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TA-16

NOV 20 1992

Mr. Benito Garcia, Chief
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Bureau
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Dear Mr. Garcia:

In recent discussions between the New Mexico Environment Department (NMED) and David McInroy of the Los Alamos National Laboratory (LANL) Environmental Management Division, NMED expressed a willingness to allow the Area P Landfill closure to be addressed under the ongoing Resource Conservation and Recovery Act (RCRA) corrective action program at LANL. This letter serves to describe a methodology for the Department of Energy (DOE) to incorporate the Area P Landfill closure design in the RCRA Facility Investigation (RFI) process currently ongoing at LANL.

The Area P Landfill is located within Operable Unit 1082 which includes Technical Area 16 (TA-16). In accordance with the Hazardous and Solid Waste Amendments (HWSA) module to LANL's RCRA permit, the RCRA Facility Investigation (RFI) Work Plan for Operable Unit (OU) 1082 must be submitted to the EPA in May 1993. As you are aware, DOE submitted a modified closure and post-closure plan for the Area P Landfill under letter of February 3, 1988. This plan has not yet been approved by NMED. In developing the RFI Workplan for OU 1082 of which the Area P Landfill is a part, it has come to our attention that several technical issues and concerns about the previously proposed closure have not been fully addressed. The RFI process would offer an ideal opportunity to complete a full investigation and characterization of the Landfill site and it would aid in a final determination concerning whether contaminant migration will be adequately prevented after final closure.

In making the decision to include the Area P Landfill in the RFI process, LANL has conducted a Focused Feasibility Study of nearly a dozen likely closure alternatives for the Landfill site, including in-place closure and "clean closure" alternatives. This study is enclosed for your review and information. The feasible in-place closure alternative would involve capping and monitoring with the possible addition of downgradient alluvial water collection and treatment. The clean

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closure alternatives would involve excavation, mandated treatment of RCRA wastes with possible recycling of non-RCRA wastes, and disposal in permitted facilities of LANL or in other permitted commercial facilities. These two basic closure alternatives were judged to be the most feasible remedial options for the Area P Landfill based on the criteria of implementability, long-term effectiveness and permanence, protectiveness of the environment and public health, and cost.

The RFI Program for OU 1082 will provide for a two year phased approach to thoroughly examine potential contaminant migration routes and the existence of contamination away from the Landfill. The first phase of this process would include substantial sampling and analysis of suspect routes of migration including surface and alluvial water, seeps from the alluvial area in the canyon walls, and the sediment transport in the drainage courses of the canyon downgradient from the Landfill. Also included in this phase of investigation would be the installation of borings beneath the landfill and conducting column leaching studies on barium sand waste materials similar to those in the Landfill. The second phase of the program would be developed to more closely analyze any contaminant migration route found in the first phase. This phased approach will provide the as yet unavailable, but necessary information to develop a closure method with satisfactory assurance of permanence.

It is proposed, therefore, that a modified closure document for the Area P Landfill of TA-16 be submitted to NMED by August 30, 1993. This will allow for completion of the RFI Work Plan in May 1993 and the incorporation of the final sampling and analysis program in the revised closure plan. Both the closure in-place alternative and the clean closure alternative described above would be included in revised closure plan with a detailed description of the two year sampling and analysis program that will be utilized to determine which method should be instituted. The implementation of the RFI sampling program for OU 1082 including Area P Landfill is currently scheduled to begin in the Fiscal Year 1995.

In the meantime, commencing with the submission of the closure plan, LANL will implement an interim field evaluation program including:

- quarterly visual physical inspection of stability of the landfill slope face and surface

- stormwater sampling Canon del Valle stream, upstream and downstream from the landfill, three to four times per year for barium and other indicator parameters

- continuation of the current research investigation begun in the summer of 1992 on environmental barium transport in the vicinity of the Area P Landfill. A letter report of this work will be provided to NMED when the research is completed. This work will include column leaching studies on barium sands similar to those disposed of in the landfill.

Please let me know if this approach will be acceptable. If it would be desirable to schedule a meeting to discuss this plan of action for the closure of Area P Landfill, please contact Mr. Steve Slaten of my staff by telephone at (505) 665-5050.

Sincerely,

Joseph C. Vozella

Joseph C. Vozella, Acting Chief
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Focused Feasibility Study for Area P Landfill

28 September 1992
Revision 1

Prepared for
Operable Unit 1082
Los Alamos National Laboratory
Environmental Restoration Program
Los Alamos, NM

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SECTION 1 INTRODUCTION

1.1 Purpose and Scope

Environmental Resources Management, Inc. (ERM) was tasked under Environmental Restoration Program Work Release 92-0008 dated 10 August 1992 to conduct a focused feasibility study of Remedial Options for the Area P Landfill Site located at Technical Area 16 (TA-16).

The purpose of this focused feasibility study is to develop and review technologically possible options for remediation. An evaluation will be performed for each alternative utilizing the baseline criteria of: implementability; long term effectiveness and permanence; protectiveness of the environment and public health; and cost. This evaluation will then be used to perform a relative ranking of alternatives to aid in decision-making about the site. Alternatives that are not feasible based on the criteria utilized may be identified and other alternatives that are most feasible will be highlighted. While this type of a focused study is not sufficient to select a final remedial alternative, it can provide a sound basis for the design of site characterization studies and for predesign studies of site closure as well as to identify specific data to be collected during sampling. In the instance of the Area P Landfill, a closure plan has already been developed for closure in place by capping and leachate collection. A possible alternative scenario is remediation/closure under the RCRA corrective action process following inclusion of the site in the RCRA Facility Investigation for Operable Unit 1082 (of which TA-16 is a part). The focus of this study will be to aid in the determination of whether to proceed with efforts to obtain State regulatory approval of the previously developed closure plan, or to include the site in the planned RCRA Facility Investigation prior to final determination of the appropriate remedial/closure option that should be implemented.

Los Alamos National Laboratory (LANL) operated Area P as an industrial landfill from the 1950s to 1984. Disposed materials primarily consist of residues and noncombustible debris resulting from burning high explosive-contaminated equipment, building materials, and trash. The landfilling procedure was to dump this waste material over the edge of the slope that forms the beginning of the canyon wall. The landfill covers an area of approximately two (2) acres and contains an estimated 16,000 cubic yards of material. Disposal records do not exist to document the types, amounts, and locations of wastes buried at the Area P site. Several waste residue samples taken in 1984 exceeded the hazardous waste Extraction Procedure (EP) toxicity limit for barium and, subsequently, the landfill became

regulated under the New Mexico Hazardous Waste Management Regulations. LANL opted not to continue operation of the Area P Landfill and waste disposal was discontinued at the site in 1985. Following the loss of interim status provisions, LANL submitted a closure and post-closure plan to the New Mexico Environmental Improvement Division in 1988, and the state regulatory review process is pending.

1.2 Report Organization

This feasibility study report includes a list of the technologically possible remedial options for the Area P Landfill Site and a comparative evaluation of those options using the following criteria:

- Implementability
- Long-term effectiveness and permanence
- Protectiveness of the environment and public health
- Cost

The use of these criteria will help narrow the field of possible options in later, more formal evaluations under the Corrective Measures Studies of the RCRA Corrective Action provisions of LANL's hazardous waste facilities permit.

In order to develop remedial alternatives, detailed reviews of existing data (archival information, reports, maps, etc.), EPA and State regulatory constraints, and remedial precedents were conducted. In addition, the site was inspected to view current site conditions and to make simple field measurements to verify existing site area and volume estimates.

The first section of the report, Section 1, discusses site history, the scope of previous investigations, and the physical site inspection that was conducted by ERM. Section 2 provides an interpretation of contaminants of concern identified by the previous investigations and the available data. An analysis of the known extent of the contamination and the possible routes of exposure is also provided in Section 2.

Section 3 discusses regulatory issues which govern the closure/remediation of the site. This section also provides the results of a literature search for precedents from closure/remediation of similar sites.

Section 4 identifies and evaluates remedial alternatives that are judged technically possible. The alternatives are compared based on the criteria

mentioned above to narrow the probable alternatives that may ultimately be chosen for the site.

Lastly, Section 5 provides recommendations concerning the suggested actions that should be followed in order to develop sufficient data upon which final closure/remediation decisions can be made.

1.3 Site History and Description

Material Disposal Area P (MDA P) is an industrial landfill located in TA-16 that was active from the 1950s to approximately 1985. In 1984, the landfill became subject to RCRA regulation when several landfill soil/waste residue samples were analyzed for EP toxicity and threshold limits for barium were exceeded. There are no records documenting the types, quantities, or locations of wastes placed into the MDA P Landfill. Since the early 1950s, the site was used to dispose of building demolition rubble and equipment and waste materials that had been contaminated with high explosives. Prior to November 1985, high explosive (HE) contaminated wastes and equipment were burned on sand-covered pads at S Site (TA-16). After the burn, the sand and burned wastes were removed and placed in the landfill. The sources of barium in the residue are oxidized and environmentally degraded byproducts of barium nitrate that were used in the formulation of some high explosives. Known wastes placed in the landfill include concrete rubble, structural steel, burn pad sand, burned equipment, and empty solvent cans. Lead shielding, beryllium metal fragments, and other metals may be present in the landfill. It is not known if radiologically contaminated materials, such as depleted uranium, incorrectly found their way into the landfill.

The Area P Landfill (Figure 1) is located in a topographic saddle of a short, eastern-trending, narrow mesa. The saddle is near the southern rim of Canon de Valle, immediately north of the TA-16 thermal treatment pad number 387. A 1983 photograph of the site is enclosed following Figure 1. Figures 2 and 3 show the areas influenced by the landfill as determined by a comparison between a pre-landfill survey and a more recent survey (Delta H Engineering, Ltd., 1985). The surface runoff over the face of the landfill shown in Figure 2 is currently collected by a drainage trench located immediately north of and parallel to the fence. This collected surface water runoff is directed around the eastern edge of the landfill into the canyon. The area impacted by the landfill is approximately two acres and contains an estimated 16,000 cubic yards of waste construction debris, crushed tuff, sandy clay fill material, and barium contaminated sands and wastes. Within this two acre site are two distinct waste lobes created as landfilling progressed from the west to the east. The west area of the landfill was closed by leveling and covering the wastes with crushed tuff and sandy clay

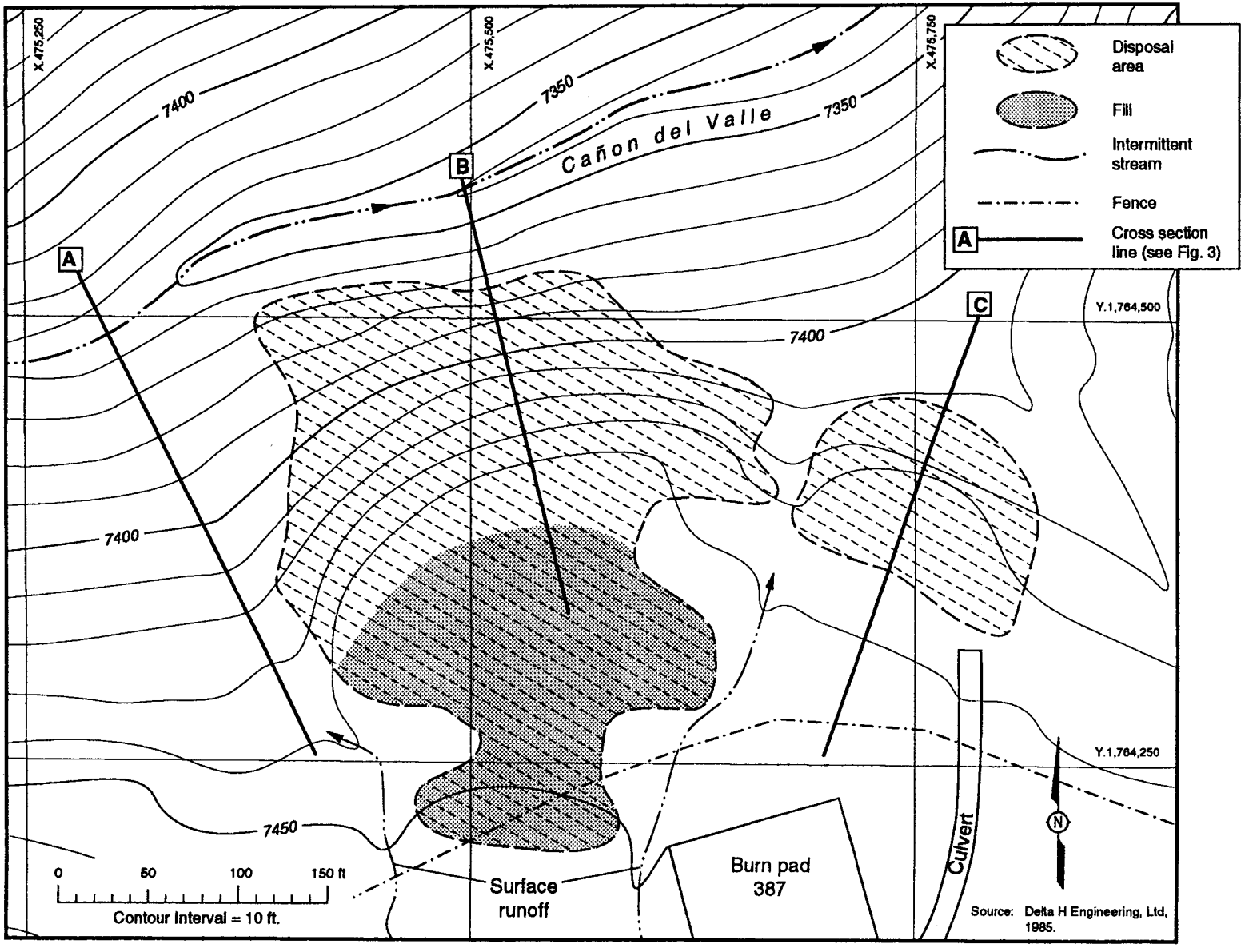
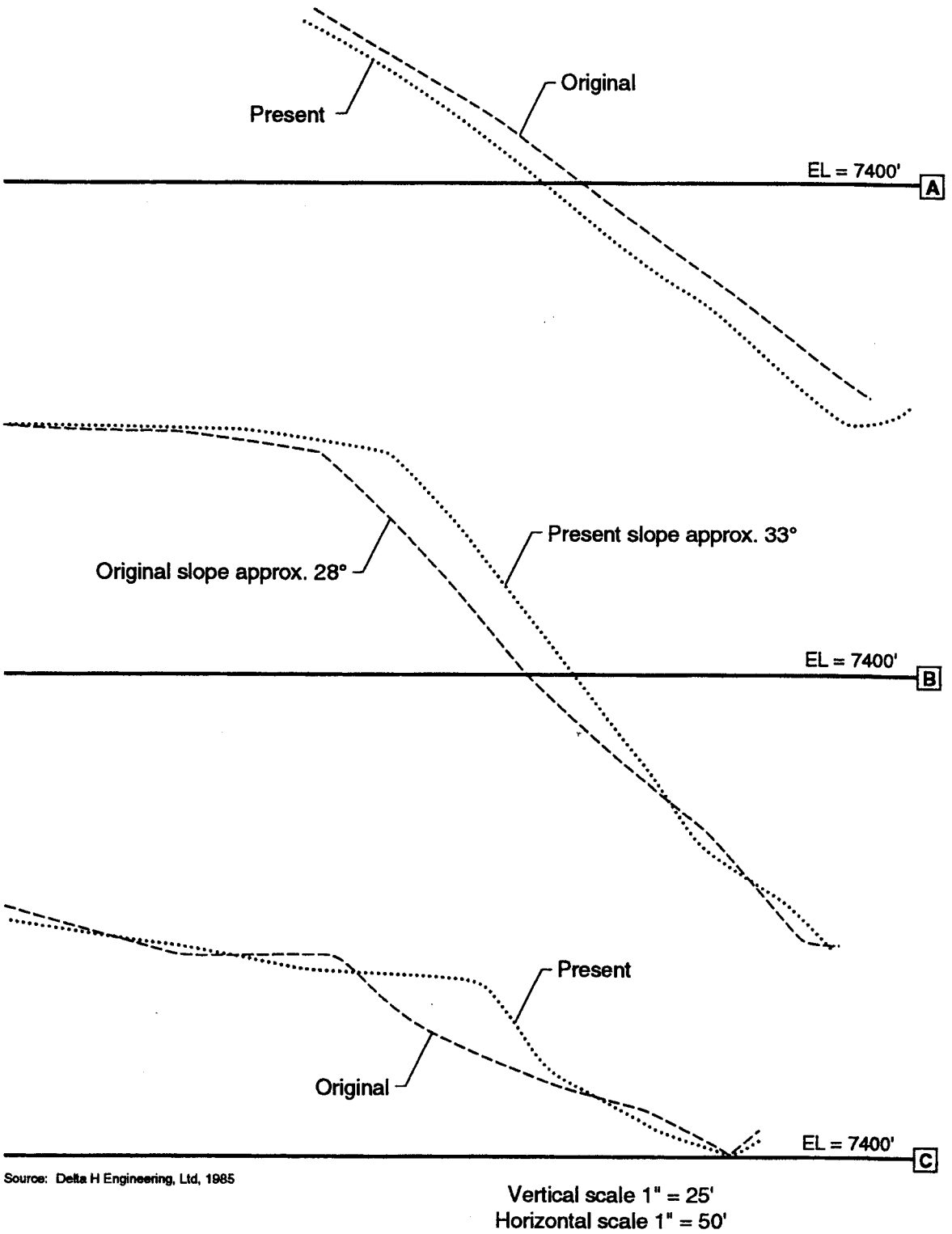


Figure 2. Area P landfill.



Source: Delta H Engineering, Ltd, 1985

Figure 3. Area P cross sections A, B, and C.

soils. The leveling process overflowed the rim in the northwest quadrant of the west area, as documented by the original undisturbed elevation changes shown in cross section A. Cross sections B and C (respectively in the western and eastern areas of the landfill) show large quantities of wastes (12 to 14 feet deep at the rim) located on the steep canyon slope. While the cross sections suggest that waste deposition begins only 30-40 feet south from the rim, the visual inspection (and Figure 2) indicate that this deposition distance may be three or four times higher. It should be noted that the cross sections shown resulted in a 1985 volume estimate of 13,000 cubic yards. The 16,000 cubic yard estimate was computed by ERM based on field measurements (see Section 1.4).

The western area of the site is believed to be covered with approximately one foot or more of cover material. The eastern area was covered with earth as waste deposition proceeded. The depth of the eastern cover material is unknown and is probably less than the cover placed over the western area. Past proposals have suggested different closure schemes to the western and eastern areas because of this difference in cover material and depth. No evidence could be found in historical documents, however, to differentiate waste materials placed in the western versus eastern areas.

1.4 Site Visit

ERM conducted a site visit on 18 August to view current site conditions and to make field measurements to confirm landfill volume estimates. Current site status is consistent with previous reports and documents. The site appears essentially the same today with the exception of surface drainage control.

As previously described in past documents, the landfill has two distinct portions; the west area that was partially closed by leveling and covering with soil and the smaller east area that was the most recently active portion of the site. Sandy clay soil covers the west side of the landfill and supports fair stands of grasses and brush. Although leveled and covered, demolition rubble and piping remain visible on parts of the western portion north slope. The east landfill area progressed from south to north, with some cover material being applied as the landfill advanced. The covered portion of the east area supports very little vegetation and the wastes on the north slope remain virtually totally exposed. The steep landfill slopes appear to be only partially stable, as indicated by the amount of debris that has fallen to the canyon floor. Surface drainage skirts the southeastern boundary of the eastern landfill area. A well-drilling access road that leads around the west perimeter of the western landfill area is heavily eroded by surface runoff.

A wide variety of waste types have been placed in MDA P based on visual observation. The types of wastes observed include large items such as sumps, filter baskets, foundation concrete blocks, structural steel supports, and metal piping. Many types of empty containers are present ranging from small metal solvent cans, glassware, and bottles to large 55-gallon drums.

In order to confirm reported landfill volume, taped field measurements were made across the top of the two disposal areas. The original slope angle and height were approximated at 32° and 80 feet, respectively. Using the disposal depth documented by the previous cross sections and simple straight line geometry, the landfill disposal volume was calculated to be approximately 16,000 cubic yards. This quantity is consistent with previous reported estimates of 13,000 cubic yards.

1.5 Previous Investigations

Previous investigations and studies at MDA P have focused respectively on: establishing a database of information; submitting landfill closure and post-closure plans; and identifying landfill closure alternatives. These three types of investigations/studies will be discussed in the following three subsections.

1.5.1 Data Collection

Data collection has proceeded in two phases that include: characterization, monitoring the subsurface, and sampling and analyzing site media. Phase 1 was conducted from mid-1987 to early-1988 and involved groundwater monitoring well installation along the north face of the landfill, analyses of core samples from these well borings for metal contamination and hydraulic properties, and stream surface and sediment sampling. Phase 2, conducted in late-1988, consisted of installation of vadose zone monitoring wells through the landfill wastes, core analyses from these well borings for barium, nitrate, and explosives contamination, and a survey of stream surface water and sediments.

The Phase 1 investigation began with a drilling program to characterize the subsurface and to sample the groundwater beneath the site. Seventeen boreholes were drilled and logged in the vicinity of the landfill site. Four holes were completed as RCRA groundwater monitoring wells (P-3, P-4, P-6, and P-8) and are located at the northern limit of the waste disposal area. These wells have been screened partially in the alluvium and partially in the underlying tuff to detect liquids travelling along the alluvium-tuff horizon. Four additional holes were completed as wells (P-1, P-5, P-7, and P-9) to detect groundwater in the alluvium between the canyon stream and the

landfill. Five boreholes were completed as neutron moisture access wells (P-0, P-12A, P-13, P-14, and P-16A) and four boreholes (P-2, P-10, P-11, and P-15) were sealed and closed after logging. Monitoring did not detect free-flowing groundwater in any of the 17 holes. Core samples recovered from borehole P-16A were analyzed for metal concentrations, volumetric moisture content, and average gravimetric moisture content. Additional laboratory analyses were conducted on unidentified core samples for saturated hydraulic conductivity, unsaturated hydraulic conductivity, initial moisture content, bulk density, and porosity. The Phase 1 investigation concluded with a reconnaissance water quality and sediment sampling survey. Five surface water samples (57, 59, 63, 64, and 70) and 11 stream sediments and soil samples (55, 56, 58, 60, 61, 62, and 65-69) were collected and analyzed for metal concentrations.

Thirteen boreholes were installed to complete a vadose monitoring well system as part of the Phase 2 investigations. Each borehole penetrates through the landfill and into the underlying tuff material. These boreholes were completed as a coupled network of seven pressure-vacuum lysimeters in four boreholes (L-17 through L-20), four neutron moisture access wells (P-17 through P-20), and five exploration boreholes (B-1 through B-5) that were plugged and abandoned after logging. The pressure-vacuum lysimeter and neutron moisture access boreholes were completed as two-well nests; each well nest consists of a lysimeter well and a neutron moisture access well; approximately 8 feet separates the wells from each other (horizontally). Landfill soil and underlying tuff samples were recovered and analyzed for barium, nitrate, and residual explosives concentrations. Pore water samples collected by lysimeters were tested for barium and nitrate concentration. Similar to Phase 1, Phase 2 investigations concluded with a stream sampling survey. Stream surface water and sediment samples were collected at 14 stations along Canon de Valle and analyzed for barium and nitrate concentrations.

No radiological surveys have been performed on materials or wastes at the site.

The Phase 1 and 2 investigations have yielded the following findings:

- Several landfill residue core samples have exceeded the RCRA regulated EP toxicity limit for barium. Other metals in leachate extracts from these samples are below detectable limits. Nitrate concentrations in the same leachate extracts are at or below 2.6 mg/l. This can be compared to a drinking water maximum contaminant level (MCL) of 10 mg/l for nitrate.

- Stream water and sediment samples taken on the stream and in drainage channels from the landfill surface indicate that the landfill is not the

source of elevated barium concentrations levels in the stream water and sediment. These contaminants apparently originate from upstream wastewater discharges. Lead was the only other metal identified above detection limits, appearing in only one sediment sample taken from a surface runoff drainage channel on the surface of the landfill.

- Landfill materials contain low levels of residual explosives (less than 1.5 wt.% acetonitrile solubles).

- Barium concentrations in recovered lysimeter pore water samples are significant, ranging from 1.1 mg/l to 37.8 mg/l. The barium MCL is 2 mg/l.

1.5.2 Landfill Closure Plans

The Area P Landfill Closure and Post-Closure Plan was originally prepared by Delta H Engineering, Ltd. in 1985. The plan was later modified by LANL and submitted to the New Mexico Environmental Improvement Division in 1988. The plan modifications were submitted with the intent that the Area P landfill fully comply both with interim status (40 CFR Part 265) for closure and permitting (40 CFR Part 265) for post closure care. The plan documents closure and post-closure activities based on current knowledge of the site, including landfill extent, possible hazardous constituents, geology, and hydrology. The west and the east area of the landfill site were proposed to be closed separately. Because the west area of the landfill is already leveled and covered, the closure plan includes only the installation of an adequate monitoring system. Monitoring consists of using neutron probe test holes and two trenches to detect and collect leachate, if generated. The east area closure plan requires surficial stabilization and a cap. The face of the east area would be stabilized by constructing a concrete blanket and installing a RCRA cap. Monitoring through the post-closure period for both east and west portions includes:

- leachate sampling and analysis
- neutron probe measurement of tuff below landfill
- erosion rate monitoring
- ground water monitoring of perched water in canyon
- surface water monitoring

1.5.3 Landfill Closure Alternatives

Closure alternatives for the Area P landfill have been outlined in a 1990 report by IT Corporation. The report provides a general discussion of the options available for closure. Also included are the geotechnical and regulatory issues and the health and safety and cost considerations regarding each option in general terms. The four conceptual closure options included in this report are total removal, partial removal, in situ treatment, and no removal-no treatment. The total removal option requires excavation of the entire landfill and contaminated tuff, treatment on- or off-site, and disposal on- or off-site. Partial removal involves excavation, treatment and disposal of only the hazardous portions of the landfill. The in situ treatment alternative uses either in situ leaching or in situ stabilization. There are three methods pertaining to the no removal-no treatment alternative: total encapsulation, partial encapsulation, and no action. Total and partial encapsulation would involve stabilizing the slopes and covering either the entire area or only a portion of the landfill. No action leaves the landfill in its current state. All three of the no removal-no treatment alternatives would require post-closure monitoring.

SECTION 2 CHARACTERIZATION OF SITE CONTAMINATION

2.1 Contaminants of Concern

As explained in Section 1.5, contaminants that have been monitored during the various past investigations at the site have included: nitrate; metals including arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver; high explosives including, total acetonitrile solubles, HMX, RDX, TNT, and DNT. No analyses on environmental or waste samples from the site or site area have been performed for solvents, beryllium, or radiological contaminants.

Based on the analysis of available data, it is apparent that barium is the primary contaminant of concern at the site. It is the constituent of the waste materials that originally caused the site to be regulated as a RCRA facility and it is soluble in water as well. Additionally, barium is also a constituent for which there is an established maximum contaminant level (MCL) under the safe drinking water act of 2 mg/l. This level of barium therefore could be used as a threshold level in groundwater and surface waters to determine if significant contaminant migration is indeed taking place. The MCL would also likely be applied as a clean-up goal for any

landfill closure/remedial activities as a level that must be maintained in groundwater and surface waters around the site.

A second contaminant of concern, that has only been analyzed to a limited extent at the site, is nitrate. Although nitrate is not a constituent that would cause a waste to be regulated under RCRA, it is a contaminant for which an MCL exists of 10 mg/l. Additionally, as was previously mentioned, existing sampling of surface water and sediment from drainage channels across the face of the landfill and in the stream on the canyon floor did not detect any metal contamination with the exception of one positive result for lead. Although this is a strong indication that lead is not migrating at the site, historical records indicate that it is highly possible that quantities of lead materials could be disposed in the landfill. Lead could also be naturally occurring. For this reason, lead should continue to be an ongoing constituent of concern.

Previously, analyses for high explosives (both total acetonitrile and specific HE compounds) have revealed no safety hazards in samples taken from the landfill. Sampling for these materials has not been conducted in surface water or sediment around the landfill site, however. Because there are environmental concerns in addition to those safety concerns for the migration of HE constituents from the landfill, HE should continue to be a contaminant of concern.

Lastly, no analyses for beryllium or for radiological materials that may be present in the landfill has ever been conducted. It has believed unlikely that radiological materials or beryllium are present in significant quantity in the landfill. However, parameters of concern for future characterization of the potential landfill contaminant migration should include basic radiological screening (gamma, alpha, and beta) and analyses for beryllium to confirm that none of these materials are present.

In summary, contaminants of concern include the following:

- barium
- nitrate
- lead
- HE including HMX, RDX, TNT, DNT
- screen for gamma, alpha, beta radiation
- beryllium

2.2 Extent of Contamination

Although the distribution of contaminants within the landfill is not well characterized, there is a substantial amount of data to show that at least some of the contaminants of concern previously mentioned have not significantly migrated outside the landfill area. This data would include analyses for barium and for other metals. Vertical migration of barium into the tuff underlying the landfill has been documented to a depth of approximately six (6) feet beneath the landfill in at least one (1) boring that penetrated directly through the landfill. Additionally, pore water samples taken from pressure vacuum lysimeters located within the waste materials showed results of up to 37.8 mg/l barium to be present. No lysimeter samples of pore water were able to be obtained from the tuff materials located under the landfill. All of the lysimeters located at wells surrounding the landfill have also failed to yield any water samples.

In summary, the existing data shows that the only contaminant of concern that has migrated beyond the landfill limits of waste materials is barium, which has been documented to have been carried into the tuff under the landfill to a depth of 6 feet; it is not known if barium has migrated further than this distance vertically. There is no significant evidence of migration of any other contaminants of concern via surface water runoff, sediment erosion, seeps or any perched areas of alluvial ground water.

2.3 Routes of Exposure

Based on the review of the previous investigation data, it is apparent that two potential routes of exposure exist for the migration of contaminants of concern. The first potential route of exposure is physical transport of waste materials via stormwater erosion, seeps from the landfill caused by precipitation intrusion into the surface of the landfill, or surface-derived water from the hillside underneath the landfill. The second potential route of exposure is through soluble contaminant migration via infiltrated precipitation or seeps as above mentioned.

The first route of migration is made possible due to the incomplete cover of the surface of the landfill and the north face of both the eastern and western areas of the landfill where waste materials are present at the surface. This route of migration has been mitigated by the previously described covering of portions of the landfill and also by the rerouting of surface drainage around the landfill. The second route of exposure via the vertical infiltration of precipitation into the landfill is much more difficult to

quantify. Previous attempts have been made to model this migration route in a report by Nyhan dated March 1989. There is little information, however, concerning the existence or possible extent of any migration of water into the landfill through the bottom surface of the landfill via cracks or seeps in the former canyon hillside. The only possible migration route for any dissolved contamination that would originate from the landfill would be through surface water transport via the stream that flows through the canyon. McLin (1989) has reported that the downward movement of water in the vadose zone is greatly restricted due to the very low rated hydraulic conductivity of the shallow tuff materials beneath the landfill and the existence of several densely welded tuff units at deeper depths that have even lower unsaturated hydraulic conductivity values. The main aquifer is located approximately 1,230 feet below ground surface. As reported in the Delta Engineering closure report (as modified by the Laboratory in January 1988), the moderately welded and welded tuff underlying the landfill has saturated hydraulic conductivity for moderately welded tuff ranging from 0.1 to 1.7 ft/day, and for welded tuff ranging from 0.009 to 0.26 ft/day. The possibility of a joint penetrating several layers of tuff and forming a conduit to ground water is highly unlikely. Generally these joints are filled, particularly at the surface, with clay weathered from the tuff, effectively sealing the joint.

In summary, the two routes of contaminant migration are:

- physical erosion via contact of surface water runoff or precipitation infiltration with the waste materials

- dissolved migration of contaminants through lateral seepage or infiltration of surface water into the landfill and movement of contaminants to the surface water stream in the canyon.

SECTION 3 REGULATORY ISSUES

3.1 RCRA Closure Requirements

At closure, owners/operators of hazardous waste management facilites are allowed to choose between removing/decontaminating all hazardous wastes and waste residues ("clean closures") which terminates responsibility for the unit, or closing the unit with hazardous wastes or waste residues remaining in place and instituting post-closure care.

The interim status requirements for clean closure are now nearly identical to the Part 264 Permit Requirements. Owner/operators can remove or decontaminate hazardous wastes and waste residues to avoid the post-closure care requirements. This means that an owner/operator must remove

all wastes or waste residues that pose a "substantial present or potential threat to human health or the environment." EPA intends to review site-specific demonstrations submitted by the owner/operator to determine if the removal or decontamination is sufficient. The closure demonstrations to be submitted must document that the contaminants left in the soil and/or groundwater will not have an impact on ground water, surface water, or the atmosphere, in excess of EPA-recommended limits, and direct contact through dermal exposure, inhalation, or ingestion will not result in a threat to human health or the environment. If an owner/operator can demonstrate that a unit is clean-closed in accordance with regulations, a post-closure permit is not required. However, if EPA determines that the facility did not close in accordance with the clean-closure requirements, the facility is subject to the post-closure care and permitting requirements.

If an owner/operator either chooses not to conduct a clean closure, or fails to do so, the owner/operator must provide post-closure care. At closure of the landfill, the owner/operator must place a final cover over the landfill to control the infiltration of moisture that could increase leaching and to prevent erosion or escape of contaminated soil. After the final cover is installed, the owner/operator must conduct certain monitoring and maintenance activities during the post-closure care period, which continues for 30 years. The post-closure plan must outline procedures to maintain the integrity and effectiveness of the final cover, maintain and monitor the groundwater monitoring system, prevent run-on and run-off from eroding or damaging the final cover, and protect and maintain surveyed benchmarks showing the location of the landfill. An approved ground and surface water and vadose zone monitoring program would be included in the post-closure plan in order to first establish background levels and then to detect contaminant migration. Typical sampling frequency is quarterly for the first year and then annually for the following years.

3.2 Land Disposal/Restrictions

The Hazardous and Solid Waste Amendments established Land Disposal Restrictions (LDRs) to minimize or eliminate reliance on land disposal, particularly landfills and surface impoundments. These restrictions prohibit continued land dispoal of hazardous wastes beyond specified dates unless it has been demonstrated to EPA "to a reasonable degree of certainty that there will be no migration of hazardous consitituents for the disposal unit for as long as the waste remains hazardous; or unless the waste meets promulgated treatment standards. The statute requires treatment standards based on concentration levels or available treatment technologies that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the disposal unit so

that short-term and long-term threats to human health and the environment are minimized.

Previous investigations indicate that the major hazardous constituent present in the Area P Landfill is barium. However, the possibility exists that other regulated constituents have been disposed. While barium is not acutely toxic, its potential quantities and mobility present significant risk. EPA lists barium as hazardous for land disposal and has established its treatment standard at an EP toxicity concentration of 100 mg/l.

3.3 Remedial Action/Corrective Action Evaluation Criteria

RCRA corrective action regulations have several evaluation criteria that are used to determine which remedial options are the appropriate actions to be taken at a site. In the case of the focused feasibility study, however, it is more appropriate to perform a preselection review of possible alternatives using a limited number of criteria. For this study four criteria have been selected which are:

- protectiveness of the environment and public health,
- implementability,
- long-term effectiveness and permanence, and
- cost

These criteria are judged to be the most important for making a preliminary decision as to what remedial alternatives may be feasible at the Area P Landfill Site. Several factors must be considered in the evaluation of these criteria. Protectiveness of the environment and public health should include a determination as to whether the proposed remedy can achieve Applicable or Relevant and Appropriate Requirements (ARARs). In the case of the Area P Landfill this would mean that a remedy would have to ensure that no degradation of ground water or surface waters existed via the two previously-mentioned pathways of exposure. The standard that would be used to make this judgement would be the MCL level, as was previously mentioned. Factors to consider concerning the implementability of a particular remedial alternative would include issues such as technology development status and commercial availability of a particular technology, permitting and regulatory complexity, state/community/laboratory acceptance, and site/transportation logistics. The factors that would affect ranking of a particular alternative for long-term effectiveness and permanance would include the likelihood that a particular remedy would need to be supplemented or replaced. For example, should a landfill cap be

installed at this time but later be shown to not be able to achieve satisfactory protectiveness of the environment and public health, subsequent clean closure may need to be accomplished by removing all waste materials.

3.4 Similar Remedial Precedents

In order to determine whether the USEPA has established a remedial precedent regarding barium-contaminated landfills, an EPA record of decision (ROD) search was conducted using the ROD-SCAN service. Five barium-contaminated landfill sites that have proceded with EPA-approved remedial actions were identified; however, barium was not the primary contaminant of concern for any of the sites. The selected remedial actions for these sites are site-specific. Two sites required excavation, off-site stabilization/treatment, and disposal in RCRA cells. Two other sites required only RCRA landfill caps, site regrading and revegetating, and post-closure ground water monitoring. Remedal actions at the final site included onsite fixation and construction of a slurry wall ground water barrier and impermeable cap containment system. To date, there is no EPA remedial action precedent pertaining to barium-contaminated landfills.

SECTION 4 EVALUATION OF REMEDIAL ALTERNATIVES

4.1 Identification of Remedial Technologies

Technologies that may be applicable to the Area P Landfill Site may be grouped into three catagories: removal, containment, and treatment technologies. Each of these groups of remediation technologies will be discussed in the following paragraphs.

All technologies associated with removal would include some form of treatment prior to either on-site or off-site disposal. The treatments required would involve segregation of RCRA hazardous from non-RCRA hazardous materials and the flashing or other treatment of non-RCRA hazardous materials (non-porous rubble, metal, and other solid objects) to ensure that no HE hazard exists prior to recycling this material. Recyclable non-RCRA hazardous rubble material would likely have to be taken to the Los Alamos County Landfill or to a recycler for reuse.

RCRA hazardous waste materials that receive Land Disposal Restriction treatment to comply with regulations would require ultimate disposal in a RCRA-permitted hazardous waste landfill. This disposal could be either on-site in a Laboratory-permitted landfill or off-site in a permitted facility that would accept the wastes, such as the secure land burial facility operated by USPCI near Salt Lake City, Utah. Requirements in various EPA regions

concerning the replacement of LDR-treated RCRA hazardous wastes in the same location from which they were excavated have varied considerably. At one time, EPA guidance required that this was only permissible if the waste materials were never physically excavated but could be treated in place by such techniques as in-situ stabilization of the sludge materials in a lagoon, for example, without pumping the sludge out of the lagoon. This guidance was recently relaxed to allow the excavation of waste materials and replacement following treatment in the same location on a case by case basis. Given the margin of suitability of the Area P Landfill Site for even construction demolition debris, the acceptability of this on-site landfilling of RCRA treated wastes would prohibit this from being a feasible technology.

Containment technologies that have been judged to be feasible for the Area P Landfill site include:

- site capping
- immobilization by in-situ stabilization utilizing polymer or grout injection

Capping of the landfill, while technically difficult because of the slope and unstable location of waste materials, is feasible with substantial movement of the wastes and probable use of a containment wall at the foot of the waste slope. The feasibility of in-situ grout or polymer injection to immobilize waste materials, either with or without an associated chemical fixation step is somewhat questionable. The presence of large amounts of concrete rubble, very small to very large pieces of metal wastes of all types (including even a demolished truck), and other non-homogenous waste materials would make the introduction of grout or polymer through small borings extremely difficult. This technology has been retained, however, as potentially feasible.

Treatment techologies that are possible for the waste materials at Landfill P include:

- stabilization with cement or pozolonic materials and chemical fixation for barium
- ex-situ soil washing for barium
- in-situ soil flushing for barium
- in-situ bio-remediation
- downgradient surface water/alluvial water interception and treatment

Technologies that have been rejected as being unfeasible for the Area P Landfill Site include:

- vitrification - for reasons of the extensive presence of metal materials
- incineration - due to the presence of metals such as barium and lead which will not be rendered non-hazardous by incineration
- thermal desorption - which is not appropriate for materials of low volatility

4.2 Development of Remedial Alternatives

Technologies discussed in the previous section can be grouped into three areas of potential remedial alternatives. These include excavation treatments (either partial or complete), in-situ treatments, and capping and monitoring, possibly with the inclusion of surface water/alluvial ground water interception and treatment. Utilizing these groupings, ten remedial alternatives have been developed for the site. These options are listed below:

Alternative A. Excavation, segregation, partial fixation/recycle, and off-site disposal

Alternative B. Excavation, segregation, partial soil washing/recycle and off-site disposal

Alternative C. Excavation, fixation, and off-site disposal

Alternative D. Partial removal, fixation, and off-site disposal, cap and monitor remainder

Alternative E. Partial insitu stabilization (polymer/grout injection/chemical fixation), cap and monitor

Alternative F. Insitu soil flushing (leaching)

Alternative G. Insitu bioremediation

Alternative H. Downgradient surface water/alluvial ground water interception and treatment-discharge, cap and monitor

Alternative I. Cap and monitor

Alternative J. No action

Section 4.3 Comparison of Alternatives

Table 1 lists the ten remedial alternatives that have been developed for the Area P Landfill and provides rating factors for the four criteria for evaluation. The rating factors show a 0, +, or -, by each criteria to assist in the evaluation of the group of alternatives as a whole. Based on this evaluation as illustrated by Table 1, five of the ten alternatives have been judged to be not feasible. The following paragraph will provide a discussion of each non-feasible option and the reasons why there were rejected.

Alternative D involves partial removal and fixation and off-site disposal of waste materials containing barium, and capping and monitoring of the remaining portion of the Area P Landfill. This alternative was judged to not be implementable because of the uncertainty of the location of the barium-containing waste materials. Based on the previous investigations, it is apparent that barium wastes may be distributed throughout any portion of the landfill and also may have migrated into other landfill materials and underlying tuff. Therefore, the entire excavation of the waste materials would be necessary in order to find all barium-containing wastes. Additionally, segregation of barium-containing materials from non-barium materials would be extremely difficult (beyond the level of segregation of rubble and metal from soil and loose materials). Therefore, the partial removal Alternative D is rejected.

Similarly Alternative E involves partial in-situ stabilization and is rejected due to the inability to locate which waste materials should be stabilized in-situ. An additional factor disqualifying this alternative is the great difficulty in implementing either partial or complete in-situ stabilization due to the large amount of rubble and large metallic objects present in the landfill.

In-situ soil flushing, Alternative F, is judged to be unacceptable due to the possibility of enhanced risk to the environment and public health that might be caused. This alternative would require introduction of either aqueous- or solvent-based solutions into the waste material to dissolve and flush constituents of concern. This technique involves collection of introduced water or solvent from either wells through ground water withdrawal, or shallow ground water diversion devices such as infiltration galleries or collection drains. Given the complex geology of the area, there is a definite possibility that some of the introduced liquids could not be recovered. Therefore, the danger of increased mobility of waste constituents by this alternative causes this scheme to be rejected.

In-situ bioremediation, Alternative G, is also rejected due to the need to introduce liquid materials to the waste. It would be necessary to introduce

Table 1
Comparison of Remedial Alternative Criteria

Alternative	Protectiveness of the Environment and Public Health	Implementability	Long-term Effectiveness and Permanence	Cost	Relative Ranking
A	+	+	+	0	1
B	+	–	–	0	3
C	+	+	+	–	2
D	–	–	0	0	
E	–	–	–	0	
F	–	–	0	0	
G	–	–	0	0	
H	–	0	0	+	4
I	0	+	+	+	1
J	–	na	na	+	

Note: (1) Alternatives D,E,F,G and J are rejected
(2) Alternatives A and I are both equally ranked
na = not applicable

nutrient materials as well as oxygen to the wastes in place to encourage bioremediation. There is no current means of physical introduction of nutrients or oxygen other than by liquids. Therefore, this alternative is rejected as unimplementable due to the danger of encouraging the migration of constituents.

Alternative J, no action, is rejected due to the minimum requirement of RCRA site closure by capping and long-term monitoring.

Of the remaining Alternatives, (A, B, C, H, and I), Alternative I involves capping and monitoring which has previously been proposed as the RCRA closure alternative. Alternative H involves the same capping and monitoring with the addition of alluvial ground water and surface water interception downgradient of the landfill and subsequent treatment of this collected water prior to discharge to the stream. The other three alternatives involve excavation of all of the waste materials and various schemes for segregation and appropriate treatment and either on-laboratory disposal or off-site disposal of the segregated portions of the waste. Most importantly, prior to the selection of any of the above five feasible alternatives, a more thorough site characterization and determination of the resultant risk to public health and the environment should be completed to determine the relative protectiveness of the alternatives.

An order of magnitude cost estimate for each of the five feasible alternatives listed above is provided in Tables 2 through 6. Alternative C, Excavation, Fixation (of all wastes), and Off-site Disposal is the most costly feasible remedial option. The cost of this alternative is estimated at $21.8 million (present worth). Alternative I, Cap and Monitor, is the least costly feasible remedial action at a cost of $7.5 million (present worth), including a substantial 30-year monitoring plan. All cost estimates include 50% contingency allowance and 30% administrative cost for engineering, technical, and legal costs. The contingency costs are included to allow for uncertainties of waste quantities and variability of unit prices for individual treatment elements.

SECTION 5 SUMMARY AND RECOMMENDATIONS

The previously submitted RCRA closure plan recommended that the site be capped and monitored pursuant to RCRA requirements and that no other action would be necessary to ensure no migration of the waste materials. Based on the review contained in this report of the previous investigations of the site, it is believed that there is currently insufficient data to show that all of the constituents of concern that may be present in the landfill are not migrating via the two routes of exposure identified. These routes are (1) by physical transport of sediment/waste materials, and (2) by dissolved

Table 2
Alternative A
Excavate, Segregate, Partial Fixation/Recycle,
and Off-Site Disposal Alternative
TA-16 Area P Landfill

Item	Quantity	Unit Cost	Cost
Excavate and Segregate	16,000 cy*	$100/cy	$1,600,000
Fixate**	12,960 tons	$120/ton	$1,600,000
Transportation**	12,960 tons	$81/ton	$1,100,000
Tax**	12,960 tons	$35/ton	$500,000
Disposal**	12,960 tons	$120/ton	$1,600,000
Transportation and Disposal***	12,960 tons	$15/ton	$200,000
	Total Direct Cost		**$6,600,000**
	Contingency Allowance @ 50%		**$3,300,000**
	Subtotal		**$9,900,000**
	Engineering , Technical, and Legal Costs @ 30%		**$3,000,000**
	Estimated Total Cost		**$12,900,000**

*16,000 cy = 25,920 tons @ density of 120 lb/cf (3,240 lb/cy)
**Half of waste is fixated, transported, and disposed at USPCI in Salt Lake City
***Half of waste transported and disposed at local Class C landfill

Table 3
Alternative B
Excavate, Segregate, Partial Soil Washing/Recycle
and Off-Site Disposal Alternative
TA-16 Area P Landfill

Item	Quantity	Unit Cost	Cost
Excavate and Segregate	16,000 cy	$100/cy	$1,600,000
Soil Washing*	12,960 tons	$240/ton	$3,200,000
Transportation*	12,960 tons	$81/tons	$1,100,000
Tax*	12,960 tons	$35/ton	$500,000
Disposal*	12,960 tons	$120/ton	$1,600,000
Transportation and Disposal**	12,960 tons	$15/ton	$200,000
	Total Direct Cost		**$8,200,000**
	Contingency Allowance @ 50%		**$4,100,000**
	Subtotal		**$12,300,000**
	Engineering , Technical, and Legal Costs @ 30%		**$3,700,000**
	Estimated Total Cost		**$16,000,000**

*Half of waste is washed, then transported and disposed at USPCI in Salt Lake City
**Half of waste transported and disposed at local Class C landfill

Table 4
Alternative C
Excavate, Fixate, and
Off-Site Disposal Alternative
TA-16 Area P Landfill

Item	Quantity	Unit Cost	Cost
Excavate and Segregate	16,000 cy	$100/cy	$1,600,000
Fixate*	25,920 tons	$120/ton	$3,200,000
Transportation*	25,920 tons	$81/ton	$2,100,000
Tax*	25,920 tons	$35/ton	$1,000,000
Disposal*	25,920 tons	$120/ton	$3,200,000
	Total Direct Cost		**$11,100,000**
	Contingency Allowance @ 50%		**$5,600,000**
	Subtotal		**$16,700,000**
	Engineering , Technical, and Legal Costs @ 30%		**$5,100,000**
	Estimated Total Cost		**$21,800,000**

*Fixated, transported, and disposed at USPCI in Salt Lake City

Table 5
Alternative H
Down Gradient Surface Water/Alluvial Ground Water Interception and Treatment-Discharge, Cap and Monitor Alternative
TA-16 Area P Landfill

Item	Quantity	Unit Cost	Cost
Cap and Monitor		TDC from Alternative I	$3,800,000
Construct Interception System (assuming 10 gpm)	1	$500,000	$500,000
Construct Treatment System	1	$400,000	$400,000
Ground Water Treatment Operation and Maintenance			
Labor	1,460 hr/yr	$30/hr	($44,000/yr)
Utilities/Chemicals		$20,000/yr	($20,000/yr)
Sludge Disposal	4 tons/yr	$500/ton	($2,000/yr)
		O & M Annual Total:	($66,000/yr)
		30-Year O & M Total*:	$1,100,000

Total Direct Cost	**$5,800,000**
Contingency Allowance @ 50%	**$2,900,000**
Subtotal	**$8,700,000**
Engineering , Technical, and Legal Costs @ 30%	**$2,700,000**
Estimated Total Cost (present worth)	**$11,400,000**

* Annual costs multiplied by Present Worth Factor (15.372, 30 yr, 5%)

Table 6
Alternative I
Cap and Monitor
Alternative
TA-16 Area P Landfill

Item	Quantity	Unit Cost	Cost
Stabilize Landfill and Slope		$250,000	$250,000
Install RCRA Cap	88,000 sq ft*	$5.00/sq ft	$440,000
Monitor Ground Water, Surface Water, and Vadose Zone ; Sampling and Reporting	100 samples/yr	$1,000/sample $100,000/yr	($100,000/yr) ($100,000/yr)
		Monitoring Annual Total: 30-Year Monitoring Total**:	($200,000/yr) $3,100,000

Total Direct Cost	**$3,800,000**
Contingency Allowance @ 50%	**$1,900,000**
Subtotal	**$5,700,000**
Engineering , Technical, and Legal Costs @ 30%	**$1,800,000**
Estimated Total Cost (present worth)	**$7,500,000**

*Two-acre site is approximately 88,000 sq ft (1 acre = 43,560 ft)
** Annual costs multiplied by Present Worth Factor (15.372, 30 yr, 5%)

contaminant transport via water. The data that has been taken is focused largely on barium and little or no data has been collected to show whether or not migration of lead and HE materials is occurring. Also, the potential migration of beryllium or radiological materials, if they are present in the waste, has not been disproven because these constituents have not been analyzed in samples of site materials.

The McLin report of August 1989 supports these conclusions. This report additionally goes on to make recommendations, most of which are believed to still be applicable. These recommendations include the collection of additional data to enable a decision concerning closure/remedial alternatives to be made with more certainty of permanence. The recommendations from the McLin report include:

- the installation of additional lysimeters based on moisture measurements taken from existing neutron moisture access wells.
- soil column leaching studies on sample waste materials, including waste barium sands.
- two-and three-dimensional vadose zone flow modeling studies to assist in the evaluation of alternative landfill cover designs.
- the installation of additional vadose zone monitoring wells through the landfill and into the shallow tuff to supplement the existing monitoring well network. Also additional vadose zone monitoring wells should be installed in the floor of Canon de Valle immediately north of the landfill.

Many of these above recommendations are still applicable. The installation of additional wells through the landfill waste materials may not be required; however, a better understanding of whether liquid-born contaminants are entering the tuff materials outside of the area of the landfill should be gained.

In summary, a better understanding of whether any of the contaminants of concern are migrating in surface water/alluvial groundwater must be made in order to make a correct decision on site closure. It is likely that the contaminants of concern are not migrating through either route of exposure in sufficient quantities to cause unacceptable risk to the environment or human health. If this can be determined to be the case, capping and monitoring the site may be an acceptable closure. The purpose of the capping would be to further limit infiltration and to remove the pathway of physical erosion of waste materials. It is possible, however, after additional sampling and analysis, that some migration of waste constituents may be occurring. If this is the case, modeling will be able to determine what type

of cap, if any, can limit this migration sufficiently so that no significant environmental degradation will occur. Until additional data collection and monitoring are accomplished, the efficacy and permanence of the cap as an ultimate remediation for the site cannot be accurately determined. Therefore, it is prudent to include the Area P Landfill in the RFI process for Operable Unit 1082. Thus, in a two to three year period, sufficient site characterization data will be obtained to make a more accurate decision on the choice between site closure by capping and monitoring or one of the three removal options.

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