PART 2: THE DECISION SUMMARY

A. Site Name, Location, and Brief Description

The CSMRI Site has historically included the soil stockpile (material removed from the settling pond) formerly located near the Colorado School of Mines (School) softball field, the Fenced Area (including the settling pond), and the Clay Pits area located south of the intersection of Birch and 12th Streets. For the purposes of this document only, the Site is defined as the Fenced Area (excluding the settling pond) and the Clay Pits area.

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 about 475 feet northwest of the intersection of Birch and 12th Street in Golden, Colorado. A chain-link fence restricts access to the Site, except for a small area located south of 12th Street known as the Clay Pits area. A settling pond was previously located within the perimeter fence but the pond was cleaned up and closed by the U.S. Environmental Protection Agency (EPA) in 1997 as part of an Emergency Removal Action under CERCLA and is not part of the School's remedial action. The softball field area, where the pond stockpile had been located, has also been cleaned up and removed from the scope of CSMRI's radioactive materials license for the Site.

The Site (excluding the Clay Pits area and the former settling pond area) covers an area of about six acres and is currently defined by the shaded area shown in Figure 1-2. The Clay Pits area also is shown in Figure 1-2. In accordance with CERCLA and the 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 proximity to the contamination. Consequently, the Site boundary may be modified or expanded to address the needs of the remedial action.

Colorado School of Mines is the lead agency for the Site for this remedial action. Its remedial action and its work plans are being reviewed and approved by CDPHE. The School is the source of the cleanup monies for this remedial action.

The Site is former metallurgical and mining research facility. Numerous mineral research projects (some of which involved the mineral extraction and beneficiation of materials that contained levels of radionuclides and/or metals above background) were conducted at the Site from 1912 until approximately 1987. The research projects utilized 17 buildings on the Site that were subsequently removed in the mid-1990s. An impoundment (settling pond) also was situated between the building complex and Clear Creek to store wastewater generated in the laboratories and research facilities. Wastewater discharged from the buildings was transferred to the settling pond through a system of sumps and floor drains in the buildings. Materials form the research had also been disposed of at the Site.

B. Site History and Enforcement Activities

Site research operations ceased in 1987. From approximately 1985 to 1992, CSMRI performed investigation and closure activities.

On January 25, 1992, a water main owned by the City of Golden broke on the site and began discharging a large volume of water into the settling pond. EPA's Emergency Response

Branch responded in February 1992 and performed a number of activities to stabilize conditions at the site, including:

- excavation of the contaminated sediments and soil,
- stockpiling of the material (the Stockpile),
- decontamination of building drains,
- demolition and removal of several buildings,
- consolidation of existing drums and disposal of compressed gas cylinders,
- sampling of sediments and water, and
- closure of the settling pond.

EPA subsequently contacted many of the entities that had sent materials to the Site and requested that the Stockpile be removed off site. This culminated in the issuance of a Unilateral Administrative Order (UAO) on December 22, 1994 to certain entities (the respondents). Among other things, the UAO required the respondents to develop and evaluate disposal options for the Stockpile (approximately 20,000 cubic yards) and ultimately implement the selected disposal alternative. Some of the respondents prepared a *Removal Action Options Analysis* (RAOA) report that was issued on June 12, 1995. The RAOA report identified and evaluated various disposal options for the Stockpile. The Colorado School of Mines and the State of Colorado were the only respondents that subsequently implemented the preferred disposal option. The EPA removal action was completed in 1997.

The School also participated in a mediation in 1997 with some potentially responsible parties, including some of the respondents to the UAO. Settlement agreements for reimbursement of some response costs incurred up to May 31, 1997 (but not response costs incurred after May 31, 1997) were executed and some monies paid to EPA and the School as a result of the mediation.

In addition to the mediation, the School filed a lawsuit against many PRPs in 1999. Over the course of the next several years, the School settled with most of the defendant PRPs and recovered some monies. The lawsuit is still pending against a few PRPs.

The School hired AWS Remediation to remove the remaining research buildings from the Site in the mid-1990s. Following demolition of the buildings, the existing pits and basements were backfilled to grade; building foundations and concrete footers were left on-site.

A *Characterization Survey Work Plan* (CSWP) was prepared by URS Corporation (URS) on July 23, 2001. The purpose of the CSWP was to guide field investigation activities to supplement existing data and evaluate the risks associated with the release of residual metals and radioactive materials found in soils within the Fenced Area and the Clay Pits Area. Working in accordance with the CSWP, URS completed the characterization of the concrete and asphalt slabs and issued two Draft Final Reports on February 11, 2002 and May 18, 2002, respectively.

The CSWP identified demolition of the remaining concrete and asphalt materials as an integral part of the Site characterization process. Consequently, in April 2002, the School hired New Horizons Environmental Consultants, Inc. (New Horizons) to remove the remaining concrete and asphalt slabs and to characterize surface and subsurface soils on the Site. New Horizons prepared a comprehensive set of work plans that guided the characterization activities which were conducted at the Site. These plans were subsequently approved by CDPHE.

During November and December 2002, all remaining concrete and asphalt were removed from the Site and either transported as demolition debris to BFI's Foothills Landfill (BFI) in Golden, CO (a permitted Subtitle D solid waste facility) or transported to Recycled Materials, Inc.'s (RMI) plant in Arvada, CO for recycling. Detailed documentation regarding the removal of the concrete and asphalt slabs is provided in New Horizons' April 11, 2003 report entitled *Concrete and Asphalt Removal and Disposal [Final Report]*.

During December 2002 and January 2003, New Horizons collected surface and subsurface soil samples, which were analyzed for metals and radionuclides. Quarterly ground-water samples were collected for four quarters beginning in February 2003. The results of the Site investigation were presented in a remedial investigation/feasibility study and proposed plan, dated January 21, 2004 (the RI/FS). The RI/FS evaluated alternative remedial actions and proposed off-Site removal of the affected soils and natural attenuation of the ground water with continued monitoring as the preferred remedial alternative.

A number of historical investigations have been completed at both the Fenced Area and the Clay Pits area. Results from these investigations are included in the following reports:

- *Surface Gamma Ray Scanner Survey*, U.S. Environmental Protection Agency, 1982.
- *CSMRI Environmental Assessment,* Jacobs Engineering Group Inc., October 1987.
- *Claypits Report to CDPHE*, Robert MacPherson, October 20, 1988.
- *Preliminary Assessment of Radiological Risks at CSMRI, Creekside,* L. Hersloff, Radiant Energy Management, September 1989.
- *Tailings Pond, CSMRI, Creekside Sampling Report, Industrial Compliance Inc.,* October 1989.
- *Preliminary Assessment of the Potential for Water-Borne Migration of Contaminants in the Claypits,* J. Kunkel, Advanced Science, October 20, 1989.
- *CSM Environmental Sampling & Analysis Program: Claypits Site & CSMRI Facility*, James L. Grant & Associates, August 9, 1990.
- *Characterization Plan for Claypits & CSMRI Creekside and Table Mountain Research Center Sites*, James L. Grant & Associates, March 22, 1991.
- *Preliminary Remedial Alternative Evaluation for the CSM Creekside Stockpile*, SR & K, August 25, 1994.
- *Removal Action Options Analysis (*RAOA*),* Multiple authors, June 12, 1995 (3 vols.).
- *Concrete and Asphalt Characterization Report*, URS Corporation, May 18, 2002.

- *CSMRI Characterization Summary*, New Horizons Environmental Consultants, Inc., August 21, 2003.

Site Licensing History

The CSMRI Site licensing and permitting history shows that the regulatory programs that provided facility oversight determined which regulatory program(s) was most appropriate for the Site activities. Governmental regulators concluded that the facility regulation would be 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 applied for and received a Part A permit. On August 24, 1984 EPA requested that CSMRI complete the permitting process by submitting a Part B permit. In undertaking the more detailed Part B application it became apparent that CSMRI had filed the original Part A application 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 C.F.R part 261.4(b)(7) (this point is discussed in more detail below). The Colorado Department of Health reviewed this information and determined the facility was exempt from Subtitle C of RCRA. RAOA Attachment 21 contains four letters that discuss the RCRA history at the Site.

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 NORM, source, and by-product material (Colorado Radioactive Materials License Number 617-01S).

The following is a chronological summary of the U.S. Atomic Energy Commission ("U.S. AEC") and the State of Colorado licensing actions at the Colorado School of Mines Research Institute site:

Summary of U.S. AEC Licensing Actions at CSMRI:

Time Period	License Details
Terminated 1948	Weinig had License No. R-120 from the U.S. AEC for source material, which terminated in 1948. V2731, V2732. Weinig's clients also may have had separate licenses from the U.S. AEC for research at the Site. V1436.
1958 -1967	The State of Colorado has records of U.S. Atomic Energy Commission ("U.S. AEC") licensing actions dating from January 1958 through December 1967.
1958 - 1967	U.S. AEC By-product 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	U.S. 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:

Date	License Details
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).
October 31, 1975	Amendment No. 6 to License Number: Colo. 08 – 01 (F).
	Note: The State does not have record(s) 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. 617-01
March 30, 2001	Amendment No. 4 to License No. 617-01
February 11, 2002	Amendment No. 5 to License No. 617-01. Issued to: Colorado School of Mines Research Institute Authorized uses: Possess and store naturally occurring, source and by-product.

The Site was licensed by both the Atomic Energy Commission (AEC) and the State of Colorado for numerous types of radioactive materials over several decades. The current license includes NORM, source material, and by-product material. Previous licenses authorized possession and use of any radioactive materials having atomic numbers 3 through 88 inclusive, americium, and plutonium. The scant available records related to plutonium materials indicate that disposal of certain plutonium materials occurred at Rocky Flats west of Denver (RAOA, Attachment 22). The licenses authorizing the use of americium state that the americium was for the calibration of instruments and for gauges. The amounts of americium for these instruments must have been minute. There are no records related to the disposal of americium.

C. Community Participation

Community participation activities for this Site began after the water main break in 1992 and upon the issuance of the UAO in 1994. Many community meetings were held through 1995, including a public meeting and comment period for the RAOA that documented the proposed off-Site disposal alternative for the stockpiled soils in 1995. The community participation activities for the recent RI/FS built upon those prior efforts.

A community open house was held at the School in 2003 prior to the completion of the RI/FS to solicit input on the ongoing RI/FS activities. In addition, School representatives met with CPDHE and some PRP representatives to solicit input on the ongoing RI/FS activities. The RI/FS Report and Proposed Plan for the CSMRI Site in Golden, Colorado, were made available to the public in January 2004. They can be found in the Administrative Record file and the information repository maintained at the Golden and School public libraries. The notice of the availability of these two documents was published in the Golden Transcript, the Denver Post, and the Rocky Mountain News. A 30-day public comment period was held, including an extension of time to the public comment period requested by some parties. Moreover, additional comments were accepted from CDPHE after the close of the public comment period but before the publication of this record of decision. In addition, a public meeting was held in February 2004 to present the Proposed Plan to a community audience. At this meeting, representatives from CDPHE and the School answered questions about problems at the Site and the remedial alternatives. The School's response to the comments received during this period is included in the Responsiveness Summary, which is part of this Record of Decision.

D. Scope and Role of Operable Unit or Response Action

As noted above in Part II.A, numerous Site investigation and cleanup activities have been ongoing for years. The scope of this Record of Decision addresses the last remaining areas that need cleanup at the Site: most of the Fenced Area, the Clay Pits Area, and the ground water. The former settling pond area (located within the Fenced Area) and the softball field area have already been addressed in prior efforts. The remaining remedial action is being performed under the authority of CERCLA and State laws that authorize the School to take action and expend money on the remediation.

After the affected surface and subsurface soils have been removed from the Site during the course of the remedial action, the remaining surface areas will be stabilized, including the use of backfill, and used for unrestricted beneficial purposes again, such as recreation. While the recreation is ongoing, the School will continue to monitor the ground water to demonstrate the effectiveness of source removal and natural attenuation. After this demonstration, the ground water will also be available for unrestricted uses.

E. Site Characteristics

In general the approximately 6-acre Site slopes gently to the north with a major elevation break above the former settling pond (Figure 2-1). The majority of the buildings located on the eastern side of the main driveway had shallow foundations resulting in relatively uniform topography after the concrete removal operations had been completed. Buildings on the western side of the Site had fairly deep foundations and removal operations resulted in significantly deeper excavations.

Utilities remaining on the Site at the start of the RI included an overhead electrical line, water mains and a sewer line owned by the City of Golden, and irrigation lines owned by the School. All other utilities had been disconnected prior to the concrete/asphalt removal operation.

The Colorado Historical Society advised that no significant historical or archeological resources are known in the immediate vicinity of the Site. Additionally, the City of Golden's Planning Department also advised that there are no known historical or archeological resources that would affect the FS alternatives evaluation or selection process.

The Site is located immediately south of Clear Creek, the primary surface-water conveyance in the area. Clear Creek is a perennial tributary of the South Platte River with a drainage basin area above the Site of approximately 400 square miles. The headwaters of Clear Creek are located along the Continental Divide near Loveland Basin Ski Area. From the headwaters the stream drops over 8,000 feet in about 50 miles, passing through steep canyons on its way to the Golden area. East of Golden, Clear Creek flows through the plains for about 14 miles to its confluence with the South Platte River in Denver, Colorado.

In the vicinity of the Site, the 100-year flood elevation is 5,682 feet. The 500-year flood level is about 5 feet higher than the 100-year elevation or about 5,687 feet. The elevation at the lowest point of the Site is approximately 5,670 feet (former settling pond area next to Clear Creek), which is in the flood plain. However, the majority of the Site lies between about 5,700 feet and 5,720 feet, which are at least 23 feet above the 100-year elevation and 18 feet above the 500-year elevation.

Chimney Gulch is a small drainage that passes about 100 feet west of the western gate of the Site. Chimney Gulch is a tributary of Clear Creek with a drainage basin of approximately 482 acres. This tributary's headwaters begin on Lookout Mountain and its confluence with Clear Creek is about 200 feet northwest of the Site. During most of the year, Chimney Gulch is dry. However, when the Welch Ditch is being used, excess water in the ditch is routinely drained into Chimney Gulch and back into Clear Creek.

Clear Creek passes through an historic mining region of the Colorado Mineral Belt. Several reaches of Clear Creek have been designated EPA Superfund Sites because of the extensive mining operations. Numerous mine adits along the stream contribute to seasonally elevated concentrations of metals, primarily manganese and zinc.

The Site is located along the eastern edge of the Rocky Mountain Front Range foothills. The foothills include the areas where “older” deposits were folded and pushed aside as the “younger” Rocky Mountains uplifted. The foothills rock types range from unconsolidated sediment deposits (25 thousand to 1 million years old) to sedimentary rocks (primarily sandstone and shale – 300 million to 63 million years old) to igneous and metamorphic rocks (over 1 billion years old). These formations remain as horizontal layers beneath Denver and the eastern plains. The Clay Pits area is a surface expression of the unconsolidated sediment deposits (Laramie – Fox Hills Sandstone – these deposits have been tilted almost vertical) and the bedrock underlying the Site is a sedimentary rock (Pierre Shale). The Golden fault, a high-angle reverse fault, is present along the eastern edge of the foothills west of the Site.

Weimer's cross section shows that the geologic strata are overturned and steeply dipping. Measurements of the strike of the beds in the Clay Pits area show a North 37° West trend with dips ranging from about 70° to 80° to the west (James L. Grant & Associates, Inc., April 1990). Further east the beds become vertical and then east dipping. The Site is located in an area of surficial deposits overlying the Pierre Shale. Van Horn (1976) characterizes the Golden fault as a moderately to steeply west-dipping reverse fault of large displacement.

Small areas of Pierre Shale are evident along the western end of the former settling pond, exposed by the erosion action of Clear Creek. Weimer (1976) characterized the unit as consisting of dark gray shale with minor, thin laminae of tan-weathered limonitic siltstone and silty, very fine-grained sandstone. Pierre Shale underlies much of the Site including part of the parking area. The Pierre Shale is estimated to be at least 2,000 feet thick beneath the Site.

In the immediate vicinity, exposures of the Fox Hills are limited because of localized faulting. Where exposed, the sandstone is tan to yellow, fine-grained, subrounded, friable, calcareous sandstone with thin beds or laminae of siltstone and gray montmorillonitic claystone. The exposed thickness of the Fox Hills near 12th Street (Figure 2-4) is about 40 feet; however, the exact thickness is questionable because of faulting and could be as much as 75 feet (Weimer 1976). The Fox Hills underlies a part of the eastern-most practice field and some of the former Site buildings and parking area. The outcrop of this formation is visible to the west of the claypits site.

The surficial deposits that overlie the bedrock in the vicinity of the Site include the following (the order presented below does not show the age relationship):

- Louviers Alluvium
- Younger Alluvial Fan Colluvium
- Post-Piney Creek Alluvium
- Artificial Fill

The Louviers deposit is typically a coarse cobbly sand and gravel that is poorly sorted. Generally, there is less than 10 percent silt and clay present. Boulders as large as one-foot across are present, but the common large size is 6 inches. Based on the subsurface work performed at this location, this unit is about 10 feet thick and extends south under the baseball and practice fields to the approximate location shown where it pinches out against the bedrock. The Louviers is overlain by younger alluvial fan, colluvium, and artificial fill deposits. Locally, the post-Piney Creek Alluvium overlies eroded Louviers deposits.

The subsurface investigation of the Site included 36 test pits and 28 borings (see Section 3.3.4). The majority of the subsurface material would be classified colluvium. The eastern portion of the Site is covered with a clay layer that varies in thickness between 5 and 6 feet. Below the clay is a layer of red, brown sandy clay followed by a layer of orange, red, brown clayey sand. These layers vary in thickness from about one foot to three feet. These differences reflect the origin of the colluvium. Potentially, the clay materials have been derived from the Pierre Shale; the reddish-brown sand from the Fountain Formation (present on the west side of the Golden fault); and the brown sand from the Fox Hills formation.

Underlying the colluvial material is an alluvial cobble zone. The cobble zone consists of a small quantity of pinkish, reddish sand intermixed with numerous flat cobbles/boulders (up to 12 inches). Up to 13 feet of this alluvial material was encountered in the borings. This zone could not be penetrated by the backhoe used for the test pits.

Artificial fills areas were identified during the RAOA and are shown in Figure 2-4. The identified fill was used primarily for highway construction and for enhancing the usable area of the athletic fields and the adjacent area. The fills include tan to brown clay, medium to stiff, silty, sandy, and slightly gravelly (athletic field) and the artificial fill consists of silty clay to clayey sand with some gravel and construction debris (softball field area).

A comparative analysis of the topographic changes in the last several decades was performed as part of the RAOA. The analysis revealed that fills in the baseball field and western-most practice field may have been generated from cuts (up to 15 feet) in the infield portion of the baseball field.

Additional artificial fill was identified during the RI including:

- Sandy, silty cobbles for roadbed construction,

- Imported uniform sand used for fill around foundations and under roads,

- Bricks and miscellaneous building debris mixed with varying mixtures of clay and sand, and

- A variety of bricks, clays and sands, and miscellaneous debris used for roadbeds and fill around building foundations.

Because of the extensive construction activities on the Site, very little “A” horizon material remained. Small areas of an “A” horizon were encountered along the northern side of the eastern and western access road. A treed area is located along Clear Creek in the northeastern corner of the Site has a shallow “A” horizon underlain by sandy, silty sub-soils. No additional subsurface investigation was completed in this area for the RI. The majority of the Site is covered with “B” or “C” horizon subsoils that were exposed as the buildings and roads were constructed.

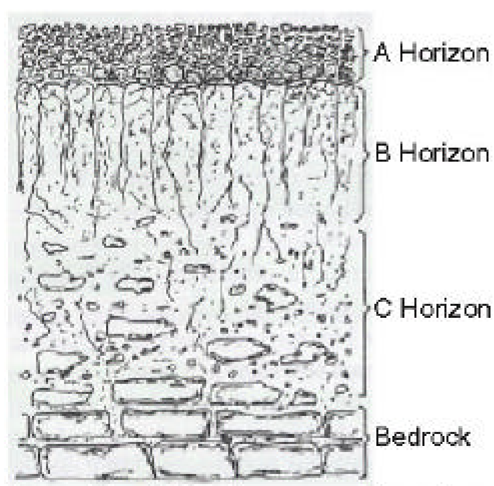

Figure 2-3a Schematic representation of an hypothetical soil profile, with its underlying parent rock. The A horizon is typically referred to as "top soil" (Hillel, 1982)

Ground water is present in the following bedrock units: the Laramie/Fox Hills units, the Arapahoe, and some of the Denver. Ground water is also present in the Louviers Alluvium and post-Piney Creek Alluvium. The Laramie/Fox Hills and the Arapahoe are important aquifers of regional significance and the Louviers Alluvium, post-Piney Creek Alluvium, and the Denver Formation can be locally significant. Regional studies by Robson (1983 and 1984) and Robson, et. al. , (198l a and 1981 b) indicate that the outcrop areas for these units in the area covered in Figure 2-4a are part of the recharge area. Recharge is primarily expected to occur from direct rainfall and snowmelt infiltration and by percolation from Clear Creek directly through the alluvium. However, RI observations suggest the reach of Clear Creek along the northern Site border may be a gaining reach because of the artesian nature of Laramie Fox-Hills aquifer in this area (several seeps are visible in the area).

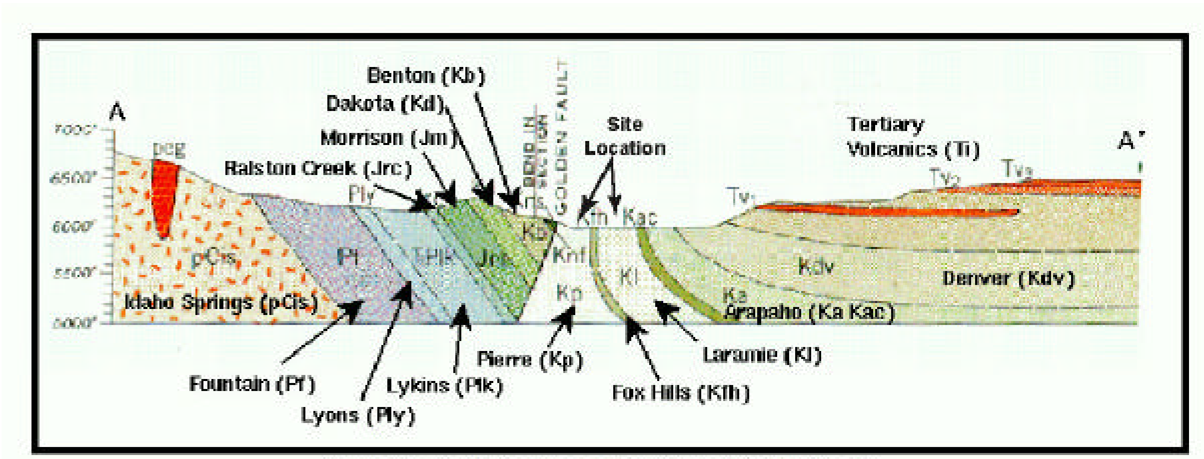

Figure 2-4a Geological cross section in the vicinity of the Site

The most relevant water-bearing unit on the western side of the Site is the alluvial deposit above the weathered Pierre Shale (see Figure 2-3). The Pierre Shale acts as an aquitard, allowing water from infiltration and nearby stream losses to move downgradient to Clear Creek. The Pierre Shale was encountered in four of the borings installed as part of the RI. Depth to the unit varied from about 10-feet below ground surface (bgs) north of the former Building 101N location to about 40-feet bgs near the baseball field. The ground-water zone above the formation varies between about one to four feet above the unit near the former Building 101N location and between about 6- to 15-feet near the baseball field. Ground water was encountered about 30-feet below the baseball field and about 54-feet below the practice fields during the RAOA.

The most relevant water-bearing unit on the eastern side of the Site is the Laramie Fox-Hills aquifer (see Figures 2-3 and 2-4a). The outcrop of the Arapahoe formation appears to be located to the east of the Site and does not influence Site hydrology.

A complex ground-water system underlies the Site because of the area geology. Bedrock in the vicinity is a complicated system of nearly vertical sediment deposits overlying Precambrian, crystalline bedrock. Sediment layers that once were located deep under the Denver Basin were pushed up as a result of the uplift of the Rocky Mountains. The Site is located at the western edge of the Denver Basin aquifer system, which includes the following four aquifers – Dawson, Denver, Arapahoe, and Laramie-Fox Hills. These aquifers are unconfined along these uplifted beds and the potentiometric surface (water table) associated with each aquifer is typically closer to the surface than the majority of the aquifer. The aquifers are confined in the deeper portions of the basin, providing the pressure required to raise the ground water closer to the surface. This artesian effect appears to be occurring in the portion of the Laramie Fox-Hills aquifer that underlies the Site.

The ground-water direction is governed by the underlying weathered Pierre Shale and appears to be flowing northeasterly toward Clear Creek. The surface expression of the Laramie – Fox

Hills Sandstone may influence ground-water movement in the vicinity of the Clay Pits causing a northwestern movement. Weathering has removed any surface expression of the sandstone along Clear Creek so it is difficult to determine if the northwest movement is actually happening.

It appears that the majority of the western Site ground water comes from surface infiltration from the surrounding foothills, surface irrigation of the baseball/softball fields, and the seasonal influence of the nearby Welch ditch. The eastern Site ground water appears to be a mixture of the infiltration water and the Laramie Fox-Hills aquifer.

The original operations that generated the affected material no longer exist on the Site. The Site was used for mining-related research projects and was in operation from 1912 until about 1987. Because buildings and equipment were removed prior to the RI, only the residual affected material (primarily soil) remained on the Site.

Source investigations that were conducted as part of the RI in 2002 and 2003 included a surface gamma survey, collection of surface samples, excavation of test pits for gamma surveys and sample collection, installation of bore holes for gamma surveys and sample collection, and collection of ground-water samples. These investigations are discussed below.

The Fenced area and the Clay Pits area were gamma surveyed as part of the RI. The area around the former settling pond adjacent to Clear Creek was excluded because it had previously been surveyed and released by EPA during the 1992 response action. In addition, the density of survey locations was limited in the northeast corner of the Site due to dense vegetation and steep slopes, which made this area relatively inaccessible. Several areas of the Site were inaccessible because of unstable slopes that remained after the removal of the concrete and asphalt slabs and sidewalls. The survey consisted of dividing the Site into an approximate 3.3 meter x 3.3 meter (10 feet x 10 feet) grid and recording a 10-second gamma reading inside each grid square. Each survey coordinate was recorded using a global positioning system (GPS) unit. Additional readings were collected in areas that exhibited elevated gamma readings to better define the extent of the anomaly. Prior to the Site gamma survey, gamma measurements were made in areas adjacent to the fenced area and Clay Pits area. These measurements were used to establish the Site background gamma levels. A total of 3,282 survey points were measured during the surface gamma survey.

Surface soil samples were collected to determine the type, the extent, and activities/concentrations of the contaminants. The primary focus of the sampling program was metals and radionuclides, but organic compounds were investigated if necessary. Samples were collected from surface soils at 163 locations on the Site in accordance with the approved SAP and using the guidance provided in MARSSIM (Figure 3-3). The Site was divided into 12 sections with up to 10 samples collected from each section. A GPS unit was used to delineate the section boundaries. Once the boundaries were established, sample locations were selected by randomly placing markers in the area.

Thirty-six trenches/test pits and 28 borings were used to investigate the subsurface soils at the Site. The test pit subsurface investigation primarily focused on those areas where drains or pipelines had penetrated building flooring (these locations were identified prior to the removal of the concrete and asphalt slabs and relocated by Flatirons after New Horizons completed the removal operations) and other visually suspect areas identified following the concrete and asphalt removal. The borings were primarily focused in those areas with elevated surface gamma readings.

A backhoe was used to excavate test pits (i.e., pot holes) at 36 locations on the Site. Test pit dimensions varied depending on the site characteristics (pipelines, debris, and soil consistency). The objective was to excavate to at least 10 feet bgs; however, various obstacles prevented completion to this depth on some of the pits. All pits were refilled after the completion of the investigation.

A percussion hammer drill rig was used to advance 28 borings on the Site (see Figure 3-5). The borings were primarily used to investigate areas that indicated elevated gamma readings. Most of the borings were completed to 10 feet bgs. Two of the borings were subsequently converted to ground-water monitoring wells.

Portions of walls and floor slabs of Building 103 that had been covered during the original concrete characterization study were subsequently discovered during the concrete removal operations conducted by New Horizons. Test pits CP1 and CP2 were excavated to determine the nature and extent of the buried Building 103 wall remnants and floor slabs.

Two ground water monitoring wells were installed using two of the borings drilled during the subsurface investigation. The purpose of the installation was to provide additional ground-water (upgradient and downgradient) data for the Site. The upgradient well (CSMRI-06) location was positioned along the north-south boundary with the baseball field. The downgradient well (CSMRI-07) was positioned north of the former Building 101N foundation, and above the former settling pond. CSMRI-06 is 43.5 feet deep and CSMRI-07 is 20 feet deep.

Five existing wells and the two new monitoring wells were sampled as part of the investigation to determine current ground-water conditions in and near the Site. The existing wells included three wells located along Clear Creek (CSMRI-01, -04, and -05), one background well located south of the Clay Pits (CSMRI-02), and one well located downgradient of the Clay Pits (CSMRI-03).

From October 24, 2002 through January 31, 2003 twenty-six air samples were collected during investigation activities likely to release airborne dust. Activities sampled included excavation of foundations, size reduction of concrete, loading trucks, backhoe operations and drilling.

Historical site activities left deposits of mining research waste over a large portion of the Site. Contaminants of concern include:

- Metals – Primarily arsenic, lead, and mercury, but the soil analyses included barium, cadmium, chromium, molybdenum, selenium, silver, vanadium, and zinc.
- Radionuclides – Primarily radium, thorium, and uranium, but gamma spectroscopy was used to examine an additional 38 radioisotopes.

All of the surface soil samples contained arsenic at concentrations above the proposed Tier 2 soil standards found in the proposed CDPHE Soil Remediation Objectives policy (1997 and 2003). However, background arsenic concentrations vary greatly in different types of geology. The western states typically have geological formations with elevated arsenic concentrations. The highest arsenic concentrations appear to be around the excavated building formations and around the western side of the site, but there are a number of areas to the east that have concentrations above the background value. Subsurface soil samples indicate that concentrations of arsenic decrease with depth in the vicinity of the buildings (see Figures 4-9 and 4-11) but none of the samples drop below the proposed residential soil standard.

About 21-percent of the surface samples contain lead above CDPHE proposed soil standards. The highest concentrations of lead appear to again be located in the vicinity of the excavated building formations. Lead concentrations decrease significantly with depth suggesting the lead-affected material was imported to the site.

Mercury was detected in all of the surface soil samples, but the species of mercury was not determined. Mercury can occur as inorganic elemental or metallic mercury (Hg^0), mercurous Hg (Hg^{1+}), and mercuric Hg (Hg^{2+}) or as organic methylmercury and ethylmercury. The elemental and organic forms of mercury are considered to carry the greatest risk to human health and the environment. Because of the types of research conducted on the Site and the instruments associated with such research, elemental mercury could be present. But the mercury also could come from mineral ores brought to the site, which would be composed of mercury compounds. About 47-percent of the surface soil samples exceed the CDPHE proposed residential standard for elemental mercury. However, only 3-percent of the samples exceed the CDPHE proposed residential standard if the material consists of mercury compounds. Mercury concentrations also decrease with depth (average concentration of 0.5 mg/kg in the upper 2 feet of soil, compared to average concentrations of less than 0.1 in the underlying layers), which again suggested that the mercury-affected material was imported to the Site.

A small number of the soil samples contained cadmium (about one percent), molybdenum (less than two percent), and vanadium (less than one percent) above CDPHE proposed residential soil standards. All of these samples were co-located with soil that contained elevated concentrations of other metals or radionuclides.

Risk modeling indicates that Ra-226 is the primary radionuclide of concern on the Site. The majority of the radium-affected material appears to be located in the vicinity of the buildings on the western side of the former Main Street (Buildings 101 and 115) with a limited number of outlying areas. Subsurface-soil samples indicate that activities of radium decrease with depth in the vicinity of the former buildings.

Modeling also indicated that Th-230 was a radionuclide of concern over time (decays to radium). As with the radium, thorium appears to be located around the excavated building foundations on the western side of the Site. Thorium activities also decrease with depth in the vicinity of the former buildings.

Uranium also is considered a radionuclide of concern because it contributes over 30-percent of the activity of the surface soil samples. The uranium appears primarily to be co-located with the radium and thorium in the vicinity of the western former buildings. In general, uranium activities also decrease with depth.

The TCLP results indicate that the affected material is not hazardous waste and may be disposed of in a licensed solid waste landfill.

Based upon the operational history of the Site and analysis of laws, the affected materials are RCRA solid wastes.

The findings of the ground-water sampling rounds suggest up to three types of water mixing under the Site producing a complex ground-water system. Water infiltrating into the alluvial material from precipitation, irrigation, and surface-water sources (Welch ditch and Chimney

Gulch) travels southwest to northeast along the Pierre Shale aquitard toward Clear Creek. Artesian water from Laramie Fox-Hills aquifer appears to move through the more permeable sandstone in a southeast to northwest direction (although some of this movement may be redirected by paleochannels). And the alluvial channel of Clear Creek moves water in a west to east direction. The three water sources then mix somewhere in the vicinity of the Site.

The ground-water sample results suggest the movement of affected material to ground water. Uranium concentrations increased in two of the downgradient wells (CSMRI-04 and -07) during the July sampling round (concentrations were above EPA's Maximum Contaminant Levels [MCL] for total uranium). The uranium concentrations decreased during the October sampling round, which suggests the material was no longer moving to ground water.

The uranium movement is consistent with the precipitation events that occurred during the 2003 season. After an extended dry period a March snowstorm delivered significant precipitation to the area. Spring rains also added to overall soil moisture. Eliminating the Site asphalt and concrete essentially removed a cap that limited the movement of precipitation into the soil column. Removal of the former Building 101N created a depression that now acts as a detention pond during storm events. The bottom of the "pond" is located in the alluvial cobble zone. Calculations showed that precipitation along with the associated ponding would have saturated the soil column and allowed the movement of soluble material and fine particles to ground water. The return of dry weather for the remainder of the summer and fall dried out the soil column, eliminating the ground-water pathway. Metals also appear in the ground water samples but at concentrations at or near the detection levels, making it difficult to predict trends.

The two monitoring wells located along Clear Creek contain relatively consistent, low concentrations of a variety of VOCs. Several of these compounds tend to "pancake" at the bottom of an aquifer resulting in a small continuing source of material for an extended time period. A small quantity of these solvents can produce this result. All of the reported VOC concentrations have been below the MCLs with the exception of the fourth round CSMRI-04 sample, which was 0.1 µg/L above the trichloroethene standard (5.0 µg/L).

Using kriging analysis, there are approximately 10,000 cubic yards of affected soil materials that would be removed from the Site. The actual volumes will depend on Site conditions during the excavation and sampling work.

The potential routes of migration associated with the Site currently include:

- Wind erosion, moving material primarily to the east (prevailing winds are from the west),
- Water erosion, transferring material off-site or into Clear Creek,
- Wind borne diffusion, moving radon and radon decay products off-site (again driven by prevailing west winds),
- Plant material transport, moving material taken up by plants as wind or water borne plant debris,
- Particle transfer, moving material via attachment to personnel and/or vehicle, and

- Solute and particle transport, transferring material into the underlying ground water through percolation and preferential pathways.

Wind and water erosion is currently controlled on the Site by storm-water best management practices. Minimal vegetation is currently growing on the Site, limiting the amount of material that can be transported in this manner. Particle transport is controlled by site-specific safety requirements. Radon diffusion and solute transport is not controlled at this time.

The primary contaminants of concern (COC) on the Site include metals and radionuclides. These materials are very persistent in the environment. Organic compounds discovered near the baseball field included petroleum hydrocarbons and chlorinated solvents. The combination of these materials provided the proper environment for biodegradation of both materials. Current soil concentrations of the organic compounds are below current proposed CDPHE Soil Screening Levels.

Affected material migration prior to the removal of the asphalt and concrete was minimal, influenced only by minor soil exposure, plant uptake, and water infiltration. An estimated 90-percent of the Site was covered with asphalt or concrete prior to removal operations. Removal and transportation activities did result in some portion of the material being displaced from its original location. Excavation of large foundation blocks and walls required soil to be moved and additional soil was moved to provide access roads for the trucks. Efforts were made to minimize the disturbed areas, but a small amount of material transfer did occur. However, none of the material left the Site.

Metals and radionuclides currently present in Site soils provide a continuing source of contaminants to the underlying ground water. Factors including precipitation and ponding, material speciation and solubility, cation exchange capacity, and soil type, pH, and compaction can all affect the movement of the material to ground water. Minor precipitation events can transport material deeper into the soil column where material concentrations increase until a major event transports the material to ground water. Ground-water levels also can raise enough to interact with this material periodically. Sandy soil typically provides minimal resistance to transport of radionuclides and metals, while clays and organic materials can adsorb these materials, slowing the movement to ground water. However, soil acidity and acid rain can reverse the adsorption process (hydrogen cations replace the metal/radionuclide cations), allowing continued material movement. The metal cations also compete with each other for available adsorption sites, continuing downward movement of material through the soil column.

The metal and radionuclide affected material identified during the RI were less mobile prior to the removal of the asphalt and concrete "cap". Without the cap the affected material can now migrate to ground water more readily. The on-site ground water is not a drinking water supply so there is no current threat to human health. But the ground water flows into Clear Creek, which is a drinking-water supply for downstream communities. A boundary ground water well (CSMRI-04) had total uranium concentrations above the MCL during two of the quarterly sampling rounds. This well is at the point of compliance. Dilution effects would significantly reduce concentrations in Clear Creek but the CDPHE, Water Quality Control Commission requires that uranium levels in surface water be maintained at the lowest practical level. Precipitation events can be expected to continue to move additional material to ground water.

Radon generated by the natural decay of the radionuclides diffuses through the soil and migrates to the atmosphere. Radon is typically a problem when a building foundation is in contact with the affected soil and the radon is trapped inside the building. There are no buildings on the Site at this time, although there are two valve pits that are part of the baseball field irrigation system.

The U.S. Department of Energy and U.S. Nuclear Regulatory Commission model for site-specific dose assessment of residual radioactivity, RESRAD 6.21 was used to model migration pathways such as wind and water erosion. Because of the limited nature of the ground-water modeling package provided with RESRAD, Visual Modflow Pro in combination with Modflow SURFACT (Waterloo Hydrogeologic) was used in an attempt to model the movement of COCs to ground water. Because only limited number of ground-water system parameters had been identified, the programs were primarily used to examine potential pathways for the contaminants.

Obvious particle pathways (material moves down to the Pierre Shale and then to Clear Creek) were predicted by preliminary modeling efforts. A decision was made during the RI/FS process to focus resources on the control of the source area rather than expending additional resources to generate a complex and expensive model with a large degree of uncertainty. Rough calculations show that saturating the soil column will move material to ground water either through particle movement or solubility. The exact timing of the contaminant movement and the resulting concentrations are largely dependent on the precipitation amounts.

F. Current and Potential Future Land and Water Uses

There is no current beneficial land use for the Site. The Site had been used for mining and metallurgical research until 1987, when Site operations ceased.

The Site (except for the Clay Pits Area) is surrounded with a chain link fence and posted. Since the removal of the asphalt and concrete, access has been limited to several weeks of sample collection and maintenance activities. There are no drinking water supply wells in the immediate vicinity of the Site.

Although the ground water is not used as a drinking water source, it eventually enters the Clear Creek alluvial system. The City of Golden uses Clear Creek as the primary drinking water source, but the surface-water diversion is located about 0.9 mile upstream of the Site. Coors Brewing Company uses alluvial wells located about 0.4 mile downstream from the Site. Additional downstream diversions that supply drinking water include the Agricultural Ditch (0.6-mile) and the Farmer's Ditch (0.7-mile).

Golden's historic residential district is located near the Site to the east, while Golden public facilities such as a recreation and community center are located just north of the Site across from Clear Creek. The School's football field is located to the east and School athletic fields are located to the west and southwest. The Clay Pits are located to the south of the Site. Clear Creek bounds the Site to the north.

Near term land use scenarios could include a recreational area, such as athletic fields and a parking lot for recreational users and spectators. Foreseeable land use could include the construction of student housing or academic buildings. However, future land use could include an urban resident or potentially a subsistent farmer considering the persistence of the metals and the longevity of the radionuclides (half-life: Ra-226, 1.6×10^{3} years; Th-230, 7.6×10^{4} years). The requirements of 40 CFR §192.02 require that remedies for sites with similar radionuclide contaminants provide up to 1,000 years of protection to human health and the environment (at least 200 years). For a CERCLA NCP baseline risk assessment the conservative subsistence farmer scenario was used as the baseline. To provide an overall picture of relative risk, urban residential and recreational scenarios were provided in the RI/FS for comparison.

The original Alternative 5 in the RI/FS used a conservative approach, subsistence farmer to model the on-site receptor. It was assumed that the farm family grew their own food, used cattle grazing on site for milk and meat, used the ground water, and spent considerable time on the property. At the suggestion of CDPHE a slightly less conservative receptor, the urban resident, was allowed. However, the urban resident was specified to be the maximally exposed individual, which is a conservative assumption. The maximally exposed individual leads the life style of an urban resident but consumes ground water from the Site and has a backyard garden that is a primary source of food (up to 50-percent of fruits and vegetables). The change in receptors resulted in a moderately reduced dose and risk and somewhat higher DCGLs for the radionuclides of concern. The radionuclide DCGLs proposed in the RI/FS and Proposed Plan were as follows for the subsistence farmer at 15 mrem/yr doses:

Radionuclide	**Subsistence Farmer (15 mrem/yr)**
Radium-226	0.84
Radium-228	1.4
Thorium-228	2.7
Thorium-230	3.8
Thorium-232	0.96
Uranium-234	14
Uranium-235	3.2
Uranium-238	15

Note: All units in picocuries per gram

The radionuclide DCGLs developed for the record of decision based on public comments are slightly higher:

Radionuclide	**Urban Resident – 15 mrem/yr**
Lead-210	4.44
Polonium-210	192
Radium-226	1.44
Radium-228	2.20
Thorium-228	3.77
Thorium-230	9.83
Thorium-232	1.48
Uranium-234	253
Uranium-235	4.88
Uranium-238	20.2

Note: All units in picocuries per gram

As a practical matter, the differences are insignificant because field excavation activities under either version of the DCGLs would likely remove a similar amount of soils due to the analytical parameters of field instrumentation and the small differences in activity levels between the prior and the current ones for Ra-226, which is the primary driver of risk at the Site, the variability of activity levels in soils at the Site, and the cost effectiveness strategy of excavating enough affected soil to ensure that a second round of excavation and confirmation sampling be avoided. The change in receptors for radionuclides has not materially altered the remedy selection or its performance.

The assumptions for metals remained the same between the RI/FS and the ROD: residential uses.

G. Summary of Site Risks

The baseline risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment for this Site.

Radium, thorium-230 and uranium-238 are the main chemicals of concern at this Site for radionuclides. The metals of arsenic, lead, mercury, cadmium are the main chemicals of concern for the Site for the metals. The primary metals of concern identified during the RI include arsenic, cadmium, lead, and mercury. Additional metals were identified during the RI but are co-located with the metals of concern. In general the highest metal concentrations are co-located with the radionuclides, but there are areas where the metals are the primary contaminant. The following tables describe the range of detected concentrations for the chemicals of concern in samples taken of the surface soils, in subsurface test pits, and subsurface borings:

Surface Soils:

Metal	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean
Arsenic	30.8	16	13	41.4	1.8	330	17.9
Barium	325	180	170	405	48	2900	228
Cadmium	3.28	0.84	0.02	7.01	ND	51	0.604
Chromium	17.1	15	14	9.27	6	79	15.6
Lead	465	140	140	1280	6.4	14000	153
Mercury	5.89	0.81	0.57	32.4	0.015	400	0.942
Molybdenum	37.6	13	1.8	92.6	0.89	980	13.7
Selenium	1.85	1.2	1.1	1.76	ND	11	1.34
Silver	2.67	0.83	0.02	6.14	ND	58	0.670
Vanadium	45.8	37	29	36.7	15	350	39.2
Zinc	673	260	110	1120	49	7100	314

Notes: All data units are in milligrams per kilogram; ND, not detected.

Isotope	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean
Thorium-	2.84	1.86	1.48	8.47	0.94	109	2.03

228							
Thorium-230	9.21	3.105	1.25	25	0.75	272	3.98
Thorium-232	2.63	1.685	1.37	8.32	0.76	107	1.85
Uranium-234	6.19	2.46	2.25	11.1	ND	85	3.14
Uranium-235	0.34	0.123	0.0510	0.628	ND	4.9	0.162
Uranium-238	6.2	2.335	1.12	11.3	0.63	88	3.06

Notes: All data units are in picocuries per gram.

Isotope	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean
Bi-212	2.20	2.0	1.5	1.10	ND	8.0	1.99
Bi-214	7.63	3.3	1.3	15.4	0.66	110	3.69
K-40	20.6	20	20	4.00	7.3	36	20.2
Pb-212	2.17	1.9	1.5	0.984	0.76	6.8	2.00
Pb-214	8.71	3.6	1.6	18.8	0.78	150	4.13
Ra-226	10.6	4.6	1.8	22.6	0.93	170	5.07
Ra-228	1.98	1.8	1.4	0.937	0.68	7.3	1.82
Th-234	5.25	3.3	3.8	6.23	0.55	42	3.62
Tl-208	0.626	0.55	0.55	0.295	0.209	2.2	0.575

Notes: All data units are in picocuries per gram.

Test Pits:

Metal	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean
Arsenic	21.9	8.4	11	36.9	0.98	180	9.26
Barium	211	140	120	216	16	1300	156
Cadmium	1.51	0.05	0.05	3.55	ND	17	0.226
Chromium	15.8	14	12	16.5	ND	130	12.7
Lead	502	72.5	16	1680	7.2	12000	83.8
Mercury	5.78	0.3	1.1	29.5	0.004	220	0.32
Molybdenum	43.6	5.3	1.2	115	1	610	7.6
Selenium	3.16	1.2	1.4	4.91	ND	24	1.58
Silver	3.52	0.16	0.02	16.3	ND	120	0.182
Vanadium	38.8	30.5	29	27.4	0.071	130	29.3
Zinc	511	160	75	820	13	3300	191

Notes: All data units are in milligrams per kilogram; ND, not detected.

Isotope	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean

Thorium-228	2.46	2	1.4	1.62	0.27	8.3	2.02
Thorium-230	10.8	1.6	1.6	23.7	0.46	102	2.95
Thorium-232	2.32	1.8	1.8	1.55	0.14	7.9	1.89
Uranium-234	8.08	1.6	1.4	16.7	0.28	66	2.52
Uranium-235	0.423	0.089	0.0580	0.88	0.024	3.7	0.135
Uranium-238	8.06	1.55	1.3	16.5	0.27	71	2.55

Notes: All data units are in picocuries per gram.

Isotope	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean
Bi-212	2.76	2.4	1.5	1.88	ND	9.7	2.18
Bi-214	15.7	1.75	1.1	59.5	0.39	430	2.94
Co-56	0.324	0.275	0.35	0.25	ND	1.6	0.271
K-40	20.9	22	25	5.95	4.5	41	19.9
Pb-212	2.69	2.3	2.5	1.740	0.17	10	2.19
Pb-214	18.10	1.95	1.3	71.4	0.37	520	3.31
Ra-226	21.8	2.4	1.6	84.1	0.49	610	4.03
Ra-228	2.50	2.1	1.7	1.670	ND	9.4	1.99
Th-234	7.60	2.9	2.9	12.60	ND	59	3.77
Tl-208	0.788	0.655	1.3	0.514	ND	2.9	0.629

Notes: All data units are in picocuries per gram.

Borings:

Metal	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean
Arsenic	20.5	5.55	1.9	41.1	0.96	180	7.06
Barium	151	120	120	136	43	920	122
Cadmium	2.14	0.025	0.025	7.26	ND	52	0.084
Chromium	14	14	12	3.71	5.9	25	13.5
Lead	182	21	18	431	5	2400	39.5
Mercury	0.568	0.0465	0.014	1.6	0.0058	11	0.078
Molybdenum	10.2	1.6	1.3	25	0.49	160	2.8
Selenium	0.93	0.745	0.2	0.911	ND	4.8	0.639
Silver	1.12	0.02	0.02	2.91	ND	18	0.079
Vanadium	44	28.5	34	118	10	1000	29.6
Zinc	560	85	100	1674	26	13000	155

Notes: All data units are in milligrams per kilogram; ND, not detected.

Isotope	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean

Thorium-228	2.29	2.1	1.4	1.01	0.93	6.7	2.1
Thorium-230	7.7	1.45	1.1	27	0.76	210	2.17
Thorium-232	2.19	1.95	1.5	1.08	0.88	7.5	1.99
Uranium-234	8.62	1.4	1.1	20.1	0.59	110	2.4
Uranium-235	0.52	0.094	0.0560	1.15	ND	5.8	0.139
Uranium-238	8.7	1.3	1.1	20.3	0.64	110	2.42

Notes: All data units are in picocuries per gram.

Isotope	Mean	Median	Mode	Standard Deviation	Minimum	Maximum	Lognormal Mean
Bi-212	2.30	2.0	1.4	1.22	0.72	8.7	2.07
Bi-214	8.17	1.1	1.6	30.1	0.54	210	1.78
Co-56	0.956	0.15	0.08	3.80	ND	26	0.192
K-40	20.4	19	19	3.68	14	36	20.1
Pb-212	2.21	2	1.2	1.160	1.1	8.3	1.99
Pb-214	9.23	1.25	1.1	34.8	0.58	250	2.01
Ra-226	11.2	1.5	1.3	42.0	0.71	300	2.47
Ra-228	2.04	1.8	1	1.060	0.99	7.2	1.83
Th-234	6.32	2.55	1.4	11.50	ND	62	3.25
Tl-208	0.655	0.565	1	0.347	0.31	2.5	0.591

Notes: All data units are in picocuries per gram.

For the baseline risk assessment the exposure scenarios examined include a subsistence farmer, an urban resident, and a recreational user. Baseline exposure scenarios were examined for a 30-year period and assumed minimal changes to the current topography (depressions left by the removal of building foundations would remain). Exposure for the subsistence farmer assumes a farmhouse constructed on the existing soil, ground water as the primary drinking water source (including farm animals), and consumption of crops, meat, and milk produced from the local soil. The urban resident assumes a house similar to neighborhood housing but drinking water would come from city water mains and minimal consumption of fruits and vegetables raised in a backyard garden. The recreational receptor assumes regular use by a nearby resident who would use the area for a variety of activities. Factors associated with the exposure scenarios are used in the RESRAD and RAIS models. As noted above, the assumptions for the users of the Site was adjusted from a subsistence farmer to an urban resident.

To determine the dose for the theoretical receptor (farmer, resident, recreational user), the RESRAD model was used to define the property where the individual is exposed for 30 years (6 years as a child and 24 years as an adult). The modeled property consists of an area with Site specific residual radionuclides to an assumed depth. The model incorporates a large number of parameters to numerically simulate the pathways that the radionuclides can use to affect the receptor. A summary of these parameters is provided in Appendix I of the RI/FS.

The RAIS model was used to determine to toxicity of nine of the metals, but cadmium and lead were determined using other methods. The literature indicates that radionuclides also have toxicity effects but there are no currently published referenced doses in IRIS. Additional reference material was consulted, but no agreed upon reference dose was identified. Typically health effects for radionuclides focus on cancer risks.

IRIS (and other reference material) lists both cadmium and lead as possible human carcinogens but neither has been assigned slope factors because of ongoing debates about sensitive populations and cancer causing mechanisms. These same debates carry over to the associated hazard quotient determination and currently there is no reference dose provided for either metal. Estimation of the toxicity associated with each metal is discussed in the following sections. Risk estimates are provided for specific species of arsenic and chromium. The remaining seven metals evaluated during the RI are not currently considered carcinogenic.

Risk and hazard quotients for the water exposure route (use of on-site ground water) estimated in RAIS using metal concentrations recently measured in the downgradient monitoring wells. The effects of the metals are included in the RAIS results tables (see RI/FS Section 6.4.4). Risks associated with the radionuclides were determined separately using highest activities measured in the downgradient well (CSMRI-04).

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

Risk = CDI x SF

where: risk = a unitless probability (e.g., 2 x 10-5) of an individual's developing cancer

CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as (mg/kg-day)-1.

These risks are probabilities that usually are expressed in scientific notation (e.g., 1x10-6). An excess lifetime cancer risk of 1x10-6 indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for site-related exposures is 10-4 to 10-6.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., life-time) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemical(s) of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI > 1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

where:

CDI = Chronic daily intake
RfD = reference dose.
CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

The baseline risk assessment indicates that taking no future action and leaving the Site in its current condition is not protective of human health and the environment. The subsistence farmer and urban resident would be exposed to excessive risk with current site conditions. Although there are minimal direct risks to the recreational user, the Site would be a continuing problem for the underlying ground water and Clear Creek. Long-term institutional controls would be necessary to protect neighborhood children from exposure. Erosion controls would need to be maintained to minimize the transport of affected sediment to surrounding areas and eventually into Clear Creek. Radionuclides such as radium-226 and thorium-230 are very persistent in the environment, with half-lives of $1.6x10^3$ and $7.5x10^4$ respectively. Environmental factors such as acid rain can affect metal mobility.

The following table summarizes some of the factors used to evaluate the baseline risk assessment. Overall, there are sufficient risks and hazards associated with the Site to warrant remediation.

Scenario	Risk <10^{-6}	RISK 10^{-6} TO 10^{-4}	Risk <10^{-4}	Dose <15 mrem/yr	Dose <25 mrem/yr	Ra-226 + Ra-228 <5 pCi/g	Hazard Index <1	PbB <10 ?g/dL	Soil Lead <1200 mg/kg	Soil Lead <400 mg/kg	Protective of Ground Water	Satisfies ALARA
Current Conditions – Average Soil Activities								Y	Y	Y	N	N
Subsistence Farmer	N	N	N	N	N	N	N					
Urban Resident	N	N	N	N	N	N	N					
Recreational User	N	Y	Y	Y	Y	N	Y					
Current Conditions – Ra Biased Soil Activities								Y	Y	Y	N	N
Subsistence Farmer	N	N	N	N	N	N	N					
Urban Resident	N	N	N	N	N	N	N					
Recreational User	N	Y	Y	Y	Y	N	Y					
Current Conditions – Pb Biased Soil Activities								N	Y	N	N	N
Subsistence Farmer	N	N	N	N	N	N	N					
Urban Resident	N	N	N	N	N	N	N					
Recreational User	N	Y	Y	Y	Y	N	Y					

Notes: Y, meets requirement; N, does not meet requirement

The response action selected in this Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. The cumulative excess carcinogenic risk to an individual exceeds 10-4 (using reasonable maximum exposure (RME) assumptions for either the current or reasonably anticipated future land use or current or potential beneficial use of ground/surface water). The non-carcinogenic hazard index is greater than one (using RME assumptions for either the current or reasonably anticipated future land use or current or potential use of ground/surface water). The Site contaminants may cause adverse environmental impacts. In addition, chemical-specific standards or other measures that define acceptable risk levels are exceeded and exposure to contaminants above these acceptable levels is predicted for the RME. Examples include soil in excess of State metals and radiation dose standards and ground water in excess of drinking water standards when that ground water is a current or potential source of drinking water.

An ecological risk assessment was not performed because of anthropogenic activities at the Site dating back over 100 years. Only one small wooded area by Clear Creek remained relatively undisturbed, but it was insignificant and no sensitive species were located. There is very little natural habitat left at the Site.

H. Remedial Action Objectives

Remedial Action (RA) objectives for the Site are designed to prevent or mitigate further release of affected materials to the surrounding environment and to eliminate or minimize risk to human health and the environment. The affected material is the surface and subsurface soil located in the vicinity of the former building, and the ground waters. Potential receptor pathways include direct radiation, inhalation, and ingestion of plants and soil. Another pathway is the migration of the affected material to ground water. The following objectives were established for the Site:

- Eliminate or minimize the pathway for dermal contact, inhalation, and ingestion of site specific radionuclides to human receptors, in order to achieve a level of protection in compliance with the National Contingency Plan levels of acceptable cancer risk (10^{-4} to 10^{-6}).
- Develop receptor specific DCGLs to limit unacceptable radiation doses (TEDE to less than 25 mrem/yr and 15 mrem/yr, distinguishable from background) for the radionuclides found in the affected material (i.e., soil). Radium-226, thorium-230, uranium-234, uranium-235, and uranium-238 are present on Site at activities above receptor specific DCGLs. A number of additional radionuclides were identified during the RI (radium-228, thorium-228, and thorium-232) but at activities consistent with background.
- Prevent exposure to indoor air concentrations of radon gas and radon decay products greater than 4 picocuries per liter (pCi/L) and 0.02 working level (WL), respectively. Exposure to 4 pCi/L of air for radon corresponds to an approximate annual average exposure of 0.02 WL for radon decay products, when assuming residential land use. As discussed in the baseline risk assessment, there is significant uncertainty in the RESRAD prediction of radon risks. The possibility of radon exposure will be examined for each alternative but actual radon exposures will need to be evaluated after completion of the remedy.
- Prevent long term dermal, inhalation, and ingestion exposures to trace metal affected materials with concentrations greater than the CDPHE Proposed Residential/Unrestricted Land-Use Standards (except for arsenic) or that generate hazard indexes greater than 1.

Because of the relative concentrations and distribution, arsenic, cadmium, lead, and mercury are the primary metals of concern. CDPHE proposed Residential Land-Use Standards (Tier 2) for the metals of concern are:

Metal	Proposed Standard (mg/kg)
Arsenic	0.39
Barium	5,277
Cadmium	76.1
Chromium (total – includes Cr VI)	223
Lead	400
Mercury (elemental)	1.1
Mercury (compounds)	23
Molybdenum	390[1]
Selenium	380
Silver	380
Vanadium	550[1]
Zinc	22,825

[1] EPA Region 9 proposed soil standard

- Address specific issues associated with the hazards associated with soil containing elevated concentrations of lead (possible access issues with neighborhood children).
- Arsenic will be cleaned up to the upper confidence level for background because that background level exceeds the CDPHE Table 2 value.
- Prevent off-site migration of affected material that could result in the exposures described above. This includes the ground-water pathway.
- Implement remedial measures that limit ground- and surface-water concentrations to non-zero maximum contaminant level goals (MCLGs), established under the Safe Drinking Water Act. While the affected ground water is not a current drinking water supply it eventually enters Clear Creek, which is used by downstream users for drinking water. Uranium, arsenic, barium, and cadmium are the primary ground-water contaminants of concern.
- Implement remedial actions that reduce exposures from ionizing radiation to levels that are as low as reasonably achievable (ALARA).
- Comply with soil-, location- and action-specific ARARs. (See RI/FS Section 8.1 and RI/FS Appendix K for ARAR discussion).

The remediation goals for the CSMRI site include:

- Adequate characterization of the affected material to ensure that appropriate landfill acceptance criteria and shipping requirements are met. A statistically significant number of samples will be collected from the affected material for ISOCS and/or laboratory analysis. Material sent to the BFI Foothill facility or the CSI facility (without additional risk assessment) will be consistent with the ANSI/HSP N13.12-1999 standard. Materials in excess of the ANSI standard, which may be sent to the CSI or BFI facilities, will meet landfill-specific risk assessment criteria for solid waste landfills, as appropriate. Material sent to U.S. Ecology in Idaho will meet that facility's RCRA waste acceptance criteria.
- Sufficient verification samples will be collected to ensure that sufficient material has been removed from the Site and site-specific DCGLs and proposed Tier 2 metals soil standards (as adjusted for arsenic) are met. Sample collection will be driven by MARSSIM (NUREG-1575, Rev. 1, EPA 402-R-97-016, Rev. 1, DOE/EH-0624, Rev. 1) guidance, Visual

Sampling Plan (Pacific Northwest National Laboratory, Contract DE-AC06-76RL01830) software, and US Environmental Protection Agency guidance for lead contaminated sites (*The Superfund Lead-Contaminated Residential Sites Handbook*, OSWER 9285.7-50, August 2003). A combination of ISOCS and laboratory analysis will be used.

- Ground-water samples will be collected to show that natural attenuation of groundwater is occurring at the Site following removal of impacted materials. These samples will be collected during remediation operations and then quarterly for two years or until natural attenuation can be demonstrated. Samples will be compared to current drinking water standards (Maximum Contaminant Levels). A map of the ground-water sample sites is provided in Appendix A.
- Surface-water samples necessary to show that material did not migrate off Site because of removal operations or through localized ground-water recharge. Samples will be compared to current drinking water standards (Maximum Contaminant Levels). A map of the surface-water sample sites is provided in Appendix A.
- Eliminate risks to return the Site to beneficial unrestricted uses.
- Decommission the radioactive materials license for the Site.

I. Description of Alternatives

Five site-specific alternatives were developed that use a combination of techniques to protect human health and the environment. The options were arranged according to the amount of excavation required to complete the process and included treatment and non-treatment options. The five alternatives include:

Alternative	Description	Excavation Required?	Institutional Controls Required?
1	No further action	No	Yes
2A	Engineered cap	No	Yes
2B	Engineered cap and slurry wall	No[1]	Yes
3A	Engineered cap with partial removal[2] (areas with combined radium activity >15 pCi/g)	Yes	Yes
3B	Engineered cap with partial removal[3] (areas with combined radium activity >5 pCi/g)	Yes	Yes
4A	On-site solidification with engineered cap	Yes	Yes
4B	On-site engineered disposal cell	Yes	Yes
5A	Off-site disposal at solid waste facility	Yes	No
5B	Off-site disposal at solid waste facility and portion to specialized waste facility	Yes	No

[1] Some excavation required to install slurry wall
[2] Estimated removed volume between 500 and 1,000 cubic yards
[3] Estimated removed volume about 5,000 cubic yards

The following describes the remedy components for each remedy.

<u>Alternative 1 – No Further Action</u>

<u>Treatment Components</u>:

· None

<u>Containment Components</u>:

· The affected soils would remain as is without any removal, treatment, containment, or mitigating technologies being implemented.

Institutional Components:

· Only institutional controls would be implemented: physical barriers such as fencing, signs, monitoring and surveillance systems, or deed restrictions put on the land so that it may not be used for activities that would disturb the affected material. Specifically, the following institutional controls and air and ground-water-monitoring activities will occur as part of this alternative:

- Relocation of the water main by the City of Golden.
- Maintenance of the perimeter security fencing that currently surrounds the Site to prevent public access.
- Maintenance of erosion and sediment controls to minimize off-site migration of affected materials.
- Continuation of other institutional controls such as prohibition of construction and selected land uses on or immediately adjacent to the facility.
- Continuation of an air-monitoring program to provide information regarding potential exposures to nearby residents or users of the adjacent recreational facilities and to use in the periodic reviews.
  Redesign and enhancement of ground-water monitoring system along with implementation of a long-term ground-water-monitoring program to provide information regarding potential contamination of the ground water and to use in the periodic reviews.

Alternatives 2A and 2B – Engineered cap with and without slurry wall

Treatment Components:

· None

Containment Components:

· slurry wall installation, if slurry wall option selected

· Fill material will be required to bring the existing Site to a grade appropriate for the installation of the cap.

· The cap would be installed in 6-inch lifts and compacted to engineering requirements.

· Geotechnical samples would be collected to verify compliance with compaction requirements. The fill material and cap would be surveyed to ensure sufficient material has been placed in all areas.

Institutional Control Components:

· Limited use could be made of the area, such as parks and recreational areas, but construction of structures would be discouraged because of the possibility of compromising the cap.

· Redesign and enhancement of the ground-water monitoring system along with implementation of a long-term ground-water-monitoring program to provide information regarding potential contamination of the ground water and to use in the periodic reviews.

· Subsurface markers/barriers are also recommended above areas contaminated with lead to warn future excavators of the risk.

Alternatives 3A and 3B – Engineered cap with partial material removal

Treatment Components:

- None

Containment Components:

- Same as Alternative 2A above (without slurry wall), except some soil removal before cap constructed.

Institutional Control Components:

- Same as Alternative 2.

Alternatives 4A and 4B – On-site solidification with engineered cap or on-site engineered disposal cell

Treatment Components:

- Alternative 4A involves the consolidation and stabilization of on-site soils using concrete and fly ash.

Containment Components:

- Alternative 4A will require a pilot test to determine the appropriate mixture of concrete, fly ash, and soil.
- On-site materials will need to be excavated and segregated into soil types. Some crushing of cobbles may be required. An area at a high enough elevation to remain above ground-water fluctuations will be selected for the final placement of the solidified material. Operational concrete and fly ash will be stockpiled on site and a batch processor will be brought in to mix the materials. A water supply also will be required. Batches of material will be placed in lifts and solidification will be verified with test cores.
- a clay cap (depth of three feet) will be constructed over the structure to limit leaching effects.
- Alternative 4B requires the construction of an engineered disposal cell.
- Geotechnical testing would be required to verify proper placement of the cell and a clay sub-liner would be installed. A geosynthetic liner will be installed over the clay to ensure containment.
- The affected material will then be excavated from the Site and placed in the cell. Once the removal operation is complete, a clay cap (3-feet deep) will be installed over the material.

Institutional Control Components:

- The structure and cap footprint would require institutional controls on about 0.85 acre of land if one assumes 2:1 slope from the top of the cap. Long-term cap maintenance and ground-water monitoring in the vicinity of the solidified matrix would be required.

Alternatives 5A and 5B – Off-site disposal at solid-waste landfill or combination of solid-waste and specialized landfills

Treatment Components:

- None

Consolidation Components:

- None

Institutional Control Components:

· After excavation and disposal, ground water and surface water monitoring will occur until it shows that source removal and natural attenuation have been effective.

Elements that are common to all of the RA alternatives (except for Alternative 1 - No Further Action) are presented below.

Work Plan Preparation

Once the RA is selected, a Work Plan will be submitted to the CDPHE. The elements of that Work Plan will vary with the selected alternative but will, at a minimum, include the following:

- Materials handling and storage.
- Confirmatory sampling, analysis, and disposal plans.
- Health and safety plan
- Storm-water pollution prevention plan
- Engineering designs including, at a minimum, specifications, plans, final configuration of the affected areas, dust suppression, erosion control, backfill, and revegetation.
- Community participation plan
- Transportation approaches including work force access, deliveries of supplies and materials, and equipment access to and from the Site including proposed routes, placarding, dust suppression, and permit requirements.
- Reporting requirements

Mobilization Activities

Mobilization activities for each alternative will typically include the following:

- Installation of trailers for Site personnel and equipment associated with the RA contractor, project management, health and safety, personnel decontamination, and oversight activities,
- Modification of temporary fencing system,
- Installation of temporary utilities,
- Modification of the Site security and access system,
- Construction of a temporary access road from U.S. Highway 6 to the Site if appropriate,
- Implementation of a vehicle parking policy,
- Construction of an equipment and vehicle decontamination pad, and
- Construction of a storm-water management system.

Dust Suppression/Perimeter Air Monitoring

Dust control procedures that will be used during excavation and handling of materials will typically include the following:

- Using water hoses with mist or fog nozzles to spray light applications of water over the work area during excavation activities.
- Using water hoses or water trucks to spray areas that are extensively used by equipment and enforcing reduced speed limits for construction equipment.
- Minimizing use of disturbed areas during extended non-operational periods.
- Storm-water BMPs will be used to control stockpiles and prevent off-site migration.
- Temporary stabilization BMPs may be used during non-operational periods to prevent wind and water erosion.

A perimeter air monitoring system will be designed and installed.

ARARs
All ARARs will be met with alternative 5.

Summary of Remedial Alternatives

Alternative 1 – No Further Action

Estimated Capital Cost: $61,100
Estimated Operation and Maintenance Cost (Present Value): $2,107,000
Estimated Present Worth Cost: $2,108,000
Estimated Construction Timeframe: NA
Estimated Time to Achieve Remedial Action Objectives: Not Achieved

Alternative 1 provides a comparative baseline against which other alternatives can be evaluated. Under Alternative 1, the affected soils would remain as is without any removal, treatment, containment, or mitigating technologies being implemented. Only institutional controls would be implemented. Institutional controls are items that limit the accessibility of the Site. Items may be physical barriers such as fencing, signs, monitoring and surveillance systems, or deed restrictions put on the land so that it may not be used for activities that would disturb the affected material. Institutional controls will be used to limit the accessibility of a site where no work was performed (no action). Specifically, the following institutional controls and air and ground-water-monitoring activities will occur as part of this alternative:

- Relocation of the water main by the City of Golden.
- Maintenance of the perimeter security fencing that currently surrounds the Site to prevent public access.
- Maintenance of erosion and sediment controls to minimize off-site migration of affected materials.
- Continuation of other institutional controls such as prohibition of construction and selected land uses on or immediately adjacent to the facility.
- Continuation of an air-monitoring program to provide information regarding potential exposures to nearby residents or users of the adjacent recreational facilities and to use in the periodic reviews.
- Redesign and enhancement of ground-water monitoring system along with implementation of a long-term ground-water-monitoring program to provide information regarding potential contamination of the ground water and to use in the periodic reviews.

Metals and radionuclides migration to ground water and incursions by neighborhood children (external radiation and radionuclide and lead ingestion exposures) present the highest risks for this scenario.

Alternative 1 has an additional cost associated with the loss of property value. Appraisal information indicates that without site cleanup, the land value decreases by up to $1,920,000. The estimated present worth cost would be $4,028,000 if the land value loss were included.

Alternatives 2A and 2B – Engineered cap with and without slurry wall

Estimated Capital Cost: $1,938,000 (2A); $2,831,000 (2B)
Estimated Operation and Maintenance (Present Value) Cost: $1,126,000 (both 2A & 2B)

Estimated Present Worth Cost: $3,723,000 (2A); $4,617,000 (2B)
Estimated Construction Timeframe: 4 months (2A & 2B)
Estimated Time to Achieve Remedial Action Objectives: RAO's only partially achieved, monitoring required for at least 100 years

Alternative 2 involves the use of an engineered cap to prevent exposure to metals and radionuclides and to control surface water infiltration, preventing material migration to ground water. Alternative 2A examines only a cap while alternative 2B adds a slurry wall to ensure protection of ground water. The cap was assumed to cover the entire Site because of the widespread presence of elevated arsenic concentrations.

If Alternative 2B is selected the first operation would be the installation of a slurry wall. Again because of the widespread presence of arsenic, it was assumed the wall would be installed around the entire Site. The slurry wall is installed using excavation or trenching equipment to make a trench in the soil overlying the bedrock. It is necessary to surround the Site to divert upgradient ground water around the Site (no ground water would pass under the Site) and to prevent downgradient ground water from backing up into the Site during years when flooding occurs. The overlying cap prevents precipitation infiltration.

Fill material will be required to bring the existing Site to a grade appropriate for the installation of the cap. Current Site topography would be inappropriate for a cap because of drainage issues. Depressions formed by the removal of several of the building foundations would need to be filled and the base material would need to be contoured to ensure drainage off of the cap (no ponding is permitted). Borrow areas have been identified on nearby State property, eliminating the need to transport material on roads to the Site, but fill material may need to be imported if the School decides not to disturb these areas.

The nearby borrow area also contains clay suitable for capping material at sufficient quantities to cap the entire Site. A cap thickness of three feet is proposed. Caps are often covered with topsoil and planted with suitable vegetation to limit erosion.

Both alternatives would require long-term institutional controls to ensure the integrity of the cap. Limited use could be made of the area, such as parks and recreational areas, but construction of structures would be discouraged because of the possibility of compromising the cap. Controls would include the redesign and enhancement of the ground-water monitoring system along with implementation of a long-term ground-water-monitoring program to provide information regarding potential contamination of the ground water and to use in the periodic reviews. Subsurface markers/barriers also are recommended above areas contaminated with lead to warn future excavators of the risk.

Additional borings and samples may be required for alternative 2A to ensure material has not migrated to areas that potentially can be reached when ground-water levels are high. Soil under the foundation of Building 101N contained elevated radionuclides and metals and is the lowest point on the Site. The significant precipitation event associated with the March 2003 snowstorm may have driven additional affected materials further down into the soil column.

Alternative 2 has the additional cost associated with the loss of property value. Although a remediation process is completed, the land value may still decrease by up to $1,920,000. The estimated present worth cost would be $5,643,000 for Alternative 2A or $6,537,000 for Alternative 2B if the land value loss were included.

Alternatives 3A and 3B – Engineered cap with partial material removal

Estimated Capital Cost: $2,103,000 (3A); $2,806,000 (3B)
Estimated Operation and Maintenance (Present Value) Cost: $1,126,000 (both 3A & 3B)
Estimated Present Worth Cost: $4,083,000 (3A); $5,180,000 (3B)
Estimated Construction Timeframe: 5 months (3A); 8 months (3B)
Estimated Time to Achieve RAOs: RAOs only partially achieved, monitoring required for at least 100 years

Alternative 3 again involves the use of an engineered cap to prevent exposure to metals and radionuclides and to control surface water infiltration, preventing material migration to ground water. The difference in this option is the removal of some of the radionuclide containing material. Alternative 3A would address the areas with combined radium activities in excess of 15 pCi/g. Removal activities would be focused on the areas with elevated gamma radiation. An estimated 500 to 1,000 cubic yards would be removed in this alternative. Alternative 3B would address areas with combined radium activities in excess of 5 pCi/g. About half of the Site has radium activity at this level. An estimated 5,000 cubic yards would be removed for this alternative.

As discussed in the Alternatives 2A and 2B section, fill would be required to prepare the Site for a cap. The capping requirements are the same as Alternative 2. It is assumed that the School borrow area would be used for both the fill and cap material. Both alternatives assume cap constructed of three feet of clay

Alternative 3 has an excavation and removal component. Because the material is not uniformly distributed, soil would be excavated and stockpiled until confirmation sampling is complete. The soil stockpile would then be shipped to an appropriate landfill. Both versions of this alternative would require the construction of the temporary access road to U.S. Highway 6 in order to avoid transporting affected material through the historic district of downtown Golden. The transportation route from U.S. Highway 6 would be dependent on the landfill selection.

Alternative 3A would require between 40 and 80 truckloads to transport the material to the landfill. Alternative 3B would require about 380 truckloads.

Both alternatives would require long-term institutional controls to ensure the integrity of the cap. Limited use could be made of the area, such as parks and recreational areas, but construction of structures would be discouraged because of the possibility of compromising the cap. Controls would include the redesign and enhancement of the ground-water monitoring system along with implementation of a long-term ground-water-monitoring program to provide information regarding potential contamination of the ground water and to use in the periodic reviews. Subsurface markers/barriers are also recommended above areas contaminated with lead to warn future excavators of the risk.

Confirmation samples will be collected to ensure the radium activity limits have been met. However, these alternatives only address radium. Elevated metal concentrations may remain in excavated areas and additional borings and samples may be required to ensure material has not migrated to areas that potentially can be reached by high ground-water levels. Soil in the area around the former Building 101N contains both elevated radionuclides and metals. Metals may have been driven deeper in the soil column by the March 2003 precipitation event.

Alternative 3 has the additional cost associated with the loss of property value. Although a remediation process is completed, the land value may still decrease by up to $1,920,000. The estimated present worth cost would be $6,003,000 for Alternative 3A or $7,100,000 for Alternative 3B if the land value loss were included.

Alternatives 4A and 4B – On-site solidification with engineered cap or on-site engineered disposal cell

Estimated Capital Cost: $3,462,000 (4A); $3,130,000 (4B)
Estimated Operation and Maintenance (Present Value) Cost: $1,126,000 (both 4A & 4B)
Estimated Present Worth Cost: $5,568,000 (4A); $5,095,000 (4B)
Estimated Construction Timeframe: 8 months (4A); 7 months (4B)
Estimated Time to Achieve RAOs: RAOs only partially achieved, monitoring required for at least 100 years

Both versions of Alternative 4 require capping, but for this alternative the cap would only cover limited areas. Alternative 4A involves the consolidation and stabilization of on-site soils using concrete and fly ash. Alternative 4B includes the consolidation of material and the construction of an engineered disposal cell. Alternative 4 assumes that all of the affected on-site material (about 10,000 cubic yards) will be solidified or placed in a disposal cell. Confirmation sampling will be performed to ensure both metal and radionuclide limits are achieved.

Alternative 4A will require a pilot test to determine the appropriate mixture of concrete, fly ash, and soil. Once the proper mixture is determined, on-site materials will need to be excavated and segregated into soil types. Some crushing of cobbles may be required. An area at a high enough elevation to remain above ground-water fluctuations will be selected for the final placement of the solidified material. Operational concrete and fly ash will be stockpiled on site and a batch processor will be brought in to mix the materials. A water supply also will be required. Batches of material will be placed in lifts and solidification will be verified with test cores.

Once the solidification of the structure has been confirmed, a clay cap (depth of three feet) will be constructed over the structure to limit leaching effects. About 0.85 acre of property would be required for the solidified matrix. Long-term cap maintenance and ground-water monitoring in the vicinity of the solidified matrix would be required. The remaining property would be available for unrestricted use although a limited ground-water-monitoring program may be required to monitor the natural attenuation of current metal concentrations and radionuclide activities. Some backfill would be required to bring the Site to a useable elevation and to provide storm-water control.

Transportation requirements for this option include materials and equipment. The U.S. Highway 6 temporary access would be the preferred route to avoid movement of large equipment through local neighborhoods.

Alternative 4B requires the construction of an engineered disposal cell. An area above ground-water fluctuations would be selected for the construction of the cell. About one acre of property would be required for the disposal cell. The affected material would be excavated from the Site and placed in the cell. Once the removal operation is complete, a clay cap (3-feet deep) will be installed over the material. Again institutional controls would be required for the one-acre cell to ensure the integrity of the cap and to monitor ground water in the vicinity of the cell. Limited ground-water monitoring may be required to monitor the natural attenuation of current metal concentrations and radionuclide activities. Backfill would be required to bring the Site to a useable elevation and to provide storm-water control.

As with Alternative 4A, the U.S. Highway 6 temporary access would be the preferred route to avoid movement of large equipment through local neighborhoods.

Variations of Alternative 4 could include the solidification or containment of a portion of the affected material. However, solidification or containment of all of the material does allow for unrestricted use of the majority of the property.

Alternative 4 has the additional cost associated with the loss of property value for the portion of the property that contains the disposal area. Although a remediation process is completed, the land value may still decrease by up to $352,000 (could be more because of the perception associated with a nearby disposal area). The estimated present worth cost would be $5,920,000 for Alternative 4A or $5,447,000 for Alternative 4B if the land value loss were included.

Alternatives 5A and 5B – Off-site disposal at solid-waste landfill or combination of solid-waste and specialized landfills

Estimated Capital Cost: $272,900 (5A); $286,800 (5B)
Estimated Operation and Maintenance (Present Value) Cost: $226,300 (both 5A & 5B)
Estimated Present Worth Cost: $3,380,000 (5A); $3,714,000 (5B)
Estimated Construction Timeframe: 6 months (5A & 5B)
Estimated Time to Achieve RAOs: 5 years (assumes natural attenuation of ground water)

Alternative 5 involves the excavation and removal of all of the affected material to an approved landfill. Alternative 5A assumes all of the material can be placed in a local RCRA subtitle D solid-waste landfill. Alternative 5B assumes that solid waste landfill acceptance criteria may require some of the material to be transported to a RCRA subtitle C facility in Idaho. Both versions of this alternative would require the construction of the temporary access road to U.S. Highway 6. The transportation route from U.S. Highway 6 would be dependent on the landfill selection.

Excavated material would be stockpiled prior to shipping to maximize the use of the trucks (eliminates waiting time for trucks). Alternative 5A would require about 760 truckloads to transport the material to the landfill. Alternative 5B would require between 680 and 720 truckloads to the solid-waste facility and the equivalent of 40 to 80 truckloads to the Idaho facility (or shipping site).

Upon completion of the off-site disposal, all of the property would have unrestricted use. Backfill material would be required to bring the Site to a useable elevation and for storm-water control and safety. Surface water and ground water monitoring would continue until it demonstrates that source removal and natural attenuation were effective in meeting the remedial objectives. The surface of some of the Site would be used for recreational purposes while the ground water and surface water monitoring would continue.

Because all of the affected material would be removed from the Site, Alternative 5 would not experience the loss in property value associated with the other alternatives.

J. Comparative Analysis of Alternatives

Nine criteria are used to evaluate the different remediation alternatives individually and against each other in order to select a remedy. The nine criteria fall into three groups. The first group, the threshold criteria, includes overall protection of human health and the environment and compliance with the ARARs. If an alternative does not meet these criteria, it is not eligible for future consideration. The second group, the balancing criteria, include long-term effectiveness and permanence, reduction of toxicity, mobility, or volume through treatment, short-effectiveness, implementability, and cost. These criteria are weighed against each other to determine a preferred option. The last group, the modifying criteria, includes State and community acceptance. The modifying criteria are often used to make a final selection.

The following sections profile the relative performance of each of the alternatives against the other alternatives. The nine evaluation criteria are individually discussed in the following sections. Detailed discussion of the alternative evaluation can be found in Sections 7.0 and 8.0 of the RI/FS.

- *Overall protection of human health and the environment,*

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

All of the alternatives, except the "no further action" alternative, provide a degree of protection to human health and the environment, primarily through disposal or a combination of engineering and institutional controls. Metals and radionuclides are very persistent in the environment (limited treatment options are available) and the most cost-effective methods involve containing the material. Some uncertainty would remain for the ground-water pathway and long-term effectiveness of institutional controls for Alternatives 2 and 3 (cap integrity). These same uncertainties would be a problem to a lesser extent for Alternative 4. The only alternative with minimal uncertainty is Alternative 5.

Because the "no further action" alternative is not protective of human health and the environment, it was eliminated from consideration under the remaining eight criteria.

- *Compliance with ARARs*

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for a invoking waiver.

Most of the ARARs are met for Alternatives 2 through 4. Alternative 5 would meet all of the ARARs assuming the natural attenuation of the ground water is successful.

- *Long-term effectiveness and permanence*

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

Because of the requirement for a cap for Alternatives 2 through 4, the long-term effectiveness and permanence of these options may be questionable. The solidification process used for Alternative 4A also could be a problem in the future (other solidification structures have failed over time). Alternative 5 meets the long-term effectiveness and permanence criteria because the material is removed from the Site.

- *Reduction of toxicity, mobility, or volume through treatment*

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

With the exception of Alternative 4A, none of the alternatives use treatment to reduce toxicity, mobility, or volume. Although there are a number of technologies available to treat soils contaminated with similar material, the processes are typically expensive and have varying degrees of success. While treatment associated with Alternative 4A does reduce the toxicity (through lessening bioavailability) and mobility of the material, the volume of material would actually increase.

- *Short-term effectiveness*

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternatives 3 through 5 would have additional short-term risks because of the excavation of the material (increasing exposure to the material through radiation exposure and inhalation). A somewhat lesser risk would be associated with Alternative 2 because there is no excavation associated with this option. Alternatives 3 and 5 also would have additional risks associated with the transportation of the materials (i.e., traffic accidents).

- *Implementability*

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

All of the alternatives use proven technology, but developing the proper concrete/soil mixture for Alternative 4A could be problematic. Alternatives 2 through 4 use varying degrees of on-site disposal and may require a permit unless an on-site waiver were possible. Alternatives 3 and 5 have uncertainties associated with the acceptance criteria for the landfills where the material would be sent. Alternative 5A may have more significant administrative feasibility issues than Alternative 5B with meeting landfill waste acceptance criteria and obtaining local approval for the disposal of materials with the most elevated radioactivity. However, the determination of what materials will go to which landfill will be made during excavation as the nature and volume of affected materials will be actually determined.

- *Cost*

The least expensive alternative is Alternative 5 (see Section 8.0 of the RI/FS). If the value of the land is considered, Alternative 5 has significantly less cost than the other alternatives because it allows unrestricted future use of the property.

- *State acceptance*

CDPHE prefers the off-site disposal alternative (Alternative 5). This also is the School's preferred alternative. On-site disposal would be difficult to justify to the CDPHE because of recent events including the Shattuck Superfund site.

- *Community acceptance*

For comments that expressed a preference among the five alternatives, all supported the off-site disposal plan (Alternative 5). On-site disposal would be difficult to justify to the public because of recent events including the Shattuck Superfund site.

K. Principal Threat Wastes

The principal threat wastes are radionuclides and metals in the surface and subsurface soils. Only Alternative four provides for treatment of these wastes through solidification. Given the high cost and technical uncertainties of Alternative four in comparison to Alternative 5, Alternative 5 is a preferred alternative.

L. Selected Remedy

The preferred alternative presented in the RI/FS was the off-site disposal of the affected material or Alternative 5. After consideration of input and comments by reviewers of the RI/FS including CDPHE and PRPs, especially the administrative feasibility comments, Alternative 5B has been chosen as the selected remedy. The purpose of this document, the Record of Decision, is to notify interested parties of the selected remedy and provide information about the decision process.

The following sections describe the details of the Alternative 5B remediation project.

Affected Material

Alternative 5B involves the excavation and removal of all of the affected material to off-site disposal facilities. The characterization work done during the remedial investigation (RI) portion of the RI/FS identified areas with elevated radionuclide activity (above background) and areas where radionuclide activity was minimal or equal to background. The areas with elevated activity have been designated Class 1 areas in accordance with the regulatory guidance used for the cleanup of sites with radioactive material [U.S. Environmental Protection Agency and U.S. Department of Energy, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),* NUREG-1575, Rev. 1]. The remainder of the Site has been designated a Class 2 area because of the potential for some remaining radioactive material.

The primary radionuclides of concern identified during the RI include radium-226 and -228, thorium-228, -230, and -232, and uranium-234, -235, and -238. Additional radionuclides were identified during the RI but are co-located with the radium, thorium, and uranium.

The primary metals of concern identified during the RI include arsenic, cadmium, lead, and mercury. Additional metals were identified during the RI but are co-located with the metals of concern. In general the highest metal concentrations are co-located with the radionuclides, but there are areas where the metals are the primary contaminant.

There was significant discussion of the RI/FS selected background samples by the PRPs and CDPHE in the comments to the RI/FS. After review, CDPHE agreed that the selected background sample locations were acceptable and that the upper 95-percent confidence limit could be used for the Site background values for metals and radionuclides. This resulted in slightly lower risk calculations and higher DCGLs for the Site in the ROD than the figures presented in the RI/FS.

One change to the originally proposed Alternative 5B includes instrumentation, material handling, and verification of natural attenuation. In-Situ Object Counting System (ISOCS) instrumentation will be used for screening samples and a portion of the verification samples. The ISOCS will allow a faster determination of disposal facilities material categories and will assist in determining if areas have achieved remediation goals. Material handling has been re-evaluated to minimize the number of vehicles that require access to the Site, which minimizes screening requirements. The ground-water monitoring program has been changed from five to two years (re-evaluated at that time) and three surface-water sample locations were added to the monitoring program. The purpose of the added surface-water samples is to verify that material is not moving off site into Clear Creek.

Excavation Operations

The material with the highest levels of radioactivity from the Class 1 areas will be excavated and loaded directly into Transport Plastics, Inc., Lift Liner™ bags that can be sealed to prevent spillage on Site and during transport. The bags will be held on Site until there is a sufficient number for shipment and waste acceptance analysis is performed. Samples will be collected from these Class 1 areas to ensure that the material meets the landfill acceptance criteria and transportation requirements. An estimated 500 to 1,000 cubic yards of soil are anticipated to contain the highest levels of radioactivity. These materials will either be transported to the U.S

Ecology facility in Idaho or to a local solid waste landfill after a waste acceptance risk assessment demonstrates that the receiving facility may properly accept this material.

The remaining material from the Class 1 areas and the material from the Class 2 areas will be excavated and collected in stockpiles prior to shipment. Stockpile sizes will be controlled to limit wind- and water-borne erosion. Samples will be collected from these stockpiles to ensure the material meets the solid waste landfill acceptance criteria required by CDPHE when no waste acceptance risk assessment is performed (see Disposal Sites section). An estimated 7,000 to 9,500 cubic yards falls into these material designations.

Disposal Sites

The highest level material from Class 1 areas will be sent to U.S. Ecology Idaho, Inc located in Grand View, Idaho (hazardous waste – RCRA Subtitle C landfill) or Waste Management - CSI located in Bennett, Colorado (solid waste – RCRA Subtitle D landfill). A landfill specific risk assessment would need to be completed prior to material acceptance for the CSI landfill. Depending on the final quantity of material determined to fall into these categories, some of the material may go to U.S. Ecology with the balance going to CSI. The decision will be made after the materials have been excavated and analyzed for landfill waste acceptance purposes.

The remainder of material from Class 1 areas and the material from the Class 2 areas will be sent to the BFI Foothills solid waste landfill (Subtitle D landfill) located north of Golden, Colorado. The Colorado Department of Public Health and Environment (CDPHE) requires that material sent to the BFI Foothills landfill meet the ANSI/HSP N13.12-1999 standard (*Surface and Volume Radioactivity Standards for Unconditional Clearance*, January 2000) if no waste acceptance risk assessment is performed for the affected materials designated for disposal at BFI.

Transportation

The bagged material from the Class 1 areas will be loaded by crane or other mechanical equipment onto a flatbed truck and transported to U.S. Ecology by way of the CAST Transportation facility in Henderson, Colorado or to the Waste Management - CSI facility in Bennett, Colorado.

CAST operates a transloading facility (Irondale Station) at Henderson where material is transferred into Burlington Northern & Santa Fe (BNSF) rail cars for shipment to Idaho. Typically three to four truckloads are required to fill a rail car. The route from the Site to the CAST facility starts at the recently constructed temporary access on U.S. Route 6 and includes Colorado Route 58 to U.S. Interstate-70 (I-70) to I-76 to the 96th Avenue Exit off I-76. The route continues east on 96th Avenue to Heinze Way to Havana Street. The total distance is about 24 miles.

The route to the CSI facility would include U.S. Route 6 to Colorado Route 58 to I-70 to Exit 295 (Watkins). From the exit the trucks would head north on Colorado Route 97 and then east on Colorado Route 36. The trucks then head north on Colorado Route 25 and the east on East 88th Avenue. The total distance is about 49 miles.

Trucks hauling the bagged material will be loaded at a designated clean area adjacent to the Site using material handling equipment. Sealed bags will be lifted from the Site onto the waiting trucks.

All other material (i.e. non-bagged material) will be loaded from the stockpiles directly into long-bed dump trucks (stockpiles minimize the waiting period during transportation operations) and transported to the BFI facility. All trucks will be covered during material transportation operations. The route from the Site starts at the temporary access on U.S. Route 6 and continues north along State Route 93 to the landfill. The total distance is about 8 miles.

Trucks hauling the non-bagged material will be loaded on Site and may require screening prior to entry and exit from the Site. Details of the screening operations are provided in the project specific operational work plans (CSMRI Site Remediation Sampling and Analysis Plan).

Final Status Survey

Following the removal and transportation operations the Site will be surveyed using a combination of portable meter scans and soil samples to verify that the soil remediation has been successful. On Site instrumentation (In Situ Object Counting System) and laboratory analysis will be used for the verification samples. A data report of the findings will be presented at the end of the project.

Ground- and Surface-Water Monitoring

In addition to off-Site disposal of the material, quarterly ground- and surface-water monitoring will be performed for a minimum of two years following removal of Class 1 and Class 2 materials to demonstrate natural attenuation. Monitoring will include measurement of field parameters (dissolved oxygen, pH, specific conductance, and temperature) and the collection and analysis of ground- and surface-water samples for identified contaminants of concern.

Final Site Conditions

Upon completion of the off-Site disposal, all of the property will be available for unrestricted use. Backfill material would be required to bring the Site to a useable elevation and for storm-water control and safety. A portion of the surface of the Site will be used for beneficial purposes, such as recreation, while the surface water and ground water monitoring is ongoing.

M. Statutory Determinations

The purpose of this section is to provide a brief, site-specific description of how the Selected Remedy satisfies the statutory requirements of CERCLA §121 (as required by NCP §300.430(f)(5)(ii)). The following sections describe how Alternative 5B meets the nine criteria.

Overall protection of human health and the environment

The selected remedy requires the complete removal of the affected material using site-specific derived concentration guideline levels (DCGLs) and the proposed Tier 2 residential soil standards, except for arsenic (see RI/FS). CDPHE allowed the substitution of an urban resident (maximally exposed individual) for the originally proposed subsistence farmer. Using the urban resident, RESRAD (see RI/FS for discussion of RESRAD) predicts a dose of 4.5×10^{-2} mrem/yr and a risk of 8.4×10^{-7} for the property after material removal. These dose and risk levels assume no backfilling of the Site. Doses and risks associated with radon were not calculated because of the variability discussed in the RI/FS. Radon flux measurements may be used to verify radon levels during the verification sampling.

Alternative / Receptor	RESRAD Dose (mrem/yr)	RESRAD Risk[1]	Hazard Index	RAIS Risk	Combined Risk[1] (RESRAD & RAIS)
5B – Urban Resident – Following Removal of Affected Soils	4.5×10^{-2}	8.4×10^{-7}	0.58	3.5×10^{-5}	3.5×10^{-5}

[1] Radon pathway not included in risk or dose assessment

Because natural background arsenic concentrations are typically elevated in western states, the risk from arsenic produces an overall risk greater than 1.0×10^{-6}. However, re-grading and backfilling operations required for storm-water control, safety, and Site restoration may reduce the overall risk even further (assuming clean fill).

The following list provides the site-specific DCGLs accepted by CDPHE for the Site remediation. The DCGLs do not include background levels; thus, the final cleanup level is the DCGL plus background.

Radionuclide	Urban Resident – 15 mrem/yr
Lead-210	4.44
Polonium-210	192
Radium-226	1.44
Radium-228	2.20
Thorium-228	3.77
Thorium-230	9.83
Thorium-232	1.48
Uranium-234	253
Uranium-235	4.88
Uranium-238	20.2

Note: All units in picocuries per gram

The following table (See Table 4-9 of the RI/FS) provides the upper confidence level values that will be used as background values for the Site:

Metal / Isotope	Mean	Lognormal Mean	Background Upper Limit[1]
Arsenic	6.9	6.5	13
Barium	180	150	370
Cadmium	0.34	0.096	1.5
Chromium	12	12	16
Lead	33	26	86
Mercury	0.18	0.11	0.63

Molybdenum	2.7	2.3	6.1
Selenium	0.72	0.65	1.7
Silver	0.065	0.057	0.12
Vanadium	27	26	44
Zinc	120	100	250
Thorium-228	1.7	1.6	2.7
Thorium-230	1.2	1.2	1.7
Thorium-232	1.5	1.5	2.4
Uranium-234	1.0	0.98	1.9
Uranium-235	0.059	0.057	0.098
Uranium-238	1.0	0.99	1.6
Bi-212	1.8	1.7	2.7
Bi-214	1.2	1.1	1.9
Co-56	0.16	0.14	0.34
K-40	21	21	27
Pb-212	1.8	1.7	2.7
Pb-214	1.4	1.3	2.3
Ra-226	1.7	1.6	2.7
Ra-228	1.6	1.5	2.4
Th-234	2.2	2.1	4.1
Tl-208	0.50	0.49	0.74

Notes: All metals units in milligrams per kilogram, all isotope units in picocuries per gram; Background upper limit represents 95-percent confidence limit using small sample set statistics.

The DCGLs are driven by the receptor definition and the specified basic radiation dose limit. The DCGLs will be applied to the on-site verification samples using the sum-of-the-fractions rule (defined in MARSSIM). Area factors also may be applied to portions of the Site. A discussion of area factors was provided in the RI/FS.

Soil metals concentrations (primarily arsenic, cadmium, lead, and mercury) will be remediated to the proposed Tier 2 soil standards, except for arsenic, which is established at the upper confidence number for background levels at the Site. These standards have been determined to be protective of human health and the environment and have been agreed to by CDPHE. The cleanup values presented below for metals are inclusive of background, unlike the DCGLs for radionuclides presented above.

Metal	Proposed Standard (mg/kg)
Arsenic	13
Barium	5,277
Cadmium	76.1
Chromium (total – includes Cr VI)	223
Lead	400
Mercury (elemental)	1.1
Mercury (compounds)	23
Molybdenum	390[1]
Selenium	380
Silver	380
Vanadium	550[1]
Zinc	22,825

[1] EPA Region 9 proposed soil standard

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

Alternative 5B complies with all of the ARARs the listed that were in Section 8.1 of the RI/FS, with the possible exception of some requirements for short-term ground-water monitoring. The proposed ground- and surface-water monitoring program is designed to demonstrate the effectiveness of source removal and natural attenuation. Questions concerning landfill acceptance criteria have been addressed in preparation of the project.

The principal ARARs to be met are as follows:

Media	Site Specific Applicable or Relevant and Appropriate Requirements and To Be Considered
Soil	10 CFR §20.1402 and 1403, NRC Standards for Protection Against Radiation, Radiological Criteria for Unrestricted and Restricted Use – Requires that exposures to on-site receptors do not result in a dose in excess of 25 mrem/yr.
	6 CCR 1007-1, §4.61.2 – 4.61.3, Colorado Radiation Control regulations, Radiological Criteria for Unrestricted and Restricted Use - Requires that exposures to on-site receptors do not result in a dose in excess of 25 mrem/yr.
	EPA Memorandum, Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, OSWER No. 9200.4-18, August 1997 – Uses a risk-based approach to recommend limiting exposures to less than 15 mrem/yr.
	EPA Memorandum, Reassessment of Radium and Thorium Soil Concentrations and Annual Dose Rates, July 22, 1996 – Initial discussion that resulted in the recommended 15 mrem/yr dose.
	EPA Memorandum, Use of Soil Cleanup Criteria in 40 CFR 192 as Remediation Goals for CERCLA Sites, Directive No. 9200.4-25, February 1998 – Clarification of the use of 40 CFR 192 for the development of radionuclide soil standards.
	EPA Memorandum, Use of Soil Cleanup Criteria in 40 CFR 192 as Remediation Goals for CERCLA Sites, Directive No. 9200.4-25, February 1998 – Clarification of the use of 40 CFR 192 for the development of radionuclide soil standards.
	40 CFR §192.12, Subpart B—Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites, Standards – Limits radium-226 surface activities (up to 15 cm) to 5 pCi/g and subsurface activities (greater than 15 cm) to 15 pCi/g. For occupied or habitable structures it requires that remedial efforts result in an annual radon decay product concentration (including background) of less than 0.2 WL (in any case the concentration should not exceed 0.3 WL). And interior gamma shall not exceed background by more than 20 microroentgens per hour.
	40 CFR §192.02, Subpart A—Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites, Standards – Specifies that the control of residual radioactive materials and their listed constituents shall be designed to be effective for up to one thousand years, and in any case for at least 200 years. Also imposes limits on acceptable radon air concentrations and requires ground-water monitoring when necessary.
	CDPHE, Proposed Soil Remediation Objectives Policy Document, December 1997
	CDPHE, Revised Proposed Residential/Unrestricted Land-Use Standards, 2003
	EPA Region 9 Memorandum, Region 9 PRGs Table 2002 Update, October 2002 – Describes risk based approach to soil cleanup and provides table of preliminary remediation goals for soils. CDPHE recommends the use of these PRGs for materials not covered by their proposed soil standards.
Ground and Surface Water	40 CFR §192.02 Standards, §192.03 Monitoring, §192.04 Corrective Action, Subpart A—Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites – Details the requirements specific to ground water.
	40 CFR §192.20 Guidance for implementation, §192.20 Criteria for applying supplemental standards, Subpart C – Implementation – Additional ground water requirements.
	40 CFR 141.11, National Primary Drinking Water Regulations, Maximum contaminant levels for inorganic chemicals
	40 CFR 141.15, National Primary Drinking Water Regulations, Maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity in community water systems.
	40 CFR 141.51, National Primary Drinking Water Regulations, Maximum contaminant level goals for inorganic contaminants.
	40 CFR 141.55, National Primary Drinking Water Regulations, Maximum contaminant level goals for radionuclides.
	5 CCR 1003-1, Art. 5, Colorado Primary Drinking Water Regulations, Maximum contaminant levels for inorganic chemicals
	5 CCR 1002-41, Colorado Department Of Health, Water Quality Control Commission Regulation No. 41, Basic Standards for Ground Water
	5 CCR 1002-8, §3.1.1, Colorado Department Of Health, Water Quality Control Commission Regulation No. 8, Establishes basic standards, anti-degradation standard, and system for classifying State water.
	5 CCR 1002-38, Colorado Department Of Health, Water Quality Control Commission Regulation No. 38, Classifications And Numeric Standards South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin

5 CCR 1002-31, Colorado Department Of Public Health And Environment, Water Quality Control Commission, Regulation No. 31, The Basic Standards And Methodologies For Surface Water, Section 31.8 Antidegradation Rule.

Long-Term Effectiveness and Permanence

Disposal at a solid waste landfill successfully mitigates the potential long-term effects associated with the elevated metals and radionuclides on the Site. This alternative provides unrestricted use for the entire property.

Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative does not reduce the toxicity, mobility, or volume of affected material through treatment. All of the material is moved to an off-site landfill where it can be properly managed, but no treatment will occur. Metals and radionuclides are very persistent in the environment and treatment technologies used to reduce toxicity, mobility, or volume typically are very expensive and difficult to implement. For these reasons the reduction of toxicity, mobility, and volume were major considerations leading to the selection of an off-Site disposal alternative selection.

Short Term Effectiveness

Excavation and transport activities pose an elevated short-term exposure risk to on-site workers, transportation workers, and nearby residents due to airborne particulate generation. Direct exposure of workers during implementation of this alternative will be minimized through use of appropriate safety measures and procedural controls (project specific Health and Safety Plan). The RI/FS presented predicted dose and risk values that fell within acceptable limits. Hazards associated with metals would be expected to be minimal during remedial operations. Assuming two months of excavation operations in the elevated areas the RAIS model produced a hazard index of 0.28 and a risk of $2.0x10^{-7}$ (primarily arsenic through dermal and inhalation pathways). Again these values would be mitigated by material handling equipment and safety equipment. Risks associated with inhalation of fugitive dusts are controllable through air monitoring, the use of appropriate health and safety equipment and dust suppression techniques. Air monitoring also would be used to identify potential off-site risks to the neighboring community.

A low to moderate risk to the local area would be associated with the truck traffic required to move equipment and material (i.e., traffic accidents). CDOT limited the number of trucks that could exit the site (during non-peak hours) to ten trucks per hour to minimize the risk. Material movement is not allowed during peak traffic hours.

Based on worker risk assessment evaluations, there is a minimal short-term risk of potential adverse health consequences during a transportation-related accident. Exposure times would result in a risk significantly lower than the $1x10^{-6}$ threshold (assumes cleanup operations are completed within 24-hours and the only receptors are emergency response personnel). Typically access to transportation related spills is not allowed to members of the general public.

An accident involving an overturned truckload of affected material would have a small environmental risk if the material were to enter a drainage channel. However, the environmental risk would be limited because of the nature of the material (soil versus liquid) and containment procedures followed by emergency response teams.

Some operational noise can be expected that could be noticed by nearby residents.

Implementability

The technical feasibility of off-site disposal at a solid waste landfill relies on use of conventional excavation and transport technology. Necessary equipment is readily available for implementation of this alternative.

Approval for the access to State Highway 6 was obtained from Colorado Department of Transportation (CDOT). Waste profiles have been submitted to the appropriate landfill facilities and the acceptance process is proceeding. The risk assessment for the CSI facility is still in progress.

Cost

Cost elements associated with Alternative 5B include material excavation and stockpiling, separation of specific soils, transportation to two locations, and re-grading of the Site. After the source removal a minimum of two years of ground- and surface-water monitoring will be required. The total present value of these cost elements is estimated at $3,714,000 in the RI/FS. Property values are not as significantly affected by this alternative as it would be with on-Site alternatives because the land will be available for unrestricted use (see RI/FS). The estimated schedule for Alternative 5B is about three to four months.

The original alternative costs submitted in the RI/FS were generated making general assumptions that could be carried through the entire range of alternatives. This was done for remedy selection purposes. The information in the RI/FS cost estimate summary was based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements were likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Once the alternative was selected, the cost information was examined in detail and project modifications were made and subcontractors were compared to provide the best possible price. Therefore, the actual costs for implementing Alternative 5B may be less than the estimated costs n the RI/FS.

CERCLA allows more than one alternative to be cost effective. CERCLA does not mandate that the selection of the most cost-effective cleanup alternative. Nor does the most cost-effective always provide the best balance of tradeoffs.

State Acceptance

CDPHE indicated that Alternative 5B was the preferred alternative. Comments submitted by CDPHE concerning the RI/FS are addressed on the CSMRI Site website and below in Part III. A number of meetings have been held with CDPHE to clarify requirements since the issuance of the RI/FS. CDPHE has provided guidance for landfill acceptance criteria, DCGLs, accepted background values, ground- and surface-water sampling requirements, and general project acceptance.

Community Acceptance

Comments received during an open house and an RI/FS review meeting indicated that local residents preferred Alternative 5B. Some PRPs preferred Alternative 5A. A summary of the public comments are available on the CSMRI Site website at http://www.is.mines.edu/ehs/CSMRI/CSMRI.htm.

N. Documentation of Significant Changes from Preferred Alternative of Proposed Plan

There are no significant changes from the preferred alternative identified in the Proposed Plan. The Proposed Plan for the CSMRI Site was released for public comment in January 2004. The Proposed Plan identified Alternative 5, off-Site disposal, as the Preferred Alternative for soil remediation. The School reviewed all written and oral comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.