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FINAL
FEASIBILITY STUDY REPORT ADDENDUM
FOR
OPERABLE UNIT 1
VASQUEZ BOULEVARD/INTERSTATE 70
SUPERFUND SITE
DENVER, COLORADO

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APPROVAL PAGE

This feasibility study addendum has been prepared in accord with USEPA national and regional guidelines and is approved for release without condition.

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12/20/02
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INTRODUCTION

This document presents an addendum to the Feasibility Study (FS) Report for Operable Unit 1 of the Vasquez Boulevard and Interstate 70 (VB/I70) Superfund Site located in the north-central section of Denver, Colorado.

The purpose of the FS is to identify and evaluate a range of remedial alternatives to address predicted unacceptable human health risks associated with potential exposure to contaminated soils and homegrown vegetables in residential yards. The FS Report was finalized in November, 2001. In that report, EPA established preliminary action levels, remedial action objectives, and preliminary remediation goals. Five remedial alternatives were developed and evaluated. The five alternatives were:

- Alternative 1 - No Action
- Alternative 2 – Community Health Program, Tilling/Treatment (Lead), Targeted Removal and Disposal (Arsenic)
- Alternative 3 – Community Health Program, Targeted Removal and Disposal
- Alternative 4 – Community Health Program, Expanded Removal and Disposal
- Alternative 5 – Removal and Disposal

Based on the evaluation of the 5 alternatives in the FS Report, EPA and the Colorado Department of Public Health and Environment (CDPHE) identified Alternative 4 as the preferred alternative giving substantial consideration to the State Acceptance criterion. In May, 2002, EPA issued a proposed plan that summarized the evaluation of alternatives, identified Alternative 4 as the preferred alternative, and requested public comment.

A 60-day public comment period followed the release of the proposed plan. The pubic provided extensive comments on EPA's and CDPHE's preferred alternative. Many who provided comments expressed concern that under Alternative 4, soil with lead levels above EPA OSWER's screening level for lead in soil of 400 mg/Kg (EPA, 1994) would not be removed and replaced. Some were concerned that the EPA regulations under the Toxic Substances and Control Act establish the following lead-based paint hazards (40 CFR Part 745.65): "bare soil on residential real property or on the property of a child-occupied facility that contains total lead equal to or exceeding 400 parts per million in a play area or average of 1,200 parts per million of bare soil in the rest of the yard based on soil samples." The commenters suggested that EPA would not be following its own regulations unless soil was removed from properties in OU1 where lead levels exceed 400 mg/Kg. Some who provided comments expressed concern that soil with arsenic levels above the 70 mg/Kg action level established in 1993 for residential properties at the Asarco Globe site would not be removed and replaced and asked EPA for an explanation of the differences in the levels established for Globe and VB/I-70 as well as other sites.

A remedial alternative that requires soil removal and replacement at yards where the arsenic EPC is greater than 70 mg/Kg or the lead EPC is greater than 400 mg/Kg was not evaluated in the November 2001 FS Report Consequently, EPA, the State, and the community did not have information about how effectively such an alternative meets the nine criteria in the National Contingency Plan (NCP) (40 CFR Part 300).

EPA responded to the public comments on the May 2002 proposed plan by developing and evaluating a new alternative, Alternative 6 that would require soil removal and replacement at yards where the arsenic EPC is greater than 70 mg/Kg or the lead EPC is greater than 400 mg/Kg. These arsenic and lead levels are consistent with the arsenic action level at the Globe site and EPA's screening level for lead in soil (EPA, 1994). The development and evaluation of Alternative 6 will be presented to the State and the community in a new Proposed Plan. EPA will evaluate State acceptance and community acceptance of Alternative 6 once comments are received on the new Proposed Plan.

This addendum to the November 2001 FS Report provides the development and evaluation of the new Alternative 6 against the nine criteria in the NCP. The addendum includes the following new or modified report sections and appendices:

- Executive Summary (revised);
- Section 5.6 – Development of Remedial Alternatives; Alternative 6 Community Health Program, Further Expanded Removal and Disposal (new);
- Section 6.6 – Detailed Analysis of Remedial Alternatives; Alternative 6 Community Health Program, Further Expanded Removal and Disposal (new);
- Section 7.0 – Comparative Analysis (revised);
- Section 8.0 – References (revised);
- Figure 5-2 – Residential Properties with Yard Soils Containing Lea or Arsenic Concentrations Above Action Levels (Alternative 6) (new);
- Appendix B – Detailed Cost Estimates (revised); and
- Appendix C – Management of Risks Associated with Lead and Arsenic in Residential Soils, Vasquez Boulevard/Interstate 70 Superfund Site (revised).

REVISED EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

INTRODUCTION

This document presents the Feasibility Study (FS) for the Off-Facility Soils Operable Unit of the Vasquez Boulevard and Interstate 70 (VB/I70) Superfund Site located in the north-central section of Denver, Colorado. The VB/I70 Site is an Environmental Justice site because the community is predominantly low income and minority and is disproportionately affected by environmental impacts from many sources including industry, other Superfund sites, and major transportation corridors. The purpose of the FS is to identify and evaluate a range of remedial alternatives to address the predicted unacceptable health risks associated with potential exposure to contaminated soils and homegrown vegetables in residential yards. This FS has been prepared in accordance with EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA and consistent with EPA regulations in the National Contingency Plan (NCP) (40 CFR Part 300).

The VB/I70 site covers an area of approximately four square miles in north-central Denver, Colorado. For the purpose of investigation and remedy development, the site has been divided into 3 operable units (OUs). The residential soils evaluated in this report are known as the Off-Facility Soils Operable Unit 1 (OU1) portion of the site. The locations of the former Omaha & Grant Smelter and Argo Smelter are identified as On-Facility Soils OU2 and OU3, respectively. The site is composed of a number of neighborhoods that are largely residential, including Swansea/Elyria, Clayton, Cole, and portions of Globeville. Most residences at the site are single-family dwellings, but there are also some multi-family homes and apartment buildings. There are approximately 4,000 residential properties within the site boundaries. The site also contains a number of schools, parks, and playgrounds, as well as commercial and industrial properties.

The site came to the attention of the U.S. Environmental Protection Agency (USEPA) following studies directed by the Colorado Department of Public Health and Environment (CDPHE) at the nearby Globe Smelter. These studies had identified elevated concentrations of arsenic and/or lead in residential yards within Globeville, and also extending into the Elyria and Swansea neighborhoods.

The USEPA Emergency Response Program conducted two removal assessment-sampling programs, known as Phase I and Phase II, at residential properties within the VB/I70 study area during 1998. The sampling results at 18 properties warranted time critical soil removal based on surface soil concentrations exceeding 450 mg/Kg arsenic or 2,000 mg/Kg lead.

Based on the Phase I and Phase II results, the USEPA determined that residential properties within the VB/I70 site contained soils with arsenic or lead at levels that could present human health concerns over long-term exposures. On this basis, the site was proposed for listing and was added to the National Priorities List (NPL) on July 22, 1999.

SUMMARY OF REMEDIAL INVESTIGATION FINDINGS

A study and two additional investigations were performed between 1998 and 2000 in support of the Baseline Human Health Risk Assessment:

- Physico-Chemical Characterization Study
- Residential Risk Based Sampling Investigation
- Phase III Field Investigation

Data generated from these investigations are reported in the Remedial Investigation (RI) report, which was issued in final form in July 2001. The Baseline Human Health Risk Assessment was also issued in final form in August 2001. Key RI and risk assessment findings with respect to the development of and evaluation remedial alternatives for VB/I70 OU1 are as follows:

- Generally, metals concentrations are highest in the first two inches of soil and decrease with depth.

- Ninety-one percent of the properties contain mean lead concentrations below the EPA screening level for lead in soil of 400 mg/Kg.

- It is estimated that background levels of arsenic are well-characterized as a lognormal distribution with a mean of 8 mg/Kg and a standard deviation of 3.6 mg/Kg. Based on this, background levels may range up to about 15 mg/Kg or slightly higher.

- Lead levels in bulk soils range from below the detection limit (about 52 mg/Kg) up to a maximum of more than 1,000 mg/Kg. If it is assumed that the upper range of lead concentrations resulting from natural and area-wide anthropogenic sources is about 400 mg/Kg, then the mean of all samples that are less than 400 mg/Kg is about 195 mg/Kg.

- There is only a weak correlation between the occurrence of elevated lead and elevated arsenic in soil, suggesting that the main sources of lead and the main sources of arsenic in yard soil are not likely to be the same.

- Some residential properties contain arsenic at concentrations substantially higher than the expected natural levels. Properties with elevated levels of arsenic occur at widely scattered locations across the site with no clear spatial pattern. At an affected property, the contamination appears to be distributed across the yard area, with a fairly clear boundary between the affected property and the adjacent property. The chemical form of arsenic is predominantly arsenic trioxide.

- Lead also occurs at elevated levels in soil at some residential properties. Elevations occur in all neighborhoods of the site, but levels tend to be higher on the western part of the site than the eastern part.

- Lead was detected in paint at most locations where paint was sampled, with 130 out of 144 samples having values above 1 mg/cm^2. These data suggest that interior and/or exterior leaded paint might be a source of lead exposure in area children, either directly (by paint chip ingestion), or indirectly (by ingestion of dust or soil containing paint chips).

- Using EPA's IEUBK model to evaluate the risk to children, it is estimated that about 45% of residences have levels that exceed USEPA's health-based goal (no more than a 5% chance that a child will have a blood lead value above 10 ug/dL). Of these, many (about 71%) have mean lead concentrations lower than 400 ppm (the USEPA screening level for lead in soil). This is mainly because the site-

specific relative bioavailability for lead (84%) is higher than the default value (60%). In order to help determine whether the IEUBK model is yielding reliable predictions at the VB/I70 site, USEPA compared the IEUBK model predictions to actual observations of blood lead levels in the population of children currently living at the site. Even though the available data are from studies that were not designed to support risk assessment, they do support the following

A. Elevated blood lead levels occur in children residing within the site.
B. Soil is not likely to be the main source of elevated blood lead levels.
C. Elevations are not clearly different from areas outside VB/I70.

In order to investigate the uncertainty of the IEUBK model predictions, USEPA performed alternate IEUBK modeling by revising the model parameters using newly published data. Using the most-recent data available on soil intake rates by children measured during a study by Stanek and Calabrese, the IEUBK model predicts that there are no residences where USEPA's health based goal will be exceeded.

- Mean arsenic concentrations in surface soils in schools and parks range from below the method detection limit of 11 mg/Kg to 26 mg/Kg. The mean lead concentrations range from 67 to 256 mg/Kg.

- In some cases, levels of arsenic in yard soil are sufficiently elevated to pose a reasonable maximum exposure (RME) excess lifetime cancer risk above a level of 1E-04. Based on current data, about 3 percent of all properties fall into this category. Monte Carlo modeling performed as part of the uncertainty analysis in the Baseline Human Health Risk Assessment indicates that the RME point estimate is located at or above the 99th percentile of the probability distribution of risk. Non-cancer risks from chronic or sub-chronic RME exposures to arsenic are also above a level of human health concern at some properties. All of these properties are also predicted to have RME cancer risks above 1E-04. 30 properties had arsenic levels that warranted time critical soil removal. These 30 properties were cleaned up by EPA in the fall of 2000.

Screening level calculations suggest that high level intake of soil associated with pica behavior in children might be of acute non-cancer concern at a large number of properties at the site. Because data are so sparse on the actual magnitude and frequency of soil pica behavior, and considering that discussions continue to occur nationally on the most appropriate acute Reference Dose (RfD) for arsenic, it is difficult to judge which (if any) of these properties should be considered to be an authentic acute health risk to children. In this regard, it should be noted that even though many people are exposed to arsenic levels in soils that are predicted to be

> of acute concern, both within the VB/I70 site and elsewhere across the country and around the world, to the best of USEPA's knowledge, there has never been a single case of acute arsenic toxicity reported in humans that was attributable to arsenic in soil. Thus, these results for the acute pica scenario are considered to be especially uncertain, since they predict a very substantial risk for which there is no corroborating medical or epidemiological evidence.

Since the FS Report was released by EPA in November, 2001, a community health study known as the "Kids at Play" (KAP) Health Survey has been performed within the VB/I70 Site by the Colorado Department of Public Health and Environment (CDPHE) and the University of Colorado Health Sciences Center. The study was funded through a grant from the Agency for Toxic Substances and Disease Registry (ATSDR). EPA funded and performed the chemical analysis of biological samples. The door-to-door survey includes: (1) a census of resident children less than 6 years old; (2) a questionnaire about child behaviors related to soil contact; (3) collection of samples for blood lead analysis and urine arsenic analysis. To date, 1340 children have participated in the KAP survey. Preliminary results indicate that less than 3.2% of children tested have blood lead levels greater than 10 micrograms per deciliter (ug/dL) and less than 1% of children tested have initial urinary arsenic levels greater than 30 micrograms per liter (ug/L), a level which ATSDR considers to be within normal levels. Upon repeat sampling no children had urinary arsenic levels greater than 30 ug/L.

REMEDIAL ACTION OBJECTIVES

The overall Remedial Action Objective (RAO) is to protect human health. Based on the findings of the risk assessment, the exposure pathways of concern for residents in VB/I70 OU1 are: incidental ingestion of soil and dust in and about the home and yard; ingestion of home-grown vegetables; and intentional ingestion of large amounts of soil by children who exhibit soil pica behavior. The contaminants of concern are arsenic and lead. EPA developed the following specific RAOs for arsenic and lead in soil at OU1:

RAOs for Arsenic in Soil

A. For residents of the VB/I70 site, prevent exposure to soil containing arsenic in levels predicted to result in an excess lifetime cancer risk associated with ingestion of soil and ingestion of home grown garden vegetables which exceeds 1×10^{-4} using reasonable maximum exposure assumptions.

B. For residents of the VB/I70 site, prevent exposure to soil containing arsenic in levels predicted to result in a chronic or sub-chronic hazard quotient associated with ingestion of soil and ingestion of home grown garden vegetables which exceeds 1 using reasonable maximum exposure assumptions.

C. For children with pica behavior who reside in the VB/I70 site, reduce the potential for exposures to arsenic in soil that result in acute effects.

RAO for Lead in Soil

D. Limit exposure to lead in soil such that no more than 5 percent of young children (72 months or younger) who live within the VB/I70 site are at risk for blood lead levels higher than 10 ug/dL from such exposure.

This objective is consistent with EPA guidance in the Office of Solid Waste and Emergency Response (OSWER) Directive 9355.4-12, that EPA should " ..limit exposure to soil lead levels such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5 percent of exceeding the 10 ug/dL blood lead level."

Preliminary Remediation Goals (PRGs) were established based on the evaluation and findings of the Baseline Human Health Risk Assessment. In accordance with the NCP (40 CFR Part 300), PRGS are the desired endpoint concentrations of lead and arsenic in soils that are protective of human health for the various exposure scenarios. The PRGs help to focus the development of remedial alternatives on technologies that can achieve the goals. At VB/I70 OU1, PRGs were set at background concentrations for both lead and arsenic. Remedial alternatives will be evaluated for how effective they are in achieving the PRGs at those properties where remedial action is warranted.

It is estimated that background levels of arsenic are well-characterized as a lognormal distribution with a mean of 8 mg/Kg and a standard deviation of 3.6 mg/Kg. Based on this, background levels may range up to about 15 mg/Kg or slightly higher. Lifetime cancer risk associated with exposure to background concentrations of arsenic is approximately $1x10^{-5}$, a level within EPA's acceptable risk range. However, the screening level calculations of acute risk associated with soil pica behavior indicate that the acute hazard quotient exceeds 1 under some scenarios even where arsenic is at background levels.

Lead levels in bulk soils range from below the detection limit (about 52 mg/Kg) up to a maximum of more than 1,000 mg/Kg. If it is assumed that the upper range of lead concentrations resulting from natural and area-wide anthropogenic sources is about 400 mg/Kg, then the mean of all samples that are less than 400 mg/Kg is about 195 mg/Kg. This value is considered by EPA to be a rough estimate of the average background concentration of lead in soil at VB/I70 OU1.

In order to identify the specific residential properties for which remedial alternatives will be developed and evaluated, EPA has established Preliminary Action Levels in the FS. These are exposure point concentrations (EPCs) above which some remedial action is warranted. An EPC is a conservative estimate of the mean concentration within an individual yard. These preliminary action levels are: (1) an EPC of 47 mg/Kg arsenic, which is the level at which the Baseline Human Health Risk Assessment predicts the RME acute non-cancer Hazard Quotient is greater than 1 for the Case 2 pica scenario; (2) an EPC of 240 mg/Kg arsenic, which is the level at which the Baseline Human Health Risk Assessment predicts RME lifetime cancer risks exceed 10^{-4}; (3) an EPC of 208 mg/Kg lead, which equates to a less than 5% chance that any child will have a blood lead value above 10 ug/dL based on the IEUBK model adjusted by using site-specific data on the levels of lead in house dust and the relative bioavailability of lead in site soils; and (4) an EPC of 540 mg/Kg lead, which also equates to a less than 5% chance that any child will have a blood lead value above 10 ug/dl based on an alternate IEUBK model run (see Appendix C).

These concentrations equate to the EPCs used in the Baseline Human Health Risk Assessment and any evaluation of concentrations of lead or arsenic in residential yard soils must use the same sampling

methodology as the RI and same evaluation methodology as the risk assessment to provide comparable results.

DEVELOPMENT OF REMEDIAL ALTERNATIVES

Based on site conditions and RAOs, a range of General Response Actions (GRAs) was identified. GRAs are general categories of remedial activities (e.g. no action, institutional controls, containment, etc.) that may be taken, either singly or in combination, to satisfy the requirements of the RAOs. Remedial technologies and process options are more specific applications of the GRAs. Remedial technologies and process options were identified for each GRA and screened in accordance with procedures described in RI/FS guidance. In the first screening step, remedial technologies that have limited or no potential for implementation at the site were eliminated. Remedial technologies and process options that passed the initial screening test were then subjected to a second, more rigorous, screening evaluation of their anticipated effectiveness, potential implementability and relative cost. The remedial technologies and process options that survived the screening were carried forward for consideration in the development of remedial alternatives.

Based on this process, five remedial alternatives were identified as follows:

- Alternative 1 - No Action
- Alternative 2 – Community Health Program, Tilling/Treatment (Lead), Targeted Removal and Disposal (Arsenic)
- Alternative 3 – Community Health Program, Targeted Removal and Disposal
- Alternative 4 – Community Health Program, Expanded Removal and Disposal
- Alternative 5 – Removal and Disposal

Detailed descriptions of the alternatives are provided below.

Alternative 1 - No Action

The no action alternative provides a baseline for the evaluation of other alternatives in accordance with the NCP. No additional protective or remediation measures would be taken for the no-action option. Soils have already been removed from 48 residential properties at the site in Time Critical Removal Actions conducted by EPA in 1998 and 2000.

In general, the no-action alternative may be viable if constituent concentrations are below preliminary action levels. This alternative may also be appropriate for materials or soils which do not pose unacceptable risks to human health or the environment, if implementation of remedial actions would create a greater risk, or if the cost of remediation is excessive when compared to the risk reduction.

Alternative 2 – Community Health Program, Tilling/Treatment (Lead), Targeted Removal and Disposal (Arsenic)

Alternative 2 contains the following principal components:

- Implementation of a community health program.

The community health program alternative for the VBI70 site would be composed of two separate (but partially overlapping) elements. The first element would be designed to address risks to area children from non-soil sources of lead, and to the extent that they exist, risks from lead in un-remediated soils above the preliminary action level of 208 mg/Kg. The second element would be designed to address risks to area children from pica ingestion of arsenic in un-remediated soil above the preliminary action level of 47 mg/Kg. Each of these two main elements of the program is described below. Participation in one or both elements of the program would be strictly voluntary, and there would be no charge to eligible residents and property owners for any of the services offered by the community health program.

PUBLIC HEALTH PROGRAM TO REDUCE RISKS FROM LEAD

The program for reduction of lead risks is intended to be general. That is, it is intended to assess risks from lead from any and all potential sources of exposure, with response actions tailored to address the different types of exposure source that may be identified. The lead program will consist of three main elements:

1) Community and individual education about potential pathways of exposure to lead, and the potential health consequences of excessive lead exposure.

2) A biomonitoring program by which any child (up to 72 months old) may be tested to evaluate actual exposure.

3) A program to respond to any observed lead exposures that are outside the normal range. This will include any necessary follow-up sampling, analysis, and investigation at a child's home to help identify the likely source of exposure, and to implement an appropriate response that will help reduce the exposure.

A key component of the response program is that all potential sources of lead at a property would be sampled, including soil and interior/exterior paint. If soil is judged to be the most likely source of exposure, a series of alternative actions will be evaluated to identify the most effective way to reduce that exposure. These will include a wide range of potential alternatives, including such things as education, sodding or capping of contaminated soil, tilling/treatment, etc. If exterior paint is the source of lead contamination in soil, remediation of the paint may be considered. If the main source of a child's exposure is judged to be non-soil related, responses may include things such as education and counseling, or referral to environmental sampling/response programs offered by other agencies, as appropriate.

PUBLIC HEALTH PROGRAM TO REDUCE RISKS FROM PICA INGESTION OF ARSENIC

Chronic cancer and non-cancer risks from incidental ingestion of arsenic in soil will be addressed by the soil removal/disposal component of this remedial alternative. The public health alternative for arsenic is designed to focus specifically on the potential risks to young children from pica behavior. The program for arsenic will consist of three main elements:

1) Community and individual education about identification and potential hazards of pica behavior and the potential health consequences of excessive acute oral exposure to arsenic and to soil.

2) A biomonitoring program by which any child may be tested to evaluate actual soil pica exposure to arsenic.

3) A program to respond to any observed inorganic arsenic exposures that are outside the normal range. This will include any necessary follow-up sampling, analysis, and investigation at a child's home to help identify the likely source of exposure, and to implement an appropriate response that will help reduce the exposure.

- In yards with arsenic EPCs equal to or greater than 240 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead at or below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 113 residential properties within the entire site.

- In yards with lead EPCs greater than 540 mg/Kg, surface soils would be tilled to a depth of 6 inches and treated with phosphate. Pre-remediation yard features would then be restored. Based on RI data, it is estimated that this would occur at a total of 89 residential properties at the site (it is estimated that 8 of the properties with lead EPCs above 540 mg/Kg also have arsenic EPCs above 240 mg/Kg and would therefore be remediated by soil removal).

- To date, EPA has sampled the soil at approximately 75% of the residential properties within the VBI70 site boundary. Because the spatial pattern of lead and arsenic contamination is variable between properties, it is not possible to assess potential risks at a specific property without data from that property. Therefore, upon request from the owner or current resident (if access is granted by the owner), EPA will provide a program of on-going testing for lead and arsenic in soil at any residential property within the site boundaries that has not already been adequately tested. If the lead EPC exceeds 540 mg/Kg and the arsenic EPC is below 240 mg/Kg, soil at the property would be tilled and treated with phosphate. If the arsenic EPC equals or exceeds 240 mg/Kg, soil would be removed and disposed offsite. This sampling program will operate for as the on-site construction of the remedy is occurring.

Alternative 3 – Community Health Program, Targeted Removal and Disposal

Alternative 3 contains the following principal components:

- Implementation of a community health program, identical to the one described for Alternative 2, except that future response actions on soils would entail removal and offsite disposal.

- In yards with arsenic EPCs equal to or greater than 240 mg/Kg or with lead EPCs above 540 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead at or below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 202 residential properties (105 properties for arsenic only, 8 for both arsenic and lead, and 89 for lead only).

- Implementation of a sampling program identical to the one described under Alternative 2. Under this alternative, at properties with lead EPCs greater than 540 mg/Kg or with arsenic EPCs equal to or greater than 240 mg/Kg, soil would be removed and disposed offsite.

Alternative 4 – Community Health Program, Expanded Removal and Disposal

Alternative 4 contains the following principal components:

- Implementation of a community health program, identical to the one described for Alternative 3.

- In yards with arsenic EPCs greater than 128 mg/Kg or with lead EPCs above 540 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead at or below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 403 residential properties (306 properties for arsenic only, 31 for both arsenic and lead, and 66 for lead only).

- Implementation of a sampling program identical to the one described under Alternative 2. Under this alternative, at properties with lead EPCs greater than 540 mg/Kg or with arsenic EPCs greater than 128 mg/Kg, soil would be removed and disposed offsite.

Alternative 4 was developed and evaluated at the request of CDPHE . Specifically, CDPHE requested that EPA develop alternatives that would protect residents from cancer risks greater than a range of 3×10^{-5} to 8×10^{-5} to be consistent with cleanup objectives at the adjacent Asarco Globe site. Information from the Public Health Evaluation for the Asarco Globe site (CDPHE, 1989) and the Record of Decision for the Asarco Globe Site (CDPHE, 1993) indicates that the arsenic action level of 70 mg/Kg established for residential properties at the Globe site was associated with a cancer risk of 8×10^{-5} estimated using less protective exposure assumptions than those used at VB/I-70 OU1 (e.g., 250 days /year of exposure versus 350 days/year assumed at VB/I70 and lower soil ingestion rates for children). When exposure assumptions consistent with those used at the VB/I-70 site are used, the cancer risk associated with 70 mg/Kg at the Globe site is estimated to be 2×10^{-4} Nevertheless, EPA complied with CDPHE's request and developed Alternative 4 which requires soil removal at an arsenic EPC of 128 mg/Kg corresponding to a point estimate risk level of 8×10^{-5} based on the findings of the Baseline Human Health Risk Assessment for OU1. This is a more protective risk level than that provided at the Globe site.

Alternative 5 – Removal and Disposal

Alternative 5 contains the following principal components:

- In yards with arsenic EPCs greater than 47 mg/Kg or with lead EPCs above 208 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead below PRGs, and pre-remediation yard features restored.

This alternative would also include sampling of properties that were not sampled during the RI with soil removal at properties where lead or arsenic exceed the preliminary action levels. It is estimated that soil removal would be required at a total of 2,122 residential properties.

The 5 remedial alternatives were evaluated against the nine criteria in the NCP. Based on this analysis, EPA and CDPHE identified Alternative 4 as the preferred alternative, giving substantial consideration to the State Acceptance criterion. In May, 2002, EPA issued a proposed plan that summarized the evaluation of alternatives, identified Alternative 4 as the preferred alternative, and requested public comment.

A 60-day public comment period followed the release of the proposed plan. The pubic provided extensive comments on EPA's and CDPHE's preferred alternative. Many who provided comments expressed concern that under Alternative 4, soil with lead levels above EPA OSWER's screening level for lead in soil of 400 mg/Kg (EPA, 1994) would not be removed and replaced. Some were concerned that the EPA regulations under the Toxic Substances and Control Act establish the following lead-based paint hazards (40 CFR Part 745.65): "bare soil on residential real property or on the property of a child-occupied facility that contains total lead equal to or exceeding 400 parts per million in a play area or average of 1,200 parts per million of bare soil in the rest of the yard based on soil samples". The commenters suggested that EPA would not be following its own regulations unless soil was removed from properties in OU1 where lead levels exceed 400 mg/Kg. Some who provided comments expressed concern that soil with arsenic levels above the 70 mg/Kg action level established in 1993 for residential properties at the Asarco Globe site would not be removed and replaced and asked EPA for an explanation of the differences in the levels established for Globe and VB/I-70 as well as other sites.

A remedial alternative that requires soil removal and replacement at yards where the arsenic EPC is greater than 70 mg/Kg or the lead EPC is greater than 400 mg/Kg was not evaluated in the November 2001 FS Report. Consequently, EPA, the State, and the community did not have information about how effectively such an alternative meets the nine criteria in the National Contingency Plan (40 CFR Part 300)

EPA responded to the public comments on the May 2002 proposed plan by developing and evaluating a new alternative, Alternative 6 that would require soil removal and replacement at yards where the arsenic EPC is greater than 70 mg/Kg or the lead EPC is greater than 400 mg/Kg. These arsenic and lead levels are consistent with the arsenic action level at the Globe site and EPA's screening level for lead in soil (EPA, 1994). The development and evaluation of Alternative 6 will be presented to the State and the community in a new Proposed Plan. EPA will evaluate State acceptance and community acceptance of Alternative 6 once comments are received on the new Proposed Plan.

Alternative 6 – Community Health Program, Further Expanded Removal and Disposal

Alternative 6 contains the following principal components:

- Implementation of a community health program, identical to the one described for Alternatives 3 and 4.

- In yards with arsenic EPCs greater than 70 mg/Kg or with lead EPCs above 400 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead at or below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 853 residential properties (508 properties for arsenic only, 108 for both arsenic and lead, and 237 for lead only).

- Implementation of a sampling program identical to the one described under Alternative 2. Under this alternative, at properties with lead EPCs greater than 400 mg/Kg or with arsenic EPCs greater than 70 mg/Kg, soil would be removed and disposed offsite.

COMPARATIVE ANALYSIS OF ALTERNATIVES

The 6 remedial alternatives were evaluated against the threshold and balancing criteria specified in the NCP and FS Guidance to ensure that the selected remedial alternative will: protect human health and the environment; comply with or include a waiver of Applicable or Relevant and Appropriate requirements (ARARs); be cost-effective; utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and address the statutory preference for treatment as a principal element. The modifying criteria of State and Community acceptance will be addressed by the USEPA after a new Proposed Plan is released, public comment period is completed, consideration is given to all comments, and prior to the finalization of the Record of Decision.

The nine evaluation criteria specified in the National Contingency Plan (NCP) are:

- Threshold Criteria
  - Overall Protection of Human Health and the Environment
  - Compliance with ARARs

- Primary Balancing Criteria
  - Short-Term Effectiveness
  - Long-Term Effectiveness and Permanence

- Reduction of Toxicity, Mobility and Volume Through Treatment
- Implementability
- Cost

- Modifying Criteria
  - State Acceptance
  - Community Acceptance

Detailed analyses were performed for each alternative, applying each of the threshold and primary balancing criteria. The remedial alternatives were also evaluated comparatively, relative to one another, within each criterion.

The No Action Alternative is not evaluated in the comparative analysis, but is considered as the baseline condition. The Baseline Human Health Risk Assessment indicates that no further action would be effective in preventing exposures to arsenic in soil above a $1x10^{-4}$ lifetime cancer risk, a chronic hazard quotient greater than 1, or a sub-chronic hazard quotient greater than 1 for residents who have average or central tendency exposures. However, if no further action is taken at the site, screening level calculations suggest that high rates of soil intake associated with soil pica behavior in children might result in doses of arsenic which exceed an acute hazard quotient of 1, even for the central tendency pica exposure scenario. Also, no further action would not meet the RAOs for arsenic since they are established to be protective of RME exposures.

For lead, the probability of elevated blood lead levels predicted by the IEUBK Model provides the basis for EPA's evaluation of the No Action Alternative. When the IEUBK model is run using recently published data on soil ingestion rates for children (Stanek & Calabrese, 2000), the site-specific relative bioavailability and site-specific soil/dust ratio adjustments, it predicts that no further action is necessary to achieve the RAO for lead in soil. When the IEUBK model is run using default assumptions for all parameters except the site-specific relative bioavailability and soil/dust ratio, it predicts that no further action would <u>not</u> be effective in achieving the RAO for lead in soil. The range of results reflects the uncertainty in using the IEUBK Model to predict whether further action is required to achieve the RAO for lead at the site

In order to help determine whether the IEUBK model is yielding reliable predictions at the VB/I70 site, USEPA compared the IEUBK model predictions to actual observations of blood lead levels in the population of children currently living at the site. Even though the available data are from studies that were not designed to support risk assessment, they do support the following:

A. Elevated blood lead levels occur in children residing within the site.
B. Soil is not likely to be the main source of elevated blood lead levels.
C. Elevations are not clearly different from areas outside VB/I70.

New information from the KAP Health Survey indicates that of the approximately 1340 children that have participated, preliminary results indicate that less than 3.2% of children tested have blood lead levels greater than 10 ug/dL . The data on blood lead levels in children residing in OU1 suggest that the No Action Alternative may be effective in meeting the RAO for lead in soil as predicted by the IEUBK Model run with recently published data on soil ingestion rates for children, the site-specific relative bioavailability, and the site-specific soil/dust ratio.

A summary of the comparative analysis is provided below.

Overall Protection of Human Health

There is not a large difference between each of the 6 alternatives in overall protection of human health. However, the highest level of overall protection of human health (as measured by how well the RAOS will be met and short-term effectiveness) would be achieved by Alternative 3.

In Alternative 3, removal and offsite disposal of yard soils with arsenic EPCs at or above 240 mg/Kg or lead EPCs greater than 540 mg/Kg would be effective in preventing exposure to these soils, which are of the greatest concern with respect to human health risk. This would effectively achieve the first 2 RAOs for arsenic in soil and the RAO for lead in soil. Implementation of a community health program would be effective in achieving the third RAO for arsenic in soil and the RAO for lead in soil by addressing the risks of exposure to non-soil sources of lead and the risks from soil pica behavior through the components education, biomonitoring, source sampling and analysis, and response actions as necessary.

The community health program would provide additional protection for the community, because it would provide the mechanism for evaluating other sources of lead (such as lead paint) that may be the sources of elevated blood lead levels in the children residing in VB/I70, and for addressing soil pica behavior which may be associated with other risks in addition to the risk of acute arsenic exposure. Even if there were no detectable arsenic or lead in soil, soil pica behavior may lead to development of significant gastrointestinal disturbances and/or blockages, abdominal pain, parasitic infection, and iron deficiency. The community health program would include strategies to reduce soil pica behavior within the population of children living in VB/I70 Reduction in soil pica behavior would reduce the risk of these other health effects. Alternative 3 would also minimize short-term risks.

Alternative 2 may provide a similar level of protection compared to Alternative 3, but there is some uncertainty associated with the tilling/treatment component to address soils with lead EPCs above 540 mg/Kg. Uncertainties are associated with the effect of tilling on surface soil concentrations. This is because concentration profiles were not generated with depth or in different yard locations for the target properties, and therefore the resultant lead concentrations in surface soil after tilling are difficult to predict Also, the effectiveness of phosphate treatment is uncertain. This is because site-specific testing would be required to determine the chemical form and application rate necessary to achieve the preliminary remediation goals for lead in soil; this would lead to a delay of at least a year in implementing this portion of the remedy.

Alternative 4 differs from Alternative 3 by adding soil removal from properties with arsenic concentrations greater than 128 mg/Kg. This alternative was developed and evaluated at the request of CDPHE (see Appendix D). Specifically, CDPHE requested that EPA develop alternatives that would protect residents from cancer risks greater than a range of 3×10^{-5} to 8×10^{-5} to be consistent with cleanup objectives at the adjacent Asarco Globe site. Based on the findings of the Baseline Human Health Risk Assessment, an arsenic EPC of 128 mg/Kg corresponds to a point estimate risk level of 8×10^{-5}.

Under Alternative 4, remedial action would be taken at approximately 200 properties where predicted RME cancer risks are within EPA's acceptable risk range and where the first 2 RAOs for arsenic in soil are currently being met. In addition, the predicted point estimate is at the 99th percentile of the risk

distribution for the exposed population, indicating that there is a 99% probability that the true risks are lower than the estimated risks and the combination of exposure assumptions for OU1 characterizes exposures that are very likely not occurring at the VB/I70 site. Thus, it is not necessary to take remedial action at properties where risks within EPA's acceptable risk range in order to be protective at the VB/I-70 site OU1.

The first and second RAOs for arsenic in soil are consistent with the guidance set out in the OSWER Directive 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions". In part, this guidance states that "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less that 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action is not warranted unless there are adverse environmental impacts." The directive further states that consideration of uncertainties in the baseline risk assessment may lead a risk manager to decide that risks lower than 10^{-4} are unacceptable, triggering the need for remedial action. EPA considered the uncertainty in the arsenic risk calculations for VB/I70 to determine whether remedial action is needed at properties where risks are predicted to be less than or equal to 10^{-4}. The uncertainty analysis in the Baseline Human Health Risk Assessment indicates that actual risks are much more likely to be lower than the calculated point estimates of risks. Providing protection at the 1×10^{-4} risk level based on the point estimates of risk (the first RAO for arsenic in soil) is likely to provide a level of protectiveness for the RME scenario in the range of 2×10^{-5} to 7×10^{-5}. Therefore, it is not necessary to perform soil removals where arsenic EPCs are lower than 240 mg/Kg in order to achieve protectiveness in the range requested by CDPHE for the RME scenario.

To the extent that there may be unacceptable health risks associated with exposure to soil with arsenic EPCs below 240 mg/Kg and lead EPCs below 540 mg/Kg, Alternative 5 would provide the highest level of long-term protection because soils with arsenic and lead levels above 47 mg/Kg and 208 mg/kg respectively would be removed. However, the following information from the baseline risk assessment indicates that below 240 mg/Kg arsenic and 540 mg/Kg lead, soil is <u>not</u> a major source of exposure and risk in OU1.

For arsenic, potential unacceptable health risk where arsenic EPCs are below 240 mg/Kg is associated with soil pica behavior. Screening level calculations suggest that removing and replacing soil

below 240 mg/Kg will not effectively protect children from the risk of acute effects since under at least one set of assumptions, the acute HQ is greater than 1 at background levels of arsenic. Also, children with soil pica behavior are at risk of experiencing other health risks unrelated to arsenic that will not be addressed by removing and replacing soil.

In the case of lead, it is likely that other, non-soil sources of lead exist in VB/I-70 that would not be identified under Alternative 5. Evidence from other studies indicates that unless the non-soil sources are addressed, removing more soil will not be more protective. The USEPA sponsored a study in urban areas of Baltimore, Boston and Cincinnati to investigate the efficacy of soil and dust abatement techniques in reducing blood lead values in children (USEPA 1995). Because of the study design, this investigation is usually referred to as the "three cities study". Among the key findings of this study was the conclusion that:

"... soil abatement alone will have little or no effect on reducing exposure to lead unless there is a substantial amount of lead in soil and unless this lead is the primary source of lead in house dust"

The report did not rigorously define "substantial", but it was only when soil lead levels were higher than 1,000 to 2,000 mg/Kg that a benefit from soil remediation was detectible. Conversely, in two cities where soil lead levels were mainly less than 1,000 mg/Kg, no substantial decrease in blood leads could be detected following soil remediation. As noted earlier, 99% of all properties tested in Phase III at the VB/I70 site have soil lead concentrations below 700 mg/Kg, with only three properties being above 1,000 mg/Kg. Also recall that, at the VB/I70 site, available data indicate that only about 34% of the mass of interior dust appears to be derived from yard soil. Thus, it appears that neither of the two conditions needed for soil removal to be effective is likely to apply at most properties at the VB/I70 site.

Evaluation of overall protection must also consider that the extensive removals under Alternative 5 would entail the greatest amount of short-term risks to the community compared to all the other alternatives due to the presence and operation of heavy equipment and the greater number of truck trips required to dispose excavated soil offsite and to transport clean fill to the site. Another short-term impact to the community is the impact of the additional water use required to establish grass at remediated properties. Colorado is experiencing drought conditions and water use is restricted in the City of Denver. EPA

estimates that Alternative 5 will require 10 times more water to implement than Alternatives 2 or 3, and 5 times more water than Alternative 4.

Alternative 6 differs from Alternatives 2, 3, and 4 by adding soil removal from properties with arsenic EPCs greater than 70 mg/kg and/or lead EPCs greater than 400 mg/kg. This alternative was developed and evaluated in response to comments received on the May 2002 Proposed Plan. Those comments requested an explanation of why EPA was not considering removing soil from properties where arsenic exceeds 70 mg/Kg as was done at the Asarco Globe site and where lead exceeds 400 mg/Kg to be consistent with EPA's screening level for lead in soil.

Based on the findings of the Baseline Human Health Risk Assessment, an arsenic EPC of 70 mg/Kg corresponds to a point estimate risk level of 5×10^{-5}. However, there is a range of soil EPCs associated with this same point estimate of RME cancer risk. That range of soil EPCs is 60 mg/Kg to 76 mg/kg. Therefore, some properties with the same estimated risk levels (i.e. with arsenic EPCs above 60 mg/kg, but below 70 mg/kg) would not undergo soil removal under this alternative.

To the extent that there may be unacceptable health risks associated with exposure to soil with arsenic EPCs below 240 mg/Kg and lead EPCs below 540 mg/Kg, Alternative 6 would provide a higher level of long-term protection when compared to Alternatives 2,3 and 4 because soils with arsenic and lead levels above 47 mg/Kg and 208 mg/kg respectively would be removed. However, as discussed in the evaluation of Alternative 5, available information indicates that below 240 mg/Kg arsenic and 540 mg/Kg lead, soil is <u>not</u> a major source of exposure and risk in OU1.

Under Alternative 6, remedial action would be taken at 400 properties where predicted RME cancer risks are within EPA's <u>acceptable</u> risk range. In addition, the predicted risks are at the 99th percentile of the risk distribution for the exposed population indicating that the combination of exposure assumptions used for OU1 characterizes exposures that are very likely not occurring at the site.

The first and second RAOs for arsenic in soil are consistent with guidance set out in the OSWER Directive 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions". In

part, this guidance states that "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less that 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action is not warranted unless there are adverse environmental impacts." The directive further states that consideration of uncertainties in the baseline risk assessment may lead a risk manager to decide that risks lower than 10^{-4} are unacceptable, triggering the need for remedial action. EPA considered the uncertainty in the arsenic risk calculations for VB/I70 to determine whether remedial action is needed at properties where risks are predicted to be less than or equal to 10^{-4}. The uncertainty analysis in the Baseline Human Health Risk Assessment indicates that actual risks are much more likely to be lower than the calculated point estimates of risks.

Providing protection at the 1×10^{-4} risk level based on the point estimate of risk (as in Alternatives 2 and 3) is likely to provide a level of protectiveness for the RME scenario in the range of 2×10^{-5} to 7×10^{-5}. Therefore, it is not necessary to perform soil removals where arsenic EPCs exceed 70 mg/Kg in order to achieve protectiveness for the RME scenario.

EPA performed additional quantitative uncertainty analysis for Alternative 6 using Monte Carlo techniques consistent with those in the Baseline Human Health Risk Assessment. The analysis indicates that at an arsenic EPC of 70 mg/kg, the point estimate of cancer risk is 5×10^{-5} and the 90th – 95th percentile cancer risk (the range of RME risks) is 1×10^{-5} to 4×10^{-5}, not a significant reduction in RME cancer risks when compared to Alternative 3 (where the range is 2×10^{-5} to 7×10^{-5}), yet the short-term risks associated with Alternative 6 are higher.

For lead, Alternative 6 would require soil removal from properties with lead EPCs lower than Alternatives 3 and 4 (400 mg/kg, compared to 540 mg/kg). As described above, alternatives with soil removal actions at 540 mg/kg lead are expected to be effective in achieving the RAO for lead in soil. Therefore removal of additional soil with lead EPCs between 400 mg/kg and 540 mg/kg would not contribute significantly to meeting the RAO. Since the FS was prepared, the community health study known as the KAP survey has been performed within the VB/I70 site. CDPHE and the University of Colorado Health Sciences Center have been awarded a grant from ATSDR to conduct the KAP health

survey. The door-to-door survey includes (1) a census to count resident children less than 6 years old, (2) completion of questionnaires about child behaviors related to soil contact and (3) collection of blood samples for lead analysis and urine samples for arsenic analysis. EPA is performing the chemical analyses of these biological samples. Approximately 1,340 children participated in the survey. Preliminary results of the survey indicate that RAO for lead in soil is currently being met within the site. This provides further evidence that reducing the action level for soil removal for lead from 540 mg/kg to 400 mg/kg is not necessary to achieve the RAO for lead in soil.

Evaluation of overall protection must also consider that the additional removals under Alternative 6 would entail greater short-term risks to the community compared to Alternatives 2,3, and 4 due to the presence and operation of heavy equipment and the greater number of truck trips required to dispose excavated soil offsite and to transport clean fill to the site. Another short-term impact to the community is the impact of the additional water use required to establish grass at remediated properties. Colorado is experiencing drought conditions and water use is restricted in the City of Denver. EPA estimates that Alternative 6 will require 4 times more water to implement than Alternatives 2 or 3 and twice as much water as Alternative 4.

Compliance with Applicable or Relevant and Appropriate Requirements

All of the remedial alternatives evaluated in the comparative analysis would be expected to comply with ARARs. ARARs relating to the generation of fugitive dust and lead concentrations in ambient air would be applicable to the range of engineering actions under evaluation. Although the potential exists for dust generation during soil tilling and excavation, and transport and backfilling activities, engineering controls would be readily implementable and effective to achieving compliance with the applicable regulations. ARARs relating to the characterization, transport and disposal of solid wastes would be applicable for excavated soils and would be met by standard construction and transportation practices.

In response to the public comments concerning lead based paint hazards established by EPA under the Toxic Substances and Control Act (TSCA) (40 CFR Part 745.65), EPA concluded that these

regulations are not ARARs for OU1. However, Alternatives 2,3,4,5,and 6 are consistent with the TSCA regulations. The preamble to the regulations includes an explanation of the relationship of the TSCA soil standards to Superfund soil cleanup standards. The preamble states in part that the Superfund program "relies on the IEUBK model for relating environmental levels to blood lead levels in children The OSWER soil lead guidance (EPA, 1994) recommends that the IEUBK Model be applied to utilize site-specific information that can be very important in evaluating the risks at Superfund sites". The preamble also states that "Site-specific information at Superfund sites would provide a basis to identify a soil lead level different from the level identified in the TSCA rule that would be protective of health". Therefore, establishing that Superfund remedial action is required at properties in VB/I70 where the lead EPC is different from the 400 mg/Kg or 1200 mg/Kg identified in the TSCA rule (as in Alternatives 2, 3, 4, and 5) is consistent with the rule.

Short-Term Effectiveness

Alternative 3 provides the highest level of short-term effectiveness. Soil removal actions could be quickly and effectively implemented with less risk to workers or the community than Alternatives 4,5, and 6. Implementation of the community health program would be effective in the short term due to the components of education, biomonitoring, soil sampling and analysis, and response actions when warranted

Consistent with the NCP (40 CFR Part 300), the evaluation of short-term effectiveness also considered the environmental impacts of soil removal actions, specifically water use required to establish grass cover in remediated yards. Since the publication of the FS Report in November, 2001, the State of Colorado has experienced a drought. The severity of the drought is illustrated by the fact that the City of Denver has placed a complete ban on lawn watering beginning October 1, 2002.

Watering of replacement lawns and plants is a critical component of soil removal actions. Soil removal actions within the adjacent Globeville neighborhood required an estimated 9.35 gallons of water to establish one square foot of replacement sod (Asarco, 1997). An average yard in VB/I70 has an estimated 5,200 square foot area of soil (EPA, 2001). Assuming that 70% of the soil area is sod, approximately

50,000 gallons of water would be required to establish sod at a typical property. Based on these assumptions, Alternative 3 would require 10 million gallons of water to implement.

Alternative 2 could be implemented with less risk to workers and the community than Alternatives 3,4,5, and 6. However, Alternative 2 provides a slightly lower level of short-term effectiveness than Alternative 3, primarily because tilling/treatment actions would be delayed while treatability testing was performed and because there would be some uncertainties with the immediate effectiveness of the tilling/treatment activities due to lack of data on lead concentrations with depth and at different locations in the targeted yards. Alternative 2 would require an amount of water equal to that required under Alternative 3.

Alternative 4 provides a slightly lower level of short-term effectives than Alternative 3, primarily because additional removals at properties with arsenic EPCs greater than 128 mg/Kg would entail greater risks to the community due to the operation of heavy equipment in residential areas over a longer period of time and to truck traffic associated with transportation of excavated soil offsite and import of clean backfill through neighborhood streets. Alternative 4 would require an estimated 20 million gallons of water to implement. This is twice as much water as estimated would be required by Alternatives 2 and 3. Yet the additional removals would not contribute to additional long-term protection of human health as set out by the requirements of the RAOs.

Alternative 6 provides a lower level of short-term effectiveness than Alternative 4, primarily because additional removals at properties with arsenic EPCs greater than 70 mg/Kg and with lead EPCs greater than 400 mg/Kg would entail greater risks to the community due to the operation of heavy equipment in residential areas over a longer period of time and to truck traffic associated with transportation of a larger volume of excavated soil offsite and import of clean backfill through neighborhood streets. Alternative 6 would require an estimated 43 million gallons of water to implement. This is 4 times as much water as estimated would be required by Alternatives 2 and 3. However, additional long-term protection of human health as set out by the requirements of the RAOs would not be enjoyed since the requirements of the RAOs would be met by Alternatives 2,3, and 4.

Alternative 5 would provide the lowest level of short-term effectiveness because of increased risks to workers and the community due to the prolonged operation of heavy equipment in the residential areas. There would also be increased risk to the community from truck traffic associated with transportation of the largest volume of excavated soil offsite and import of clean backfill (approximately 43,000 truck trips would be required). Alternative 5 would require an estimated 106 million gallons of water to implement. This is 10 times as much water as estimated would be required by Alternatives 2 and 3. However, additional long term protection of human health as set out by the requirements of the RAOs would not be enjoyed since the requirements of the RAOS would be met by Alternatives 2,3 and 4. An additional consideration is that Alternative 5 does not include a Community Health Program component and so it is highly uncertain that it would be effective in achieving the third RAO for arsenic in soil.

Long-Term Effectiveness and Permanence

To the extent that unacceptable health risks are associated with exposure to soil with arsenic EPCs below 240 mg/Kg and lead EPCs below 540 mg/Kg, Alternative 5 would provide the highest level of long-term protection and permanence because soils would be removed where arsenic or lead levels are above 47 mg/Kg or 208 mg/kg respectively. However, available information from the baseline risk assessment and other EPA studies indicates that below 240 mg/Kg arsenic and 540 mg/Kg lead, soil is not a major source of exposure and risk at OU1. The information is summarized below.

For arsenic, potential health risk where arsenic EPCs are below 240 mg/kg is associated with soil pica behavior. Screening level calculations suggest that removing and replacing soil below 240 mg/Kg will not effectively protect children from the risk of acute effects since under at least one set of assumptions, the acute HQ is greater than 1 at background levels of arsenic. Also, children with soil pica behavior are at risk of experiencing other health risks unrelated to arsenic that will not be addressed by removing and replacing soil. In the case of lead , Alternative 5 may not provide the highest overall protection since, in OU1, it is likely that there are other, non-soil sources of lead (such as lead-based paint), which would not be evaluated and addressed. Alternatives 2,3, 4, and 6 would provide an equal level of long-term effectiveness by addressing soils with lead or arsenic EPCs above preliminary action levels of 240 mg/Kg arsenic and 540 mg/kg lead by tilling and treatment and/or removal. The benefit of Alternatives 2,3,4, and 6 is that risks associated with non-soil sources of lead and with soil pica behavior would be effectively addressed by implementation of a community health program under these alternatives. The additional benefit of the

community health program is it would provide the community a mechanism to identify sources of lead exposure other than soils, and a means of addressing them (e.g., through lead paint abatement). Abatement of exterior lead-paint would be performed under this program if soils at a property are remediated and paint abatement is required to protect the remedy. Abatement of exterior paint may be accomplished by referral to another program if soils do not require remediation. The Community Health Program would also provide a program to reduce the likelihood of soil pica behavior in children within VB/I70. Every lead paint abatement, whether accomplished directly or indirectly under the Community Health Program, is a permanent solution to a non-soil source of lead exposures. Alternative 2 would provide slightly less long-term effectiveness when compared to Alternative 3 since the effectiveness of tilling and treatment is less certain than soil removal.

Reduction of Toxicity, Mobility or Volume Through Treatment

Alternatives 3, 4, 5 and 6 do not contain a treatment component and therefore Alternative 2 would result in the highest reduction of toxicity and mobility due to treatment. However, there are uncertainties with the treatment process and site-specific testing would have to be performed to evaluate the chemical form and application rate of phosphate and to evaluate the overall treatment effectiveness once implemented.

Implementability

Alternatives 3, 4, 5 and 6 would be readily implementable with standard equipment and services, and adequate personnel would be readily available for this type of work. The construction technologies required to implement these alternatives are commonly used and widely accepted. For Alternative 2, tilling of residential soils may be difficult to implement. Areas of accessible soils within yards are relatively small and typically have features such as trees or large shrubs, which would make access and implementation of deep tilling difficult unless the features were removed and replaced. It is likely that due to access constraints tilling would have to be performed using rototillers, which typically have a working depth of about 6 inches. Lead concentrations with depth have not been generated for the target properties and if deeper tilling is found to be necessary to meet the RAOs it would be difficult to implement.

Cost

Estimated costs for each alternative considered in the comparative analysis are shown below. These costs include direct and indirect capital costs and review costs for 30 years (there are no operation and maintenance costs associated with any of the alternatives).

Remedial Alternative	Net Present Worth Cost (Millions)
Alternative 2	10.6
Alternative 3	11.1
Alternative 4	17.5
Alternative 5	61.0 (1)
Alternative 6	31.1

Note. (1) Of this amount, approximately $15.6 million is associated with remediation of properties with arsenic EPCs above 47 mg/Kg but below 128 mg/Kg.

All alternatives meet the threshold requirements of protection of human health and compliance with ARARs. Alternative 3 provides a greater level of overall certainty for protecting human health compared to Alternative 2 and entails lower costs and lower short-term risks than Alternatives 4, 5, and 6.

NEW SECTION 5.6 – DEVELOPMENT OF REMEDIAL ALTERNATIVES; ALTERNATIVE 6 COMMUNITY HEALTH PROGRAM, FURTHER EXPANDED REMOVAL AND DISPOSAL

5.6 Alternative 6 – Community Health Program, Further Expanded Removal and Disposal

Alternative 6 was developed in response to comments received on the May 2002 Proposed Plan. Alternative 6 contains the following principal components:

Implementation of a Community Health Program

Implementation of a community health program identical to the one described for Alternative 3.

Soil Removal

In yards with arsenic EPCs greater than 70 mg/Kg or with lead EPCs above 400 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead at or below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 853 residential properties (508 properties for arsenic only, 108 for both arsenic and lead, and 237 for lead only).

On-Going Soil Sampling Program

Identical to the program described under Alternative 2, upon request from the owner or current resident (if access is granted by the owner), EPA will provide a program of on-going testing for lead and arsenic in soil at any residential property within the site boundaries that has not already been adequately tested. Under Alternative 6, if the lead EPC exceeds 400 mg/Kg or the arsenic EPC exceeds 70 mg/Kg, soil would be removed and disposed offsite at an appropriate facility. This sampling program will operate for as long as the on site construction of the remedy is occurring.

New Section 6.6 – Detailed Analysis of Remedial Alternatives; Alternative 6 Community Health Program, Further Expanded Removal and Disposal

6.6 Alternative 6 – Community Health Program, Further Expanded Removal and Disposal

Alternative 6 contains the following principal components:

- Implementation of a community health program offered primarily to children at residences where yard soil EPCs exceed 47 mg/Kg arsenic and/or 208 mg/Kg lead, but available to any child that resides in the VB/I70 site.

- In yards with arsenic EPCs greater than 70 mg/Kg or with lead EPCs above 400 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 853 residential properties (508 properties for arsenic only, 108 for both lead and arsenic and 237 for lead).

- Upon request from the owner or current resident (if access is granted by the owner), soil will be sampled and tested for lead and arsenic at any residential property within the site boundaries that has not already been adequately tested. If the level of lead exceeds 400 mg/Kg or the level of arsenic exceeds 70 mg/Kg, soil will be removed and disposed offsite.

6.6.1. Overall Protection of Human Health

Alternative 6 would meet the requirements of the RAOs and therefore be protective of human health.

Removal and offsite disposal of yard soils with arsenic EPCs above 70 mg/Kg or lead greater than 400 mg/Kg would be effective in preventing exposure to these soils and would achieve RAOs A and B for arsenic in soil and would achieve RAO D for lead in soil. For properties where engineering actions were not taken, but which have lead or arsenic EPCs above preliminary action levels of 47 mg/Kg arsenic (established based on acute non-cancer effects) and 208 mg lead (established based on an IEUBK Model prediction), implementation of a community health program would be effective in addressing risks related to non-soil sources of lead and risks related to soil pica behavior. The effectiveness would be achieved due to the components of education, biomonitoring, soil sampling and analysis and response actions when warranted.

Alternative 6 therefore would achieve RAO C for arsenic in soil and RAO D for lead in soil when combining the community health program with the soil removal/disposal component. As discussed in Appendix A, educational interventions have been effective in reducing children's blood-lead concentrations, either alone or in combination with dust control programs. These interventions have also been effective in reducing residential dust-lead loadings, a potential non-soil source of exposure to lead. No information was located on the efficacy of education programs intended to reduce pica behavior in children. However, there are many examples of public education programs intended to make people aware of the potential health risks of certain behaviors (smoking, drinking, use of drugs, unprotected sex, etc) and to prevent or change the behavior. Some of these programs are aimed at parental monitoring and intervention in behaviors that are hazardous in their children (depression, drug use, etc). Based on successes of these parental and other programs, it is expected that a program aimed at reduction of soil pica behavior in the population of children living in OU1 would be effective in achieving RAO C for arsenic in soil since the risk is associated with a particular behavior. Biomonitoring, soil sampling and analysis, and response actions would add certainty in achieving RAOs C and D. The community health program would moreover provide an additional public health benefit to the community since reducing soil pica behavior will likely address health risks other than those associated with potential exposure to arsenic. Soil pica behavior is not healthy for children as it may lead to the development of significant gastrointestinal disturbances and/or blockages, abdominal pain, parasitic infection and iron deficiency.

6.6.2 Compliance with ARARs

ARARs relating to the generation of fugitive dust and lead concentrations in ambient air would be applicable to actions performed to implement Alternative 6. Although the potential exists for dust generation during soil excavation, transport and backfilling activities, engineering controls would be readily implementable and effective to achieving compliance with the applicable regulations. ARARs relating to the characterization, transport and disposal of solid wastes would be applicable and would be met by standard construction and transportation practices. Alternative 6 would therefore meet the requirements of all ARARs.

In response to the public comments concerning lead based paint hazards established by EPA under the Toxic Substances and Control Act (TSCA) (40 CFR Part 745.65), EPA concluded

that these regulations are not ARARs for OU1. The preamble to the regulations includes an explanation of the relationship of the TSCA soil standards to Superfund soil cleanup standards. The preamble states in part that the Superfund program "relies on the IEUBK model for relating environmental levels to blood lead levels in children. The OSWER soil lead guidance (EPA, 1994) recommends that the IEUBK Model be applied to utilize site-specific information that can be very important in evaluating the risks at Superfund sites". The preamble also states "Site-specific information at Superfund sites would provide a basis to identify a soil lead level different from the level identified in the TSCA rule that would be protective of health". Therefore it is not necessary to require Superfund remedial action at properties in VB/I70 where the lead EPC is 400 mg/Kg or 1200 mg/Kg to be consistent with the TSCA rule.

6.6.3. Short-Term Effectiveness

Short-term risks would be posed to the community and workers during the implementation of this alternative due to the operation of heavy equipment in the residential areas and by truck traffic associated with transportation of excavated soil offsite and import of clean backfill. As a screening level estimate, a total of approximately 17,000 semi-truck trips would be needed to transport the excavated soil to the disposal facility and to transport the clean backfill soil to the site (about 170,000 cubic yards of excavated soil and 170,000 cubic yards of backfill transported in 20 cubic yard capacity trucks). The injury and fatality rates for accidents involving large trucks in 1997 (most recent data available) were 50.7 per 100 million vehicle miles driven and 2.5 per 100 million vehicle miles driven, respectively. Assuming a transport distance of 15 miles to both the disposal facility and to the backfill source, application of the 1997 statistics estimates that there would be a 25 percent probability that one of the trucks would be involved in an accident that injures someone and a 1.3 percent chance of a fatality. It is noted that use of these statistics in this type of screening-level evaluation likely overestimates the actual risks at the VB/I70 site because the probabilities are based on vehicle miles driven, which includes all weather conditions. The risks would be reduced at VB/I70 by following a transportation plan and performing transportation during the summer construction period only.

Consistent with the NCP (40 CFR Part 300), the evaluation of short-term effectiveness also considers the environmental impacts of soil removal actions, specifically water use required to establish grass cover in remediated yards. Since the publication of the FS Report in November 2001, the State of Colorado has experienced a drought. The severity of the drought condition is

illustrated by the fact that the City of Denver has placed a complete ban on lawn watering beginning October 1, 2002.

Watering of replacement lawns and plants is a critical component of soil removal actions. Soil removal actions within the adjacent Globeville neighborhood required an estimated 9.35 gallons of water to establish one square foot of replacement sod (Asarco, 1997). An average yard in VB/I70 has an estimated 5,200 square foot area of soil (Washington Group, 2001). Assuming that 70% of the soil area is sod, approximately 50,000 gallons of water would be required to establish sod at a typical property. Based on these assumptions, Alternative 6 will require an estimated 43 million gallons of water to implement.

Implementation of the community health program would be effective in the short term in addressing the risks related to non-soil sources of lead and soil pica behavior due to the combination of components of education, biomonitoring, soil sampling and analysis, and response actions when warranted. As discussed in Appendix A, educational interventions have been effective in reducing children's blood-lead concentrations, either alone or in combination with dust control programs. These interventions have also been effective in reducing residential dust-lead loadings, a potential source of exposure to lead. The addition of biomonitoring, soil sampling and analysis, and response will increase the effectiveness of the community health program at the VB/I70 site. No published studies were located regarding a program to reduce human exposure to arsenic associated with soil pica behavior through a public health type program. However, it is expected that the types of programs that are successful in reducing lead exposure via soil or dust will also be successful in reducing exposure to arsenic in soil at the VB/I70 site, especially if education is tailored to the prevention of soil pica behavior.

6.6.4 Long-Term Effectiveness and Permanence

Based on the findings of the Baseline Human Health Risk Assessment, an arsenic EPC of 70 mg/Kg corresponds to a point estimate risk level of 5×10^{-5}. However, there is a range of soil EPCs associated with this same point estimate of RME cancer risk. That range of soil EPCs is 60 mg/Kg to 76 mg/kg. Therefore, some properties with the same estimated risk levels (i.e. with arsenic EPCs above 60 mg/kg, but below 70 mg/kg) would not undergo soil removal under this alternative.

To the extent that there may be unacceptable health risks associated with exposure to soil with arsenic EPCs below 240 mg/Kg and lead EPCs below 540 mg/Kg, Alternative 6 would provide a high level of long-term protection because soils with arsenic and lead levels above 70 mg/Kg and 400 mg/kg respectively would be removed. However, information from the baseline risk assessment and other EPA studies indicates that below 240 mg/Kg arsenic and 540 mg/Kg lead, soil is not a major source of exposure and risk in OU1.

Under Alternative 6, remedial action would be taken at 400 properties where predicted RME cancer risks are within EPA's acceptable risk range. In addition, the predicted point estimate of risk risks is at the 99th percentile of the risk distribution for the exposed population indicating that there is a 99% probability that the true risks are lower than the estimated risks and the combination of exposure assumptions used for OU1 characterizes exposures that are very likely not occurring at the site.

The first and second RAOs for arsenic in soil are consistent with the guidance set out in the OSWER Directive 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions". In part, this guidance states, "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less that 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action is not warranted unless there are adverse environmental impacts." The directive further states that consideration of uncertainties in the baseline risk assessment may lead a risk manager to decide that risks lower than 10^{-4} are unacceptable, triggering the need for remedial action. EPA considered the uncertainty in the arsenic risk calculations for VB/I70 to determine whether remedial action is needed at properties where risks are predicted to be less than or equal to 10^{-4}. The uncertainty analysis in the Baseline Human Health Risk Assessment indicates that actual risks are much more likely to be lower than the calculated point estimates of risks.

Providing protection at the 1×10^{-4} risk level based on the point estimates of risk (by achieving the first RAO for arsenic in soil) likely will provide a level of protectiveness for the RME scenario in the range of 2×10^{-5} to 7×10^{-5}. Therefore, it is not necessary to perform soil removals where arsenic EPCs exceed 70 mg/Kg but are lower than 240 mg/Kg in order to achieve protectiveness for the RME scenario.

EPA performed additional quantitative uncertainty analysis for Alternative 6 using Monte Carlo techniques consistent with those in the Baseline Human Health Risk Assessment. The analysis indicates that, at an arsenic EPC of 70 mg/kg, the point estimate of cancer risk is 5×10^{-5} and the 90th – 95th percentile cancer risk (the range of RME risks) is 1×10^{-5} to 4×10^{-5}.

For lead, Alternative 6 would require soil removal from properties with lead EPCs greater than 400 mg/Kg. Since the FS was prepared, the community health study known as the KAP survey has been performed within the VB/I70 site. CDPHE and the University of Colorado Health Sciences Center have been awarded a grant from ATSDR to conduct the KAP survey. The door-to-door survey includes (1) a census to count resident children less than 6 years old, (2)a questionnaire about child behaviors related to soil contact and (3) collection of samples for blood lead analysis and urine arsenic analysis. EPA is performing the chemical analyses of these biological samples. Approximately 1,340 children participated in the survey. Preliminary results indicate that less than 3.2% of the children tested have blood lead levels greater than 10 ug/dL. These preliminary results of the survey indicate that the RAO for lead in soil is currently being met within the site. This provides further evidence that requiring soil removal at properties where the lead EPC exceeds 400 mg/kg but is less than 540 mg/Kg is not necessary to achieve the RAO for lead in soil.

The community health program would be effective in addressing risk associated with non-soil sources of lead and risk associated with soil pica behavior through education, biomonitoring, and environmental sampling and response programs. The additional benefit of the community health program is it would provide the community a mechanism to identify sources of lead exposure other than soils, and a means of addressing them (e.g., through lead paint abatement). Abatement of exterior lead-paint would be performed under this program if soils at a property are remediated and paint abatement is required to protect the remedy. Abatement of exterior paint may be accomplished by referral to another program if soils do not require remediation. The community health program would also provide a program to reduce the likelihood of soil pica behavior in children within VB/I70. Every lead paint abatement, whether accomplished directly or indirectly under the Community Health Program, is a permanent solution to a non-soil source of lead exposures.

6.6.5. Reduction of Toxicity, Mobility or Volume Through Treatment

Alternative 6 does not include a treatment component to reduce toxicity, mobility or volume of contaminated soil.

6.6.6. Implementability

The removal/disposal component of Alternative 6 would be implementable with standard equipment and services, and adequate personnel would be readily available for this type of work. The construction technologies required to implement this alternative are commonly used and widely accepted. Numerous similar projects of comparable and larger scale have been implemented across the Region and in Denver. Soil removal and replacement is a reliable technology and no future remedial actions would be required because soils of concern would be removed from the site.

The community health program would be readily implementable. From a technical perspective, these types of programs are commonly implemented, both at Superfund sites and at sites with lead paint in residential areas. The would also be readily implementable from an administrative perspective as funding would be available and there are established community organizations, such as neighborhood associations and environmental coalitions that could assist in the distribution of materials. Also, State and local City and County agencies have lead awareness and intervention programs already in place. The addition of arsenic testing and development of educational programs specific to soil pica behavior would be easily added to the current local lead programs since the organizational structure is in place.

6.6.7. Cost

The present net worth cost for Alternative 6 is approximately $31.1 million. Detailed information on the unit rates, quantities and assumptions used in the development of the costs are presented in Appendix B.

REVISED SECTION 7, COMPARATIVE ANALYSIS

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents a comparative analysis of the remedial alternatives developed for the residential soils of VB/I70 OU1. The purpose of this analysis is to compare the advantages and disadvantages of each remedial alternative brought forth in the detailed analysis against the threshold and balancing criteria presented in Section 6.0. The comparison focuses on the significant areas of difference, especially identification of any alternative that is clearly superior in meeting a criterion.

The No Action Alternative is not evaluated in the comparative analysis, but is considered as the baseline condition. The Baseline Human Health Risk Assessment indicates that no further action would be effective in preventing exposures to arsenic in soil above a $1x10^{-4}$ lifetime cancer risk, a chronic hazard greater than 1, or a sub-chronic hazard quotient greater than 1 for residents who have average or central tendency exposures. However, if no further action is taken at the site, screening level calculations suggest that high rates of soil intake associated with soil pica behavior in children might result in doses of arsenic that exceed an acute hazard quotient of 1, even for the central tendency pica exposure scenario. Also, no further action would not meet the RAOs for arsenic since they are established to be protective of RME exposures.

For lead, the probability of elevated blood lead levels predicted by the IEUBK Model provides the basis for EPA's evaluation of the No Action Alternative. When the IEUBK model is run using recently published data on soil ingestion rates for children (Stanek & Calabrese, 2000), the site-specific relative bioavailability and site-specific soil/dust ratio adjustments, it predicts that no further action is necessary to achieve the RAO for lead. When the IEUBK model is run using default assumptions for all parameters except the site-specific relative bioavailability and soil/dust ratio, it predicts that no further action would <u>not</u> be effective in achieving the RAO for lead in soil. The range of results reflects the uncertainty in using the IEUBK Model to predict whether further action is required to achieve the RAO for lead at the site.

In order to help determine whether the IEUBK model is yielding reliable predictions at the VB/I70 site, USEPA compared the IEUBK model predictions to actual observations of blood lead levels in the population of children currently living at the site. Even though the available data are from studies that were not designed to support risk assessment, they do support the following:

A. Elevated blood lead levels occur in children residing within the site.
B. Soil is not likely to be the main source of elevated blood lead levels.

C. Elevations are not clearly different from areas outside VB/I70.

Recently available preliminary results from the KAP Survey indicate that of the approximately 1340 children that have participated in the KAP survey, less than 3.2% of children tested have blood lead levels greater than 10 ug/dL. The data on blood lead levels in children residing in OU1 suggest that the No Action Alternative may be effective in meeting the RAO for lead in soil as predicted by the IEUBK Model run with recently published data on soil ingestion rates for children, the site-specific relative bioavailability, and the site-specific soil/dust ratio.

The first stage of the analysis, presented in Section 7.1, summarizes and comparatively analyzes each alternative's achievement of the threshold criteria of overall protectiveness and compliance with ARARs, as required by the NCP. The second stage of the analysis involves a discussion of the relative advantages and disadvantages of the alternatives with respect to the five primary balancing criteria under the NCP, and is discussed in Section 7.2. A summary of the comparative analysis is presented in Table 7-1.

The modifying criteria of State and Community acceptance will be addressed by the USEPA after a new Proposed Plan is released, public comment period is completed, consideration is given to all comments, and prior to the finalization of the Record of Decision.

7.1 Threshold Criteria Analysis

7.1.1. Overall Protection of Human Health

There is not a large difference between each of the 6 alternatives in overall protection of human health. However, the highest level of overall protection of human health (as measured by how well the RAOS will be met and short-term effectiveness) would be achieved by Alternative 3.

In Alternative 3, removal and offsite disposal of yard soils with arsenic EPCs at or above 240 mg/Kg or lead EPCs greater than 540 mg/Kg would be effective in preventing exposure to these soils, which are of the greatest concern with respect to human health risk. This would effectively achieve the first 2 RAOs for arsenic in soil and the RAO for lead in soil. Implementation of a community health program would be effective in achieving the third RAO for arsenic in soil and the RAO for lead in soil by addressing the risks of exposure to non-soil sources of lead and the risks from soil pica behavior through the components of education, biomonitoring, source sampling and analysis, and response actions as

necessary. The community health program would provide additional protection for the community, because it would provide the mechanism for evaluating other sources of lead (such as lead paint) that may cause exposures in the future, and for addressing soil pica behavior that may be associated with other risks in addition to the risk of acute arsenic exposure. Even if there were no detectable arsenic or lead in soil, soil pica behavior may lead to development of significant gastrointestinal disturbances and/or blockages, abdominal pain, parasitic infection, and iron deficiency. The community health program would include strategies to reduce soil pica behavior within the population of children living in VB/I70. Reduction in soil pica behavior would reduce the risk of these other health effects. Alternative 3 would also minimize short-term risks.

Alternative 2 may provide a similar level of protection compared to Alternative 3, but there is some uncertainty associated with the tilling/treatment component to address soils with lead EPCs above 540 mg/Kg. Uncertainties are associated with the effect of tilling on surface soil concentrations. This is because concentration profiles were not generated with depth or in different yard locations for the target properties, and therefore the resultant lead concentrations in surface soil after tilling are difficult to predict. Also, the effectiveness of phosphate treatment is uncertain. This is because site-specific testing would be required to determine the chemical form and application rate necessary to achieve the preliminary remediation goals for lead in soil; this would lead to a delay of at least a year in implementing this portion of the remedy.

Alternative 4 differs from Alternative 3 by adding soil removal from properties with arsenic concentrations greater than 128 mg/Kg. This alternative was developed and evaluated at the request of CDPHE (see Appendix D). Specifically, CDPHE requested that EPA develop alternatives that would protect residents from cancer risks greater than a range of 3×10^{-5} to 8×10^{-5} to be consistent with cleanup objectives at the adjacent Asarco Globe site. Based on the findings of the Baseline Human Health Risk Assessment, an arsenic EPC of 128 mg/Kg corresponds to a point estimate risk level of 8×10^{-5}.

Under Alternative 4, remedial action would be taken at approximately 200 properties where predicted RME cancer risks are within EPA's acceptable risk range and where the first 2 RAOs for arsenic in soil are currently being met. In addition, the predicted point estimate risks is at the 99th percentile of the risk distribution for the exposed population, indicating that there is a 99% probability that the true risks are lower than the estimated risks and the combination of exposure assumptions for OU1 characterizes exposures that are very likely not occurring at the VB/I70 site. Thus, it is not

necessary to take remedial action at properties where risks within EPA's acceptable risk range (as in Alternative 4) in order to be protective at the VB/I-70 site OU1.

The first and second RAOs for arsenic in soil are consistent with guidance set out in the OSWER Directive 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions". In part, this guidance states, "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less that 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action is not warranted unless there are adverse environmental impacts." The directive further states that consideration of uncertainties in the baseline risk assessment may lead a risk manager to decide that risks lower than 10^{-4} are unacceptable, triggering the need for remedial action. EPA considered the uncertainty in the arsenic risk calculations for VB/I70 to determine whether remedial action is needed at properties where risks are predicted to be less than or equal to 10^{-4}. The uncertainty analysis in the Baseline Human Health Risk Assessment indicates that actual risks are much more likely to be lower than the calculated point estimates of risks. Providing protection at the 1×10^{-4} risk level based on the point estimates of risk (the first RAO for arsenic in soil) is likely to provide a level of protectiveness for the RME scenario in the range of 2×10^{-5} to 7×10^{-5}. Therefore, it is not necessary to perform soil removals where arsenic EPCs are lower than 240 mg/Kg in order to achieve protectiveness in the range requested by CDPHE for the RME scenario.

To the extent that there may be unacceptable health risks associated with exposure to soil with arsenic EPCs below 240 mg/Kg and lead EPCs below 540 mg/Kg, Alternative 5 would provide the highest level of long-term protection because soils with arsenic and lead levels above 47 mg/Kg and 208 mg/kg respectively would be removed. However, the following information from the baseline risk assessment and other EPA studies indicates that below 240 mg/Kg arsenic and 540 mg/Kg lead, soil is <u>not</u> a major source of exposure and risk in OU1.

For arsenic, potential unacceptable health risk where arsenic EPCs are below 240 mg/Kg is associated with soil pica behavior. Screening level calculations suggest that removing and replacing soil below 240 mg/Kg will not effectively protect children from the risk of acute effects since under at least one set of assumptions, the acute HQ is greater than 1 at background levels of arsenic. Also, children with soil pica behavior are at risk of experiencing other health risks unrelated to arsenic that will not be addressed by removing and replacing soil.

In the case of lead, it is likely that other, non-soil sources of lead exist in VB/I-70 that would not be identified under Alternative 5. Evidence from other studies indicates that unless the non-soil sources are addressed, removing more soil will not be more protective. The USEPA sponsored a study in urban areas of Baltimore, Boston and Cincinnati to investigate the efficacy of soil and dust abatement techniques in reducing blood lead values in children (USEPA 1995). Because of the study design, this investigation is usually referred to as the "three cities study". Among the key findings of this study was the conclusion that:

"... soil abatement alone will have little or no effect on reducing exposure to lead unless there is a substantial amount of lead in soil and unless this lead is the primary source of lead in house dust"

The report did not rigorously define "substantial", but it was only when soil lead levels were higher than 1,000 to 2,000 mg/Kg that a benefit from soil remediation was detectible. Conversely, in two cities where soil lead levels were mainly less than 1,000 mg/Kg, no substantial decrease in blood leads could be detected following soil remediation. As noted earlier, 99% of all properties tested in Phase III at the VB/I70 site have soil lead concentrations below 700 mg/Kg, with only three properties being above 1,000 mg/Kg. Also recall that, at the VB/I70 site, available data indicate that only about 34% of the mass of interior dust appears to be derived from yard soil. Thus, it appears that neither of the two conditions needed for soil removal to be effective is likely to apply at most properties at the VB/I70 site.

Evaluation of overall protection must also consider that the extensive removals under Alternative 5 would entail the greatest amount of short-term risks to the community compared to all the other alternatives due to the presence and operation of heavy equipment and the greater number of truck trips required to dispose excavated soil offsite and to transport clean fill to the site. Another short-term impact to the community is the impact of the additional water use required to establish grass at remediated properties. Colorado is experiencing drought conditions and water use is restricted in the City of Denver. EPA estimates that Alternative 5 will require 10 times more water to implement than Alternatives 2 or 3, and 5 times more water than Alternative 4.

Alternative 6 differs from Alternatives 2, 3, and 4 by adding soil removal from properties with arsenic EPCs greater than 70 mg/kg and/or lead EPCs greater than 400 mg/kg. This alternative was developed and evaluated in response to comments received on the May 2002 Proposed Plan. Those comments requested an explanation of why EPA was not considering removing soil from properties

where arsenic exceeds 70 mg/Kg as was done at the Asarco Globe site and where lead exceeds 400 mg/Kg to be consistent with EPA's screening level for lead in soil.

Based on the findings of the Baseline Human Health Risk Assessment, an arsenic EPC of 70 mg/Kg corresponds to a point estimate risk level of 5×10^{-5}. However, there is a range of soil EPCs associated with this same point estimate of RME cancer risk. That range of soil EPCs is 60 mg/Kg to 76 mg/kg. Therefore, some properties with the same estimated risk levels (i.e. with arsenic EPCs above 60 mg/kg, but below 70 mg/kg) would not undergo soil removal under this alternative.

To the extent that there may be unacceptable health risks associated with exposure to soil with arsenic EPCs below 240 mg/Kg and lead EPCs below 540 mg/Kg, Alternative 6 would provide a higher level of long-term protection when compared to Alternatives 2,3 and 4 because soils with arsenic and lead levels above 70 mg/Kg and 400 mg/kg respectively would be removed. However, as discussed in the evaluation of Alternative 5, available information from the baseline risk assessment and other EPA studies indicates that below 240 mg/Kg arsenic and 540 mg/Kg lead, soil is not a major source of exposure and risk in OU1.

Under Alternative 6, remedial action would be taken at 400 properties where predicted RME cancer risks are within EPA's acceptable risk range. In addition, the predicted point estimate is at the 99th percentile of the risk distribution for the exposed population indicating that there is a 99% probability that the true risks are lower than the estimated risks and the combination of exposure assumptions used for OU1 characterizes exposures that are very likely not occurring at the site.

The first and second RAOs for arsenic in soil are consistent with the guidance set out in the OSWER Directive 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions". In part, this guidance states that "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less that 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action is not warranted unless there are adverse environmental impacts." The directive further states that consideration of uncertainties in the baseline risk assessment may lead a risk manager to decide that risks lower than 10^{-4} are unacceptable, triggering the need for remedial action. EPA considered the uncertainty in the arsenic risk calculations for VB/I70 to determine whether remedial action is needed at properties where risks are predicted to be less than or equal to 10^{-4}. The uncertainty analysis in the Baseline Human Health Risk Assessment indicates that actual risks are much more likely to be lower than the calculated point estimates of risks.

Providing protection at the 1×10^{-4} risk level based on the point estimates of risk (as in Alternatives 2 and 3) is likely to provide a level of protectiveness for the RME scenario in the range of 2×10^{-5} to 7×10^{-5}. Therefore, it is not necessary to perform soil removals where arsenic EPCs exceed 70 mg/Kg but are lower than 240 mg/Kg in order to achieve protectiveness for the RME scenario.

EPA performed additional quantitative uncertainty analysis for Alternative 6 using Monte Carlo techniques consistent with those in the Baseline Human Health Risk Assessment. The analysis indicates that, at an arsenic EPC of 70 mg/kg, the point estimate of cancer risk is 5×10^{-5} and the 90th – 95th percentile cancer risk (the range of RME risks) is 1×10^{-5} to 4×10^{-5}, not a significant reduction in RME cancer risks when compared to Alternative 3 (where the range is 2×10^{-5} to 7×10^{-5}), yet the short-term risks associated with Alternative 6 are higher.

For lead, Alternative 6 would require soil removal from properties with lead EPCs lower than Alternatives 3 and 4 (400 mg/kg, compared to 540 mg/kg). As described above, alternatives with soil removal actions at 540 mg/kg lead are expected to be effective in achieving the RAO for lead in soil. Therefore removal of additional soil with lead EPCs between 400 mg/kg and 540 mg/kg would not contribute significantly to meeting the RAO. Since the FS was prepared, the community health study known as the KAP survey has been performed within the VB/I70 site. CDPHE and the University of Colorado Health Sciences Center have been awarded a grant from ATSDR to conduct the study. The door-to-door survey includes (1) a census to count resident children less than 6 years old, (2) a questionnaire about child behaviors related to soil contact and (3) collection of samples for blood lead analysis and urine arsenic analysis. EPA is performing the chemical analyses of these biological samples. Approximately 1340 children participated in the survey. Preliminary results of the survey indicate that RAO for lead in soil is currently being met within the site. This provides further evidence that reducing the action level for soil removal for lead from 540 mg/kg to 400 mg/kg is not necessary to achieve the RAO for lead in soil.

Evaluation of overall protection must also consider that the additional removals under Alternative 6 would entail greater short-term risks to the community compared to Alternatives 2,3, and 4 due to the presence and operation of heavy equipment and the greater number of truck trips required to dispose excavated soil offsite and to transport clean fill to the site. Another short-term impact to the community is the impact of the additional water use required to establish grass at remediated properties. Colorado is experiencing drought conditions and water use is restricted in the City of Denver. EPA estimates that

Alternative 6 will require 4 times more water to implement than Alternatives 2 or 3 and twice as much water as Alternative 4.

7.1.2. Compliance with Applicable or Relevant and Appropriate Requirements

All of the remedial alternatives evaluated in the comparative analysis would be expected to comply with ARARs. ARARs relating to the generation of fugitive dust and lead concentrations in ambient air would be applicable to the range of engineering actions under evaluation. Although the potential exists for dust generation during soil tilling and excavation, and transport and backfilling activities, engineering controls would be readily implementable and effective to achieving compliance with the applicable regulations. ARARs relating to the characterization, transport and disposal of solid wastes would be applicable for excavated soils and would be met by standard construction and transportation practices.

In response to the public comments concerning lead based paint hazards established by EPA under the Toxic Substances and Control Act (TSCA) (40 CFR Part 745.65), EPA concluded that these regulations are not ARARs for OU1. However, Alternatives 2,3,4,5,and 6 are consistent with the TSCA regulations. The preamble to the regulations includes an explanation of the relationship of the TSCA soil standards to Superfund soil cleanup standards. The preamble states in part that the Superfund program "relies on the IEUBK model for relating environmental levels to blood lead levels in children. The OSWER soil lead guidance (EPA, 1994) recommends that the IEUBK Model be applied to utilize site-specific information that can be very important in evaluating the risks at Superfund sites". The preamble also states, "Site-specific information at Superfund sites would provide a basis to identify a soil lead level different from the level identified in the TSCA rule that would be protective of health". Therefore, establishing that Superfund remedial action is required at properties in VB/I70 where the lead EPC is different from the 400 mg/Kg or 1200 mg/Kg identified in the TSCA rule (as in Alternatives 2, 3, 4, and 5) is consistent with the rule.

7.2 Primary Balancing Criteria Analysis

7.2.1 Short-Term Effectiveness

Alternative 3 provides the highest level of short-term effectiveness. Soil removal actions could be quickly and effectively implemented with less risk to workers or the community than Alternatives 4, 5,

and 6. Implementation of the community health program would be effective in the short term due to the components of education, biomonitoring, soil sampling and analysis, and response actions when warranted.

Consistent with the NCP (40 CFR Part 300), the evaluation of short-term effectiveness also considered the environmental impacts of soil removal actions, specifically water use required to establish grass cover in remediated yards. Since the publication of the FS Report in November 2001, the State of Colorado has experienced a drought. The severity of the drought is illustrated by the fact that the City of Denver has placed a complete ban on lawn watering beginning October 1, 2002.

Watering of replacement lawns and plants is a critical component of soil removal actions. Soil removal actions within the adjacent Globeville neighborhood required an estimated 9.35 gallons of water to establish one square foot of replacement sod (Asarco, 1997). An average yard in VB/I70 has an estimated 5,200 square foot area of soil (EPA, 2001). Assuming that 70% of the soil area is sod, approximately 50,000 gallons of water would be required to establish sod at a typical property. Based on these assumptions, Alternative 3 would require 10 million gallons of water to implement.

Alternative 2 could be implemented with less risk to workers and the community than Alternatives 3,4,5, and 6. However, Alternative 2 provides a slightly lower level of short-term effectiveness than Alternative 3, primarily because tilling/treatment actions would be delayed while treatability testing was performed and because there would be some uncertainties with the immediate effectiveness of the tilling/treatment activities due to lack of data on lead concentrations with depth and at different locations in the targeted yards. Alternative 2 would require an amount of water equal to that required under Alternative 3.

Alternative 4 provides a slightly lower level of short-term effectives than Alternative 3, primarily because additional removals at properties with arsenic EPCs greater than 128 mg/Kg would entail greater risks to the community due to the operation of heavy equipment in residential areas over a longer period of time and to truck traffic associated with transportation of excavated soil offsite and import of clean backfill through neighborhood streets. Alternative 4 would require an estimated 20 million gallons of water to implement. This is twice as much water as estimated would be required by Alternatives 2 and 3. Yet the additional removals would not contribute to additional long-term protection of human health as set out by the requirements of the RAOs.

Alternative 6 provides a lower level of short-term effectiveness than Alternative 4, primarily because additional removals at properties with arsenic EPCs greater than 70 mg/Kg and with lead EPCs greater than 400 mg/Kg would entail greater risks to the community. Increased short term risks are due to the larger scope of removal actions, which would require transportation of a larger volume of excavated soil and clean backfill through neighborhood streets by truck. Alternative 6 would require an estimated 43 million gallons of water to implement. This is 4 times as much water as estimated would be required by Alternatives 2 and 3. However, additional long-term protection of human health as set out by the requirements of the RAOs would not be enjoyed since the requirements of the RAOs would be met by Alternative 2or 3.

Alternative 5 would provide the lowest level of short-term effectiveness because of increased risks to workers and the community due to the prolonged operation of heavy equipment in the residential areas. There would also be increased risk to the community from truck traffic associated with transportation of the largest volume of excavated soil offsite and import of clean backfill (approximately 43,000 truck trips would be required). Alternative 5 would require an estimated 106 million gallons of water to implement. This is 10 times as much water as estimated would be required by Alternatives 2 and 3. However, additional long term protection of human health as set out by the requirements of the RAOs would not be enjoyed since the requirements of the RAOS would be met by Alternatives 2,3 and 4. An additional consideration is that Alternative 5 does not include a Community Health Program component and so it is highly uncertain that it would be effective in achieving the third RAO for arsenic in soil

7.2.2 Long-Term Effectiveness and Permanence

To the extent that unacceptable health risks are associated with exposure to soil with arsenic EPCs below 240 mg/Kg and lead EPCs below 540 mg/Kg, Alternative 5 would provide the highest level of long-term protection and permanence because soils would be removed where arsenic or lead levels are above 47 mg/Kg or 208 mg/kg respectively. However, the following information from the baseline risk assessment indicates that below 240 mg/Kg arsenic and 540 mg/Kg lead, soil is not a major source of exposure and risk at OU1.

For arsenic, potential health risk where arsenic EPCs are below 240 mg/kg is associated with soil pica behavior. Screening level calculations suggest that removing and replacing soil below 240 mg/Kg will not effectively protect children from the risk of acute effects since under at least one set of assumptions, the acute HQ is greater than 1 at background levels of arsenic. Also, children with soil pica

behavior are at risk of experiencing other health risks unrelated to arsenic that will not be addressed by removing and replacing soil.

In the case of lead, Alternative 5 may not provide the highest overall protection since, in OU1, it is likely that there are other, non-soil sources of lead (such as lead-based paint), which would not be evaluated and addressed. Alternatives 2,3, 4, and 6 would provide an equal level of long-term effectiveness by addressing soils with lead or arsenic EPCs above preliminary action levels of 240 mg/Kg arsenic and 540 mg/kg lead by tilling and treatment and/or removal. The benefit of Alternatives 2,3,4, and 6 are that risks associated with non-soil sources of lead and with soil pica behavior would be effectively addressed by implementation of a community health program under these alternatives. The additional benefit of the community health program is it would provide the community a mechanism to identify sources of lead exposure other than soils, and a means of addressing them (e.g., through lead paint abatement). Abatement of exterior lead-paint would be performed under this program if soils at a property are remediated and paint abatement is required to protect the remedy. Abatement of exterior paint may be accomplished by referral to another program if soils do not require remediation. The Community Health Program would also provide a program to reduce the likelihood of soil pica behavior in children within VB/I70. Every lead paint abatement, whether accomplished directly or indirectly under the Community Health Program, is a permanent solution to a non-soil source of lead exposures. Alternative 2 would provide slightly less long-term effectiveness when compared to Alternative 3 since the effectiveness of tilling and treatment is less certain than soil removal.

7.2.3 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternatives 3, 4, 5 and 6 do not contain a treatment component and therefore Alternative 2 would result in the highest reduction of toxicity and mobility due to treatment. However, there are uncertainties with the treatment process and site-specific testing would have to be performed to evaluate the chemical form and application rate of phosphate and to evaluate the overall treatment effectiveness once implemented.

7.2.4 Implementability

Alternatives 3, 4, 5 and 6 would be readily implementable with standard equipment and services, and adequate personnel would be readily available for this type of work. The construction technologies required to implement these alternatives are commonly used and widely accepted. For Alternative 2, tilling of residential soils may be difficult to implement. Areas of accessible soils within yards are

relatively small and typically have features such as trees or large shrubs, which would make access and implementation of deep tilling difficult unless the features were removed and replaced. It is likely that due to access constraints tilling would have to be performed using rototillers, which typically have a working depth of about 6 inches. Lead concentrations with depth have not been generated for the target properties and if deeper tilling were found to be necessary to meet the RAOs it would be difficult to implement.

7.2.5 Cost

Estimated costs for each alternative considered in the comparative analysis are shown below. These costs include direct and indirect capital costs and review costs for 30 years (there are no operation and maintenance costs associated with any of the alternatives).

Remedial Alternative	Net Present Worth Cost (Millions)
Alternative 2	10.6
Alternative 3	11.1
Alternative 4	17.5
Alternative 5	61.0 (1)
Alternative 6	31.1

Note: (1) Of this amount, approximately $15.6 million is associated with remediation of properties with arsenic EPCs above 47 mg/Kg but below 128 mg/Kg.

All alternatives meet the threshold requirements of protection of human health and compliance with ARARs. Alternative 3 provides a greater level of overall certainty for protecting human health compared to Alternative 2 and entails lower costs and lower short-term risks than Alternatives 4, 5, and 6.

TABLE 7-1
SUMMARY OF THE COMPARATIVE ANALYSIS

Evaluation Criterion	Alternative 2 – Community Health Program, Tilling/Treatment (Lead), Targeted Removal and Disposal (Arsenic)	Alternative 3 – Community Health Program, Targeted Removal and Disposal	Alternative 4 – Community Health Program, Expanded Removal and Disposal	Alternative 5 – Removal And Disposal	Alternative 6 – Community Health Program, Further Expanded Removal and Disposal
Threshold Criteria					
Overall Protection of Human Health	Meets the requirements of the RAOs – however, there is some uncertainty with respect to treatment/tilling component	Meets the requirements of the RAOs	Meets the requirements of the RAOs	Meets the requirements of the RAOs-however there is uncertainty with respect to preventing acute exposures associated with soil pica behavior	Meets the requirements of the RAOs
Compliance with ARARs	Complies with ARARs	Complies with ARARs	Complies with ARARs	Complies with ARARs	Complies with ARARs
Balancing Criteria					
Short-Term Effectiveness	Reduction in short-term effectiveness compared to Alternative 3, because implementation would be delayed to allow for treatability testing of tilling/phosphate treatment component and because of uncertainties associated with effectiveness of tilling/treatment 3.3 % probability of accident involving injury 0.16 % probability of accident involving fatality estimated 10 million gallons of water required	High level of short-term effectiveness 6% probability of accident involving injury 0.29 % probability of accident involving fatality estimated 10 million gallons of water required	Reduction in short-term effectiveness compared to Alternative 3, because of risks associated with soil removal for properties with arsenic concentrations below RAO risk levels 12% probability of accident involving injury 0.6% probability of accident involving fatality estimated 20 million gallons of water required	Lowest level of short-term effectiveness because of risks to workers and the community during implementation – particularly associated with operation of heavy equipment and truck transportation in residential areas 65% probability of accident involving injury 3.2 % probability of accident involving fatality estimated 106 million gallons of water required	Reduction in short-term effectiveness compared to Alternative 3, because of risks associated with soil removal for properties with arsenic concentrations below RAO risk levels 25 % probability of accident involving injury 1.3 % probability of accident involving fatality estimated 43 million gallons of water required

Evaluation Criterion	Alternative 2 – Community Health Program, Tilling/Treatment (Lead), Targeted Removal and Disposal (Arsenic)	Alternative 3 – Community Health Program, Targeted Removal and Disposal	Alternative 4 – Community Health Program, Expanded Removal and Disposal	Alternative 5 – Removal And Disposal	Alternative 6 – Community Health Program, Further Expanded Removal and Disposal
Long-Term Effectiveness and Permanence	Would be effective over the long-term. Community Health Program provides additional benefit in providing a mechanism for evaluating other sources of lead	Would be effective over the long-term. Community Health Program provides additional benefit in providing a mechanism for evaluating other sources of lead	Would be effective over the long-term. Community Health Program provides additional benefit in providing a mechanism for evaluating other sources of lead	Highest possible level of long-term effectiveness for risks associated with soil because all soils with arsenic or lead above levels of concern would be removed. Would not provide information on other sources of lead. Would not reduce or prevent soil pica behavior.	Would be effective over the long-term. Community Health Program provides additional benefit in providing a mechanism for evaluating other sources of lead
Reduction of Toxicity, Mobility or Volume Through Treatment	Effectiveness of treatment with tilling expected to be effective, but there are uncertainties and site-specific testing would be required to support design	Does not contain a treatment component	Does not contain a treatment component	Does not contain a treatment component	Does not contain a treatment component
Implementability	Expected to be readily implementable. However, tilling may be difficult to implement if deep tilling is required to meet RAOs. This would be evaluated during design	Readily implementable	Readily implementable	Readily implementable	Readily implementable
Cost	$10.6 million	$11 1 million	$17.5 million	$61.0 million	$31.8 million

REVISED SECTION 8.0 - REFERENCES

8.0 REFERENCES

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NEW FIGURE 5-2 – RESIDENTIAL PROPERTIES WITH YARD SOILS CONTAINING LEAD OR ARSENIC CONCENTRATIONS ABOVE ACTION LEVELS (ALTERNATIVE 6)

REVISED APPENDIX B – DETAILED COST ESTIMATES

DETAILED COST ESTIMATES

Detailed cost estimates for each action alternative are provided in Tables 1 through 5. Alternative 1 (No Action) is the baseline for the cost estimates for the other alternatives and is assumed to have no associated cost. These detailed estimates present the quantities made in establishing the scope of work (areas, volumes, etc.) and the calculations from which the estimated costs were derived. The unit costs shown for each work item reflect an assessment of the labor, materials and equipment required for each identified item and include allowances for appurtenant and incidental work as well as contractor overhead and profit. Unit cost rates and associated productivity factors are based on historical factors, published industry data, information on previous removals actions at the VB/I70 site, and/or experience on projects of similar scope and nature. The quantities used in assessing the scope of work are based on GIS information from the site and from quantities generated during previous removal actions. However, some uncertainties exist with respect to the potential difficulties which may be encountered and accordingly, contingency allowances have been included in the estimates, consistent with the extent of the unknowns and uncertainties. The contingency allowance is intended to cover unspecified, or unidentified, work required to be completed within the scope of work and not additional work beyond the established scope of work. Notwithstanding these unknowns, the accuracy of the estimates is anticipated to fall within the acceptable range for typical feasibility study evaluations of +50% to -30%, in accordance with EPA guidance ("A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" OSWER 9355.0-75).

1.0 Initial Remedial Action Capital Cost Estimates

The initial phase of remedial action includes engineering activities (such as soil removal/replacement or soil tilling) and setting up the Community Health Program. Detailed cost estimates were generated for: (1) soil tilling/treatment and restoration at an individual property (Table 6); (2) soil removal and disposal and restoration at an individual property (Table 7); and (3) setting up the Community Health Program (Table 8).

2.0 Ongoing Remedial Action Annual Cost Estimates

After the initial phase (described above) some alternatives considered in this FS contain an ongoing Community Health Program as part of remedial action. Estimates of the annual costs for the Community Health Program were prepared for activities anticipated to be performed each year following completion of initial site remediation activities. A 30-year remedial action period has been used for costing purposes. The annual cost estimates for each alternative are included in Tables 1 through 5 and are presented in constant 2002 dollars. No escalation factors have been applied to future costs in performing the present worth analyses. Unit cost rates and associated productivity factors are based on published industry data, and/or experience on projects of similar scope and nature. For the Community Health Program a baseline annual cost was estimated (Table 9). It was assumed that the scope of this program would be reduced during the 30-year remedial action period, as health risks were identified and addressed. For the purposes of costing it was assumed that the cost of the program would reduce to 75% of the initial annual cost after 5 years, and to 33% of the initial cost after 10 years.

3.0 Periodic Costs

For the alternatives considered in this FS the only periodic costs are associated with 5-year reviews. As specified in EPA guidance (EPA, 1988a), a 30-year period has been used for costing purposes. The 5-year review cost estimates for each alternative are included in Tables 1 through 5 and are presented in constant 2002 dollars. No escalation factors have been applied to future costs in performing the present worth analyses. Unit cost rates and associated productivity factors are based on published industry data, and/or experience on projects of similar scope and nature.

4.0 Operation and Maintenance Costs

There are no Operation and Maintenance costs associated with any of the alternatives – all activities are considered to be part of remedial action.

5.0 Present Worth Calculations

Present worth analyses were performed on estimated costs associated with each remedial alternative to provide a common basis for comparison. Present worth analysis calculates a current value, or worth, of all costs incurred in the present or at some future date at an assumed constant rate of return, or discount rate. The present worth calculated represents an amount, which if invested in 2002 at a certain rate of return would yield the appropriate dollar amount to meet the required expenditures over the construction and 30-year remedial action periods. The exact duration of initial implementation and corresponding capital costs will be dependent on the results of the remedial design phase. At that time the most appropriate implementation scenario can be developed. However, the assumed durations are reasonable and allow for an objective, relative comparison of the alternatives.

Because total remedial action costs could be especially sensitive to the prevailing rate of return used in the present worth analyses, rates of return of 3%, 5%, and 10% were used to prepare present worth estimates for each alternative. The capital costs spread out over the anticipated implementation period were also discounted to constant 2002 dollars using rates of return of 3%, 5%, and 10%. For simplicity, only the present worth calculated at an assumed 5% rate of return has been presented in the text and used in the comparison of costs. The present worth analyses performed in this report are considered before-tax analyses and do not consider future escalation of costs. The expenditure of remedial action and 5-year review costs and subsequent present worth analyses for the alternatives are presented in Tables 10 through 14.

TABLE 1

DETAILED COST ESTIMATE
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 2 - COMMUNITY HEALTH PROGRAM, TILLING/TREATMENT (LEAD), TARGETED REMOVAL AND DISPOSAL (ARSENIC)

Item/Description	Quantity	Unit	Unit Cost	Extension	Total Cost
INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					
Tilling & Treatment	89	Property	$15,487		$1,378,346
Removal/Disposal	113	Property	$18,412		$2,080,556
Community Health Program	1	LS	$205,655		$205,655
SUBTOTAL INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					$3,664,557
INDIRECT INITIAL REMEDIAL ACTION CAPITAL COSTS					
Mob/Demob			10%	$366,455.73	
Engineering/Administration Costs			10%	$366,455.73	
Construction Management Costs			15%	$549,683.59	
Health & Safety			3%	$109,936.72	
SUBTOTAL INITIAL REMEDIAL ACTION INDIRECT CAPITAL COSTS					$1,392,532
Capital Cost Contingency			25%	$1,264,272.27	
TOTAL ESTIMATED CAPITAL COST FOR INITIAL REMEDIAL ACTION					$6,321,361
ONGOING REMEDIAL ACTION ANNUAL COSTS					
Community Health Program	1	Yr	$328,645		$328,645
SUBTOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$328,645
Administrative Costs			10%	$32,864.50	
Contingency			25%	$90,377.38	
TOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$451,887
PERIODIC COSTS - FIVE YEAR REVIEWS					
Labor - 2 Engineers ($70/hr) & 2 Technicians ($50/hr) - 1 week @ 40 hrs/wk	40	mh	$240	$9,600.00	
Travel	4	each	$50	$200.00	
Lab Costs	15	each	$500	$7,500.00	
Office/Admin	60	mh	$140	$8,400.00	
SUBTOTAL PERIODIC COSTS					$25,700
Periodic Cost Contingency			10%	$2,570.00	
TOTAL FIVE YEAR REVIEW COSTS					$28,270
TOTAL PRESENT WORTH (5% rate of return, 30 year period)					$10,559,000

NOTES:

Total Present Worth calculation presented in Table 10.

TABLE 2

DETAILED COST ESTIMATE
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 3 - COMMUNITY HEALTH PROGRAM, TARGETED REMOVAL AND DISPOSAL

Item/Description	Quantity	Unit	Unit Cost	Extension	Total Cost
INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					
Removal & Disposal	202	property	$18,412		$3,719,224
Community Health Program	1	LS	$205,655		$205,655
SUBTOTAL INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					$3,924,879
INDIRECT INITIAL REMEDIAL ACTION CAPITAL COSTS					
Mob/Demob			10%	$392,488	
Engineering/Administration Costs			10%	$392,488	
Construction Management Costs			15%	$588,732	
Health & Safety			3%	$117,746	
SUBTOTAL INITIAL REMEDIAL ACTION INDIRECT CAPITAL COSTS					$1,491,454
Capital Cost Contingency			25%	$1,354,033	
TOTAL ESTIMATED CAPITAL COST FOR INITIAL REMEDIAL ACTION					$6,770,416
ONGOING REMEDIAL ACTION ANNUAL COSTS					
Ongoing Remedial Action Annual Costs					
Same as Alternative 2					$320,649
SUBTOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$320,649
Administrative Costs			10%	$32,065	
Contingency			25%	$99,377	
TOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$451,087
PERIODIC COSTS - FIVE YEAR REVIEWS					
Same as Alternative 2					
SUBTOTAL PERIODIC COSTS					$25,700
Contingency			16%	$2,570	
TOTAL PERIODIC COSTS					$28,370
TOTAL PRESENT WORTH (5% rate of return, 30 year period)					$11,096,000

NOTES:

Total Present Worth calculation presented in Table 11.

TABLE 3

DETAILED COST ESTIMATE
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 4 - COMMUNITY HEALTH PROGRAM, EXPANDED REMOVAL AND DISPOSAL

Item/Description	Quantity	Unit	Unit Cost	Extension	Total Cost
INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					
Removal & Disposal	403	property	$18,412		$7,420,036
Community Health Program	1	LS	$205,655		$205,655
SUBTOTAL INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					$7,625,691
INDIRECT INITIAL REMEDIAL ACTION CAPITAL COSTS					
Mob/Demob			10%	$762,569	
Engineering/Administration Costs			10%	$762,569	
Construction Management Costs			15%	$1,143,854	
Health & Safety			3%	$228,771	
SUBTOTAL INITIAL REMEDIAL ACTION INDIRECT CAPITAL COSTS					$2,897,763
Capital Cost Contingency			25%	$2,630,863	
TOTAL ESTIMATED CAPITAL COST FOR INITIAL REMEDIAL ACTION					$13,154,317
ONGOING REMEDIAL ACTION ANNUAL COSTS					
Ongoing Remedial Action Annual Costs					
Same as Alternative 2					$328,645
SUBTOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$328,645
Administrative Costs			10%	$32,865	
Contingency			25%	$90,377	
TOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$451,887
PERIODIC COSTS - FIVE YEAR REVIEWS					
Same as Alternative 2					$25,700
SUBTOTAL FIVE YEAR REVIEW COSTS					
Five Year Review Contingency			10%	$2,570	
TOTAL FIVE YEAR REVIEW COSTS					$28,270
TOTAL PRESENT WORTH (5% rate of return, 30 year period)					$17,480,000

NOTES:

Total Present Worth calculation presented in Table 12.

TABLE 4

DETAILED COST ESTIMATE
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 5 - REMOVAL AND DISPOSAL

Item/Description	Quantity	Unit	Unit Cost	Extension	Total Cost
DIRECT CAPITAL COSTS					
Sampling and Analysis at Unsampled Properties	1000	Property	$500		$500,000
Removal & Disposal - Lead Only Above Action Level	1259	Property	$18,412		$23,180,708
Removal & Disposal - Arsenic Only Above Action Level	384	Property	$18,412		$7,070,208
Removal & Disposal - Both Lead and Arsenic Above Action Levels	479	Property	$18,412		$8,819,348
SUBTOTAL DIRECT CAPITAL COSTS					$39,570,264
INDIRECT CAPITAL COSTS					
Mob/Demob			10%	$3,957,026	
Engineering/Administration Costs			10%	$3,957,026	
Construction Management Costs			15%	$5,935,540	
Health & Safety			3%	$1,187,108	
SUBTOTAL INDIRECT CAPITAL COSTS					$15,036,700
Capital Cost Contingency			20%	$10,921,393	
TOTAL ESTIMATED CAPITAL COST					$65,528,357
PERIODIC COSTS - FIVE YEAR REVIEWS					
None					
SUBTOTAL FIVE YEAR REVIEW COSTS					$0
Five Year Review Contingency			10%	$0	
TOTAL FIVE YEAR REVIEW COSTS					$0
TOTAL PRESENT WORTH (5% rate of return, 4 year period)					$40,993,000

NOTES:

Total Present Worth calculation presented in Table 13.

TABLE 5

DETAILED COST ESTIMATE
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 6 - COMMUNITY HEALTH PROGRAM, FURTHER EXPANDED REMOVAL AND DISPOSAL

Item/Description	Quantity	Unit	Unit Cost	Extension	Total Cost
INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					
Removal & Disposal	853	property	$18,412		$15,705,436
Community Health Program	1	LS	$205,655		$205,655
SUBTOTAL INITIAL REMEDIAL ACTION DIRECT CAPITAL COSTS					$15,911,091
INDIRECT INITIAL REMEDIAL ACTION CAPITAL COSTS					
Mob/Demob			10%	$1,591,109	
Engineering/Administration Costs			10%	$1,591,109	
Construction Management Costs			15%	$2,386,664	
Health & Safety			3%	$477,333	
SUBTOTAL INITIAL REMEDIAL ACTION INDIRECT CAPITAL COSTS					$6,046,215
Capital Cost Contingency			25%	$5,489,326	
TOTAL ESTIMATED CAPITAL COST FOR INITIAL REMEDIAL ACTION					$27,446,632
ONGOING REMEDIAL ACTION ANNUAL COSTS					
Ongoing Remedial Action Annual Costs					
Same as Alternative 2					$328,645
SUBTOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$328,645
Administrative Costs			10%	$32,865	
Contingency			25%	$90,377	
TOTAL ONGOING REMEDIAL ACTION ANNUAL COSTS					$451,887
PERIODIC COSTS - FIVE YEAR REVIEWS					
Same as Alternative 2					
SUBTOTAL FIVE YEAR REVIEW COSTS					$25,700
Five Year Review Contingency			10%	$2,570	
TOTAL FIVE YEAR REVIEW COSTS					$28,270
TOTAL PRESENT WORTH (5% rate of return, 30 year period)					**$31,119,000**

NOTES:

Total Present Worth calculation presented in Table 14.

TABLE 6

DETAILED CONSTRUCTION COST ESTIMATE FOR SOIL TILLING/TREATMENT PER RESIDENTIAL YARD VASQUEZ BOULEVARD/I-70 SITE OU1

Item/Description	Quantity	Unit	Unit Cost	Extension
DIRECT CAPITAL COSTS				
Site Preparation	1	ls	$750 00	$750.00
Tilling	580	sy	$5.00	$2,900 00
Treatment Chemical Purchase	9,704	lb	$0.25	$2,425.93
Chemical handling and application	9,704	lb	$0.30	$2,911.11
Property Restoration	1	LS	$2,500.00	$2,500.00
Post-Remedy Testing	1	LS	$4,000 00	$4,000.00
TOTAL ESTIMATED CAPITAL COST				$15,487.04

Assumptions

1) Area of soils estimated at 580 square yards (Washington Group, 2001b).
2) Treatment chemical P2O5 cost $ 450 per ton.
3) Target concentration 1% P in treated soil = 0.01 * 5240 feet * 0.5 feet * 100 lbs per cubic foot = 2,620 lbs of P. = 2,620/0.27 lbs of P2O5

TABLE 7

DETAILED CONSTRUCTION COST ESTIMATE FOR SOIL REMOVAL & DISPOSAL PER RESIDENTIAL YARD
VASQUEZ BOULEVARD/I-70 SITE OU1

Item/Description	Quantity	Unit	Unit Cost	Extension
DIRECT CAPITAL COSTS				
Site Preparation	1	LS	$750.00	$750
Soil Removal	194	cy	$18.00	$3,492
Transport/ Dispose Excavated Soil	194	cy	$16.00	$3,104
Purchase/Transport Clean Fill	194	cy	$19.00	$3,686
Place & Grade Clean Fill	194	cy	$20.00	$3,880
Property Restoration	1	LS	$3,500.00	$3,500
SUBTOTAL DIRECT CAPITAL COSTS				$18,412

Assumptions

1) Volume of soils estimated at 5,240 square feet excavation areas at a property, 1 foot depth (= 194 cubic yards per property).

Table 8
Detailed Cost Estimate for Community Health Program Setup

	Labor			Materials				Services				
	Person-hours	Avg. Rate	Cost	Quantity	Units	Unit Cost	Cost	Quantity	Units	Unit Cost	Cost	Total
Community Health Program One-Time Start-Up Costs												
1 Education/Public Awareness												
Develop Public Awareness Campaign	400	$90	$36,000	10000	brochures	$2	$20,000	1	art work	$10,000	$10,000	$66,000
Newspaper												
- News/Post								1	ad budget	$6,000	$6,000	$6,000
- LaVoz								1	ad budget	$2,400	$2,400	$2,400
Direct Mail Fact Sheet				4000	fact sheet	$2	$8,000	1	mailing	$1,500	$1,500	$9,500
Task Subtotal	400		$36,000									
2 Biomonitoring Program												
Develop clinic-based biomonitoring program												
- Health Sciences Professional	180	$75	$13,500									$13,500
- Information System Development	320	$75	$24,000									$24,000
Documentation of program	160	$85	$13,600	10	copies	$50	$500					$14,100
Clinic facilities set up	120	$65	$7,800	1	supplies	$5,000	$5,000					$12,800
Task Subtotal	780		$58,900									
3 Source Investigation and Remediation												
Develop sampling and remediation program	200	$85	$17,000									$17,000
Program documentation	160	$85	$13,600	10	copies	$50	$500					$14,100
Task Subtotal	360		$30,600									
4 Program Introduction												
Public Meeting												
- Health Sciences Professional	60	$85	$5,100									$5,100
- Health Sciences Professional	60	$75	$4,500									$4,500
- Hall Rental (Community Center)								2		$150	$300	$300
- AV Equipment								2		$50	$100	$100
- Direct Mail Fact Sheet				4000	fact sheets	$2	$8,000	1	mailing	$1,500	$1,500	$9,500
Task Subtotal	120		$9,600									
Subtotal	1660		$135,100				$42,000				$21,800	$198,900
Project Management (5% of labor)			$6,755									+ $6,755
Total Start Up Costs			$141,855				$42,000				$21,800	$205,655

Table 9
Detailed Annual Cost Estimate for
Community Health Program

		Labor			Materials				Services				
		Person-hours	Avg. Rate	Cost	Quantity	Units	Unit Cost	Cost	Quantity	Units	Unit Cost	Cost	Annual Total
Community Health Program Annual Costs													
1 Education/Public Awareness													
Public education and outreach		168	$80	$13,440	4000	brochures	$1	$4,000					$17,440
Awareness promotions		100	$80	$8,000					1	promo.	$3,500	$3,500	$11,500
Newspaper advertisements													
- News/Post									1	ad budget	$1,200	$1,200	$1,200
- LaVoz									1	ad budget	$600	$600	$600
Direct mail									1	mailing	$1,500	$1,500	$1,500
Task Subtotal		268		$21,440									
2 Ongoing Clinic-based Biomonitoring													
Implement clinic based biomonitoring program													
- Blood lead sampling & analysis		400	$65	$26,000					700	samples	$35	$24,500	$50,500
- Urine arsenic sampling & analysis		400	$65	$26,000					700	samples	$45	$31,500	$57,500
- Participation Incentives	EE Series Savings Bonds				100	bonds	$25	$2,500					$2,500
Case management services		400	$65	$26,000									$26,000
Database/Records Management		400	$45	$18,000									$18,000
Clinic facilities									4	months	$1,000	$4,000	$4,000
Task Subtotal		1600		$96,000									
3 Source Investigation and Remediation													
Implement ongoing sampling program	33/yr	400	$95	$38,000									$38,000
- Interior dust/exterior paint lead samples	4 hr/res	132	$65	$8,580					66	samples	$15	$990	$9,570
- Soil lead & arsenic samples	6 hr/res	198	$65	$12,870					99	samples	$35	$3,465	$16,335
- Administer questionnaire	1 hr/residence	33	$65	$2,145									$2,145
Yard Remediation (including exterior paint abatement) when necessary	1/yr								1	property	$45,000	$45,000	$45,000
Task Subtotal		763		$61,595									
Annual Subtotal		2631		$179,035				$6,500				$116,285	$301,780
Health & Safety (10% of labor)				$17,904									+ $17,904
Project Management (5% of labor)				$8,952									+ $8,952
Annual Total				$205,890				$6,500				$116,285	$328,645

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TABLE 10

PRESENT WORTH ANALYSIS
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 2 - COMMUNITY HEALTH PROGRAM, TILLING/TREATMENT (LEAD), TARGETED REMOVAL AND DISPOSAL (ARSENIC)

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$6,321,361	$0	$6,321,361	1.0000	$6,321,361	1.0000	$6,321,361
1		$451,887	$451,887	0.9709	$438,725	0.9091	$410,806
2		$451,887	$451,887	0.9426	$425,947	0.8264	$373,460
3		$451,887	$451,887	0.9151	$413,541	0.7513	$339,909
4		$451,887	$451,887	0.8885	$401,496	0.6830	$303,645
5		$367,185	$367,185	0.8626	$316,737	0.6209	$227,993
6		$338,915	$338,915	0.8375	$283,836	0.5645	$191,309
7		$338,915	$338,915	0.8131	$275,569	0.5132	$173,917
8		$338,915	$338,915	0.7894	$267,543	0.4665	$158,106
9		$338,915	$338,915	0.7664	$259,750	0.4241	$143,733
10		$367,185	$367,185	0.7441	$273,220	0.3855	$141,566
11		$149,123	$149,123	0.7224	$107,729	0.3505	$52,267
12		$149,123	$149,123	0.7014	$104,592	0.3186	$47,515
13		$149,123	$149,123	0.6810	$101,545	0.2897	$43,195
14		$149,123	$149,123	0.6611	$98,588	0.2633	$39,269
15		$177,393	$177,393	0.6419	$113,862	0.2394	$42,466
16		$149,123	$149,123	0.6232	$92,928	0.2176	$32,453
17		$149,123	$149,123	0.6050	$90,222	0.1978	$29,503
18		$149,123	$149,123	0.5874	$87,594	0.1799	$26,821
19		$149,123	$149,123	0.5703	$85,043	0.1635	$24,383
20		$177,393	$177,393	0.5537	$98,218	0.1486	$26,360
21		$149,123	$149,123	0.5375	$80,161	0.1351	$20,151
22		$149,123	$149,123	0.5219	$77,826	0.1228	$18,319
23		$149,123	$149,123	0.5067	$75,559	0.1117	$16,654
24		$149,123	$149,123	0.4919	$73,358	0.1015	$15,140
25		$177,393	$177,393	0.4776	$84,724	0.0923	$16,373
26		$149,123	$149,123	0.4637	$69,147	0.0839	$12,512
27		$149,123	$149,123	0.4502	$67,133	0.0763	$11,375
28		$149,123	$149,123	0.4371	$65,178	0.0693	$10,341
29		$149,123	$149,123	0.4243	$63,280	0.0630	$9,401
30		$177,393	$177,393	0.4120	$73,083	0.0573	$10,165
TOTAL PRESENT WORTH				@ 3%	$11,387,000	@ 10%	$9,295,000

TABLE 11

PRESENT WORTH ANALYSIS
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 3 - COMMUNITY HEALTH PROGRAM, TARGETED REMOVAL AND DISPOSAL

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 4% Discount Factor	Rate of Return = 4% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$6,770,416	$0	$6,770,416	1.0000	$6,770,416	[illegible]	[illegible]	1.0000	$6,770,416
1		$451,887	$451,887	0.9709	$438,725	[illegible]	[illegible]	0.9091	$410,806
2		$451,887	$451,887	0.9426	$425,947	[illegible]	[illegible]	0.8264	$373,460
3		$451,887	$451,887	0.9151	$413,541	[illegible]	[illegible]	0.7513	$339,509
4		$451,887	$451,887	0.8885	$401,496	[illegible]	[illegible]	0.6830	$308,645
5		$480,157	$480,157	0.8626	$414,188	[illegible]	[illegible]	0.6209	$298,140
6		$338,915	$338,915	0.8375	$283,836	[illegible]	[illegible]	0.5645	$191,309
7		$338,915	$338,915	0.8131	$275,569	[illegible]	[illegible]	0.5132	$173,917
8		$338,915	$338,915	0.7894	$267,543	[illegible]	[illegible]	0.4665	$158,105
9		$338,915	$338,915	0.7664	$259,750	[illegible]	[illegible]	0.4241	$143,733
10		$367,185	$367,185	0.7441	$273,220	[illegible]	[illegible]	0.3855	$141,566
11		$149,123	$149,123	0.7224	$107,729	[illegible]	[illegible]	0.3505	$52,267
12		$149,123	$149,123	0.7014	$104,592	[illegible]	[illegible]	0.3186	$47,515
13		$149,123	$149,123	0.6810	$101,545	[illegible]	[illegible]	0.2897	$43,196
14		$149,123	$149,123	0.6611	$98,588	[illegible]	[illegible]	0.2633	$39,269
15		$177,393	$177,393	0.6419	$113,862	[illegible]	[illegible]	0.2394	$42,466
16		$149,123	$149,123	0.6232	$92,928	[illegible]	[illegible]	0.2176	$32,453
17		$149,123	$149,123	0.6050	$90,222	[illegible]	[illegible]	0.1978	$29,503
18		$149,123	$149,123	0.5874	$87,594	[illegible]	[illegible]	0.1799	$26,821
19		$149,123	$149,123	0.5703	$85,043	[illegible]	[illegible]	0.1635	$24,383
20		$177,393	$177,393	0.5537	$98,218	[illegible]	[illegible]	0.1486	$26,368
21		$149,123	$149,123	0.5375	$80,161	[illegible]	[illegible]	0.1351	$20,151
22		$149,123	$149,123	0.5219	$77,826	[illegible]	[illegible]	0.1228	$18,319
23		$149,123	$149,123	0.5067	$75,559	[illegible]	[illegible]	0.1117	$16,654
24		$149,123	$149,123	0.4919	$73,358	[illegible]	[illegible]	0.1015	$15,140
25		$177,393	$177,393	0.4776	$84,724	[illegible]	[illegible]	0.0923	$16,373
26		$149,123	$149,123	0.4637	$69,147	[illegible]	[illegible]	0.0839	$12,512
27		$149,123	$149,123	0.4502	$67,133	[illegible]	[illegible]	0.0763	$11,375
28		$149,123	$149,123	0.4371	$65,178	[illegible]	[illegible]	0.0693	$10,341
29		$149,123	$149,123	0.4243	$63,280	[illegible]	[illegible]	0.0630	$9,401
30		$177,393	$177,393	0.4120	$73,083	[illegible]	[illegible]	0.0573	$10,166
TOTAL PRESENT WORTH				@ 3%	$11,934,000	[illegible]	[illegible]	@ 10%	$9,814,000

TABLE 12

PRESENT WORTH ANALYSIS
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 4 - COMMUNITY HEALTH PROGRAM, EXPANDED REMOVAL AND DISPOSAL

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 5% Discount Factor	Rate of Return = 5% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$13,154,317	$0	$13,154,317	1.0000	$13,154,317	[illegible]	[illegible]	1.0000	$13,154,317
1		$451,887	$451,887	0.9709	$438,725	[illegible]	[illegible]	0.9091	$410,806
2		$451,887	$451,887	0.9426	$425,947	[illegible]	[illegible]	0.8264	$373,460
3		$451,887	$451,887	0.9151	$413,541	[illegible]	[illegible]	0.7513	$339,509
4		$451,887	$451,887	0.8885	$401,496	[illegible]	[illegible]	0.6830	$308,645
5		$480,157	$480,157	0.8626	$414,188	[illegible]	[illegible]	0.6209	$298,140
6		$338,915	$338,915	0.8375	$283,836	[illegible]	[illegible]	0.5645	$191,309
7		$338,915	$338,915	0.8131	$275,569	[illegible]	[illegible]	0.5132	$173,917
8		$338,915	$338,915	0.7894	$267,543	[illegible]	[illegible]	0.4665	$158,106
9		$338,915	$338,915	0.7664	$259,750	[illegible]	[illegible]	0.4241	$143,733
10		$367,185	$367,185	0.7441	$273,220	[illegible]	[illegible]	0.3855	$141,566
11		$149,123	$149,123	0.7224	$107,729	[illegible]	[illegible]	0.3505	$52,267
12		$149,123	$149,123	0.7014	$104,592	[illegible]	[illegible]	0.3186	$47,515
13		$149,123	$149,123	0.6810	$101,545	[illegible]	[illegible]	0.2897	$43,196
14		$149,123	$149,123	0.6611	$98,588	[illegible]	[illegible]	0.2633	$39,269
15		$177,393	$177,393	0.6419	$113,862	[illegible]	[illegible]	0.2394	$42,466
16		$149,123	$149,123	0.6232	$92,928	[illegible]	[illegible]	0.2176	$32,453
17		$149,123	$149,123	0.6050	$90,222	[illegible]	[illegible]	0.1978	$29,503
18		$149,123	$149,123	0.5874	$87,594	[illegible]	[illegible]	0.1799	$26,821
19		$149,123	$149,123	0.5703	$85,043	[illegible]	[illegible]	0.1635	$24,383
20		$177,393	$177,393	0.5537	$98,218	[illegible]	[illegible]	0.1486	$26,368
21		$149,123	$149,123	0.5375	$80,161	[illegible]	[illegible]	0.1351	$20,151
22		$149,123	$149,123	0.5219	$77,826	[illegible]	[illegible]	0.1228	$18,319
23		$149,123	$149,123	0.5067	$75,559	[illegible]	[illegible]	0.1117	$16,654
24		$149,123	$149,123	0.4919	$73,358	[illegible]	[illegible]	0.1015	$15,140
25		$177,393	$177,393	0.4776	$84,724	[illegible]	[illegible]	0.0923	$16,373
26		$149,123	$149,123	0.4637	$69,147	[illegible]	[illegible]	0.0839	$12,512
27		$149,123	$149,123	0.4502	$67,133	[illegible]	[illegible]	0.0763	$11,375
28		$149,123	$149,123	0.4371	$65,178	[illegible]	[illegible]	0.0693	$10,341
29		$149,123	$149,123	0.4243	$63,280	[illegible]	[illegible]	0.0630	$9,401
30		$177,393	$177,393	0.4120	$73,083	[illegible]	[illegible]	0.0573	$10,166
TOTAL PRESENT WORTH				@ 3%	$18,318,000	[illegible]	[illegible]	@ 10%	$16,198,000

TABLE 13

PRESENT WORTH ANALYSIS
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 5 - REMOVAL AND DISPOSAL

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	[illegible]	[illegible]	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$16,382,089	$0	$16,382,089	1.0000	$16,382,089	[illegible]	[illegible]	1.0000	$16,382,089
1	$16,382,089	$0	$16,382,089	0.9709	$15,904,941	[illegible]	[illegible]	0.9091	$14,892,808
2	$16,382,089	$0	$16,382,089	0.9426	$15,441,690	[illegible]	[illegible]	0.8264	$13,538,917
3	$16,382,089	$0	$16,382,089	0.9151	$14,991,932	[illegible]	[illegible]	0.7513	$12,308,106
4		$0	$0	0.8885	$0	[illegible]	[illegible]	0.6830	$0
5		$0	$0	0.8626	$0	[illegible]	[illegible]	0.6209	$0
6		$0	$0	0.8375	$0	[illegible]	[illegible]	0.5645	$0
7		$0	$0	0.8131	$0	[illegible]	[illegible]	0.5132	$0
8		$0	$0	0.7894	$0	[illegible]	[illegible]	0.4665	$0
9		$0	$0	0.7664	$0	[illegible]	[illegible]	0.4241	$0
10		$0	$0	0.7441	$0	[illegible]	[illegible]	0.3855	$0
11		$0	$0	0.7224	$0	[illegible]	[illegible]	0.3505	$0
12		$0	$0	0.7014	$0	[illegible]	[illegible]	0.3186	$0
13		$0	$0	0.6810	$0	[illegible]	[illegible]	0.2897	$0
14		$0	$0	0.6611	$0	[illegible]	[illegible]	0.2633	$0
15		$0	$0	0.6419	$0	[illegible]	[illegible]	0.2394	$0
16		$0	$0	0.6232	$0	[illegible]	[illegible]	0.2176	$0
17		$0	$0	0.6050	$0	[illegible]	[illegible]	0.1978	$0
18		$0	$0	0.5874	$0	[illegible]	[illegible]	0.1799	$0
19		$0	$0	0.5703	$0	[illegible]	[illegible]	0.1635	$0
20		$0	$0	0.5537	$0	[illegible]	[illegible]	0.1486	$0
21		$0	$0	0.5375	$0	[illegible]	[illegible]	0.1351	$0
22		$0	$0	0.5219	$0	[illegible]	[illegible]	0.1228	$0
23		$0	$0	0.5067	$0	[illegible]	[illegible]	0.1117	$0
24		$0	$0	0.4919	$0	[illegible]	[illegible]	0.1015	$0
25		$0	$0	0.4776	$0	[illegible]	[illegible]	0.0923	$0
26		$0	$0	0.4637	$0	[illegible]	[illegible]	0.0839	$0
27		$0	$0	0.4502	$0	[illegible]	[illegible]	0.0763	$0
28		$0	$0	0.4371	$0	[illegible]	[illegible]	0.0693	$0
29		$0	$0	0.4243	$0	[illegible]	[illegible]	0.0630	$0
30		$0	$0	0.4120	$0	[illegible]	[illegible]	0.0573	$0
TOTAL PRESENT WORTH				**@ 3% $62,721,000**		[illegible]	[illegible]	**@ 10% $57,122,000**	

TABLE 14

PRESENT WORTH ANALYSIS
VASQUEZ BOULEVARD/I-70 SITE OU1
ALTERNATIVE 6 - COMMUNITY HEALTH PROGRAM, FURTHER EXPANDED REMOVAL AND DISPOSAL

Year	Capital Costs	Ongoing Costs	Total Annual Expenditure	Rate of Return = 3% Discount Factor	Rate of Return = 3% Present Worth	Rate of Return = 7% Discount Factor	Rate of Return = 7% Present Worth	Rate of Return = 10% Discount Factor	Rate of Return = 10% Present Worth
0	$13,723,316	$0	$13,723,316	1.0000	$13,723,316	[illegible]	[illegible]	1.0000	$13,723,316
1	$13,723,316	$451,887	$14,175,203	0.9709	$13,762,333	[illegible]	[illegible]	0.9091	$12,886,548
2		$451,887	$451,887	0.9426	$425,947	[illegible]	[illegible]	0.8264	$373,460
3		$451,887	$451,887	0.9151	$413,541	[illegible]	[illegible]	0.7513	$339,509
4		$451,887	$451,887	0.8885	$401,496	[illegible]	[illegible]	0.6830	$308,645
5		$480,157	$480,157	0.8626	$414,188	[illegible]	[illegible]	0.6209	$298,140
6		$338,915	$338,915	0.8375	$283,836	[illegible]	[illegible]	0.5645	$191,309
7		$338,915	$338,915	0.8131	$275,569	[illegible]	[illegible]	0.5132	$173,917
8		$338,915	$338,915	0.7894	$267,543	[illegible]	[illegible]	0.4665	$158,106
9		$338,915	$338,915	0.7664	$259,750	[illegible]	[illegible]	0.4241	$143,733
10		$367,185	$367,185	0.7441	$273,220	[illegible]	[illegible]	0.3855	$141,566
11		$149,123	$149,123	0.7224	$107,729	[illegible]	[illegible]	0.3505	$52,267
12		$149,123	$149,123	0.7014	$104,592	[illegible]	[illegible]	0.3186	$47,515
13		$149,123	$149,123	0.6810	$101,545	[illegible]	[illegible]	0.2897	$43,196
14		$149,123	$149,123	0.6611	$98,588	[illegible]	[illegible]	0.2633	$39,269
15		$177,393	$177,393	0.6419	$113,862	[illegible]	[illegible]	0.2394	$42,466
16		$149,123	$149,123	0.6232	$92,928	[illegible]	[illegible]	0.2176	$32,453
17		$149,123	$149,123	0.6050	$90,222	[illegible]	[illegible]	0.1978	$29,503
18		$149,123	$149,123	0.5874	$87,594	[illegible]	[illegible]	0.1799	$26,821
19		$149,123	$149,123	0.5703	$85,043	[illegible]	[illegible]	0.1635	$24,383
20		$177,393	$177,393	0.5537	$98,218	[illegible]	[illegible]	0.1486	$26,368
21		$149,123	$149,123	0.5375	$80,161	[illegible]	[illegible]	0.1351	$20,151
22		$149,123	$149,123	0.5219	$77,826	[illegible]	[illegible]	0.1228	$18,319
23		$149,123	$149,123	0.5067	$75,559	[illegible]	[illegible]	0.1117	$16,654
24		$149,123	$149,123	0.4919	$73,358	[illegible]	[illegible]	0.1015	$15,140
25		$177,393	$177,393	0.4776	$84,724	[illegible]	[illegible]	0.0923	$16,373
26		$149,123	$149,123	0.4637	$69,147	[illegible]	[illegible]	0.0839	$12,512
27		$149,123	$149,123	0.4502	$67,133	[illegible]	[illegible]	0.0763	$11,375
28		$149,123	$149,123	0.4371	$65,178	[illegible]	[illegible]	0.0693	$10,341
29		$149,123	$149,123	0.4243	$63,280	[illegible]	[illegible]	0.0630	$9,401
30		$177,393	$177,393	0.4120	$73,083	[illegible]	[illegible]	0.0573	$10,166
TOTAL PRESENT WORTH				@ 3%	$32,211,000	[illegible]	[illegible]	@ 10%	$29,243,000

REVISED APPENDIX C - MANAGEMENT OF RISKS ASSOCIATED WITH LEAD AND ARSENIC IN RESIDENTIAL SOILS, VASQUEZ BOULEVARD/INTERSTATE 70 SUPERFUND SITE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET - SUITE 300
DENVER, CO 80202-2466
http://www.epa.gov/region08

November 22, 2002

Ref: 8EPR-SR

MEMORANDUM

Subject: Management of Risks Associated with Lead and Arsenic in Residential Soils, Vasquez Boulevard/Interstate 70 Superfund Site

From: Bonnie Lavelle
Remedial Project Manager

To: Administrative Record File

The purpose of this memorandum is to provide the basis for EPA's determination that remedial action is necessary to address unacceptable human health risks associated with potential exposure to lead and arsenic in the residential soils Operable Unit 1 of the Vasquez Boulevard/Interstate 70 (VB/I70) Superfund Site. This memorandum also provides the basis for VB/I70 Site-specific preliminary action levels for lead and arsenic in residential soil.

Human Health Risks Associated with Potential Exposure to Arsenic

EPA completed a quantitative baseline human health risk assessment (EPA, 2001a) which evaluated current and anticipated future exposure of residents within VB/I70 Site Operable Unit 1 to concentrations of arsenic measured in soil collected from their yards. The reasonably anticipated future land use of the residential area of VB/I70 is residential. It is not expected that the current land use will change. The exposure pathways of concern to residents are incidental ingestion of soil and dust, ingestion of home grown garden vegetables, and intentional ingestion of large amounts of soil by children with soil pica behavior. The adverse health effects associated with arsenic exposure that were considered by EPA are:

- Acute non-cancer effects (irritation of the gastrointestinal tract leading to nausea and vomiting). EPA evaluated the risk that such effects could potentially result from a one-time exposure to arsenic by a child with soil pica behavior who happens to ingest soil from a small area of a yard that contains arsenic levels higher than the average concentration in the yard.

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- Subchronic non-cancer effects (diarrhea, vomiting, anemia, injury to blood vessels, damage to kidney and liver, and impaired nerve function). EPA evaluated the risk that such effects could potentially result from lower level exposure for periods of a few months to several years by a child who plays preferentially in a small area of a yard during the summer months and happens to incidentally ingest soil at a rate characteristic of the upper percentile of the general population.

- Chronic non-cancer effects (similar to subchronic effects but also include skin abnormalities). EPA evaluated the risk that such effects could potentially result from lower level exposure over a long period of time such as that associated with long term incidental ingestion of soil and dust and ingestion of home grown garden vegetables by long time area residents who have spent their childhood and adult years living at the same residence.

- Chronic cancer effects (skin cancer, internal cancer including cancer of the bladder and lung). EPA evaluated the risk that such effects could potentially result from lower level exposure over a long period of time such as that associated with long term incidental ingestion of soil and dust and ingestion of home grown garden vegetables by long time area residents who have spent their childhood and adult years living at the same residence.

The baseline human health risk assessment quantified potential risks to residents with average levels of exposure and to residents with "reasonable maximum" levels of exposure. The intent of the reasonable maximum exposure scenario is to estimate an exposure case that is conservative, yet still within the range of possible exposures. Reasonable maximum is generally intended to characterize the 90th-95th percentile of the exposed population. Consideration of both average exposures and reasonable maximum exposures gives the risk manager a range of risk estimates to provide an indication of the variability, uncertainty, and inherent protectiveness in the assumptions used to quantify potential risks. Average exposures are sometimes referred to as "central tendency exposures". In this memorandum, the "average" and "central tendency"are used interchangeably.

Risk of Acute Effects

EPA's evaluation of the risk of acute effects from exposures to arsenic associated with soil pica behavior in children is considered to be a screening level evaluation because of the substantial uncertainty which exists in most of the exposure assumptions. The screening level calculations performed for the VB/I70 Site indicate:

- **Average soil pica exposures** may result in doses of arsenic that range from less than or equal to the reference dose (hazard quotient ≤ 1) to 100 times the reference dose (hazard quotient = 100). Between 294 and 1511 properties have arsenic concentrations that are predicted to result in an acute hazard quotient greater than 1 for average soil pica exposures.

- **Reasonable maximum soil pica exposures** may result in doses of arsenic that range from less than or equal to the reference dose (hazard quotient ≤ 1) to 300 times the reference dose (hazard quotient =300). Between 662 and 1841 properties have arsenic concentrations that are predicted to result in an acute hazard quotient greater than 1 for reasonable maximum soil pica exposures.

Risk of Subchronic Non-Cancer Effects

The baseline human health risk assessment indicates:

- At any residential property in VB/I70, children with **average levels of exposure** may incidentally ingest soil with arsenic and the resulting dose is predicted to be less than or equal to the subchronic reference dose (hazard quotient ≤ 1). There are no properties with arsenic concentrations that are predicted to result in a subchronic hazard quotient greater than 1 for average levels of exposure.

- Area children with **reasonable maximum levels of exposure** may incidentally ingest soil with arsenic that results in a dose ranging from less than or equal to the subchronic reference dose (hazard quotient ≤ 1) to 3 times the subchronic reference dose (hazard quotient = 3). There are 7 properties with arsenic concentrations that are predicted to result in a subchronic hazard quotient greater than 1 for reasonable maximum levels of exposure.

Risk of Chronic Non-Cancer Effects

The baseline human health risk assessment indicates:

- Area residents with **average levels of exposure** may, over a long period of time, incidentally ingest soil with arsenic and ingest garden vegetables with arsenic that results in a dose ranging from less than or equal to the chronic reference dose (hazard quotient ≤ 1) to 2 times the chronic reference dose (hazard quotient = 2). There are only 2 properties with arsenic concentrations that are predicted to result in a chronic hazard quotient greater than 1 for average levels of exposure.

- Area residents with **reasonable maximum levels of exposure** may, over a long period of time, incidentally ingest soil with arsenic and ingest garden vegetables with arsenic that results in a dose ranging from less than or equal to the chronic reference dose (hazard quotient ≤ 1) to 5 times the chronic reference dose (hazard quotient = 5). There are 26 properties with arsenic concentrations that are predicted to result in a chronic hazard quotient greater than 1 for reasonable maximum levels of exposure.

Cancer Risks

.The baseline human health risk assessment indicates:

- Area residents with **average levels of exposure** may, over a long period of time, incidentally ingest soil with arsenic and ingest garden vegetables with arsenic that results in a cancer risk ranging from 2×10^{-6} to 9×10^{-5}. There are no properties where cancer risks are predicted to exceed 1×10^{-4} for average levels of exposure.

- Area residents with **reasonable maximum levels of exposure** may, over a long period of time, incidentally ingest soil with arsenic and ingest garden vegetables with arsenic that results in a cancer risk ranging from 1×10^{-5} to 8×10^{-4}. There are 99 properties where cancer risks are predicted to exceed 1×10^{-4} for reasonable maximum levels of exposure.

Table 1 summarizes the results of the baseline human health risk assessment.

Determination of Unacceptable Risks due to Arsenic Exposure

EPA guidance contained in the Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-30 (EPA, 1991) states that where the cumulative carcinogenic site risk to an individual based on the reasonable maximum exposure (RME) for both current and future land use is less than 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted . The guidance further states that EPA should clearly explain why remedial action is warranted if baseline risks are within the acceptable risk range of 10^{-6} to 10^{-4}. A risk manager may decide that a level of risk lower than 10^{-4} warrants remedial action where, for example, there are uncertainties in the risk assessment results.

Risks will be managed by applying EPA guidance in OSWER Directive 9355.0-30 to each individual residential yard in Operable Unit 1 of the VB/I-70 Site. This is because the exposure unit in the baseline human health risk assessment is the individual residential yard (or a sublocation of the yard) and baseline risks were calculated for each individual residential yard. EPA will make decisions about whether remedial action is necessary on a yard by yard basis.

Consistency with the EPA guidance in OSWER Directive 9355.0-30 is thus achieved at the VB/I70 Site by comparing the predicted carcinogenic and non-carcinogenic risks at each individual property to the guidelines described in the directive.

Table 1 reveals that there are between 662 and 1841 individual properties where the predicted RME hazard quotient exceeds 1 for potential acute effects associated with soil pica behavior. In accordance with EPA guidance, remedial action is warranted at these properties.

Table 1 also reveals that there are 99 individual properties where predicted RME cancer risks exceed 10^{-4}. In accordance with EPA guidance, remedial action is warranted at these 99

properties. Of these 99 properties, there are 26 properties where the predicted RME hazard quotient exceeds 1 for chronic non-cancer effects, and 7 properties where the predicted RME hazard quotient exceeds 1 for both subchronic and chronic non-cancer effects.

Remedial action at the 99 properties which addresses unacceptable predicted RME cancer risks will also address unacceptable predicted RME non-cancer risks of subchronic and chronic effects but will NOT address unacceptable RME risks of acute effects.

Consideration of Uncertainties in the Baseline Human Health Risk Assessment for Arsenic

Uncertainties in the Estimates of Cancer Risk

OSWER Directive 9355.0-30 states that consideration of uncertainties in the baseline risk assessment may lead a risk manager to decide that risks lower than 10^{-4} are unacceptable, triggering the need for remedial action. EPA considered the uncertainty in the arsenic risk calculations for VB/I70 to determine whether remedial action is needed at properties where risks are predicted to be less than or equal to 10^{-4}.

EPA undertook several studies to increase the accuracy (reduce uncertainty) of the risk estimates for the VB/I70 Site. The first was a study to investigate the relative bioavailability of arsenic in the soil found in the VB/I70 Site (EPA, 2001c). In the absence of site specific information on relative bioavailability, it is common practice to use a default assumption as the value for this parameter or to ignore relative bioavailability altogether in risk estimates. Measurements based on site specific soils significantly reduce the uncertainty in estimates of this parameter. In the study on VB/I70 Site soils, relative bioavailability was measured in five different soils collected from residential yards in the Site. Variability in the relative bioavailability of arsenic was observed between the five different site soils EPA used a conservative estimate of the mean of the five values in the baseline risk assessment. This approach is expected to overestimate the true value of this parameter for any given soil in the residential yards in the Site. Thus the accuracy of the risk estimate was increased by using a VB/I70 Site-specific value and protectiveness was achieved by using a conservative estimate of the mean of all values measured at the Site.

The second study (EPA, 2001b) was an investigation into the VB/I70 Site-specific relationships between:

- arsenic in yard soil and arsenic in house dust;
- arsenic in yard soil and arsenic in garden soils;
- arsenic in garden soils and arsenic in garden vegetables.

Establishing these Site-specific relationships reduces the uncertainty in quantifying exposure and risk associated with incidental ingestion of soil and dust and ingestion of garden vegetables.

When risks are described as point estimates, it is difficult to evaluate the level of protectiveness inherent in the exposure assumptions used to calculate the risks. A point estimate of risk also does not provide any information about the uncertainties in the risk assessment. Uncertainty can be analyzed to some degree by comparing the central tendency point estimates and the RME point estimates. Large differences between the RME risk estimate and the central tendency risk estimate may indicate either a large amount of uncertainty in the estimates or a large amount of variability in the exposure parameters within the exposed population. At the VB/I70 site, the risk estimates indicate that cancer risks are within an acceptable range at properties if average or central tendency exposures are considered. Cancer risks are unacceptable at 99 properties if RME exposures are considered.

Another way to analyze uncertainty in risk estimates is by using Monte Carlo modeling, a computer based mathematical technique in which exposure parameters are characterized as probability density functions (PDF) rather than as point estimates. The premise of Monte Carlo modeling is that every assumption about exposure (e.g., the frequency of contact, soil ingestion rate) is a variable and can be modeled as a PDF. The PDF reflects a range of values with associated probabilities. In a Monte Carlo analysis, a risk calculation is repeated thousands of times using statistical techniques to select exposure values from the PDFs that characterize them. The thousands of combinations of exposure assumptions results in a range of risk estimates expressed as a distribution of risks that may exist at the site for the population being considered.

In theory, a Monte Carlo analysis can be performed for every property within the VB/I70 site. To simplify the analysis, EPA performed screening level Monte Carlo modeling of exposure and risk associated with a selected concentration of arsenic in soil at the VB/I70 Site. The results, which are included in the final Human Health Baseline Risk Assessment, indicate that the point estimate of risk for the RME scenario is located at the 99th percentile of the risk distribution. This means that it is highly unlikely that the chronic arsenic exposures EPA has characterized for the VB/I70 site are actually occurring in the people who reside there. The 99th percentile indicates that there is only a 1% chance that the RME chronic exposure is actually occurring at the Site and that only 1% of the population experience the RME exposure. These results indicate that the combination of exposure assumptions used by EPA for the chronic arsenic exposure assessment at this site may be at the upper bound of or even beyond the reasonable maximum exposure scenario.

The Monte Carlo analysis also showed that at properties where point estimate of risk is 1×10^{-4}, risks in the 90th percentile - 95th percentile range (the RME range) are 2×10^{-5} to 7×10^{-5}.

The uncertainty analysis indicates that actual risks are much more likely to be lower than the calculated point estimates of risks. Providing protection at the 1×10^{-4} risk level based on the point estimates of risk is likely to provide a level of protectiveness for the RME scenario in the range of 2×10^{-5} to 7×10^{-5}. Therefore, in accordance with EPA guidance in OSWER Directive 9355.0-30, based on EPA's consideration of the uncertainties in the cancer risk assessment for arsenic, remedial action is not warranted at those properties in VB/I70 where the point estimates of risk are less than or equal to 10^{-4}.

Uncertainties in the Estimates of Acute Risks

EPA also considered the uncertainty in the calculation of the risk of acute effects from exposures to arsenic associated with soil pica behavior in children. Two important facts were considered: (1) the distribution of soil ingestion rates for children with soil pica behavior is not known and (2) the frequency with which such children exhibit the behavior is also not known. Therefore, the application of Monte Carlo techniques to analyze the uncertainty in the calculations of acute risk is difficult and was not performed by EPA for the VB/I70 Site.

However, EPA characterized the theoretical average and RME point estimates of acute risk in screening level calculations. These estimates suggest that there are between 294 and 1511 individual properties with soil arsenic concentrations that are predicted to result in acute hazard quotient greater than 1 for the average soil pica scenario. There are between 662 and 1841 individual properties with soil arsenic concentrations that are predicted to result in acute hazard quotient greater than 1 for the RME soil pica scenario. The wide range of potentially affected properties, 294-1841, reflects the substantial uncertainty in quantifying these risks.

EPA guidance contained in OSWER Directive 9355.0-30 states that where the non-carcinogenic hazard quotient for an individual based on the reasonable maximum exposure for both current and future land use is less than 1, action generally is not warranted. EPA considered the range of 662 -1841 properties where application of this guidance indicates remedial action is warranted. This range is referred to as Case 1 (1841 properties) and Case 2 (662 properties) in the Baseline Human Health Risk Assessment. EPA also considered the following:

- EPA is not aware of any reported cases of acute arsenic toxicity attributable to ingestion of arsenic in soil.

- Limited data on urinary arsenic levels in residents of the VB/I70 area and the nearby Globeville neighborhood do not reveal the occurrence of high soil intakes by children.

- Inquiries by the Colorado Department of Public Health and Environment (CDPHE) into reports of known or suspected cases of arsenic poisoning in the community surrounding the VB/I70 site resulted in their conclusion, stated in a July 25, 2001 letter, that "....it appears that there is no obvious or identifiable

problem of arsenic exposure from environmental sources in the area of concern." (CDPHE, 2001).

- In the summer of 2001, a community health study known as the "Kids at Play" (KAP) Survey was conducted within the VB/I70 Site by the Colorado Department of Public Health and Environment and the University of Colorado Health Sciences Center. The survey was funded through a grant from the Agency for Toxic Substances and Disease Registry (ATSDR). The door-to-door survey included: (1) a census of resident children less than 6 years old; (2) a questionnaire about child behaviors related to soil contact; (3) collection of blood samples for lead analysis and urine samples for arsenic analysis. To date, 1340 children have participated in the KAP survey. Preliminary results indicate that less than 1% of children tested have initial urinary arsenic levels greater than 30ug/L, a level which ATSDR considers to be within normal levels. Upon repeat sampling no children had urinary arsenic levels greater than 30 ug/L.

These considerations suggest that arsenic risk from soil pica behavior may not be as significant as the theoretical calculations suggest. However, because of the high uncertainty regarding the magnitude and frequency of soil pica behavior, more reliable risk estimates for this scenario will not be possible until better data are collected on soil intake rates characteristic of soil pica behavior along with direct measurements of soil related exposures to arsenic.

Because of the substantial uncertainty in the risk calculations, the lack of evidence of soil pica behavior, the further lack of evidence that such behavior actually results in exposure to arsenic, and the lack of obvious or identifiable problem of arsenic exposure in VB/I70, EPA has determined that remediation is warranted at the minimum number of properties, 662, to address the risk of acute effects from theoretical exposures to arsenic associated with soil pica behavior in children who reside in the VB/I70 site. The Case 2 soil pica exposure scenario is considered the more appropriate scenario on which to base risk management decisions for risks associated with soil pica behavior. Remedial action is warranted at properties where the acute hazard quotient exceeds 1 for the Case 2 exposure scenario.

Development of Preliminary Action Levels for Arsenic in Residential Soils at VB/I70

Preliminary action levels are exposure point concentrations (EPCs) above which some remedial action is warranted. At the VB/I70 Site Operable Unit 1, the arsenic EPC is a conservative estimate of the mean concentration within an individual yard. An EPC for arsenic was calculated for each individual yard as part of the Baseline Human Health Baseline Risk Assessment.

Properties where remedial action is warranted will be identified by comparing the EPCs to the preliminary action levels. Consistent with OSWER Directive 9355 0-30, preliminary action levels for arsenic in residential soils at VB/I70 are:

- An EPC of 47 milligrams per Kilogram (mg/Kg) which is the level of arsenic in soil associated with an acute hazard quotient which exceeds 1 for the Case 2 RME soil pica scenario.

- An EPC of 240 mg/Kg which is the level of arsenic in soil associated with an RME cancer risk which exceeds 1×10^{-4} as a point estimate, 2×10^{-5} as the 90th percentile of the risk distribution, and 7×10^{-5} as the 95th percentile of the risk distribution.

Human Health Risks Associated with Potential Exposure to Lead

EPA's quantitative baseline human health risk assessment for the VB/I70 Site Operable Unit 1 also considered the health risks associated with exposure of residents to concentrations of lead measured in soil collected from their yards The population of most concern for exposure to lead in soil is young children EPA evaluates risks associated with exposure to lead by considering total exposure via all sources and pathways in the environment rather than to site related exposures only. This requires assumptions about the level of lead in food, air, water, and paint as well as the level of lead measured in yard soils.

The adverse health effect associated with lead exposure that was considered by EPA is lead-induced neurobehavioral effects in children. EPA's OSWER determined that, in Superfund Site cleanups, EPA will attempt to limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a blood lead level of 10 micrograms per deciliter (ug/dL) (EPA 1994). EPA has identified this blood lead level as the level at which health effects which warrant avoidance in children begin to occur.

The baseline human health risk assessment indicates that there is a greater than 5% chance that a child will have a blood level of 10 ug/dL as a result of exposure to lead in soil at 1331 properties. This prediction of lead risk was determined by using EPA's Integrated Exposure/Uptake Biokinetic (IEUBK) Model. In order to increase the accuracy of the model results, EPA used VB/I70 Site-specific data on the relationship between lead in the fine and bulk fractions of soil, the relationship between lead in yard soil and lead in house dust (EPA, 2001b), and the relative bioavailability of lead in soils (EPA, 2001d).

Consideration of Uncertainties in the Baseline Human Health Risk Assessment for Lead

In order to investigate some of the sources of uncertainty in the IEUBK model predictions for the VB/I70 Site, EPA ran the model a number of times, varying the values for dietary lead

intake, geometric standard deviation of blood lead levels, and soil intake rate to reflect recently published data. The results of the alternative model runs are presented in the final Baseline Human Health Risk Assessment document.

The range of results indicate that there is a greater than 5% chance that a child will have a blood level of 10 ug/dL as a result of exposure to lead in soil at between 2 and 1331 properties. This wide range indicates substantial uncertainty in predictions of blood lead levels using the IEUBK model at the VB/I70 site.

EPA also predicted blood lead levels in children in VB/I70 using a different model than the IEUBK. The results of this modeling effort, also presented in the final Baseline Human Health Risk Assessment, indicate that there are no properties where lead levels in soil are predicted to result in a greater than 5% chance that a child will have a blood level of 10 ug/dL, suggesting that remedial action to address lead in soil may not be warranted.

Consideration of Observed Blood Lead Values in Children Who Reside in VB/I70

EPA reviewed the available information on measured blood lead levels in the population of children in VB/I70 to better understand how well the IEUBK model was predicting blood lead levels at the Site. The CDPHE offered three separate blood lead testing programs to children living in the VB/I70 site during the period 1995 through 2000 and provided the results of this testing to EPA. Although the blood lead testing was not designed or intended to support risk assessment, the data support the following conclusions:

- elevated blood lead levels do occur in children residing within the site
- soil is not likely to be the main source of elevated blood lead levels in children
- the elevated blood lead levels that were observed in children within VB/I70 are not clearly different from the elevated levels observed in children who live outside of VB/I70

In the summer of 2001, a community health study known as the "Kids at Play" (KAP) Survey was conducted within the VB/I70 Site by the Colorado Department of Public Health and Environment and the University of Colorado Health Sciences Center. The survey was funded through a grant from the Agency for Toxic Substances and Disease Registry. The door-to-door survey included: (1) a census of resident children less than 6 years old; (2) a questionnaire about child behaviors related to soil contact; (3) collection of blood samples for lead analysis and urine samples for arsenic analysis. To date, 1340 children have participated in the KAP survey. Preliminary results indicate that less than 3.2% of children tested have blood lead levels greater than 10ug/dL.

Development of Preliminary Action Levels for Lead in Residential Soils at VB/I70

Each alternative IEUBK model run predicts that EPA's health goal for lead in soil will be met at a specific average soil lead concentration or lead EPC in an individual yard. The alternative model runs performed by EPA resulted in a range of such EPCs These are average lead concentrations in a yard above which remedial action may be warranted to achieve EPA's health goal and are referred to as preliminary action levels. The range of soil lead concentrations is presented in Table 2.

EPA considered the following factors in developing the preliminary action levels for lead from the range provided in Table 2 that will be used in the feasibility study for the VB/I70 Site:

- Available blood lead data indicates that soil is not likely to be the main source of elevated blood lead levels in children in VB/I70.

- Predictions using an alternative model suggest that remedial action of soil may not be required to achieve EPA's health goal for lead in soil.

These factors led EPA to develop two preliminary action levels for lead in soil at VB/I70:

(1) 208 mg/Kg as the yard EPC. This is the soil concentration at the lowest end of the range of soil concentrations that the IEUBK model predicts EPA's health goal will be exceeded; and

(2) 540 mg/Kg as the yard EPC. This is the soil concentration at the middle of the range of soil concentrations that the IEUBK model predicts EPA's health goal will be exceeded.

Remedial action is warranted at any individual yard where the lead EPC exceeds either of these preliminary action levels. Based on the indications from the available blood lead data and the uncertainty that remedial action is warranted at all to address lead risks, EPA considers 540 mg/Kg as the preliminary action level for engineering actions. This recognizes that soil is not likely to be main source of elevated blood lead levels.

References:

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EPA, 2001c. Relative Bioavailability of Arsenic in Soils from the VBI70 Site. Report prepared for EPA Region VIII by Syracuse Research Corporation. January 2001.

EPA, 2001d. Relative Bioavailability of Lead in Soils from the VBI70 Site. Report prepared for EPA Region VIII by Syracuse Research Corporation. February 2001.

Table 1
Summary of Baseline Human Health Risk Assessment for Arsenic
VB/I-70 Residential Soils

Health Effect	Average or Central Tendency Exposure		Reasonable Maximum Exposure	
	Range of Calculated Risks	# properties where risks are predicted to be unacceptable	Range of Calculated Risks	# properties where risks are predicted to be unacceptable
acute non-cancer effects	$.07 \leq HQ^1 \leq 100$	294-1511	$0.2 \leq HQ \leq 300$	662- 1841
subchronic non-cancer effects	$.003 \leq HQ \leq 0.8$	0	$0.01 \leq HQ \leq 3$	7
chronic non-cancer effects	$.04 \leq HQ \leq 2$	2	$0.1 \leq HQ \leq 5$	26
cancer effects	$2 \times 10^{-6} \leq$ Cancer Risk $\leq 9 \times 10^{-5}$	0	$1 \times 10^{-5} \leq$ Cancer Risk $\leq 8 \times 10^{-4}$	99

1. HQ = hazard quotient, defined as ratio of predicted site dose to reference dose

Table 2 Alternative Preliminary Action Levels for Lead in Soil VB/I70 Site				
IEUBK Model Run	**soil intake rates**	**Dietary Lead Intake Values**	**Geometric Standard Deviation of Blood Lead Values**	**Predicted Lead Soil Level at P10 < 5%[1] (mg/Kg)**
1	default	default	1.6 (default)	208
2	default	revised	1.6 (default)	246
3	default	default	1.4	326
4	default	revised	1.4	362
5	default	revised	1.3	443
6	default	default	1.2	542
7	default	revised	1.2	581
8	Stanek and Calabrese, 2000	default	1.6 (default)	1100

1. P10 < 5% = less than 5% probability that blood lead levels exceed 10 ug/dL