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Amendment to the Closure Plan for the Technical Area 35, TSL-85 Surface Impoundment

Prepared for:

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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LIST OF ABBREVIATIONS/ACRONYMS

AF	absorption factor
AT	averaging time
BEC	Benchmark Environmental Corporation
BNM	Bandelier National Monument
C	health-based action level
°C	degrees Celsius
CF	conversion factor
CFR	Code of Federal Regulations
CS	exposure concentration of constituent in soil
CSF	carcinogenic slope factor
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ED	exposure duration
EF	exposure frequency
EM-9	LANL's Environmental Chemistry Group
EPA	U.S. Environmental Protection Agency
EQL	estimated quantitation limit
FI	fraction ingested
FR	Federal Register
g	gram
HQ	hazard quotient
HS-5	LANL's Industrial Hygiene and Safety Group
HWMR-7	New Mexico Waste Management Regulations, Revision 7
I	soil intake
IR	ingestion rate
IRIS	Integrated Risk Information System
kg	kilogram
LANL	Los Alamos National Laboratory
LOQ	limit of quantitation
LT	assumed lifetime
mg	milligram

LIST OF ABBREVIATIONS/ACRONYMS (Continued)

ml	milliliter
MSDS	material safety data sheet
NMED	New Mexico Environment Department
NOS	not otherwise specified
PCBs	polychlorinated biphenyls
ppm	parts per million
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
R	assumed risk level
RAGS	"Risk Assessment Guidance for Superfund"
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
SAP	sampling and analysis plan
SF	carcinogenic slope factor
SVOC	semivolatile organic compound
TA	Technical Area
TSL	Ten Site Laboratory
UST	underground storage tank
VOC	volatile organic compound
W	body weight

1.0 INTRODUCTION

This amendment to the "Interim Status Closure Plan, Technical Area 35 TSL-85 Surface Impoundment" (Benchmark Environmental Corporation [BEC], December 1991) is being submitted to the New Mexico Environment Department (NMED) in response to NMED's letter of June 21, 1993, regarding "TA-35, TSL-85 Surface Impoundment: Denial of Clean Closure Equivalency Demonstration and Disapproval of Closure Plan" (NMED, June 1993) with an attachment entitled, "Reasons for Closure Plan Disapproval and Recommended Modifications for Approval" (NMED, May 1993). The purpose of this amendment is to show that all of NMED's concerns have been or will be addressed adequately so that clean closure of the surface impoundment (including the associated underground storage tank [UST] and ancillary piping) may be achieved in accordance with the New Mexico Hazardous Waste Management Regulations, Revision 7 (HWMR-7), Pt. VI, Part 265, Subpart G, Closure and Post-Closure. This amendment to the Closure Plan (BEC, 1991) is being submitted in lieu of a revision to the plan. This amendment includes additional information, supporting analytical data, appropriate summary tables, associated figures, photographs, and various supporting documents and is organized into five main sections:

- Introduction (Section 1.0).
- Specific responses to each NMED reason for closure plan disapproval (Section 2.0).
- Proposed sampling and analysis plan (SAP) for the additional sampling (Section 3.0).
- Proposed risk evaluation (Section 4.0).
- Proposed schedule (Section 5.0).

During the previous Resource Conservation and Recovery Act (RCRA) closure effort for the Technical Area 35 (TA-35), Ten Site Laboratory (TSL)-85 Surface Impoundment, which is detailed in the Closure Certification Report (BEC, 1991), soil samples were collected from various locations in the area of the surface impoundment. The sampling events performed in Phases I through V were conducted from 1989 through 1991. Table 1-1 is a summary of sampling and analytical Phases I through V performed for clean closure verification. A location map of Los Alamos National Laboratory (LANL) TAs is provided for reference as Figure 1-1 and a structure location map of the western portion of TA-35 is included as Figure 1-2. Figure 1-3 shows the area surrounding the surface impoundment and the locations of associated structures and piping prior to Phases I through V. Analytical data for the majority of the soil samples collected in

Phases I through V were not of the highest defensible quality due to missed holding times, surrogate recovery results outside the U.S. Environmental Protection Agency's (EPA's) limits, and interference from nonhazardous constituents. As a result, NMED has recommended that additional samples, representative of the samples that yielded poor analytical data, be collected and analyzed. Section 3.0 of this amendment provides a SAP for the proposed additional Phase VI sampling.

The Closure Certification Report (BEC, 1991) used the analytical data generated from the 1989–1991 Phases I through V sampling effort to perform a risk assessment. The risk assessment consisted of a comparison of analytical results with health-based action levels; these action levels were calculated for the soil ingestion pathway using methods outlined in proposed RCRA Subpart S (*Federal Register*, Volume 55, No. 145, pp. 30815–20 and 30865–73). Several volatile organic compounds (VOCs) were detected in Phase II soil samples but were not included in the risk assessment. In addition, NMED has requested that LANL calculate an aggregate hazard index and an aggregate risk level for constituents which are present in soils associated with the former TSL-85 Surface Impoundment at TA-35. (LANL will comply with the NMED's request for this site, however, LANL does not intend this action to set a precedent of applying Comprehensive Environmental Response, Compensation, and Liability Act-based risk assessment methodology/guidance to closures or cleanups conducted under RCRA.) The proposed risk evaluation, presented in Section 4.0 of this amendment, will evaluate analytical data of good quality from Phases I through VI and will calculate an aggregate hazard index and an aggregate risk level as appropriate. In addition, the risk evaluation will utilize the most current information from the U.S. EPA's Integrated Risk Information System (IRIS) database, which provides toxicity values for individual constituents for the purpose of risk assessment.

A proposed schedule for the additional tasks necessary to demonstrate clean closure of the former TA-35 TSL-85 Surface Impoundment (including the associated UST and ancillary piping) is included in Section 5.0 of this amendment. This schedule reflects activities required if subsequent remedial actions, including potential soil removal and site restoration activities, become necessary. With NMED approval, the necessity of additional remedial actions will be determined based on an evaluation of analytical data of good quality from Phases I through VI with health-based action levels and calculated risk.

Table 1-1

Summary of Sampling and Analytical Phases I through V Performed for Clean Closure Verification at the Technical Area 35, TSL-85 Surface Impoundment[a]

Phase	Description	No. of Samples	Analytes
I	Soil samples collected at the 1- to 2-foot depth below the surface impoundment	24	Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenols (PCBs), and metals
II	Soil samples collected from various depths in three coreholes drilled to approximately 49 feet below the surface impoundment	24	VOCs, SVOCs, PCBs, and metals
III	Soil samples collected from directly beneath the underground storage tank and associated polyvinyl chloride piping	12	VOCs, SVOCs, PCBs, and metals
IV	Soil samples collected at a depth of approximately 6 inches and located downgradient of the surface impoundment into Mortandad Canyon	12	VOCs, SVOCs, PCBs, and metals
V	Soil samples collected from various depths in two coreholes drilled to approximately 45 feet below the surface impoundment	20	VOCs, SVOCs, and total petroleum hydrocarbons

[a] Information for the 1989–1991 Phases I through V sampling effort is summarized from the "Closure Certification Report, TA-35 TSL-85 Surface Impoundment" (Benchmark Environmental Corporation, 1991).

2.0 RESPONSE TO NMED'S REASONS FOR CLOSURE PLAN DISAPPROVAL

2.1 REASON 1

2.1.1 NMED's Reason for Disapproval

"The closure plan does not include a description of the removal of contaminated subsoils pursuant to the New Mexico Hazardous Waste Management Regulations (HWMR-7), Part VI, Section 40 CFR 265.228(a)(1).

A. The subsoil near the 6-inch PVC pipe extending from Building 85 to the surface impoundment is contaminated. The contaminants found in excess of health-based action levels and their sample locations are as follows:

   1. Selenium at sample site 85PL-4;
   2. Beryllium at sample sites 85PL-1 through 85PL-12; and
   3. Antimony at sites 85PL-3 and 85PL-6 through 85PL-11.

B. Analysis of soil samples for semi-volatiles has been compromised by interference from non-hazardous di-electric waste oil. During analysis, DOE/LANL raised the limit of quantitation (LOQ) to accommodate this interference. The LOQ for some of the subsoil samples was in excess of the estimated quantitation limit (EQL) of 1 mg/kg as recommended in *SW-846* Method 8270. Those samples in excess of the EQL have been determined to be unacceptable. Since these samples do not document the absence of hazardous constituents above health-based concentrations, the subsoil is considered to be contaminated."

2.1.2 Response

In compliance with HWMR-7, Pt. VI, 265.228(a)(1), the "Interim Status Closure Plan, Technical Area 35 TSL-85 Surface Impoundment" (BEC, December 1991) (Enclosure 1 of the Closure Certification Report [BEC, 1991]) includes a soil removal, sampling, analysis and evaluation plan as Section 5.3. This plan details a five-phase approach to demonstrate clean closure verification for the TSL-85 Surface Impoundment site that includes an assessment of site conditions and subsequent management of any hazardous equipment, structures, wastes, and/or materials associated with the site. LANL has complied with this requirement by removing all waste residues, contaminated systems, structures, and equipment and has managed them as hazardous

waste. (A description of the removal of contaminated subsoils is provided below.) This amendment in conjunction with the Closure Certification Report (BEC, 1991) outlines the approach that LANL will use to ensure clean closure of the TSL-85 Surface Impoundment in compliance with HWMR-7, Pt. VI, 265.228(a)(1).

Soil removed from the site was taken from directly beneath the surface impoundment liner. Samples of this soil, collected in 1989 while the liner was still in place, were analyzed and revealed that the soil was contaminated with various VOCs. As a result, the liner was removed (Photograph 2-1) and disposed of as hazardous waste. Then 1 to 2 feet of soil and undisturbed volcanic tuff were excavated and removed by Pan Am World Services personnel using a small backhoe and various hand tools. The soils were sealed into U.S. Department of Transportation (DOT)-approved 55-gallon steel drums and placed in the TSL-85 less-than-90-day storage area. The drums were subsequently shipped off site and the contaminated soils were incinerated by Rollins Environmental Services Inc. Drums containing contaminated soils excavated from the TSL-85 Surface Impoundment were shipped to Rollins along with drums of contaminated soils excavated from the TA-35 TSL-125 Surface Impoundment. The shipping manifests and certificates of destruction associated with these soils are included as Appendix A of this amendment.

Selenium was not detected in the soil along the polyvinyl chloride (PVC) piping between the UST and the surface impoundment (Photographs 2-2, 2-3, and 2-4). This metal was not detected in Phase III soil samples at or above the LOQ as shown in Table 2-1. The action level calculated for selenium in the Closure Certification Report risk assessment (BEC, 1991) is summarized in Table 2-2 of this amendment. The LOQ of 0.1 micrograms per gram (parts per million [ppm]) is far below the calculated action level of 250 milligrams per kilogram or ppm. Therefore, the presence of selenium in the soils along the PVC piping is not a concern.

Beryllium was detected in the soil along the PVC piping between the UST and the surface impoundment. However, a comparison of the beryllium concentrations detected at sample locations 85PL-1 through 85PL-12 (Table 2-1) with background levels for beryllium (Table 2-3) shows that the beryllium concentrations are all below background levels. Therefore, the presence of beryllium is not a concern. Background levels for beryllium are documented in the report entitled "Sigma Mesa: Background Elemental Concentrations in Soil and Vegetation"

(Ferenbaugh et al., 1979) (Appendix B) and the study "Preliminary Background Elemental Concentrations in Bandelier Tuff and Selected Soil Series" (Longmire et al., November 1993). The study by Longmire et al. (1993) will be completed in November 1993; Attachment 2-1 of this amendment provides a telephone log with summaries of the background concentration data determined by Longmire et al. for antimony, beryllium, and selenium.

Antimony was detected in the soil along the PVC piping between the UST and the surface impoundment at concentrations exceeding both the action and background levels for that metal. Phase II antimony concentrations will be evaluated in the proposed risk evaluation (Section 4.0 of this amendment) and addressed as determined appropriate by NMED and LANL.

The semivolatile organic compound (SVOC) data for soil samples collected from a depth of 2 feet below the surface impoundment (Figure 2-1) were unable to demonstrate the absence of hazardous constituents above health-based action levels. The presence of nonhazardous dielectric waste oil in the soils appears to have interfered with the SVOC analyses for the soils, resulting in samples with elevated LOQs. Upon completion of the soil sampling, 1-2 feet of clean fill was placed and compacted in the excavated area of the surface impoundment to bring the area back to its original grade. As a result, soils at a depth of 2-3 feet below the existing grade will be sampled and analyzed. If necessary, samples will be diluted in accordance with *SW-846* methods in an effort to obtain analytical data with nonelevated LOQs. Section 3.0 of this amendment provides the details for this additional sampling.

2.2 REASON 2

2.2.1 NMED's Reason for Disapproval

"During the removal of the UST, the contractor discovered a 6-inch PVC pipe connected to the pipe from the UST to the surface impoundment. The origin of this pipe has not been identified. It is also unclear if the accessible portion of this pipe was removed and decontaminated and if the inaccessible portion of the pipe was pressure tested, decontaminated, grouted, and/or capped.

The origin and removal or decontamination of the 2-inch galvanized steel pipe, discovered by the contractor during pressure testing of the tank, has not been described in detail."

2.2.2 Response

The 6-inch PVC pipe, shown in Figure 2-2, was connected to a floor drain in Building 85. This drain was similar to other drains that were connected directly to the TSL-85 Surface Impoundment that are discussed in the Closure Certification Report (BEC, 1991). The accessible portion of this pipe was removed, cut into smaller pieces, placed in DOT-approved containers, and disposed as hazardous waste at an off-site RCRA-permitted disposal facility. The inaccessible portion was pump-grouted and capped.

The 2-inch galvanized steel pipe (Figure 2-2) was connected to the bottom of the UST and led to a drain in Building 85, similar to the drains that were connected directly to the TSL-85 Surface Impoundment. This pipe was discovered when, in the process of pressure testing the UST, fluids in the bottom of the tank were forced back into Building 85 through the drain. The accessible portion of the steel pipe was subsequently disconnected from the tank and removed. The inaccessible portion was pump-grouted and capped.

2.3 REASON 3

2.3.1 NMED's Reason for Disapproval

"The discovery of hazardous waste constituents which were not anticipated from the Process Knowledge investigation of Buildings 85 and 188 suggests that there may be other, as yet unknown, hazardous constituents in the soil. Soil samples were tested for a limited number of hazardous constituents."

2.3.2 Response

NMED has requested that soils be sampled and analyzed for all of the hazardous constituents found in HWMR-7, Pt. II, Part 261, Appendix VIII. However, analytical methods are not currently available for all of the analytes listed in Appendix VIII. For the proposed additional sampling presented in Section 3.0 of this amendment, LANL's Environmental Chemistry Group (EM-9) will conduct analyses for all Appendix VIII analytes that their in-house laboratories have the analytical capability to perform. A comparison between the list of analytes in Appendix VIII and EM-9's analytical capabilities is also presented in Section 3.0.

2.4 REASON 4

2.4.1 NMED's Reason for Disapproval

"The closure plan states in Section 5.2.1 Underground Storage Tank/Lines Verification Sample Risk Analysis on page 23 that:

> "The semivolatile analyses on the soil samples collected from beneath the underground storage tank and underground storage tank lines were performed after the EPA-allowable 40-day holding time. For this reason, semivolatile organic analytical results are not considered valid."

The closure plan states in Section 5.3.1 Canyon Verification Sample Risk Analysis on page 25 that:

> "The semivolatile analysis on the soil samples collected from the canyon spill path route were performed after the EPA-allowable 40-day holding time. For this reason, semivolatile organic analytical results are not considered valid."

U.S. EPA allows for a risk assessment to demonstrate that any hazardous constituents left in subsoils will not cause unacceptable risks to human health and the environment (52 FR 8704, March 19, 1987). For the underground storage tank and underground storage tank lines and canyon spill path route investigation, valid data on the semivolatiles analyses does not exist. The risk assessment is invalid because it cannot be determined whether any hazardous constituents left in subsoils will not cause unacceptable risks to human health and the environment."

2.4.2 Response

The areas sampled in 1989 during Phases III and IV (shown on Figures 2-2 and 2-3) will be resampled and analyzed for SVOCs as discussed in Section 3.0 of this amendment. The proposed risk evaluation (Section 4.0) will include an evaluation of the risk in these areas based on the new analytical data resulting from the additional sampling effort.

2.5 REASON 5

2.5.1 NMED's Reason for Disapproval

"Quality Assurance (QA) and Quality Control (QC) of Phase III Volatile Organic Compounds has been compromised. In Enclosure 4-F, Volatile Organic Analyses, Quality Assurance Report, Surrogate Results for EPA Volatiles, 64 percent of Surrogate 3 samples do not fall within the EPA limits *(SW-846)*. Samples affected by QA/QC deficiencies have been determined to be invalid."

2.5.2 Response

The area beneath the UST and associated piping, sampled in 1989 during Phase III (Figure 2-2), will be resampled and analyzed for VOCs as discussed in Section 3.0 of this amendment.

2.6 REASON 6

2.6.1 NMED's Reason for Disapproval

"Many of the soils analyses from the Phase One Clean Closure Verification Samples: Soil Samples at Two Foot Depth (Enclosure 4-D) contain the volatiles 1,1,1-Trichloroethane, 2-Butanone, o-Xylene, and Mixed-Xylenes. In the case of multiple hazardous constituents either an aggregate hazard index or aggregate risk level must be determined."

2.6.2 Response

Analytical data of poor quality, obtained during the 1989–1991 sampling effort (Phases I through V), will be considered invalid and will be replaced with the appropriate new analytical data generated from the proposed Phase VI sampling event (Section 3.0 of this amendment). With NMED's approval, the risk evaluation performed as part of the Closure Certification Report (BEC, 1991) will be superseded by the risk evaluation proposed in Section 4.0 of this amendment. The proposed risk evaluation will assess the existing analytical data of good quality from Phases I through V and the new data generated in Phase VI following proposed RCRA Subpart S (*Federal Register*, Volume 55, No. 145, pp. 30815-20 and 30865-73) (included as Appendix C to this amendment) and complying with the "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)" (selected portions included as Appendix D to this amendment). In addition, the risk evaluation will include calculation of aggregate hazard index and/or risk and will utilize the most current IRIS reference dose (RfD) and carcinogenic slope factor (SF) values.

2.7 REASON 7

2.7.1 NMED's Reason for Disapproval

"Enclosure 4-E, Phase Two Clean Closure Verification Samples: Corehole Samples to Approximately 49 Feet, Volatile Organic Analyses, lists the detection of Acetone, Benzene, 2-Butanone, Tetrachloroethylene and 4-Isopropyltoluene. In the Enclosure 5, Risk Assessment Calculation Results and Methodology, Soil Removal/Corehole Verification Samples, the risk calculation tables do not include these hazardous constituents. Neither an aggregate hazard index nor aggregate risk level has been described."

2.7.2 Response

As discussed in Section 2.6.2, the proposed risk evaluation (Section 4.0) will assess analytical data from the proposed additional sampling (Phase VI) along with the existing analytical data of good quality from Phases I through V. The analytical data for benzene and tetrachloroethylene resulting from the proposed Phase VI sampling event will be included in the proposed risk evaluation. Acetone and 4-isopropyltoluene are not listed in Appendix VIII; therefore, they were not included in the Closure Certification Report risk assessment (BEC, 1991) and they will not be included in the proposed risk evaluation. 2-Butanone concentrations were evaluated in the risk assessment included in the Closure Certification Report (BEC, 1991) under the synonym methyl ethyl ketone. Refer to Enclosure 5 of the Closure Certification Report for the previous risk assessment methodology and calculations.

2.8 CONCERN I

2.8.1 NMED's Concern

"Volatile organic chemical analysis revealed the presence of 1,1,1-Trichloroethane. The closure plan must be revised to include a detailed description of the degreasing solvents used at these buildings. Copies of the MSDS should be included. 1,1,1-Trichloroethane appears in the Hazardous Waste from Non-specific Sources list in Part II, Section 40 CFR 261.31 with the Industry and EPA Hazardous Waste Number of F001 and F002, and possibly F003, F004, and/or F005. Hazardous wastes with any of these Industry and EPA Hazardous Waste Numbers may require removal down to a concentration of 0."

2.8.2 Response

Pure 1,1,1-trichloroethane was the primary degreasing solvent used in Buildings 85 and 188. The material safety data sheet (MSDS) for 1,1,1-trichloroethane is provided as Attachment 2-2. Current analytical methods are unable to measure concentrations of hazardous constituents down to a concentration of 0. As outlined in the proposed risk evaluation (Section 4.0), it will be demonstrated that any contamination potentially remaining at the site will not pose an unacceptable risk to human health or the environment.

2.9 CONCERN II

2.9.1 NMED's Concern

"In the Enclosure 5, Risk Assessment Calculation Results and Methodology, Explanation for Risk Calculation Tables it states that the "Reference for CSF and RfD data is EPA's IRIS data base April 1991 edition." Verification must be provided that the current and April 1991 Integrated Risk Information System (IRIS) Reference Dose (RfD) and Carcinogenic Slope Factors (CSFs) correspond. In the case of multiple hazardous constituents, either an aggregate hazard index or aggregate risk level must be determined."

2.9.2 Response

The proposed risk evaluation, outlined in Section 4.0 of this amendment, includes the calculation of action levels and aggregate hazard/risk using current RfD and SF values. As previously stated, the proposed risk evaluation will assess analytical data of good quality from Phases I through V and new data from proposed Phase VI. The most current IRIS values will be utilized in the proposed risk evaluation and a summary of those IRIS values will be provided with the completed risk evaluation for NMED review.

2.10 ADDITIONAL NMED REQUESTS

NMED made two additional requests for information in an October 6, 1993, meeting with LANL and representatives of the U.S. Department of Energy Los Alamos Area Office. These additional requests are addressed in the following sections.

2.10.1 Request 1

2.10.1.1 NMED's Request

NMED requested that a reference be provided for hazardous constituents that are detected in the analytical results for the TA-35 TSL-85 Surface Impoundment site but that are not directly related to the RCRA closure of the surface impoundment (specifically for polychlorinated biphenyls [PCBs]). This reference needs to include planned or proposed remedial actions addressing these hazardous constituents.

2.10.1.2 Response

PCBs were detected in Phases I, III, and IV at concentrations listed in Enclosure 4 of the Closure Certification Report (BEC, 1991) that exceeded calculated action levels. However, all detected concentrations of PCBs were below the NMED clean closure required cleanup level of 10 mg/kg (ppm) as specified in the Closure Certification Report risk assessment. Therefore, PCB concentrations are not considered a concern at the site and unless determined otherwise do not require any remedial action.

2.10.2 Request 2

2.10.2.1 NMED's Request

NMED also requested that a table showing a direct comparison between April 1991 and current IRIS values be provided in this amendment.

2.10.2.2 Response

Inclusion of a table depicting such a comparison in this amendment or in the Revised Closure Certification Report would not provide any useful information. The proposed risk evaluation will assess all analytical data of good quality from Phases I through VI. The previous risk assessment submitted as part of the Closure Certification Report (BEC, 1991) will be superseded by the proposed risk evaluation outlined in Section 4.0 of this amendment. A summary of the most current IRIS values used for the proposed risk evaluation will be included with the submittal of the Revised Closure Certification Report as part of the risk evaluation.

Table 2-1

Phase III Analytical Data for Antimony, Beryllium, and Selenium for Soils Beneath the Underground Storage Tank and Associated Piping at the Technical Area 35, TSL-85 Surface Impoundment[a]

	Sample Location Number											
Metal	85PL-1	85PL-2	85PL-3	85PL-4	85PL-5	85PL-6	85PL-7	85PL-8	85PL-9	85PL-10	85PL-11	85PL-12
Antimony	18[b]	20	30	25	25	35	30	30	30	35	35	20
Beryllium	0.35	0.4	0.5	0.4	0.35	0.45	0.5	0.33	0.3	0.6	0.6	0.45
Selenium[c]	<0.1[d]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

a Analytical data for the 1989 Phase III sampling effort is summarized from the "Closure Certification Report, TA-35 TSL-85 Surface Impoundment" (Benchmark Environmental Corporation, 1991).

b Units for all analytical data are micrograms per gram (parts per million).

c Duplicates of all samples were run for selenium; the highest concentration detected is reported in this table.

d "<" indicates metal concentration is less than the given limit of quantitation.

Table 2-2

Action Levels Determined for Antimony and Selenium in the Closure Certification Report Risk Assessment for the Technical Area 35, TSL-85 Surface Impoundment[a]

Constituent	Class[b]	Oral SF[c] $(mg/kg\text{-}day)^{-1}$	Oral RfD[d] (mg/kg-day)	Risk[e]	Weight[f] (kg)	LT[g] (yrs)	Intake[h] (kg/day)	AF[i]	ED[j] (yrs)	Action Level (mg/kg)
Antimony	D	1.00	0.0004	1.00	10	1	0.0002	1	1	20
Selenium	D	1.00	0.005	1.00	10	1	0.0002	1	1	250

a Information regarding action level determination is taken from the "Closure Certification Report, TA-35 TSL-85 Surface Impoundment" (Benchmark Environmental Corporation, 1991).

b "Class" refers to U.S. Environmental Protection Agency category based on the weight of evidence that a constituent is a potential carcinogen. "D" refers to a systemic (noncarcinogenic) toxicant.

c "SF" refers to a carcinogenic slope factor. Units are $(\text{milligrams per kilogram-day})^{-1}$.

d "RfD" refers to a reference dose for a systemic toxicant. Units are milligrams per kilogram-day.

e "Risk" refers to an assumed risk level based on the class of the constituent.

f "Weight" refers to an assumed weight of an individual. Units are kilograms.

g "LT" refers to an assumed lifetime for an individual. This is not applicable to the scenario evaluated, therefore, the default value was set to one year. Units are years.

h "Intake" refers to an assumed intake for an individual. Units are kilograms per day.

i "AF" refers to an assumed absorption factor.

j "ED" refers to an assumed exposure duration. Units are years.

Table 2-3

Background Antimony and Beryllium Concentrations[a] for Los Alamos National Laboratory

Metal	Sigma Mesa Report[b]	Bandelier Report[c]
Antimony	Not Listed	0.27 - 1.59
Beryllium	1.1 - 3.3	1.00 - 4.4

a Units are milligrams per kilogram (parts per million).

b "Sigma Mesa Report" refers to "Sigma Mesa: Background Elemental Concentrations in Soil and Vegetation" (Ferenbaugh et al., 1979).

c "Bandelier Report" refers to "Preliminary Background Elemental Concentrations in Bandelier Tuff and Selected Soil Series" (Longmire et al., November 1993); refer to Attachment 2-1 of this amendment.

ATTACHMENT 2-1

Telephone Log Summarizing Background Concentrations for Selenium, Beryllium, and Antimony Determined in the Study "Preliminary Background Elemental Concentrations in Bandelier Tuff and Selected Soil Series"

INTERNATIONAL TECHNOLOGY CORPORATION

RECORD OF ☑ TELECON ☐ MEETING

Project Name	Number	Phase	Task	Subtask
TA-35, TSL-85	301625	03	01	

Date 9/1/93 Time 8:30 am

CALL FROM ☐ CALL TO ☑ NAME: Pat Longmire

CALL FROM ☐ CALL TO ☑ NAME: (same as above)

Telephone Number: 665-1264

Company Name: LANL

Address: INC-9

City

State Zip Code

Other Participants — Name/Location/Representing:

— NA —

Topic Obtain Labwide Background Beryllium & Antimony Concentrations

Summary (Decisions & Specific Actions Required by Named Persons):

8:30 AM – Contacted Pat to request info. on the previously referenced topic.

Pat said that no samples were specifically taken from TA-35, but that samples were taken lab-wide and the minimum, average, and maximum background levels for beryllium & antimony summarized from those samples are as follows:

antimony: (57 samples)
min. 0.27 ppm
ave. 0.69 "
max. 1.59 "
} analyzed using neutron activation

beryllium: (75 samples)
min. 1.00 ppm
ave. 2.37 "
max. 4.40 "
} analyzed using ICP

~~Required Action:~~

Pat mentioned that these samples were currently being analyzed again using ICP/AA analytical methods to see if they will generate similar values/ranges.

Prepared by (Signature): Wendi D. Knutsen

Distribution:
Original to Project File
Copy to Project Manager
Copy to Preparer

☐ Other Distribution (By Preparer)
Tanya Blacic

548A-8-87

INTERNATIONAL TECHNOLOGY CORPORATION

RECORD OF ☑ TELECON ☐ MEETING

Project Name	Number	Phase	Task	Subtask
TA-35, TSL-85	301625	03	01	

Date 9/1/93 Time 8:30 am

CALL FROM ☐ CALL TO ☑ NAME: Pat Longmire

Other Participants — Name/Location/Representing:

-NA-

CALL FROM ☐ CALL TO ☑ NAME: (same as above)

Telephone Number: 665-1264

Company Name: LANL

Address: INC-9

City

State Zip Code

Topic Obtain Labwide Background Beryllium & Antimony Concentrations

Summary (Decisions & Specific Actions Required by Named Persons):

I asked if this information was in report form yet. Pat said that it was still in draft form but that it would be completed Nov. 23rd as part of the 1993 IWP and that it would be called, "Preliminary Background Elemental Concentrations in Bandelier Tuff and Selected Soil Series, 1993" by Pat Longmire, Clarence Duffy, and Steven Reneau.

Pat said that these background values/ranges were already being referenced by others and that we could reference the report in prep w/ the 1993 IWP and reflect that it was still in production, but would be completed Nov. 23, 1993

Pat asked if any of our values for beryllium & antimony were out of the ranges he had given me. Our beryllium values range from (0.3-0.6 ppm) and our antimony values range from (30-35 ppm). We agreed that the beryllium values were within/below background. Antimony, however, did exceed the background range.

~~Required Action:~~

Prepared by (Signature): Wendi D. Knutson

Distribution:
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☐ Other Distribution (By Preparer)

548A-8-87

INTERNATIONAL TECHNOLOGY CORPORATION

RECORD OF ☑ TELECON ☐ MEETING

Project Name	Number	Phase	Task	Subtask
TA-35, TSL-85	301625	03	01	

Date 9/1/93 Time 8:30am

CALL FROM ☐ CALL TO ☑ NAME: Pat Longmire

Other Participants — Name/Location/Representing:

- NA -

CALL FROM ☐ CALL TO ☑ NAME: (same as above)

Telephone Number: 665-1264

Company Name: LANL

Address: INC-9

City

State Zip Code

Topic Obtain Lab wide-Background Beryllium & Antimony Concentrations

Summary (Decisions & Specific Actions Required by Named Persons):

Pat mentioned that the Lab had established action levels that if exceeded additional sampling or analyses would have to be conducted. He said these action levels were not clean-up standards. Pat had the following action levels:

beryllium: 0.16 ppm → agreed w/our value
antimony: 32 ppm → (our value was 20ppm)

If Pat is correct that the action level for antimony is really 32 ppm and not 20ppm ~~that~~ then most of the antimony levels/samples are below the action level and could be removed from further consideration.

Pat said that these action levels were generated by Elizabeth Kelly's Group and that Allison Dabnes (5-4791 or 5-4611) in the ER-assessmt group drives these levels. I will call her to verify the value for antimony.

Required Action:

Pat said to feel free to call him again w/additional questions

Prepared by (Signature): Wendi D. Knutsen

Distribution:
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Copy to Project Manager
Copy to Preparer

☐ Other Distribution (By Preparer)

548A-8-87

ATTACHMENT 2-2

Material Safety Data Sheet for 1,1,1-Trichloroethane Used in Buildings 85 and 188 at Technical Area 35

Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8854

Section 1. Material Identification

Methyl Chloroform ($C_2H_3Cl_3$) Description: Derived by catalytic addition of hydrogen chloride to 1,1-dichloroethylene or by re-fluxing chlorine monoxide with carbon tetrachloride and chloroethane. Available in technical and solvent grades which differ only in the amount of stabilizer added to prevent metal parts corrosion. Used as a solvent for oils, waxes, tars, cleaning precision instruments, and pesticides; as a component of inks and drain cleaners; in degreasing metals, and textile processing. In recent years, methyl chloroform (TCE) has found widespread use as a substitute for carbon tetrachloride.

Other Designations: CAS No. 71-55-6, α-trichloroethane; Inhibisol; 1,1,1-trichloroethane; Strobane; TCE.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: TCE is a skin, eye, and respiratory tract irritant and can become narcotic with an anesthetic effect at high concentrations.

* Data on skin absorption via methyl chloroform is conflicting.[133] Some studies show definite absorption where others don't.

R	1
I	2
S	2*
K	1

Genium

HMIS
H 2
F 1
R 1
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Methyl chloroform, ca 92 to 97%*

1990 OSHA PELs
8-hr TWA: 350 ppm (1900 mg/m^3)
15-min STEL: 450 ppm (2450 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
15-min Ceiling: 350 ppm (1900 mg/m^3)

1991-92 ACGIH TLVs
TWA: 350 ppm (1910 mg/m^3)
STEL: 450 ppm (2460 mg/m^3)

1990 DFG (Germany) MAKs
TWA: 200 ppm (1080 mg/m^3)
Half-life: 2 hr to shift length
Peak Exposure Limit: 1000 ppm/30 min (average value)/2 per shift

1985-86 Toxicity Data†
Human, oral, TD_{Lo}: 670 mg/kg produced diarrhea, nausea, and vomiting
Human, inhalation, LC_{Lo}: 27 g/m^3/10 min; toxic effects not yet reviewed
Man, eye: 450 ppm/8 hr produced irritation
Rat, inhalation, TC_{Lo}: 2100 ppm/24 hr for 14 days prior to mating and from 1 to 20 days of pregnancy produced specific developmental abnormalities of the musculoskelatal system

* Methyl chloroform usually contains inhibitors (3 to 8%) to prevent corrosion of aluminum and some other metals. Typical inhibitors are nitromethane, butylene oxide, secondary butyl alcohols, ketones, and glycol diesters.
† See NIOSH, *RTECS* (KJ2975000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 165 °F (75 °C)
Freezing Point: -22 °F (-30 °C)
Vapor Pressure: 100 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 4.55
Corrosivity: Readily corrodes aluminum and its alloys
Refraction Index: 1.43765 at 69.8 °F (21 °C)
Viscosity: 0.858 cP at 68 °F (20 °C)
Molecular Weight: 133.42
Density: 1.3376 at 68/39.8 °F (20/4 °C)
Water Solubility: Insoluble
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, carbon tetrachloride, and carbon disulfide
% in Saturated Air: 16.7% at 77 °F (25 °C)
Relative Evaporation Rate (butyl acetate = 1): 12.8
Appearance and Odor: Colorless liquid with a sweetish, chloroform-like odor. The odor threshold is 44 ppm.

Section 4. Fire and Explosion Data

Flash Point: None (in conventional CC tests)	Autoignition Temperature: 932 °F (500 °C)	LEL: 7% v/v	UEL: 16% v/v

Extinguishing Media: *Noncombustible liquid* whose *vapor* burns in the presence of excess oxygen or a strong ignition source. For small fires, use dry chemical or carbon dioxide (CO_2). For large fires use fog or regular foam. If these materials are unavailable, a water spray may be used but be aware that water reacts slowly with methyl chloroform to release hydrochloric acid.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and may travel to a strong ignition source and flash back. Air/vapor mixtures may explode when heated. Container may explode in heat of fire. Exposure to open flames or arc welding can produce hydrogen chloride and phosgene.
Special Fire-fighting Procedures: TCE's burning rate is 2.9 mm/min. Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides limited protection. Wear clothing specifically recommended by the manufacturer for use in fires involving methyl chloroform. Apply cooling water to container sides until after fire is extinguished. Stay away from ends of tanks. Isolate area for 1/2 mile if fire involves tank, truck, or rail car. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: TCE is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can occur in contact with aluminum trichloride.
Chemical Incompatibilities: TCE is incompatible with sodium hydroxide, nitrogen tetroxide, oxygen (liquid or gas), strong oxidizers, and chemically active metals like aluminum, zinc, and magnesium powders; reacts violently with caustics to form dichloroacetylene; reacts slowly with water to form hydrochloric acid; forms shock sensitive mixtures with potassium; and polymerizes in contact with aluminum trichloride.
Conditions to Avoid: Exposure to moisture, strong ignition sources, and arc-welding units, and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition (temperatures >500 °F, contact with hot metals, or under UV rays) of methyl chloroform can produce carbon dioxide (CO_2) and toxic dichloroacetylene, hydrogen chloride, and phosgene gases.

Section 6. Health Hazard Data

Carcinogenicity: The IARC (Class 3, inadequate evidence),[164] NTP,[142] and OSHA[164] do not list methyl chloroform as a carcinogen.
Summary of Risks: Methyl chloroform is considered one of the least toxic of the liquid chlorinated hydrocarbons. It is irritating to eyes, skin, and respiratory tract. Although low in systemic toxicity, TCE is an anesthetic capable of causing death at high concentrations (>15,000 ppm), generally in poorly ventilated, enclosed areas. Quick and complete recovery is observed after prompt removal of unconscious persons from area of exposure. Like many other solvents, TCE sensitizes the heart to epinephrine (blood pressure-raising hormone) and may induce cardiac arrhythmias and arrest.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous (CNS) and cardiovascular (CVS) systems.

Continue on next page

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Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation, skin contact.
Acute Effects: TCE defats the skin causing irritation, redness, dryness, and scaling. Contact with eyes produces irritation and mild conjunctivitis. Vapor inhalation can cause headache, dizziness, equilibrium disturbances, and in high concentrations may lead to CNS depression, unconsciousness, and coma. During a 60-min exposure period these effects are observed: 100 ppm is the observed odor threshold, at 500 ppm there is obvious odor and decreased reaction time, 1000 ppm causes slight equilibrium loss, at 5000 ppm there is definite incoordination, and 20,000 ppm produces surgical strength anesthesia with possible death. Mild liver and kidney dysfunction may occur after CNS depression recovery. Although unlikely, if ingestion occurs, symptoms include nausea, vomiting, diarrhea, and possible esophageal burns. The acute lethal human dose is ~500 to 5000 mg/kg.
Chronic Effects: None reported.
FIRST AID
Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center, and unless they advise otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. When deciding whether to induce vomiting, carefully consider amount ingested, time since ingestion, and availability of medical help. If large amounts are recently ingested (absorption into the body is not yet likely to have occurred), and medical help or transportation to a medical facility is not readily available, induce vomiting. Otherwise, vomiting is not recommended since aspiration of vomitus can produce chemical pneumonitis.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Do not use adrenaline or sympathomimetic amines in treatment because of the increased cardiac sensitivity involved.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. If possible without risk, shut off leak. Cleanup personnel should wear fully encapsulating vapor-protective clothing. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material. Using nonsparking tools, place in suitable containers for disposal or reclamation. For large spills, dike far ahead of liquid spill for later disposal or reclamation. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: In water, methyl chloroform's half-life is hours to weeks depending on wind and mixing conditions. It is very persistent in groundwater. On land it volatilizes due to its high vapor pressure and leaches extensively. When released to the atmosphere, methyl chloroform can be transported long distances and returned to earth via rain. It is slowly degraded by reaction with hydroxyl radicals and has a half-life of 6 months to 25 years. The Natural Resources Defenses Council reported recently that TCE depletes ozone.
Ecotoxicity Values: *Pimephales promelas* (fathead minnow), LC_{50}: 52.8 mg/L/96 hr; *Poecilia reticulata* (guppy), LC_{50}: 133 ppm/7 day.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U226
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [* per RCRA, Sec. 3001, CWA, Sec. 307(a), and CAA, Sec. 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear splash-proof, protective chemical safety goggles or faceshields, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact. Viton and butyl rubber [with breakthrough times (BTs) of >8 hr and 4 to 7.9 hr, respectively] are recommended materials for protective gear. *Do not use* neoprene, polyvinyl chloride (PVC), natural rubber, or polyethylene because these materials have a BT of <1 hr.
Ventilation: Provide general and local exhaust (in some cases, explosion-proof) ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in cool, dry, well-ventilated (use pressure-vacuum ventilation) area away from ignition sources, arc-welding operations, and incompatibles (Sec. 5). Regularly monitor inhibitor levels. *Do not* store in aluminum containers or use pressure-spraying equipment when methyl chloroform is involved.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all equipment used in methyl chloroform manufacturing, use, storage, transfer, and shipping.
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize CNS, CVS, liver and skin.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: 1,1,1-Trichloroethane
DOT Hazard Class: ORM-A
ID No.: UN2831
DOT Label: None
DOT Packaging Exceptions: 173.505
DOT Packaging Requirements: 173.605

IMO Shipping Name: 1,1,1-Trichloroethane
IMO Hazard Class: 6.1
ID No.: UN2831
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection **References:** 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 148, 153, 159, 162, 163, 164
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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3.0 PROPOSED SAMPLING AND ANALYSIS PLAN

This sampling and analysis plan (SAP) presents the proposed Phase VI sampling and analytical effort. In order to verify clean closure of the TSL-85 Surface Impoundment (including the associated UST and ancillary piping), representative analytical data must document the absence of RCRA-regulated hazardous constituents at concentrations above health-based action levels or at concentrations that pose an unacceptable risk to human health or the environment. Phase VI sampling is required to obtain analytical data of good quality that are representative of the soils sampled previously below the surface impoundment (Phase I), beneath the UST and associated piping (Phase III), and along the Mortandad Canyon spill path (Phase IV).

This SAP provides guidance for the additional sampling and analysis in the form of specified procedures, tables summarizing analytes for which analyses will be performed, associated analytical methods, and figures locating proposed sample locations. All samples will be handled, preserved, and documented in accordance with EPA methods as outlined in Enclosure 1 of the Closure Certification Report (BEC, 1991). All analyses, QA, and QC will follow guidance specified in "Test Methods for Evaluating Solid Waste" (*SW-846*) (U.S. EPA, 1992). If hazardous constituents are detected in any of the samples, a risk evaluation will be performed, as outlined in Section 4.0 of this amendment. As a result of the risk evaluation, all detected hazardous constituents will be addressed as determined appropriate by LANL with NMED approval.

3.1 PHASE VI SAMPLING OF SOILS BENEATH LOCATION OF FORMER TSL-85 SURFACE IMPOUNDMENT

The analyses performed for Phase I soil samples generated analytical data for VOCs and SVOCs that are suspect due to surrogate recovery results outside EPA limits and missed EPA-allowable holding times. In addition, the SVOC data were compromised due to interference from nonhazardous dielectric waste oil resulting in elevated LOQs. Therefore, Phase VI soil samples will be collected in the area of the former surface impoundment at locations representative of the locations sampled during Phase I. Six soil samples will be collected at a depth of 2 to 3 feet at the approximate locations shown on Figure 3-1. The soil samples will be collected with a hand auger in accordance with the procedure described in Section 3.4.1.2, placed in approved containers, and preserved appropriately (Table 3-1). Samples will be accompanied by the proper chain-of-custody and request for analysis forms. LANL's EM-9 will analyze the samples for all Appendix VIII VOCs (Table 3-2), SVOCs (Table 3-3), pesticides and herbicides (Table 3-4), and

metals (Table 3-5) that their in-house laboratories have the analytical capability to perform (see also Section 2.3). Table 3-6 has been provided for reference and summarizes the Appendix VIII constituents for which EM-9 can analyze with the associated *SW-846* methods.

3.2 PHASE VI SAMPLING OF SOILS BELOW LOCATION OF FORMER UNDERGROUND STORAGE TANK AND ASSOCIATED PIPING

The analytical data for VOCs, SVOCs, and mercury generated for soil samples collected in Phase III of the original closure effort were determined to be suspect due to surrogate recovery results outside EPA limits and missed EPA-allowable holding times. As a result, Phase VI soil samples will be collected from below the approximate location of the former UST and associated piping. Twelve soil samples will be collected, following the procedures described in Section 3.4.1.2, at a depth of 3.5 to 4.5 feet at approximately the same sampling locations as the Phase III samples. Sampling personnel will attempt to collect these samples below the approximate location of the twelve joints in the former PVC pipe that connected the UST and Building 85 to the surface impoundment (Figure 3-2). The soil samples will be collected with a hand auger in accordance with the procedure described in Section 3.4.1.2, placed in approved containers, and preserved appropriately as summarized in Table 3-1. They will be accompanied by the proper chain-of-custody and request for analysis forms. The samples will be analyzed for VOCs (Table 3-2), SVOCs (Table 3-3), pesticides and herbicides (Table 3-4), and metals (Table 3-5).

3.3 PHASE VI SAMPLING OF SOILS ALONG MORTANDAD CANYON SPILL PATH

The analyses performed for Phase IV soil samples generated analytical data for VOCs, SVOCs, and mercury that are suspect due to missed EPA-allowable holding times and surrogate recovery results outside EPA limits. Eleven Phase VI soil samples will be collected at a depth of 6 inches at approximately the same sampling locations from which the Phase IV samples were taken (Figure 3-3). The samples will be collected using a disposable teflon trowel or scoop in accordance with the procedure described in Section 3.4.1.1, placed in approved containers, and preserved as stated in Table 3-1. The samples will be accompanied by the proper chain-of-custody and request for analysis forms. LANL will analyze the samples for VOCs (Table 3-2), SVOCs (Table 3-3), pesticides and herbicides (Table 3-4), and metals (Table 3-5).

3.4 SAMPLING AND ANALYSIS PROCEDURES

The following sections were extracted from the Interim Status Closure Plan for the TA-35 TSL-85 Surface Impoundment (BEC, 1991) (Enclosure 1 of the Closure Certification Report [BEC, 1991]). The sections define procedures and methods for sampling, analysis, and documentation applicable to this SAP. While the procedures and methods are specific, any applicable procedure or method defined in *SW-846* (most current edition) may be used if conditions or experience shows the alternate *SW-846* method to be more appropriate.

Personnel involved with sampling will use proper protective clothing and equipment. LANL's Industrial Hygiene and Safety Group (HS-5) will be responsible for assessing hazards and determining protective clothing requirements.

3.4.1 Soil Sampling Procedures

Soil sampled from the surface to five-foot depths will be collected with a trowel, scoop, or hand-held auger. Only clean sampling equipment will be used for soil sampling. All samples will be collected in EPA-approved containers and preserved in accordance with EPA methods (Table 3-1).

3.4.1.1 Trowel or Scoop Sampling Procedures

- Take small, equal portions of sample from the surface or near the surface of the material to be sampled.
- Composite the samples in a glass container.
- Cap the container, affix the seal, attach a label, follow proper preservation requirements, record in field logbook, and complete the sample analysis request sheet and chain-of-custody record.
- Deliver the samples to the EM-9 laboratory for analysis.

3.4.1.2 Hand Auger Sampling Procedures

- Attach hand auger to the bottom of a length of pipe that has a cross arm at the top.
- Drill hole by turning the cross arm and pressing auger into the ground to the desired depth. Add additional lengths of pipe as required.

- Once filled with soil, withdraw the auger from the hole and retrieve the soil sample.
- Store the core sample in an appropriate sample container and follow proper preservation requirements (Table 3-1).
- Affix the seal, label the sample, record in the field logbook, complete sample analysis request sheet and chain-of-custody record, and deliver the samples to the EM-9 laboratory for analysis.

3.4.2 Rinsate Sampling Procedures

A composite liquid waste sampler (Coliwasa) or similar device will be used to sample rinsate from equipment cleaning. As an alternative to the Coliwasa, disposable Coliwasas or glass tubes may also be used to sample liquids. The primary advantage in utilizing a disposable Coliwasa is that it will be disposed as appropriate after each sample is collected, thus eliminating the potential for cross contamination.

3.4.2.1 Sampler Preparation

The Coliwasa sampler will be cleaned before each use. The sampler will be washed with a warm detergent solution (Liquinox® or Alconox®), rinsed several times with tap water, rinsed with distilled water, drained of excess water, and air-dried or wiped dry. A necessary piece of equipment for cleaning the tube of the Coliwasa is a bottle brush that fits tightly inside the diameter of the tube. The brush is connected to a rod of sufficient length to reach the entire length of the sampler tube. Using this ramrod and fiber-reinforced paper towels, the Coliwasa tube can be cleaned quickly. Clean Coliwasa samplers will be stored in polyethylene plastic tubes or bags in a clean and protected area until they are used.

3.4.2.2 Sampling Procedures

- Wear appropriate protective clothing and gear as determined by HS-5.
- Assemble the clean glass or disposable Coliwasa sampler.
- Slowly lower the Coliwasa sampler into the liquid at a rate that permits the levels of the liquid inside and outside the sampler tube to remain the same.
- When the sampler reaches the bottom of the liquid, slowly withdraw the sampler with one hand while wiping the sampler tube with a clean disposable cloth with the other hand.

- Carefully discharge the sample into a glass container by slowly lifting the inner glass tube of the Coliwasa; cap the glass container, attach a label and seal.
- Follow appropriate preservation requirements as outlined in *SW-846*.
- Record in the field logbook and complete the sample analysis request sheet and chain-of-custody record.
- Deliver the samples to the EM-9 laboratory for analysis.

3.4.3 Sample Handling and Documentation

Sample containers will be sealed with a gummed paper seal attached to the container in such a way that the seal must be broken in order to open the container. The seal and sample label will be completed with a waterproof pen. The sample label is necessary to prevent misidentification of samples. Field information, in the case of soil sampling, shall include observations such as the soil texture and surface appearance, ambient temperature and cloud cover at the time of sampling, and precipitation conditions 24 hours before sampling. A chain-of-custody form is necessary to trace sample possession from the time of collection and must accompany every sample. A closure sampling log will be kept and will contain all information pertinent to field surveys/investigation, sampling, and analysis. Sampling situations vary widely. No specific rule can be given as to the extent of information that must be entered in the logbook. A good general rule, however, is to record sufficient information so that someone can reconstruct the sampling event without relying on the collector's memory.

The sampling shipment and chain-of-custody record will be accompanied by a sample analysis request sheet. The request sheet has two parts: field and laboratory. The field portion of this form will be completed by the person collecting the sample and will include most of the pertinent information noted in the logbook. The laboratory portion is intended to be completed by the laboratory personnel when the sample is received.

3.4.4 Sample Analysis

All analyses, QA, and QC will follow methods defined in *SW-846*. The analytical methods expected to be employed for analysis of samples collected during closure activities are denoted in Table 3-6.

3.5 EQUIPMENT DECONTAMINATION

Prior to use, equipment will be rinsed with distilled water. A representative sample of the wash water, prior to use, and the rinsate will be collected, preserved, and analyzed in accordance with the procedures described in Section 3.4.2 and outlined in *SW-846*. The samples will be analyzed for all Appendix VIII VOCs (Table 3-2), SVOCs (Table 3-3), pesticides and herbicides (Table 3-4), and metals (Table 3-5) that LANL's EM-9 in-house laboratories have the analytical capability to perform. These analyses will determine if the wash water or the equipment is contaminated with hazardous constituents prior to use. Any equipment that cannot be decontaminated will be disposed as hazardous waste. Representative samples of the final rinsate will also be collected and analyzed as described in Section 3.4.2. Protective clothing utilized during the sampling effort will be collected and disposed as hazardous waste at an off-site RCRA-permitted facility.

Table 3-1

Soil Sample Containers and Preservatives

Constituent	Container Type	Container Size	Preservative
Volatile Organic Compounds	Glass, silica/teflon septa	(2) 40 ml[a]	Cool to 4°C[b]
Semivolatile Organic Compounds	Glass, silica/teflon septa	250 ml	Cool to 4°C
Metals	Glass, silica/teflon septa	250 ml	Cool to 4°C

[a] Units are milliliters.
[b] "°C" refers to degrees Celsius.

Table 3-2

EM-9's[a] Volatile Organic Compound Analytical Capabilities by *SW-846*[b] Method 8260

Acetonitrile
Acrolein
Acrylonitrile
Allyl chloride
Benzene
Bromoform
Carbon disulfide
Carbon tetrachloride
Chlorinated ethane, NOS[c]
Chlorobenzene
2-Chloroethyl vinyl ether
Chloroform
1,2-Dibromo-3-chloropropane
1,4-Dichloro-2-butene
Dichlorodifluoromethane
Dichloroethylene, NOS
1,1-Dichloroethylene
1,2-Dichloroethylene
Dichloropropane, NOS
Dichloropropene, NOS
1,3-Dichloropropene
Ethyl methacrylate
Isobutyl alcohol
Methyacrylonitrile
Methyl bromide
Methyl chloride
Methyl chloroform
Methyl ethyl ketone
Methyl iodide
Methylacrylonitrile
Methylene bromide
Methylene chloride
Tetrachloroethane, NOS
Tetrachloroethylene
1,1,1,2-Tetrachloroethane
1,1,2,2-Tetrachloroethane
Toluene
Trichloroethylene
1,1,2-Trichloroethane
Trichloromonofluoromethane
Trichloropropane, NOS
Vinyl chloride

a "EM-9" refers to the Los Alamos National Laboratory's Environmental Chemistry Group.

b "*SW-846*" refers to "Test Methods for Evaluating Solid Waste" (U.S. Environmental Protection Agency, 1992).

c "NOS" is defined as "not otherwise specified."

Table 3-3

EM-9's[a] Semivolatile Organic Compound Analytical Capabilities by *SW-846*[b] Method 8270

Aniline	2,4-Dimethylphenol
Benz(a)anthracene	4,6-Dinitro-o-cresol
Benzidine	2,4-Dinitrophenol
Benzo(b)fluoranthene	2,4-Dinitrotoluene
Benzo(a)pyrene	2,6-Dinitrotoluene
4-Bromophenyl phenyl ether	Di-n-octyl phthalate
Butyl benzyl phthalate	Fluoranthene
Chlorinated naphthalene, NOS[c]	Hexachlorobenzene
p-Chloroaniline	Hexachlorobutadiene
p-Chloro-m-cresol	Hexachlorocyclopentadiene
beta-Chloronaphthalene	Hexachloroethane
o-Chlorophenol	Indeno{1,2,3-cd}pyrene
Chrysene	Naphthalene
Cresols, NOS	Nitric oxide
Dibenz(a,h)anthracene	p-Nitroaniline
Dibutyl phthalate	Nitrobenzene
Dichlorobenzene, NOS	p-Nitrophenol
m-Dichlorobenzene	N-Nitrosodimethylamine
o-Dichlorobenzene	Pentachlorophenol
p-Dichlorobenzene	Phenol
3,3-Dichlorobenzidine	Phthalic acid esters, NOS
2,4-Dichlorophenol	1,2,4-Trichlorobenzene
Diethyl phthalate	2,4,5-Trichlorophenol
Diethylhexylphthalate	2,4,6-Trichlorophenol
Dimethyl phthalate	

a "EM-9" refers to the Los Alamos National Laboratory's Environmental Chemistry Group.
b "*SW-846*" refers to "Test Methods for Evaluating Solid Waste" (U.S. Environmental Protection Agency, 1992).
c "NOS" is defined as "not otherwise specified."

Table 3-4

EM-9's[a] Pesticide and Herbicide Analytical Capabilities by *SW-846*[b] Methods 8080/8150

8080
Aldrin
Chlordane
DDD
DDE
DDT
Dieldrin
Endosulfan I and II
Endrin
Endrin metabolites
Heptachlor
Heptachlor epoxide
Heptachlor epoxide a,b,g isomers
Lindane
Methoxychlor
Toxaphene

8150
2,4-D
2,4-D salts and esters
Dinoseb
Silver (2,4,5-tp)
2,4,5-T

a "EM-9" refers to the Los Alamos National Laboratory's Environmental Chemistry Group.

b "*SW-846*" refers to "Test Methods for Evaluating Solid Waste" (U.S. Environmental Protection Agency, 1992).

Table 3-5

EM-9's[a] Metal Analytical Capabilities by *SW-846*[b] Methods 6000/7000

Antimony
Antimony compounds, NOS[c]
Arsenic
Arsenic acid
Arsenic compounds, NOS
Arsenic pentoxide
Arsenic trioxide
Barium
Barium compounds, NOS
Barium cyanide
Beryllium
Beryllium compounds, NOS
Cadmium
Cadmium compounds, NOS
Calcium chromate
Calcium cyanide
Chromium
Chromium compounds, NOS
Lead
Lead acetate
Lead compounds, NOS
Lead phosphate
Lead subacetate
Mercury
Nickel
Nickel compounds, NOS
Nickel cyanide
Selenium compounds, NOS
Selenium dioxide
Selenium sulfide
Silver
Silver compounds, NOS
Silver cyanide
Thallic oxide
Thallium
Thallium compounds, NOS
Thallium (i) acetate
Thallium (i) carbonate
Thallium (i) chloride
Thallium (i) nitrate
Thallium selenite
Thallium (i) sulfate

a "EM-9" refers to the Los Alamos National Laboratory's Environmental Chemistry Group.

b "*SW-846*" refers to "Test Methods for Evaluating Solid Waste" (U.S. Environmental Protection Agency, 1992).

c "NOS" is defined as "not otherwise specified."

Table 3-6

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Acetonitrile	Acetonitrile	8260
Acetophenone		8270
2-Acetaminefluorene		8270
Acetyl chloride		
1-Acetyl-2-thiorurea		8270
Acrolein	Acrolein	8260
Acrylamide		
Acrylonitrile	Acrylonitrile	8260
Aflatoxins		
Aldicarb		
Aldrin	Aldrin	8080
Allyl alcohol		
Allyl chloride	Allyl chloride	8260
Aluminum phosphide		
4-Aminobiphenyl		8270
5-(Aminomethyl)-3-isooxazolol		
4-Aminopyridine		
Amitrole		
Ammonium vanadate		
Aniline	Aniline	8270
Antimony	Antimony	6000/7000
Antimony compounds, NOS[d]	Antimony compounds, NOS	6000/7000
Aramite		8270
Arsenic	Arsenic	6000/7000
Arsenic compounds, NOS	Arsenic compounds, NOS	6000/7000
Arsenic acid	Arsenic acid	6000/7000
Arsenic pentoxide	Arsenic pentoxide	6000/7000
Arsenic trioxide	Arsenic trioxide	6000/7000
Auramine		
Azaserine		
Barium	Barium	6000/7000
Barium compounds, NOS	Barium compounds, NOS	6000/7000
Barium cyanide	Barium cyanide	6000/7000
Benz(c)acridine		
Benz(a)anthracene	Benz(a)anthracene	8270
Benzal chloride		
Benzene	Benzene	8260
Benzenearsonic acid		
Benzidine	Benzidine	8270
Benzo(b)fluoranthene	Benzo(b)fluoranthene	8270
Benzo(j)fluoranthene		
Benzo(a)pyrene	Benzo(a)pyrene	8270
p-Benzoquinone		
Benzotrichloride		

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Benzyl chloride		
Beryllium	Beryllium	6000/7000
Beryllium compounds, NOS	Beryllium compounds, NOS	6000/7000
Bromoacetone		
Bromoform	Bromoform	8260
4-Bromophenyl phenyl ether	4-Bromophenyl phenyl ether	8270
Bricine		
Butyl benzyl phthalate	Butyl benzyl phthalate	8270
Cacodylic acid		
Cadmium	Cadmium	6000/7000
Cadmium compounds, NOS	Cadmium compounds, NOS	6000/7000
Calcium chromate	Calcium chromate	6000/7000
Calcium cyanide	Calcium cyanide	6000/7000
Carbon disulfide	Carbon disulfide	8260
Carbon oxyfluoride		
Carbon tetrachloride	Carbon tetrachloride	8260
Chloral		
Chlordane	Chlordane	8080
Chlordane (a and g isomers)		
Chlorinated benzenes, NOS		
Chlorinated ethane, NOS	Chlorinated ethane, NOS	8260
Chlorinated fluorocarbons, NOS		
Chlorinated naphthalene, NOS	Chlorinated naphthalene, NOS	8270
Chlorinated phenol, NOS		
Chlornaphazin		
Chloroacetaldehyde		
Chloroalkyl ethers, NOS		
p-Chloroaniline	p-Chloroaniline	8270
Chlorobenzene	Chlorobenzene	8260
Chlorobenzilate		8270
p-Chloro-m-cresol	p-Chloro-m-cresol	8270
2-Chloroethyl vinyl ether	2-Chloroethyl vinyl ether	8260
Chloroform	Chloroform	8260
Chloromethyl methyl ether		
beta-Chloronaphthalene	beta-Chloronaphthalene	8270
o-Chlorophenol	o-Chlorophenol	8270
1-(o-Chlorophenyl)thiourea		
Chloroprene		
3-Chloropropionitrile		
Chromium	Chromium	6000/7000
Chromium compounds, NOS	Chromium compounds, NOS	6000/7000
Chrysene	Chrysene	8270
Citrus red No. 2		
Coal tar creosote		

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Copper cyanide		
Creosote		
Cresols, NOS	Cresols, NOS	8270
Crotonaldehyde		
Cyanides, NOS		
Cyanogen		
Cyanogen bromide		
Cyanogen chloride		
Cycasin		
2-Cyclohexyl-2,6-dinitrophenol		
Cyclophosphamide		
2,4-D	2,4-D	8150
2,4-D salts and esters	2,4-D salts and esters	8150
Daunomycin		
DDD	DDD	8080
DDE	DDE	8080
DDT	DDT	8080
Diallate		8270
Dibenz(a,h)acridine		
Dibenz(a,j)acridine		8270
Dibenz(a,h)anthracene	Dibenz(a,h)anthracene	8270
Dibenzo carbazole		
Dibenzo(a,e)pyrene		
Dibenzo(a,h)pyrene		
Dibenzo(a,i)pyrene		
1,2-Dibromo-3-chloropropane	1,2-Dibromo-3-chloropropane	8260
Dibutyl phthalate	Dibutyl phthalate	8270
o-Dichlorobenzene	o-Dichlorobenzene	8270
m-Dichlorobenzene	m-Dichlorobenzene	8270
p-Dichlorobenzene	p-Dichlorobenzene	8270
Dichlorobenzene, NOS	Dichlorobenzene, NOS	8270
3,3-Dichlorobenzidine	3,3-Dichlorobenzidine	8270
1,4-Dichloro-2-butene	1,4-Dichloro-2-butene	8260
Dichlorodifluoromethane	Dichlorodifluoromethane	8260
Dichloroethylene, NOS	Dichloroethylene, NOS	8260
1,1-Dichloroethylene	1,1-Dichloroethylene	8260
1,2-Dichloroethylene	1,2-Dichloroethylene	8260
Dichloroethyl ether		
Dichloroisopropyl ether		
Dichloromethoxy ethane		
Dichloromethyl ether		
2,4-Dichlorophenol	2,4-Dichlorophenol	8270
2,6-Dichlorophenol		8270
Dichlorophenylarsine		

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Dichloropropane, NOS	Dichloropropane, NOS	8260
Dichloropropanol, NOS		
Dichloropropene, NOS	Dichloropropene, NOS	8260
1,3-Dichloropropene	1,3-Dichloropropene	8260
Dieldrin	Dieldrin	8080
1,2,3,4-Diepoxybutane		
Diethylarsine		
1,4-Diethyleneoxide		
Diethylhexylphthalate	Diethylhexylphthalate	8270
N,N-Diethyl hydrazine		
O,O-Diethyl s-methyl dithiophosphate		
Diethyl-p-nitrophenyl phosphate		
Diethyl phthalate	Diethyl phthalate	8270
O,O-Diethyl o-pyrazinyl phosphorothioate		
Diethylstilbesterol		
Dihydrosafrole		
Diisopropylfluorophosphate		
Dimethoate		8270
3,3'-Dimethoxybenzidine		
p-Dimethylaminoazobenzene		8270
7,12-Dimethylbenz(a)anthracene		8270
3,3'-Dimethylbenzidine		8270
Dimethylcarbamoyl chloride		
1,1-Dimethyl hydrazine		
1,2-Dimethyl hydrazine		
a,a-Dimethylphenethylamine		8270
2,4-Dimethylphenol	2,4-Dimethylphenol	8270
Dimethyl phthalate	Dimethyl phthalate	8270
Dimethyl sulfate		
Dinitrobenzene, NOS		8270
4,6-Dinitro-o-cresol	4,6-Dinitro-o-cresol	8270
4,6-Dinitro-o-cresol salts		
2,4-Dinitrophenol	2,4-Dinitrophenol	8270
2,4-Dinitrotoluene	2,4-Dinitrotoluene	8270
2,6-Dinitrotoluene	2,6-Dinitrotoluene	8270
Dinoseb	Dinoseb	8150
Di-n-octyl phthalate	Di-n-octyl phthalate	8270
Diphenylamine		8270
1,2-Diphenylhydrazine		8270
Di-n-propyinitrosamine		
Disulfoton		8270
Dithiobiuret		
Endosulfan I and II	Endosulfan I and II	8080

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Endothall		
Endrin	Endrin	8080
Endrin metabolites	Endrin metabolites	8080
Epichlorohydrin		
Epinephrine		
Ethyl carbamate		
Ethyl cyanide		
Ethylenebisdithiocarbamic acid		
Ethylenebisdithiocarbamic acid, salts and esters		
Ethylene dibromide		
Ethylene dichloride		
Ethylene glycol monoethyl ether		
Ethyleneimine		
Ethylene oxide		
Ethylenethiourea		
Ethylidene dichloride		
Ethyl methacrylate	Ethyl methacrylate	8260
Ethyl methanesulfonate		8270
Famphur		8270
Fluoranthene	Fluoranthene	8270
Fluorine		
Fluoroacetamide		
Fluoroacetic acid sodium salt		
Formaldehyde		
Formic acid		
Glycidyaldehyde		
Halomethanes, NOS		
Heptachlor	Heptachlor	8080
Heptachlor epoxide	Heptachlor epoxide	8080
Heptachlor epoxide a,b,g isomers	Heptachlor epoxide a,b,g isomers	8080
Hexachlorobenzene	Hexachlorobenzene	8270
Hexachlorobutadiene	Hexachlorobutadiene	8270
Hexachlorocyclopentadiene	Hexachlorocyclopentadiene	8270
Hexachlorodibenzo-p-dioxin		8280
Hexachlorodibenzofurans		8280
Hexachloroethane	Hexachloroethane	8270
Hexachlorophene		8270
Hexachloropropene		8270
Hexaethyl tetraphosphate		
Hydrazine		
Hydrogen cyanide		
Hydrogen fluoride		
Hydrogen sulfide		

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Indeno{1,2,3-cd}pyrene	Indeno{1,2,3-cd}pyrene	8270
Isobutyl alcohol	Isobutyl alcohol	8260
Isodrin		8270
Isosafrole		8270
Kepone		8270
Lasiocaprine		
Lead	Lead	6000/7000
Lead compounds, NOS	Lead compounds, NOS	6000/7000
Lead acetate	Lead acetate	6000/7000
Lead phosphate	Lead phosphate	6000/7000
Lead subacetate	Lead subacetate	6000/7000
Lindane	Lindane	8080
Maleic anhydride		
Maleic hydrazide		
Malononitrile		
Melphalan		
Mercury	Mercury	6000/7000
Mercury compounds, NOS		
Mercury fulminate		
Methyacrylonitrile	Methyacrylonitrile	8260
Methapyrilene		8270
Methomyl		
Methoxychlor	Methoxychlor	8080
Methyl bromide	Methyl bromide	8260
Methyl chloride	Methyl chloride	8260
Methyl chlorocarbonate		
Methyl chloroform	Methyl chloroform	8260
Methylcholanthrene		8270
Methylenebis(2-chloroaniline)		8270
Methylene bromide	Methylene bromide	8260
Methylene chloride	Methylene chloride	8260
Methyl ethyl ketone	Methyl ethyl ketone	8260
Methylethyl ketone peroxide		
Methyl hydrazine		
Methyl iodide	Methyl iodide	8260
Methyl isocyanate		
Methylacrylonitrile	Methylacrylonitrile	8260
Methyl methacrylate		8260
Methyl methanesulfonate		8270
Methyl parathion		8270
Methylthiouracil		
Mitomycin C		
MNNG		
Mustard gas		

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Naphthalene	Naphthalene	8270
1,4-Napthoquinone		8270
a-Napthylamine		8270
b-Napthylamine		8270
a-Naphthylthiourea		
Nickel	Nickel	6000/7000
Nickel compounds, NOS	Nickel compounds, NOS	6000/7000
Nickel carbonyl		
Nickel cyanide	Nickel cyanide	6000/7000
Nicotine		
Nicotine salts		
Nitric oxide	Nitric oxide	8270
p-Nitroaniline	p-Nitroaniline	8270
Nitrobenzene	Nitrobenzene	8270
Nitrogen dioxide		
Nitrogen mustard		
Nitrogen mustard, hydrochloric acid salt		
Nitrogen mustard n-oxide		
Nitrogen mustard, n-oxide, hydrochloride salt		
Nitroglycerin		
p-Nitrophenol	p-Nitrophenol	8270
2-Nitropropane		
Nitrosoamines, NOS		8270
N-Nitrosodi-n-butylamine		8270
N-Nitrosodiethanolamine		
N-Nitrosodiethylamine		8270
N-Nitrosodimethylamine	N-Nitrosodimethylamine	8270
N-Nitroso-n-ethylurea		
N-Nitrosomethylethylamine		8270
N-Nitroso-n-methylurea		
N-Nitroso-n-methylurethane		
N-Nitrosomethylvinylamine		
N-Nitrosomorpholine		8270
N-Nitrosonomicotine		
N-Nitrosopiperidine		8270
N-Nitrosopyrrolidine		8270
N-Nitrososarcosine		
5-Nitro-o-toluidine		8270
Octamethylpyrophosphoramide		8270
Osmium tetroxide		
Paraldehyde		
Parathion		8270

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Pentachlorobenzene		8270
Pentachlorodibenzo-p-dioxins		8280
Pentachlorodisbezofurans		8280
Pentachloroethane		8260/8270
Pentachloronitrobenzene		8270
Pentachlorophenol	Pentachlorophenol	8270
Phenacetin		8270
Phenol	Phenol	8270
Phenylenediamine		8270
Phenylmercury acetate		
Phenylthiourea		
Phosgene		
Phosphine		
Phorate		8270
Phthalic acid esters, NOS	Phthalic acid esters, NOS	8270
Phthalic anhydride		8270
2-Picoline		8270
Polychlorinated biphenyls, NOS	Polychlorinated biphenyls, NOS	8080
Potassium cyanide		
Potassium silver cyanide		
Pronamide		8270
1,3-Propane sulfone		
n-Propylamine		
Propargyl alcohol		
Propylene dichloride		
1,2-Propyleneimine		
Propylthiouracil		
Pyridine		8270
Reserpine		
Resorcinal		8270
Saccharin		
Saccharin salts		
Safrole		8270
Selenium compounds, NOS	Selenium compounds, NOS	6000/7000
Selenium dioxide	Selenium dioxide	6000/7000
Selenium sulfide	Selenium sulfide	6000/7000
Selenourea		
Silver	Silver	6000/7000
Silver compounds, NOS	Silver compounds, NOS	6000/7000
Silver cyanide	Silver cyanide	6000/7000
Silver (2,4,5-tp)	Silver (2,4,5-tp)	8150
Sodium cyanide		
Streptozotocin		
Strychnine		

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Strychnine salts		
2,3,7,8-TCDD		8280
1,2,4,5-Tetrachlorobenzene		8270
Tetrachlorodibenzo-p-dioxins		8280
Tetrachlorodibenzofurans		8280
Tetrachloroethane, NOS	Tetrachloroethane, NOS	8260
1,1,1,2-Tetrachloroethane	1,1,1,2-Tetrachloroethane	8260
1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	8260
Tetrachloroethylene	Tetrachloroethylene	8260
2,3,4,6-Tetrachlorophenol		8270
Tetraethyldithiopyrophosphate		
Tetraethyl lead		
Tetraethyl pyrophosphate		
Tetranitromethane		
Thallium	Thallium	6000/7000
Thallium compounds, NOS	Thallium compounds, NOS	6000/7000
Thallic oxide	Thallic oxide	6000/7000
Thallium (i) acetate	Thallium (i) acetate	6000/7000
Thallium (i) carbonate	Thallium (i) carbonate	6000/7000
Thallium (i) chloride	Thallium (i) chloride	6000/7000
Thallium (i) nitrate	Thallium (i) nitrate	6000/7000
Thallium selenite	Thallium selenite	6000/7000
Thallium (i) sulfate	Thallium (i) sulfate	6000/7000
Thioacetamide		
Thiofanox		
Thiomethanol		
Thiophenol		8270
Thiosemicarbizide		
Thiourea		
Thiram		
Toluene	Toluene	8260
Toluenediamine		
Toluene-2,4-diamine		
Toluene-2,6-diamine		
Toluene-3,4-diamine		
Toluene diisocyanate		
o-Toluidine		8270
o-Toluidine hydrochloride		
p-Toluidine		
Toxaphene	Toxaphene	8080
1,2,4-Trichlorobenzene	1,2,4-Trichlorobenzene	8270
1,1,2-Trichloroethane	1,1,2-Trichloroethane	8260
Trichloroethylene	Trichloroethylene	8260
Trichloromethanethiol		

See footnotes at end of table.

Table 3-6 (Continued)

Comparison of Appendix VIII[a] and Associated *SW-846*[b] Methods with EM-9's[c] Analytical Capabilities

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Trichloromonofluoromethane	Trichloromonofluoromethane	8260
2,4,5-Trichlorophenol	2,4,5-Trichlorophenol	8270
2,4,6-Trichlorophenol	2,4,6-Trichlorophenol	8270
2,4,5-T	2,4,5-T	8150
Trichloropropane, NOS	Trichloropropane, NOS	8260
Tris(1-aziridinyl)phosphine sulfide		
Tris(2,3-dibromopropyl)phosphate		8270
Trypan blue		
Uracil mustard		
Vanadium pentoxide		
Vinyl chloride	Vinyl chloride	8260
Warfarin		
Warfarin salts at conc. < 0.3%		
Warfarin salts at conc. > 0.3%		
Zinc cyanide		
Zinc phosphide		

[a] "Appendix VIII" refers to the New Mexico Hazardous Waste Management Regulations, Revision 7 (HWMR-7) Pt. II, Part 261, Appendix VIII.

[b] "*SW-846*" refers to "Test Methods for Evaluating Solid Waste" (U.S. Environmental Protection Agency, 1992).

[c] "EM-9" refers to the Los Alamos National Laboratory's Environmental Chemistry Group.

[d] "NOS" is defined as "not otherwise specified."

4.0 PROPOSED RISK EVALUATION

The risk evaluation proposed in this amendment to the Closure Certification Report for the TA-35 TSL-85 Surface Impoundment consists of calculation of 1) health-based soil concentration action levels, 2) aggregate hazard index for systemic toxicants, and 3) aggregate risk for carcinogens. Three areas of concern associated with the surface impoundment have been identified: the area of the impoundment itself, soils beneath the UST and associated piping, and soils along the spill path route downslope from the surface impoundment into Mortandad Canyon. A separate risk evaluation will be performed for each of the three areas using Phase VI analytical results in combination with validated Phase I through V data, as appropriate.

4.1 CALCULATION OF ACTION LEVELS

Health-based soil concentration action levels will be calculated for the constituents listed in Tables 3-2 through 3-5 only if a slope factor and/or reference dose are available in the most current IRIS database. The health-based action levels will be calculated using procedures and assumptions outlined in proposed RCRA Subpart S (*Federal Register*, Volume 55, No. 145, pp. 30815-20 and 30865-73) for the soil ingestion pathway only. The relevant portions of proposed Subpart S are included in this amendment as Appendix C. Per EPA guidance, the receptor is assumed to be a child for calculating health-based action levels for systemic toxicants; the receptor is assumed to be an adult for calculating health-based action levels for carcinogenic constituents.

The governing equation for calculation of health-based action levels for systemic toxicants is:

$$C = (RfD*W)/(I*CF)$$

where:

C = health-based action level in the soil (milligrams per kilogram [mg/kg])
RfD = reference dose, constituent specific, from current IRIS database (mg/kg/day)
W = body weight, 16 kg child (Appendix D of Subpart S)
I = soil intake, 0.2 gram (g)/day (Appendix D of Subpart S)
CF = conversion factor (0.001 kg/g)

The governing equation for calculation of health-based action levels for carcinogenic constituents is:

$$C = (R*W*LT)/(SF*I*ED*CF)$$

where:

C = health-based action level in the soil (mg/kg)
R = assumed risk level (dimensionless) (10^{-6} for class A & B; 10^{-5} for class C carcinogens)
W = body weight, 70 kg (Appendix D of Subpart S)
LT = assumed lifetime, 70 years (Appendix D of Subpart S)
SF = carcinogenic slope factor, constituent specific, from current IRIS database [$(mg/kg/day)^{-1}$]
I = soil intake, 0.1 g/day (Appendix D of Subpart S)
ED = exposure duration, 70 years (Appendix D of Subpart S)
CF = conversion factor (0.001 kg/g)

4.2 CALCULATION OF AGGREGATE HAZARD AND AGGREGATE RISK

The hazard quotient or risk associated with individual constituents can be calculated for the soil ingestion pathway using the approach presented in EPA's "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)" (EPA/540/1-89/002, December 1989) (RAGS). Aggregate hazard and risk indices are normally calculated for a site by summing these individual hazard quotients and risks, respectively, over the major constituents that are observed at a given site.

A complete risk assessment entails a site-specific exposure assessment from which reasonable maximum intake of constituents by various exposure routes can be derived. For the three areas associated with the former TSL-85 Surface Impoundment at TA-35, however, the conservative intake assumptions of Appendix D of proposed Subpart S (i.e., direct soil ingestion rates of 0.1 g/day for an adult and 0.2 g/day for a child) will be used because the observed levels are too low to warrant a more extensive calculation. The equation for calculation of intake is:

$$\text{Intake (mg/kg-day)} = (CS*IR*CF*FI*EF*ED)/(W*AT)$$

where:

CS = exposure concentration of the constituent in soil (see below) (mg/kg)
IR = ingestion rate: 200 mg/day for child; 100 mg/day for adult
CF = conversion factor: 10^{-6} kg/mg
FI = fraction ingested: conservatively set to 1.0 (dimensionless)
EF = exposure frequency: 365 days/year
ED = exposure duration: 70 years
W = body weight: 16 kg for child; 70 kg for adult
AT = averaging time: 70 years (25,550 days)

Hazard and risk will be calculated for the soil ingestion pathway only for constituents for which a reference dose and/or slope factor are available in the most current IRIS database. After the individual hazard quotients and risks are calculated, they will be summed based on the approach identified in RAGS to develop the aggregate hazard index and aggregate risk for each of the three sites. Selected portions of the RAGS document are included in this amendment as Appendix D.

For each constituent, the exposure concentration used as input to the intake equation will be based on the analytical data. If the LOQs for all samples for a given constituent are below the action level, the constituent will not be considered further. Three situations which will result in calculation of hazard and/or risk are possible:

1. If the constituent is detected above the LOQ in all samples, the 95 percent upper confidence limit of the arithmetic average will be used (per RAGS).

2. If the constituent is present above the LOQ in only some of the samples, those samples with concentrations less than the LOQ will be assumed to have a concentration of one-half of the sample-specific LOQ. The 95 percent upper confidence limit of the arithmetic average will then be used from the actual sample concentrations and the one-half LOQ values, as appropriate.

3. For the remaining constituents, if any of the sample-specific LOQs exceed the calculated health-based action level, additional consideration is necessary.

   - For a given constituent, if the action level is greater than or equal to one-half the LOQ for all samples, the constituent will not be included in the calculation of aggregate hazard index or aggregate risk. This is based on RAGS, which calls for one-half the LOQ to be used as the concentration for constituents below LOQs.

   - For a given constituent, if the health-based action level for one or more of the samples is less than one-half the sample-specific LOQ, and if there is some reason to believe that the constituent may be present, the 95 percent upper confidence limit of the arithmetic average will be used based on one-half the sample-specific LOQ for each sample.

If a given constituent is not detected in any of the samples and if there is no reason to believe that it may be present (e.g., it was not identified through process knowledge and was not detected at any of the three sites associated with the TSL-85 Surface Impoundment), the constituent will not be included in the calculation of the aggregate hazard or aggregate risk (per RAGS, Sections 5.3.1 and 5.3.5; see Appendix D of this amendment).

The hazard quotient (HQ) for systemic toxicants is calculated from:

$$HQ = intake/RfD$$

where the intake is calculated as shown above, and the RfD is the constituent-specific value obtained from the current IRIS database.

The carcinogenic risk is calculated from:

$$Risk = intake * SF$$

where the intake is calculated as shown above, and the SF is the constituent-specific value from the current IRIS database.

The formula to calculate the aggregate noncancer hazard index for chronic exposure is:

$$\text{Hazard Index} = \sum HQ_i$$

where:

HQ_i = Hazard quotient for the ith toxicant.

Aggregate risk is calculated from:

$$\text{Aggregate Risk} = \sum \text{Risk}_i$$

where Risk_i = risk estimate for the ith carcinogenic substance.

The risk calculations proposed in this section are based on a number of conservative assumptions and default values, and therefore presents a conservative upper bound for the actual risk associated with the TSL-85 Surface Impoundment. If the aggregate hazard index is greater than or equal to 1 or the aggregate risk exceeds 1×10^{-6}, risk assessment using a site-specific, realistic exposure assessment will be performed. The results of the in-depth risk assessment will be evaluated by NMED and LANL to determine whether the site poses an unacceptable risk to human health or the environment. If it is determined that the site poses an unacceptable risk, additional cleanup will be performed to a degree agreed to by NMED and LANL. Cleanup of the site will be considered complete when it has been demonstrated that the site does not pose an unacceptable risk to human health or the environment.

If the aggregate hazard index is less than one and the aggregate risk is lower than 1×10^{-6}, clean closure of the site will be considered achieved because the site does not pose an unacceptable risk to human health or the environment.

4.3 RISK CHARACTERIZATION

A risk characterization will be included in the Amended Closure Certification Report that presents quantitative and qualitative descriptions of risk. As stated in the RAGS document, "A risk characterization cannot be considered complete unless the numerical expressions of risk are accompanied by explanatory text interpreting and qualifying the results."

5.0 PROPOSED SCHEDULE

A certification of final clean closure for the TA-35 TSL-85 Surface Impoundment site, along with an amended closure certification report, will be submitted in August 1995, although initiation of closure activities will occur as early as the spring of 1994. The proposed schedule, provided as Figure 5-1, will commence upon receipt of a notice of approval of this amendment from NMED; the dates shown in Figure 5-1 assume that NMED will approve the amendment by the end of March 1994. Significant milestones include the initiation of field activities (4/1/94), completion of field activities (4/11/95), and submittal of an amended closure certification report and certification documentation (8/3/95).

This schedule includes optional remediation, sampling, and site restoration activities. Thus, the schedule in Figure 5-1 is considered to represent a reasonable maximum duration for the project. However, field activities are subject to delay based on weather conditions and interactions with outside agencies (e.g., closure plan approval). If remediation, verification sampling, and site restoration activities are not warranted, as determined jointly by NMED and LANL, the significant milestones would include the initiation of field activities (4/1/94), completion of field activities (4/28/94), and submittal of an amended closure certification report and certification documentation (1/31/95).

6.0 REFERENCES

Benchmark Environmental Corporation, 1991a, "Closure Certification Report, TA-35 TSL-85 Surface Impoundment," prepared for Los Alamos National Laboratory, Los Alamos, New Mexico.

Benchmark Environmental Corporation, 1991b, "Interim Status Closure Plan, Technical Area 35 TSL-85 Surface Impoundment, Los Alamos National Laboratory, Los Alamos, New Mexico," Rev. 3, Los Alamos National Laboratory, Los Alamos, New Mexico.

EPA, see U.S. Environmental Protection Agency.

Ferenbaugh, R.W., E.S. Gladney, G.H. Brooks, Jr., 1990, "Sigma Mesa: Background Elemental Concentrations in Soil and Vegetation, 1979", *LA-11941-MS*, Los Alamos National Laboratory, Los Alamos, New Mexico.

IT Corporation (IT), 1992, "RFI Work Plan for Operable Unit 1129," *LA-UR-92-800*, prepared for Los Alamos National Laboratory, Los Alamos, New Mexico.

IT Corporation (IT), 1991, "Waste Stream Characterization Report, Technical Area 35," prepared for Los Alamos National Laboratory, Los Alamos, New Mexico.

LANL, see Los Alamos National Laboratory.

Longmire, P., C. Duffy, S. Reneau, 1993, "Preliminary Background Elemental Concentrations in Bandelier Tuff and Selected Soil Series, 1993", in progress, Los Alamos National Laboratory, Los Alamos, New Mexico.

Los Alamos National Laboratory (LANL), 1993, "Amendment to the Final Closure Plan, TA-40 Scrap Detonation Site," Los Alamos National Laboratory, Los Alamos, New Mexico.

Los Alamos National Laboratory (LANL), 1990, "Structure Location Map, TA-35 Ten Site," *ENG-R5117*, Los Alamos National Laboratory, Los Alamos, New Mexico.

Los Alamos National Laboratory (LANL), 1975, "Structure Location Plan, TA-35, Ten Site," *ENGR-2461* and *ENGR-2462*, Los Alamos National Laboratory, Los Alamos, New Mexico.

McLin, S., Los Alamos National Laboratory, 1990, "Report for RCRA Surface Impoundment Closures," personal communication, Los Alamos National Laboratory, Los Alamos, New Mexico.

NMED, see New Mexico Environment Department.

New Mexico Environment Department (NMED), 1993, "TA-35 TSL-85 Surface Impoundment: Denial of Clean Closure Equivalency Demonstration and Disapproval of Closure Plan," letter from Kathleen Sisneros (NMED) to Jerry Bellows (Department of Energy Los Alamos Area Office), June 21, 1993.

Roy F. Weston Inc., 1989, "Site Database, Task 7, TA-35," prepared for U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico.

U.S. Environmental Protection Agency (EPA), 1992a, *Code of Federal Regulations*, Title 40, Parts 260 to 299 (40 CFR 260-299).

U.S. Environmental Protection Agency (EPA), 1992b, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Laboratory Manual," *EPA-SW-846*, U.S. Government Printing Office, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1989, "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, (Part A)," *EPA/540/1-89/002*, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Government Printing Office, 1990, "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities," *Federal Register*, Volume 55, No. 145, July 27, 1990, Proposed Rules.

APPENDIX A

Shipping Manifests and Certificates of Destruction

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

SEP 25 1992

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. NM0890001051 Manifest Document No. 87201

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN: PAT JOSEY
Los Alamos National Labs
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number: № 00067357

B. State Generator's ID: 9935

5. Transporter 1 Company Name: CUSTOM ENVIRONMENTAL TRANSPORT

6. US EPA ID Number: TXD980918858

C. State Transporter's ID: 40356

D. Transporter's Phone: (303) 779-0761

7. Transporter 2 Company Name

8. US EPA ID Number

E. Transporter 2 ID

F. Transporter 2 Phone

9. Designated Facility Name and Site Address
ROLLINS ENVIRONMENTAL SERVICE
2027 BATTLEGROUND ROAD
DEER PARK, TX 77536

10. US EPA ID Number: TXD055141378

G. Facility's ID

H. Facility's Phone: (713) 930-2300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol
X	a. RQ Hazardous Waste, solid, n.o.s. ORM-E NA 9189	5 0 65 DPB	DM	34540 45100 42250 DPB	TS/R P
	b.				
	c.				
	d.				

I. Additional Descriptions for Materials Listed Above

J. Additional Owner/Operator Name/Date

15. Special Handling Instructions and Additional Information In case of accident or spills contact Chemtrec @ 1-800-424-9300 or Texas Water Commission @ 1-512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If undeliverable, return to generator.
TRCC # 79286E

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name: PATRICK JOSEY | Signature | Month Day Year: 9 20 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials | Date

Printed/Typed Name: GREGORY JONES | Signature | Month Day Year: 9 20 89

18. Transporter 2 Acknowledgement of Receipt of Materials | Date

Printed/Typed Name | Signature | Month Day Year

FACILITY

19. Discrepancy Indication Space
Per Matt Evans with Chemfab, the above quantity has been changed to reflect the correct amount recd by RES (TX) Inc

20. Facility Owner or Operator Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name: ANTHONY OWEN | Signature | Date: 9-25-89 | Month Day Year: 9 25 89

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

When using the Uniform Waste Manifest for rail or water (bulk shipment) or international shipments refer to the applicable TWC regulations.

REPORT SPILLS AND/OR DISCHARGES TO THE TEXAS SPILL RESPONSE CENTER AT 512/463-7727 (24 HOURS)

INSTRUCTIONS TO GENERATOR (Please Type or Print Clearly)

(1) Enter the Generator's U.S. EPA twelve digit identification number and the unique five digit number assigned to this manifest by the generator if you are shipping hazardous waste.

(2) Enter the total number of pages used to complete this manifest.

(3) Enter the company name and mailing address.

(4) Provide a phone number where an authorized agent of your firm may be reached in the event of an emergency.

(5) Enter the company name of the first transporter and their U.S. EPA ID Number.

(6) If applicable, enter the company name of the second transporter and their U.S. EPA ID Number. If more than two transporters are used, enter each additional transporter's information on the Continuation Sheet (EPA form 8700-22A).

(7) Enter the company name, site address, and U.S. EPA ID Number of the facility designated to receive the waste listed on this manifest.

(8) **COMPLETE ALL STATE OF TEXAS INFORMATION A. THROUGH H. IN THE SHADED AREAS.**

(9) Complete the waste description table as follows:

(A) ITEM 11A - When shipping an EPA/DOT regulated hazardous waste or material in conjunction with solely state regulated waste enter an "x" in the HM box before each EPA/DOT regulated waste/material description.

(B) ITEM 11 - Enter the U.S. DOT Proper Shipping Name, Hazard Class, and ID Number (UN/NA) for each waste identified. If it is a Class I nonhazardous waste use the Texas Waste Code description.

(C) ITEM 12 - Enter the number of containers for each waste and the appropriate abbreviation for type located in Subchapter A of the TWC Industrial Solid Waste Rules.

(D) ITEM 13 - Enter the total quantity of waste described on each line.

(E) ITEM 14 - Enter the appropriate letter from the table below for the unit of measure.

G = Gallons (liquids only)	Y = Cubic Yards	M = Metric Tons (1000 kg.)
P = Pounds	L = Liter (Liquids only)	N = Cubic Meters
T = Tons (2000 lbs.)	K = Kilograms	

(F) ITEM I - Enter the appropriate TWC State Waste Code for each waste you are shipping.

(10) The Generator must read, sign (by hand), and date the certification statement. If a mode other than highway is used, the word "highway" should be lined out and the appropriate mode (rail, water or air) inserted in the space below. In signing the waste minimization certification statement, those generators shipping hazardous waste who have not been exempted by statute or regulation from the duty to make a waste minimization certification are also certifying that they have complied with the waste minimization requirements.

(11) The manifest must be signed and dated by the first transporter in the presence of the Generator. If more than one transporter is to be used, the Generator must provide additional copies for their use.

*(12) Generator retains green copy, sending remaining copies with the driver.

INSTRUCTIONS FOR THE TRANSPORTER (Please Type or Print clearly)

(1) As driver of the transport vehicle, you are responsible for ensuring that all waste received by you arrives at the specified destination.

(2) Sign and date the space provided, certifying the waste amounts in **PART I** were received for transport. **NOTE:** If you are unable to carry out the delivery of the shipment as specified, dial the emergency phone numbers given in **PART I** notifying the **GENERATOR.**

(3) Upon delivery of the shipment, the **TSD** Facility Owner/Operator is to sign for the shipment in your presence and fill in "date received".

*(4) Separate the yellow copy and retain for your records. Leave the remaining copies with the **TSD** Facility Owner/Operator.

INSTRUCTIONS TO TREATMENT, STORAGE AND DISPOSAL (TSD) FACILITY OWNER/OPERATOR (Please Type or Print Clearly)

(1) The authorized representative of the designated (or alternate) facility's owner or operator must note in **ITEM 19** any significant discrepancy between the waste described on the manifest and the waste actually received at the facility.

(2) Enter date received and sign in the presence of the driver declaring receipt of the wastes and verifying the quantities in the table in **PART I**.

(3) Retain the pink copy for your records and return the completed original (white) copy to the **GENERATOR**.

* U.S. EPA and TWC regulations require that copies of this Uniform Hazardous Waste Manifest be retained for a period of three (3) years in your company records. Do not send to TWC unless otherwise notified by these departments.

Public reporting burden for this collection of information is estimated to average: 37 minutes for generators, 15 minutes for transporters, and 10 minutes for treatment, storage and disposal facilities. This includes time for reviewing instructions, gathering data, and completing and reviewing the form. Send comments regarding the burden estimate, including suggestions for reducing this burden, to: Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M Street SW., Washington, DC 20460; and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

1.1 x.1 m 101

HO 44908-25

SEP 25 1992

Dear Customer:

Federal regulations requires that the generator submit to their Regional EPA Administrator, formal Demonstration and Certification that a good faith effort has been made to locate and contract with treatment and recovery facilities which provide the greatest environmental benefit for each waste stream covered by 40 CFR 268.8 The attached Demonstration and Certification Forms can be used for that purpose. It is recommended that in addition to forwarding a copy to your Regional EPA office, you retain a copy for your records. Our CHEMPAK Chemist will assist in their preparation.

INSTRUCTIONS FOR COMPLETING: Page 1 and 2 DEMONSTRATION/CERTIFICATION

PAGE 1: Incineration Demonstration/Certification Letter: This form lists those waste numbers that are restricted from land disposal and will be incinerated to comply with current regulations. If any waste numbers are checked off, the generator must sign and submit to EPA. A copy MUST accompany the shipment. If no waste numbers apply write NOT APPLICABLE across form and do not mail or sign.

PAGE 2: Chemical Stabilization Demonstration/Certification letter. This form list those waste numbers that are restricted from direct landfill and can not be incinerated by RES. They will be treated before land disposal. If any waste numbers are checked off generator must sign and submit to US EPA. A copy must accompany shipment. If this treatment is not used and/or no waste numbers are checked off DO NOT mail or sign. Write not applicable.

PAGE 3 THRU 9: Facility Notifications - Must Accompany Shipment

PAGE 3: This form must be completed and signed whenever waste is being incinerated regardless of waste numbers involved. Enter all information and sign. If information is not complete shipment could be rejected by receiving facility.

PAGE 4: Check off constituents for F001-F005 if these wastes are being handled. Generator must sign. At the bottom of the page, add all other waste numbers from manifest with the exceptions of those found on page three and page six.

PAGE 5: Landfill and/or Stabilization. Complete for all restricted waste numbers (including incinerator ash) handled DE or RES. If yes, all information must be entered regardless of waste numbers involved. Be sure to include all "CA List" and "HOC's". Generator must then sign. If this method is not being used, write NOT APPLICABLE and generator needs not sign.

PAGE 6: Complete if necessary.

Make three (3) copies of each page for distribution as follows:

- GENERATOR
- SHIPMENT
- CHEMPAK OFFICE

Should you have any questions concerning these certification/notification requirements, our chemist(s) assigned to your project will answer them. If further information is required contact the Rollins CHEMPAK National Quality Control Manager at 302-479-3446.

SEP 2 5 1992

INCINERATION STREAMS
REGIONAL ADMINISTRATOR
U. S. ENVIRONMENTAL PROTECTION AGENCY (CHECK REGION)

[ ] EPA REGION 1
JFK Federal Building
Boston, Massachusetts 02203
(617) 223-2468
Connecticut, Massachusetts, Maine
New Hampshire, Rhode Island, Vermont

[ ] EPA REGION II
26 Federal Plaza
New York, New York 10278
(212) 264-5175
New Jersey, New York, Puerto Rico,
Virgin Islands

[ ] EPA REGION III
841 Chestnut Street
Philadelphia, Pennsylvania 19107
(215) 597-9336
Delaware, Maryland, Pennsylvania,
Virginia, West Virginia,
District of Columbia

[ ] EPA REGION IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365
(404) 347-3016
Alabama, Florida, Georgia
Kentucky, Mississippi, North
Carolina, South Carolina, Tennessee

[ ] EPA REGION V
230 South Dearborn Street
Chicago, Illinois 60604
(312) 353-2000
Illinois, Indiana, Michigan,
Minnesota, Ohio, Wisconsin

[X] EPA REGION VI
1445 Ross Avenue
Dallas, Texas 75202
(214) 655-6700
Arkansas, Louisiana, New Mexico,
Oklahoma, Texas

[ ] EPA REGION VII
726 Minnesota Avenue
Kansas City, Kansas 66101
(913) 236-2800
Iowa, Kansas, Missouri, Nebraska

[ ] EPA REGION VIII
One Denver Place
999 18th Street, Suite 1300
Denver, Colorado 80202-2413
(303) 293-1502
Colorado, Montana, North Dakota,
South Dakota, Utah, Wyoming

[ ] EPA REGION IX
215 Freemont Street
San Francisco, California 94105
(415) 974-7472
Arizona, California, Hawaii,
Nevada, American Samoa, Guam,
Trust Territories of the Pacific

[ ] EPA REGION X
1200 Sixth Avenue
Seattle, Washington 98101
(206) 442-2777
Alaska, Idaho, Oregon, Washington

RE: SECTION 268.8 (a)(1) DEMONSTRATION AND CERTIFICATION

This DEMONSTRATION AND CERTIFICATION is submitted pursuant to 40 CFR 268. 8(a)(1). (LAB PACKS/SMALL QUANTITIES) It is submitted in connection with a hazardous waste stream generated at this facility. The stream(s) is classified by EPA waste code number (see below) which is a "First Third" or "Second Third" soft hammer waste. Pursuant to section 268.8 we have made an effort to locate treatment or recovery facilities which provide the greatest environmental benefit. Because this stream is an organic stream, the greatest environmental benefit would be provided by RCRA authorized incineration which destroys the hazardous constituents. Since such treatment is available, we have contracted with a RCRA authorized incineration facility for treatment of the waste by incineration. That facility is:

[ ] Rollins Environmental Services (LA) Inc.
Baton Rouge, LA
EPA ID#: LAD010395127

[ ] Rollins Environmental Services (NJ) Inc.
Bridgeport, NJ
EPA ID#: NJD053288236

[X] Rollins Environmental Services (TX) Inc.
Houston, TX
EPA ID#: TXD055141378

[ ] OTHER _____

NOT APPLICABLE

The restricted waste is properly classified by the following EPA waste numbers.

Check off appropriate waste numbers.

[ ] P001	[ ] P036	[ ] P069	[ ] U005	[ ] U022	[ ] U049	[ ] U070	[ ] U098	[ ] U119	[ ] U140	[ ] U163	[ ] U179	[ ] U210	[ ] U248	
[ ] P002	[ ] P037	[ ] P070	[ ] U007	[ ] U023	[ ] U050	[ ] U073	[ ] U099	[ ] U122	[ ] U142	[ ] U164	[ ] U180	[ ] U211	[ ] Other	
[ ] P003	[ ] P038	[ ] P072	[ ] U008	[ ] U026	[ ] U051	[ ] U076	[ ] U101	[ ] U124	[ ] U143	[ ] U165	[ ] U185	[ ] U213	[ ] _____	
[ ] P004	[ ] P049	[ ] P081	[ ] U009	[ ] U029	[ ] U053	[ ] U077	[ ] U103	[ ] U127	[ ] U147	[ ] U168	[ ] U188	[ ] U218	[ ] _____	
[ ] P005	[ ] P050	[ ] P082	[ ] U010	[ ] U031	[ ] U057	[ ] U078	[ ] U105	[ ] U128	[ ] U149	[ ] U169	[ ] U189	[ ] U219	[ ] _____	
[ ] P007	[ ] P054	[ ] P084	[ ] U011	[ ] U035	[ ] U059	[ ] U083	[ ] U106	[ ] U129	[ ] U150	[ ] U170	[ ] U192	[ ] U220	[ ] _____	
[ ] P008	[ ] P057	[ ] P102	[ ] U012	[ ] U036	[ ] U060	[ ] U084	[ ] U108	[ ] U130	[ ] U154	[ ] U171	[ ] U193	[ ] U226	[ ] _____	
[ ] P014	[ ] P058	[ ] P105	[ ] U014	[ ] U037	[ ] U061	[ ] U089	[ ] U109	[ ] U131	[ ] U155	[ ] U172	[ ] U196	[ ] U227		
[ ] P016	[ ] P059	[ ] P108	[ ] U015	[ ] U041	[ ] U062	[ ] U092	[ ] U110	[ ] U133	[ ] U157	[ ] U173	[ ] U200	[ ] U228		
[ ] P018	[ ] P060	[ ] P112	[ ] U016	[ ] U043	[ ] U063	[ ] U093	[ ] U111	[ ] U134	[ ] U158	[ ] U174	[ ] U203	[ ] U237		
[ ] P020	[ ] P066	[ ] P123	[ ] U018	[ ] U044	[ ] U064	[ ] U094	[ ] U114	[ ] U135	[ ] U159	[ ] U176	[ ] U206	[ ] U238		
[ ] P026	[ ] P067	[ ] U002	[ ] U019	[ ] U046	[ ] U066	[ ] U095	[ ] U115	[ ] U137	[ ] U161	[ ] U177	[ ] U208	[ ] U239		
[ ] P027	[ ] P068	[ ] U003	[ ] U020	[ ] U047	[ ] U067	[ ] U097	[ ] U116	[ ] U138	[ ] U162	[ ] U178	[ ] U209	[ ] U244		

IF ANY OF THE ABOVE BOXES ARE CHECKED, GENERATOR MUST SIGN BELOW STATEMENT.

I certify under penalty of law that the requirements of 40 CFR 268.8(a)(1) have been met and that I have contracted to treat my waste (or will otherwise provide treatment) by the practically available technology which yields the greatest environmental benefit, as indicated in my demonstration. I believe that the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Very truly yours,

_____
COMPANY

_____
EPA ID#

_____
REPRESENTATIVE

cc: To disposal facility, local Rollins CHEMPAK office

REGIONAL ADMINISTRATOR
U. S. Environmental Protection Agency
Check Region

SEP 25 1992

[ ] EPA REGION 1
JFK Federal Building
Boston, Massachusetts 02203
(617) 223-2468
Connecticut, Massachusetts, Maine
New Hampshire, Rhode Island, Vermont

[ ] EPA REGION II
26 Federal Plaza
New York, New York 10278
(212) 264-5175
New Jersey, New York, Puerto Rico,
Virgin Islands

[ ] EPA REGION III
841 Chestnut Street
Philadelphia, Pennsylvania 19107
(215) 597-9336
Delaware, Maryland, Pennsylvania,
Virginia, West Virginia,
District of Columbia

[ ] EPA REGION IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365
(404) 347-3016
Alabama, Florida, Georgia
Kentucky, Mississippi, North
Carolina, South Carolina, Tennessee

[ ] EPA REGION V
230 South Dearborn Street
Chicago, Illinois 60604
(312) 353-2000
Illinois, Indiana, Michigan,
Minnesota, Ohio, Wisconsin

[ ] EPA REGION VI
1445 Ross Avenue
Dallas, Texas 75202
(214) 655-6700
Arkansas, Louisiana, New Mexico,
Oklahoma, Texas

[ ] EPA REGION VII
726 Minnesota Avenue
Kansas City, Kansas 66101
(913) 236-2800
Iowa, Kansas, Missouri, Nebraska

[ ] EPA REGION VIII
One Denver Place
999 18th Street, Suite 1300
Denver, Colorado 80202-2413
(303) 293-1502
Colorado, Montana, North Dakota,
South Dakota, Utah, Wyoming

[ ] EPA REGION IX
215 Freemont Street
San Francisco, California 94105
(415) 974-7472
Arizona, California, Hawaii,
Nevada, American Samoa, Guam,
Trust Territories of the Pacific

[ ] EPA REGION X
1200 Sixth Avenue
Seattle, Washington 98101
(206) 442-2777
Alaska, Idaho, Oregon, Washington

RE: Section 268.8 (a)(1) DEMONSTRATION AND CERTIFICATION
(LAB PACK OR SMALL QUANTITIES)

This DEMONSTRATION AND CERTIFICATION is submitted pursuant to 40 CFR 268.8(a)(2)(ii). It is submitted in connection with a hazardous waste stream generated at this facility. The stream is classified by EPA waste code number (see below), which is a "1ST/2ND" "soft hammer" waste. Pursuant to Section 268.8 we have made an effort to locate treatment or recovery facilities which provide the greatest environmental benefit. The hazardous constituents in this stream are metals. Based on our effort to locate treatments and facilities, we have concluded that chemical stabilization would provide the greatest environmental benefit. Since such treatment is available, we have contracted with a RCRA authorized facility for treatment of this waste by chemical stabilization. That facility is:

[ ] Rollins Environmental Services (LA) Inc.
Baton Rouge, LA
EPA ID#: LAD010395127

[ ] OTHER _____

NOT APPLICABLE

The restricted waste is properly classified by the following EPA waste numbers.

Check off appropriate boxes.

[ ] P010	[ ] P110	[ ] U144	[ ] U217	[ ] K036WW
[ ] P011	[ ] P113	[ ] U146	[ ] U249	[ ] K060WW
[ ] P012	[ ] P114	[ ] U151	[ ] F019	[ ] K084
[ ] P015	[ ] P115	[ ] U205	[ ] K004WW	[ ] K086 (Non-solvent wash subcategory)
[ ] P087	[ ] P120	[ ] U214	[ ] K008WW	[ ] K100WW
[ ] P092	[ ] P122	[ ] U215	[ ] K021WW	[ ] K101WW (More than 1% As subcategory)
[ ] P107	[ ] U032	[ ] U216	[ ] K025WW	[ ] K102WW (More than 1% As subcategory)
			[ ] K031	[ ] K106

IF ANY OF THE ABOVE BOXES ARE CHECKED OFF, GENERATOR MUST SIGN BELOW

I certify under penalty of law that the requirements of 40 CFR 268.8(a)(1) have been met and that I have contracted to treat my waste (or will otherwise provide treatment) by the practically available technology which yields the greatest environmental benefit, as indicated in my demonstration. I believe that the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Very truly yours,

_____
COMPANY

_____
REPRESENTATIVE

_____
EPA ID#

cc: Disposal Facility
Local Rollins CHEMPAK Office

FACILITY NOTIFICATION "RESTRICTED WASTE" for INCINERATION — Rollins CHEMPAX

SEP 25 1992 page 3

Stream # H044908-25

Generator: LANL

EPA ID # NM0890010515

Address: P.O. Box 1663
Las Alamos, NM 87545

Under manifest number(s) 000067357 we are shipping to you for incineration waste that 40 CFR 268.8

[X] applies [ ] does not apply, because the waste stream is:(If answer is"does not apply"skip below sections and sign page 4)

(A) [ ] California List (check off constituents) [ ] pH less than or equal 2.0 [ ] PCB greater than or equal 50 ppm

Liquid waste containing those metals equal/greater than: [ ] As 500 mg/l [ ] Cd 100 mg/l [ ] Cr 500 mg/l [ ] Pb 500 mg/l [ ] Hg 20 mg/l [ ] Ni 134 mg/l [ ] Se 100 mg/l [ ] Tl 130 mg/l

[ ] Total HOC's greater tthan or equal to 1000 mg/kg including:

a. wastewater greater than or equal to 1000 but less than 10,000 mg/kg
b. non-wastewater liquid waste (including free water) with HOC's greater than or equal to 10,000 mg/kg
c. solid hazardous waste with HOC greater than or equal to 1000 mg/kg

[X] Solvent/Dioxin [ ] "First/Second" Third waste

THE ABOVE RESTRICTED WASTE IS PROPERLY CLASSIFIED BY THE BELOW EPA WASTE NUMBERS (Complete sections B,C,D,E)

(B) Solvent/Dioxin Waste [ ] F001 [X] F002 [X] F003 [ ] F004 [ ] F005

If any of these waste number apply, also check off F(2) below and table CCWE, page 4.

[ ] F020 [ ] F021 [ ] F022 [ ] F023 [ ] F026 [ ] F027 [ ] F028

(C) First/Second Third "soft-hammer". If any of these waste numbers apply, also check F(4) below.

[ ] P001	[ ] P026	[ ] P066	[ ] P108	[ ] U012	[ ] U031	[ ] U051	[ ] U070	[ ] U094	[ ] U110	[ ] U130	[ ] U149	[ ] U165	[ ] U179	[ ] U208	[ ] U237
[ ] P002	[ ] P027	[ ] P067	[ ] P112	[ ] U014	[ ] U035	[ ] U053	[ ] U073	[ ] U095	[ ] U111	[ ] U131	[ ] U150	[ ] U168	[ ] U180	[ ] U209	[ ] U238
[ ] P003	[ ] P037	[ ] P068	[ ] P123	[ ] U015	[ ] U036	[ ] U057	[ ] U074	[ ] U097	[ ] U114	[ ] U133	[ ] U154	[ ] U169	[ ] U185	[ ] U210	[ ] U239
[ ] P004	[ ] P048	[ ] P069	[ ] U002	[ ] U016	[ ] U037	[ ] U059	[ ] U077	[ ] U098	[ ] U115	[ ] U134	[ ] U155	[ ] U170	[ ] U188	[ ] U211	[ ] U244
[ ] P005	[ ] P049	[ ] P070	[ ] U003	[ ] U018	[ ] U041	[ ] U060	[ ] U078	[ ] U099	[ ] U116	[ ] U135	[ ] U157	[ ] U171	[ ] U189	[ ] U213	[ ] U248
[ ] P007	[ ] P050	[ ] P072	[ ] U005	[ ] U019	[ ] U043	[ ] U061	[ ] U083	[ ] U101	[ ] U119	[ ] U137	[ ] U158	[ ] U172	[ ] U192	[ ] U218	
[ ] P008	[ ] P054	[ ] P081	[ ] U007	[ ] U020	[ ] U044	[ ] U062	[ ] U086	[ ] U103	[ ] U122	[ ] U138	[ ] U159	[ ] U173	[ ] U193	[ ] U219	
[ ] P014	[ ] P057	[ ] P082	[ ] U008	[ ] U022	[ ] U046	[ ] U063	[ ] U089	[ ] U105	[ ] U126	[ ] U140	[ ] U161	[ ] U174	[ ] U196	[ ] U220	
[ ] P016	[ ] P058	[ ] P084	[ ] U009	[ ] U023	[ ] U047	[ ] U064	[ ] U092	[ ] U106	[ ] U127	[ ] U142	[ ] U162	[ ] U176	[ ] U200	[ ] U226	
[ ] P018	[ ] P059	[ ] P102	[ ] U010	[ ] U026	[ ] U049	[ ] U066	[ ] U093	[ ] U108	[ ] U128	[ ] U143	[ ] U163	[ ] U177	[ ] U203	[ ] U227	
[ ] P020	[ ] P060	[ ] P105	[ ] U011	[ ] U029	[ ] U050	[ ] U067	[ ] U094	[ ] U109	[ ] U129	[ ] U147	[ ] U164	[ ] U178	[ ] U206	[ ] U228	

(D) First/Second Third (organic/non-metal) with treatment standards. See table CCW or CCWE 40 CFR 268.

[ ] P013 [ ] P029 [ ] P039 [ ] P071 [ ] P094 [ ] P098 [ ] P121 [ ] U069 [ ] U102 [ ] U190
[ ] P021 [ ] P030 [ ] P063 [ ] P089 [ ] P097 [ ] P106 [ ] U028 [ ] U088 [ ] U107 [ ] U235

If any of these waste numbers apply, also check F(2) below

(E) First/second Third with treatment method specified.

[ ] P040 [ ] P041 [ ] P043 [ ] P044 [ ] P062 [ ] P085 [ ] P109 [ ] P111 [ ] U058 [ ] U087 [ ] U221 [ ] U223

If any of these waste numbers apply,also check F(1) below

(F) THE ABOVE WASTE STREAMS MUST BE INCINERATED BECAUSE:

[ ] 1. Incineration is the treatment technology prescribed by 40 CFR 268.42. (PCB's and HOC's (except wastewater) greater than than or equal to 1000 mg/kg.

[X] 2. The stream is an F001-F005 solvent or a "First/Second Third" waste with organic or other non-metal treatment standards

[ ] 3. The stream is a liquid hazardous waste that is primarily water and contains HOC's in total concentration greater/equal to 1000 mg/l and less than 10000 mg/l.

[ ] 4. The stream is a "soft-hammer" waste containing organics or other non-metal and must be treated by the best treatment practically available . Enclosed is a copy of the signed and dated demonstration and certification which we have submitted to the EPA Regional Administrator pursuant to 40 CFR 268.8 (a)(2)(ii).

Revision 6/89

7.18.1 MIC

SEP 25 1992

Rollins CHEMPAK
FACILITY NOTIFICATION OF
"RESTRICTED WASTE FOR INCINERATION"
(FOR F001-F005 WASTES)
(CHECK OFF CONSTITUENTS)

TABLE CCME-CONSTITUENT IN WASTE EXTRACT

F001-F005 SPENT SOLVENTS	CONCENTRATION (IN mg/l) WASTEWATERS CONTAINING SPENT SOLVENTS	ALL OTHER SP SOLVENT WAST
Acetone	( ) 0.05	(X) 0.59
n-Butyl alcohol	( ) 5.0	( ) 5.0
Carbon disulfide	( ) 1.05	( ) 4.81
Carbon tetrachloride	( ) .05	( ) .96
Chlorobenzene	( ) .15	( ) .05
Cresols (and cresylic acid)	( ) 2.82	( ) .75
Cyclohexanone	( ) .125	( ) .75
1,2 - dichlorobenzene	( ) .68	( ) .125
Ethyl acetate	( ) .05	( ) .75
Ethyl benzene	( ) .05	( ) .053
Ethyl ether	( ) 5.0	( ) 5.0
Isobutanol	( ) .25	( ) .75
Methanol	( ) .25	( ) .75
Methylene chloride	( ) .20	( ) .96
Methyl ethyl ketone	( ) 0.05	( ) 0.75
Methylisobutyl ketone	( ) 0.05	( ) 0.33
Nitrobenzene	( ) 0.65	( ) 0.125
Pryidine	( ) 1.12	( ) 0.33
Tetrachloroethylene	( ) 0.079	(X) 0.05
Toluene	( ) 1.12	(X) 0.33
1, 1, 1 - Trichloroethane	( ) 1.05	( ) 0.41
1, 2, 2 - Trichloro -	( ) 1.05	( ) 0.96
1, 2, 2 trifluroethane	( ) 1.05	( ) 0.96
Trichloroethylene		
Trichlorofluoromethane	( ) 0.062	( ) 0.091
Xylene	( ) 0.05	( ) 0.15

Authorized Representative Signature X [signature]

Print or Type Name X Robert Josey

Title X STAFF Date X 20 SEPT 89

This waste stream also includes other waste numbers for incineration and/or landfill for which there are no current land restrictions. They are:

Revision 6/89

FACILITY NOTIFICATION "RESTRICTED WASTE" for LAND DISPOSAL — Rollins CHEMPAK

Stream # H044908-25

SEP 25 1992

Generator: LANL

EPA ID #: NM0890010515

Address: P.O. Box 1663
Los Alamos, NM 87545

Under manifest number(s) 00067357 we are shipping to you for land fill waste that 40 CFR 268.8 [ ] applies [X] does not apply, because the waste stream: (If answer is "does not" skip below and sign on page 6)

(I) California List (check off constituents): [ ] pH less than or equal to 2.0 [ ] PCB greater than or equal to 50 ppm

Liquid waste containing these metals equal to or greater than: [ ] As 500 mg/l [ ] Cd 100 mg/l [ ] Cr 500 mg/l [ ] Pb 500 mg/l [ ] Hg 20 mg/l [ ] Ni 134 mg/l [ ] Se 100 mg/l [ ] Tl 130 mg/l

[ ] Total HOC's greater than or equal to 1000 mg/l including:
a. wastewater greater than or equal to 1000 but less than 10,000 mg/l
b. nonwastewater waste (including free liquids) with HOC greater than or equal to 10,000 mg/kg
c. solid hazardous waste with HOC's greater or equal to 10,000 mg/kg
and or the following:
[ ] Solvent/Dioxin [ ] "First/Second Third"

THE ABOVE RESTRICTED WASTE IS PROPERLY CLASSIFIED BY THE BELOW EPA WASTE NUMBERS

(II)

[ ] P010	[ ] P015	[ ] P107	[ ] P114	[ ] P122	[ ] U146	[ ] U214	[ ] 217	[ ] D004	[ ] D008	other
[ ] P011	[ ] P087	[ ] P110	[ ] P115	[ ] U032	[ ] U151	[ ] U215	[ ] U249	[ ] D006	[ ] D009	[ ] ____
[ ] P012	[ ] P092	[ ] P113	[ ] P120	[ ] U144	[ ] U205	[ ] U216	[ ] D002	[ ] D007	[ ] D010	[ ] ____

(III) This stream can be (check one) [ ] directly landfilled or [ ] treated/landfilled because:

[ ] 1. The generator has been granted by the EPA, for this waste, a time extension under 40 CFR 268.5 or a "treatability variance" under 40 CFR 268.44. (Copy of EPA approval must be attached)
[ ] 2. The stream does not exceed the treatment standard specified in either table CCW or CCWE in 40 CFR 268. An authorized respresentative has signed the required certification.
[ ] 3. The waste is contaminated soil or debris from: (check one) [ ] reponse action under CERCLA, at ____ or [ ] b. corrective action pursuant to EPA 3008(h) order # ____. (valid until 11/8/90 in a MTR)
[ ] 4. The waste is a residue of "multi-source leachate".
5. The waste is a California List waste and can be chemical stabilizated because: (check reason below)
* [ ] a. The metal or free cyanide indicated above has been treated to a concentration not exceeding the shown value.
* [ ] b. The pH value has been treated to above 2.0
* [ ] c. The waste is chemical stabilizated to be a non-liquid, not containing any free liquids
[ ] d. The waste will be chemical stabilizated to be a non-liquid, not containing any free liquids
[ ] 6. The waste is a "First Third" K048-K052 or K071 stream and can be placed in a MTR unit until 8/8/90
[ ] 7. The waste is a "First/Second Third" soil/debris contaminated with a K001, K015, K016, K018-20, K022, K024, K030, K037, K083, K086, K087, K101, or K102 and may be landfilled until 8/8/90.
[ ] 8. It is a "Second Third" soil or debris contaminated with F010 greater than 5% oil/grease, F024, K009, K010, K011, K013, K014, K023, K027, K028, K036 W/,K038, K039, K040, K043, K093, K094, K113, K114, K115, K116, P039, P040, P041 P043, P044, P062, P071, P085, P089, P094, P109, P111, U028, U058, U069, U087, U088, U102, U107, U190, U221, U223, or U235 and can be landfilled until 6/8/91.
[ ] 9. It is a "soft-hammer" waste identified above in section (II) which does not contain organics or other non-metal and can be stabilizated and landfilled. Attached in a copy of the signed demonstration and certification which we have submitted to the EPA Reg. Administrator pursuant to 40 CFR 268.8(a)(2)(ii).
[ ] 10. Treatment standards for this waste category have been established for metals in table CCW or CCWE indicated below. RES has agreed to meet these standards.

Constituent: ____ Treatment Standard ____ Per table [ ] CCW [ ] CCWE
Constituent: ____ Treatment Standard ____ Per table [ ] CCW [ ] CCWE

Generator Signature: X [signature]
Title: X STAFF
Print Name: X PATRICK [illegible]
Date: X 20 SEP 89

* If checked page 6 MUST BE COMPLETED by generator.

Revision 6/89

SEP 25 1992

COMPLETE ONLY IF SECTION III 5a, 5b, or 5c IS CHECKED.

GENERATOR CERTIFICATION THAT WASTE MEETS TREATMENT STANDARD FOR LANDFILLING (40 CFR 268.7 (a) (2) (ii)

I certify under penalty of law that I personally have examined and am familiar with the waste through analysis and testing or through knowledge of the waste to support this certification that the waste complies with the treatment standards specified in 40 CFR, Part 268, subpart D and all applicable prohibitions set forth in 40 CFR 268. 32 or RCRA section 3004(d). I believe that the information I submitted is true, accurate and complete. I am aware that there are significant penalties for submitting a false certification, including the possibility of a fine and imprisonment. The applicable treatment standard and all applicable prohibitions are set forth below.

Applicable Treatment Standards (use reverse side for additional constituents):

CONSTITUENT	TREATMENT STANDARDS	CCW	CCWE

Applicable Prohibition (California List):

_____, _____, _____,
_____, _____, _____,
_____,

Authorized Representative:

Signature: _____ Date: _____

Print Name: _____ Title: _____

7.13.1m

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

SEP 25 1992

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

NOVEMBER 15, 1989

LOS ALAMOS NATIONAL LABORATORY
P. O. BOX 1663
LOS ALAMOS, NM 87545

ATTN: Mr. Pat Josey

Dear Mr. Josey:

This is to certify the material referenced below was destroyed as of 09/26/89 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P. O. Box 609, Deer Park, Texas 77536.

DATE RECEIVED	-09/21/89
RES (TX) INC. B/L NUMBER	-111222
TWC MANIFEST NO.	-00067357

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES CHEMPAK/LA
Steve Bergersen

Please call (713) 930-2318 if there are any questions concerning the information on this Certificate of Destruction.

7.12.1m102

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

SEP 25 1992

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. NM0890010515 Manifest Document No. 89201

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
Los Alamos National Labs
P.O. Box 1663
Los Alamos, NM 87545
ATTN: PAT JOSEY

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number: № 00067358

B. State Generator's ID: 99935

5. Transporter 1 Company Name: CUSTOM ENVIRONMENTAL TRANSPORT

6. US EPA ID Number: DED980918858

C. State Transporter's ID: 40756

D. Transporter's Phone: (302) 479-2761

7. Transporter 2 Company Name

8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address
ROLLINS ENVIRONMENTAL SERVICE
2027 BATTLEGROUND ROAD
DEER PARK, TX 77536

10. US EPA ID Number: TXD055141378

G. State Facility's ID: HWF 50089-001

H. Facility's Phone: (713) 930-2300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	15. Waste No.
X	a. RQ Hazardous Waste, solid, n.o.s. ORM-E NA 9189	5 ~~0~~ 5	DM	~~45100~~ ~~42250~~	P	978400
	b.	OB		35320	TS/RC	
	c.					
	d.					

J. Additional Descriptions for Materials Listed Above [redacted] K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information In case of accident or spills contact Chemtrec at 1-800-424-9300 or Texas Water Commission at 512-463-8175. Avoid contact, Avoid breathing vapors. Contain waste. If undeliverable, return to generator. (TRUCK # 79279E)

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name: PATRICK JOSEY Signature: [signature] Month 9 Day 25 Year 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name: REYNOLD ULMER Signature: Reynold Ulmer Month 9 Day 20 Year 89

18. Transporter 2 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name Signature Month Day Year

FACILITY

19. Discrepancy Indication Space
Per Matt Evans with ChemPak, the above quantity has been changed to reflect the correct amount rec'd by RES (TX) INC

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19 — Date 9-25-89

Printed/Typed Name: ANTHONY OWNSEN Signature: [signature] Month 9 Day 21 Year 89

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

SEP 25 1992

NOVEMBER 15, 1989

LOS ALAMOS NATIONAL LABORATORY
P. O. BOX 1663
LOS ALAMOS, NM 87545

ATTN: Mr. Pat Josey

Dear Mr. Josey:

This is to certify the material referenced below was destroyed as of 10/03/89 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P. O. Box 609, Deer Park, Texas 77536.

DATE RECEIVED	-09/21/89
RES (TX) INC. B/L NUMBER	-111221
TWC MANIFEST NO.	-00067358

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES CHEMPAK/LA
Steve Bergersen

Please call (713) 930-2318 if there are any questions concerning the information on this Certificate of Destruction.

7.18.1 m 104

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

SEP 25 1992

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. N.M.0.8.9.0.0.1.0.5.1.5 Manifest Document No. 89 2 0 2

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN PAT JOSEY
Los Alamos National Labs
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number No 00067360

B. State Generator's ID 99035

5. Transporter 1 Company Name
CUSTOM ENVIRONMENTAL TRANSPORT

6. US EPA ID Number
D.E.D.9.8.0.9.1.8.8.5.8

C. State Transporter's ID 40756

D. Transporter's Phone 302-479-2761

7. Transporter 2 Company Name

8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address
Rollins Environmental Services
2027 Battleground Road
Deer Park, TX 77536

10. US EPA ID Number
T.X.D.0.5.5.1.4.1.3.7.8

G. State Facility's ID HW-50089-001

H. Facility's Phone 713-930-2300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	Waste No.
X	a. RQ Hazardous Waste, solid, n.o.s. ORM-E NA 9189	063	DM	41160	P	980790
	b.					
	c.					
	d.					

I. Additional Descriptions for Materials Listed Above

J. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information In case of accident or spills contact Chemtrec @ 800-424-9300 or Texas Water Commission @ 512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If undeliverable, return to generator.

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name: PATRICK JOSEY — Signature: [signature] — Month Day Year: 9 28 89

17. Transporter 1 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name: REYNOLD ULMER — Signature: [signature] — Month Day Year: 9 28 89

18. Transporter 2 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name — Signature — Month Day Year

19. Discrepancy Indication Space

20. Facility Owner or Operator Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name: ANTHONY OWNSEN — Signature: [signature] — Date Month Day Year: 9 29 89

GENERATOR — TRANSPORTER — FACILITY

TWC-0311 (Rev. 01/01/89)

White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

7.16.1m104

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

SEP 25 1992

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

FEBRUARY 19, 1990

LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1633 MAIL STOP E-518
LOS ALAMOS, NM 87545

ATTN: Mr. Larry Hupke

Dear Mr. Hupke:

This is to certify the material referenced below was destroyed as of 01/31/90 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P.O. Box 609 Deer Park, Texas 77536 (EPA ID# TXD055141378).

DATE RECEIVED	-09/29/89
RES (TX) INC. B/L NUMBER	-111518
TWC MANIFEST NO.	-00067360

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES Chempak - LA

Please call (713) 930-2317 if there are any questions concerning the information on this Certificate of Destruction.

7.18.1 MICS

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

SEP 25 1992

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 09-30-94

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. N M 0 8 9 0 0 1 0 5 1 5 Manifest Document No. 0 9 2 0 2

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN
PAT JOSEY
Los Alamos National Labs
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number: Nº 00067359

B. State Generator's ID: 99935

5. Transporter 1 Company Name: CUSTOM ENVIRONMENTAL TRANSPORT

6. US EPA ID Number: D E D 9 8 0 9 1 8 8 5 8

C. State Transporter's ID: 40756

D. Transporter's Phone: 302-479-2761

7. Transporter 2 Company Name

8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address
Rollins Environmental Services
2027 Battleground Road
Deer Park, TX 77536

10. US EPA ID Number: T X D 0 5 5 1 4 1 3 7 8

G. State Facility's ID: HWS 50089-001

H. Facility's Phone: 713-930-2300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	I. Waste No.
X	a. RQ Hazardous Waste, solid, n.o.s. ORM-E NA 9189	062	DM	37690	P	980790
	b.					
	c.					
	d.					

J. Additional Descriptions for Materials Listed Above

K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information In case of accident or spills contact Chemtrec @ 800-424-9300 or Texas Water Commission @ 512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If undeliverable, return to generator.

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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GENERATOR

Printed/Typed Name: PATRICK JOSEY | Signature | Month Day Year: 9 28 89

17. Transporter 1 Acknowledgement of Receipt of Materials | Date

Printed/Typed Name: Ricky Reller | Signature | Month Day Year: 9 28 89

18. Transporter 2 Acknowledgement of Receipt of Materials | Date

Printed/Typed Name | Signature | Month Day Year

TRANSPORTER

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name: ANTHONY Oman | Signature | Month Day Year: 9 28 89

FACILITY

TWC-0311 (Rev. 01/01/89)

White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

7.18.1 M105

SEP 25 1992

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

FEBRUARY 19, 1990

LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1633 MAIL STOP E-518
LOS ALAMOS, NM 87545

ATTN: Mr. Larry Hupke

Dear Mr. Hupke:

This is to certify the material referenced below was destroyed as of 01/31/90 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P.O. Box 609 Deer Park, Texas 77536 (EPA ID# TXD055141378).

DATE RECEIVED	-09/29/89
RES (TX) INC. B/L NUMBER	-111517
TWC MANIFEST NO.	-00067359

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES Chempak - LA

Please call (713) 930-2317 if there are any questions concerning the information on this Certificate of Destruction.

7.18.1M101

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

SEP 25 1992

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. NM0890010515 Manifest Document No. 89202

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN Pat Josey
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number (S) Nº 00067349
B. State Generator's ID 99935
C. State Transporter's ID 70756
D. Transporter's Phone 713-457-2761
E. Transporter's ID
F. Transporter's Phone
G. State Facility's ID 44260089
H. Facility's Phone (713) 930-2100

5. Transporter 1 Company Name: Custom Environmental Transport
6. US EPA ID Number: DED980918858

7. Transporter 2 Company Name
8. US EPA ID Number

9. Designated Facility Name and Site Address
Rollins Environmental Services
2027 Battleground Road
Deer Park, TX 77536
10. US EPA ID Number: TXD055141378

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol
X	a. RQ Hazardous Waste solid, N.O.S. ORM-E NA 9189	062	DM	39545	P
	b.				
	c.				
	d.				

J. Additional Descriptions for Materials Listed Above
K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information: In case of accident or spills contact CHEMTREC at 1-800-424-9300 or the Texas Water Commission at 1-512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If undeliverable, return to generator.

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name: Pat Josey | Signature: Patrick Josey | Month 10 Day 5 Year 89

GENERATOR

17. Transporter 1 Acknowledgement of Receipt of Materials | Date
Printed/Typed Name: Roy L. Benoit | Signature: Roy L. Benoit | Month 10 Day 5 Year 89

18. Transporter 2 Acknowledgement of Receipt of Materials | Date
Printed/Typed Name | Signature | Month Day Year

TRANSPORTER

19. Discrepancy Indication Space

FACILITY

20. Facility Owner or Operator Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.
RES TX Inc
Printed/Typed Name: Anthony Chorusu | Signature: Anthony Chorusu | Date Month 10 Day 06 Year 89

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

SEP 25

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

FEBRUARY 20, 1990

LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1633
LOS ALAMOS, NM 87545

ATTN: Mr. Pat Josey

Dear Mr. Josey:

This is to certify the material referenced below was destroyed as of 12/08/89 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P.O. Box 609 Deer Park, Texas 77536 (EPA ID# TXD055141378).

DATE RECEIVED	-10/06/89
RES (TX) INC. B/L NUMBER	-111809
TWC MANIFEST NO.	-00067349

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES Chempak - LA

Please call (713) 930-2317 if there are any questions concerning the information on this Certificate of Destruction.

1.10.1 111100

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

SEP 25 1992

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. NM0890010515 Manifest Document No. 89202

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN Pat Josey
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

5. Transporter 1 Company Name: Custom Environmental Transport

6. US EPA ID Number: DED980918858

7. Transporter 2 Company Name

8. US EPA ID Number

9. Designated Facility Name and Site Address
Rollins Environmental Services
2027 Battleground Road
Deer Park, TX 77536

10. US EPA ID Number: TXD055141378

State Manifest Document Number: NR 00067384
State Generator's ID: 99935
State Transporter's ID: 40756
Transporter's Phone: (302) 479-2316
State Transporter's ID
Transporter's Phone
State Facility's ID: 0089
Facility's Phone: (713) 930-1300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol
X	a. RQ Hazardous Waste solid, N.O.S., ORM-E NA9189	062	DM	35215	P
	b.				
	c.				
	d.				

J. Additional Descriptions for Materials Listed Above
D(a). F002, D003

15. Special Handling Instructions and Additional Information In case of accident or spills contact CHEMTREC at 1-800-424-9300 or the Texas Water Commission at 1-512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If undeliverable, return to generator.

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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Printed/Typed Name: PATRICK JOSEY | Signature | Month Day Year: 10 05 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials | Date

Printed/Typed Name: GREGORY JONES | Signature | Month Day Year: 10 05 89

18. Transporter 2 Acknowledgement of Receipt of Materials | Date

Printed/Typed Name | Signature | Month Day Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.
RES TX INC

Date

Printed/Typed Name: ANTHONY OWSEN | Signature | Month Day Year: 10 06 89

TWC-0311 (Rev. 01/01/89)

White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

7.18.1 DIVE 8

SEP 25 1990

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

NOVEMBER 15, 1989

LOS ALAMOS NATIONAL LABORATORY
P. O. BOX 1663
LOS ALAMOS, NM 87545

ATTN: Mr. Pat Josey

Dear Mr. Josey:

This is to certify the material referenced below was destroyed as of 10/24/89 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P. O. Box 609, Deer Park, Texas 77536.

DATE RECEIVED	-10/06/89
RES (TX) INC. B/L NUMBER	-111808
TWC MANIFEST NO.	-00067334

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES CHEMPAK/LA
Steve Bergersen

Please call (713) 930-2318 if there are any questions concerning the information on this Certificate of Destruction.

7.18.1 M109

SEP 25 1992

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

*** 8.9218 ***

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. Manifest Document No. NM0890010515189204

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address: Los Alamos National Labs, P.O. Box 1663, Los Alamos, NM 87545 ATTN: Pat Josey

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number: No 00070318

B. State Generator's ID: 9935

5. Transporter 1 Company Name: Custom Environmental Transport

6. US EPA ID Number: IDED980918858

C. State Transporter's ID: 40756

7. Transporter 2 Company Name

8. US EPA ID Number

D. Transporter's Phone: 302-[illegible]

9. Designated Facility Name and Site Address: Rollins Environmental Services, 2027 Battleground Road, Deer Park, TX 77536

10. US EPA ID Number: TXD055141378

E. Transporter's Phone

Facility's Phone: 713-930-2800

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol
X	a. RQ Hazardous Waste, solid, n.o.s ORM-E NA 9189	63	DM	38550	P
	b.				
	c.				
	d.				

J. Additional Descriptions for Materials Listed Above: D001, D002

K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information: In case of accident or spills contact Chemtrec @ 1-800-424-9300 or the Texas Water Commission @ 512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If undeliverable, return to generator.

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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Printed/Typed Name: PATRICK JOSEY — Signature: [signature] — Date: Month 10 Day 13 Year 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name: Michael J. Moore — Signature: [signature] — Date: Month 10 Day 13 Year 89

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name — Signature — Date: Month Day Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name: ANTHONY OWNSEN — Signature: [signature] — Date: Month 10 Day 13 Year 89

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

7.18.1m109

SEP 25 1992

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

FEBRUARY 19, 1990

LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1633 MAIL STOP E-518
LOS ALAMOS, NM 87545

ATTN: Mr. Larry Hupke

Dear Mr. Hupke:

This is to certify the material referenced below was destroyed as of 01/31/90 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P.O. Box 609 Deer Park, Texas 77536 (EPA ID# TXD055141378).

DATE RECEIVED	-10/14/89
RES (TX) INC. B/L NUMBER	-111986
TWC MANIFEST NO.	-00070318

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES Chempak - LA

Please call (713) 930-2317 if there are any questions concerning the information on this Certificate of Destruction.

9.18.1 M111

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

*** 8.9217 *** SEP 25 1989

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) Form approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. NM 0 8 9 0 0 1 0 5 1 5 Manifest Document No. 8 9 2 0 4

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN: Pat Josey
Los Alamos National Labs
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number NO 00070317
B. State Generator's ID 9995
C. State Transporter's ID 10756
D. Transporter's Phone (302) 477-2561
E. State Transporter's ID
F. Transporter's Phone
G. State Facility's ID 50029-001
H. Facility's Phone (713) 930-2006

5. Transporter 1 Company Name: Custom Environmental Transport
6. US EPA ID Number: TED 980918858

7. Transporter 2 Company Name
8. US EPA ID Number

9. Designated Facility Name and Site Address
Rollins Environmental Service
2027 Battleground Road
Deer Park, TX 77536
10. US EPA ID Number: TXD055141378

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol
X	a. RQ Hazardous Waste, solid, n.o.s. ORM-E NA 9189	72	DM	45200	P
	b.				
	c.				
	d.				

J. Additional Descriptions for Materials Listed Above
Ha D002, D003

K. Handling Codes for Wastes Listed Above
D7

15. Special Handling Instructions and Additional Information In case of accident or spills contact Chemtrec @ 1-800-424-9300 or the Texas Water Commission @ 512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If undeliverable, return to generator.

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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Printed/Typed Name: PATRICK JOSEY
Signature: [signature]
Month Day Year: 10 / 2 / 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials
Printed/Typed Name: RONNIE ROWE
Signature: [signature]
Date: Month 10 Day 13 Year 89

18. Transporter 2 Acknowledgement of Receipt of Materials
Printed/Typed Name
Signature
Date: Month Day Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.
RES (TX) INC
Printed/Typed Name: ANTHONY OWSEN
Signature: [signature]
Date: Month 10 Day 16 Year 89

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

7.18.1 [illegible]

SEP 5 1992

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

FEBRUARY 19, 1990

LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1633 MAIL STOP E-518
LOS ALAMOS, NM 87545

ATTN: Mr. Larry Hupke

Dear Mr. Hupke:

This is to certify the material referenced below was destroyed as of 01/31/90 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P.O. Box 609 Deer Park, Texas 77536 (EPA ID# TXD055141378).

DATE RECEIVED	-10/14/89
RES (TX) INC. B/L NUMBER	-111987
TWC MANIFEST NO.	-00070317

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES Chempak - LA

Please call (713) 930-2317 if there are any questions concerning the information on this Certificate of Destruction.

7.12.1 m112

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

SEP 25 1992

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. N.M.0.8.9.0.0.1.0.5.1.5 Manifest Document No. 8.9.2.0.5

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN
PAT JOSEY
Los Alamos National Labs
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number NM 00067350

B. State Generator's ID 89935

5. Transporter 1 Company Name
CUSTOM ENVIRONMENTAL TRANSPORT

6. US EPA ID Number DED.9.8.0.9.1.8.8.5.8

C. State Transporter's ID 40756

D. Transporter's Phone 302-479-2761

7. Transporter 2 Company Name

8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address
Rollins Environmental Services
2027 Battleground Road
Deer Park, TX 77536

10. US EPA ID Number TXD.0.5.5.1.4.1.3.7.8

G. State Facility's ID TX 50089-00

H. Facility's Phone 713-930-2300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	Waste No.
X	a. RQ Hazardous Waste, solid, n.o.s. ORM-E NA 9189	066	DM	29400 ~~33850~~	P	980790
	b.					
	c.					
	d.					

[redacted]

15. Special Handling Instructions and Additional Information In case of accident or spill call Chemtrec at 1-800-424-9300 or the Texas Water Commission at 512-463-8175. Avoid contact. Avoid breathing vapors. Contain waste. If unable to deliver, return to generator.

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name: PATRICK JOSEY — Signature: Pat Josey — Month Day Year: NOV 9 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name: REYNOLD ULMER — Signature: Reynold Ulmer — Month Day Year: 10 19 89

18. Transporter 2 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name — Signature — Month Day Year

FACILITY

19. Discrepancy Indication Space
Per my telephone conversation with Pat Josey, the above quantity has been changed to reflect the actual amount received by RES (TX). J. Milum 10/23/89

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name: ANTHONY OWENS — Signature — Date: Month Day Year: 10 20 89

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

SEP 25 1992

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

NOVEMBER 15, 1989

LOS ALAMOS NATIONAL LABORATORY
P. O. BOX 1663
LOS ALAMOS, NM 87545

ATTN: Mr. Pat Josey

Dear Mr. Josey:

This is to certify the material referenced below was destroyed as of 10/20/89 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P. O. Box 609, Deer Park, Texas 77536.

DATE RECEIVED	-10/20/89
RES (TX) INC. B/L NUMBER	-112122
TWC MANIFEST NO.	-00067350

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES CHEMPAK/LA
Steve Bergersen

Please call (713) 930-2318 if there are any questions concerning the information on this Certificate of Destruction.

7.18.1m113

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

*** 8.9220 ***

SEP 25 1992

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 03-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. NM0890010515 Manifest Document No. 89205

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
ATTN: Pat Josey
Los Alamos National Labs
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number № 00067351

B. State Generator's ID 89935

5. Transporter 1 Company Name: CUSTOM ENVIRONMENTAL TRANSPORT

6. US EPA ID Number: TXD980918858

C. State Transporter's ID 40756

D. Transporter's Phone 512-459-2161

7. Transporter 2 Company Name

8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address
Rollins Environmental Services
2027 Battleground Road
Deer Park, TX 77536

10. US EPA ID Number: TXD055141378

G. State Facility's ID

H. Facility's Phone 713-930-2600

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	Waste No.
X	a. RQ Hazardous Waste, solid, n.o.s. ORM-E (F002) NA 9189	066	DM	41500	P	[illegible]
	b.					
	c.					
	d.					

J. Additional Descriptions for Materials Listed Above [illegible] K. Handling Codes for Wastes Listed Above [illegible]
F002 [illegible]

15. Special Handling Instructions and Additional Information In case of accident or spills contact Chemtrec @ 1-800-424-9300 or the Texas Water Commission @ 512-463-8175. Avoid contact. Avoid Breathing vapors. Contain Waste. If unable to deliver, return to generator.

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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Printed/Typed Name: PATRICK JOSEY — Signature: [signature] — Month 10 Day 19 Year 89

GENERATOR

17. Transporter 1 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name: Rick Keller — Signature: [signature] — Month 10 Day 19 Year 89

18. Transporter 2 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name — Signature — Month Day Year

TRANSPORTER

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.
RES (TX) INC

Printed/Typed Name: CTLEYES — Signature: [signature] — Date Month 10 Day 20 Year 89

FACILITY

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

7.18.1M 113

SEP 25 1992

ROLLINS
ENVIRONMENTAL SERVICES (TX) INC.

P.O. Box 609, Deer Park, TX 77536, 713/930-2300, FAX 713/930-2316

FEBRUARY 19, 1990

LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1633 MAIL STOP E-518
LOS ALAMOS, NM 87545

ATTN: Mr. Larry Hupke

Dear Mr. Hupke:

This is to certify the material referenced below was destroyed as of 01/31/90 at our Deer Park facility - Rollins Environmental Services (TX) Inc., P.O. Box 609 Deer Park, Texas 77536 (EPA ID# TXD055141378).

DATE RECEIVED	-10/20/89
RES (TX) INC. B/L NUMBER	-112123
TWC MANIFEST NO.	-00067351

SINCERELY,
RES (TX) INC.

ROBERT S. WHITLOCK
OPERATIONS MANAGER

cc: RES Chempak - LA

Please call (713) 930-2317 if there are any questions concerning the information on this Certificate of Destruction.

7.18.1 M121

SEP 25 1992

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

*** 8.9257 ***

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. N.M.0.8.9.0.0.1.0.5.1.5 Manifest Document No. 89.2.1

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
Contact: Pat Josey
Los Alamos National Laboratory
P.O. Box 1663
Los Alamos, NM 87545

4. Generator's Phone (505) 667-4301

5. ~~Transporter 1 Company Name~~ ~~Custom Environmental Transport~~

6. US EPA ID Number ~~LA 1.6.6.8.3.0.5.1.0~~

7. Transporter 2 Company Name
Environmental Transporters, Inc.

8. US EPA ID Number LAD 068 30 510

9. Designated Facility Name and Site Address
Rollins Environmental Services (TX), Inc.
2027 Battleground Rd.
Deer Park, TX 77536

10. US EPA ID Number T.X.D.0.5.5.1.4.1.3.7.8

A. State Manifest Document Number NM 00070293

B. State Generator's ID 9435

C. State Transporter's ID

D. Transporter 1 Phone

E. Transporter 2 ID

F. Transporter 2 Phone

G. Designated Facility ID 1989-

H. Designated Facility Phone 450-2500

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol
X	a. RQ Hazardous Waste solid, N.O.S. ORM-E, NA 9189	065	DM	39310	P
	b.				
	c.				
	d.				

J. Additional Descriptions for Materials Listed Above
(Ha). F002, F003 - CONTAMINATED SOIL

K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information In case of accident or spills contact CHEMTREC at 800-424-9300 or the Texas Water Commission at 512-463-8175. Avoid contact with hazardous material. Avoid breathing vapors. Contain waste. If unable to deliver, return to generator.

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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GENERATOR

Printed/Typed Name: PATRICK JOSEY — Signature: [signature] — Month Day Year: 1 1 6 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name: Ricky Keller — Signature: [signature] — Month Day Year: 1 1 6 89

18. Transporter 2 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name — Signature — Month Day Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name: Matt Evans — Signature: [signature] — Date: Month Day Year: 1 1 7 89

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

7.18.1 M122

SEP 25 1992

*** 8.9258 ***

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. N M 0 8 9 0 0 1 0 5 1 5 — Manifest Document No. 8 9 2 1 2

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address: Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM 87545 — Attn: Pat Josey

4. Generator's Phone (505) 667-4301

A. State Manifest Document Number: NM 00070287

B. State Generator's ID: 99435

5. Transporter 1 Company Name: Environmental Transporters Inc.

6. US EPA ID Number: L A D 0 6 0 8 3 0 5 1 0

C. State Transporter's ID: 41360

D. Transporter's Phone: (504) 340-0378

7. Transporter 2 Company Name

8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address: Rollins Environmental Services (TX), Inc., 2027 Battleground Road, Deer Park, TX 77536

10. US EPA ID Number: T X D 0 5 5 1 4 1 3 7 8

G. State Facility's ID: HW-50845-004

H. Facility's Phone: (713) 930-2300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	Waste No.
X	a. RQ Hazardous Waste Solid, N.O.S., ORM-E, NA 9189	031	DM	18500	P	980790
	b.					
	c.					
	d.					

GENERATOR

J. Additional Descriptions for Materials Listed Above: 11. a. D002, F006

K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information: In case of accident or spills contact CHEMTREC at 800-424-9300 or Texas Water Commission at 512-463-8175. Avoid contact with hazardous material. Avoid breathing vapors. Contain waste. If unable to deliver, return to the generator.

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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Printed/Typed Name: A. Drypolcher — Signature: A. Drypolcher — Month Day Year: 11 28 89

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name: Ricky Keller — Signature: Ricky Keller — Month Day Year: 11 28 89

18. Transporter 2 Acknowledgement of Receipt of Materials — Date

Printed/Typed Name — Signature — Month Day Year

19. Discrepancy Indication Space

FACILITY

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

RSCA Inc — Date

Printed/Typed Name: Karen Donly — Signature: Karen Donly — Month Day Year: 1 12 90

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

TRUCK # 79282
9845

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

7.48.TM127
SEP 25 1992

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Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. N M 0 8 9 0 0 1 0 5 1 5 — Manifest Document No. 40025
2. Page 1 of 1
Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1663 MS E518
LOS ALAMOS, NM 87545

4. Generator's Phone (505) 667-4301 ATTN: PAT JOSEY

A. State Manifest Document Number NP 00145184
B. State Generator's ID 09935
C. State Transporter's ID 21180
D. Transporter's Phone (505) 340-0378
E. Facility's ID 0089-901
F. Facility's Phone (713) 330-2300

5. Transporter 1 Company Name
ENVIRONMENTAL TRANSPORTERS, INC.
6. US EPA ID Number A D 0 6 0 8 3 0 5 1 0

7. Transporter 2 Company Name
8. US EPA ID Number

9. Designated Facility Name and Site Address
ROLLINS ENVIRONMENTAL SERVICES(TX), INC.
2027 BATTLEGROUND ROAD
DEER PARK, TX. 77536
10. US EPA ID Number T X D 0 5 5 1 4 1 3 7 8

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol
X	a. RQ HAZARDOUS WASTE SOLID, N.O.S. ORM-E (F002) NA9189	045	DM	18660 211 1/0	TS P
	b.				
	c.				
	d.				

J. Additional Descriptions for Materials Listed Above
NO 14908 25
SOLVENT CONTAMINATED SOILS

K. Handling Codes for Wastes Listed Above
G

15. Special Handling Instructions and Additional Information
IN CASE OF ACCIDENT OR SPILLS, CONTACT CHEMTREC AT (800) 424-9300 and the TEXAS WATER COMMISSION AT (512)463-7727. AVOID CONTACT. AVOID BREATHING VAPORS. CONTAIN WASTE. IF UNABLE TO DELIVER, RETURN TO THE GENERATOR.

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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Printed/Typed Name: PATRICK JOSEY — Signature: [signature] — Month Day Year: 1 V 8 90

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials
Printed/Typed Name: Roosevelt Harris Jr. — Signature: Roosevelt Harris Jr. — Date: Month 1 Day 18 Year 90

18. Transporter 2 Acknowledgement of Receipt of Materials
Printed/Typed Name — Signature — Date: Month Day Year

FACILITY

19. Discrepancy Indication Space
Per my phone conversation with Andy Montoya the above quantity has been changed to reflect the actual amount received by RES(TX) Inc. Lynlett Squilla 1229

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.
RES (TX) Inc.

Printed/Typed Name: Donald Moore — Signature: Donald Moore — Date: Month 10 Day 20 Year 90

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

98447

7.18.1 M127

SEP 25 1992

TEXAS WATER COMMISSION
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form approved. OMB No. 2050-0039, expires 09-30-91

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. N M 0 8 9 0 0 1 0 5 1 5 | Manifest Document No. 90026

2. Page 1 of 1

Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address
LOS ALAMOS NATIONAL LABORATORY
P.O. BOX 1663 MS E518
LOS ALAMOS, NM 87545

4. Generator's Phone (505) 667-4301 ATTN: PAT JOSEY

A. State Manifest Document Number
№ 00145183

B. State Generator's ID
99935

5. Transporter 1 Company Name
ENVIRONMENTAL TRANSPORTERS, INC

6. US EPA ID Number
LAD 060 830 510

C. State Transporter's ID
413.00

D. Transporter's Phone
(504) 340-2376

7. Transporter 2 Company Name

8. US EPA ID Number

E. Transporter's Phone

9. Designated Facility Name and Site Address
ROLLINS ENVIRONMENTAL SERVICES(TX), INC.
2027 BATTLEGROUND ROAD
DEER PARK, TX. 77536

10. US EPA ID Number
T X D 0 5 5 1 4 1 3 7 8

F. State Facility's ID
HW-50089-001

G. Facility's Phone
(713) 930-2300

11A. HM	11. US DOT Description (including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	I. Waste No.
X	a. RQ HAZARDOUS WASTE SOLID, N.O.S. ORM-E (F002) NA 9189	0.48	DM	27760 3.1948	P	980780 F002, F003
	b.					
	c.					
	d.					

J. Additional Descriptions for Materials Listed Above
HO-44908-25
SOLVENT CONTAMINATED SOILS.

K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information
IN CASE OF ACCIDENT OR SPILLS, CONTACT CHEMTREC AT (800) 424-9300 AND THE TEXAS WATER COMMISSION AT (512) 463-7727. AVOID CONTACT. AVOID BREATHING VAPORS. CONTAIN WASTE. IF UNABLE TO DELIVER, RETURN TO THE GENERATOR.

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations, including applicable state regulations.
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Printed/Typed Name: PATRICK JOSEY | Signature | Month Day Year: 11 8 90

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name: HAROLD ARCENEAUX | Signature | Date: Month Day Year: 1 18 90

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Date: Month Day Year

FACILITY

19. Discrepancy Indication Space
Per my phone conversation with Andy Monteya the above quantity has been changed to reflect the actual amount received by RES(TX) Inc.
Burlett Sailer 1-22-90

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name: ANTHONY OWNEN | Signature | Date: Month Day Year: 10 12 90

TWC-0311 (Rev. 01/01/89) White - original Pink-TSD Facility Yellow-Transporter Green-Generator's first copy

APPENDIX B

"Sigma Mesa: Background Elemental Concentrations in Soil and Vegetation"

LA-11941-MS

UC-902
Issued: October 1990

Sigma Mesa: Background Elemental Concentrations in Soil and Vegetation, 1979

Roger W. Ferenbaugh
Ernest S. Gladney
George H. Brooks, Jr.

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

SIGMA MESA:

BACKGROUND ELEMENTAL CONCENTRATIONS IN SOIL AND VEGETATION, 1979

by

Roger W. Ferenbaugh, Ernest S. Gladney, and George H. Brooks, Jr.

ABSTRACT

In 1979, soil and vegetation samples were collected on Sigma Mesa to provide background data before construction on the mesa. Elemental data are presented for soil, grass, juniper, piñon pine, and oak. None of the data looks out of the ordinary.

I. INTRODUCTION

In 1979, Sigma Mesa was a relatively undisturbed area east of the buildings located immediately adjacent to Diamond Drive. At that time, the only activity that had occurred on the mesa at any distance from Diamond Drive was the erection of an antenna farm about 1 mile from the road. In 1979, the decision was made to drill a geothermal well on Sigma Mesa. This activity was scheduled to begin in the summer of 1979. Sigma Mesa also was projected to be a growth area for contractor facilities. For these reasons, a project was initiated in the Environmental Surveillance Group (H-8, renamed the Environmental Protection Group [HSE-8] in 1989) to undertake a comprehensive soil and vegetation sampling program on Sigma Mesa. The purpose of the sampling program was to acquire, before any disturbance, a set of data to be used as background for future impact analysis.

II. METHODS

A sampling grid was established using the proposed location of the geothermal well as the center of the grid. Transects were run at eight compass points: N, NE, E, SE, S, SW, W, and NW. Samples were collected along these transects at 250 ft, 500 ft, and thereafter at intervals of 500 ft out to 2500 ft, or as far as possible before the transect was terminated because of obstacles (such as mesa walls and roads). Table I gives a tabulation of sampling sites and samples collected at each site. Figure 1 shows the location of the sampling area within Laboratory boundaries, and Fig. 2 shows individual sampling locations.

At each location, surface soil samples (0 to 2 in. deep) and grass samples were collected. Foliage samples were collected if tree species were present. The three tree species that were encountered were oak (*Quercus undulata*), piñon pine (*Pinus edulis*), and juniper (*Juniperus monosperma*). Grasses were not identified as to species.

Soil samples were passed through a coarse sieve (20 mesh) to remove matter such as pebbles and twigs, and then the samples were air-dried and ground in a Spex Industries shatterbox. Vegetation samples were dried in a

TABLE I. Sampling Locations and Samples Collected

Sample Designation	Location	Type of Sample Collected				
		Soil	Grass	Juniper	Piñon	Oak
1N	250 ft	X	X	X		
2N	500 ft	X	X		X	X
3N	1000 ft	X	X		X	
4N	Gravel pit	X	X		X	
5N	Above pit	X	X	X		
1NE	250 ft	X	X	X		
2NE	500 ft	X	X	X		X
3NE	1000 ft	X	X	X		
4NE	1500 ft	X	X		X	
5NE	2000 ft	X	X		X	
6NE	2640 ft	X	X		X	
1E	250 ft	X	X	X		
2E	500 ft	X	X	X		X
3E	1000 ft	X	X	X		
4E	1500 ft	X	X	X		
5E	2000 ft	X	X	X		
6E	2640 ft	X	X		X	
7E	Knoll	X	X	X		
1SE	250 ft	X	X	X		X
2SE	500 ft	X	X		X	X
3SE	TA-35, above ponds	X	X		X	
1S	250 ft	X	X	X		X
2S	500 ft	X	X		X	X
3S	TA-35	X	X		X	
1SW	250 ft	X	X	X		X
2SW	500 ft	X	X			X
3SW	Trailers at TA-35	X	X		X	
1W	Wellhead	X	X	X		
2W	250 ft	X	X	X		
3W	500 ft	X	X	X		
4W	1000 ft	X	X	X		
5W	1500 ft	X	X		X	
6W	2000 ft	X	X	X		
7W	2640 ft	X	X	X		
1NW	250 ft	X	X	X		
2NW	500 ft	X	X		X	
3NW	1000 ft	X	X		X	
4NW	1500 ft	X	X		X	
5NW	2000 ft	X	X		X	
6NW	2640 ft	X	X		X	

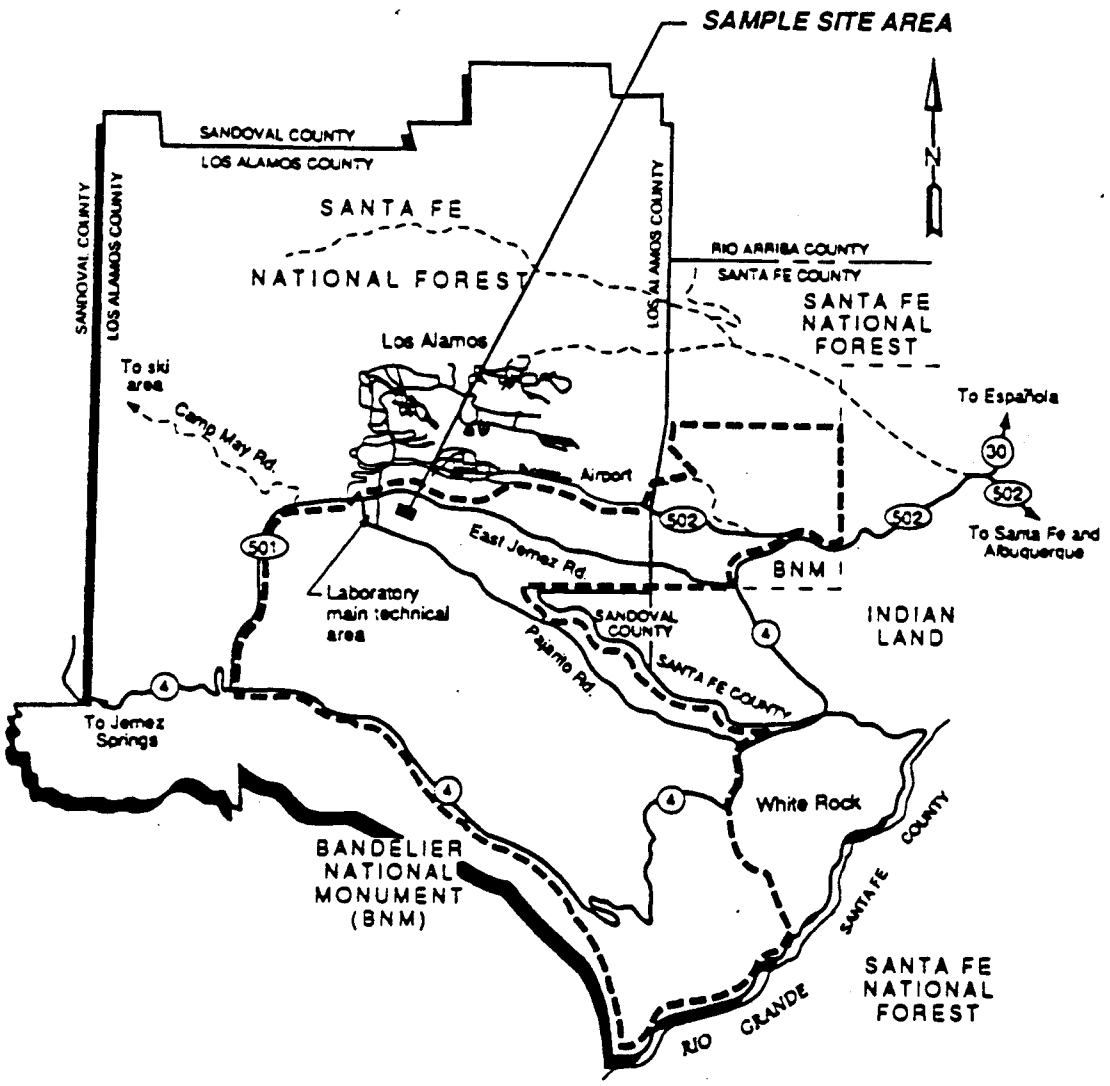

Fig. 1. Location of sampling area.

forced-air circulation oven at 60°C for 2 days and then were ground in the shatterbox.

After the samples were prepared, as described above, they were submitted for a variety of elemental analyses. Several analytical techniques were used, including neutron activation analysis, atomic absorption, ion chromatography, ion selective electrode analysis, and some special analytical techniques. The procedures used for these analyses have been described in detail in Gautier and Gladney (1986) and Gladney et al. (1980). Quality assurance was provided by concurrent analysis of a variety of National Bureau of Standards (NBS), United States Environmental Protection Agency (EPA), and United States Geological Survey (USGS) reference materials using the approach documented in Gladney et al. (1981).

III. RESULTS

Table II summarizes the means and standard deviations of the soil data, Tables III through VI summarize

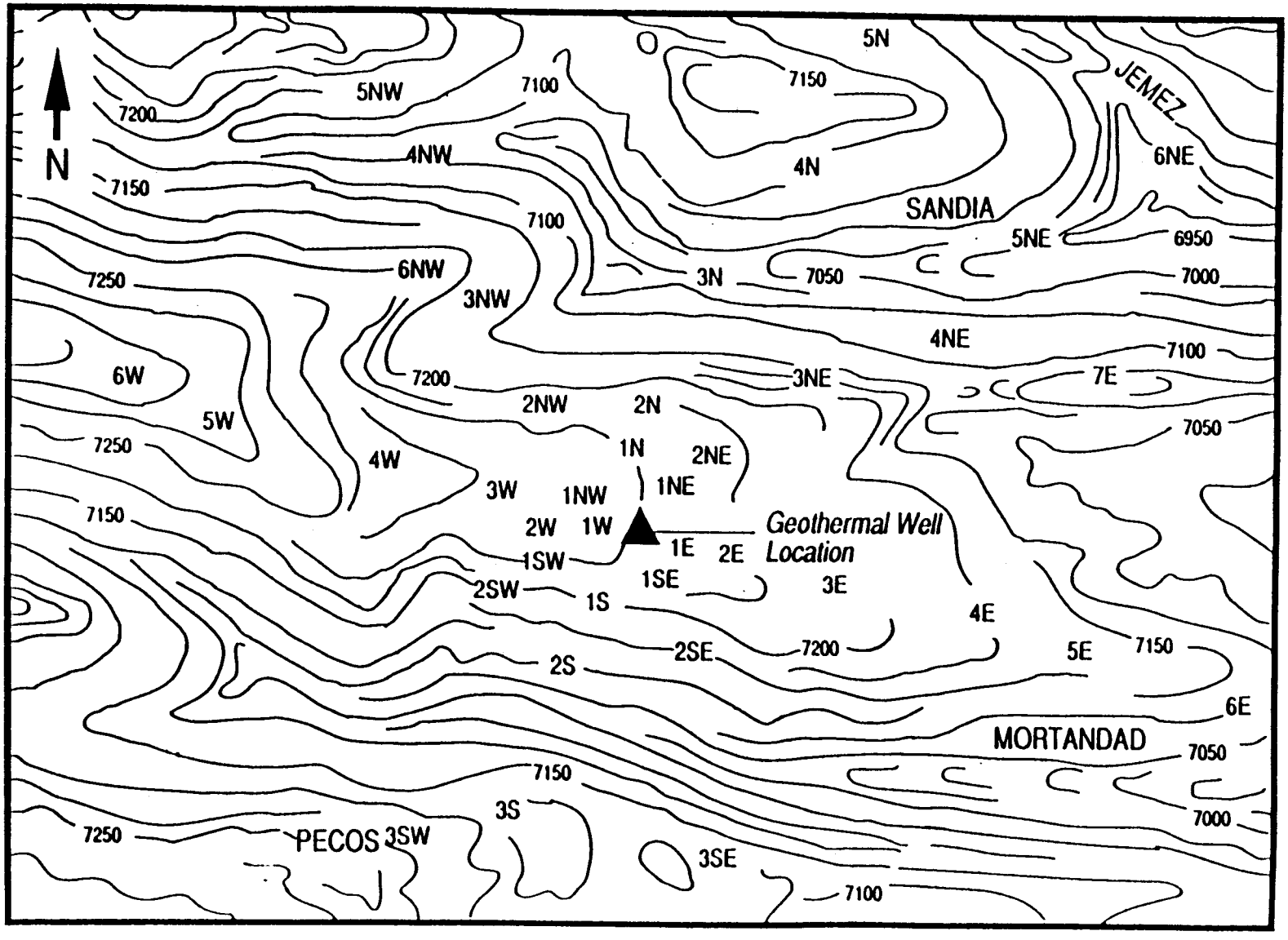

Fig. 2. Locations of sampling sites.

TABLE II. Elemental Concentrations in Soil

Element[a]	Mean	Standard Deviation	No. of Samples	Maximum	Minimum
Al (%)	5.8	0.35	40	6.7	5.3
As	3.9	1.6	40	6.7	1.3
B	16	7.2	38	27	7.0
Ba	410	220	40	810	120
Be	1.9	0.49	37	3.3	1.1
Br	1.9	1.2	38	5.7	0.40
Cd (ppb)	170	100	36	520	30
Cl	<100		40		
Cr	27	24	40	136	4.2
Cu	10	4.5	40	18	2.0
F	240	74	40	390	50
Fe (%)	1.7	0.48	40	2.6	1.0
Hg (ppb)	18	6.0	39	29	7.0
Li	24	4.6	40	39	19
Mg (%)	0.23	0.12	40	0.40	0.051
Mn	510	130	40	840	330
Ni	8.9	4.8	40	19	1.6
NO_3	8.1	6.5	30	26	0.50
Pb	24	15	40	98	8.0
PO_4	11	20	21	94	0.10
Rb	120	15	40	160	90
SO_4	10	13	39	59	2.0
Ti (%)	0.26	0.15	40	0.49	0.079
Zn	54	12	40	71	38

[a]Data are reported in parts per million (ppm) unless otherwise noted.

vegetation data, and Table VII shows soil data from other sources for comparison with the data in Table II. In general, the Sigma Mesa data agree well with the data from other sources. Those instances where there is some discrepancy can be attributed to the chemical characteristics of the volcanic tuff from which the Sigma Mesa soil is derived.

The results of the individual analyses are tabulated in the Appendix, Tables A-I through A-V.

TABLE III. Elemental Concentrations in Grass

Element[a]	Mean	Standard Deviation	No. of Samples	Maximum	Minimum
Al	650	770	39	4400	150
As (ppb)	360	210	38	960	60
B	14	7.0	29	34	7.0
Ba	73	50	15	200	13
Be (ppb)	12	10	14	42	4.0
Br	40	41	40	160	2.7
Cd	<200		15		
Cl (%)	0.19	0.12	40	0.60	0.034
Cr	5.5	3.2	40	13	1.6
Cu	6.8	3.0	16	14	3.3
F	1.1	0.60	40	3.4	0.60
Fe	260	190	40	810	60
Li (ppb)	40	190	11	750	200
Mg (%)	0.12	0.028	16	0.17	0.061
Mn	48	35	40	180	13
Ni	26	11	15	55	7.0
NO_3	420	380	37	1300	60
Pb	1.7	1.1	11	4.0	1.0
PO_4 (%)	0.19	0.083	40	0.47	0.070
Rb	5.6	3.2	37	18	2.1
SO_4	690	360	40	1500	120
Ti	46	60	15	250	12
Zn	21	11	15	52	9.4

[a]Data are reported in parts per million (ppm) unless otherwise noted.

TABLE IV. Elemental Concentrations in Juniper

Element[a]	Mean	Standard Deviation	No. of Samples	Maximum	Minimum
Al	350	180	21	960	140
As (ppb)	90	40	18	170	40
B	23	8.0	21	50	15
Ba	110	100	9	290	22
Be (ppb)	18	7.0	9	29	11
Br	21	18	21	65	3.2
Cd (ppb)	140	60	10	250	100
Cl	910	390	21	2000	350
Cr	3.5	1.4	21	5.9	1.5
Cu	5.9	2.5	9	10	3.5
F (ppb)	250	140	21	600	100
Fe	160	91	21	500	60
Li (ppb)	320	90	6	440	200
Mg (%)	0.24	0.061	9	0.36	0.17
Mn	48	10	21	62	26
Ni	5.2	3.7	9	11	1.9
NO_3	110	41	19	240	43
Pb	2.5	1.3	4	4.0	1.0
PO_4 (%)	0.23	0.096	21	0.43	0.11
Rb	3.1	1.4	19	6.9	1.1
SO_4	470	210	21	830	170
Ti	67	51	9	150	16
Zn	21	5.0	9	27	9.2

[a]Data are reported in parts per million (ppm) unless otherwise noted.

TABLE V. Elemental Concentrations in Piñon Pine

Element[a]	Mean	Standard Deviation	No. of Samples	Maximum	Minimum
Al	200	65	18	310	100
As (ppb)	150	60	17	300	80
B	22	7.0	18	46	11
Ba	24	6.0	3	28	17
Be (ppb)	16	7.0	4	24	8.0
Br	13	14	18	55	1.7
Cd (ppb)	110	60	4	200	50
Cl	570	860	18	4000	230
Cr	3.2	1.5	18	6.8	1.0
Cu	3.9	2.2	4	7.0	2.2
F (ppb)	190	160	18	700	100
Fe	87	33	18	150	40
Li	3.4	2.7	5	7.0	0.70
Mg (%)	0.19	0.064	6	0.31	0.12
Mn	200	160	18	540	58
Ni	5.5	4.4	4	12	2.2
NO_3 [b]					
Pb [b]					
PO_4 (%)	0.18	0.077	17	0.32	0.080
Rb	4.4	2.2	16	9.8	1.5
SO_4	750	380	17	1700	19
Ti	94	160	4	340	11
Zn	34	26	6	69	4.0

[a]Data are reported in parts per million (ppm) unless otherwise noted.
[b]No average was calculated (see data in the Appendix).

TABLE VI. Elemental Concentrations in Oak

Element[a]	Mean	Standard Deviation	No. of Samples	Maximum	Minimum
Al	510	220	9	860	210
As (ppb)	170	110	9	440	70
B	63	13	9	81	48
Ba	39	30	3	73	18
Be (ppb)	46	39	3	90	18
Br	6.4	4.6	9	16	2.2
Cd (ppb)	<200		3		
Cl	260	92	9	380	65
Cr	4.0	2.0	9	6.9	1.9
Cu	7.0	1.3	3	8.1	5.5
F (ppb)	260	150	9	600	100
Fe	210	68	9	350	140
Li	4.3	3.5	3	7.1	0.31
Mg (%)	0.25	0.026	3	0.28	0.23
Mn	500	180	9	870	220
Ni	4.4	0.40	3	4.8	4.0
NO_3	120	34	7	190	80
Pb	<3.0		3		
PO_4 (%)	0.17	0.076	9	0.28	0.019
Rb	17	10	3	26	5.9
SO_4	470	320	8	990	200
Ti	29	5.0	3	34	24
Zn	25	6.0	3	30	18

[a]Data are reported in parts per million (ppm) unless otherwise noted.

TABLE VII. Elemental Abundance in the Earth's Crust

Element	Concentrations (ppm)			
	Mason[a]	Vinogradov[b]	Vinogradov[c]	Wedepohl[d]
Al	81 300	104 500	71 300	78 300
As	1.8	6.6	5	1.7
Ba	425	800	500	590
Be	2.8	7	6	2
Br	2.5	6	5	2.9
Cd	0.2	0.3	0.5	0.1
Cl	130	160	100	320
Cr	100	160	200	70
Cu	55	57	20	30
F	625	500	200	720
Fe	50 000	33 300	38 000	35 400
Hg	0.08	0.4	0.01	0.03
Li	20	60	30	30
Mg	20 900	13 400	6 300	13 900
Mn	950	670	850	690
Ni	75	95	40	44
Pb	13	20	10	15
Rb	90	400	100	120
Ti	4 400	4 500	4 600	4 700
Zn	70	80	50	60
Ag	0.07	0.9	0.1	0.06
Au	0.004	—	—	0.004
Ca	36 300	25 300	13 700	28 700
Ce	60	30	50	75
Co	25	23	8	12
Cs	3	12	5	2.7
Dy	3	4	—	6.1
Eu	1.2	1	—	1.4
Ga	15	40	30	17
Gd	5.4	5	—	8
Ge	1.5	7	1	1.3
Hf	3	4	6	3
I	0.5	1	5	0.5
In	0.1	—	—	0.07
K	25 900	22 800	13 600	28 200
La	30	40	40	44
Lu	0.5	0.2	—	0.6
Mo	1.5	2	2	1
Na	28 300	6 600	6 300	24 500
Nb	20	20	—	20
Nd	28	18	—	>30
S	260	3 000	850	310
Sb	0.2	1	—	0.2
Sc	22	10	7	14
Se	0.05	0.6	—	0.09
Si	277 000	248 000	330 000	305 000

TABLE VII (Continued)

Element	Concentrations (ppm)			
	Mason[a]	Vinogradov[b]	Vinogradov[c]	Wedepohl[d]
Sm	6	5	—	>7
Sn	2	30	10	3
Sr	375	450	300	290
Ta	2	3.5	—	3.4
Tb	0.9	0.9	—	<1.4
Te	0.01	—	—	0.002
Th	7.2	11	6	11
U	1.8	3.2	1	3.5
V	135	130	100	95
W	1.5	—	—	1.3
Y	33	33	50	34
Yb	3.4	2.2	—	3.4
Zr	165	200	300	160

[a]Crustal concentrations (Mason 1966).
[b]Sedimentary rocks, shales, and clays (Vinogradov 1959).
[c]Soil concentrations (Vinogradov 1959).
[d]Crustal concentrations (Wedepohl 1968).

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APPENDIX

TABLE A-I. Soil: Elemental Concentrations[a]

Location	Al (%)	As (ppm)	B (ppm)	Ba (ppm)	Be (ppm)	Br (ppm)	Cd (ppb)	Cl (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Fe (%)
1N	5.5 ± 0.5	5.8 ± 0.7	24 ± 5	680 ± 100	2.7 ± 0.2	4.0 ± 0.5	170 ± 20	<100	41 ± 4	16 ± 2	280 ± 30	2.4 ± 0.1
2N	5.8 ± 0.5	6.0 ± 0.7	27 ± 5	620 ± 90	<0.2	<0.3	150 ± 20	<100	43 ± 4	13 ± 1	260 ± 30	2.2 ± 0.1
3N	5.8 ± 0.5	3.0 ± 0.5	10 ± 5	210 ± 30	<0.2	0.87 ± 0.5	80 ± 20	<100	9.2 ± 1.1	6 ± 1	180 ± 20	1.3 ± 0.1
4N	5.9 ± 0.5	1.8 ± 0.4	10 ± 5	180 ± 30	2.6 ± 0.2	0.61 ± 0.5	290 ± 30	<100	9.0 ± 1.4	6 ± 1	50 ± 10	1.2 ± 0.1
5N	5.7 ± 0.5	3.1 ± 0.4	8 ± 5	400 ± 60	2.1 ± 0.2	1.3 ± 0.4	210 ± 20	<100	6.7 ± 1.0	15 ± 2	150 ± 10	1.2 ± 0.1
1NE	6.2 ± 0.5	4.8 ± 0.5	20 ± 5	570 ± 90	1.5 ± 0.2	5.7 ± 0.7	140 ± 20	<100	27 ± 2	13 ± 1	310 ± 30	2.0 ± 0.1
2NE	6.0 ± 0.5	6.2 ± 0.7	25 ± 5	620 ± 90	1.4 ± 0.2	3.3 ± 0.5	260 ± 20	<100	41 ± 4	18 ± 2	340 ± 30	2.1 ± 0.1
3NE	5.8 ± 0.5	1.3 ± 0.3	<5	150 ± 20	3.3 ± 0.3	0.72 ± 0.5	210 ± 20	<100	140 ± 11	6 ± 1	150 ± 10	1.1 ± 0.1
4NE	6.2 ± 0.5	1.8 ± 0.4	7 ± 5	120 ± 20	1.8 ± 0.2	1.5 ± 0.6	200 ± 20	<100	5.1 ± 1.1	5 ± 1	160 ± 20	1.1 ± 0.1
5NE	5.8 ± 0.5	2.7 ± 0.4	10 ± 5	180 ± 30	1.6 ± 0.2	0.99 ± 0.3	200 ± 20	<100	8.9 ± 1.1	6 ± 1	170 ± 20	1.2 ± 0.1
6NE	5.3 ± 0.5	3.7 ± 0.5	11 ± 5	240 ± 40	2.2 ± 0.2	1.6 ± 0.3		<100	13 ± 2	8 ± 1	190 ± 20	1.3 ± 0.1
1E	5.5 ± 0.5	5.7 ± 0.6	27 ± 5	720 ± 110	1.6 ± 0.2	2.2 ± 0.5	170 ± 20	<100	39 ± 4	15 ± 2	360 ± 40	2.1 ± 0.1
2E	6.2 ± 0.5	5.0 ± 0.6	23 ± 5	590 ± 90	<0.2	2.3 ± 0.4	80 ± 20	<100	40 ± 4	14 ± 1	210 ± 20	2.4 ± 0.1
3E	6.2 ± 0.5	4.1 ± 0.5	15 ± 5	390 ± 60	1.7 ± 0.2	1.4 ± 0.4	110 ± 20	<100	27 ± 2	9 ± 3	220 ± 20	2.1 ± 0.1
4E	5.7 ± 0.5	4.2 ± 0.6	13 ± 5	300 ± 50	2.1 ± 0.2	2.8 ± 0.6	60 ± 20	<100	15 ± 2	11 ± 1	210 ± 20	1.5 ± 0.1
5E	6.3 ± 0.5	2.8 ± 0.5	10 ± 5	260 ± 40	2.3 ± 0.2	0.57 ± 0.4	160 ± 20	<100	14 ± 2	6 ± 2	210 ± 20	1.7 ± 0.1
6E	5.9 ± 0.5	2.6 ± 0.5	9 ± 5	190 ± 30	2.0 ± 0.2	1.2 ± 0.4		<100	8.9 ± 1.2	3 ± 1	230 ± 20	1.0 ± 0.1
7E	6.2 ± 0.5	1.8 ± 0.5	10 ± 5	180 ± 30	2.6 ± 0.2	1.7 ± 0.6	100 ± 20	<100	6.8 ± 1.0	4 ± 1	300 ± 30	1.2 ± 0.1
1SE	6.0 ± 0.5	3.5 ± 0.4	14 ± 5	440 ± 70	1.8 ± 0.2	2.8 ± 0.4	160 ± 20	<100	18 ± 2	10 ± 1	240 ± 20	1.5 ± 0.1
2SE	5.4 ± 0.5	1.7 ± 0.3	9 ± 5	130 ± 20	2.1 ± 0.2	3.5 ± 0.5	140 ± 20	<100	4.4 ± 1.2	5 ± 1	190 ± 20	1.0 ± 0.1
3SE	6.0 ± 0.5	1.6 ± 0.3	7 ± 5	140 ± 20	2.2 ± 0.2	1.6 ± 0.3	260 ± 20	<100	4.3 ± 0.9	2 ± 2	270 ± 30	1.1 ± 0.1
1S	5.3 ± 0.5	4.3 ± 0.5	16 ± 5	390 ± 60	1.7 ± 0.2	3.6 ± 0.7	390 ± 30	<100	21 ± 2	14 ± 1	220 ± 20	1.7 ± 0.1
2S	5.4 ± 0.5	2.1 ± 0.4	9 ± 5	150 ± 20	1.9 ± 0.2	1.9 ± 0.6	180 ± 20	<100	4.2 ± 0.8	5 ± 1	140 ± 10	1.0 ± 0.1
3S	5.7 ± 0.5	1.7 ± 0.3	<5	350 ± 50	2.3 ± 0.2	0.70 ± 0.5	110 ± 20	<100	54 ± 4	7 ± 1	150 ± 10	2.6 ± 0.1
1SW	6.0 ± 0.5	4.5 ± 0.5	19 ± 5	590 ± 90	1.8 ± 0.2	2.9 ± 0.4	140 ± 20	<100	39 ± 4	11 ± 1	270 ± 30	2.2 ± 0.1
2SW	6.4 ± 0.5	4.9 ± 0.6	18 ± 5	380 ± 60	2.0 ± 0.2	2.7 ± 0.5		<100	26 ± 3	16 ± 2	300 ± 30	1.9 ± 0.1
3SW	6.7 ± 0.5	3.5 ± 0.4	13 ± 5	200 ± 30	2.4 ± 0.2	1.7 ± 0.5	100 ± 20	<100	16 ± 2	13 ± 1	320 ± 30	1.7 ± 0.1
1W	5.3 ± 0.5	6.7 ± 0.7	27 ± 5	810 ± 120	1.4 ± 0.2	2.8 ± 0.4	260 ± 20	<100	40 ± 4	17 ± 2	270 ± 30	2.2 ± 0.1
2W	5.9 ± 0.5	5.5 ± 0.6	24 ± 5	610 ± 90	0.9 ± 0.2	1.8 ± 0.4	190 ± 20	<100	48 ± 4	14 ± 1	320 ± 30	2.2 ± 0.1
3W	5.5 ± 0.5	4.8 ± 0.6	25 ± 5	570 ± 90	1.4 ± 0.2	0.44 ± 0.4	90 ± 20	<100	38 ± 3	11 ± 1	340 ± 30	1.9 ± 0.1
4W	6.0 ± 0.5	5.7 ± 0.6	20 ± 5	690 ± 100	1.7 ± 0.2	4.1 ± 0.6	30 ± 20	<100	42 ± 4	15 ± 2	390 ± 40	2.2 ± 0.1
5W	5.7 ± 0.5	5.7 ± 0.6	19 ± 5	700 ± 110	1.6 ± 0.2	1.0 ± 0.4	520 ± 50	<100	46 ± 4	14 ± 1	320 ± 30	2.0 ± 0.1
6W	5.5 ± 0.5	5.4 ± 0.6	25 ± 5	650 ± 100	1.8 ± 0.2	1.4 ± 0.4	130 ± 20	<100	41 ± 4	13 ± 1	160 ± 20	1.9 ± 0.1
7W	5.3 ± 0.5	5.3 ± 0.6	24 ± 5	620 ± 90	1.3 ± 0.2	3.0 ± 0.5	30 ± 20	<100	40 ± 4	12 ± 1	280 ± 30	2.0 ± 0.1
1NW	5.5 ± 0.5	5.6 ± 0.6	27 ± 5	660 ± 100	1.1 ± 0.2	2.4 ± 0.5		<100	32 ± 4	16 ± 2	310 ± 30	2.0 ± 0.1
2NW	5.4 ± 0.5	5.1 ± 0.6	26 ± 5	700 ± 110	1.4 ± 0.2	0.42 ± 0.3	150 ± 20	<100	45 ± 4	14 ± 1	250 ± 20	2.1 ± 0.1
3NW	5.7 ± 0.5	3.2 ± 0.4	9 ± 5	200 ± 30	1.5 ± 0.2	<0.3	250 ± 20	<100	7.6 ± 1.1	6 ± 1	180 ± 20	1.1 ± 0.1
4NW	5.8 ± 0.5	2.5 ± 0.4	10 ± 5	160 ± 20	2.1 ± 0.2	0.73 ± 0.5	100 ± 20	<100	8.8 ± 1.3	6 ± 1	160 ± 20	1.2 ± 0.1
5NW	6.3 ± 0.5	3.0 ± 0.4	11 ± 5	260 ± 40	2.4 ± 0.2	0.40 ± 0.4	150 ± 20	<100	11 ± 1	7 ± 1	220 ± 20	1.6 ± 0.1
6NW	6.2 ± 0.5	2.4 ± 0.4	8 ± 5	220 ± 30	2.1 ± 0.2	0.65 ± 0.5	140 ± 20	<100	8.5 ± 1.3	5 ± 1	190 ± 20	1.3 ± 0.1

TABLE A-1 (Continued)

Location	Hg (ppb)	Li (ppm)	Mg (ppm)	Mn (ppm)	Ni (ppm)	NO_3 (ppm)	Pb (ppm)	PO_4 (ppm)	Rb (ppm)	SO_4 (ppm)	Ti (ppm)	Zn (ppm)
1N	22 ± 4	24 ± 2	3800 ± 380	770 ± 80	15 ± 2	6.0 ± 0.6	18 ± 2	15 ± 1	120 ± 15	10 ± 1	4200 ± 400	51 ± 3
2N	14 ± 4	23 ± 2	3400 ± 340	530 ± 50	13 ± 2	6.0 ± 0.6	33 ± 3	<0.6	120 ± 14	9.0 ± 0.9	4300 ± 450	41 ± 2
3N	18 ± 4	29 ± 3	1500 ± 150	400 ± 40	6.5 ± 1	2.0 ± 0.2	18 ± 2	<0.6	130 ± 15	4.0 ± 0.4	1200 ± 170	58 ± 3
4N		28 ± 3	850 ± 90	400 ± 40	4.7 ± 1	6.0 ± 0.6	28 ± 2	<0.6	150 ± 18	4.0 ± 0.4	1100 ± 170	52 ± 3
5N	12 ± 4	25 ± 3	2400 ± 240	350 ± 40	6.8 ± 1	10 ± 1	65 ± 6	<0.6	120 ± 13	4.0 ± 0.4	1300 ± 220	64 ± 3
1NE	22 ± 4	25 ± 3	3700 ± 370	740 ± 70	14 ± 2	23 ± 2	18 ± 2	<0.6	120 ± 14	59 ± 6	3700 ± 390	52 ± 3
2NE	27 ± 4	25 ± 3	4000 ± 400	570 ± 60	14 ± 2	<0.9	20 ± 2	2.0 ± 0.2	150 ± 18	10 ± 1	3800 ± 390	52 ± 3
3NE	14 ± 4	24 ± 2	670 ± 70	390 ± 40	3.1 ± 1	<0.9	12 ± 2	7.0 ± 0.7	120 ± 14	6.0 ± 0.6	810 ± 140	64 ± 3
4NE	10 ± 4	26 ± 3	510 ± 50	460 ± 50	2.7 ± 1	<0.9	15 ± 2	4.0 ± 0.4	130 ± 15	2.0 ± 0.2	1000 ± 180	71 ± 4
5NE	17 ± 4	26 ± 3	1200 ± 120	470 ± 50	6.8 ± 1	<0.9	32 ± 3	<0.6	120 ± 13	3.0 ± 0.3	1300 ± 140	63 ± 3
6NE	22 ± 4	26 ± 3	1600 ± 160	640 ± 60	5.2 ± 1	<0.9	30 ± 3	3.0 ± 0.3	130 ± 15	6.0 ± 0.6	1200 ± 120	71 ± 4
1E	21 ± 4	25 ± 3	3800 ± 380	630 ± 60	15 ± 2	7.0 ± 0.7	25 ± 2	8.0 ± 0.8	120 ± 17	9.0 ± 0.9	4300 ± 450	45 ± 2
2E	13 ± 4	25 ± 3	4000 ± 400	840 ± 80	19 ± 2	6.0 ± 0.6	12 ± 2	<0.6	120 ± 14	8.0 ± 0.8	4900 ± 280	50 ± 3
3E	17 ± 4	24 ± 2	2700 ± 270	430 ± 40	6.9 ± 1	11 ± 1	20 ± 2	<0.6	110 ± 12	7.0 ± 0.7	2900 ± 330	48 ± 2
4E	27 ± 4	24 ± 2	1800 ± 180	430 ± 40	6.3 ± 1	14 ± 1	25 ± 2	<0.6	90 ± 11	14 ± 1	2000 ± 240	62 ± 3
5E	11 ± 4	27 ± 3	1400 ± 140	390 ± 40	5.6 ± 1	16 ± 1	16 ± 2	<0.6	120 ± 14	5.0 ± 0.5	1700 ± 210	53 ± 3
6E	13 ± 4	26 ± 3	930 ± 90	360 ± 40	3.2 ± 1	4.0 ± 0.4	8 ± 2	<0.6	110 ± 12	3.0 ± 0.3	1100 ± 180	47 ± 2
7E	17 ± 4	29 ± 3	1100 ± 110	400 ± 40	3.8 ± 1	12 ± 1	19 ± 2	5.0 ± 0.5	130 ± 14	3.0 ± 0.3	790 ± 150	55 ± 6
1SE	15 ± 4	25 ± 3	2700 ± 270	390 ± 40	8.1 ± 1	6.0 ± 0.6	19 ± 2	3.0 ± 0.3	90 ± 10	6.0 ± 0.6	2500 ± 260	45 ± 2
2SE	13 ± 4	19 ± 2	810 ± 80	440 ± 40	3.8 ± 1	<0.9	14 ± 2	25 ± 2	120 ± 14	34 ± 3	850 ± 90	59 ± 3
3SE	7 ± 4	26 ± 3	860 ± 90	420 ± 40	12 ± 2	<0.9	8 ± 2	<0.6	110 ± 12	2.0 ± 0.2	950 ± 100	58 ± 3
1S	29 ± 4	25 ± 2	2200 ± 220	540 ± 50	8.7 ± 1	0.5 ± 0.1	28 ± 2	94 ± 9	120 ± 15	22 ± 2	2100 ± 240	62 ± 3
2S	16 ± 4	22 ± 2	760 ± 80	400 ± 40	34 ± 1	4.0 ± 0.4	19 ± 2	23 ± 2	110 ± 12	<0.6	810 ± 140	56 ± 2
3S	22 ± 4	22 ± 2	1700 ± 170	460 ± 50	13 ± 2	12 ± 1	11 ± 2	5.0 ± 0.5	100 ± 15	56 ± 6	4000 ± 920	60 ± 3
1SW	18 ± 4	24 ± 2	3400 ± 340	460 ± 50	1.6 ± 1	<0.9	19 ± 2	0.3 ± 0.1	120 ± 15	8.0 ± 0.8	4200 ± 430	49 ± 3
2SW	20 ± 4	27 ± 3	3000 ± 300	520 ± 50	7.5 ± 1	6.0 ± 0.6	20 ± 2	<0.6	120 ± 14	9.0 ± 0.9	3100 ± 340	51 ± 3
3SW	29 ± 4	28 ± 3	2800 ± 280	330 ± 30	10 ± 2	<0.9	24 ± 2	2.0 ± 0.2	110 ± 14	13 ± 1	1400 ± 190	56 ± 3
1W	17 ± 4	22 ± 2	3300 ± 330	690 ± 70	16 ± 2	8.0 ± 0.8	25 ± 2	4.0 ± 0.4	120 ± 15	10 ± 1	4200 ± 250	48 ± 2
2W	22 ± 4	25 ± 3	3600 ± 360	670 ± 70	11 ± 2	6.0 ± 0.6	24 ± 2	10 ± 1	150 ± 20	10 ± 1	3800 ± 400	46 ± 2
3W	16 ± 4	20 ± 2	3000 ± 300	540 ± 50	9.5 ± 1	22 ± 2	25 ± 2	4.0 ± 0.4	120 ± 15	10 ± 1	3600 ± 220	39 ± 2
4W	23 ± 4	26 ± 3	3900 ± 390	650 ± 60	16 ± 2	5.0 ± 0.5	25 ± 2	2.0 ± 0.2	110 ± 14	2.0 ± 0.2	3900 ± 410	45 ± 2
5W	21 ± 4	24 ± 2	3900 ± 370	600 ± 60	14 ± 2	26 ± 2	23 ± 2	<0.6	120 ± 14	12 ± 1	4200 ± 240	41 ± 2
6W	10 ± 4	21 ± 2	3300 ± 330	530 ± 50	12 ± 2	8.0 ± 0.8	25 ± 2	<0.6	100 ± 14	7.0 ± 0.7	4300 ± 460	42 ± 2
7W	18 ± 4	23 ± 2	2700 ± 270	570 ± 60	12 ± 2	6.0 ± 0.6	23 ± 2	<0.6	120 ± 14	7.0 ± 0.7	4500 ± 260	38 ± 2
1NW	31 ± 4	23 ± 2	3400 ± 340	660 ± 70	16 ± 2	2.0 ± 0.2	98 ± 9	8.0 ± 0.8	110 ± 13	12 ± 1	4300 ± 440	47 ± 2
2NW	20 ± 4	22 ± 2	3300 ± 330	640 ± 60	14 ± 2	4.0 ± 0.4	24 ± 2	<0.6	130 ± 16	9.0 ± 0.9	4400 ± 460	39 ± 2
3NW	18 ± 4	24 ± 2	1100 ± 110	330 ± 30	4.5 ± 1	2.0 ± 0.2	22 ± 2	<0.6	100 ± 12	3.0 ± 0.3	940 ± 160	48 ± 2
4NW	20 ± 4	28 ± 3	950 ± 100	360 ± 40	3.6 ± 1	2.0 ± 0.2	16 ± 2	2.0 ± 0.2	130 ± 15	4.0 ± 0.4	940 ± 150	56 ± 3
5NW	7 ± 4	39 ± 4	1200 ± 120	600 ± 60	4.8 ± 1	<0.9	22 ± 2	<0.6	160 ± 17	2.0 ± 0.2	1200 ± 160	110 ± 5
6NW	15 ± 4	23 ± 2	1100 ± 110	370 ± 40	3.7 ± 1	1.0 ± 0.1	23 ± 2	0.1 ± 0.1	110 ± 13	3.0 ± 0.3	1100 ± 170	52 ± 3

[a]Insufficient sample for analysis where no data are reported. Uncertainties represent analytical uncertainties.

TABLE A-II. Grass: Elemental Concentrations[a]

Location	Al (ppm)	As (ppm)	B (ppm)	Ba (ppm)	Be (ppb)	Br (ppm)	Cd (ppm)	Cl (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)
1N	1300 ± 380	<0.08	<10			160 ± 20		2700 ± 400	5.0 ± 0.5		1.6 ± 0.2
2N	1500 ± 460	0.17 ± 0.05	22 ± 5			130 ± 10		1700 ± 260	4.3 ± 0.4		2.6 ± 0.3
3N	230 ± 70	0.06 ± 0.02	7 ± 5			16 ± 2	<0.2	1500 ± 220	3.1 ± 0.3		2.4 ± 0.2
4N	4400 ± 1300	<0.03	6 ± 5	44 ± 10	21 ± 2	31 ± 3	<0.2	2400 ± 360	4.0 ± 0.4	3.3 ± 0.3	2.2 ± 0.2
5N	320 ± 100	0.32 ± 0.06	14 ± 5	90 ± 20	11 ± 2	20 ± 2		2000 ± 300	3.7 ± 0.4	4.4 ± 0.4	1.3 ± 0.1
1NE	720 ± 220	0.57 ± 0.10	<5			110 ± 10		2400 ± 360	7.5 ± 0.8		0.8 ± 0.1
2NE	460 ± 140	0.25 ± 0.06	8 ± 5			32 ± 3		1500 ± 220	13 ± 1.3		0.9 ± 0.1
3NE	260 ± 80	0.55 ± 0.08	23 ± 5			10 ± 1		900 ± 140	9.7 ± 1.0		0.7 ± 0.1
4NE	280 ± 90	0.23 ± 0.05	<5			11 ± 1	0.07 ± 0.01	1500 ± 230	6.1 ± 0.6		0.6 ± 0.1
5NE	220 ± 70	0.51 ± 0.07	9 ± 5			10 ± 1		2600 ± 380	6.5 ± 0.7		0.6 ± 0.1
6NE	300 ± 90	0.53 ± 0.08	8 ± 5			13 ± 1		1500 ± 230	4.3 ± 0.4		0.7 ± 0.1
1E	1300 ± 380	0.17 ± 0.06	<5			51 ± 5		1400 ± 210	3.9 ± 0.4		0.9 ± 0.1
2E	310 ± 90	0.08 ± 0.05	<5			34 ± 3		960 ± 140	2.1 ± 0.2		1.5 ± 0.1
3E	2000 ± 610	0.15 ± 0.07	13 ± 5			29 ± 3	<0.2	2100 ± 310	9.6 ± 1.0		1.6 ± 0.2
4E	240 ± 70	0.50 ± 0.07	11 ± 5	50 ± 10	4 ± 2	12 ± 1		980 ± 150	2.1 ± 0.2	5.0 ± 0.5	1.1 ± 0.1
5E	290 ± 90	0.19 ± 0.07	<5			50 ± 5		2700 ± 400	2.5 ± 0.3		0.8 ± 0.1
6E	150 ± 50	0.31 ± 0.05	10 ± 5			6.2 ± 0.6	<0.2	1300 ± 190	1.6 ± 0.2		0.8 ± 0.1
7E	250 ± 80	0.61 ± 0.08	10 ± 5	42 ± 10	6 ± 2	13 ± 1	<0.2	1400 ± 220	3.5 ± 0.4	5.0 ± 0.5	1.0 ± 0.1
1SE	330 ± 100	0.33 ± 0.06	8 ± 5	13 ± 10	17 ± 2	12 ± 1	<0.2	1500 ± 220	3.3 ± 0.3	6.6 ± 0.7	0.9 ± 0.1
2SE	260 ± 80	0.24 ± 0.04	9 ± 5	86 ± 20	8 ± 2	2.7 ± 0.3	<0.2	400 ± 60	3.1 ± 0.3	4.8 ± 0.5	1.0 ± 0.1
3SE	240 ± 70	0.32 ± 0.06	14 ± 5	90 ± 20	8 ± 2	33 ± 3	<0.2	2100 ± 320	7.6 ± 0.8	14 ± 1.4	0.9 ± 0.1
1S	290 ± 90	0.19 ± 0.04	12 ± 5			13 ± 1		1100 ± 160	3.9 ± 0.4		0.6 ± 0.1
2S	250 ± 70	0.27 ± 0.04	10 ± 5			25 ± 2		1600 ± 240	3.5 ± 0.4		0.7 ± 0.1
3S	240 ± 70	0.39 ± 0.06	<5	90 ± 20	<3	15 ± 2	<0.3	6000 ± 890	13 ± 1.3	6.9 ± 0.7	0.7 ± 0.1
1SW	460 ± 140	0.31 ± 0.05	21 ± 5	22 ± 10	6 ± 2	3.9 ± 0.4	<0.2	340 ± 50	3.9 ± 0.4	9.2 ± 0.9	1.2 ± 0.1
2SW	250 ± 70	0.29 ± 0.05	9 ± 5	45 ± 10	6 ± 2	19 ± 2	<0.2	1300 ± 200	3.5 ± 0.4	7.6 ± 0.8	0.7 ± 0.1
3SW	240 ± 70	0.31 ± 0.07	<5	150 ± 30	5 ± 2	23 ± 2	<0.2	5600 ± 850	13 ± 1.3	3.9 ± 0.4	0.6 ± 0.1
1W	1500 ± 460	0.81 ± 0.12	34 ± 5			77 ± 8		1600 ± 250	6.9 ± 0.7		3.4 ± 0.3
2W	600 ± 180	0.37 ± 0.11	<5	100 ± 20	10 ± 2	98 ± 10	<0.5	1900 ± 280	4.1 ± 0.4	3.4 ± 0.3	1.3 ± 0.1
3W	1100 ± 340	0.72 ± 0.13	12 ± 5	44 ± 10	10 ± 2	150 ± 15	<0.2	4200 ± 630	5.9 ± 0.6	6.8 ± 0.7	1.2 ± 0.1
4W	810 ± 240	0.48 ± 0.10	26 ± 5			69 ± 7		940 ± 140	3.2 ± 0.3	9.7 ± 1.0	1.6 ± 0.2
5W		0.96 ± 0.14	12 ± 5			91 ± 9		2300 ± 340	13 ± 1.3	11 ± 1.1	1.5 ± 0.1
6W	1200 ± 350	0.59 ± 0.10	29 ± 5	200 ± 40	42 ± 4	72 ± 7	<0.2	2400 ± 370	2.1 ± 0.2	7.6 ± 0.8	1.0 ± 0.1
7W	710 ± 210	0.20 ± 0.06	11 ± 5	32 ± 10	16 ± 2	37 ± 4	<0.2	2000 ± 300	5.1 ± 0.5		0.8 ± 0.1
1NW	880 ± 260	0.29 ± 0.08	7 ± 5			47 ± 5		1900 ± 280	5.2 ± 0.5		1.1 ± 0.1
2NW	540 ± 160	0.62 ± 0.11	17 ± 5			24 ± 2		410 ± 60	6.3 ± 0.6		1.1 ± 0.1
3NW	190 ± 60	0.13 ± 0.04	11 ± 5			5.9 ± 0.6		1800 ± 270	8.1 ± 0.8		0.6 ± 0.1
4NW	390 ± 120	0.22 ± 0.04	<5			15 ± 2		970 ± 150	4.3 ± 0.4		0.9 ± 0.1
5NW	220 ± 70	0.25 ± 0.05	<5			17 ± 2		2300 ± 350	6.3 ± 0.6		0.7 ± 0.1
6NW	150 ± 50	0.32 ± 0.05	9 ± 5			19 ± 2		1900 ± 290	2.8 ± 0.3		0.7 ± 0.1

TABLE A-II (Continued)

Location	Fe (ppm)	Li (ppm)	Mg (ppm)	Mn (ppm)	Ni (ppm)	NO_3 (ppm)	Pb (ppm)	PO_4 (ppm)	Rb (ppm)	SO_4 (ppm)	Ti (ppm)	Zn (ppm)
1N	490 ± 100			52 ± 11		110 ± 10		2500 ± 250	4.4 ± 1.2	360 ± 40		
2N	540 ± 100			45 ± 10		810 ± 80		1400 ± 140	4.9 ± 1.2	450 ± 50		
3N	90 ± 20			28 ± 6		4.0 ± 0.4		2000 ± 200	5.3 ± 1.2	990 ± 100		
4N	810 ± 160	0.20 ± 0.10	1300 ± 130	52 ± 11	18 ± 2	1300 ±130	3.0 ± 1.0	2000 ± 200	18 ± 1.2	270 ± 30	21 ± 3	9.4 ± 0.9
5N	130 ± 30	<0.20	1200 ± 120	17 ± 5	7.0 ± 1.0	450 ± 50	2.0 ± 1.0	1100 ± 110	7.1 ± 1.2	570 ± 60	16 ± 3	21 ± 2
1NE	300 ± 60			39 ± 8		200 ± 20		2600 ± 260	11 ± 1.2	920 ± 90		
2NE	270 ± 50			33 ± 7		93 ± 9		2100 ± 210	2.2 ± 1.2	1300 ± 130		
3NE	240 ± 50			73 ± 15		<0.9		2000 ± 200	4.3 ± 1.2	520 ± 50		
4NE	140 ± 30			32 ± 7		190 ± 20		2000 ± 200	6.4 ± 1.2	540 ± 50		
5NE	100 ± 20			35 ± 7		300 ± 30		2000 ± 200	9.5 ± 1.2	470 ± 50		
6NE	100 ± 20			57 ± 12		200 ± 20		1300 ± 130	2.6 ± 1.2	740 ± 70		
1E	460 ± 90			36 ± 8		200 ± 20		1600 ± 160	5.4 ± 1.2	320 ± 30		
2E	110 ± 20			24 ± 5		100 ± 10		1900 ± 190	<1.2	610 ± 60		
3E	230 ± 40			17 ± 4		600 ± 60		1500 ± 150	5.5 ± 1.2	1100 ± 110		
4E	110 ± 20	<0.20	1100 ± 110	23 ± 5	35 ± 4	150 ± 20	<3.0	1100 ± 110	3.6 ± 1.2	820 ± 80	16 ± 3	14 ± 1
5E	110 ± 20			24 ± 5		410 ± 40		700 ± 70	11 ± 1.2	230 ± 20		
6E	60 ± 10			31 ± 6		250 ± 30		2000 ± 200	4.2 ± 1.2	990 ± 100		
7E	90 ± 20	<0.20	1200 ± 120	31 ± 6	15 ± 2	60 ± 6	1.0 ± 1.0	820 ± 80	2.7 ± 1.2	1200 ± 120	12 ± 3	16 ± 2
1SE	150 ± 30	0.50 ± 0.05	820 ± 80	26 ± 5	28 ± 3	270 ± 30	1.0 ± 1.0	1900 ± 190	2.2 ± 1.2	1500 ± 150	29 ± 3	12 ± 1
2SE	170 ± 30	0.37 ± 0.04	1100 ± 110	79 ± 16	20 ± 3	260 ± 30	1.0 ± 1.0	1100 ± 110	2.6 ± 1.2	270 ± 30	25 ± 3	22 ± 2
3SE	150 ± 30	0.20 ± 0.10	1500 ± 150	32 ± 7	29 ± 3	<0.9	1.0 ± 1.0	1100 ± 110	8.8 ± 1.2	320 ± 30	17 ± 3	24 ± 2
1S	130 ± 20			25 ± 5		100 ± 10		1700 ± 170	4.4 ± 1.2	840 ± 80		
2S	70 ± 20			30 ± 6		100 ± 10		2300 ± 230	3.8 ± 1.2	950 ± 90		
3S	200 ± 40	<0.20	1500 ± 150	64 ± 13	32 ± 4	660 ± 70	<3.0	2000 ± 200	2.3 ± 1.2	130 ± 10	16 ± 3	39 ± 4
1SW	160 ± 30	0.71 ± 0.07	1100 ± 110	180 ± 35	22 ± 3	600 ± 60	1.0 ± 1.0	760 ± 80	<1.2	290 ± 30	22 ± 3	16 ± 2
2SW	150 ± 30	0.35 ± 0.04	980 ± 100	61 ± 12	28 ± 3	<0.9	<3.0	1400 ± 140	2.1 ± 1.2	1100 ± 110	24 ± 3	19 ± 2
3SW	150 ± 30	<0.20	1300 ± 130	60 ± 12	20 ± 3	180 ± 20	<1.0	4700 ± 470	7.0 ± 1.2	590 ± 60	36 ± 3	52 ± 5
1W	720 ± 140			87 ± 18		1200 ±120		4100 ± 410	8.0 ± 1.2	1200 ± 120		
2W	270 ± 50	0.27 ± 0.10	610 ± 60	38 ± 8	24 ± 3	110 ± 10	<3.0	1900 ± 190	5.0 ± 1.2	880 ± 90	88 ± 8	14 ± 1
3W	610 ± 120	0.75 ± 0.08	1100 ± 110	54 ± 11	25 ± 3	690 ± 70	3.0 ± 1.0	3100 ± 310	7.0 ± 1.2	970 ± 100	56 ± 5	23 ± 2
4W	350 ± 70	0.45 ± 0.05	1000 ± 100	59 ± 12		1100 ±110	4.0 ± 1.0	3200 ± 320	2.6 ± 1.2	450 ± 50		
5W	580 ± 120			41 ± 9		200 ± 20		1800 ± 180	4.8 ± 1.2	750 ± 80		
6W	470 ± 90	0.34 ± 0.03	1500 ± 150	52 ± 11	34 ± 4	1100 ±110	1.0 ± 1.0	2400 ± 240	6.9 ± 1.2	740 ± 70	250 ± 25	22 ± 2
7W	430 ± 80	0.28 ± 0.03	1700 ± 170	74 ± 15	55 ± 6	310 ± 30	1.0 ± 1.0	1600 ± 160	5.0 ± 1.2	1100 ± 110	64 ± 6	15 ± 2
1NW	380 ± 70			38 ± 8		240 ± 20		2100 ± 210	3.5 ± 1.2	810 ± 80		
2NW	270 ± 50			170 ± 33		140 ± 10		910 ± 90	<1.2	880 ± 90		
3NW	130 ± 30			26 ± 6		1200 ±120		1900 ± 190	8.1 ± 1.2	280 ± 30		
4NW	170 ± 30			26 ± 6		290 ± 30		1300 ± 130	4.3 ± 1.2	120 ± 10		
5NW	160 ± 30			31 ± 7		960 ±100		2000 ± 200	6.3 ± 1.2	170 ± 20		
6NW	80 ± 20			13 ± 3		380 ± 40		980 ± 100	2.8 ± 1.2	850 ± 90		

[a]Insufficient sample for analysis where no data are reported. Uncertainties represent analytical uncertainties.

TABLE A-III. Juniper: Elemental Concentrations[a]

Location	Al (ppm)	As (ppm)	B (ppm)	Ba (ppm)	Be (ppb)	Br (ppm)	Cd (ppm)	Cl (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)
1N	300 ± 90	0.17 ± 0.05	28 ± 5			26 ± 3		790 ± 120	3.7 ± 0.4		0.40 ± 0.04
5N	560 ± 160	0.08 ± 0.02	17 ± 5			9.5 ± 1.0	0.13 ± 0.01	780 ± 120	4.7 ± 0.5		0.30 ± 0.03
1NE	400 ± 120	0.10 ± 0.03	16 ± 5			33 ± 3		1200 ± 180	4.0 ± 0.4		0.40 ± 0.04
2NE	270 ± 80	0.05 ± 0.02	22 ± 5			5.5 ± 0.5		1100 ± 170	5.9 ± 0.6		0.30 ± 0.03
3NE	250 ± 70	0.06 ± 0.02	27 ± 5			6.3 ± 0.6	0.11 ± 0.02	1200 ± 180	3.0 ± 0.3		0.10 ± 0.01
1E	260 ± 80	0.10 ± 0.04	23 ± 5			38 ± 4	0.10 ± 0.02	1300 ± 200	2.0 ± 0.2		0.10 ± 0.01
2E	240 ± 70	0.06 ± 0.03	24 ± 5	22 ± 10	12 ± 2	42 ± 5	<0.20	920 ± 140	2.9 ± 0.3	4.7 ± 0.5	0.30 ± 0.03
3E	200 ± 60	0.06 ± 0.02	18 ± 5			7.6 ± 0.8	0.20 ± 0.02	460 ± 70	2.9 ± 0.3		0.10 ± 0.01
4E	140 ± 40	<0.02	16 ± 5			3.7 ± 0.4		350 ± 50	5.0 ± 0.5		0.10 ± 0.01
5E	150 ± 50	0.04 ± 0.02	15 ± 5			4.3 ± 0.4	0.22 ± 0.02	540 ± 80	3.5 ± 0.4		0.10 ± 0.01
7E	280 ± 80	0.15 ± 0.02	16 ± 5	52 ± 20	27 ± 2	3.8 ± 0.4	<0.20	480 ± 70	1.6 ± 0.2	3.6 ± 0.4	0.10 ± 0.01
1SE	480 ± 150	0.15 ± 0.04	17 ± 5	290 ± 50	29 ± 3	5.7 ± 0.6	<1.0	460 ± 70	1.5 ± 0.2	4.0 ± 2.0	0.20 ± 0.02
1S	250 ± 70	0.08 ± 0.02	21 ± 5			3.2 ± 0.3	0.10 ± 0.01	800 ± 120	5.9 ± 0.6		0.20 ± 0.02
1SW	330 ± 100	0.06 ± 0.02	23 ± 5	31 ± 10	14 ± 4	3.6 ± 0.4	0.10 ± 0.10	710 ± 110	1.7 ± 0.2	3.5 ± 0.4	0.10 ± 0.01
1W	310 ± 90	0.14 ± 0.04	22 ± 5			34 ± 3	0.13 ± 0.01	990 ± 150	2.9 ± 0.3		0.60 ± 0.06
2W	250 ± 70	<0.03	34 ± 5	28 ± 10	11 ± 2	30 ± 3	0.25 ± 0.10	1100 ± 170	2.5 ± 0.3	5.9 ± 0.6	0.40 ± 0.04
3W	520 ± 220	0.08 ± 0.03	27 ± 5	180 ± 40	12 ± 2	27 ± 3	<0.30	830 ± 120	4.0 ± 0.4	9.4 ± 0.9	0.30 ± 0.03
4W	460 ± 140	<0.03	50 ± 5	83 ± 20	24 ± 2	51 ± 5	0.10 ± 0.10	1400 ± 210	4.6 ± 0.5	7.7 ± 0.8	0.30 ± 0.03
6W	960 ± 290	0.06 ± 0.04	29 ± 5	220 ± 40	22 ± 2	65 ± 7	<0.70	2000 ± 290	4.7 ± 0.5	10 ± 1.0	0.40 ± 0.04
7W	430 ± 130	0.06 ± 0.02	22 ± 5	44 ± 10	14 ± 2	18 ± 2	<0.20	780 ± 120	1.9 ± 0.2	4.7 ± 0.5	0.30 ± 0.03
1NW	300 ± 90	0.08 ± 0.04	21 ± 5			32 ± 3		970 ± 150	4.1 ± 0.4		0.10 ± 0.01

TABLE A-III (Continued)

Location	Fe (ppm)	Li (ppm)	Mg (ppm)	Mn (ppm)	Ni (ppm)	NO_3 (ppm)	Pb (ppm)	PO_4 (ppm)	Rb (ppm)	SO_4 (ppm)	Ti (ppm)	Zn (ppm)
1N	140 ± 30			55 ± 11		<0.9		2400 ± 240	1.9 ± 1.2	610 ± 60		
5N	200 ± 40			37 ± 8		43 ± 4		1100 ± 110	3.0 ± 1.2	180 ± 20		
1NE	180 ± 40			38 ± 8		98 ± 10		4300 ± 430	6.9 ± 1.2	830 ± 80		
2NE	140 ± 30			57 ± 11		110 ± 10		3800 ± 380	2.4 ± 1.2	790 ± 80		
3NE	170 ± 30			58 ± 12		<0.9		1400 ± 140	2.9 ± 1.2	440 ± 40		
1E	90 ± 20			44 ± 9		88 ± 9		3400 ± 340	3.4 ± 1.2	520 ± 50		
2E	60 ± 10	<0.20	2500 ± 250	56 ± 11	9.0 ± 1.0	130 ± 10	<3.0	3200 ± 320	1.9 ± 1.2	350 ± 40	30 ± 3	20 ± 2
3E	80 ± 20			38 ± 8		90 ± 9		1500 ± 150	2.1 ± 1.2	280 ± 30		
4E	70 ± 20			26 ± 5		88 ± 9		1600 ± 160	5.0 ± 1.2	220 ± 20		
5E	80 ± 20			37 ± 8		97 ± 10		1200 ± 120	2.0 ± 1.2	280 ± 30		
7E	110 ± 20	0.24 ± 0.10	1700 ± 170	43 ± 9	3.0 ± 1.0	150 ± 20	3.0 ± 1.0	1600 ± 160	1.8 ± 1.2	530 ± 50	41 ± 5	19 ± 2
1SE	180 ± 40	<1.0	1700 ± 170	30 ± 6	2.0 ± 1.0	130 ± 10	4.0 ± 2.0	1200 ± 120	<1.2	170 ± 20	150 ± 20	9.2 ± 0.9
1S	140 ± 30			53 ± 11		55 ± 5		1900 ± 190	2.6 ± 1.2	340 ± 30		
1SW	110 ± 20	<0.20	2300 ± 230	46 ± 9	2.0 ± 1.0	71 ± 7	<3.0	1600 ± 160	1.9 ± 1.2	240 ± 20	23 ± 6	24 ± 2
1W	160 ± 30			54 ± 11		240 ± 20		2200 ± 220	<1.2	370 ± 40		
2W	140 ± 30	0.20 ± 0.10	2500 ± 250	62 ± 13	11.0 ± 2.0	120 ± 10	<3.0	2100 ± 210	2.5 ± 1.2	820 ± 80	16 ± 3	21 ± 5
3W	190 ± 40	0.30 ± 0.10	3000 ± 300	51 ± 10	4.3 ± 0.5	110 ± 10	1.0 ± 1.0	3100 ± 310	3.5 ± 1.2	560 ± 60	65 ± 6	20 ± 2
4W	240 ± 40	0.35 ± 0.04	2600 ± 260	58 ± 12	1.9 ± 0.5	110 ± 10	2.0 ± 1.0	3400 ± 340	4.7 ± 1.2	520 ± 50	48 ± 3	27 ± 3
6W	500 ± 100	0.44 ± 0.04	3600 ± 360	55 ± 11	9.8 ± 1.0	110 ± 10	<3.0	3400 ± 340	4.1 ± 1.2	600 ± 60	150 ± 15	27 ± 3
7W	170 ± 40	0.41 ± 0.04	2000 ± 200	44 ± 9	4.1 ± 0.5	110 ± 10	<3.0	2400 ± 240	1.1 ± 1.2	720 ± 70	78 ± 8	19 ± 2
1NW	160 ± 30			56 ± 11		90 ± 9		2400 ± 240	4.3 ± 1.2	590 ± 60		

[a]Insufficient sample for analysis where no data are reported. Uncertainties represent analytical uncertainties.

TABLE A-IV. Piñon: Elemental Concentrations[a]

Location	Al (ppm)	As (ppm)	B (ppm)	Ba (ppm)	Be (ppb)	Br (ppm)	Cd (ppm)	Cl (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)
2N	140 ± 40	<0.03	18 ± 5			19 ± 2		320 ± 50	2.9 ± 0.3		0.40 ± 0.04
3N	190 ± 60	0.09 ± 0.03	14 ± 5			7.9 ± 0.8		230 ± 30	3.6 ± 0.4		0.30 ± 0.03
4N	130 ± 40	0.18 ± 0.04	22 ± 5			5.0 ± 0.5	0.10 ± 0.01	420 ± 60	3.1 ± 0.3		0.30 ± 0.03
4NE	220 ± 70	0.15 ± 0.03	22 ± 5			15 ± 2		280 ± 40	4.2 ± 0.4		0.10 ± 0.01
5NE	140 ± 40	0.10 ± 0.02	21 ± 5			5.1 ± 0.5		470 ± 70	2.8 ± 0.3		0.10 ± 0.01
6NE	180 ± 60	0.11 ± 0.03	11 ± 5			9.9 ± 1		330 ± 50	2.3 ± 0.2		0.10 ± 0.01
6E	140 ± 40	0.15 ± 0.02	25 ± 5	27 ±10	18 ± 2	6.0 ± 0.6	<0.30	400 ± 60	1.4 ± 0.1	2.2 ± 0.2	0.10 ± 0.01
2SE	250 ± 70	0.20 ± 0.03	17 ± 5			5.1 ± 0.5	0.10 ± 0.02	260 ± 40	1.9 ± 0.2	7.0 ± 3.0	0.20 ± 0.02
3SE	310 ± 90	0.17 ± 0.03	28 ± 5	28 ±10	13 ± 2	8.3 ± 0.8	0.20 ± 0.01	370 ± 60	3.6 ± 0.4	2.5 ± 0.3	0.10 ± 0.01
2S	230 ± 70	0.08 ± 0.02	19 ± 5	17 ±10	8 ± 2	1.7 ± 0.2	<0.20	440 ± 70	1.0 ± 0.1		0.10 ± 0.01
3S	290 ± 90	0.30 ± 0.04	18 ± 5			7.3 ± 0.7	<0.50	230 ± 40	1.8 ± 0.2	4.0 ± 1.0	0.20 ± 0.02
3SW	220 ± 70	0.21 ± 0.03	46 ± 5			9.4 ± 0.9		4000 ± 600	4.1 ± 0.4		0.20 ± 0.02
5W	280 ± 80	0.19 ± 0.04	23 ± 5			55 ± 6	0.05 ± 0.01	710 ± 110	2.1 ± 0.2		0.70 ± 0.07
2NW	100 ± 30	0.18 ± 0.05	17 ± 5			41 ± 4		460 ± 70	6.8 ± 0.7		0.10 ± 0.01
3NW	290 ± 90	0.15 ± 0.03	17 ± 5			9.7 ± 1		390 ± 60	5.2 ± 0.5		0.10 ± 0.01
4NW	200 ± 60	0.14 ± 0.04	23 ± 5	<100	24 ± 4	29 ± 3	<8.0	450 ± 70	3.3 ± 0.3	<15	0.10 ± 0.01
5NW	230 ± 70	0.08 ± 0.02	25 ± 5			3.0 ± 0.3		250 ± 40	4.8 ± 0.5		0.20 ± 0.02
6NW	120 ± 40	0.09 ± 0.02	23 ± 5			3.6 ± 0.4		330 ± 50	2.7 ± 0.3		0.10 ± 0.01

TABLE A-IV (Continued)

Location	Fe (ppm)	Li (ppm)	Mg (ppm)	Mn (ppm)	Ni (ppm)	NO_3 (ppm)	Pb (ppm)	PO_4 (ppm)	Rb (ppm)	SO_4 (ppm)	Ti (ppm)	Zn (ppm)
2N	72 ± 20			74 ± 15		<0.9		<0.6	4.8 ± 1.2	19 ± 2		
3N	110 ± 20			190 ± 39		8 ± 1		1600 ± 160	4.9 ± 1.2	1000 ± 100		
4N	53 ± 10			100 ± 18		<0.9		2400 ± 240	9.8 ± 1.2	730 ± 70		
4NE	95 ± 20			500 ± 100		<0.9		820 ± 80	2.7 ± 1.2	1300 ± 130		
5NE	40 ± 10			220 ± 44		<0.9		2000 ± 20	3.8 ± 1.2	770 ± 80		
6NE	47 ± 10			150 ± 31		100 ± 10		800 ± 80	1.6 ± 1.2	470 ± 50		
6E	40 ± 10	5.3 ± 0.5	2000 ± 200	86 ± 17	2.2 ± 0.5	<0.9	1.0 ± 1.0	2200 ± 220	5.3 ± 1.2	840 ± 80	13 ± 3	39 ± 4
2SE	99 ± 20	7.0 ± 2.0	1200 ± 120	130 ± 25		<0.9	<20	1400 ± 140	4.0 ± 1.2	610 ± 60		
3SE	130 ± 30	1.1 ± 0.1	1800 ± 180	190 ± 38	3.5 ± 0.5	50 ± 5	1.0 ± 1.0	890 ± 90	1.8 ± 1.2	960 ± 100	11 ± 3	23 ± 2
2S	70 ± 20	2.7 ± 0.3	1700 ± 170	150 ± 31	4.1 ± 0.5	<0.9		3100 ± 310	6.7 ± 1.2	650 ± 70	13 ± 3	39 ± 4
3S	150 ± 30	0.7 ± 0.5	1600 ± 160	120 ± 24		62 ± 6	<3.0	1100 ± 110	<1.2	550 ± 60		28 ± 3
3SW	120 ± 20			76 ± 15		130 ± 10		1300 ± 130	<1.2	420 ± 40		4.0 ± 0.4
5W	130 ± 30			58 ± 12		110 ± 10		2500 ± 250	3.3 ± 1.2	360 ± 40		
2NW	94 ± 20			77 ± 15		92 ± 9		3200 ± 320	3.3 ± 1.2	130 ± 10		
3NW	89 ± 20			340 ± 70		120 ± 10		1100 ± 110	1.5 ± 1.2	1100 ± 110		
4NW	60 ± 10	<8.0	3100 ± 310	540 ± 110	12 ± 10	100 ± 10	<99	1600 ± 160	4.6 ± 1.2	630 ± 60	340 ± 100	69 ± 7
5NW	86 ± 20			460 ± 90		<0.9		2400 ± 240	6.8 ± 1.2	1700 ± 170		
6NW	79 ± 20			61 ± 12		<0.9		1400 ± 140	5.8 ± 1.2	460 ± 50		

[a]Insufficient sample for analysis where no data are reported. Uncertainties represent analytical uncertainties.

TABLE A-V. Oak: Elemental Concentrations[a]

Location	Al (ppm)	As (ppm)	B (ppm)	Ba (ppm)	Be (ppb)	Br (ppm)	Cd (ppm)	Cl (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)
2N	860 ±260	0.44 ± 0.07	81 ± 8			12 ± 1		65 ± 10	3.5 ± 0.4		0.60 ± 0.06
2NE	300 ± 90	0.07 ± 0.03	62 ± 6			3.1 ± 0.3		200 ± 30	2.9 ± 0.3		0.20 ± 0.02
2E	760 ±230	0.16 ± 0.04	69 ± 7			16 ± 2	0.34 ± 0.03	230 ± 30	2.4 ± 0.2		0.20 ± 0.02
1SE	370 ±110	0.20 ± 0.03	48 ± 5	25 ±10	18 ± 2	5.3 ± 0.5	<0.20	260 ± 40	2.2 ± 0.2	5.5 ± 0.6	0.10 ± 0.01
2SE	650 ±200	0.13 ± 0.03	63 ± 6	18 ±10	29 ± 3	3.4 ± 0.4	<0.20	360 ± 50	1.9 ± 0.2	7.3 ± 0.7	0.20 ± 0.02
1S	350 ±110	0.10 ± 0.04	66 ± 7			5.3 ± 0.5		280 ± 40	6.5 ± 0.7		0.20 ± 0.02
2S	580 ±180	0.14 ± 0.04	79 ± 8	73 ±20	90 ± 9	5.3 ± 0.5	<0.20	280 ± 40	3.3 ± 0.3	8.1 ± 0.8	0.40 ± 0.04
1SW	470 ±140	0.12 ± 0.04	48 ± 5			5.4 ± 0.5		380 ± 60	6.9 ± 0.7		0.20 ± 0.02
2SW	210 ± 60	0.14 ± 0.03	49 ± 5			2.2 ± 0.2		240 ± 40	6.4 ± 0.6		0.20 ± 0.02

Location	Fe (ppm)	Li (ppm)	Mg (ppm)	Mn (ppm)	Ni (ppm)	NO_3 (ppm)	Pb (ppm)	PO_4 (ppm)	Rb (ppm)	SO_4 (ppm)	Ti (ppm)	Zn (ppm)
2N	350 ± 70			430 ± 86		<0.9		190 ± 20		<0.6		
2NE	190 ± 40			220 ± 43		<0.9		1900 ± 190		230 ± 20		
2E	280 ± 60			390 ± 78		120 ± 10		2800 ± 280		930 ± 90	24 ± 3	18 ± 2
1SE	180 ± 40	0.31 ± 0.03	2300 ± 230	500 ± 100	4.8 ± 0.5	80 ± 10	<3.0	1100 ± 110	18 ± 2	200 ± 20	34 ± 10	26 ± 3
2SE	150 ± 30	7.1 ± 0.7	2400 ± 240	550 ± 110	4.0 ± 1.0	110 ± 10	<3.0	1400 ± 140	26 ± 3	290 ± 30		
1S	140 ± 30			450 ± 90		100 ± 10		1800 ± 180		490 ± 50		
2S	210 ± 40	5.4 ± 0.5	2800 ± 280	590 ± 120	4.4 ± 0.5	130 ± 10	3.0 ± 1	2500 ± 250	5.9 ± 1.2	990 ± 100	30 ± 3	30 ± 3
1SW	240 ± 50			500 ± 100		190 ± 20		1600 ± 160		250 ± 30		
2SW	170 ± 40			870 ± 170		120 ± 10		1600 ± 160		380 ± 40		

[a]Insufficient sample for analysis where no data are reported. Uncertainties represent analytical uncertainties.

APPENDIX C

Proposed Resource Conservation and Recovery Act (RCRA) Subpart S,
***Federal Register*, Volume 55, No. 145**
pp. 30815-20 and 30865-73

many cases contamination from SWMUs will greatly exceed action levels. The Agency believes that the diversity of SWMUs and contamination scenarios calls for some discretion in the requirement to perform statistical analyses. For example, in some situations, contamination from a SWMU may be known to be extensive in size and concentration. In such situations, statistical analyses are not needed to determine that an action level has been exceeded. In other situations, a contaminant release at a SWMU may not be extensive enough (either in size or concentration) to clearly indicate contamination. In these cases, a statistical test may be required to determine if a release has actually occurred in excess of action levels. The Agency requests comment on its proposed approach of providing discretion to the Regional Administrator in requiring statistical analyses, and on the alternative of making such analyses mandatory in determining whether action levels have been exceeded.

The Agency examined but did not propose two alternatives to requiring the Corrective Measure Study which did not involve the use of action levels. Under one approach, the Agency would have required the permittee to conduct a Corrective Measure Study concurrently with the remedial investigations conducted pursuant to § 264.510. Under this option, the Agency would have used the same trigger for requiring a CMS as is used to require an RFI—the finding of an existing or likely release pursuant to an RFA. This alternative was rejected because of its potential for requiring unnecessary studies.

The second alternative considered by the Agency would have required the permittee to conduct a Corrective Measure Study only after completion of the remedial investigation conducted pursuant to proposed § 264.510 and a determination of the need to protect human health and the environment. If the Agency had adopted this approach, it would not have required the permittee to conduct a CMS until all contamination and contaminant sources at the facility were fully characterized and the need for corrective measures at the facility was established. The Agency rejected the alternative because of the delay that would be associated with conducting these phases of the investigations sequentially even in cases where early data indicate that remediation is highly likely to be required.

The Agency also examined alternative approaches for setting action levels. One alternative would have required a Corrective Measure Study whenever background levels of contaminants were exceeded. Experience in the subpart F program has demonstrated that the determination of background levels can be a lengthy, controversial process. Furthermore, background levels will often be much lower than health-based levels. Thus, this alternative was rejected, since it might delay the initiation of the CMS and ultimate cleanup, and might often require Corrective Measure Studies even where levels were significantly below health and environmental-based standards.

A second alternative would have required a CMS whenever detection limits were exceeded. This alternative was also rejected, since detection limits can be difficult to define and do not directly relate to the goal of corrective action; that is, protection of human health and the environment.

The Agency also considered but did not adopt an alternative for requiring the Corrective Measure Study that would involve the use of a range of action levels. Under this approach, the Agency would select constituent-specific action levels within the 1×10^{-4} to 1×10^{-6} risk range based on the exposure scenarios proposed under §§ 264.521 (a)(2), (b), (c)(3), and (d), depending on the likelihood that exposure would in fact occur. For example, if the Agency could be convinced that there is a minimal opportunity for human exposure through one medium or several media, an action level could be established at the 1×10^{-6} risk level. This alternative was considered because the Agency is concerned about the possibility that some SWMUs might be triggered into a CMS at the 1×10^{-6} level even though they do not pose a threat to human health and the environment due to a lack of current and low probability of future exposure. Although it is the Agency's view that the proposed regulations have enough flexibility to avoid requiring a Corrective Measure Study where it is not necessary, the Agency is requesting comment on the use of a range of action levels.

The Agency believes the approach proposed in today's rule provides it with the flexibility to require the permittee to investigate corrective measures sufficiently early (whether simultaneously with the RFI or sequentially) in the corrective action process, while minimizing the potential for unnecessary investigations. Experience in the Superfund program suggests that early consideration of potential remedies allows focused investigations and prevents delays without imposing unnecessary resource burdens on either the permittee or the Agency.

b. *Criteria for Determining Action Levels.* In several cases, EPA has promulgated health-based standards appropriate for action levels for specific media. Where these standards are available, EPA intends to use them as action levels. The most obvious of these are maximum contaminant levels (MCLs), which establish drinking water standards under the Safe Drinking Water Act (SDWA). EPA will use these standards to set action levels for ground water, and, in some cases, for surface water.

In the overwhelming majority of cases, however, promulgated standards will not be available. Nevertheless, health-based levels that have undergone extensive scientific review, but which have not been formally promulgated, are available for many chemicals. The Agency is proposing today in § 264.521(a)(2)(i)–(iv) criteria which enable the Regional Administrator to use such non-promulgated health-based levels to derive action levels.

Concentrations derived from non-promulgated health-based levels that meet the following four criteria included in today's proposal could be used for action levels. First, the concentration must be derived in a manner consistent with principles and procedures set forth in Agency guidelines for assessing the health risks of environmental pollutants, which were published in the Federal Register on September 24, 1986 (51 FR 33992, 34003, 34014, 34028). Second, toxicology studies used to derive action levels must be scientifically valid, conducted in accordance with the Good Laboratory Practice Standards (40 CFR part 792), or equivalent. The Good Laboratory Practice Standards prescribe good laboratory practices for conducting studies related to health effects, environmental effects, and chemical fate testing, and are intended to assure quality data of integrity. The guidelines are for ensuring scientifically valid studies, and also may be useful as guidance. In addition, the Agency guidelines for assessing the health risks of environmental pollutants (cited above) cite several publications which outline procedures for evaluating studies for scientific adequacy and statistical soundness. Third, concentrations used as action levels must (for carcinogens) be associated with a 1×10^{-6} upperbound excess cancer risk for Class A and B carcinogens, and a 1×10^{-5} upperbound excess cancer risk for Class C carcinogens. Finally, for systemic toxicants (referring to toxic chemicals

that cause effects other than cancer or mutations), the action level must be a concentration to which the human population (including sensitive subgroups) could be exposed on a daily basis that is likely to be without appreciable risk of adverse effects during a lifetime. These criteria are similar to those upon which promulgated health-based standards and criteria are based. Action levels derived according to these criteria represent valid, reasonable estimates of levels in media at or below which corrective action is unlikely to be necessary.

As mentioned previously, guidance levels are available for many chemicals. Appendix A of this preamble lists concentrations for selected hazardous constituents in water, soil, and air which the Agency believes meet these four criteria. EPA established these concentrations by an assessment process which evaluated the quality and weight-of-evidence of supporting toxicological, epidemiological, and clinical studies, and which relied on the exposure assumptions in appendix D of this preamble.

The Agency's approach to assessing the risks associated with systemic toxicity is different from that for the risks associated with carcinogenicity. This is because different mechanisms of action are thought to be involved in the two cases. In the case of carcinogens, the Agency assumes that a small number of molecular events can evoke changes in a single cell that can lead to uncontrolled cellular proliferation. This mechanism for carcinogenesis is referred to as "nonthreshold," since there is essentially no level of exposure for such a chemical that does not pose a small, but finite, possibility of generating a carcinogenic response. In the case of systemic toxicity, organic homeostatic, compensating, and adaptive mechanisms exist that must be overcome before the toxic end point is manifested. For example, there could be a large number of cells performing the same or similar function whose population must be significantly depleted before the effect is seen.

The threshold concept is important in the regulatory context. The individual threshold hypothesis holds that a range of exposures from zero to some finite value can be tolerated by the organism with essentially no chance of expression of the toxic effect. Further, it is often prudent to focus on the most sensitive members of the population; therefore, regulatory efforts are generally made to keep exposures below the population threshold, which is defined as the lowest of the thresholds of the individuals within a population.

Thus, for the chemicals on appendix A which cause systemic toxic effects, the Agency has estimated reference doses (RfDs). The RfD is an estimate of the daily exposure an individual (including sensitive individuals) can experience without appreciable risk of health effects during a lifetime, and is consistent with the threshold concept described above.

For the chemicals on appendix A which are believed to cause cancer, the Agency has estimated carcinogenic slope factors (CSFs). Since the Agency assumes that no such threshold exists for carcinogens, the issue to be resolved in health assessments of carcinogens is the probability of the occurrence of an effect. The CSF, or unit cancer risk, is an estimate of the excess lifetime risk due to a continuous constant lifetime exposure from one unit of carcinogenic concentration (*e.g.*, mg/kg/day by ingestion, ug/m^3 by inhalation). Chemicals which cause cancer and mutations also commonly evoke other toxic effects. Thus, an RfD and CSF may both be available for a single chemical. In these cases, the level which is lower (more protective) should be used as an action level. Generally, the protective level for cancer will be lower.

For carcinogens, EPA believes that action levels corresponding to a 1×10^{-6} risk level (or 1×10^{-5} for Class C carcinogens) generally are appropriate. This is at the higher protective end of the 10^{-4} to 10^{-6} risk range. (See discussion in section VI.F.5 of today's preamble.) Using a value from the high end of this range ensures that the hazardous constituents screened out at this point are those for which corrective measures are unlikely to be necessary.

In adopting the 1×10^{-4} to 1×10^{-6} risk range for this proposed rule, the Agency recognized that 1×10^{-4} risk levels of constituents may not be protective at all sites, due to multiple constituents, multiple exposure pathways, or other site-specific factors.

Thus, the alternative of establishing actions levels at the lower protective end of the risk range (*e.g.*, 1×10^{-7}) was rejected since it would be too insensitive a trigger—*i.e.*, it would fail to require a Corrective Measure Study at some sites which may pose a threat to human health and the environment. The Agency believes that the selected risk levels are reasonable points to establish action levels for carcinogens.

Section 264.521(a)(2)(iii) provides some flexibility to the Regional Administrator to consider the overall weight of evidence of carcinogenicity in setting action levels for carcinogens. EPA has explained its classification scheme for carcinogens based on the weight of evidence for carcinogenicity its cancer guidelines (51 FR 33992). The constituent concentrations provided as example action levels in appendix A reflect this approach. In this table, known or probable human carcinogens (known as Class A and Class B carcinogens, respectively, under the Agency guidelines) are listed at a 1×10^{-6} risk level, whereas concentrations listed for constituents for which the weight of evidence of carcinogenicity is weaker (known as Class C, or possible human carcinogens under the Agency's guidelines), correspond to a 1×10^{-5} risk level. Some experts have argued that it is inappropriate to weight Class C carcinogens in this way, and that all substances classified as carcinogens should be weighted equally, whereas others argue that Class C carcinogens should be weighted more heavily (*i.e.*, more stringently) because of the greater uncertainty associated with the limited evidence of their carcinogenicity. The Agency solicits comments on how it should handle Class C carcinogens in setting action levels.

Many of the RfDs and CSFs used to derive the concentrations listed in appendix A are available through the Integrated Risk Information System (IRIS), a computer-housed, electronically communicated catalogue of Agency risk assessment and risk management information for chemical substances. IRIS is designed especially for Federal, State, and local environmental health agencies as a source of the latest information about Agency health assessments and regulatory decisions for specific chemicals. (To establish an IRIS account, call Dialcom at (202) 488-0550.) The risk assessment information (*i.e.*, RfDs and CSFs) contained in IRIS, except as specifically noted, has been reviewed and agreed upon by intra-agency review groups, and represents a Agency consensus. As EPA working groups continue to review and verify risk assessment values, additional chemicals and data components will be added to IRIS. IRIS hardcopy will be available through the National Technical Information Service (NTIS). In addition, EPA will routinely update appendix A as new data on hazardous constituents are developed.

c. *Action Levels for Ground Water.* Proposed § 264.521(a) establishes action levels for ground water in aquifers. By specifying the term "aquifer" in this context, the Agency intends to define broadly the type of ground-water

contamination situations that may require Corrective Measure Studies, while triggering such studies only in situations where actual ground-water cleanup is a reasonable remedial approach.

The Agency considered using the term "uppermost aquifer," but decided that this would limit its flexibility in addressing contamination in lower aquifers that are not hydraulically connected with the uppermost aquifer. Such a situation could arise if waste were leaked from the casing of an underground injection well. Thus, the wording of § 264.521(a) will explicitly allow the Agency to address any such unusual instances where solid waste management units have contaminated ground water that is not in an "uppermost" aquifer as defined in § 264.510.

The Agency also considered not using the term "aquifer" in § 264.521(a). This would have required Corrective Measure Studies for ground water to be performed even when the ground water is of negligible use as a resource, such as a small pocket of soil which becomes saturated only episodically. Although contamination in any saturated zone that could act as a pathway transporting contaminants to aquifers could be a concern, the Agency would intend to address those situations in the context of setting action levels for soils (see § 264.521(d)), including "deep soils" that could act as a ground-water contaminant pathway.

EPA has, under a number of statutes, promulgated standards and criteria relevant to protection of environmental media. Among the most important of these are maximum contaminant levels (MCLs) promulgated under the Safe Drinking Water Act (42 U.S.C. section 300(f) *et seq.*), which have been incorporated into this rule as action levels for ground water under § 264.521(a)(1). MCLs promulgated under the Safe Drinking Water Act are maximum concentrations of contaminants allowed in water used for drinking (see appendix B). The use of MCLs for action levels is consistent with current RCRA ground-water protection standards (40 CFR part 264, subpart F), which set the interim primary drinking water standards (MCLs) for 14 constituents (which existed at the time subpart F regulations were promulgated) as ground-water protection standards in the absence of another Agency decision. Currently there are 34 MCLs promulgated, of which six are microbiological contaminants, three are radionuclides, and 25 are organic and inorganic contaminants; the MCLs for the chemical contaminants are listed in appendix B.

Where MCLs are available for a particular constituent but the ground water at a site is not currently used for a drinking water supply, and is unsuitable for use as a drinking water supply in the future, MCLs will still ordinarily be used as action levels (*i.e.*, to require a CMS); however, cleanup to the MCL might not be required (see section VI.F.5 for discussion of media cleanup standards). The Agency is persuaded that, in cases where ground water is contaminated at levels above action levels, further study is necessary (*e.g.*, to make sure that sources of releases are controlled).

Where MCLs have not been promulgated for hazardous constituents, EPA would develop levels according to the criteria specified in proposed § 264.521(a)(2)(i)–(iv) and described in detail above in this preamble (see section VI.E.2.b). In this analysis, the Agency would use the standard exposure assumptions of two liters a day for a 70 kilogram adult over a 70 year lifetime (see appendix D), assumptions that are used extensively throughout EPA and other agencies. Appendix A lists levels that were developed for water by the Agency according to these principles and which the Agency believes would be appropriate for ground-water action levels. In addition, proposed (but not yet promulgated) MCLs would also typically meet the criteria proposed in § 264.521(a)(2)(i)–(iv) and could serve as ground-water action levels.

Where data are insufficient to develop action levels according to these criteria, the Agency would establish levels according to the procedures in proposed § 264.521(e), which are described in more detail in section VI.E.2.g of this preamble. The Agency solicits comment on the proposed approach and alternative approaches to establishing action levels for ground water.

d. *Action Levels for Air.* Proposed § 264.521(b) identifies criteria for establishing action levels for air, assuming exposure through inhalation of air contaminated with the hazardous constituent. Appendix A lists possible action levels that meet these criteria. The Agency used the following procedures to develop concentrations in air listed in appendix A:

Note: Appendix A action levels are currently taken exclusively from the IRIS data base, and developed using only procedures 1 and 4; this appendix will be modified to include other health-based numbers not currently on IRIS, derived from procedures 2 and 3. This is consistent with current Superfund practices and policy.

1. Where an Agency-verified health-based intake level for inhalation (*e.g.*, RfD) was available, that level was used to calculate the concentration in air.

2. Where an Agency-verified level (as in (1), above) was not available, a level based on a valid inhalation study was used, even if it had not yet gone through the formal intra-Agency verification process.

3. If a level based on an inhalation study (as in (1) or (2) above) was not available, a health-based intake level (*e.g.*, RfD) based on an oral study was used, with a conversion factor of one for route-to-route extrapolation to calculate the concentration in air—except where such an extrapolation factor was determined to be inappropriate. For example, it is not appropriate where a constituent that is a systemic toxicant through the oral route of exposure causes local adverse effects on the lung through the inhalation route. A constituent might also be determined to be an inappropriate candidate for route-to-route extrapolation due to significant differences in metabolism or absorption. Where the extrapolation from oral route to inhalation route of exposure is determined to be inappropriate, and a level based on an inhalation study (as in (1) or (2) above) is not available, appendix A does not list a concentration in air (see section VI.E.2.g for a discussion of how to set action levels where health- and environment-based levels are not available). While the concentrations in air listed in appendix A (and C) are being evaluated further by the Agency with regard to the appropriateness of this route-to-route extrapolation, they will be used only as an interim measure. The Agency will adopt RfDs based on actual inhalation toxicity data as soon as the data become available.

4. The standard exposure assumption for air typically used in Agency risk assessments (i.e., $20m^3$/day for a 70 kilogram adult for a 70 year lifetime) was used (see appendix D).

Under proposed § 264.521(a)(2), action levels would be measured or estimated at the facility boundary, or another location closer to the unit if necessary to protect human health and the environment.

The Agency has chosen the facility boundary as the location where air action levels are proposed to be typically measured, for several reasons. Measuring at the facility boundary will have the effect of requiring Corrective Measure Studies to be conducted whenever potentially health-threatening levels of airborne constituents that originate from waste management units

are being released to areas outside the facility property. The Agency recognizes that in some cases this could require owner/operators to study potential remedial solutions where actual remediation of air releases will not be required—under today's proposal, the requirement actually to remediate air releases is tied to actual exposure; *i.e.*, exceedence of health-based levels at the most exposed individual (see the discussion of air cleanup standards in section VI.F.7.a of today's preamble). However, under this scenario, if exposure conditions were to subsequently change and trigger the need for corrective action for air emissions, the owner/operator would be able to more expeditiously implement the remedy that had already been developed in the Corrective Measure Study. The Agency believes that measuring action levels at the facility boundary, while environmentally conservative, will not represent an undue burden on owner/operators.

Under today's proposal, the Regional Administrator could, when necessary, require action levels to be measured at one or more locations within the facility. An example would be if individuals were actually residing on the facility property, as might be the case at a Federal facility (*e.g.*, a military base). On-site worker exposure would not generally be a determining factor in establishing locations for action levels, since such exposure is regulated by the Occupational Safety and Health Administration (see further discussion in section VI.F.7.a(2) of today's preamble).

The Agency considered, but did not propose, other locations for establishing action levels for air releases. These alternative locations would have involved determining action levels at (1) the unit boundary, or (2) the most exposed individual. The alternative of determining action levels at the unit boundary was rejected as unnecessarily stringent, since it would likely have the effect of very often triggering the need for a Corrective Measure Study, where no actual or potential threat to human health and the environment existed. The option of measuring action levels at the most exposed individual was not chosen because in some cases a CMS would not be triggered based on current locations of receptors, even though future residential development close to the facility were planned and could result in exposure above action levels. The Agency specifically requests comment on the most appropriate location for measuring action levels for the air medium.

e. *Action Levels for Surface Water.* Proposed § 264.521(c) identifies action levels for surface water. Notwithstanding these action levels, some releases from solid waste management units to surface water may be subject to the National Pollutant Discharge Elimination System (NPDES) pursuant to section 402 of the Clean Water Act (CWA). The CWA prohibits the unregulated discharge of any pollutant to waters of the United States from any point source. Releases to surface waters that are nonpoint sources may be subject to the Nonpoint Source Management Program established under sections 208 and 319 of the CWA. If the Agency discovers releases from solid waste management units which are point sources, but lack an NPDES permit, CWA authorities will generally be used to address the release. It should be understood that the term surface water in this context includes wetlands, as prescribed under section 404 of the CWA. Section 404 permits are required for dredge and/or fill into wetlands.

Proposed § 264.521(c) specifies that State water quality standards established pursuant to section 303 of the CWA that are expressed as numerical values will be used as action levels, where they have been established for the surface water body in question. However, EPA anticipates that such numerical standards may, in some cases, not have been established at the time when remedial investigations are being conducted at RCRA facilities. In these cases, action levels may be established as numeric interpretations of State narrative water quality standards.

Water quality standards both establish water quality goals, and serve as a basis for establishing treatment controls, based on the use or uses which the State designates for the receiving water (*e.g.*, recreation or public water supply). The standards consist of a designated use or uses, and the water quality criteria which will protect such uses. Criteria are expressed as either numeric constituent concentration levels or narrative statements that represent a quality of water that supports a particular use.

In applying narrative standards to specific water bodies, some States have prescribed methods for calculating numeric values for the water body. Such methods vary from State to State in their complexity, the time required to establish the numeric values, and the procedures involved. Although deriving these numeric interpretations from narrative standards will often be straightforward, the Agency expects that in some situations the derivation of such values could be relatively complex and time-intensive. In such cases, the Regional Administrator could determ that the use of numeric interpretations of narrative water quality standards was not appropriate for the purpose of establishing action levels. EPA emphasizes that the use of such narrative standards must not delay the corrective action process.

Where numeric water quality standards have not been established by the State, and where numeric interpretations of narrative standards are either unavailable or inappropriate (for reasons described above), proposed § 264.521(c)(3) provides that maximum contaminant levels (MCLs) promulgated under the Safe Drinking Water Act will be used as action levels, if the surface water has been designated as a drinking water source by the State (see discussion in previous section on the use of MCLs as action levels in ground water).

In situations where a numerical water quality standard, a numeric interpretation of narrative standards, or an MCL is not available for a particular hazardous constituent in surface water designated by the State for drinking, proposed § 264.524(c)(4) specifies that the criteria under § 264.521(a)(2) (i)-(iv) be used for establishing action levels surface water, assuming exposure through consumption of the water contaminated with the hazardous constituent. The standard exposure assumptions of two liters/day for a 70 kg adult over a 70 year lifetime in appendix D should be used, unless people also consume aquatic organisms from the surface water. In these cases, the Agency suggests that Federal Water Quality Criteria be used as action levels, since they satisfy the criteria for action levels established under § 264.521(a)(2) (i)-(iv). Federal Water Quality Criteria are concentrations of contaminants determined to be protective of human health and/or aquatic organisms. Criteria for protection of human health are based on exposure through drinking water, as well as exposure through drinking water and ingesting aquatic organisms. Criteria for protection of freshwater/estuarine and marine organisms are also available. EPA has promulgated water quality criteria for 126 pollutants under the Clean Water Act.

In situations where a numerical water quality standard is not available for a particular hazardous constituent in surface water designated by the State for uses other than drinking, proposed § 264.524(c)(5) provides the Regional

Administrator with the flexibility to consider the State-designated use of the surface water in establishing a concentration as the action level. For example, in some surface waters designated for industrial uses, the Agency believes that an MCL may be too sensitive a trigger for a CMS. In other situations, MCLs may be too insensitive a trigger for a CMS (for example, in trout streams). Federal Water Quality Criteria may provide useful guidance in setting action levels under § 264.524(c)(5).

If Federal Water Quality Criteria are used as action levels, the purposes for which such criteria were developed should be considered in determining which criteria are appropriate to use. For example, for a surface water body used for fishing and drinking, the criteria for protection of human health based on drinking water and eating aquatic organisms would be most appropriate. For Class A and Class B carcinogens, the criteria corresponding to a 10^{-6} risk level should be used, whereas for Class C carcinogens, the Agency suggests that the criteria corresponding to 10^{-5} risk level be used. (See discussion of Agency-established classes of carcinogens and relative risk levels considered appropriate in section VI.E.2.c of this preamble.)

If contaminants attributable to releases from a SWMU exceed an action level anywhere in surface water, a Corrective Measure Study may be required. Proposed § 264.521(c) does not specify where in surface waters concentrations should be measured against action levels. In determining appropriate sampling locations, the Agency will generally attempt to specify locations in the surface water where the highest concentrations of hazardous constituents released from SWMUs are expected to occur—*i.e.*, at or near the point or points where releases enter the surface water. However, in some cases, establishing the precise point(s) where releases enter the surface water may be difficult and time-consuming, such as in the case of a ground-water plume in a complex hydrogeologic setting that flows into a lake. In these cases, the Agency would not wish to delay the initiation of a Corrective Measure Study while the point of release is located, if concentrations greater than action levels could already be detected in the surface water.

EPA specifically requests comment on today's proposal for establishing action levels for surface water.

Proposed § 264.520(b), which allows the Regional Administrator to require a CMS when necessary to protect human health and the environment, even when no action levels have been exceeded, may be particularly important for surface water. For example, the Regional Administrator may determine that a threat from consumption of aquatic organisms exists at levels at or below the MCL, since the MCL does not incorporate exposure through ingestion of contaminated organisms.

A Corrective Measure Study may also be required under § 264.520(b) if the Regional Administrator determines that there is a threat to human health or the environment from contaminated sediments even though action levels for surface water have not been exceeded. The Agency believes it is important to clarify its authority to address sediments contaminated by releases from solid waste management units under sections 3004 (u) and (v) of HSWA, although today's proposal does not establish action levels specifically for sediments. The Agency is currently developing sediment criteria which, when promulgated, may be used as guidance in evaluating contaminated sediments. However, no health-based or environmental levels are currently available which are appropriate as sediment action levels. Thus, until such criteria are developed, the need for Corrective Measure Studies based on sediment contamination will be determined on a case-by-case basis. The Agency requests comment on this approach to addressing sediments.

Finally, the Regional Administrator may require a Corrective Measure Study for surface water under § 264.520(b) when a threat to aquatic health exists at levels at or below action levels. Federal Water Quality Criteria for protection of aquatic health should be used as guidance in making this determination.

f. Action Levels for Soil. Proposed § 264.521(d) establishes criteria for establishing action levels for soil, assuming exposure through consumption of the soil contaminated with the hazardous constituent. Action levels would be set on the basis of the exposure assumptions in appendix D, which assume a residential use pattern, with long-term direct contact and soil ingestion by children. Action levels for soil would typically be measured on the surface (generally the upper two feet of earth).

The exception to this approach, is where EPA has already established standards for the cleanup of spilled polychlorinated biphenyls (PCBs), which are regulated under the Toxic Substances Control Act (TSCA). The Agency has determined that the use of these promulgated standards, as action levels and cleanup standards for soil, is relevant to RCRA corrective action. This policy is also consistent with Superfund policy. The PCB Spill Policy under TSCA is discussed more fully in section VII.B of this preamble.

Although action levels for soils are established using direct contact assumptions most appropriate for surficial soils, it is intended that these action levels will often also be used as a presumption that a CMS may be necessary for contaminated deep soils which may pose a threat to ground water in aquifers. The Agency does not believe that generic action levels based on the potential for hazardous constituents in soil to contaminate ground water can be developed at this time, since the type of soil, distance to ground water, and other site-specific factors, as well as the properties of the hazardous constituent, influence this potential. A permittee may attempt to rebut this presumption by demonstrating that there is no threat to human health and the environment from such deep soil contamination, either through direct contact or migration to aquifers or surface water. Alternatively, § 264.520(b) may be used to require a CMS in situations where deep soils are contaminated below action levels, but pose a threat to ground water in aquifers.

Although estimates of soil intake are not as frequently used by the Agency as are estimates of air or water intake, appendix D provides recommended exposure assumptions for non-carcinogenic and carcinogenic soil contaminants given an unrestricted use scenario. A soil ingestion rate of 0.1 g/day is recommended for carcinogens, and a rate of 0.2 g/day, based on an average child's body weight of 16 kg, is recommended for non-carcinogens.

In the case of non-carcinogenic contaminants, the oral RfD would be used to calculate an action level, or threshold concentration below which adverse effects would not occur, assuming 0.2 gram per day of soil is consumed. Sixteen kilograms represents an average body weight for children aged one to six. The Agency believes these exposure assumptions are reflective of a conservative average scenario in which children ages 1–6 years (*i.e.*, the time period during which children exhibit the greatest tendency for hand-to-mouth activity) are assumed to ingest an above-average amount of soil on a daily basis. The exposure levels estimated in this manner are calculated to keep exposures well below the population "threshold" for toxic effects (see earlier preamble discussion). Since the toxic effect of concern is assumed to occur once the threshold

level is exceeded, the amount of soil ingested on a daily basis becomes of major importance in determining non-carcinogenic effects. Therefore, to account properly for the risk from elevated exposure to non-carcinogenic soil contaminants during early childhood years, it is important that the exposure not be estimated over a lifetime; to do so would "smear" out the peak exposure occurring during the above-mentioned time period of five years and result in the failure to detect an unacceptable exposure level (*i.e.*, a level which exceeds the RfD).

In the case of carcinogens, the action level would be derived by assuming consumption of 0.1 g/day averaged out over a lifetime, based on an adult body weight of 70 kilograms. Because the expression of carcinogenic effects is principally a function of cumulative dose (*i.e.*, the time course of exposure is usually secondary), the Agency believes, in general, that elevated exposures during early childhood are relatively unimportant in determining lifetime cancer risk. Therefore, total lifetime (cumulative) soil ingestion can be averaged to derive a per day value. These exposure assumptions do, however, reflect a reasonable worst-case scenario—0.1 g/day is an upper-range estimate of soil ingestion for older children and adults.

The above recommendations are based on the conservative assumptions that 100 percent of the ingested non-carcinogenic and carcinogenic soil contaminants are absorbed across the gastrointestinal tract and that ingestion occurs 365 days/year, regardless of climatic conditions or age. The Agency solicits comment on the above assumptions for soil exposure for establishing action levels.

The Agency considered the use of other generic exposure assumptions for establishing action levels for soil based on direct contact (*e.g.*, exposure through dermal contact, exposure through ingestion under a non-residential scenario), but rejected these alternatives for several reasons. First, establishing action levels based on generic assumptions for dermal exposure or exposure via ingestion of soil under a non-residential scenario would be a far less sensitive trigger, and could in effect cause a "false negative" in situations where the Agency believes corrective action would be necessary. Second, the data base for developing action levels based on dermal exposure or exposure via ingestion of soil under a non-residential exposure scenario is limited.

In addition to considering generic exposure assumptions, the Agency considered the use of site-specific, direct contact exposure factors for deriving soil action levels. However, the Agency believes that assessing site-specific exposure in setting action levels would be a resource-intensive process, and would run counter to the objective of using action levels as a simple screening mechanism. The Agency recognizes that the proposed approach is conservative. Nevertheless, the Agency believes that these levels are appropriate as action levels (as opposed to cleanup targets)—that is, they can reasonably serve as rebuttable presumptions that further study, including analysis of possible remedies, is necessary.

Soil cleanup levels are discussed in more detail in section VI.F.5 of this preamble. However, it should be recognized that facilities with soil contamination above an action level—particularly where the levels would pose no threat under current conditions of exposure—would have a wide range of remedial options open to them, including "conditional" remedies (for which the permit would specify appropriate exposure controls), or the covering of the contaminated soil with a soil cap. In this case, a Corrective Measure Study might simply be a proposal to clean up to protective levels, assuming industrial land use, and to ensure restricted access for the life of the permit. This raises the issue of "conditional" remedies, which is discussed in more detail in section VI.F.8 of this preamble.

g. *Action Levels Where Health- and Environmental-Based Levels Are Not Available.* If, for any medium, Agency-promulgated standards or criteria, or other health-based levels meeting the proposed criteria are not available or cannot be developed for use as action levels, § 264.521(e) allows the Regional Administrator to set an action level for any constituent on the basis of available data and reasonable worst-case assumptions. In most cases, partial data or data on structural analogs will allow the Regional Administrator to estimate whether the detected level of a contaminant is likely to cause a problem. In other cases, other contaminants will be present at high levels (triggering a CMS in any case), and it will be clear that the constituent is not a driving factor in determining the risk at the site, even under worst-case assumptions concerning its toxicity. In such cases it may not be necessary to specify an action level for the constituent. Finally, under proposed § 264.521(e)(2), the Regional Administrator would have the authority to set the action level at background for a hazardous constituent for which data were inadequate to set a health- or environment-based action level. This option, however, is providad primarily as a fall-back position. The Agency believes that it will very rarely be necessary to set action levels at background.

As indicated earlier, appendix A lists possible action levels for a range of hazardous constituents based on the criteria proposed in § 264.521(a)(2). EPA's Office of Solid Waste (OSW) is developing, for the purpose of guidance, health-based numbers on additional constituents. These levels would also satisfy the criteria of proposed § 264.521(a)(2). As these additional health-based levels are developed, they will be entered into tha Integrated Risk Information System (IRIS). For information on these guidance numbers, the OSW Technical Assessment Branch/Health Assessment Section should be consulted at (202) 382-4761.

h. *Authority to Require a Corrective Measure Study Where Action Level Have Not Been Exceeded.* The Agency believes it is important to provide the Regional Administrator authority to require a CMS under § 264.520(b) even when no constituents exceed action levels. For example, a CMS could be required if there are threats to certain sensitive environmental receptors at a particular facility with contamination at or below action levels. Also, a CMS could be required in situations where the risk posed by the presence of multiple contaminants may be high enough to warrant a Corrective Measure Study even if no single constituent exceeds the individual action level for the constituent. Similarly, if individuals living near the site are receiving significant exposures from sources other than SWMUs at the site, the incremental exposure due to SWMUs at the site may result in a cumulative risk large enough to warrant a CMS. In addition, there may be situations where "cross-media" risks could indicate the need for a CMS, even though action levels in a particular medium have not been exceeded. An example might be where at nearby residences releases in both the air and ground water are present at very low levels, but the cumulative risks from both pathways of exposure are sufficiant to be of concern. Although such situations are expected to be relatively rare, the Agency will examine such cross-media risks when site-specific conditions indicate the potential for such exposure factors.

A CMS may also be required if constituents pose a threat through exposure pathways other than that assumed in setting action levels. For example, constituents in surface wat that do not exceed MCLs may still pos

develop and conduct these further Regulatory Impact Analyses.

The new analyses will be conducted in accordance with the existing Agency guidance on Regulatory Impact Analysis and the draft Regulatory Impact Analysis Guidance published in the 1988 Regulatory Program of the United States. The analyses will explicitly examine the costs, health and environmental benefits, and technological limitations for the key regulatory requirements contained in the proposal—especially for the several alternative approaches to ground water remediation outlined in the proposed rule. This analysis will also estimate the aggregate impacts, identified above, for sites eligible for remediation under this rule and for those sites which are listed on the NPL, and will, therefore, look to this rule as an ARAR, under the provisions of CERCLA. Upon completion of the revised analyses, EPA will solicit comment on the results of the analyses and the methodology used to derive them. The Agency will then assess these comments, along with comments which will have been received previously on the proposed rule. Through these actions EPA will ensure that the net social benefits (including environmental and health benefits) of the rule proposed today are maximized, taking into account costs, technological limitations, risks, and realistic assessments of both actual and reasonably expected uses of each site. If the revised RIA, together with the comments received, demonstrate that the rule proposed today does not achieve this outcome, the Agency will make appropriate modifications to the final rule, or if necessary, will repropose the rule.

B. Regulatory Flexibility Act

The Regulatory Flexibility Act requires Federal agencies to fully analyze the economic effects of regulations on small entities. The Agency analyzed the economic impacts for the regulatory options that are most similar to today's proposed rule (*i.e.*, "Immediate Cleanup to Health-Based Standards" and "Flexible Cleanup to Health-Based Standards").

The RIA assumes that a small business is significantly impacted if its excess of cash flow over ten percent of its total liabilities is insufficient to meet corrective action costs, or if its net income is insufficient to meet its corrective action costs.

For the alternative analyzed, it was found that small firms encounter more severe impacts from the corrective action requirements than large firms. The options most similar to the proposed rule result in incremental impacts (*i.e.*, relative to the baseline) on approximately 9 to 11 percent of small businesses owning RCRA facilities.

Based on the Agency's guidelines for implementing the Regulatory Feasibility Act, the results of the analysis as summarized above, suggest that the proposed rule does not impose significant impacts on small entities.

C. Paperwork Reduction Act

The information collection requirements in this proposed rule have been submitted for approval to the Office of Management and Budget (OMB) under the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.* Reporting and recordkeeping burden on the public for this collection is estimated at 42,497 hours for the 674 respondents, with an average of 1.151 hours per response. (Burden estimates should include all aspects of the collection effort and may include time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, completing and reviewing the collection of information, *etc.*)

If you wish to submit comments regarding any aspect of the collection of information, including suggestions for reducing the burden, or if you would like a copy of the information collection request (please reference ICR #1451), contact Rick Westlund, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460 (202-382-2745); and Tim Hunt, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503. The final rule will respond to any OMB or public comments on the information collection requirements contained in this proposal.

List of Subjects in 40 CFR Parts 264, 265, 270, and 271

Administrative practice and procedure, Corrective action, Hazardous waste; Insurance, Reporting and recordkeeping requirements.

Dated: July 5, 1990.

William Reilly,

Administrator.

XI. Supplementary Documents

APPENDIX A.—EXAMPLES OF CONCENTRATIONS MEETING CRITERIA FOR ACTION LEVELS

[Section 264.521(a)(2)(i-iv)]

Constituent name	Class	Air(ug/m^3)	Water (mg/L)	Soils (mg/kg)
Acetone	D		4E-00	8E+03
Acetonitrile	D		2E-01	5E+02
Acetophenone	D	2E-01	4E-00	8E+03
Acrylamide	B2	8E-04	8E-08	2E-01
Acrylonitrile	B1	1E-02	6E-08	1E-00
Aldicarb	D		5E-02	1E+02
Aldrin	B2	2E-04	2E-06	4E-02
Allyl alcohol	D		2E-01	4E+02
Aluminum phosphide	D		1E-02	3E+01
Aniline	B2		6E-03	1E+02
Antimony	D		1E-02	3E+01
Arsenic	A	7E-06	(1)	8E+01
Asbestos (2)	A	2E-02		
Barium cyanide	D		2E-00	6E+03
Barium, ionic	D	4E-01	(1)	4E+03
Benzidine	A	2E-06	2E-07	3E-03
Beryllium	B2	4E-04	6E-08	2E-01
Bis(2-ethylhexyl)phthalate	B2		3E-03	5E+01
Bis(chloroethyl)ether	B2	3E-03	3E-06	6E-01
Bromodichloromethane (3)	B2		3E-06	5E-01
Bromoform (3)	D		7E-01	2E+03
Bromomethane	D	3E+01	5E-02	1E+02
Butyl benzyl phthalate	C		7E-00	2E+04

APPENDIX A.—EXAMPLES OF CONCENTRATIONS MEETING CRITERIA FOR ACTION LEVELS—Continued

[Section 264.521(a)(2)(i-iv)]

Constituent name	Class	Air (µg/m³)	Water (mg/L)	Soils (mg/kg)
Cadmium	B1	6E−04	(1)	4E+01
Calcium cyanide	D		1E−00	3E+00
Carbon disulfide	D		4E−00	6E+03
Carbon tetrachloride	B2	3E−02	3E−04	5E−00
Chloral	D		7E−02	2E+02
Chlordane	B2	3E−00	3E−06	8E−01
Chlorine cyanide	D		2E−00	4E+03
Chlorobenzene	D	2E+01	7E−01	2E+00
Chloroform (3)	B2	4E−02	6E−06	1E+02
2-Chlorophenol	D		2E−01	4E+02
Chromium (VI)	A	6E−06	(1)	4E+02
Copper cyanide	D		2E−01	4E+02
m-Cresol	D		2E−00	4E+00
o-Cresol	D		2E−00	4E+03
p-Cresol	D		2E−00	40+03
Cyanide	D		7E−01	2E+00
Cyanogen	D		1E−00	3E+00
Cyanogen bromide	D		3E−00	7E+00
DDD	B2		1E−04	3E−00
DDE	B2		1E−04	2E−00
DDT	B2	1E−02	1E−04	2E−00
Dibutyl phthalate	D		4E−00	8E+03
Dibutylnitrosamine	B2	6E−04	6E−00	1E−01
3,3'-Dichlorobenzidine	B2		8E−05	2E−00
Dichlorodifluoromethane	D	2E+02	7E−00	2E+04
1,2-Dichloroethane	B2	4E−02	(1)	6E−00
1,1-Dichloroethylene	C	3E−02	(1)	1E+01
2,4-Dichlorophenol	D		1E−01	2E+02
2,4-Dichlorophenoxyacetic acid	D		4E−01	6E+02
1,3-Dichloropropene	B2		1E−02	2E+01
Dieldrin	B2	3E−04	2E−00	4E−02
Diethyl phthalate	D		3E+01	6E+04
Diethylnitrosamine	B2	2E−05	2E−07	5E−00
Dimethoate	D		7E−01	2E+00
Dimethylnitrosamine	B2	7E−05	7E−07	1E−02
m-Dinitrobenzene	D		4E−00	8E−00
2,4-Dinitrophenol	D		7E−02	2E+02
2,3-Dinitrotoluene (and 2,6-, mixture)	B2		6E−05	1E-00
1,4-Dioxane	B2		3E−00	6E+01
Diphenylamine	D		9E−04	2E+00
1,2-Diphenylhydrazine	B2	4E−03	4E−05	9E−01
Disulfoton	D		1E−03	3E−00
Endosulfan	D		2E−00	4E−00
Endothall	D		7E−01	2E+00
Endrin	D		(1)	2E+01
Epichlorohydrin	B2	6E−01	4E−00	7E+01
Ethylbenzene	D		4E-00	8E+03
Ethylene dibromide	B2	5E−00	4E−07	8E−00
Formaldehyde	B1	6E−02		
Formic acid	D		7E+01	2E+05
Glycidylaldehyde	D		1E−02	3E+01
Heptachlor	B2	6E−04	6E−00	2E−01
Heptachlor epoxide	B2	4E−04	4E−00	8E−02
Hexachlorobenzene-p-dioxin	B2	6E−07	1E−00	1E−04
Hexachlorobutadiene	C	4E−01	4E−00	8E+01
alpha-Hexachlorocyclohexane	B2	6E−04	6E−00	1E−01
beta-Hexachlorocyclohexane	C	2E−02	2E−04	4E−00
Hexachlorocyclopentadiene	D	7E−02	2E−01	6E+02
Hexachloroethane	C	3E−00	3E−02	8E+01
Hexachlorophene	D		1E−02	2E+01
Hydrazine	B2	2E−04	1E−05	2E−01
Hydrogen cyanide	D		7E−01	2E+00
Hydrogen sulfide	D		1E−01	2E+02
Isobutyl alcohol	D		1E+01	2E+04
Isophorone	C		6E−02	2E+03
Lead	B2		(1)	
Lindane (gamma-hexachlorocyclohexane)	B2/C		(1)	6E−01
m-Phenylenediamine	D		2E−01	5E+02
Maleic anhydride	D		4E−00	8E+03
Maleic hydrazide	D		2E+01	4E+04
Mercury (inorganic)	D		(1)	2E+01
Methacrylonitrile	D	7E−01	4E−00	8E-00
Methomyl	D		8E−01	2E+00
Methyl dithiocarbamate	D			
Methyl ethyl ketone	D	3E+02	2E−00	4E+03
Methyl isobutyl ketone	D	7E+01	2E−00	4E+03
Methyl parathion	D		9E−00	2E+01

APPENDIX A.—EXAMPLES OF CONCENTRATIONS MEETING CRITERIA FOR ACTION LEVELS—Continued

[Section 264.521(a)(2)(i-iv)]

Constituent name	Class	Air(ug/m^3)	Water (mg/L)	Soils (mg/kg)
Methylene chloride	B	3E-01	5E-03	9E+01
n-Nitroso-di-n-butylamine	B2	6E-04	6E-08	1E-01
n-Nitroso-n-ethylurea	B			
n-Nitroso-n-methylethylamine	B2		2E-08	3E-02
n-Nitrosodi-n-propylamine	B2		5E-08	1E-01
n-Nitrosodiethanolamine	B2		1E-08	3E-01
n-Nitrosodiphenylamine	B2		7E-03	1E+02
n-Nitrosopyrrolidine	B2	2E-03	2E-08	3E-01
Nickel	D		7E-01	2E+03
Nickel refinery dust	A	4E-03		
Nitric oxide	D		4E-00	8E+03
Nitrobenzene	D	2E-00	2E-02	4E+01
Nitrogen dioxide	D		4E+01	8E+04
Osmium tetroxide	D		4E-04	8E-01
Parathion	C		2E-01	5E-02
Pentachlorobenzene	D		3E-02	6E+01
Pentachloronitrobenzene	C	1E-01	1E-01	2E+02
Pentachlorophenol	D		1E-00	2E+03
Phenol	D		2E+01	5E+04
Phenyl mercuric acetate	D		3E-03	6E-00
Phosphine	D		1E-02	2E+01
Phthalic anhydride	D		7E+01	2E+05
Polychlorinated biphenyls	B2		5E-08	9E-02
Potassium cyanide	D		2E-00	4E+03
Potassium silver cyanide	D		7E-00	2E+04
Pronamide	D		3E-00	6E+03
Pyridine	D		4E-02	8E+01
Selenious acid	D		1E-01	2E+02
Selenourea	D		2E-01	4E+02
Silver	D		(1)	2E+02
Silver cyanide	D		4E-00	8E+03
Sodium cyanide	D		1E-00	3E+03
Strychnine	D		1E-02	2E+01
Styrene	C		7E-00	2E+04
1,1,1,2-Tetrachloroethane	C	1E-09	1E-02	3E+02
1,2,4,5-Tetrachlorobenzene	D		1E-02	2E+01
1,1,1,2-Tetrachloroethane	C	1E-09	1E-02	3E+02
1,1,2,2-Tetrachloroethane	C	2E-01	2E-03	4E+01
Tetrachloroethylene	B2	1E-09	7E-04	1E+01
2,3,4,6-Tetrachlorophenol	D		1E-09	2E+03
Tetraethyl lead	D		4E-09	8E-03
Tetraethyldithiopyrophosphate	D		2E-02	4E+01
Thallic oxide	D		2E-03	6E-00
Thallium acetate	D		3E-03	7E-00
Thallium carbonate	D		3E-03	6E-00
Thallium chloride	D		3E-03	6E-00
Thallium nitrate	D		3E-03	7E-00
Thallium sulfate	D		3E-08	6E-00
Thiosemicarbazide	D		2E-01	5E+02
Thiram	D		2E-01	4E+02
Toluene	D	7E+03	1E+01	2E+04
Toxaphene	B2	3E-03	(1)	6E-01
1,2,4-Trichlorobenzene	D	1E+01	7E-01	2E+03
1,1,1-Trichloroethane	D	1E+03	3E-00	7E+03
1,1,2-Trichloroethane	C	6E-01	6E-03	1E+02
Trichloroethylene	B2		(1)	6E+01
Trichloromonofluoromethane	D	7E+02	1E+01	2E+04
2,4,5-Trichlorophenol	D		4E-00	8E+03
2,4,6-Trichlorophenol	B2	2E-01	2E-03	4E+01
2,4,5-Trichlorophenoxyacetic acid	D		(1)	8E+02
1,2,3-Trichloropropane	D		2E-01	5E+02
Vanadium pentoxide	D		3E-01	7E+02
Xylenes	D	1E+03	7E+01	2E+03
Zinc cyanide	D		2E-00	4E+03
Zinc phosphide	D		1E-02	2E+01

(1) MCL available; see appendix B.

(2) The air action level for asbestos is measured in units of fibers/milliliters.

(3) There is an MCL for total trihalomethanes, which includes four constituents: bromoform, bromodichloromethane, chloroform, and dibromochloromethane. Concentration derived using exposure assumptions in appendix D and reference doses for systemic toxicants and verified risk-specific doses at 10−6 for Class A and B carcinogens and 10−5 for Class C carcinogens (see section VI.F.2.6 for further discussion).

A, B and C represents class A, B and C carcinogens, respectively; D represents a systemic toxicant.

Appendix B—Maximum Contaminant Levels

Constituent	MCL (ppm)
Arsenic	0.05
Barium	1
Benzene	0.005
Cadmium	0.010
Carbon tetrachloride	0.005
Chromium VI	0.05
p-Dichlorobenzene	0.075
1,2-Dichloroethane	0.005
1,1-Dichloroethylene	0.007

Appendix B—Maximum Contaminant Levels—Continued

Constituent	MCL (ppm)
2,4-D	0.1
2,4,5-TP Silvex	0.01
Endrin	0.0002
Fluoride	4.0
Lead	0.05
Lindane	0.004
Mercury	0.002
Methoxychlor	0.1
Nitrate	10

Appendix B—Maximum Contaminant Levels—Continued

Constituent	MCL (ppm)
Selenium	0.01
Silver	0.05
Toxaphene	0.005
1,1,1-Trichloroethane	0.2
Trichloroethylene	0.005
Trihalomethanes, total [1]	0.10
Vinyl chloride	0.002

[1] Including chloroform, bromoform, bromodichloromethane, and dibromochloromethane

Appendix C—Range of Concentrations for Establishing Media Protection Standards for Carcinogens

Constituent name	Class	MaxAir (ug/m 3)	MinAir (ug/m 3)	Max-Water (mg/L)	MinWater (mg/L)	MaxSoil (mg/kg)	MinSoil (mg/kg)
Acetone	D						
Acetonitrile	D						
Acetophenone	D						
Acrylamide	B2	8E-02	8E-04	8E-04	8E-06	2E+01	2E-01
Acrylonitrile	B1	1E-00	1E-02	6E-03	6E-05	1E+02	1E-00
Aldicarb	D						
Aldrin	B2	2E-02	2E-04	2E-04	2E-06	4E-00	4E-02
Allyl alcohol	D						
Aluminum phosphide	D						
Aniline	B2			6E-01	6E-03	1E+04	1E+02
Antimony	D						
Arsenic	A	7E-03	7E-05				
Asbestos (2)	A	2E-00	2E-02				
Barium cyanide	D						
Barium, ionic	D						
Benzidine	A	2E-05	2E-05	2E-05	2E-07	3E-01	3E-03
Beryllium	B2	4E-02	4E-04	8E-04	8E-06	2E+01	2E-01
Bis(2-ethylhexyl)phthalate	B2			3E-01	3E-03	5E+03	5E+
Bis(chloroethyl)ether	B2	3E-01	3E-03	3E-03	3E-05	6E+01	6E
Bromodichloromethane	B2			3E-03	3E-05	5E+01	5E
Bromoform	D						
Bromomethane	D						
Butyl benzyl phthalate	C						
Cadmium	B1	6E-02	6E-04				
Calcium cyanide	D						
Carbon disulfide	D						
Carbon tetrachloride	B2	3E-00	3E-02	3E-02	3E-04	5E+02	5E-00
Chloral	D						
Chlordane	B2	3E-01	3E-03	3E-03	3E-05	5E+01	5E-01
Chlorine cyanide	D						
Chlorobenzene	D						
Chloroform	B2	4E-03	4E-02	6E-01	6E-03	1E+04	1E+02
2-Chlorophenol	D						
Chromium (VI)	A	9E-02	9E-04				
Copper cyanide	D						
m-Cresol	D						
o-Cresol	D						
p-Cresol	D						
Cyanide	D						
Cyanogen	D						
Cyanogen bromide	D						
DDD	B2			1E-02	1E-04	3E+02	3E-00
DDE	B2			1E-02	1E-04	2E+02	2E-00
DDT	B2	1E-03	1E-02	1E-02	1E-04	2E+02	2E-00
Dibutyl phthalate	D						
Dibutylnitrosamine	B2	6E-02	6E-04	6E-04	6E-06	1E+01	1E-01
3,3'-Dichlorobenzidine	B2			8E-03	8E-05	2E+02	2E-00
Dichlorodifluoromethane	D						
1,2-Dichloroethane	B2	4E-03	4E-02	4E-02	4E-04	8E+02	8E-00
1,1-Dichloroethylene	C	3E-01	3E-03	6E-03	6E-05	1E+02	1E-00
2,4-Dichlorophenol	D						
2,4-Dichlorophenoxyacetic acid	D						
1,3-Dichloropropene	B2						
Dieldrin	B2	2E-02	2E-04	2E-04	2E-06	4E-00	4E-02
Diethyl phthalate	D						

APPENDIX C—RANGE OF CONCENTRATIONS FOR ESTABLISHING MEDIA PROTECTION STANDARDS FOR CARCINOGENS—Continued

Constituent name	Class	MaxAir (ug/m 3)	MinAir (ug/m 3)	Max-Water (mg/L)	MinWater (mg/L)	MaxSoil (mg/kg)	MinSoil (mg/kg)
Diethylnitrosamine	B2	2E-03	2E-05	2E-06	2E-07	5E-01	5E-03
Dimethoate	D						
Dimethylnitrosamine	B2	7E-03	7E-05	7E-06	7E-07	1E-00	1E-02
m-Dinitrobenzene	D						
2,4-Dinitrophenol	D						
2,3-Dinitrotoluene (and 2,6-, mixture)	B2			5E-03	5E-06	1E+02	1E-00
1,4-Dioxane	B2			3E-01	3E-03	6E+03	6E+01
Diphenylamine	D						
1,2-Diphenylhydrazine	B2	4E-01	4E-03	4E-03	4E-06	9E+01	9E-01
Disulfoton	D						
Endosulfan	D						
Endothall	D						
Endrin	D						
Epichlorohydrin	B2	8E+01	8E-01	4E-01	4E-03	7E+03	7E+01
Ethylbenzene	D						
Ethylene dibromide	B2	5E-01	5E-03	4E-06	4E-07	8E-01	8E-03
Formaldehyde	B1	8E-00	8E-02				
Formic acid	D						
Glycidylaldehyde	D						
Heptachlor	B2	8E-02	8E-04	8E-04	8E-06	2E+01	2E-01
Heptachlor epoxide	B2	4E-02	4E-04	4E-04	4E-06	8E-00	8E-02
Hexachlorodibenzo-p-dioxin	B2	6E-05	6E-07	6E-07	1E-08	1E-02	1E-04
Hexachlorobutadiene	C	4E-00	4E-02	4E-02	4E-04	9E+02	9E-00
alpha-Hexachlorocyclohexane	B2	6E-02	6E-04	6E-04	6E+06	1E-01	1E-01
beta-Hexachlorocyclohexane	C	2E-01	2E-03	2E-03	2E-05	4E+01	4E-01
Hexachlorocyclopentadiene	D						
Hexachloroethane	C	3E+01	3E-01	3E-01	3E-03	5E+03	5E+01
Hexachlorophene	D						
Hydrazine	B2	2E-02	2E-04	1E-03	1E-05	2E+01	2E-01
Hydrogen cyanide	D						
Hydrogen sulfide	D						
Isobutyl alcohol	D						
Isophorone	C			9E-01	9E-03	2E+04	2E+02
Lead	B2						
Lindane (gamma-hexachlorocyclohexane)	B2/C			3E-03	3E-05	5E+01	5E-01
m-Phenylenediamine	D						
Maleic anhydride	D						
Maleic hydrazide	D						
Mercury (inorganic)	D						
Methacrylonitrile	D						
Methomyl	D						
Methyl chlorocarbonate	D						
Methyl ethyl ketone	D						
Methyl isobutyl ketone	D						
Methyl parathion	D						
Methylene chloride	B	3E+01	3E-01	5E-01	5E-03	9E+03	9E+01
n-Nitroso-di-n-butylamine	B2	6E-02	6E-04	6E-04	6E+06	1E-01	1E-01
n-Nitroso-n-ethylurea	B						
n-Nitroso-n-methylethylamine	B2			2E-04	2E-06	3E-00	3E-02
n-Nitrosodi-n-propylamine	B2			5E-04	5E-06	1E+01	1E-01
n-Nitrosodiethanolamine	B2			1E-03	1E-05	3E+01	3E-01
n-Nitrosodiphenylamine	B2			7E-01	7E-03	1E+04	1E+02
n-Nitrosopyrrolidine	B2	2E-01	2E-03	2E-03	2E-05	3E+01	3E-01
Nickel	D						
Nickel refinery dust	A	4E-01	4E-03				
Nitric oxide	D						
Nitrobenzene	D						
Nitrogen dioxide	D						
Osmium tetroxide	D						
Parathion	C						
Pentachlorobenzene	D						
Pentachloronitrobenzene	C	1E-00	1E-02				
Pentachlorophenol	D						
Phenol	D						
Phenyl mercuric acetate	D						
Phosphine	D						
Phthalic anhydride	D						
Polychlorinated biphenyls	B2			5E-04	5E-06	9E-00	9E-02
Potassium cyanide	D						
Potassium silver cyanide	D						
Pronamide	D						
Pyridine	D						
Selenious acid	D						
Selenourea	D						
Silver	D						
Silver cyanide	D						
Sodium cyanide	D						
Strychnine	D						

APPENDIX C—RANGE OF CONCENTRATIONS FOR ESTABLISHING MEDIA PROTECTION STANDARDS FOR CARCINOGENS—Continued

Constituent name	Class	MaxAir (ug/m 3)	MinAir (ug/m 3)	Max-Water (mg/L)	MinWater (mg/L)	MaxSoil (mg/kg)	MinSoil (mg/kg)
Styrene	C						
1,1,1,2-Tetrachlorethane	C	1E+01	1E-01	1E-01	3E+03	3E+08	3E+01
1,2,4,5-Tetrachlorobenzene	D						
1,1,1,2-Tetrachloroethane	C	1E+01	1E-01	1E-01	1E-03	3E+08	3E+01
1,1,2,2-Tetrachloroethane	C	2E-00	2E-02	2E-02	2E-04	4E+02	4E-09
Tetrachloroethylene	B2	1E+02	1E-00	7E-02	7E-04	1E+03	1E+01
2,3,4,6-Tetrachlorophenol	D						
Tetraethyl lead	D						
Tetraethyldithiopyrophosphate	D						
Thallic oxide	D						
Thallium acetate	D						
Thallium carbonate	D						
Thallium chloride	D						
Thallium nitrate	D						
Thallium sulfate	D						
Thiosemicarbazide	D						
Thiram	D						
Toluene	D						
Toxaphene	B2	3E-01	3E-03	3E-03	3E-05	6E+01	6E-01
1,2,4-Trichlorobenzene	D						
1,1,1,Trichloroethane	D						
1,1,2-Trichloroethane	C	6E-00	6E-02	6E-02	6E-04	1E+03	1E+01
Trichloroethylene	B2			3E-01	3E-03	6E+03	6E+01
Trichloromonofluoromethane	D						
2,4,5-Trichlorophenol	D						
2,4,6-Trichlorophenol	B2	2E-01	2E-01	2E-01	2E-03	4E+03	4E+01
2,4,5-Trichlorophenoxyacetic acid	D						
1,2,3-Trichloropropane	D						
Vanadium pentoxide	D						
Xylenes	D						
Zinc cyanide	D						
Zinc phosphide	D						

Appendix D: Recommended Exposure Assumptions for Use in Deriving Action Levels

(Sections 264.521 (a)(2); (b); (c)(3); and (d))

1. In deriving action levels for hazardous constituents in ground-water, assume a water intake of 2 liters/day for 70 kg adult/70 year lifetime exposure period.

2. In deriving action levels for hazardous constituents in air, assume air intake of 20 cubic meters/day for 70 kg adult/70 year lifetime exposure period.

3. In deriving action levels for hazardous constituents in soil, which are known or suspected to be carcinogens, assume soil intake of 0.1 gram/day for 70 kg adult/70 year lifetime exposure period.

4. In deriving action levels for hazardous constituents in soil, other than those which are known or suspected to be carcinogens, assume soil intake of 0.2 gram/day for 16 kg child/5 year exposure period (age 1–6).*

5. In deriving action levels for hazardous constituents in surface water designated by the State for use as a drinking water source, assume a water intake of 2 liters/day for 70 kg adult/70 year lifetime exposure period, unless intake of aquatic organisms is also of concern.

*Not to be averaged over a 70-year lifetime.

Appendix E: Examples of Calculations of Action Levels

I. Governing Equations for Calculating Action Levels

A. *Systemic Toxicants*

$C_m = [RfD \cdot W]/[I \cdot A]$

where:

C_m = action level in medium (units are medium-dependent);
RfD = reference dose (mg/kg/day);
W = body weight (kg);
I = intake assumption (units are medium-dependent); and
A = absorption factor [1] (dimensionless).

B. *Carcinogenic Constituents*

$C_m = [R \cdot W \cdot LT]/[CSF \cdot I \cdot A \cdot ED]$

where:

C_m = action level in medium (units are medium-dependent);
R = assumed risk level (dimensionless) (10^{-6} for class A & B; 10^{-5} for class C carcinogens);
W = body weight (kg);
LT = assumed lifetime (years);
CSF = carcinogenic slope factor $(mg/kg/day)^{-1}$;
I = intake assumption (units are medium-dependent);
A = absorption factor (dimensionless); and
ED = exposure duration (years).

[1] Assumed to be 1 for this appendix, based upon the assumption that the human absorption rate will be the same as the rate in the study upon which the RfD or CPF was developed.

II. Example Calculations for Hazardous Constituents in Air

A. *Systemic Toxicants*

Example calculation for 2,4-dinitrophenol:

$C_a = [0.002\ (mg/kg/d) \cdot 1000\ (\mu g/mg) \cdot 70(kg)]/[20\ (m^3/d) \cdot 1] = 7.0\ \mu g/m^3$

where:

C_a = action level in air ($\mu g/m^3$)
RfD = 0.002 mg/kg/day
W = 70 kg adult
I = 20 m^3/day
A = 1

B. *Carcinogenic Constituents*

Example calculation for 1,1,2,2-tetrachloroethane:

$C_a = [10^{-6} \cdot 1000\ (\mu g/mg) \cdot 70\ (yrs) \cdot 70\ (kg)]/[0.20\ (mg/kg/day)^{-1} \cdot 20\ (m^3/day) \cdot 1 \cdot 70\ (yrs)] = .175\ \mu g/m$

where:

C_a = action level in air ($\mu g/m^3$)
R = 10^{-6} (1,1,2,2-Tetrachloroethane is a Class C carcinogen)
W = 70 kg adult
LT = 70 year lifetime
CSF = 0.20 $(mg/kg/day)^{-1}$
I = 20 m^3/day
A = 1
ED = 70 year exposure duration

III. Sample Calculation for Hazardous Constituents in Water

A. *Systemic Toxicants*

Sample calculation for toluene:

$C_w = [0.30\ (mg/kg/day) \cdot 70\ (kg)]/[2\ (L/day) \cdot 1] = 10.5\ mg/L$

where:

C_w = action level in water (mg/L)

APPENDIX F—LIST OF CONSTITUENTS SHOWING ACTION LEVEL SOURCE DATA—Continued

Constituent name	Class	Noncarcinogenic effects		Carcinogenic effects	
		Oral RfD (mg/kg/d)	Inhalation RfD (mg/kg/d)	Oral slope factor (mg/kg/d)-1	Inhalation slope factor (mg/kg/d)
Dimethoate	D	2.0E-02			
Dimethylnitrosamine	B2			5.1E+01	5.1E+01
m-Dinitrobenzene	D	1.0E-04			
2,4-Dinitrophenol	D	2.0E-03			
2,3-Dinitrotoluene (and 2,6-, mixture)	B2			6.8E-01	
1,4-Dioxane	B2			1.1E-02	
Diphenylamine	D	2.5E-02			
1,2-Diphenylhydrazine	B2			8.0E-01	8.0E-01
Disulfoton	D	4.0E-06			
Endosulfan	D	5.0E-06			
Endothall	D	2.0E-02			
Endrin	D	3.0E-04			
Epichlorohydrin	B2	2.0E-03		9.9E-03	4.2E-03
Ethylbenzene	D	1.0E-01			
Ethylene dibromide	B2			8.5E+01	7.5E-01
Formaldehyde	B1				4.5E-02
Formic acid	D	2.0E-03			
Glycidylaldehyde	D	4.0E-04			
Heptachlor	B2	5.0E-04		4.5E-00	4.5E-00
Heptachlor epoxide	B2	1.3E-05		9.1E-00	9.1E-00
Hexachlorodibenzo-p-dioxin	B2			6.2E+03	6.2E+03
Hexachlorobutadiene	C	2.0E-03		7.8E-02	7.8E-02
alpha-Hexachlorocyclohexane	B2			6.3E-00	6.3E-00
beta-Hexachlorocyclohexane	C			1.8E-00	1.8E-00
Hexachlorocyclopentadiene	D	7.0E-03	2.0E-05		
Hexachloroethane	C	1.0E-03		1.4E-02	1.4E-02
Hexachlorophene	D	3.0E-04			
Hydrazine	B2			3.0E-00	1.7E+01
Hydrogen cyanide	D	2.0E-02			
Hydrogen sulfide	D	3.0E-03			
Isobutyl alcohol	D	3.0E-01			
Isophorone	C	2.0E-01		4.1E-03	
Lead	B2				
Lindane (gamma-hexachlorocyclohexane)	B2/C	3.0E-04		1.3E-00	
m-Phenylenediamine	D	6.0E-03			
Maleic anhydride	D	1.0E-01			
Maleic hydrazide	D	6.0E-01			
Mercury (inorganic)	D	3.0E-04			
Methacrylonitrile	D	1.0E-04	2.0E-04		
Methomyl	D	2.5E-02			
Methyl chlorocarbonate	D				
Methyl ethyl ketone	D	5.0E-02	9.0E-02		
Methyl isobutyl ketone	D	5.0E-02	2.0E-02		
Methyl parathion	D	2.5E-04			
Methylene chloride	B	6.0E-02		7.5E-03	1.4E-02
n-Nitroso-di-n-butylamine	B2			5.4E-00	5.4E-00
n-Nitroso-n-ethylurea	B				
n-Nitroso-n-methylethylamine	B2			2.2E+01	
n-Nitrosodi-n-propylamine	B2			7.0E-00	
n-Nitrosodiethanolamine	B2			2.8E-00	
n-Nitrosodiphenylamine	B2			4.9E-03	
n-Nitrosopyrrolidine	B2			2.1E-00	2.1E-00
Nickel	D	2.0E-02			
Nickel refinery dust	A				8.4E-01
Nitric oxide	D	1.0E-01			
Nitrobenzene	D	5.0E-04	6.0E-04		
Nitrogen dioxide	D	1.0E-00			
Osmium tetroxide	D	1.0E-05			
Parathion	C	6.0E-03			
Pentachlorobenzene	D	8.0E-04			
Pentachloronitrobenzene	C	3.0E-03			2.5E-01
Pentachlorophenol	D	3.0E-02			
Phenol	D	6.0E-01			
Phenyl mercuric acetate	D	8.0E-05			
Phosphine	D	3.0E-04			
Phthalic anhydride	D	2.0E-00			
Polychlorinated biphenyls	B2			7.7E-00	
Potassium cyanide	D	5.0E-02			
Potassium silver cyanide	D	2.0E-01			
Pronamide	D	7.5E-02			
Pyridine	D	1.0E-03			
Selenious acid	D	3.0E-03			
Selenourea	D	5.0E-03			
Silver	D	3.0E-03			
Silver cyanide	D	1.0E-01			
Sodium cyanide	D	4.0E-02			

RfD = 0.30 mg/kg/day for toluene
W = 70 kg adult
I = 2 L/day
A = 1

B. *Carcinogenic Constituents*

Sample calculation for 1,1,2,2-tetrachloroethane:

$C_w = [10^{-6} * 70\ (kg) * 70\ (yr)]/[0.20\ (mg/kg/day)^{-1} * 2\ (L/day) * 1 * 70\ (yr)] = 1.75E-03\ mg/L$

where:
C_w = action level in water (mg/L)
R = 10^{-6} (1,1,2,2-Tetrachloroethane is a Class C carcinogen)
W = 70 kg adult
LT = 70 year lifetime
CSF = 0.20 $(mg/kg/day)^{-1}$
I = 2 L/day
A = 1
ED = 70 year exposure duration

IV. Sample Calculations for Hazardous Constituents in Soils

A. *Systemic Toxicants*

Example calculations for toluene:

$C_s = [0.30\ (mg/kg/day) * 16\ (kg)]/[0.2\ (g/day) * 1 * 0.001\ (kg/g)] = 24.000\ mg/kg$

where:
C_s = action level in soil (mg/kg)
RfD = 0.30 mg/kg/day for toluene
W = 16 kg (5 year old child)
I = 0.2 g/day
A = 1

B. *Carcinogenic Constituents*

Sample calculation for 1,1,2,2-tetrachloroethane:

$C_s = [10^{-6} * 70\ (kg) * 70\ (yrs)]/[0.20\ (mg/kg/day)^{-1} * 0.1\ (g/day) * 0.001\ (kg/g) * 1 * 70\ (yrs)] = 35.0\ mg/kg$

where:
C_s = action level in soil (mg/kg)
R = 10^{-6} (1,1,2,2-tetrachloroethane is a Class C carcinogen)
W = 70 kg adult
LT = 70 year lifetime
CSF = 0.20 $(mg/kg/day)^{-1}$
I = 0.1 g/day
A = 1
ED = 70 year exposure duration

APPENDIX F—LIST OF CONSTITUENTS SHOWING ACTION LEVEL SOURCE DATA

Constituent name	Class	Noncarcinogenic effects		Carcinogenic effects	
		Oral RfD (mg/kg/d)	Inhalation RfD (mg/kg/d)	Oral slope factor (mg/kg/d)-1	Inhalation slope factor (mg/kg/d)-1
Acetone	D	1.0E-01			
Acetonitrile	D	6.0E-03			
Acetophenone	D	1.0E-01	5.0E-05		
Acrylamide	B2	2.0E-04		4.5E-00	4.5E-00
Acrylonitrile	B1			5.4E-01	2.4E-01
Aldicarb	D	1.3E-03			
Aldrin	B2	3.0E-05		1.7E+01	1.7E+01
Allyl alcohol	D	5.0E-03			
Aluminum phosphide	D	4.0E-04			
Aniline	B2			5.7E-03	
Antimony	D	4.0E-04			
Arsenic	A	1.0E-03			5.0E+01
Asbestos (2)	A				2.3E-01
Barium cyanide	D	7.0E-02			
Barium, ionic	D	5.0E-02	1.0E-04		
Benzidine	A	3.0E-03		2.3E+02	2.3E+02
Beryllium	B2	5.0E-03		4.3E-00	8.4E-00
Bis(2-ethylhexyl)phthalate	B2	2.0E-02		1.4E-02	
Bis(chloroethyl)ether	B2			1.1E-00	1.1E-00
Bromodichloromethane	B2	2.0E-02		1.3E-00	
Bromoform	D	2.0E-02			
Bromomethane	D	1.4E-03	8.0E-03		
Butyl benzyl phthalate	C	2.0E-01			
Cadmium	B1	5.0E-04			6.1E-00
Calcium cyanide	D	4.0E-02			
Carbon disulfide	D	1.0E-01			
Carbon tetrachloride	B2	7.0E-04		1.3E-01	1.3E-01
Chloral	D	2.0E-03			
Chlordane	B2	6.0E-05		1.3E-00	1.3E-00
Chlorine cyanide	D	5.0E-02			
Chlorobenzene	D	2.0E-02	5.0E-03		
Chloroform	B2	1.0E-02		6.1E-03	8.1E-02
2-Chlorophenol	D	5.0E-03			
Chromium (VI)	A	5.0E-03			4.1E+01
Copper cyanide	D	5.0E-03			
m-Cresol	D	5.0E-02			
o-Cresol	D	5.0E-02			
p-Cresol	D	5.0E-02			
Cyanide	D	2.0E-02			
Cyanogen	D	4.0E-02			
Cyanogen bromide	D	9.0E-02			
DDD	B2			2.4E-01	
DDE	B2			3.4E-01	
DDT	B2	5.0E-04		3.4E-01	3.4E-01
Dibutyl phthalate	D	1.0E-01			
Dibutylnitrosamine	B2			5.4E-00	5.4E-00
3,3'-Dichlorobenzidine	B2			4.5E-01	
Dichlorodifluoromethane	D	2.0E-01	5.0E-02		
1,2-Dichloroethane	B2			9.1E-02	9.1E-02
1,1-Dichloroethylene	C	9.0E-03		6.0E-01	1.2E-00
2,4-Dichlorophenol	D	3.0E-03			
2,4-Dichlorophenoxyacetic acid	D	1.0E-02			
1,3-Dichloropropene	B2	3.0E-04			
Dieldrin	B2	5.0E-05		1.6E+01	1.6E+01
Diethyl phthalate	D	8.0E-01			
Diethylnitrosamine	B2			1.5E+02	1.5E+02

APPENDIX F—LIST OF CONSTITUENTS SHOWING ACTION LEVEL SOURCE DATA—Continued

Constituent name	Class	Noncarcinogenic effects		Carcinogenic effects	
		Oral RfD (mg/kg/d)	Inhalation RfD (mg/kg/d)	Oral slope factor (mg/kg/d)-1	Inhalation slope factor (mg/kg/d) [1]
Strychnine	D	3.0E−04			
Styrene	C	2.0E−01			
1,1,1,2-Tetrachloroethane	C	3.0E−02		2.6E−02	2.6E−02
1,2,4,5-Tetrachlorobenzene	D	3.0E−04			
1,1,1,2-Tetrachloroethane	C	3.0E−02		2.6E−02	2.6E−02
1,1,2,2-Tetrachloroethane	C			2.0E−01	2.0E−01
Tetrachloroethylene	B2	1.0E−02		5.1E−02	3.3E−03
2,3,4,6-Tetrachlorophenol	D	3.0E−02			
Tetraethyl lead	D	1.0E−07			
Tetraethyldithiopyrophosphate	D	5.0E−04			
Thallic oxide	D	7.0E−05			
Thallium acetate	D	9.0E−05			
Thallium carbonate	D	8.0E−05			
Thallium chloride	D	8.0E−05			
Thallium nitrate	D	9.0E−05			
Thallium sulfate	D	8.0E−05			
Thiosemicarbazide	D	6.0E−03			
Thiram	D	5.0E−03			
Toluene	D	3.0E−01	2.0E−00		
Toxaphene	B2			1.1E−00	1.1E−00
1,2,4-Trichlorobenzene	D	2.0E−02	3.0E−03		
1,1,1-Trichloroethane	D	9.0E−02	3.0E−01		
1,1,2-Trichloroethane	C	4.0E−03		5.7E−02	5.7E−02
Trichloroethylene	B2			1.1E−02	
Trichloromonofluoromethane	D	3.0E−01	2.0E−01		
2,4,5-Trichlorophenol	D	1.0E−01			
2,4,6-Trichlorophenol	B2			2.0E−02	2.0E−02
2,4,5-Trichlorophenoxyacetic acid	D	1.0E−02			
1,2,3-Trichloropropane	D	6.0E−03			
Vanadium pentoxide	D	9.0E−03			
Xylenes	D	2.0E−00	3.0E−01		
Zinc cyanide	D	5.0E−02			
Zinc phosphide	D	3.0E−04			

For the reasons set out in the preamble, 40 CFR parts 264, 265, 270, and 271 are proposed to be amended as follows:

PART 264—STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES

1. The authority citation for part 264 continues to read as follows:

Authority: 42 U.S.C. 6905, 6912(a), 6924, and 6925.

2. Section 264.1 is amended by revising paragraphs (d) and (g) introductory text to read as follows:

§ 264.1 Purpose, scope and applicability.

* * * * *

(d) The requirements of this part apply to a person disposing of hazardous waste by means of underground injection subject to a permit issued under an Underground Injection control (UIC) program approved or promulgated under the Safe Drinking Water Act only to the extent they are required by § 144.14 of this chapter and to the extent they are included in a RCRA permit by rule granted to such a person under part 270 of this chapter.

* * * * *

(g) Except as required under subpart S of this part governing releases from solid waste management units, the requirements of this part do not apply to:

* * * * *

§ 264.101 [Removed]

3. In 40 CFR part 264, subpart F, it is proposed to remove § 264.101.

4. In 40 CFR part 264, subpart G, it is proposed to amend § 264.113 by redesignating paragraphs (a)(1)(ii) as (a)(1)(iii) and (b)(1)(ii) as (b)(1)(iii), and by adding new paragraphs (a)(1)(ii) and (b)(1)(ii) to read as follows:

§ 264.113 Closure time allowed for closure.

* * * * *

(a) * * *

(1) * * *

(ii) Corrective action required at the unit or the facility under subpart S will delay the completion of partial or final closure; or

* * * * *

(b) * * *

(1) * * *

(ii) Corrective action required at the unit or the facility under subpart S will delay the completion of partial or final closure; or

* * * * *

5. 40 CFR part 264 is amended by adding subpart S to read as follows:

Subpart S—Corrective Action for Solid Waste Management Units

264.500 Purpose and applicability.
264.501 Definitions.
264.502–264.509 [Reserved].
264.510 Requirement to perform remedial investigations.
264.511 Scope of remedial investigations.
264.512 Plans for remedial investigations.
264.513 Reports of remedial investigations.
264.514 Determination of no further action.
264.515–264.519 [Reserved]
264.520 Requirement to perform corrective measure study.
264.521 Action levels.
264.522 Scope of corrective measure studies.
264.523 Plans for corrective measure studies.
264.524 Reports of corrective measure studies.
264.525 Selection of remedy
264.526 Permit modification for remedy.
264.527 Remedy design.
264.528 Progress reports.
264.529 Review of remedy implementation.
264.530 Completion of remedies.

APPENDIX D

"Risk Assessment Guidance for Superfund, Volume I,
Human Health Evaluation Manual (Part A)"
Sections 5.3, 6.4.1, and 8.2

Analytical results that are not specific for a particular compound (e.g., total organic carbon [TOC], total organic halogens [TOX]) or results of insensitive analytical methods (e.g., analyses using portable field instruments such as organic vapor analyzers and other field screening methods) may be useful when considering sources of contamination or potential fate and transport of contaminants. These types of analytical results, however, generally are not appropriate for quantitative risk assessment; therefore, the risk assessor may not want to include them in the summary of chemicals of potential concern for the quantitative risk assessment. In addition, the results of analytical methods associated with unknown, few, or no QA/QC procedures should be eliminated from further quantitative use. These types of results, however, may be useful for qualitative discussions of risk in other sections of the risk assessment report.

The outcome of this step is a set of site data that has been developed according to a standard set of sensitive, chemical-specific methods (e.g., SW-846 Methods [EPA 1986], EPA 600 Methods [EPA 1984], CLP Statements of Work [EPA 1988b,c]), with QA/QC procedures that are well-documented and traceable. The data resulting from analyses conducted under the CLP, which generally comprise the majority of results available from a Superfund site investigation, fall into this category.

Although the CLP was developed to ensure that consistent QA/QC methods are used when analyzing Superfund site samples, it does not ensure that all analytical results are consistently of sufficient quality and reliability for use in quantitative risk assessment. Neither the CLP nor QA/QC procedures associated with other methods make judgments concerning the ultimate "usability" of the data. Do not accept at face value all remaining analytical results, whether from the CLP or from some other set of analytical methodologies. Instead, determine -- according to the steps discussed below -- the limitations and uncertainties associated with the data so that only data that are appropriate and reliable for use in a quantitative risk assessment are carried through the process.

5.3 EVALUATION OF QUANTITATION LIMITS

This step involves evaluation of quantitation limits and detection limits (QLs and DLs) for all of the chemicals assessed at the site. This evaluation may lead to the re-analysis of some samples, the use of "proxy" (or estimated) concentrations, and/or the elimination of certain chemicals from further consideration (because they are believed to be absent from the site). Types and definitions of QLs and DLs are presented in the box on the next page.

Before eliminating chemicals because they are not detected (or conducting any other manipulation of the data), the following points should be considered:

(1) the sample quantitation limit (SQL) of a chemical may be greater than corresponding standards, criteria, or concentrations derived from toxicity reference values (and, therefore, the chemical may be present at levels greater than these corresponding reference concentrations, which may result in undetected risk); and

(2) a particular SQL may be significantly higher than positively detected values in other samples in a data set.

These two points are discussed in detail in the following two subsections. A third subsection provides guidance for situations where only some of the samples for a given medium test positive for a particular chemical. A fourth subsection addresses the special situation where SQLs are not available. The final subsection addresses the specific steps involved with elimination of chemicals from the quantitative risk assessment based on their QLs.

5.3.1 SAMPLE QUANTITATION LIMITS (SQLs) THAT ARE GREATER THAN REFERENCE CONCENTRATIONS

As discussed in Chapter 4, QLs needed for the site investigation should be specified in the sampling plan. For some chemicals, however, SQLs obtained under RAS or SAS may exceed

certain reference concentrations (e.g., maximum contaminant levels [MCLs], concentrations corresponding to a 10^{-6} cancer risk). The box on the next page illustrates this problem. For certain chemicals (e.g., antimony), the CLP contract-required quantitation limits (CRQLs) exceed the corresponding reference concentrations for noncarcinogenic effects, based on the EPA-verified reference dose and a 2-liter per day ingestion of water by a 70-kilogram person.[1] Estimation of cancer risks for several other chemicals (e.g., arsenic, styrene) at their CRQLs yields cancer risks exceeding 10^{-4}, based on the same water ingestion factors. Most potential carcinogens with EPA-derived slope factors have CRQLs that yield cancer risk levels exceeding 10^{-6} in water, and none of the carcinogens with EPA-derived slope factors have CRQL values yielding less than 10^{-7} cancer risk levels (as of the publication date of this manual; data not shown).

Three points should be noted when considering this example.

(1) Review of site information and a preliminary determination of chemicals of potential concern at a site prior to sample collection may allow the specification of lower QLs (i.e., using SAS) before an investigation begins (see Chapter 4). This is the most efficient way to minimize the problem of QLs exceeding levels of potential concern.

(2) EPA's Analytical Operations Branch currently is working to reduce the CRQL values for several chemicals on the TCL and TAL, and to develop an analytical service for chemicals with special standards (e.g., MCLs).

TYPES AND DEFINITIONS OF DETECTION LIMITS AND QUANTITATION LIMITS

Strictly interpreted, the detection limit (DL) is the lowest amount of a chemical that can be "seen" above the normal, random noise of an analytical instrument or method. A chemical present below that level cannot reliably be distinguished from noise. DLs are chemical-specific and instrument-specific and are determined by statistical treatment of multiple analyses in which the ratio of the lowest amount observed to the electronic noise level (i.e., the signal-to-noise ratio) is determined. On any given day in any given sample, the calculated limit may not be attainable; however, a properly calculated limit can be used as an overall general measure of laboratory performance.

Two types of DLs may be described -- instrument DLs (IDLs) and method DLs (MDLs). The IDL is generally the lowest amount of a substance that can be detected by an instrument; it is a measure only of the DL for the instrument, and does not consider any effects that sample matrix, handling, and preparation may have. The MDL, on the other hand, takes into account the reagents, sample matrix, and preparation steps applied to a sample in specific analytical methods.

Due to the irregular nature of instrument or method noise, reproducible quantitation of a chemical is not possible at the DL. Generally, a factor of three to five is applied to the DL to obtain a quantitation limit (QL), which is considered to be the lowest level at which a chemical may be accurately and reproducibly quantitated. DLs indicate the level at which a small amount would be "seen," whereas QLs indicate the levels at which measurements can be "trusted."

Two types of QLs may be described -- contract-required QLs (CRQLs) and sample QLs (SQLs). (Contract-required detection limits [CRDL] is the term used for inorganic chemicals. For the purposes of this manual, however, CRQL will refer to both organic and inorganic chemicals.) In order to participate in the CLP, a laboratory must be able to meet EPA CRQLs. CRQLs are chemical-specific and vary depending on the medium analyzed and the amount of chemical expected to be present in the sample. As the name implies, CRQLs are not necessarily the lowest detectable levels achievable, but rather are levels that a CLP laboratory should routinely and reliably detect and quantitate in a variety of sample matrices. A specific sample may require adjustments to the preparation or analytical method (e.g., dilution, use of a smaller sample aliquot) in order to be analyzed. In these cases, the reported QL must in turn be adjusted. Therefore, SQLs, not CRQLs, will be the QLs of interest for most samples. In fact, for the same chemical, a specific SQL may be higher than, lower than, or equal to SQL values for other samples. In addition, preparation or analytical adjustments such as dilution of a sample for quantitation of an extremely high level of only one compound could result in non-detects for all other compounds included as analytes for a particular method, even though these compounds may have been present at trace quantities in the undiluted sample. Because SQLs take into account sample characteristics, sample preparation, and analytical adjustments, these values are the most relevant QLs for evaluating non-detected chemicals.

EXAMPLE OF HEALTH RISKS FROM INGESTION OF WATER CONTAMINATED WITH SELECTED CHEMICALS AT THEIR QUANTITATION LIMITS[a]

Chemical	CAS #	CRQL or CRDL (ug/L)[b]	CRDL/RfC[c]	Cancer Risk at CRQL or CRDL[d]
Antimony	7440-36-0	60	4.3	
Arsenic	7440-38-2	10		$5x10^{-4}$
Benz(a)pyrene	50-32-8	10		$3x10^{-3}$
Bis(2-Chloroethyl)ether	111-44-4	10		$3x10^{-4}$
2,4-Dinitrotoluene	121-14-2	10		$2x10^{-4}$
Hexachlorobenzene	118-74-1	10		$5x10^{-4}$
N-Nitroso-di-n-dipropylamine	621-64-7	10		$2x10^{-3}$
PCB-1254	11096-69-1	1		$2x10^{-4}$[e]
PCB-1260	11096-82-5	1		$2x10^{-4}$
Styrene	100-42-5	5		$4x10^{-4}$
Vinyl chloride	75-01-4	10		$7x10^{-4}$

[a] All values in this example are for illustration purposes only.

[b] CRQL = Contract-required quantitation limit (organics) of the Contract Laboratory Program (revised April 1989).
CRDL = Contract-required detection limit (inorganics) of the Contract Laboratory Program (revised July 1988).

The CRQL and CRDL values presented here are for the regular multi-media multi-concentration CLP methods.

[c] RfC = Reference concentration (based on the August 1989 reference dose for oral exposure, assuming a 70-kilogram adult drinks 2 liters of contaminated water per day).

[d] Cancer Risk at CRQL or CRDL = Excess upper-bound lifetime cancer risk (based on the August 1989 slope factor for oral exposure, assuming a 70-kilogram adult drinks 2 liters of contaminated water per day).

[e] PCB-1260 slope factor was used.

(3) In several situations, an analytical laboratory may be able to attain QLs in particular samples that are below or above the CRQL values.

If SAS was not specified before sampling began and/or if a chemical is not detected in any sample from a particular medium at the QL, then available modeling data, as well as professional judgment, should be used to evaluate whether the chemical may be present above reference concentrations. If the available information indicates the chemical is not present, see Section 5.3.5 for guidance on eliminating chemicals. If there is some indication that the chemical is present, then either re-analyze selected samples using SAS, if time allows, or address the chemical qualitatively. In determining which option is most appropriate for a site, a screening-level risk assessment should be performed by assuming that the chemical is present in the sample at the SQL (see Section 5.3.4 for situations where SQLs are not available). Carry the chemical through the screening risk assessment, essentially conducting the assessment on the SQL for the particular chemical. In this way, the risks that would be posed if the chemical is present at the SQL can be compared with risks posed by other chemicals at the site.

Re-analyze the sample. This (preferred) option discourages elimination of questionable chemicals (i.e., chemicals that may be present below their QL but above a level of potential concern) from the risk assessment. If time allows and a sufficient quantity of the sample is available, submit a SAS request to re-analyze the sample at QLs that are below reference concentrations. The possible outcome of this option is inclusion of chemicals positively detected at levels above

reference concentrations but below the QLs that would normally have been attained under routine analysis of Superfund samples in the CLP program.

Address the chemical qualitatively. A second and less desirable option for a chemical that may be present below its QL (and possibly above its health-based reference concentration) is to eliminate the chemical from the quantitative risk assessment, noting that if the chemical was detected at a lower QL, then its presence and concentration could contribute significantly to the estimated risks.

5.3.2 UNUSUALLY HIGH SQLs

Due to one or more sample-specific problems (e.g., matrix interferences), SQLs for a particular chemical in some samples may be unusually high, sometimes greatly exceeding the positive results reported for the same chemical in other samples from the data set. Even if these SQLs do not exceed health-based standards or criteria, they may still present problems. If the SQLs cannot be reduced by re-analyzing the sample (e.g., through the use of SAS or sample cleaning procedures to remove matrix interferences), exclude the samples from the quantitative risk assessment if they cause the calculated exposure concentration (i.e., the concentration calculated according to guidance in Chapter 6) to exceed the maximum detected concentration for a particular sample set. The box on this page presents an example of how to address a situation with unusually high QLs.

EXAMPLE OF UNUSUALLY HIGH QUANTITATION LIMITS

In this example, concentrations of semivolatile organic chemicals in soils have been determined using the CLP's RAS.

	Concentration (ug/kg)			
Chemical	Sample 1	Sample 2	Sample 3	Sample 4
Phenol	330 U[a]	390	19,000 U	490

[a] U = Compound was analyzed for, but not detected. Value presented (e.g., 330 U) is the SQL.

The QLs presented in this example (i.e., 330 to 19,000 ug/kg) vary widely from sample to sample. SAS would not aid in reducing the unusually high QL of 19,000 ug/kg noted in Sample 3, assuming it was due to unavoidable matrix interferences. In this case, the result for phenol in Sample 3 would be eliminated from the quantitative risk assessment because it would cause the calculated exposure concentrations (from Chapter 6) to exceed the maximum detected concentration (in this case 490 ug/kg). Thus, the data set would be reduced to three samples: the non-detect in Sample 1 and the two detected values in Samples 2 and 4.

5.3.3 WHEN ONLY SOME SAMPLES IN A MEDIUM TEST POSITIVE FOR A CHEMICAL

Most analytes at a site are not positively detected in <u>each</u> sample collected and analyzed. Instead, for a particular chemical the data set generally will contain some samples with positive results and others with non-detected results. The non-detected results usually are reported as SQLs. These limits indicate that the chemical was not measured above certain levels, which may vary from sample to sample. The chemical may be present at a concentration just <u>below</u> the reported quantitation limit, or it may not be present in the sample at all (i.e., the concentration in the sample is zero).

In determining the concentrations most representative of potential exposures at the site (see Chapter 6), consider the positively detected results together with the non-detected results (i.e., the SQLs). If there is reason to believe that the chemical is present in a sample at a concentration below the SQL, use one-half of the SQL as a proxy concentration. The SQL value itself can be used if there is reason to believe the concentration is closer to it than to one-half the SQL. (See the next subsection for situations where SQLs are not available.) Unless site-specific information indicates that a chemical is not likely to be present in a sample, do not substitute the value zero in place of the SQL (i.e., do not assume that a chemical that is not detected at the SQL would not be detected in the sample if the analysis was extremely sensitive). Also, do not simply omit the non-detected results from the risk assessment.

5.3.4 WHEN SQLs ARE NOT AVAILABLE

A fourth situation concerning QLs may sometimes be encountered when evaluating site data. For some sites, data summaries may not provide the SQLs. Instead, MDLs, CRQLs, or even IDLs may have been substituted wherever a chemical was not detected. Sometimes, no detection or quantitation limits may be provided with the data. As a first step in these situations, always attempt to obtain the SQLs, because these are the most appropriate limits to consider when evaluating non-detected chemicals (i.e., they account for sample characteristics, sample preparation, or analytical adjustments that may differ from sample to sample).

If SQLs cannot be obtained, then, for CLP sample analyses, the CRQL should be used as the QL of interest for each non-detected chemical, with the understanding that these limits may overestimate or underestimate the actual SQL. For samples analyzed by methods different from CLP methods, the MDL may be used as the QL, with the understanding that in most cases this will underestimate the SQL (because the MDL is a measure of detection limits only and does not account for sample characteristics or matrix interferences). Note that the IDL should rarely be used for non-detected chemicals since it is a measure only of the detection limit for a particular instrument and does not consider the effect of sample handling and preparation or sample characteristics.

5.3.5 WHEN CHEMICALS ARE NOT DETECTED IN ANY SAMPLES IN A MEDIUM

After considering the discussion provided in the above subsections, generally eliminate those chemicals that have not been detected in any samples of a particular medium. On CLP data reports, these chemicals will be designated in each sample with a U qualifier preceded by the SQL or CRQL (e.g., 10 U). If information exists to indicate that the chemicals are present, they should not be eliminated. For example, if chemicals with similar transport and fate characteristics are detected frequently in soil at a site, and some of these chemicals also are detected frequently in ground water while the others are not detected, then the undetected chemicals are probably present in the ground water and therefore may need to be included in the risk assessment as ground-water contaminants.

The outcome of this step is a data set that only contains chemicals for which positive data (i.e., analytical results for which measurable concentrations are reported) are available in at least one sample from each medium. Unless otherwise indicated, assume at this point in the evaluation of data that positive data to which no uncertainties are attached concerning either the assigned identity of the chemical or the reported concentration (i.e., data that are not "tentative," "uncertain," or "qualitative") are appropriate for use in the quantitative risk assessment.

5.4 EVALUATION OF QUALIFIED AND CODED DATA

For CLP analytical results, various qualifiers and codes (hereafter referred to as qualifiers) are attached to certain data by either the laboratories conducting the analyses or by persons performing data validation. These qualifiers often pertain to QA/QC problems and generally indicate questions concerning chemical identity, chemical concentration, or both. All qualifiers must be addressed before the chemical can be used in quantitative risk assessment. Qualifiers used by the laboratory may differ from those used by data validation personnel in either identity or meaning.

5.4.1 TYPES OF QUALIFIERS

A list of the qualifiers that laboratories are permitted to use under the CLP -- and their potential use in risk assessment -- is presented in Exhibit 5-4. A similar list addressing data validation qualifiers is provided in Exhibit 5-5. In general, because the data validation process is intended to assess the effect of QC issues on data usability, validation data qualifiers are attached to the data after the laboratory qualifiers and supersede the laboratory qualifiers. If data have both laboratory and validation qualifiers and they appear contradictory, ignore the laboratory qualifier and consider only the validation qualifier. If qualifiers have been attached to certain data by the laboratory and have not been removed, revised, or superseded during data validation, then

and also is useful as documentation of the exposure pathway analysis. Exhibit 6-8 provides a sample format for presenting this information.

6.4 STEP 3: QUANTIFICATION OF EXPOSURE: GENERAL CONSIDERATIONS

The next step in the exposure assessment process is to quantify the magnitude, frequency and duration of exposure for the populations and exposure pathways selected for quantitative evaluation. This step is most often conducted in two stages: first, exposure concentrations are estimated, then, pathway-specific intakes are quantified. The specific methodology for calculating exposure concentrations and pathway-specific exposures are presented in Sections 6.5 and 6.6, respectively. This section describes some of the basic concepts behind these processes.

6.4.1 QUANTIFYING THE REASONABLE MAXIMUM EXPOSURE

Exposure is defined as the contact of an organism with a chemical or physical agent. If exposure occurs over time, the total exposure can be divided by a time period of interest to obtain an average exposure rate per unit time. This average exposure rate also can be expressed as a function of body weight. For the purposes of this manual, exposure normalized for time and body weight is termed "intake", and is expressed in units of mg chemical/kg body weight-day.

Exhibit 6-9 presents a generic equation for calculating chemical intakes and defines the intake variables. There are three categories of variables that are used to estimate intake:

(1) chemical-related variable -- exposure concentration;

(2) variables that describe the exposed population -- contact rate, exposure frequency and duration, and body weight; and

(3) assessment-determined variable -- averaging time.

Each intake variable in the equation has a range of values. For Superfund exposure assessments, intake variable values for a given pathway should be selected so that the combination of all intake variables results in an estimate of the reasonable maximum exposure for that pathway. As defined previously, the reasonable maximum exposure (RME) is the maximum exposure that is reasonably expected to occur at a site. Under this approach, some intake variables may not be at their individual maximum values but when in combination with other variables will result in estimates of the RME. Some recommendations for determining the values of the individual intake variables are discussed below. These recommendations are based on EPA's determination of what would result in an estimate of the RME. As discussed previously, a determination of "reasonable" cannot be based solely on quantitative information, but also requires the use of professional judgment. Accordingly, the recommendations below are based on a combination of quantitative information and professional judgment. These are general recommendations, however, and could change based on site-specific information or the particular needs of the risk manager. Consult with the RPM before varying from these recommendations.

Exposure concentration. The concentration term in the intake equation is the arithmetic average of the concentration that is contacted over the exposure period. Although this concentration does not reflect the maximum concentration that could be contacted at any one time, it is regarded as a reasonable estimate of the concentration likely to be contacted over time. This is because in most situations, assuming long-term contact with the maximum concentration is not reasonable. (For exceptions to this generalization, see discussion of hot spots in Section 6.5.3.)

Because of the uncertainty associated with any estimate of exposure concentration, the upper confidence limit (i.e., the 95 percent upper confidence limit) on the arithmetic average will be used for this variable. There are standard statistical methods which can be used to calculate the upper confidence limit on the arithmetic mean. Gilbert (1987, particularly sections 11.6 and 13.2) discusses methods that can be applied to data that are distributed normally or log normally. Kriging is another method that

potentially can be used (Clark 1979 is one of several reference books on kriging). A statistician should be consulted for more details or for assistance with specific methods.

If there is great variability in measured or modeled concentration values (such as when too few samples are taken or when model inputs are uncertain), the upper confidence limit on the average concentration will be high, and conceivably could be above the maximum detected or modeled value. In these cases, the maximum detected or modeled value should be used to estimate exposure concentrations. This could be regarded by some as too conservative an estimate, but given the uncertainty in the data in these situations, this approach is regarded as reasonable.

For some sites, where a screening level analysis is regarded as sufficient to characterize potential exposures, calculation of the upper confidence limit on the arithmetic average is not required. In these cases, the maximum detected or modeled concentration should be used as the exposure concentration.

Contact rate. Contact rate reflects the amount of contaminated medium contacted per unit time or event. If statistical data are available for a contact rate, use the 95th percentile value for this variable. (In this case and throughout this chapter, the 90th percentile value can be used if the 95th percentile value is not available.) If statistical data are not available, professional judgment should be used to estimate a value which approximates the 95th percentile value. (It is recognized that such estimates will not be precise. They should, however, reflect a reasonable estimate of an upper-bound value.)

Sometimes several separate terms are used to derive an estimate of contact rate. For example, for dermal contact with chemicals in water, contact rate is estimated by combining information on exposed skin surface area, dermal permeability of a chemical, and exposure time. In such instances, the combination of variables used to estimate intake should result in an estimate approximating the 95th percentile value. Professional judgment will be needed to determine the appropriate combinations of variables. (More specific guidance for determining contact rate for various pathways is given in Section 6.6.)

Exposure frequency and duration. Exposure frequency and duration are used to estimate the total time of exposure. These terms are determined on a site-specific basis. If statistical data are available, use the 95th percentile value for exposure time. In the absence of statistical data (which is usually the case), use reasonable conservative estimates of exposure time. National statistics are available on the upper-bound (90th percentile) and average (50th percentile) number of years spent by individuals at one residence (EPA 1989d). Because of the data on which they are based, these values may underestimate the actual time that someone might live in one residence. Nevertheless, the upper-bound value of 30 years can be used for exposure duration when calculating reasonable maximum residential exposures. In some cases, however, lifetime exposure (70 years by convention) may be a more appropriate assumption. Consult with the RPM regarding the appropriate exposure duration for residential exposures. The exposure frequency and duration selected must be appropriate for the contact rate selected. If a long-term average contact rate (e.g., daily fish ingestion rate averaged over a year) is used, then a daily exposure frequency (i.e., 365 days/year) should be assumed.

Body weight. The value for body weight is the average body weight over the exposure period. If exposure occurs only during childhood years, the average child body weight during the exposure period should be used to estimate intake. For some pathways, such as soil ingestion, exposure can occur throughout the lifetime but the majority of exposure occurs during childhood (because of higher contact rates). In these cases, exposures should be calculated separately for age groups with similar contact rate to body weight ratios; the body weight used in the intake calculation for each age group is the average body weight for that age group. Lifetime exposure is then calculated by taking the time-weighted average of exposure estimates over all age groups. For pathways where contact rate to body weight ratios are fairly constant over a lifetime (e.g., drinking water ingestion), a body weight of 70 kg is used.

A constant body weight over the period of exposure is used primarily by convention, but also because body weight is not always independent of the other variables in the exposure equation (most notably, intake). By keeping body weight

constant, error from this dependence is minimized. The average body weight is used because, when combined with the other variable values in the intake equation, it is believed to result in the best estimate of the RME. For example, combining a 95th percentile contact rate with a 5th percentile body weight is not considered reasonable because it is unlikely that smallest person would have the highest intake. Alternatively, combining a 95th percentile intake with a 95th percentile body weight is not considered a maximum because a smaller person could have a higher contact rate to body weight ratio.

Averaging time. The averaging time selected depends on the type of toxic effect being assessed. When evaluating exposures to developmental toxicants, intakes are calculated by averaging over the exposure event (e.g., a day or a single exposure incident). For acute toxicants, intakes are calculated by averaging over the shortest exposure period that could produce an effect, usually an exposure event or a day. When evaluating longer-term exposure to noncarcinogenic toxicants, intakes are calculated by averaging intakes over the period of exposure (i.e., subchronic or chronic daily intakes). For carcinogens, intakes are calculated by prorating the total cumulative dose over a lifetime (i.e., chronic daily intakes, also called lifetime average daily intake). This distinction relates to the currently held scientific opinion that the mechanism of action for each category is different (see Chapter 7 for a discussion). The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime (EPA 1986b). This approach becomes problematic as the exposures in question become more intense but less frequent, especially when there is evidence that the agent has shown dose-rate related carcinogenic effects. In some cases, therefore, it may be necessary to consult a toxicologist to assess the level of uncertainty associated with the exposure assessment for carcinogens. The discussion of uncertainty should be included in both the exposure assessment and risk characterization chapters of the risk assessment report.

6.4.2 TIMING CONSIDERATIONS

At many Superfund sites, long-term exposure to relatively low chemical concentrations (i.e., chronic daily intakes) are of greatest concern. In some situations, however, shorter-term exposures (e.g., subchronic daily intakes) also may be important. When deciding whether to evaluate short-term exposure, the following factors should be considered:

- the toxicological characteristics of the chemicals of potential concern;
- the occurrence of high chemical concentrations or the potential for a large release;
- persistence of the chemical in the environment; and
- the characteristics of the population that influence the duration of exposure.

Toxicity considerations. Some chemicals can produce an effect after a single or very short-term exposure to relatively low concentrations. These chemicals include acute toxicants such as skin irritants and neurological poisons, and developmental toxicants. At sites where these types of chemicals are present, it is important to assess exposure for the shortest time period that could result in an effect. For acute toxicants this is usually a single exposure event or a day, although multiple exposures over several days also could result in an effect. For developmental toxicants, the time period of concern is the exposure event. This is based on the assumption that a single exposure at the critical time in development is sufficient to produce an adverse effect. It should be noted that the critical time referred to can occur in almost any segment of the human population (i.e., fertile men and women, the conceptus, and the child up to the age of sexual maturation [EPA 1989e]).

Concentration considerations. Many chemicals can produce an effect after a single or very short-term exposure, but only if exposure is to a relatively high concentration. Therefore, it is important that the assessor identify possible situations where a short-term exposure to a high concentration could occur. Examples of such a

EXHIBIT 6–14

RESIDENTIAL EXPOSURE: INGESTION OF CHEMICALS IN SOIL[a]

Equation:

$$\text{Intake (mg/kg–day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

Where:

CS = Chemical Concentration in Soil (mg/kg)
IR = Ingestion Rate (mg soil/day)
CF = Conversion Factor (10^{-6} kg/mg)
FI = Fraction Ingested from Contaminated Source (unitless)
EF = Exposure Frequency (days/years)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (period over which exposure is averaged — days)

Variable Values:

CS: Site–specific measured value

IR: 200 mg/day (children, 1 through 6 years old; EPA 1989g)
100 mg/day (age groups greater than 6 years old; EPA 1989g)

NOTE: IR values are default values and could change based on site–specific or other information. Research is currently ongoing to better define ingestion rates. IR values do not apply to individuals with abnormally high soil ingestion rates (i.e., pica).

CF: 10^{-6} kg/mg

FI: Pathway–specific value (should consider contaminant location and population activity patterns)

EF: 365 days/year

ED: 70 years (lifetime; by convention)
30 years (national upper–bound time (90th percentile) at one residence; EPA 1989d)
9 years (national median time (50th percentile) at one residence; EPA 1989d)

BW: 70 kg (adult, average; EPA 1989d)
16 kg (children 1 through 6 years old, 50th percentile; EPA 1985a)

AT: Pathway–specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70 year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year).

[a] *See Section 6.4.1 and 6.6.2 for a discussion of which variable values should be used to calculate the reasonable maximum exposure. In general, use 95th or 90th percentile values for contact rate and exposure frequency and duration variables.*

8.2 QUANTIFYING RISKS

This section describes steps for quantifying risk or hazard indices for both carcinogenic and noncarcinogenic effects to be applied to each exposure pathway analyzed. The first subsection covers procedures for individual substances, and is followed by a subsection on procedures for quantifying risks associated with simultaneous exposures to several substances. Sample table formats for recording the results of these calculations as well as recording associated information related to uncertainty and absorption adjustments are provided in Exhibits 8-2 through 8-4.

8.2.1 CALCULATE RISKS FOR INDIVIDUAL SUBSTANCES

Carcinogenic effects. For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen (i.e., incremental or excess individual lifetime cancer risk). The guidelines provided in this section are consistent with EPA's (1986a) *Guidelines for Carcinogen Risk Assessment*. For some carcinogens, there may be sufficient information on mechanism of action that a modification of the approach outlined below is warranted. Alternative approaches may be considered in consultation with ECAO on a case-by-case basis.

The slope factor (SF) converts estimated daily intakes averaged over a lifetime of exposure directly to incremental risk of an individual developing cancer. Because relatively low intakes (compared to those experienced by test animals) are most likely from environmental exposures at Superfund sites, it generally can be assumed that the dose-response relationship will be linear in the low-dose portion of the multistage model dose-response curve. (See the Background Document 2 of IRIS for a discussion of the multistage model.) Under this assumption, the slope factor is a constant, and risk will be directly related to intake. Thus, the linear form of the carcinogenic risk equation is usually applicable for estimating Superfund site risks. This linear low-dose equation is described in the next box.

LINEAR LOW-DOSE CANCER RISK EQUATION

$$\text{Risk} = \text{CDI} \times \text{SF}$$

where:

Risk = a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer;

CDI = chronic daily intake averaged over 70 years (mg/kg-day); and

SF = slope factor, expressed in $(\text{mg/kg-day})^{-1}$.

The CDI is identified in Exhibits 6-11 through 6-19 and 6-22 and the SF is identified in Exhibit 7-3.

However, this linear equation is valid only at low risk levels (i.e., below estimated risks of 0.01). For sites where chemical intakes might be high (i.e., risk above 0.01), an alternate calculation equation should be used. The one-hit equation, which is consistent with the linear low-dose model given above and described in the box on page 8-11, should be used instead.

Because the slope factor is often an upper 95th percentile confidence limit of the probability of response based on experimental animal data used in the multistage model, the carcinogenic risk estimate will generally be an upper-bound estimate. This means that EPA is reasonably confident that the "true risk" will not exceed the risk estimate derived through use of this model and is likely to be less than that predicted.

Noncarcinogenic effects. The measure used to describe the potential for noncarcinogenic toxicity to occur in an individual is not expressed as the probability of an individual suffering an adverse effect. EPA does not at the present time use a probabilistic approach to estimating the potential for noncarcinogenic health effects. Instead, the

ONE-HIT EQUATION FOR HIGH CARCINOGENIC RISK LEVELS

$$Risk = 1 - \exp(-CDI \times SF)$$

where:

Risk = a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer;

exp = the exponential;

CDI = chronic daily intake averaged over 70 years (mg/kg-day); and

SF = slope factor, in $(mg/kg\text{-}day)^{-1}$.

NONCANCER HAZARD QUOTIENT

Noncancer Hazard Quotient = E/RfD

where:

E = exposure level (or intake);

RfD = reference dose; and

E and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or shorter-term).

potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose derived for a similar exposure period. This ratio of exposure to toxicity is called a hazard quotient and is described in the box in the opposite column.

The noncancer hazard quotient assumes that there is a level of exposure (i.e., RfD) below which it is unlikely for even sensitive populations to experience adverse health effects. If the exposure level (E) exceeds this threshold (i.e., if E/RfD exceeds unity), there may be concern for potential noncancer effects. As a rule, the greater the value of E/RfD above unity, the greater the level of concern. Be sure, however, not to interpret ratios of E/RfD as statistical probabilities; a ratio of 0.001 does not mean that there is a one in one thousand chance of the effect occurring. Further, it is important to emphasize that the level of concern does not increase linearly as the RfD is approached or exceeded because RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects. Thus, the slopes of the dose-response curve in excess of the RfD can range widely depending on the substance.

Three exposure durations that will need separate consideration for the possibility of adverse noncarcinogenic health effects are chronic, subchronic, and shorter-term exposures. As guidance for Superfund, chronic exposures for humans range in duration from seven years to a lifetime; such long-term exposures are almost always of concern for Superfund sites (e.g., inhabitants of nearby residences, year-round users of specified drinking water sources). Subchronic human exposures range in duration from two weeks to seven years (as a Superfund program guideline) and are often of concern at Superfund sites. For example, children might attend a junior high school near the site for no more than two or three years. Exposures less than two weeks in duration are occasionally of concern at Superfund sites. For example, if chemicals known to be developmental toxicants are present at a site, short-term exposures of only a day or two can be of concern.

8.2.2 AGGREGATE RISKS FOR MULTIPLE SUBSTANCES

At most Superfund sites, one must assess potential health effects of more than one chemical (both carcinogens and other toxicants). Estimating risk or hazard potential by considering one chemical at a time might significantly underestimate the risks associated with simultaneous exposures to several substances. To assess the overall potential for cancer and noncancer effects posed by multiple chemicals, EPA (1986b) has developed *Guidelines for the Health Risk Assessment of Chemical Mixtures* that can also be applied to the case of simultaneous exposures to several chemicals from a variety of

sources by more than one exposure pathway. Although the calculation procedures differ for carcinogenic and noncarcinogenic effects, both sets of procedures assume dose additivity in the absence of information on specific mixtures.

Information on specific mixtures found at Superfund sites is rarely available. Even if such data exist, they are often difficult to use. Monitoring for "mixtures" or modeling the movement of mixtures across space and time present technical problems given the likelihood that individual components will behave differently in the environment (i.e., fate and transport). If data are available on the mixtures present at the site, but are not adequate to support a quantitative evaluation, note the information in the "assumptions" documentation.

Carcinogenic effects. The cancer risk equation described in the box below estimates the incremental individual lifetime cancer risk for simultaneous exposure to several carcinogens and is based on EPA's (1986a,b) risk assessment guidelines. This equation represents an approximation of the precise equation for combining risks which accounts for the joint probabilities of the same individual developing cancer as a consequence of exposure to two or more carcinogens.[1] The difference between the precise equation and the approximation described in the box is negligible for total cancer risks less than 0.1. Thus, the simple additive equation is appropriate for most Superfund risk assessments.

CANCER RISK EQUATION FOR MULTIPLE SUBSTANCES

$$Risk_T = \Sigma\, Risk_i$$

where:

$Risk_T$ = the total cancer risk, expressed as a unitless probability; and

$Risk_i$ = the risk estimate for the ith substance.

The risk summation techniques described in the box on this page and in the footnote assume that intakes of individual substances are small. They also assume independence of action by the compounds involved (i.e., that there are no synergistic or antagonistic chemical interactions and that all chemicals produce the same effect, i.e., cancer). If these assumptions are incorrect, over- or under-estimation of the actual multiple-substance risk could result.

Calculate a separate total cancer risk for each exposure pathway by summing the substance-specific cancer risks. Resulting cancer risk estimates should be expressed using one significant figure only. Obviously, the total cancer risk for each pathway should not exceed 1. Exhibit 8-2 provides a sample table format for presenting estimated cancer risks for specified exposure pathways in the "Total Pathway Risk" column.

There are several limitations to this approach that must be acknowledged. First, because each slope factor is an upper 95th percentile estimate of potency, and because upper 95th percentiles of probability distributions are not strictly additive, the total cancer risk estimate might become artificially more conservative as risks from a number of different carcinogens are summed. If one or two carcinogens drive the risk, however, this problem is not of concern. Second, it often will be the case that substances with different weights of evidence for human carcinogenicity are included. The cancer risk equation for multiple substances sums all carcinogens equally, giving as much weight to class B or C as to class A carcinogens. In addition, slope factors derived from animal data will be given the same weight as slope factors derived from human data. Finally, the action of two different carcinogens might not be independent. New tools for assessing carcinogen interactions are becoming available (e.g., Arcos *et al.* 1988), and should be considered in consultation with the RPM. The significance of these concerns given the circumstances at a particular site should be discussed and presented with the other information described in Section 8.6.

Noncarcinogenic effects. To assess the overall potential for noncarcinogenic effects posed by more than one chemical, a hazard index (HI) approach has been developed based on EPA's

(1986b) *Guidelines for Health Risk Assessment of Chemical Mixtures*. This approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures. The hazard index is equal to the sum of the hazard quotients, as described in the box below, where E and the RfD represent the same exposure period (e.g., subchronic, chronic, or shorter-term). When the hazard index exceeds unity, there may be concern for potential health effects. While any single chemical with an exposure level greater than the toxicity value will cause the hazard index to exceed unity, for multiple chemical exposures, the hazard index can also exceed unity even if no single chemical exposure exceeds its RfD.

NONCANCER HAZARD INDEX

$$\text{Hazard Index} = E_1/RfD_1 + E_2/RfD_2 + \ldots + E_i/RfD_i$$

where:

E_i = exposure level (or intake) for the ith toxicant;

RfD_i = reference dose for the ith toxicant; and

E and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or shorter-term).

It is important to calculate the hazard index separately for chronic, subchronic, and shorter-term exposure periods as described below. It is also important to remember to include RfDs for the noncancer effects of carcinogenic substances.

(1) Noncarcinogenic effects -- chronic exposures. For each chronic exposure pathway (i.e., seven year to lifetime exposure), calculate a separate chronic hazard index from the ratios of the chronic daily intake (CDI) to the chronic reference dose (RfD) for individual chemicals as described in the box below. Exhibit 8-3 provides a sample table format for recording these results in the "Pathway Hazard Index" column.

CHRONIC NONCANCER HAZARD INDEX

$$\text{Chronic Hazard Index} = CDI_1/RfD_1 + CDI_2/RfD_2 + \ldots + CDI_i/RfD_i$$

where:

CDI_i = chronic daily intake for the ith toxicant in mg/kg-day, and

RfD_i = chronic reference dose for the ith toxicant in mg/kg-day.

The CDI is identified in Exhibits 6-11 through 6-19 and 6-22 and the RfD is identified in Exhibit 7-2.

(2) Noncarcinogenic effects -- subchronic exposures. For each subchronic exposure pathway (i.e., two week to seven year exposure), calculate a separate subchronic hazard index from the ratios of the subchronic daily intake (SDI) to the subchronic reference dose (RfD_s) for individual chemicals as described in the box on the next page. Exhibit 8-4 provides a sample table format for recording these results in the "Pathway Hazard Index" column. Add only those ratios corresponding to subchronic exposures that will be occurring simultaneously.

(3) Noncarcinogenic effects -- less than two week exposures. The same procedure may be applied for simultaneous shorter-term exposures to several chemicals. For drinking water exposures, 1- and 10-day Health Advisories can be used as reference toxicity values. Depending on available data, a separate hazard index might also be calculated for developmental toxicants (using RfD_{dt}s), which might cause adverse