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7. Development and Screening of Alternatives

The 2004 RI/FS presented five alternatives (a no-action alternative and four sets of treatment/disposal alternatives). Due to the rejection of several of these alternatives in the 2004 RI/FS and the technique used to segregate impacted soil from un-impacted soil on the Site during the 2006 RI, several of the alternatives proposed in the 2004 RI/FS are no longer considered alternatives in this RI/FS. Six new/revised remedial alternatives are presented in this section (a no-further-action alternative and five sets of treatment/disposal alternatives).

The 2004 RI/FS proposed offsite disposal as the remedy (Alternative 5) and rejected the four other onsite alternatives (Alternatives 1 – 4). With the excavation of the contaminated soils and placement into two stockpiles onsite, the alternatives that included leaving some of the contaminated soil in-situ have been rejected and are not re-evaluated in this RI/FS. Therefore, Alternatives 1 – 3 in the 2004 RI/FS are eliminated. However, a variation of the no-action alternative that will be considered is leaving the two contaminated soil stockpiles in place (no further action). Furthermore, Alternative 4 from the 2004 RIFS can be considered because that alternative included the excavation of contaminated soils, management of those soils, and then placing them back onsite as part of the remedy.

Finally, this RI/FS includes as an environmental covenant requiring radon mitigation for any structure built on this site to meet ARARs and as a best management practice. With the exception of the No Further Action alternative (Alternative 1), this covenant applies to all the remedial alternatives due to residual impacted soils remaining after excavation and to the relatively high concentration of background Ra-226.

The first six sections of this RI/FS described the remedial investigation phase of the process. The RI was completed through two efforts, the first providing valuable data with respect to the nature and extent of contamination and on the complexity of the contaminant distribution on Site, and the second implementing a different and more successful approach to the investigation, using the data from the first effort. The 2004 characterization indicated that sufficient onsite metals and radionuclides warrant remedial action, and this was confirmed by the second characterization in 2006 - 2007.

The remainder of this RI/FS document will focus on the FS, which develops, screens, and evaluates available alternatives for remedial actions. The FS process presents the remedial action alternatives to a decision-maker and aids the selection of the appropriate remedy. The primary requirement of the alternative selection is that it shall be protective of human health and the environment by eliminating, reducing, and/or controlling risks posed through each Site pathway.

The purpose of this section is to explain the processes used to identify possible alternatives and screen out alternatives that may be impractical, unworkable, or not protective of health and environment at the Site. The development of the alternatives requires:

- Identification of remedial action objectives,

- Identification of potential treatment, resource recovery, and containment technologies that will satisfy the objectives,
- Evaluation of technologies based on effectiveness, implementability, and cost,
- Screening out of potential alternatives that do not meet the objectives, and
- Generation of alternatives to be evaluated further by detailing the technologies and their associated containment or disposal requirements.

An FS was originally presented in the RI/FS, dated 2004. The alternatives analysis performed at that time is still mostly valid. The volume of impacted material requiring management under each alternative was assumed to be approximately 10,000 in place cubic yards, and the actual volume is approximately 13,000 stockpiled (uncompacted or fluffed) cubic yards, only 30 percent higher which is well within the fluff factor for this material. The validity of the previous alternatives analysis was not compromised by the issues the previous consultant had with their site characterization or their inability to successfully implement the selected alternative. The data that formed the basis of their alternatives analysis, partially incorporated herein, remain valid.

The 2004 FS eliminated the no-further action alternative and indicated that leaving the impacted soil in place was not an acceptable option. Further, the selected remedial alternative was excavation and offsite disposal of impacted soils above the DCGLs.

The 2006 RI began with a re-evaluation of contaminant distribution information derived during the 2004 RI. These data combined with a post-mortem evaluation of the failed remedial alternative implementation led to an understanding of the complexity and nature of the distribution of impacted Site soils. An investigation strategy was developed based on these studies in which Site characterization was achieved through the excavation of successive 1-foot-thick soil layers from the Site and segregation by radionuclide activity into two stockpiles on Site. After each 1-foot layer was excavated, the underlying surface was tested to determine the level of remaining impacts, and additional contaminated material was then segregated into the appropriate stockpile. This continued until material below the DCGLs was encountered. Two soil stockpiles were established for excavated materials: Stockpile A contains material over 100 pCi/g total activity and contains approximately 200 cubic yards of material. Stockpile B contains the majority of the excavated material (less than 100 pCi/g total activity but greater than the tentative Site DCGL) and contains approximately 12,800 fluffed cubic yards, or 9,700 in place cubic yards, of material.

Characterizing the Site soils in this way had the additional cost-savings benefit of excavating soil that would have had to be excavated eventually during the implementation of the remedial options eligible for implementation in the findings of the 2004 FS, which concluded that the impacted material could not be left in place. Because New Horizons learned during remedy implementation that the nature and extent of contamination was greater than that estimated in the 2004 RI/FS, it was clear that the no-action alternative and the *in-situ* alternatives would not be reasonable alternatives and extensive excavation of Site soils would still be required. Characterizing the Site soils in the more traditional manner of drilling numerous boreholes across the entire Site for a site with this degree of heterogenous complexity would have cost an amount that was comparable to the excavation and segregation method that was used, with little increase in accuracy.

The alternatives can be designed to address either of the two existing stockpiles separately (pile A or pile B) or both of the stockpiles in the same manner. CDPHE has determined that the remaining Site soils (except for the Clay Pits Area and portions of the flood plain that will be excavated to Stockpile B in the spring of 2007) are below the tentative Site DCGLs, or cleanup action levels. Therefore, these areas are a part of the remedial alternatives to the extent that some or all of these areas are required for implementation of the onsite alternative remedies. Additionally, an environmental covenant requiring radon mitigation for all structures built on the Site will be recorded for the site to meet ARARs and as a best management practice.

After potential alternatives have been developed, options that do not meet the objectives are screened out to reduce the number of alternatives for further evaluation. The screening process involves evaluating alternatives with respect to their effectiveness, implementability, and cost.

7.1 Identification of Remedial Action Objectives

Both RIs identified elevated concentrations of radionuclides and metals. Based on existing information, site-specific remedial action objectives to protect human health and the environment were developed. The objectives specify the materials and media of concern, the exposure routes and receptors, and an acceptable contaminant (material) level or range of levels for each exposure route (i.e., preliminary remediation goals).

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 was the surface and subsurface soil located in the vicinity of the former buildings prior to soil segregation activities. After soil segregation, most of the affected material is located in either Stockpile A or Stockpile B. Potential receptor pathways included direct radiation, inhalation, and ingestion of plants and soil. Another potential exposure pathway is the migration of the affected material to groundwater and subsequent ingestion. The following objectives, originally established for the Site prior to soil segregation activities, remain valid:

- Eliminate or minimize the pathway for dermal contact, inhalation, and ingestion of site-specific radionuclides to human receptors to achieve a level of protection in compliance with the NCP 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; and less than 100 mrem/yr above background if institutional controls fail for onsite restricted-use remedies) for the radionuclides found in the affected material (i.e., soil). Radium-226, thorium-228, thorium-230, thorium-232, and uranium-238 are present onsite at activities above tentative DCGLs. Additional radionuclides were identified during the characterization (radium-228, uranium-234, and uranium-235) 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.

- 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 or that generate HIs greater than 1. The primary trace metals of concern are arsenic, lead, mercury, molybdenum, and vanadium.
- Address specific issues associated with the hazards associated with soil containing elevated concentrations of lead (possible access issues with neighborhood children).
- Implement remedial measures that limit groundwater and surface-water concentrations to the maximum contaminant levels (MCLs) at the points of compliance and to non-zero maximum contaminant level goals (MCLGs), established under the Safe Drinking Water Act and under Colorado law. Although the affected groundwater is not a current drinking water supply, it eventually enters Clear Creek, which is used by downstream users for drinking water. Uranium and arsenic are the primary groundwater contaminants of concern.
- Prevent offsite migration of affected material that could result in the exposures described above. This includes the groundwater pathway.
- 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. (Section 8.1 and Appendix I)

Table 7-1 presents the Site action levels agreed to in the CDPHE-approved 2006 Site Characterization Work Plan. These DCGLs, originally developed prior to the 2004 RI/FS, have been considered tentative for all Site work and documentation prior to this point in this document. The tentative DCGLs were agreed to by the School and CDPHE in 2004 and have only been modified for Arsenic since that time. These DCGLs, in combination with the environmental covenant, allow the School to comply with all ARARs and allow for future development of the Site. From this point forward, DCGLs are no longer referred to as "tentative." They are considered final DCGLs.

Table 7-1
Site DCGLs and Cleanup levels

Metal	**DCGL (mg/kg)**	**Site Action Level (inclusive of background) (mg/kg)**
Arsenic	1.0	39
Lead	NA	400*
Mercury (elemental)	1.1	1.1
Mercury (compounds)	NA	23
Molybdenum	NA	390
Vanadium	NA	550
Radioisotope	**DCGL (pCi/g)**	**Site Action Level (pCi/g)**
Radium 226	1.44	4.14
Radium 228	2.20	4.6
Thorium 228	3.77	6.47

Thorium 230	9.83	11.53
Thorium 232	1.48	3.88
Uranium 234	253	254.9
Uranium 235	4.88	4.97
Uranium 238	20.2	21.8

[1] NA – Not applicable

* DCGLs not calculated for some metals. Site action levels use ARARs for cleanup goals.

Receptor definition is important for the determination of risks and hazards. Exposure times and multiple pathways place the urban resident at greater risk than an occasional recreational user. The persistence of the affected material would place receptors at risk for over 1,000 years, and land use could change significantly in that amount of time. Both the urban resident and the recreational user will be evaluated for each scenario because of the future land use uncertainty and because it is reasonably foreseeable that the Site would be used for urban residents by the School or other future owners of the Site. Additionally, exposures resulting from each alternative must comply with a 1997 NRC rule (10 CFR Part 20, Subpart E), which has been adopted by Colorado (6 CCR 1007-1 4.61.3), which establishes a dose criterion for decommissioning a site. This rule includes a provision that permits decommissioning under restricted release conditions, such as those proposed herein. Under a restricted release (a release including an environmental covenant), the dose to the average member of the critical group must not exceed 25 mrem/yr with the restrictions in place, and, if the restrictions were to fail, the dose due to residual radioactivity must not exceed 100 mrem/yr.

Soil segregation activities completed in 2006 were implemented to characterize the nature and extent of impacted soils on the Site. These activities comply with the results of the 2004 FS in that leaving the impacted material in place was not an option. All viable options evaluated in the 2004 FS required being able to accurately quantify the volume of impacted soil and required the impacted soil to be relocated. The characterization through segregation allows each of the viable options identified in the 2004 FS to be re-considered in this FS. Therefore, the objectives of the remedial actions listed above in Section 7.1 remain valid.

7.2 Identification of Treatment, Recovery, or Containment Options

NCP requirements detailed in 40 CFR 300.430(e)(ii) and (iii) require the identification and evaluation of potentially suitable technologies to comply with ARARs and the assembly of suitable technologies into alternative remedial actions.

The initial step of the NCP process is to identify the general action groups. 40 CFR 300.430(e) requires the evaluation of a range of alternatives including:

- No action – may involve no-further action if some removal or remedial action has already occurred at the Site.
- No treatment – involves little or no treatment but provides protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants. This may be accomplished through engineering controls such as containment, and, as necessary, institutional controls to protect human health and the environment and to assure continued effectiveness of the response action.

- Treatment – identifies treatment(s) that reduces the toxicity, mobility, or volume of the hazardous substances, pollutants, or contaminants. Innovative treatments are to be considered.
- Removal – involves removal of affected material to an offsite landfill or equivalent location designed to contain such material.

The no-action alternative was rejected in the 2004 RI/FS but will nonetheless be re-examined as a no-further action option with the stockpiles in their current *ex-situ* locations. Although not necessary because of the previous rejection in the 2004 RI/FS, this alternative will be evaluated to determine if the *ex-situ* locations are protective of human health and the environment.

The remaining action groups need to be evaluated to determine what is appropriate for this Site. A number of guidance documents and methodologies are available to assist with this process. The following primary sources of information were used for this portion of the FS:

- Remediation Screening Matrix (http://www.frtr.gov/matrix2/top_page.html) prepared for the U.S. Department of Defense and other federal agencies participating in the Federal Remediation Technology Roundtable
- Presumptive Remedy for Metals-in-Soil Sites (EPA 1999). Developed in a joint effort between the EPA and the DOE
- Contaminants and Remedial Options at Selected Metal-Contaminated Sites (EPA 1995)
- Rules of Thumb for Superfund Remedy Selection (EPA 1997b)

According to the program expectations listed in 40 CFR 300.430(a)(1)(iii)(A-F), EPA generally has the following expectations when appropriate remedial alternatives are developed:

- Use of treatment to address the principal threats posed by a site, wherever practicable.
- Use of engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable.
- Use of a combination of methods, as appropriate, to achieve protection of human health and the environment.
- Use of institutional controls, such as water use and deed restrictions, to supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants.
- Consideration of innovative technology when such technology offers the potential for comparable or superior treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance than demonstrated technologies.
- Return of usable groundwaters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site.

Because of the persistent nature of metals and radionuclides, remediation options are typically limited. Current technologies that apply include immobilization, reclamation and recovery, containment, institutional controls, other onsite treatment, and offsite disposal (EPA 1999). Concentrations of the materials do not warrant the consideration of the reclamation and recovery option, reducing the list to the remaining five options.

7.3 Evaluation of Technologies

Immobilization includes processes that change the physical or chemical properties that affect the leaching characteristics of a treated waste or decrease its bioavailability and concentration. This treatment locks metals within a solidified matrix (solidification) and/or converts the waste constituent into a more immobile form, usually by chemical reaction (stabilization). The process involves mixing a reagent (usually cement kiln dust, proprietary agents, cement, fly ash, blast furnace slag, bitumen) and generally solidifying the material with the contaminated soil. Reagents are selected based on soil characteristics and metal contaminants present. The treatment would be required to be performed *ex-situ* in either onsite or offsite units. Waste minimization is not achieved with this option because of the addition of the stabilization reagents. The literature suggests that the more volatile metals (arsenic and mercury – these metals also are methylated by bacteria and fungi) may continue to migrate out of the completed matrix but at a slower rate than the untreated soil. Vitrification is another immobilization method that uses an electric current to melt soil at extremely high temperatures to solidify the soil/metals mixture. Vitrification is an expensive process and can potentially transfer the more volatile metals (arsenic and mercury) to the atmosphere. Soil mixing, using large augers to mix in the concrete/fly ash mix, also has been used but typically requires additional solidification materials and makes verification of cleanup levels more difficult. Immobilized materials generally are managed in a landfill with the associated containment barriers (e.g., caps). These methods require some type of institutional control to prevent construction or earthwork that could damage the matrix. The institutional controls will involve long-term operation and maintenance costs.

Containment of wastes in place includes vertical and horizontal barriers. This remedial technology can provide sustained isolation of contaminants and can prevent mobilization of soluble compounds over long periods of time. It also reduces surface water infiltration, provides a stable surface over wastes, limits direct contact, and improves aesthetics. Containment is typically handled with the construction of an engineered onsite waste cell. Onsite materials are consolidated and placed in a cell with a clay or synthetic liner. The area is then capped to prevent the migration of precipitation into the cell. Institutional controls are used to prevent damage to the cap. Groundwater monitoring is often required to ensure the integrity of the cap and liner. Long-term operation and maintenance costs are associated with this option.

In addition to the stabilization option, a number of onsite treatment technologies exist for removing metals from soils. Soil acid washing, phytoremediation, and electrokinetic separation have been used with varying degrees of success to remove metals from soils.

Acid extraction involves adding an acid and water mixture to the affected soil. This technique is typically performed in an onsite treatment cell to prevent the migration of material to groundwater. In this process, soils are first screened to remove coarse solids. Hydrochloric acid is then introduced into the soil in the extraction unit. The residence time in the unit varies depending on the soil type, contaminants, and contaminant concentrations but generally ranges between 10 to 40 minutes. The soil-leachate mixture is continuously pumped out of the mixing tank, and the soil and leachate are separated using hydrocyclones. The technique is based on the idea that most metals are cations adsorbed to soil particles (primarily clay) and adding the acid increases the mobility of the metals. The leachate from the process is collected and the metals are extracted. However, the technique is often problematic for metal mixtures that exhibit a variety of solubility behaviors in response to pH (e.g., some forms of arsenic are more mobile at high pH). The treatment cell construction in combination with consumable costs makes this option relatively expensive. Hazards associated with the onsite handling of acids also make this option less attractive. If successful, onsite soils can be cleaned to regulatory requirements, allowing unrestricted use of the property.

Phytoremediation uses vegetation to extract metals from the soils. The vegetation is then harvested and disposed at an approved landfill. The technique has shown promise for several metals, but as with the acid washing technique, varying metal solubilities make the extraction process difficult to predict. Sites have tried using chelating agents such as EDTA to improve metal solubilities only to drive the metals to groundwater. The technique also requires a number of growing seasons before significant decreases in metal concentrations can be observed. While initial costs for this option are relatively low, the long-term nature of the process can be costly. Institutional controls would be needed to limit access to the Site for the duration of the process. The vegetation also can be an ecological risk to local wildlife. The technique provides no initial control of the groundwater pathway and may accelerate the metals migration if the selected vegetation requires irrigation.

Electrokinetic separation relies upon application of a low-intensity direct current through the soil between ceramic electrodes that are divided into a cathode array and an anode array. This mobilizes charged species, causing ions and water to move toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode. The current creates an acid front at the anode and a base front at the cathode. The acid or base front may help to mobilize sorbed metal contaminants for transport to the collection system at the cathode. Limitations of electrokinetic separation include the requirement of soil moisture contents in excess of 10 percent (can be problematic in a semiarid climate), the presence of buried metallic or insulating material can induce variability in the electrical conductivity making the technique ineffective, the heterogeneity of the soil can be problematic – the technique is most effective in clays, and the oxidation/reduction reactions can produce undesirable products such as chlorine gas. Engineering, equipment, and operational costs make this option relatively expensive. Again the technique provides no initial control of the groundwater pathway. If successful, onsite soils potentially can be cleaned to regulatory requirements, allowing unrestricted use of the property.

Offsite disposal involves the excavation, transportation, and disposal of the affected material to an offsite landfill. The material is placed in a licensed landfill that can accept all of the materials contained in the soil. Factors to consider for this option include the risks and costs associated with the transportation of the material. Movement of the material can sometimes make community acceptance more difficult. Determining the feasibility of offsite disposal requires knowledge of land disposal restrictions and other regulations developed by state governments. Transportation costs will increase if specialized landfills are required because they are located farther away than ordinary landfills. Because the impacted soils are already excavated and stockpiled, offsite disposal costs are reduced.

7.4 Generation of Alternatives

After reviewing the remedial action alternatives, a number of technologies were eliminated in the 2004 FS because of questionable effectiveness and implementability or excessive cost. Vitrification was eliminated because of cost and the potential to off-gas volatile metals. Acid extraction was dismissed because of cost and the uncertainty associated with the technique. Movement and use of large quantities of acid also made this option problematic. Phytoremediation was dismissed because of the long-term requirements of the technology and the continued lack of groundwater protection. Electrokinetic separation was eliminated because of cost and the technique uncertainty. Onsite soils are highly heterogeneous and soil moisture is typically low for most of the year.

Even though the impacted Site soils now reside in lined stockpiles, the basis for eliminating alternatives that were eliminated in the 2004 FS remains valid. The main difference in the current state of the impacted soils from the state during preparation of the 2004 FS is that the groundwater pathway has been temporarily interrupted and the volume of impacted soils is more certain. Because the impacted soil now resides in lined stockpiles, some costs associated with the above-discussed options are reduced because the impacted soils are already separated from the unimpacted Site soils. The reduced costs are not, however, sufficient reason to re-evaluate any of the above-discussed options that have been screened out.

Table 7-2 presents the five site-specific alternatives that were developed for the 2004 FS using 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 only issue with these alternatives was they were based on the fundamental assumption that the extent and nature of impacted soils were determined during the 2004 RI. This assumption was demonstrated to be incorrect during the aborted remedial implementation.

Table 7-2
2004 Remedial Action Alternatives

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	Onsite solidification with engineered cap	Yes	Yes
4B	Onsite engineered disposal cell	Yes	Yes
5A	Offsite disposal at solid waste facility	Yes	No
5B	Offsite 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 2004 Remedial Alternative Analysis concluded that in order to reduce the risk and be protective of the environment, community, and groundwater, the most viable alternative was 5B, Offsite Disposal using two waste disposal facilities. After selection of Alternative 5B in the ROD, soil excavation was initiated but was soon halted after it became clear that the nature and extent of the contamination had been underestimated, there was no immediate way to ascertain what the nature and extent was, and the capacity for the contractor to distinguish soil destined for each landfill was not demonstrated. Had this attempt not been halted, over 10,000 cubic yards of the impacted Site soils would have been sent to a specialized waste facility in Idaho at an approximate cost of $10 million, instead of the assumed 500 cubic yards; and none of the impacted Site soil would have gone to the local solid waste landfill, instead of the 9,500 cubic yards assumed in the 2004 RI/FS.

Based on information from this attempt, the Site characterization strategy was revised, and soil segregation was determined to provide more reliable nature and extent information than conventional soil sampling from test pits and borings. The 2006 Site characterization activities were successful and the impacted Site soils were placed in the two lined stockpiles. Remedial action alternatives evaluated for this Feasibility Study are summarized in Table 7-3.

Table 7-3
2007 Remedial Action Alternatives

Alternative	Description	Excavation Required?	Institutional Controls Required?
1	No further action	NA	NA
2A	Leave Stockpile B where it is, install soccer field on top of Stockpile B, ship Stockpile A offsite	No	Yes
2B	Leave both stockpiles where they are, install soccer field on top of both stockpiles	No	Yes
3A	Engineered cap over Stockpile B where it is, ship Stockpile A offsite	Yes	Yes
3B	Engineered cap over both piles where they are	Yes	Yes
4A	Onsite solidification and cap Stockpile B, ship Stockpile A offsite	Yes	Yes
4AA	Onsite solidification and cap both stockpiles	Yes	Yes
4B	Onsite engineered disposal cell for Stockpile B, ship Stockpile A offsite	Yes	Yes
4BB	Onsite engineered disposal cell for both stockpiles	Yes	Yes
5A	Offsite disposal of both stockpiles at one waste facility	Yes	Yes
5B	Offsite disposal of both stockpiles at two waste facilities	Yes	Yes

7.4.1 Remedial Action Alternative Screening

Section 8 of this document provides detailed information concerning each alternative determined to meet the majority of the remedial objectives. This section screens out the alternatives presented in Table 7-3 that do not meet the remedial objectives.

As detailed in Section 7.1, the remedial action objectives can be summarized as being the following.

1) Eliminate or minimize human exposure pathways including
    - Dermal Contact
    - Inhalation
    - Ingestion
    - Radiation
2) Reduce potential future radiation exposure to less than 25 mrem/yr and to less than 100 mrem/yr with the failure of institutional controls
3) Attain 10^{-4} to 10^{-6} acceptable cancer risk level, and less than 1 for hazard quotient index
4) Eliminate or minimize environmental exposure pathways including
    - Groundwater
    - Surface water
    - Dust
    - Biota uptake

These objectives were evaluated for each of the above alternatives to determine if they can be eliminated from further scrutiny or if they sufficiently meet the objectives to be further evaluated. Table 7-4 presents this screening summary for the 2007 preliminary alternatives listed above. The table indicates whether the remedial alternative indicated eliminates or minimizes the pathway indicated.

Table 7-4
Remedial Action Objectives

	Human Exposure					**Environmental Exposure**			
RA	**Dermal**	**Inhalation**	**Ingestion**	**Radiation**	**Radon**	**Ground water**	**Surface water**	**Dust**	**Biota Uptake**
1	N	N	N	N	N	N	N	N	N
2A	Y	Y	Y	N	N	N	N	N	N
2B	Y	Y	Y	N	N	N	N	N	N
3A	Y	Y	Y	Y	N	N	Y	Y	Y
3B	Y	Y	Y	Y	N	N	Y	Y	Y
4A	Y	Y	Y	Y	Y	Y	Y	Y	Y
4AA	Y	Y	Y	Y	Y	Y	Y	Y	Y
4B	Y	Y	Y	Y	Y	Y	Y	Y	Y
4BB	Y	Y	Y	Y	Y	Y	Y	Y	Y
5A	Y	Y	Y	Y	Y	Y	Y	Y	Y
5B	Y	Y	Y	Y	Y	Y	Y	Y	Y

Alternatives 1, 2, and 3 do not meet the remedial action objectives because they to not provide sufficient reduction of risk from each medium and/or pathway of concern for the Site. Therefore, these alternatives are eliminated from further evaluation. One of the primary criteria for remedy selection under CERLCA is protection of human health and the environment. If this criterion is not met, the alternative(s) will not be retained for further consideration. In the description of the FS screening process in EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), it says:

> "Information available at the time of screening should be used primarily to identify and distinguish any differences among the various alternatives and to evaluate each alternative with respect to its effectiveness, implementability, and cost. Only the alternatives judged as the best or most promising on the basis of these evaluation factors should be retained for further consideration and analysis."

Alternatives 2 and 3 are essentially variations on Alternative 1, whereas Alternatives 4 and 5 contain elements that address the protectiveness of human health and the environment. Although Alternative 1 does not meet the remedial action objectives, it is carried through the detailed analysis of alternatives and discussed in Section 8 for comparative purposes.

The remaining alternatives are evaluated further in Section 8. The following sections describe the details of the implementation of each of the remaining options. A detailed analysis of the risks/hazards and compliance with the ARARs is provided in Section 8.

7.4.2 Common Alternative Elements

Elements that are common to all of the RA alternatives (except for Alternative 1 – no-further action) are presented below.

7.4.2.1 Work Plan Preparation

After 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, including onsite handling and loading of the elevated materials, equipment to be used, work/staging areas, and equipment and personnel decontamination areas.
- Confirmatory sampling, analysis, and disposal plans for the elevated material, including sampling methodology, air monitoring, radiation monitoring, equipment and personnel decontamination criteria and procedures, analytical procedures, quality assurance/quality control, and data validation.
- Health and safety plan update, including training and medical monitoring requirements for workers, personal protective equipment, evacuation procedures, emergency response, Site security, access, and organization and responsibility.
- Storm-water pollution prevention plan designed to limit erosion and sediment movement, prevent onsite spills of fuel and other hazardous materials, and prevent offsite migration of affected materials.
- Engineering designs, including, at a minimum, specifications, plans, final configuration of the affected areas, dust suppression, erosion control, backfill, and revegetation.
- 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, including periodic reports detailing Site activities, project schedule, summary of materials handled, health and safety activities, injury/accidents on the Site, and a final report providing the details of the RA and results of confirmatory samples.

7.4.2.2 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 to accommodate work area needs,
- Installation of temporary utilities such as electricity, telephone, etc., as necessary,
- Submittal of CDOT permit application for use of existing U.S. Highway 6 access lane to/from the Site if appropriate, and
- Construction of a storm-water management system (or repairs/upgrades to the existing storm-water management system) including temporary erosion and sedimentation control measures (silt fences, catch basins, etc.).

7.4.2.3 Dust Suppression/Perimeter Air Monitoring

Regardless of the RA alternative selected, dust suppression activities and perimeter air monitoring will be performed. 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/loading activities (water discharge will be carefully controlled to minimize material migration).
- 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.
- Using storm-water best management practices to control stockpiles and prevent offsite migration.
- Using temporary stabilization best management practices during non-operational periods to prevent wind and water erosion.

Fresh water or water collected during storm-water management will be used for dust control on areas containing contaminated soil. Only fresh water will be used on areas that are uncontaminated.

A perimeter air monitoring system will be designed and installed. With the exception of Alternative 1, the system will require electricity (generators or an electric line) around the perimeter of the Site and will consist of low-volume particulate air samplers to monitor radionuclide particulate emissions. Alternative 1 will use a passive, canister-type air monitoring system for gamma and radon measurement.

7.4.2.4 Environmental Covenant

An environmental covenant requiring a radon mitigation system for all structures built on Site is a part of each remedial alternative, except the no-action alternative. The environmental covenants will be implemented for several reasons. The hypothetical radon exposure from background Ra-226, regardless of the selected alternative, exceeds exposure guidelines.

Guidelines require exposures to be limited to less than 25mrem/yr. The background radium concentration of 2.7 pCi/g would produce an exposure of approximately 85 mrem/yr due to radon emanation into residential structures. Additionally, the former pond area was remediated and closed under the UMTRA standard, which is not as low as the standard used for the remainder of the site. Furthermore, residual impacted soils above background concentrations but below DCGLs that remain after excavation, including Alternatives 5A and 5B, will result in doses below 15 mrem/yr under the RESRAD modeling used in the 2004 RI/FS. A re-evaluation of that modeling in 2007 determined, however, that there is a reasonable and more protective alternative method for modeling the radon pathway in a more realistic manner. The 2007 modeling results in a dose of 42 mrem/yr for urban residents under Alternatives 5A and 5B. The environmental covenant will therefore reduce radon exposure to future occupants of the site to less than the required limits of 25 mrem/yr and 15 mrem/yr for the alternatives in the 4 and 5 series, and adds another element for achieving ALARA doses.

7.4.3 Alternative 1 – No-Further Action

Alternative 1 provides a comparative baseline against which other alternatives can be evaluated. The no-action alternative was rejected in the 2004 RI/FS for the in-situ contaminated soils. This conclusion is still valid, as explained in Section 6 of this RI/FS. Although an additional comparative baseline assessment for the no-action is not required, as explained in Section 6, this RI/FS took the extra step of considering the no-further-action alternative for the contaminated soils as found in their *ex-situ* stockpile locations. This demonstrated that some remedial action is still necessary even if the stockpiles were the baseline no-action conditions that are to be used for comparative purposes. Under Alternative 1, the affected soils would remain in the two lined stockpiles without any treatment, additional containment, or mitigating technologies being implemented.

7.4.4 Alternatives 4A and 4AA – Onsite solidification with engineered cap of Stockpile B, with Stockpile A being shipped offsite, or onsite solidification with engineered cap for both stockpiles

Stockpile A is proposed for offsite shipment in Alternative 4A because it may be unacceptable to include it in this onsite option. Both versions of Alternative 4A require soil to be solidified and capped. Alternative 4A would have an offsite component, with Stockpile A being shipped to a specialized waste facility. Alternative 4A involves the consolidation and stabilization of onsite soils using concrete and fly ash. Alternative 4 assumes that the affected onsite material (13,000 cubic yards) will be solidified, placed onsite, and capped. Confirmation sampling has already confirmed all soil above action levels is in the two stockpiles, and limited additional sampling will be performed to ensure both metal and radionuclide limits are achieved beneath the stockpiles.

Alternative 4A would require a pilot test to determine the appropriate mixture of concrete, fly ash, and soil. Additional soil tests, including particle size, Atterberg limits, moisture content, sulfate content, organic content, density, permeability, unconfined compressive strength, leachability, pH, and microstructure analysis would be required to determine the proper mixture. Leachability testing would be performed to determine the degree of contaminant immobilization. No treatability or leachability studies have been completed because it was not cost-effective at this time due to these alternatives being eliminated during the previous RI/FS.

After the proper mixture is determined, stockpiled materials will require segregation by soil type. Some crushing of cobbles may be required. An area at a high enough elevation to remain above groundwater fluctuations will be selected for the final placement of the solidified material. Operational concrete and fly ash will be stockpiled onsite, 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.

Alternative 4AA would require the mixing of Stockpile A with Stockpile B to produce a uniform distribution of activity in the resulting soil pile.

After the solidification of the structure has been confirmed, a clay cap (depth of 3 feet) will be constructed over the structure to limit leaching effects. Assuming a structure depth of 10 feet, a square structure would be about 200 feet on a side. The structure and cap footprint would require institutional controls on about 1 acre of land if one assumes 2:1 slope from the top of the cap. Long-term cap maintenance in the vicinity of the solidified matrix would be required. The remaining property would be available for unrestricted use although a limited groundwater monitoring program currently ongoing would continue to monitor the 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.

Alternative 4A would require Stockpile A (approximately 200 cubic yards) to be shipped to a special waste facility. Other 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 soil containers or large equipment through local neighborhoods.

7.4.5 Alternatives 4B and 4BB – Onsite disposal cell with engineered cap of Stockpile B, with Stockpile A being shipped offsite, or onsite disposal cell with engineered cap for both stockpiles

Stockpile A is proposed for offsite shipment in Alternative 4B because it may be unacceptable to include it in this onsite option. Alternative 4B requires the construction of an engineered disposal cell without solidification. An area above groundwater fluctuations would be selected for the construction of the cell. Allowing a material depth of 10 feet and a 4:1 slope into the cell to allow for equipment movement, the footprint of the cell would be about 1.5 acres. 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 moved from the stockpile(s) and placed in the cell. When all material is relocated to the cell, a clay cap (3 feet deep) will be installed over the material. Again institutional controls would be required for the cell to ensure the integrity of the cap and to monitor groundwater in the vicinity of the cell. Limited groundwater 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 and/or Stockpile A through local neighborhoods.

Alternative 4, solidification and/or containment of the material, allows for residential and other use of the majority of the property because a limited acreage is needed to implement the remedies.

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

Alternative 5 involves the load-out and transportation of the affected material in both stockpiles to an approved landfill. Alternative 5A assumes the material in both stockpiles must be shipped to a special solid waste landfill. Alternative 5B assumes that landfill acceptance criteria will allow Stockpile B to go to a local solid waste landfill, while Stockpile A would go to a special solid waste landfill with extra protections (i.e., a specialized landfill). Both versions of this alternative would require use of the temporary access road to U.S. Highway 6.

Excavated material has already been stockpiled prior to shipping, which will maximize the efficient use of the trucks (eliminates waiting time for trucks). The stockpiled material would be loaded onto trucks with a front-end loader or excavator. Following loading, each truck would be decontaminated as required prior to travel to the appropriate landfill. Each truck would have a capacity of 20 tons or approximately 13.3 cubic yards, assuming a weight of 1.5 tons per cubic yard for affected material. Alternative 5A would require about 977 truckloads (13,000 cubic yards/13.3 cubic yards/truck) to transport the material to the landfill. Alternative 5B would require about 962 truckloads (12,800 cubic yards/13.3 cubic yards/truck) to the local solid waste facility and 15 truckloads (200 cubic yards/13.3 cubic yards/truck) to the specialized waste facility (or shipping site). Estimated transport times were determined assuming the closest solid waste landfill. Foothills Landfill on Colorado Highway 93 is approximately 8 miles north of the Site. Transportation times may increase if other facilities are selected. The various disposal facilities considered for this material are summarized in Table 7-5 below.

During the bagged soil shipping campaign in December 2005, Stoller loaded each truck in 10 to 12 minutes, and transported 114 truckloads in 4 days to Foothills Landfill, with the maximum rate of 38 trucks in one day. A fleet of 7 trucks was used; each truck made about 5 round trips per day, taking 60 to 80 minutes on each round trip.

Assuming soil will take slightly longer to load than bags, we assume it will take 20 minutes to load each truck, and 24 trucks could be loaded during an eight-hour shift. On average, a loaded truck would leave the Site every 20 minutes, and an empty truck would enter the Site (total of 24 inward- and outward-bound trucks per day). An average of 480 tons per day and 2,400 tons per week would be shipped.

Based on an average of 120 trucks per week, Alternatives 5A and 5B would require about 8 weeks to transport the material. Additional time would be required for Site preparation, mobilization, excavation, and demobilization activities.

Upon completion of the offsite disposal and implementation of the environmental covenant, the property would be released for recreational, residential, and other use. Backfill material would be required to bring the Site to a useable elevation to make it safe and for storm-water control.

7.4.7 Disposal Facility Options

Table 7-5 summarizes the various disposal facilities and the associated cost per ton.

Table 7-5
CSMRI Site Disposal Options Summary

Disposal Facility	Transportation Cost	Tipping Fee	Total Cost	Comments
Allied Waste – BFI Foothills Landfill Golden, CO	$10.85/ton	$24.25/ton	$35.10/ton	Transportation cost assumes ½ Clean Harbors Cost/load = $225/load + $68/liner = $293/load. Assumes 18 cy/load, 1.5 tons/cy. Stockpile B soils only. +$5/load, + $50 profile fee
Clean Harbors – Deer Trail Facility Last Chance, CO	$22.88/ton	$150/ton	$172.88/ton	Transportation cost = $550/load + $68/liner = $618/load. Assumes 18 cy/load, 1.5 tons/cy. County suing facility to stop future shipments and remove prior shipments from facility.
Waste Management – CSI Facility, Bennett, CO	NA	NA	NA	County requested facility not take this type of waste, facility complying.
EnviroCare in Utah	$150/ton	$2340/ton	$2490/ton	130 per sq ft = 3510 per yard, 1.5 tons per yd = 2340 per ton.
Midway Landfill in Colorado Springs	NA	NA	NA	Maximum acceptable Ra226 activity = 10 pCi/g
Waste Control Specialist – WCS Facility Andrews, TX	NA	NA	NA	Maximum acceptable Ra226 activity = 20 pCi/g. Could only Accept Pile B – and is too pricey to transport
American Ecology – AEC Facility Grand View, ID	$150/ton	$70/ton	$220/ton	

Based on the information summarized in Table 7-5, it would seem that the most economical facility to dispose of Stockpile A is at Clean Harbors Deer trail Facility and Stockpile B at Allied Waste BFI Foothills Landfill. The Clean Harbors facility, however, is currently involved in a legal dispute that will require a letter of indemnification prior to this soil being disposed of at this facility. Adams County, in which the landfill is located, has filed a lawsuit against Clean Harbors to stop Clean Harbors from accepting materials with radiological impacts like the materials at the CSMRI Site. In addition, the County is asking the Court to order Clean Harbors to remove from the Deer Trail facility all waste with radiological impacts that are currently stored or disposed of at the Deer Trail facility. If Adams County prevails in the lawsuit, which is being opposed by Clean Harbors, there is a reasonable probability that Clean Harbors would have to remove Stockpile A away from the Deer Trail facility to another landfill at considerable cost. Clean Harbors is unwilling at this time to commit to the School to paying for such subsequent removal, and it remains unclear who would have to pay for it. There is too much cost uncertainty to select the Deer Trail facility for disposal facilities for Stockpile A. Therefore, the American Ecology facility in Idaho is selected to screen alternatives with a separate path for Stockpile A.