of the visit), to ensure that exposure conditions are not anticipated to result in doses exceeding 100 millirem to a monitored individual in a calendar year. In general, the length of the visit should not exceed one day. For exposure conditions anticipated to result in doses approaching or exceeding 100 millirem for a calendar year, the individual shall be trained and qualified as a radiological worker rather than as a visitor.

1. The information on the Visitor Dosimetry Issue Form shall be completed. Individuals with positive current year estimated doses shall be monitored as radiological workers rather than as visitors. Individuals who have already been issued dosimeters by Stoller for the calendar quarter shall be reissued that dosimeter.
2. The individual shall be briefed on the precautions listed on the form, provided the handout "Instructions for Wearing Personnel TLD Badges," and provided any other instructions deemed necessary by Health and Safety.
3. The visitor, escort, and Radiological Control Manager or designee shall sign and date the form in the appropriate locations.
4. An unassigned TLD is obtained from the dosimetry storage supply cabinet and issued to the visitor following pertinent guidance of Appendix A. After the insert card is filled out, a red line should be drawn diagonally through the card from left to right before inserting the card into the TLD badge assembly to distinguish the visitor TLD from a routine TLD.
5. The TLD database is updated with pertinent information, and the form is filed in the folder marked "Visitor Dosimetry Issue Forms."
6. An unassigned radon dosimeter, if needed, is obtained from the storage supply cabinet and issued following pertinent guidance of Appendix C.
7. Results of dose monitoring, including measured values of zero, shall be reported to visitors within 30 days of receipt of processing results in accordance with Stoller requirements.

Appendix E

Issuance of Supplemental Dosimeters

Supplemental dosimeters shall be issued to individuals identified in accordance with the applicable sections in the Health and Safety procedures as requiring monitoring.

Health and Safety shall be thoroughly familiar with the radiological conditions requiring supplemental dosimetry.

Health and Safety shall identify dose and dose rate limits for terminating work prior to exposures and shall communicate these limits to all individuals who will be exposed.

Supplemental dosimeters shall be issued to all individuals entering areas requiring such monitoring.

1. The model number, type, serial number, and Stoller property number shall be recorded for each supplemental dosimeter issued, along with the name, social security number, and whole body TLD number of the monitored individual.
2. Wearers of supplemental dosimeters shall read them at intervals necessary to prevent exceeding a control level (generally not to exceed half an hour) and shall follow all instructions of Health and Safety on use of the dosimeters.
3. Doses recorded from supplemental dosimeters shall be totaled and recorded daily, or at more frequent intervals if deemed necessary.
4. Doses recorded by supplemental dosimeters shall be maintained as the official dose record for the individual pending receipt of results from processing the individual's whole body TLD. Supplemental dosimeter monitoring results and associated documentation shall be retained in the individual's personnel radiation exposure file for future reference.

Appendix F

TLD Decontamination

Decontamination shall be performed or supervised by Health and Safety.

1. When a TLD badge is found to be contaminated, carefully remove the TLD casing from the holder, wearing gloves as a minimum to preclude the spread of contamination to the hands. Perform the decontamination effort over a surface which will contain any loose contamination.
2. Copy the individual data from the holder, and keep this information with the TLD casing.
3. Perform a contamination survey of the TLD casing.
4. If the casing is not contaminated, replace the holder and transfer the personnel data to a new label and insert it into the holder. Proceed to step [6].
5. If the casing is contaminated, then with a soft cloth, carefully wipe the external surfaces of the casing. Resurvey. If the decontamination effort was successful and the case is no longer contaminated, proceed to step [6]. If the decontamination effort was unsuccessful and the case is still contaminated, contact the RadCon Manager for further guidance.

   NOTE: *When removing the element plate from the casing, minimize the time that the elements are directly exposed to fluorescent light as this may result in accelerated fade in the elements.*

6. Process the individual's TLD and issue a new TLD in accordance with approved dosimetry procedures.

Document No: SOP-RAD-031, Rev.0

Title: Counting Systems Operation

Approved: _____ Date _____
Stoller Health and Safety Manager/
Radiation Safety Officer

Approved: _____ Date _____
Stoller Quality Assurance

Approved: _____ Date _____
Stoller Project Director and
Alternate Radiation Safety Officer

Revision Number	Date
0	1/17/05
1	10/7/05

UNCONTROLLED WHEN PRINTED

1. Introduction

1.1 Purpose

The purpose of this procedure is to provide instructions for performance testing and the routine operation of the laboratory integrated scaler counting systems. It also includes the procedure to establish the control limits used for instrument performance tests.

1.2 Scope

This procedure addresses testing and operation of integrated laboratory scaler counting systems used for radiometric measurements. It includes requirements common to all types of integrated counting systems. It does not include specific operating instructions for each counting system. These instructions are provided in the applicable instrument operating manual.

1.3 Applicability

This procedure only applies to radionuclides with a half-life of 405 days (1.1 years) or longer. This procedure does not cover the operation of field-use instruments.

2. Definitions

ALARA: As Low As Reasonably Achievable

Location: A new location or site, for the purpose of this procedure, means a location with an altitude that varies by more than 1,000 feet from the altitude at which the control limits were previously established.

3. Responsibilities and Qualifications

Personnel using this procedure must be qualified to handle radioactive sources and to operate the instrument that is being used. Documentation of this training will be maintained in the project files.

The Project Manager shall ensure that the count time(s) used for project samples generate data with a minimum detectable activity (MDA) that is adequate for the intended use of the data.

4. Safety

Gloves (latex, Nitrile, or equivalent) are required to be worn when handling samples and sources. Safety glasses are also required to be worn when handling beta-emitting sources. In addition to these minimum requirements, personal protective equipment (PPE) specified in project-specific work control documents or posted in the work area shall be worn.

Samples shall be handled with care to prevent cross-contamination.

Radioactive sources shall be handled by the edges to avoid damaging the active area.

Personnel shall use “As Low As Reasonably Achievable (ALARA)” principles to minimize exposure from sources and elevated activity samples.

5. Quality Control

5.1 Calibration

Instrument calibrations are performed, in accordance with the manufacturer's recommendations, by a qualified vendor. At a minimum, the calibration shall be performed annually. Frequently, the probe and meter will have separate calibration stickers. However, the probe and meter are required to be calibrated as a unit. Therefore, the calibration dates must be the same for both, and the calibration sticker(s) must have evidence that they were calibrated as a unit.

Only instruments with a current calibration may be used. Instruments with an expired calibration shall be tagged "Out of Service" and supervision shall be notified.

5.2 Performance Check Requirements

NOTE: If the scaler is used for both alpha and beta counting, the efficiency (check source) and background will be tested for both channels.

5.2.1 Instrument performance shall be verified each working day before the instrument is used.

5.2.2 Performance checks include miscellaneous instrument checks, efficiency (check source) checks, and instrument background checks. The performance check procedure is described in Subsection 8.2.

5.2.3 Control limits for check sources are established when the instrument is re-calibrated, when the location of the instrument changes, or when the check source used for the performance check is changed. The control limits are calculated as ± 10% of the average efficiency from ten counts of the check source.

5.2.4 The instrument background is dependent on the inherent scaler/detector background and environmental ambient radiation levels, which are affected by location and altitude. The acceptance criteria for instrument background will be based on a combination of the instrument background that is achievable (at the specific project site) and the required MDAs for data being generated with the instrument. The acceptance criteria for the instrument background(s) will be established based on these criteria at the inception of the project.

5.2.5 If the instrument fails to meet the acceptance criteria for background and/or check source (efficiency), the instrument will be tagged "Out of Service." Supervision shall be notified if this occurs.

5.2.6 The person(s) generating the data used to calculate control limits shall initial and date the top section of the check log. A second person who is technically qualified to review the data and calculations shall approve the established control limits.

5.3 Establishing Check Source Control Limits

NOTE: Control limits are established when the instrument is serviced, moved to a new location, or re-calibrated. New control limits are also established whenever a new check source will be used to perform the instrument check.

NOTE: If the instrument will be used for both alpha and beta counting, this section will be performed twice, once with each type of source. A separate log sheet will be used for alpha and beta data.

5.3.1 Obtain the appropriate check source for the instrument type.

5.3.2 Obtain a blank Integrated Scaler Performance Check Log, form SOP-RAD-31.1, Appendix A. Complete the instrument information at the top of the form and the check source information section.

5.3.3. Determine a count time for the source that will generate more than 10,000 counts. Record the Check Source Count Time on form SOP-RAD-31.1.

5.3.4 Set the count time on the scaler.

5.3.5 Count the source 10 times, removing the source and replacing it in a random position between counts. Record each count in the Check Source Information, Control Limit Data section of form SOP-RAD-31.1.

5.3.6 Calculate the average of the data set (counts) as shown in Step 9.1 and record it on form SOP-RAD-31.1 under Control Source Information Average Count.

5.3.7 Calculate the Upper and Lower Control Limits as described in Step 9.2, and record these values on form SOP-RAD-31.1 (under the Check Source Information section).

5.4 Establishing Background Control Limits

NOTE: If the limiting factor in achieving the required lower limit of detection is instrument background, the background control limit (upper limit only) may be based on the maximum background that will yield the desired MDA. If this is not the limiting factor, the control limits for background may be based on the average and standard deviation of a set of 20 background measurements.

5.4.1 Using the equation provided in Section 9.3, determine the maximum background count rate that will yield the desired MDA given the detector efficiency and desired count time. If this value is not significantly higher than the expected maximum (based upon counting statistics and normal instrument fluctuations), the maximum can be used as the upper control limit.

5.4.2 If the allowable maximum is significantly higher than expected maximum, the control limits can be established based on statistical variation in a set of background counts. If this is the appropriate method, collect 20 background counts (using the routine sample count time). Calculate the average and standard deviation of the data set. Establish the upper and lower control limits as the average count rate plus and minus 3 standard deviations, respectively.

5.4.3 Document the background count time, applicable control limit(s) and data used to generate these limits, if applicable, and the basis for those limits on form SOP-RAD-31.1.

6. Special Equipment

Integrated scaler counting system, including the instrument operating manual(s).

Applicable check source(s) for the scaler. The check source shall have the appropriate geometry (diameter and thickness), activity type, and energy for the system being checked. The activity of the source should be high enough to produce between 500 cpm and 30,000 cpm. The check source shall be manufactured from NIST traceable material.

7. Material

Stainless steel planchets or vendor-supplied sample holders

Integrated Scaler Performance Check Log, Form SOP-RAD-31.1, Appendix A

Defensap® cloth swipes, or equivalent

Tweezers or forceps

8. Instructions

8.1 Instrument Start-Up

8.1.1 If the instrument is off, turn it on and allow it to warm-up/stabilize according to manufacturer's instructions.

8.1.2 Inspect the instrument to verify that the calibration is current. Refer to Section 5 for additional information regarding calibration requirements.

8.2 Performance Checks

NOTE: Performance checks are required to be performed daily, or before each use, whichever is less frequent. If the instrument is used for both alpha and beta counting, the background and check source performance tests will be performed for both channels. Acceptable performance check results must be obtained before the instrument can be used.

8.2.1 Miscellaneous Instrument Checks

- Examine the instrument and cable(s) for visible damage or defects. If damage or defects are noted, do not use the instrument. Tag it "Out of Service" and inform supervision.
- Ensure that display(s) is(are) readable.
- Ensure that the timer light is working properly, if applicable.

8.2.2 Background Check

- Obtain a clean smear and place it on a clean planchet.
- Place the planchet into the counting instrument.
- Count the background for the pre-selected count time. The background count time should be the same as the routine sample count time. However, if the sample count times are longer than 10 minutes, a 10-minute background count time will be used, unless otherwise specified in project-specific work plans. Record the background count on form SOP-RAD-31.1.
- Repeat the background counts for a total of five background counts.
- Calculate the average background count rate (cpm) and record on form SOP-RAD-31.1.
- Compare the average background count rate to the acceptance criteria. Note the result of the evaluation (Pass/Fail) on the check log. If the background data do not meet the performance criteria, tag the instrument "Out of Service" and inform supervision.

8.2.3 Source Check

- Obtain the appropriate check source.
- Place the source into the counting instrument.
- Count the source for the pre-selected count time (as noted on the check log). Record the source count on form SOP-RAD-31.1.

- Compare the source count to the acceptance criteria. Note the result of the evaluation (Pass/Fail) on the check log. If the background data do not meet the performance criteria, tag the instrument "Out of Service" and inform supervision.

8.3 Routine Use of Instrument

8.3.1 Turn on the instrument as described in Subsection 8.1.

8.3.2 Refer to the Performance Check Log. If the instrument has not been performance checked for the day, complete the Performance Check tests as described in Subsection 8.2.

8.3.3 Select the count time for the type of sample being counted. The appropriate count time(s) for the types of samples being counted for a particular project will be posted on the instrument or specified by the Field Supervisor.

8.3.4 Using tweezers, remove the swipe from the envelope and place the swipe on a clean planchet.

8.4.5 Place the planchet in the detector, close the drawer, and start the count.

8.4.6 At the end of the count, the instrument will display the total number of alpha and/or beta, as applicable, counts that occurred.

8.4.7 Record the count time and counts on the smear envelope.

8.4.8 Remove the planchet from the drawer and return the swipe to its labeled envelope.

8.4.9 Calculate the activity of the smear (dpm) and the MDA (dpm) using the equations provided in Section 9.

8.4.10 Periodically clean (or replace) the planchet used to count swipes.

9. Calculations

Note: If the instrument is being used to measure both alpha and beta activity, the calculations below will be performed for each channel.

9.1 Efficiency Control Limits

$UCL = 1.1 * S_{Avg}$
$LCL = 0.9 * S_{Avg}$

Where:
LCL = Lower control limit
UCL =Upper control limit
S_{Avg} = Average count rate of check source data set (Step 9.1)

9.2 Sample Activity (dpm)

$$Activity = \frac{C_s - C_b}{Eff}$$

Where:

C_b	=	average count rate (cpm) of instrument background
C_s	=	average count rate (cpm) of sample
Eff	=	efficiency of detector from calibration certificate

9.3 Minimum Detectable Activity (MDA) (dpm)

$$MDA = \frac{3 + 3.29\sqrt{R_b t_s * \left(1 + \frac{t_s}{t_b}\right)}}{Eff * t_s}$$

Where:

R_b	=	count rate (cpm) of instrument background
Eff	=	efficiency instrument from calibration certificate
t_b	=	count time for background (minutes)
t_s	=	count time for sample (minutes)

10. Records

10.1 Records Generated by this Procedure

Integrated Scaler Performance Check Log Sheet, Form ST-RAD-31.1.

10.2 Supervisory Review

Review the completed documentation to ensure completeness, accuracy, legibility, and reproducibility.

Compare the data recorded with data from like instruments and data for the same instrument from previous months to determine if trends are developing or unexpected results were obtained.

Notify the Radiological Safety Officer or Project Manager of any trends or unexpected results.

10.3 Record Disposition

Maintain the documentation generated by this procedure will be maintained with the project files.

11. References

ANSI N323 – 1997, Radiation Protection Instrumentation Test and Calibration.

12. Appendices

Appendix A – Integrated Scaler Performance Check Log Sheet, Form SOP-RAD-31.1

13. Supersession

This procedure is original.

Appendix A

INTEGRATED SCALER PERFORMANCE CHECK LOG

Radiation Type (circle one) **ALPHA BETA**

Scaler/Probe Description _____ Scaler/Probe Serial Number(s)_____

Efficiency (from calibration certificate)_____

CHECK SOURCE INFORMATION			
Isotope(s)	*Serial Number*	*SV (dpm)*	*Reference Date*

BACKGROUND CONTROL LIMIT INFORMATION
Background Count Time (min)

CONTROL LIMIT DATA				

CONTROL LIMIT DATA				

Check Source Count Time (min)		Lower Control Limit	Basis for Control Limits	Lower Control Limit (cpm)
Average count		Upper Control Limit		Upper Control Limit (cpm)

Initials/Date Reviewer/Date

PERFORMANCE CHECK DATA

Date	Check Source Data		Instrument Background Data								Initials	Comments
	OV	Pass/Fail	#1	#2	#3	#4	#5	Avg.	Avg. cpm	Pass/Fail		

INTEGRATED SCALER PERFORMANCE CHECK LOG

Radiation Type (circle one) **ALPHA** **BETA**

(continuation sheet)

Scaler/Probe Description _____ Check Source LCL _____ UCL_____

Scaler/Probe Serial Number(s)_____ Bkg (cpm) LCL _____ UCL_____

Efficiency (from calibration certificate)_____

PERFORMANCE CHECK DATA												
Date	Check Source Data		Instrument Background Data								Initials	Comments
	OV	Pass/Fail	#1	#2	#3	#4	#5	Avg.	Avg. cpm	Pass/Fail		

Form SOP-RAD-31.1, Rev. 0 *Page _____*

Document No: SOP-RAD-033, Rev.0

Title: External Dose Rate Tracking

Approved: _____ Date _____
Stoller Health and Safety Manager/
Radiation Safety Officer

Approved: _____ Date _____
Stoller Quality Assurance

Approved: _____ Date _____
Stoller Project Director and
Alternate Radiation Safety Officer

Revision Number	Date
0	11/08/05

UNCONTROLLED WHEN PRINTED

1. Purpose

This procedure provides instructions for monitoring and tracking personnel external dose rates for the purpose of estimating personnel external dose when personnel dosimetry is not used and ensuring that dose rates are not at the level that would require implementing a dosimetry program.

2. Scope

This procedure covers fieldwork activities conducted under the Stoller radioactive materials license, where personnel dosimetry is not used and there is the potential for employee exposure to radionuclides.

3. Overview

The State of Colorado and DOE regulations both list an occupational dose limit for adults of 5 rem total effective dose equivalent. (6CCR 1007-1 Part 4.6, *Occupational Dose Limits for Adults,* and 10CFR Part 835.202, *Occupational Dose Limits for general employees.*) Colorado regulations require personnel dosimetry for adults likely to receive a dose in excess of 10 percent of the limit, or 500 mrem/yr (6CCR 1007-1 Part 4.18.1.1). DOE requires personnel dosimetry for radiological workers likely to receive 100 mrem/yr (10CFR Part 835.402). Stoller has adopted the lower DOE limit as an ALARA guideline, due to the amount of DOE work conducted by Stoller employees.

On Stoller work sites where radionuclide activity levels are above background but not likely to cause an occupational dose in excess of 100 mrem/yr, dose rate monitoring will be conducted in accordance with this procedure.

4. Definitions

ALARA: As Low As Reasonably Achievable

Background: Radiation from naturally occurring radioactive materials which have not been technologically enhanced; cosmic sources; global fallout; radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and consumer products containing nominal amounts of radioactive material. (10CFR Part 835.2)

Location: A new location or site, for the purpose of this procedure, means a location with an altitude that varies by more than 1,000 feet from the altitude at which the control limits were previously established.

Occupational dose: an individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. This does not include doses resulting from background radiation or doses received as a medical patient or subject in medical research. (10CFR Part 835.2)

5. Responsibilities and Qualifications

Personnel using this procedure must be qualified to handle radioactive sources and to operate the instrument that is being used. Documentation of this training will be maintained in the project files.

6. Equipment

Dose rate meter (Ludlum Model 19 or Bicron MicroRem Meter or equivalent), including the instrument operating manual(s).

Appropriate check source(s) for the meter. The check source shall be manufactured from NIST traceable material.

7. Instructions

7.1 Instrument Start-Up and Performance Checks

The dose rate meter shall be performance-checked and operated in accordance with SOP-RAD-001, *Portable Radiation Survey Instrument Operation.*

7.2 Dose Rate Monitoring

Dose rate readings shall be taken in work area(s) at the frequency specified in the applicable work plan and recorded on field form SOP-RAD-033.1. If the work plan does not specify a monitoring frequency, the default frequency shall be every hour. For long-term field assignments, monitoring frequency can be adjusted at the direction of the health and safety supervisor or RSO if consistent readings have been observed. The location(s) of the readings will be noted on the field form and can also be marked on supplemental site maps or photographs. The work area(s) expected to be occupied by workers should be surveyed, and the dose rate should be measured in the area to be occupied by the maximally exposed worker.

Workers must sign in and out of the work area on personnel rosters to document the duration of exposures.

7.3 Dose Rate Action Level

An action level may be determined based on the exposure rate guidelines that have been established for the site. For a particular site the action level may be established based on any activity exceeding background, or activity exceeding background by a specified amount. For example, dividing the annual dose limit of 100 mrem/yr by 2,000 hours worked in a typical work year yields an action limit of 50 microrem above background. The action level for a particular site will be documented in project-specific work plans or procedures.

If the dose rate action level is exceeded, work should be suspended pending investigation and review by the Stoller RSO. Corrective actions may include limiting personnel durations in the work area and/or issuing personnel dosimetry to workers.

8. Records

8.1 Records Generated by this Procedure

Dose rate monitoring, Form SOP-RAD-033.1.

Site Access Control Personnel Roster, Form ST-RAD-GEN-008

8.2 Supervisory Review

Review the completed documentation to ensure completeness, accuracy, legibility, and reproducibility.

Notify the Radiological Safety Officer or Project Manager of any trends or unexpected results.

8.3 Record Disposition

Maintain the documentation generated by this procedure with the project files. A copy must be sent to the Stoller Health and Safety Manager to comply with Stoller's duty to track the cumulative total effective dose equivalent for employees, and to provide the data to each affected employee.

9. References

Department of Energy Regulations: 10CFR Part 835, *Occupational Radiation Protection*
835.2, *Definitions*
835.202, *Occupational dose limits for general employees*
835.402, *Individual Monitoring*

Colorado Department of Public Health and Environment Regulations, 6CCR 1007-1, Part 4, *Standards for Protection Against Radiation*
4.6, *Occupational Dose Limits for Adults*, section 4.6.1.1
4.18, *Conditions Requiring Individual Monitoring of External and Internal Occupational Dose*, section 4.18.1.1

Dose Rate Monitoring
Form SOP-RAD-033.1

Location/Client:	Instrument Mfg./Model:
Date:	Serial #:
Surveyed by:	Calibration due:
Background (μR/hr):	Performance check satisfactory? Y / N

Time	Monitoring Location		Dose rate (μR/hr)
	Description	Drawing Ref.	

DRAWING SHOWING MONITORING LOCATIONS

Note: Submit completed form to project file and H&S Manager with Site Access Control Personnel Rosters

Appendix F
Field Forms

Stoller

Excavation Drawing/Notes Log

Date: _____

Location: _____

Sampler(s): _____

Picture #	Camera ID#	Description

S.M.STOLLER PACKAGE RADIOLOGICAL SURVEY FORM

Survey Type:	**INSTRUMENT DATA**					
Location:	**Mfg.**					
Purpose:	**Model**					
Date:	**Serial #**					
Time:	**Cal Due**					
Surveyed by:	**Bkg.**					
Comments:	**Efficiency**					
	MDA					

ALPHA/BETA TOTAL AND REMOVABLE CONTAMINATION SURVEY

Location	Total alpha		Removable alpha		Total beta		Removable beta	
	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2
1								
2								
3								
4								
5								
6								
7								
8								

GAMMA DOSE RATE SURVEY (µrem/hr)

Location	@ surface	@ 1 meter	Location	@ surface	@ 1 meter
1			5		
2			6		
3			7		
4			8		

DRAWING SHOWING SURVEY POINTS

ALPHA/BETA TOTAL AND REMOVABLE CONTAMINATION SURVEY
(continuation sheet)

Location	Total alpha		Removable alpha		Total beta		Removable beta	
	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2

GAMMA DOSE RATE SURVEY (µrem/hr)
(continuation sheet)

Location	@ surface	@ 1 meter	Location	@ surface	@ 1 meter

Surveyed by: _____ Date: _____

S.M.STOLLER RADIOLOGICAL SURVEY FORM

Survey Type:	INSTRUMENT DATA					
Location:	Mfg.					
Purpose:	Model					
Date:	Serial #					
Time:	Cal Due					
Surveyed by:	Bkg.					
Comments:	Efficiency					
	MDA					

SURVEY RESULTS

DRAWING SHOWING SURVEY POINTS

Stoller

Sample Collection Log

Date: _____ **Location:** _____ **Sampler(s):** _____ **Page** ____ **of** ____

Sample ID #	Time	Grab or Composite	Onsite or Offsite Lab	GPS waypoint #	Bottle #'s/Type	For composite: Gamma data pt #	For composite: XRF data pt #	Comments
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					
		G / C	On / Off					

Stoller

SITE ACCESS CONTROL
PERSONNEL ROSTER

Site: _____

PRINTED NAME	DATE	TIME IN	TIME OUT

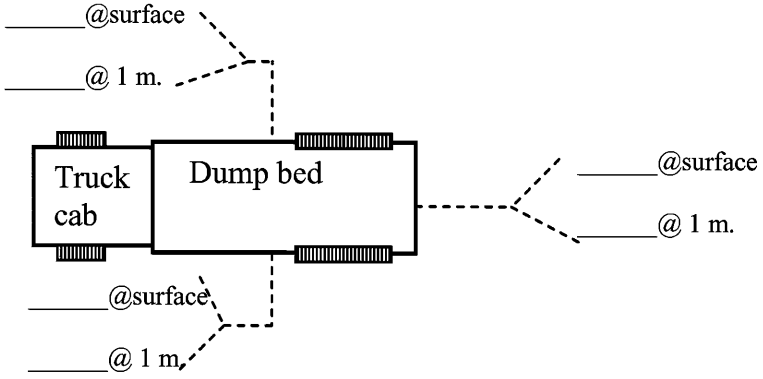
S.M. STOLLER TRUCK RADIATION SURVEY FORM

Date/Time: _____

Truck Survey: **Incoming** ☐ **or Outgoing** ☐ **Surveyed by:**_____

Trucking Company: _____**Truck license plate no. /state:** _____

Gamma Dose Rate Survey (µrem/hr)

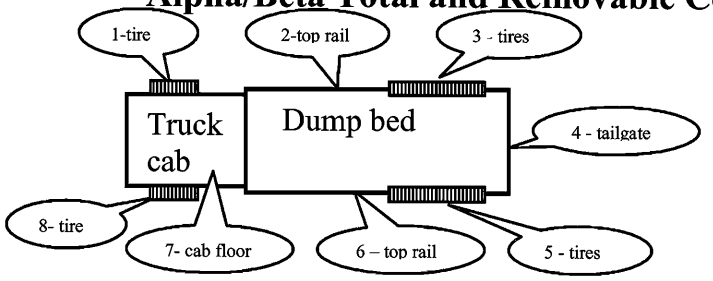


Notes:
Dose rates should be recorded at highest reading for each side.

Incoming Limits (49CFR 173.443)
0.5 mrem/hr at surface

Outgoing Limits (49CFR 173.441)
200 mrem/hr at surface
10 mrem/hr at 1 m
(If surface is <10mrem/hr, survey is complete.)

Alpha/Beta Total and Removable Contamination Survey



Removable Contamination limits:
Alpha: 220 dpm/100 cm^2
Beta: 2200 dpm/100 cm^2

*If total reading is less than limit, survey is complete. If total reading is greater than limit, collect smear and count for removable.

Location	Total alpha		Removable alpha*		Total beta		Removable beta*	
	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2	cpm/100 cm^2	dpm/100 cm^2
1								
2								
3								
4								
5								
6								
7								
8								

INSTRUMENT DATA				
Mfg.				
Model				
Serial #				
Cal Due				
Bkg.				
Efficiency				
MDA				

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Way point / ID Log

Date: _____ **Location:** _____ **Sampler(s):** _____

Instrument Data:

GPS Mfg: _____ Model: _____ Serial No. _____ _____ Performance check satisfactory? **Y / N**

XRF Mfg: _____ Model: _____ Serial No. _____ Performance check satisfactory? **Y / N**

Gamma Monitor Mfg: _____ Model: _____ Serial No. _____ } Performance check

Gamma Probe Mfg.: _____ Model: _____ Serial No. _____ } satisfactory? **Y / N**

GPS Waypoint	Time	Gamma datalogger point #	Gamma Color code	XRF datalogger point #	XRF Color code	Sample Collected? Y/N	Comments:
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		

GPS Waypoint	Time	Gamma datalogger point #	Gamma Color code	XRF datalogger point #	XRF Color code	Sample Collected? Y/N	Comments:
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		
			R / Y / G		R / Y / G		

Appendix G
ALARA Assessment

ALARA Assessment

The as low as reasonably achievable (ALARA) analysis is used to determine if the tentative clean-up goals or derived concentration guidelines (DCGLs) being proposed for a site characterization or remedial action are ALARA. The following paragraphs summarize the ALARA analysis and indicate the tentative clean-up goals for the project are more protective than what is reasonable under ALARA. The remedial effort described in this work plan will remove additional material, beyond the cleanup objective, if such removal is practical, in the spirit of ALARA.

The ALARA study requires input parameters (both default parameters and project-specific parameters), estimates of the cost of remediation, and a final end-use scenario. The parameters used and the end-use scenarios of recreational use and residential use are presented and compared in the following text.

Methods as outlined in *NUREG-1727: Consolidated NMSS Decommissioning Guidance, Volume 2, Appendix D* were used to determine clean-up levels that met ALARA requirements. According to NUREG-1727, the residual radioactivity that is ALARA is the concentration "at which the benefit from removal equals the cost of removal." The ratio of this concentration, *Conc*, to the $DCGL_W$ (the average concentration of residual radioactivity that would result in a dose of 25 mrem/yr to the average member of the critical group), is found by using the following equation:

$$\frac{Conc}{DCGL_W} = \frac{Cost_T}{\$2000 \times P_D \times 0.025 \times F \times A} \times \frac{r+\lambda}{1-e^{-(r+\lambda)N}} \qquad \text{(N-8)}$$

In equation N-8, $Cost_T$ is the sum of individual costs of the remedial action, including costs for transport and disposal of waste, worker accidents, traffic fatalities, dose received by workers, and other costs as deemed appropriate. The total cost was found using equations N-3 through N-7 in Appendix D of NUREG-1727 (shown in Table 1) and was determined to be $633,180.98. Values used in the cost calculations and other parameters used in equation N-8 are displayed in Table 2.

Table 1
Equations N-3 through N-7 as found in NUREG-1727, Volume 2, Appendix D

Description	Equation	Number
Total costs	$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + Cost_{TF} + Cost_{WDose} + Cost_{other}$	N-3
Cost for transport and disposal of waste	$Cost_{WD} = V_A \times Cost_V$	N-4
Cost of worker accidents	$Cost_{ACC} = \$3{,}000{,}000 \times F_W \times T_A$	N-5
Cost of traffic fatalities	$Cost_{TF} = \$3{,}000{,}000 \times \left(\frac{V_A}{V_{SHIP}}\right) \times F_T \times D_T$	N-6
Cost of worker dose	$Cost_{WDose} = \$2{,}000 \times D_R \times T_A$	N-7

Table 2
Values Used in ALARA Calculations

Cost of remediation action ($Cost_R$):	$275,000
Value of a person-rem averted:	$2,000[a]
Volume of waste produced (V_A):	12,745 m^3
Cost of waste disposal ($Cost_V$):	$19.62 per m^3
Workplace fatality rate (F_W):	4.20×10^{-8} [b]
Worker time required for remediation (T_A):	2,000 person-hours
Fatality rate per truck-km traveled (F_T):	3.80×10^{-8} [b]
Distance traveled (D_T):	32.5 km
Volume of one truck shipment (V_{SHIP}):	13.6 m^3 [b]
Total effective dose equivalent to workers (D_R):	0.0011 rem/hr
Planning and preparation costs ($Cost_{other}$):	$100,000
Population density for the critical group (P_D):	0.0004 people/m^2 [b]
Fraction of residual radioactivity removed (F):	0.90
Area being evaluated (A):	10,000 m^2
Monetary discount rate (r):	0.03 per year[a]
Radiological decay constant for Ra-226 (λ):	4.33×10^{-4} $year^{-1}$
Number of years over which dose is calculated (N):	1,000[b]

[a]Standard value as listed in NUREG/BR-0058.
[b]Standard value as listed in NUREG-1496, Volume 2, Appendix B, Table A.1.

Table 3 shows the ratio of *Conc* to $DCGL_W$ for each radionuclide of concern. In all cases, this ratio was greater than one; therefore, it may be concluded that the proposed tentative clean-up goals will bring radionuclide concentrations to levels that are ALARA.

Table 3
Ratio of ALARA DCGLs to Tentative DCGLs
(The number of times higher the ALARA clean-up goal is than the tentative clean-up goal)

	Ra-226	Ra-228	Th-228	Th-230	Th-232	U-234	U-235	U-238	K-40	Pb-210	Th-234
***Conc*:$DCGL_W$**	107	528	1379	106	106	106	106	106	106	214	37041

For example, the above results show that the Ra-226 concentration could be cleaned up to a level 107 times the DCGL to be considered ALARA. This is for a recreational-use scenario that limits the future use of the site. Table 4 presents the recreational-use scenario compared to the residential-use scenario.

Table 4
Recreational Use and Residential Use Scenario DCGLs for Various Project Costs

$Cost_R$ ($)	V_A (m^3)	Recreational-Use Scenario (Conc/$DCGL_W$)	Residential-Use Scenario (Conc/$DCGL_W$)
1,000,000	49,694	353.90	3.67
2,000,000	100,660	694.38	7.19
3,000,000	151,630	1,034.88	10.72
4,000,000	202,600	1,375.38	14.25
5,000,000	253,570	1,715.88	17.78

Parameters for the recreational use scenario use were replaced with values given for those parameters for the residential-use scenario (as listed in NUREG-1757, Appendix N). The values that changed are listed below.

Recreational-use scenario: P_D = 0.0004 people/m^2, r = 0.03 per year, N = 1,000 yrs.
Residential-use scenario: P_D = 0.09 people/m^2, r = 0.07 per year, N = 70 yrs.

Table 4 demonstrates as the cost increases, so does the final ratio (Conc/$DCGL_W$). If the residential-use scenario is assumed, the ALARA concentration is closer to the tentative clean-up goal (DCGL). This demonstrates the tentative clean-up goal proposed remains ALARA (as long as the cost of remediation exceeds $1,000,000) even if the end use of the site is residential development.

Appendix H
Data Validation

DATA VALIDATION REPORT

To: Ralph Rupp- Stoller
From: Richard Thurman
Report Date: February 2, 2005
Project/Site: CSMRI
Project No.: 3978
SDG No.: 04-12-207

This report presents the alpha spectrometry and gamma spectrometry radiological data validation for the data obtained during the field activities for the above referenced work assignment. The purpose of this review is to provide a technical validation of the radiological results by Paragon Procedure PAI SOP 714R9 for isotopes of uranium and thorium, PAI SOP 713R8 for Radium-226 and Radium-228 by gamma spectrometry for SDG 04-12-207 from Paragon Analytics, Inc. (Fort Collins, CO). This report consists of 12 soil samples collected on December 21, 2004 for the CSMRI/ 3978 project. The samples were analyzed on January 20, 2005 by gamma spectroscopy, January 13, 2005 for isotopic uranium, and January 12-13, 2005 for isotopic thorium by Paragon Analytics, Inc... The field sample numbers and corresponding laboratory numbers are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0412207-1	20041221021	Soil
0412207-2	20041221022	Soil
0412207-3	20041221023	Soil
0412207-4	20041221024	Soil
0412207-5	20041221025	Soil
0412207-6	20041221026	Soil
0412207-7	20041221027	Soil
0412207-8	20041221028	Soil
0412207-9	20041221029	Soil
0412207-10	20041221030	Soil
0412207-11	20041221031	Soil
0412207-12	20041221032	Soil

Data validation was conducted in accordance with the Analytical Services Division of the Rocky Flats Technology Site's (RFETS) Statement of Work for the Determination of Radionuclides by Alpha Spectrometry, Module RC01-v2, October 1, 2002, and Determination of Gamma Nuclides, Module GAM-v1, October 1, 2002.

The data were evaluated based on the following parameters:

* Data Completeness

* Holding Times and Preservation
* Instrument Initial Calibrations
* Instrument Performance Checks
* Preparation Blanks
* Duplicate Sample Results
* Laboratory Control Samples (LCS) Results
* Matrix Spike/Matrix Spike Duplicate Results
* Compound Quantitation and Reporting Limits (full validation only)

* **All criteria were met for this parameter**

Data Completeness

The data package was complete and all results remain unqualified as a result of the validation process.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met. However, holding time requirements are not applicable to radiochemistry analyses unless the isotopes of interest have short half-lives.

Iodine-131 by gamma spectrometry was reported but the decay-corrected activity was less than its MDC. The analysis date was more than three half-lives past the collection date. No action was taken. The remaining isotopes with short half-lives that were reported had decay-corrected activities that were less than their MDCs. No action was taken.

Calibrations

The instruments were calibrated at the required frequency.

Initial Calibration

All instruments were calibrated properly using NIST traceable SRM.

Instrument Performance Checks

All isotopes were within criteria.

Preparation Blanks

The preparation blank was analyzed at the required frequency.

All of the isotopes that were analyzed had activities that were below their respective MDCs in the preparation blanks with the exception of U-235 by alpha spectrometry. The activity of U-235 (0.035 pCi/g in the method blank exceeded the MDC of 0.028 pCi/g, but was below the RDL of 0.1 pCi/g. The data validation guidelines do not require qualification of sample results if the method blank detections are below the RDL and therefore no action was taken.

Duplicate Sample Analysis

Due to insufficient sample volume to perform a laboratory duplicate, an analysis duplicate for gamma analyses was performed on soil sample 20041221021. All gamma nuclides that were detected above the MDC in original and duplicate analyses met the limits of the statistical test for equivalency. No action is required.

A laboratory duplicate analysis was performed for isotopic uranium by alpha spectrometry on sample 20041221021 and for isotopic thorium by alpha spectrometry on sample 20041221023. All isotopic activities for original sample and duplicate were within the limits of the statistical test for equivalency. No action is required.

Matrix Spike/Matrix Spike Duplicates

Matrix spike/matrix spike duplicates were not performed for the samples in this SDG, nor were any required.

Laboratory Control Samples

The laboratory analyzed laboratory control samples for Uranium-238, Uranium-234, and Thorium-230 for alpha spectrometry. All recoveries were within 75-125% limits. No calculation errors or transcription errors were found.

An LCS was analyzed for gamma spectrometry that included the following isotopes of interest: Radium-226, Cesium-137, Cobalt-60, and Americium-241. All percent recoveries were within 75-125% limits.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.
All sample results were reported on a "dry weight" basis.

Radium-226 was quantitated by using a weighted mean of activities obtained from the following energy lines: Pb-214 at 351 KeV and 295 KeV, and Bi-214 at 609 KeV. Radium-228 was quantitated by using the energy line at 911 KeV. No action was required.

It was noted in the laboratory narrative that two samples in this SDG that were analyzed for isotopic uranium had tracer peak resolutions that exceeded 2.0% (>100 KeV full width at half maximum). However, the reviewer examined the individual spectral reports and there was good peak separation (no tailing) in either case. No action was taken.

Several samples that were analyzed for isotopic thorium had tracer peak resolutions that exceeded 2% (>100 KeV full width at half maximum). However, the reviewer examined the individual spectral reports and there was good peak separation (no tailing) in either case. No action was taken.

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.

The MDCs for several samples did not meet the required detection limits for the project. However, in each case the sample activity was reported above the MDC, so no action was taken.

Overall Comments

Iodine-131 by gamma spectrometry was reported but the decay-corrected activity was less than its MDA. The analysis date was more than three half-lives past the collection date. No action was taken. The remaining isotopes with short half-lives that were reported had decay-corrected activities that were less than their MDCs. No action was taken.

The activity of U-235 (0.035 pCi/g in the method blank exceeded the MDC of 0.028 pCi/g, but was below the RDL of 0.1 pCi/g. The data validation guidelines do not require qualification of sample results if the method blank detections are below the RDL and therefore no action was taken.

The results were unremarkable. All activities for isotopes of uranium and thorium by alpha spectrometry were in their natural abundances and were equivalent to environmental levels for Colorado soil. The gamma results that were obtained exhibited Radium-226 and Radium-228 activities above the MDCs and equivalent to environmental

levels.

DATA QUALIFIER DEFINITIONS

For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.

J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.

U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.

DATA VALIDATION REPORT

To: Ralph Rupp- Stoller
From: Richard Thurman
Report Date: February 3, 2005
Project/Site: CSMRI
Project No.: 3978
SDG No.: 04-12-206

This report presents the alpha spectrometry and gamma spectrometry radiological data validation for the data obtained during the field activities for the above referenced work assignment. The purpose of this review is to provide a technical validation of the radiological results by Paragon Procedure PAI SOP 714R9 for isotopes of uranium and thorium, PAI SOP 713R8 for Radium-226 and Radium-228 by gamma spectrometry for SDG 04-12-207 from Paragon Analytics, Inc. (Fort Collins, CO). This report consists of 20 soil samples collected on December 21, 2004 for the CSMRI/ 3978 project. The samples were analyzed on January 18, 2005 by gamma spectroscopy, January 19-20, 2005 for isotopic uranium, and January 13, 2005 for isotopic thorium by Paragon Analytics, Inc... The field sample numbers and corresponding laboratory numbers are presented below:

Laboratory Sample Number	Client Sample Number	Matrix
0412206-1	20041221001	Soil
0412206-2	20041221002	Soil
0412206-3	20041221003	Soil
0412206-4	20041221004	Soil
0412206-5	20041221005	Soil
0412206-6	20041221006	Soil
0412206-7	20041221007	Soil
0412206-8	20041221008	Soil
0412206-9	20041221009	Soil
0412206-10	20041221010	Soil
0412206-11	20041221011	Soil
0412206-12	20041221012	Soil
0412206-13	20041221013	Soil
0412206-14	20041221014	Soil
0412206-15	20041221015	Soil
0412206-16	20041221016	Soil
0412206-17	20041221017	Soil
0412206-18	20041221018	Soil
0412206-19	20041221019	Soil
0412206-20	20041221020	Soil

Data validation was conducted in accordance with the Analytical Services Division of the Rocky Flats Technology Site's (RFETS) Statement of Work for the Determination of Radionuclides by Alpha Spectrometry, Module RC01-v2, October 1, 2002, and Determination of Gamma Nuclides, Module GAM-v1, October 1, 2002.

The data were evaluated based on the following parameters:

* Data Completeness
* Holding Times and Preservation
* Instrument Initial Calibrations
* Instrument Performance Checks
* Preparation Blanks
* Duplicate Sample Results
* Laboratory Control Samples (LCS) Results
* Matrix Spike/Matrix Spike Duplicate Results
* Compound Quantitation and Reporting Limits (full validation only)

* **All criteria were met for this parameter**

Data Completeness

The data package was complete and all results remain unqualified as a result of the validation process.

Holding Times and Preservation

Analytical holding times were evaluated and all criteria were met. However, holding time requirements are not applicable to radiochemistry analyses unless the isotopes of interest have short half-lives.

Iodine-131 by gamma spectrometry was reported but the decay-corrected activity was less than its MDC. The analysis date was more than three half-lives past the collection date. No action was taken. The remaining isotopes with short half-lives that were reported had decay-corrected activities that were less than their MDCs. No action was taken.

Calibrations

The instruments were calibrated at the required frequency.

Initial Calibration

All instruments were calibrated properly using NIST traceable SRM.

Instrument Performance Checks

All isotopes were within criteria.

Preparation Blanks

The preparation blank was analyzed at the required frequency.

All of the isotopes that were analyzed had activities that were below their respective MDCs in the preparation blanks with the exception of U-235 by alpha spectrometry. The activity of U-238 (0.05 pCi/g in the method blank exceeded the MDC of 0.04 pCi/g, but was below the RDL of 0.1 pCi/g. The data validation guidelines do not require qualification of sample results if the method blank detections are below the RDL and therefore no action was taken.

Duplicate Sample Analysis

Due to insufficient sample volume to perform a laboratory duplicate, analysis duplicates for gamma analyses were performed on soil samples 20041221001 and 20041221005. All gamma nuclides that were detected above the MDC in original and duplicate analyses met the limits of the statistical test for equivalency. No action is required.

A laboratory duplicate analysis was performed for isotopic uranium by alpha spectrometry on sample 20041221016 and for isotopic thorium by alpha spectrometry on sample 20041221007. All isotopic activities for original sample and duplicate were within the limits of the statistical test for equivalency. No action is required.

Matrix Spike/Matrix Spike Duplicates

Matrix spike/matrix spike duplicates were not performed for the samples in this SDG, nor were any required.

Laboratory Control Samples

The laboratory analyzed laboratory control samples for Uranium-238, Uranium-234, and Thorium-230 for alpha spectrometry. All recoveries were within 75-125% limits. No calculation errors or transcription errors were found.

An LCS was analyzed for gamma spectrometry that included the following isotopes of interest: Radium-226, Cesium-137, Cobalt-60, and Americium-241. All percent recoveries were within 75-125% limits.

Analyte Quantitation and Reporting Limits

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.
All sample results were reported on a "dry weight" basis.

Radium-226 was quantitated by using a weighted mean of activities obtained from the following energy lines: Pb-214 at 351 KeV and 295 KeV, and Bi-214 at 609 KeV. Radium-228 was quantitated by using the energy line at 911 KeV. No action was required.

Several samples that were analyzed for isotopic thorium had tracer peak resolutions that exceeded 2% (>100 KeV full width at half maximum). However, the reviewer examined the individual spectral reports and there was good peak separation (no tailing) in either case. No action was taken.

Analyte quantitation was evaluated for all samples. No calculation or transcription errors were found. The results and reporting limits were correctly reported.

The MDCs for several samples did not meet the required detection limits for the project. However, in each case the sample activity was reported above the MDC, so no action was taken.

Overall Comments

Iodine-131 by gamma spectrometry was reported but the decay-corrected activity was less than its MDA. The analysis date was more than three half-lives past the collection date. No action was taken. The remaining isotopes with short half-lives that were reported had decay-corrected activities that were less than their MDCs. No action was taken.

The activity of U-238 (0.05 pCi/g in the method blank exceeded the MDC of 0.04 pCi/g, but was below the RDL of 0.1 pCi/g. The data validation guidelines do not require qualification of sample results if the method blank detections are below the RDL and therefore no action was taken.

All activities for isotopes of uranium and thorium by alpha spectrometry were in their natural abundances and approximate to the environmental levels expected for Colorado soil. The gamma results that were obtained exhibited Radium-226 and Radium-228 activities above the MDCs and also approximate environmental levels, since they are progeny of uranium and thorium.

DATA QUALIFIER DEFINITIONS

For the purpose of Data Validation, the following code letters and associated definitions are provided for use by the data validator to summarize the data quality.

R - Reported value is "rejected." Resampling or reanalysis may be necessary to verify the presence or absence of the compound.

J - The associated numerical value is an estimated quantity because the Quality Control criteria were not met.

U J - The reported quantitation limit is estimated because Quality Control criteria were not met. Element or compound was not detected.

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.

NR - Result was not used from a particular sample analysis. This typically occurs when more than one result for an element is reported due to dilutions and reanalyses.