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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
ml	milliliter
MSDS	material safety data sheet
NMED	New Mexico Environment Department
NOS	not otherwise specified
PCBs	polychlorinated biphenyls

LIST OF ABBREVIATIONS/ACRONYMS (Continued)

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 Amended Closure Plan has been prepared by the New Mexico Environment Department (NMED) as documentation of Los Alamos National Laboratory's (the Laboratory's) intent to perform a clean closure of TA-35 TSL-85 surface impoundment in accordance with the requirements of 40 CFR §265.228 (here and throughout this document, references to federal regulations include their state analogs). This plan is a an amended version of the December 1991 Closure Plan for the TA-35 TSL-85 surface impoundment, for which NMED issued a letter denying Clean Closure Equivalency Demonstration and Disapproval of Closure Plan on June 21, 1993.

Initial investigations of the surface impoundment determined that an inactive underground storage tank connects to the surface impoundment. The Laboratory intends to address decontamination and removal of the tank as part of the surface impoundment closure. The surface impoundment is located on the rim of Mortandad Canyon, and, depending on the extent of any contamination associated with the unit, soil removal undertaken to attain "clean" closure potentially impacts the stability of the canyon wall. To minimize destabilization of the site, it is desirable to maintain the existing slope and to allow the native vegetation currently established to remain as undisturbed as possible. For this reason, if contamination at the site is found to be really extensive, the Laboratory will follow U.S. EPA guidance in establishing health-based "clean level" concentrations for any hazardous wastes or constituents that analytical results show to have been released from the unit. The U.S. EPA states that closure to these health based "clean levels" is considered sufficient to meet the clean closure requirements of 40 CFR §265.228(a)(1). This Closure Plan has been amended to provide information sufficient to satisfy the equivalency determination requirements given in 40 CFR §270.1(c)(6) and further described in the Office of Solid Waste and Emergency Response Directive 9476.00-18 (May 12, 1989).

To achieve clean closure the Laboratory will remove of standing liquids, wastes and waste residues from the surface impoundment, the inactive underground storage tank, and their associated structures, and, removal of any underlying and/or surrounding soil contaminated with hazardous constituents. The Laboratory will also remove any contaminated media from the Mortandad Canyon Spill Pathway and other associated areas impacted by any releases from the unit as defined in 40 CFR § 264.501, Subpart S. A risk assessment shall be performed based upon analytical data from the site. This risk assessment will be used to determine the extent of soil removal necessary to meet clean closure criteria. All soil with contamination above the "non-detect level" will be removed as part of the closure effort, and the site will be backfilled, regraded, and seeded with native vegetation as required by EPA Cover Design Guidance Documents. In addition, decontamination and removal of the underground storage tank system will be addressed as part of this closure effort in Sections 4.3 and 5.2 of this Amended Closure Plan.

2.0 FACILITY DESCRIPTION

The Laboratory occupies an area of 43 square miles in Los Alamos County Figure 1) located in north central New Mexico. The Laboratory and the associated residential areas of Los Alamos and White Rock are situated on Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-west trending canyons. The mesa tops range in elevation from approximately 7,800 feet at the flank of the Jemez Mountains (located to the west of Los Alamos) to about 6,200 feet at their eastern extent where they terminate above the Rio Grande Valley. Streams flow intermittently through the bottoms of the east-west trending canyons.

The Laboratory is divided into 48 active Technical Areas (TAs) (Figure 2). TA-35 is north-centrally located and is flanked by Mortandad Canyon to the north and Ten Site Canyon to the south (Figure 3). TA-35 is underlain by volcanic bedrock; the main aquifer lies approximately 1,200 feet below the surface. Detailed descriptions of the geology and hydrology are presented in the RCRA Part B Permit Application for the Laboratory and in the Hydrogeologic Assessment of Technical Area 54, Areas G and L.

Building 85 is centrally located on the northern edge of TA-35 (Figure 3). The surface impoundment, built in 1985 and brought into use by early 1986, is situated just northeast of the building, close to the rim of Mortandad Canyon.

2.1 SURFACE IMPOUNDMENT

The surface impoundment was initially used to contain accidental spills. The impoundment was also used to contain liquids, primarily oil and mop water which were discharged through floor drains, from inside Building 85.

The surface impoundment is approximately 34 feet in length by 24 feet in width, covering an area of approximately 816 square feet (Photograph 2-1). The impoundment sides are sloped at a ratio of one to one and are constructed of wire mesh sprayed with approximately four inches of gunite. The bottom of the impoundment consists of a four-inch thick wire reinforced gunite slab, the surface of which is protected with a 15-mil waterproof coating. The surface impoundment is four feet deep and has an effective capacity (with a two-foot freeboard) of 7,640 gallons. Engineering drawings for the impoundment are presented in Figure 4.

There is no permanent outfall from the surface impoundment; however, the impoundment is suspected of having overtopped during the rainy spring of 1988, releasing an unknown volume of liquids. Sandbags were subsequently installed around the surface impoundment in an effort to prevent any additional overtopping.

2.2 PIPING AND ASSOCIATED STRUCTURES

Two six-inch schedule 40 PVC pipes (Photographs 2-2, 2-3, and 2-4) drain into the surface impoundment on its west side, by traversing along the top of the impoundment, five feet from the bottom, and tapering down into the impoundment. Therefore, the PVC pipe does not penetrate the gunite liner (Figure 4). One pipe leads to a drain in a bermed storage pad located on the east side of Building 85. This storage pad contains a 15,000 gallon above ground Marx tank. The other pipe is connected to an inactive underground storage tank located to the west of the surface impoundment. Although the original purpose of the underground storage tank is not known and no inflow lines are currently connected to it, Laboratory personnel indicate that it was thought to be a flow-through settling tank

(McInroy, 1991). The period during which the tank was actively used also is not known, but is believed to have ceased prior to 1985. Activities conducted in Building 85 and the nature of any discharges to the surface impoundment associated with these activities are described in Section 3.0.

3.0 PROCESS INFORMATION

Building 85 is used for developing electron guns and related laser assemblies/equipment for a Laser Technology Research Program at the Laboratory. Equipment utilized in the building requires the use of nonhazardous insulating oil. The storage pad, upon which the Marx tank is located outside Building 85, drains to the surface impoundment and may have discharged cleanup water containing accidental spills and de minimus losses of insulating oil to the surface impoundment. Other potential sources of releases that may have drained to the surface impoundment include the Marx tanks located inside Building 85 and washwater from equipment- and floor-cleaning activities. Some of these oils and liquids may have contained degreasing solvents, the primary source of hazardous constituents in the waste oil stored in the surface impoundment.

Although the likelihood for Building 188 to have historically contributed to the TSL-85 waste stream is not certain, it is considered a potential source because lines that may have been connected to the underground storage tank at one time were traced to Building 188. It is thought that the wastes from Building 188 may have been similar to those from Building 85. Building 188 was meant to be used as a high voltage test area and was used for that purpose for a short period of time, before becoming a facility for chemical analysis (gasses only) and a machine shop (Umphres, 1991). No records are available to document this potential waste stream contribution.

3.1 SURFACE IMPOUNDMENT

The surface impoundment normally receives nonhazardous insulating oil and equipment/floor cleaning rinseate via the floor drain in the bermed storage pad located outside of Building 85. In addition, the impoundment receives rainfall runoff from the bermed storage pad area. The liquids form two phases in the impoundment, an upper oil phase underlain by a water phase. Subsequent to the accumulation of rinseate from cleanup operations and insulating oil from Marx tank losses in the surface impoundment, the oil phase is pumped out and transferred to the TA-54, Area L storage area. Based on analytical results, the insulating oil is transported offsite for either recycling or disposal at RCRA permitted facilities. The remaining water phase is also removed from the impoundment and handled in the same manner.

3.2 FLOOR DRAIN AND PIPING

The floor drain in the bermed storage pad area captures rinseate and insulating oil spills that may occur inside Building 85, spills from the Marx tank located on the storage pad, and rainfall. These fluids empty directly from the floor drain to the surface impoundment via the PVC drain pipe.

3.3 UNDERGROUND STORAGE TANK AND PIPING

A past potential intermediate receptor of waste from Building 85, and possibly from Building 188, is the inactive underground storage tank system. Although no inflow lines to the underground storage tank exist today, lines may have transmitted waste to the underground storage tank from Building 85 and possibly from Building 188 in the past. Because the underground storage tank is connected to the surface impoundment via a PVC drain pipe, most waste flowing into the underground storage tank eventually drained into the surface impoundment.

4.0 WASTE INVENTORY

Process knowledge of the operations at Building 85 indicates that Shell DIALA(R) OIL AX is the only insulating oil that has been used in Building 85. Process knowledge for the types of waste contributed to the surface impoundment from operations in Building 188 is insufficient to make a judgement concerning Building 188's impact on the surface impoundment.

4.1 SURFACE IMPOUNDMENT

The surface impoundment is subject to regulation as a hazardous waste management unit because of the suspected introduction of degreasers into the waste stream during cleaning and maintenance of equipment parts and the floors in Building 85. Degreasers have entered the surface impoundment through the piping that connect the floor drain in the storage pad to TSL-85.

Analytical results of a grab sample collected from the surface impoundment on June 9, 1988 confirmed the presence of degreasers. The sample was collected using a composite liquid waste sampler (COLIWASA) illustrated in Figure 12. COLIWASA's obtain a vertical composite of the two-phase liquid and sludge. The sample was stored in appropriate containers and preserved as specified in Section 5.5. and Table 1. The sample was analyzed for volatile organics, semivolatile organics, the results of which are found in Table 8. Toxicity Characteristic Leaching Procedure (TCLP) for metals (Table 10), polychlorinated biphenyls (PCBs) (Table 11), and radionuclide activity. Results of volatile organic analyses indicate the presence of a cleaning degreaser profile with parts per million (ppm) concentrations of 1,1,2-trichloro-1,2,2-trifluoroethane and parts per million (ppm) concentrations of acetone (Table 8). Surrogate spike recoveries for the volatile organic analyses are reported in Table 9. Semivolatile organic results were inconclusive because of the presence of the oil phase in the sample. No EP Toxic concentrations of metals were detected in the liquid sample; however, the sludge sample contained a total lead concentration of 5.2 ppm (Table 10). Radiological analyses of the sample detected 10.0 picocuries per liter (pCi/L), 5.6 pCi/L, and -600 pCi/L[1] of alpha, beta, and gamma activity, respectively. These values indicate that radionuclide activity was below both background concentrations and the maximum contaminant concentration for drinking water established by U.S. EPA. Analytical results from surface impoundment oil/water grab samples collected on June 9, 1988 and previous dates indicate the absence of detectable levels of PCBs in the insulating oil waste stream on those dates (Table 11).

4.1.1 Estimate of Maximum Volume of Liquid in the Surface Impoundment

The amount of waste oil/water stored in the surface impoundment has varied with time, and no complete records of the total waste volume contained at the TSL-85 surface impoundment are available. Based on its dimensions, the maximum capacity of the surface impoundment, including the two feet of freeboard, is 7,640 gallons. During the period of heavy rainfall in the summer of 1988, however, the maximum capacity of the unit was exceeded.

4.2 FLOOR DRAIN AND PIPING

The floor drain and piping inside Building 85 and the drain below the bermed storage pad outside of Building 85 have captured spills of insulating oil and

[1]Note: Negative value indicates concentration below analytical detection limits.

equipment/floor cleaning rinsate and directed it to the surface impoundment. Introduction of volatile organic compounds such as 1,1,2-trichloro-1,2,2-trifluoroethane into the waste stream is suspected to be through the use of cleaning/degreaser compounds for floor cleaning and equipment maintenance.

4.2.1 Estimate of Floor Drain and Piping Waste Volume

The floor drain and piping that drain to the surface impoundment are designed such that liquid does not pond, but instead is drained immediately into TSL-85. Therefore, there is no standing liquid in these areas.

4.3 UNDERGROUND STORAGE TANK AND PIPING

The inactive underground storage tank located west of the surface impoundment is connected to TSL-85 through a six-inch schedule 40 PVC pipe. Laboratory personnel believe that piping from Building 85 and possibly from Building 188 may have been connected to the underground storage tank in the past. Because the contents in the underground storage tank were able to drain to TSL-85 via the PVC pipe, the underground storage tank was an intermediate receptor of surface impoundment waste prior to its decommissioning.

4.3.1 Estimate of Waste Volume in the Underground Storage Tank

No records are available identifying the total waste volume that passed through the underground storage tank. The underground storage tank has a capacity of 3,000 gallons. The contents of the underground storage tank drain through the piping into TSL-85, and the maximum volume of waste stored in the underground storage tank system would be less than the 3,000 gallons.

5.0 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). For a description of Phase I through Phase V see Table 12.

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. 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 6.0 of this Amended Closure Plan. As a result of the risk evaluation, all detected hazardous constituents will be addressed as determined appropriate by LANL with NMED approval.

5.1 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 are indicated in Figure 8. Six soil samples will be collected at a depth of 2 to 3 feet at the approximate locations shown on Figure 5. The soil samples will be collected with a hand auger in accordance with the procedure described in Section 5.4.1.2, placed in approved containers, and preserved appropriately (Table 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 2), SVOCs (Table 3), pesticides and herbicides (Table 4), and metals (Table 5) that their in-house laboratories have the analytical capability to perform. Table 6 has been provided for reference and summarizes the Appendix VIII constituents for which EM-9 can analyze with the associated *SW-846* methods. Table 7 is a list of constituents that LANL EM-9 cannot test for at this time.

5.2 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 as indicated in Figure 9. Twelve soil samples will be collected, following the procedures described in Section 5.4.1.2, at a depth of 3.5 to 4.5 feet below the location of the former Underground Storage Tank and Associated Piping. These new

samples will be taken as near the same sampling locations used for Phase III sampling as is possible. 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 6). The soil samples will be collected with a hand auger in accordance with the procedure described in Section 5.4.1.2, placed in approved containers, and preserved appropriately as summarized in Table 1. They will be accompanied by the proper chain-of-custody and request for analysis forms. The samples will be analyzed for VOCs (Table 2), SVOCs (Table 3), pesticides and herbicides (Table 4), and metals (Table 5).

5.3 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 six (6) inches at approximately the same sampling locations from which the Phase IV samples were taken (Figures 7 and 10). The samples will be collected using a disposable teflon trowel or scoop in accordance with the procedure described in Section 5.4.1.1, placed in approved containers, and preserved as stated in Table 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 2), SVOCs (Table 3), pesticides and herbicides (Table 4), and metals (Table 5).

5.4 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). 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.

5.4.1 Soil Sampling Procedures

Soil sampled from the surface to depths five-feet below the former location of the bottom of the removed surface impoundment liner will be collected with a trowel, scoop, or hand-held auger. These samples will be taken from pre selected depths and locations within the Sampling Grid illustrated in Figure 11. 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 1).

5.4.1.1 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.

5.4.1.2 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 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.

5.4.2 Rinsate Sampling Procedures

A composite liquid waste sampler (Coliwasa illustrated in Figure 12) or similar device will be used to sample rinsate from equipment cleaning. As an alternative to the Coliwasa, disposable Coliwasa 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.

5.4.2.1 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.

5.4.2.2 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.

5.4.3 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 (Figure 13). 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.

5.4.4 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 6.

5.5 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 5.4.2 and outlined in *SW-846*. The samples will be analyzed for all Appendix VIII VOCs (Table 2), SVOCs (Table 3), pesticides and herbicides (Table 4), and metals (Table 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 5.4.2. Protective clothing utilized during the sampling effort will be collected and disposed as hazardous waste at an off-site RCRA-permitted facility.

5.6 ANALYSIS NOT PERFORMED AT LANL EM-9

All samples taken from the TA-35, TSL-85 Surface Impoundment Site will be analyzed for all Appendix VIII constituents. Those constituent analysis not within the capabilities of EM-9 to Perform will be sent to an EPA recognized independent laboratory capable of performing the analysis for the constituents in question. For a list of constituents not tested for by EM-9 see Table 7.

6.0 PROPOSED RISK EVALUATION

The risk evaluation proposed in this Amended Closure Certification Plan 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 Underground Storage Tank 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. These Risk Assessments shall address the most conservative levels of risk, that of residential use standards.

6.1 CALCULATION OF ACTION LEVELS

Health-based soil concentration action levels will be calculated for the constituents listed in Tables 2 through 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) which is Appendix D of this Amended Closure Plan, for the soil ingestion pathway only. 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. Results of these calculations are found in Tables 13, 14 and 15.

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

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

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)

6.2 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) which is Appendix C of this Amended Closure Plan. 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.

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 C of this closure plan).

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:

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

where:

HQ_i = Hazard quotient for the ith toxicant.

Aggregate risk is calculated from:

$$\text{Aggregate Risk} = \Sigma\ Risk_i$$

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 $1x10^{-6}$, 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 standards for residential use. 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 $1x10^{-6}$, clean closure of the site will be considered achieved because the site does not pose an unacceptable risk to human health or the environment.

6.3 RISK CHARACTERIZATION

A risk characterization will be included in the Amended Closure Certification Report that presents quantitative and qualitative descriptions of risk at residential level of exposure. 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."

7.0 CLOSURE DESIGN

The procedures that will be implemented to close the TA-35 TSL-85 surface impoundment and associated structures are designed to achieve the following performance standards:

- Protection of human health and the environment;
- Prevention of the escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall, or waste decomposition products to the ground or surface waters or atmosphere; and
- Minimization of future maintenance.

The Laboratory plans final closure for this area by the spring of 1995.

In compliance with HWMR-7, Pt. VI, 265.228(a)(1), this closure plan for Technical Area 35 TSL-85 Surface Impoundment includes a soil removal, sampling, analysis and evaluation plan. This plan outlined, in Table 12, details a five-phase approach to demonstrate clean closure verification for TA-35, TSL-85 Surface impoundment site that includes an assessment of site conditions and subsequent management of any hazardous equipment, structrues, wastes, and/or materials associated with the site. LANL will remove all waste residues, contaminated systems, structures, and equipment an manage them as hazardous waste.

7.1 WASTE REMOVAL PROCEDURES

The waste liquids and residues contained within the surface impoundment will be removed as part of the closure process. The procedures used to remove these wastes are described in the following sections.

7.1.1 Liquid Removal

All liquid waste contained within the surface impoundment has been and will be disposed as a hazardous waste. In the past, as fluid levels approached the two-foot freeboard limit, EM-7, the Laboratory's waste management group, was contacted and an off-site transport contractor was scheduled to collect and remove the waste liquids. A dedicated transfer pump and hose were used to pump the liquid from the surface impoundment into a hazardous waste tanker truck. The fluid was then transported off-site to a RCRA-permitted TSD facility. Waste liquid disposal during closure of the surface impoundment will follow the above procedures.

All state and federal regulatory requirements pertaining to the management of these liquid wastes have been and will be observed, including the 40 CFR Part 268 land disposal restrictions.

7.1.2 Residue Removal

Solid residue remaining in the floor of the surface impoundment will be excavated and placed in DOT-approved containers. The removal method used will depend on the physical characteristics of the residue. Because previous analytical results show the residue may be hazardous (Section 4.0), it will be placed in DOT-approved containers. To expedite closure activity, an area at or near the site will be constructed where containers are able to accumulate for 90 days or less. The area will be paved, blocked off from vehicular and pedestrian traffic, and

appropriate signs will be posted around its perimeter. The containers will be properly labelled and stored on pallets, routine inspections of the area will be made, and all required documentation will be maintained. The containers will then be transferred to TA-54, Area L, the Laboratory's permitted hazardous waste storage area, to await final disposition. Any additional sampling necessary to facilitate treatment or disposal of the waste residues will be performed prior to transfer to Area L. All waste residues will be considered hazardous and managed accordingly.

7.2 DECONTAMINATION AND REMOVAL OF THE UNDERGROUND STORAGE TANK, SURFACE IMPOUNDMENT LINER, SANDBAGS, AND ASSOCIATED PIPING

The following steps will be taken to decontaminate and remove the underground storage tank, liner and sandbags, associated piping, and soil so that clean closure criteria are met.

7.2.1 Leak Testing, Decontamination, and Removal of the Underground Storage Tank and Piping

Prior to removal, the tank will be pressure tested for possible leakage. This pressure test will be conducted as follows: all plumbing fixtures will be sealed, and the tank will be filled with compressed air to approximately 10 to 25 pounds per square inch gauge. If the tank can maintain its initial charge pressure for approximately 48 hours, then it will be considered a non-leaking tank.

Both the underground storage tank and the two six-inch schedule 40 PVC pipes leading to the surface impoundment will be decontaminated using a rinse containing a surfactant such as Liquinox or Alconox. All rinsate will be collected in a temporary containment system, and subsequently transferred into DOT-approved containers. Each sample will be analyzed for volatile organic compounds identified in Table 2, Semivolatile Organics specified in Table 3, PCBs in Table 4, and Toxicity Characteristic Leaching Procedures (TCLP) metals identified in Table 5. Composite sampling will not be used for this clean closure. If analytical results characterize the rinsate as a hazardous waste, the rinsate will be managed and disposed in compliance with all state and federal requirements. The decontamination washing, rinsate collection, sampling and analyses will be repeated until the results no longer show detectable or TCLP concentrations of contaminants, as appropriate.

Due to the fact that there is an occupance of multiple hazardous waste constituents present in the soil at the closure, PCB values must be included in the calculation during risk assessment for aggregate risk or for the hazard index. The maximum concentration of PCBs detected in the soils was 1.1 parts per million (ppm). NMED standards are .09 or .9 ppm. LANL will resample the site to determine if further removal of contaminated soil and equipment is required to meet these standards.

To facilitate decontamination of the underground storage tank, it will be placed in a temporary containment system constructed for this purpose and steam-cleaned using a high-pressure, hot-water washer. The water will be collected, containerized, sampled, and analyzed in the manner described above. If decontamination of the underground storage tank and/or any of the lines cannot be accomplished, the material will be excavated, drummed, and disposed as a hazardous waste.

Areas sampled in the 1989 Phase III and Phase IV projects who's sampling locations are identified in Figures 6 and 7 will be resampled and analyzed for SVOCs. The proposed risk evaluation (Section 6) will include an evaluation of the risk in these areas based on the new analytical data resulting from the additional sampling effort and Phase VI investigation. The area beneath the UST and associated piping will be included in this new sampling effort and analysis. Composite sampling is not appropriate for this new series of sampling and analyses.

7.2.2 Decontamination and Removal of Surface Impoundment Liner and Sandbags

Soil directly below the gunite liner will be sampled and analyzed prior to its removal. To sample the soil, several one-foot square sampling ports will be cut through the gunite liner, and soil immediately below the liner will be collected to a depth of six to eight inches. ("Soil" samples will include samples of tuff when encountered.) Samples will be analyzed for volatile and semivolatile organic compounds identified in Tables 2 and 3, PCBs identified in Table 4, and metals identified in Table 5 (using the TCLP test procedure or a total metals analysis). All of the sampling ports will be closed and sealed immediately after sampling using a gunite or concrete patch material compatible with the original liner material so that no future potential fluid seepage (e.g., rainwater) can penetrate these sampling ports before the liner is removed. Detailed soil sampling procedures and the methodology used to establish a clean level for any contaminants found in the subsoil are described in Section 5.3.

If analytical results demonstrate that contamination is associated with the gunite liner, the liner will be removed and managed as a hazardous waste. The gunite liner and all below-grade contaminated soils will be broken into sizes suitable for placement into DOT-approved containers. The containers will be placed in the 90-day-or-less accumulation area on or near the site and all procedures previously described in Section 5.1.2. will be followed. The containers will then be transferred to the TA-54, Area L storage area until they can be treated at Laboratory facilities or disposed off-site at a RCRA-permitted facility.

If analytical results of the soil sampled below the gunite liner demonstrate that no contamination is present, the liner surface will be decontaminated, using the following procedures, and managed as a nonhazardous waste. First, the liner will be rinsed using a high-pressure, hot-water sprayer to remove remaining residues. The rinsate and any commingled residues will be collected and disposed as hazardous waste. Then the liner will be scrubbed using a surfactant, such as Liquinox or Alconox, and rinsed with the high-pressure, hot-water sprayer. All rinsate will be collected and handled in the same manner as the waste liquids originally removed. The rinse/wash water, prior to use, and the rinsate will be sampled, analyzed and managed in the same manner as the other liquids. When decontamination is complete, the liner will then be broken, removed, and disposed in a nonhazardous waste landfill.

As previously noted, sandbags were used to prevent overtopping of the surface impoundment. As part of the closure process, these sandbags will be drummed in DOT-approved containers and managed as hazardous waste in accordance with all applicable regulations.

7.2.3 Decontamination and Removal of Associated Piping

Following decontamination and removal of the liner and sandbags, the drain from the bermed storage pad will be disconnected from the pipe, capped, and the PVC

pipe will be removed. If it is not economical to remove all of the six-inch PVC piping, then it will be decontaminated in place. The remaining portions of decontaminated piping will be sealed and filled with cement. In no event will any piping be left in place if it has not been completely decontaminated.

The decontaminated underground storage tank's excavated piping will be disposed in a nonhazardous waste landfill along with the underground storage tank. In the event that the tank or piping cannot be decontaminated, these materials will be cut into smaller sizes and placed in DOT-approved containers. These will then be transported to an off-site RCRA-permitted TSD facility.

7.3 SOIL REMOVAL, SAMPLING, ANALYSIS AND EVALUATION PLAN

After the liner has been removed, and if samples underneath the liner indicate that contamination is present, additional sampling and analysis of the soil below the liner will be performed. The following sections present plans for further soil removal, determining the number and the location of samples to be collected and the procedures to be used for collection, storage, and preservation of samples.

Following U.S. EPA guidance the Laboratory will document that no unacceptable levels of contamination remain at the site as a result of releases from the units undergoing closure pursuant to this plan. "Contamination" is here defined as concentrations of naturally occurring contaminants that exceed background concentrations and, for non-naturally occurring contaminants, concentrations that exceed health-based limits acceptable to NMED.

As an initial screen, contaminated soil will be excavated if it exceeds the upper 90 percent confidence interval established for background concentration levels for each of the metals found in the waste liquids and waste residues. Background composite soil samples will be used to compare metal levels at the TSL-85 site. Metals concentrations in samples collected from Sigma Mesa (Ferenbaugh et al., 1990) will be used for the background samples. See Appendices A and B for these background levels.

A second screen in the removal process will involve excavating, to the extent possible, soil that contains volatile and semivolatile organic compounds in concentrations greater than 1.0 ppm. The 1.0 ppm guideline is arbitrarily established as a level below which concentrations are unlikely to exceed health-based levels. By using a field-screening technique rather than relying on time-consuming laboratory analysis, removal of soil indicating contamination over the 1.0 ppm level can expedite the clean-up process. For the Closure Certification Report Laboratory Analysis will be used to verify field screening procedure results.

A six-stage approach to soil removal, sampling, and analysis is proposed. The results of each phase will be evaluated to determine whether the next phase is necessary to verify clean closure. The following outlines the Laboratory's plan for soil removal, sampling, and analysis.

- **Gunite Liner Decontamination Verification:** Decontamination verification of the gunite liner will include sampling of soil immediately below the liner and disposal of the liner. Fourteen soil samples will be taken immediately below the gunite liner and analyzed for volatile and semivolatile organic constituents, PCBs, and metals. If the results of soil analyses indicate

contamination exceeds "clean levels," further soil sampling will be performed, as described in the following phases, and the gunite liner will be disposed as a hazardous waste. If the results of soil analyses indicate contamination meets "clean levels," no further sampling below the gunite liner will be performed, and the liner will be disposed as a nonhazardous waste.

- **Clean Closure Verification Phase 1-Soil Removal, Sampling, and Analysis:** If necessary, further clean closure verification sampling will be conducted after the surface impoundment liner and any contaminated soil located immediately below the liner have been removed. A 48-foot long by 32-foot wide grid will be centered over a diagram of the excavated impoundment location (Figure 11). This grid will consist of 384 individual two-foot square sampling locations, as seen in Figure 5-1. Approximately 24 sampling locations will be randomly selected in accordance with Test Methods for Evaluating Solid Wastes, EPA SW-846 (SW-846). Soil samples will be collected from these locations at a depth of approximately six inches below grade of the excavated impoundment area. The samples will be analyzed for volatile and semivolatile organic compounds (Tables 2 and 3), PCBs in Table 4, and metals identified in Table 5.

  If contaminants remain, their concentrations will be compared to background metals concentrations and the 1.0 ppm guideline established for volatiles and semivolatiles. Further excavation, sampling and analysis will be based on the contaminant concentrations remaining in the soil.

- **Clean Closure Verification Phase 2-Corehole Drilling, Sampling, and Analysis:** If sampling and analytical results from Phase I are not adequate to verify clean closure, core samples will be collected to determine the vertical extent of any remaining contamination. Three test holes will be drilled within the surface impoundment boundaries to approximately 45-50 feet below ground surface. Five to ten samples will be collected from each test hole at selected intervals, based on actual field and drilling conditions. These soil samples will be collected and analyzed for final clean closure verification.

- **Clean Closure Verification Phase 3-Soil, Sampling and Analysis Below the UST and Lines:** To verify decontamination of the soil below the UST and lines, approximately twelve locations will be sampled and analyzed for volatile and semivolatile organic compounds, PCBs, and metals.

- **Clean Closure Verification Phase 4-Soil Sampling and Analysis Along Canyon Spill Path Routes:** To verify that contamination above clean levels has not migrated along spill path routes into Mortandad Canyon, approximately eleven samples will be collected downgradient of the surface impoundment into Mortandad Canyon along spill path routes. The samples will be spaced approximately ten to fifteen feet apart, and collected at a depth of approximately six inches below the level of the removed contaminated material.. The soil samples will be analyzed for volatile and semivolatile organic constituents, PCBs, and metals.

- **Clean Closure Verification Phase 5-Corehole Drilling, Sampling, and Analysis:** Because of the anticipated high levels of total petroleum hydrocarbons in the soil around the TSL-85 site, an additional investigative phase may be necessary. If sampling and analytical results from Phase 1 and 2 are not adequate to verify clean closure in the area of the impoundment, additional coreholes will be drilled. Soil samples from the additional coreholes will be collected at five-foot intervals to approximately 45 feet. The soil samples will be analyzed for volatile and semivolatile organic constituents, and petroleum hydrocarbons.

All samples will be collected, stored, and preserved in accordance with protocols described in Section 5.5. Surface and subsurface soil samples will be analyzed for volatile and semivolatile organic compounds (Tables 2 and 3), PCBs in Table 4, and metals listed in Table 5. If soil remains that contains volatile and semivolatile organic compounds, PCBs, or metals, a risk assessment will be performed to determine if these constituent concentrations are below levels posing a threat to human health and the environment. If the risk assessment demonstrates that contaminants in the remaining soil pose no threat to human health or the environment, then the soil will be left in place. If the risk assessment determines that unacceptable levels of constituents remain in the soil, the soil will be excavated and removed to "clean level" concentrations.

When performed, the risk assessment will be conducted in accordance with U.S. EPA guidance documents (Appendix C) and will compare modeled exposure levels at the site to U.S. EPA-recommended limits or factors. These limits or factors include, at present, health-based limits calculated from verified reference doses (RFDs), carcinogenic potency factors (CPFs), and site-specific U.S. EPA-approved public health advisories. The exposure limits recommended by U.S. EPA are considered protective of human health and the environment.

It should be noted that, prior to performing the risk assessment, if the extent of contamination at the site is found to be minor and not extensive, then all soils within the contaminated area will be removed to the upper 90 percent confidence interval for background concentrations for total metals and to SW-846 analytical detection limits for volatile and semivolatile organic compounds and PCBs in soils. This extremely conservative approach would negate the need to perform a risk assessment and would expedite the closure process by eliminating the risk assessment step. If the volume of soil subject to removal significantly impacts the stability of the existing slopes, the risk assessment will be performed so that the most acceptable environmental impact can be determined.

7.4 GROUND WATER INVESTIGATION PLAN

A certified ground water monitoring waiver application meeting the requirements of 40 CFR §265.90 is maintained at the facility. This waiver application which is available for inspection, precludes the need for ground water monitoring in connection with closure of the TA-35 TSL-85 surface impoundment. Should the Ground Water Monitoring Waiver be denied or in the unlikely event that ground water is encountered during installation of any test hole drilled in connection with this plan, an approved ground water monitoring plan outlined in Appendix D will be implemented before Closure Certification is approved by NMED.

7.5 SAMPLING AND ANALYSIS PROCEDURES

The following sections define procedures and methods for sampling, analysis, and documentation applicable to this closure plan. 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 method to be more appropriate.

Adequate preparation ensures that proper sampling is accomplished. The sample collection personnel will be instructed to heed the following precautions:

- Do not smoke, eat, or handle any objects not necessary for sampling while performing sampling procedures.
- Do not sample downwind of any potential volatile organic compound sources such as car exhausts, open fuel tanks, etc. These could result in contamination of the sample. If any such sources are unavoidable, make a note of them in the field logbook.
- Leave caps on the sample containers until just before filling.
- Avoid handling the teflon bottle cap liners. Do not use any liner which falls out of the cap and onto the ground.
- Gloves should be worn when taking samples and when handling bottles, especially those with added preservative.

7.5.1 Waste Liquid and Rinsate Sampling Procedures

A COLIWASA sampler or similar device will be used to sample liquids in the surface impoundment and rinsate from the liner and equipment cleaning. The recommended model of the COLIWASA is shown in Figure 12. As an alternative to the COLIWASA, disposable COLIWASAs, or glass tubes may be used to sample liquids. The primary advantage in utilizing a disposable COLIWASA is that the COLIWASA will be disposed as hazardous waste after each sample is collected, thus eliminating the potential for cross-contamination.

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 quickly cleaned. Clean COLIWASA samplers will be stored in polyethylene plastic tubes or bags in a clean and protected area until they are used.

Sampling Procedures

- Assemble the clean glass COLIWASA sampler or disposable COLIWASA.
- Wear necessary protective clothing and gear and observe required sampling precautions.

- 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 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, record in the field logbook, and complete the sample analysis request sheet and chain-of-custody record (Section 5.4.3).

7.5.2 Soil Sampling Procedures

Soil sampled from the surface to five-foot depths will be collected with a trowel, scoop, or hand-held bucket auger. To sample below five-foot depths, samples will be collected using a drilling rig with continuous flight hollow stem augers and split-barrel dry core samplers and/or split-spoon samplers. Only clean sampling equipment will be used for soil sampling. All samples will be collected in U.S. EPA-approved containers and preserved in accordance with U.S. EPA methods (Table 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, attach a label, record in field logbook, and complete the sample analysis request sheet and chain-of-custody record (Section 5.4.3).

Split-Barrel Sampler

- Assemble the clean split-barrel sampler to the drill rod.
- Continuously core (split-barrel sampler) to desired depth.
- Withdraw the drill rod from the auger string and retrieve the split-barrel sampler.
- Store the core sample in an appropriate sample container and pack in an insulated container with ice.
- Label the sample, affix the seals, record in the field logbook, complete sample analysis request sheet and chain-of-custody record, and deliver the samples to the laboratory for analysis (Section 5.4.3).

Cleaning of Downhole Drilling Tools

All downhole drilling tools (augers, drill rods, etc.) will be steam cleaned or high-pressure, hot-water washed after completion of each test hole. The split-barrel sampler will be cleaned after each location or depth interval is sampled.

Drill cuttings and wash fluids will be separately collected in DOT-approved steel drums and containers, and analyzed to determine a proper disposal protocol.

Hazard Protection

Personnel involved with sampling, liquid removal, and residue removal from the surface impoundment and associated structures will use proper protective clothing and equipment. The Laboratory's Industrial Hygiene Group (HS-5) will be responsible for assessing hazards and determining protective clothing requirements.

7.5.3 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 and shall include, if applicable, the grid number referenced to positions staked on the site perimeter. The "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 situation without relying on the collector's memory.

The sample shipment and chain-of-custody record will be accompanied by a sample analysis request sheet (Figure 13) similar to Figure 5-4. 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 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.

7.5.4 Sample Analysis

All analyses, quality assurance, and quality control 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 Tables 2 through 5.

7.6 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 5.5. The samples will be analyzed for volatile and semivolatile organic compounds, PCBs, and metals for which there are TCLP standards to determine if background concentrations of hazardous constituents are present in the equipment prior to use. After use, all equipment used in sampling and removal of liquids and residues that is not dedicated to handling hazardous wastes will be scraped and brushed to remove any residue and then washed, rinsed and steam cleaned. Any nondedicated pumps will be decontaminated by pumping soap and water through the instrument. Any equipment that cannot be decontaminated will be disposed as a

hazardous waste. The residue collected will be placed in DOT-approved drums for treatment or disposal. Wash water, prior to use, and rinsate will be collected and handled in the same manner as rinsate generated from decontamination of the surface impoundment and tank. Representative samples of the final rinsate will be collected and analyzed as described above. Protective clothing will be collected and disposed as hazardous waste and shipped off-site to a RCRA-permitted facility.

After use, all equipment normally dedicated to handling hazardous wastes and used during the closure process will be scraped and brushed to remove residues and then returned to EM-7 for routine decontamination and maintenance. The residues will be managed as described above.

8.0 CLOSURE CRITERIA

8.1 CLOSURE SCHEDULE

If the preparation of documentation to establish alternative concentration limits is necessitated by really extensive contamination, the closure will require more than 180 days to complete an extension to the 180-day time limit will be requested in accordance with Pt. VI, sec. 265.112(c). The following events will be completed on or before the time indicated below:

TIME (day)	ACTIVITY
0	Closure Plan approved, closure initiated
+15	Remove fluids and residue from surface impoundment, trough, and piping; decontaminate surface impoundment and ancillary structures
+75	Collection of soil samples
+135	Removal of contaminated soil (if necessary)
+150	Further soil removal, sampling, test hole drilling, and chemical analysis, as necessary
+160	Completion of risk assessment to establish exposure limits, if necessary
+175	Removal of additional soil, as appropriate
+210	Backfill, regrade and establish vegetative cover
+220	Certification completed.

The excavation will be filled with clean indigenous soil, and compacted and regraded to its original contour. Selection and application of soil additives, such as fertilizers, and seed mixtures will follow U.S. Forest Service recommendations. The site will be watered sufficiently to establish seedlings. If weather conditions at the time of final closure activities do not allow for planting, an extension to this closure schedule will be sought to allow completion of this step as soon as practicable after the last freeze of the season. If any other circumstances require an additional extension, a letter explaining the need for the extension and including a revised schedule will be provided to NMED.

8.2 MODIFICATIONS TO THE CLOSURE PLAN

Once the closure plan is approved, if it becomes necessary for the Laboratory to amend the plan, procedures outlined in 40 CFR §265.112(c)(1),(2) will be followed.

8.3 FINAL REPORT

The final report, will be submitted within 180 days of the approval of this closure plan when all closure activities are completed. A final report contains the following information at a minimum:

a. A QA/QC summary on the adequacy of the analyses and the decontamination demonstration.

b. A copy of the file of supporting documentation such as laboratory sample analysis reports, QA/QC documentation, and chain of custody records.

c. Disposal location of all hazardous wastes and hazardous waste residues.

d. A narrative summary of all testing performed during closure activities.

e. The details of any variance from the approved closure plan and the reason for the variance.

8.4 CLOSURE CERTIFICATION

An independent registered professional engineer and the owner of the facility shall certify the closure and confirm that the closure activities follow this closure plan. Upon completion of closure, the engineer and the U.S. Department of Energy (DOE) shall prepare a letter, or letters, certifying that the area has been closed in accordance with this closure plan under the provisions of 40 CFR § 265.115. The letter(s) shall be dated and signed by each party and stamped by the registered engineer, and the original copy(s) submitted by the DOE to the Secretary of the NMED within 60 days of closure completion. One set of copies shall be maintained at the DOE offices and one set maintained by the Laboratory Environmental Surveillance Group (EM-8).

8.5 CONTINGENT CLOSURE AND POST-CLOSURE CARE PLANS

8.5.1 Contingent Closure Plan

The existence of the Underground Storage Tank as part of the system undergoing closure requires that additional closure regulations be addressed. Specifically, these regulations, set forth in 40 CFR §265.197, require that a contingent closure plan be provided for tanks without a secondary containment system. The contingent closure plan must describe closure activities that will be implemented in the event the tank has leaked and all contaminated soils cannot be removed. Under such circumstances, the tank and tank system will be considered a landfill and must meet all closure requirements applicable to landfills. This precludes clean closure option due to the release and lack of regulatory provisions for the clean closure of landfills.

At this time, it is believed that the Underground Storage Tank has never leaked. When the Underground Storage Tank was first discovered, it was filled with a water-based fluid. Since the contents could not be immediately removed, they remained in place for several weeks. At the end of that time, the original fluid level had not changed. There is no documentation of the amount of fluids that may have been added to the Underground Storage Tank during this several week period. Therefore a complete sampling and analysis of the contents and surrounding soils is required to determine if the contents is/was hazardous or any leakage occurred.

If any potential contaminated soils associated with the tank cannot be removed to the residential standard clean levels established by the results of the risk assessment, the tank and associated equipment will be closed as a landfill. A cover will be designed and constructed to minimize the migration of liquids through the unit; to function with minimum maintenance; to promote drainage and minimize erosion or abrasion of the cover; to accommodate settling and subsidence

so that the cover's integrity is maintained; and to have a permeability less than or equal to the permeability of the natural subsoils present. A berm will be constructed to prevent run-on and run-off from eroding or otherwise damaging the final cover. The cover will be maintained and repaired as necessary to correct the effects of settling, subsidence, erosion, or other events.

Should closure as a landfill be necessary, a revised closure plan will be submitted that defines an appropriate cap and ground water monitoring system for this site. A revised closure plan is required because there is no regulatory provision for clean closure of a landfill. The ground water monitoring system will be installed and a Post Closure Care Permit Application submitted as part of the revised closure plan to NMED. Part of the revised closure plan will be a revised schedule of closure completion milestones including dates for instillation of ground water monitoring wells. Any other delays in response to release investigation will be explained in detail and accompany the new closure schedule.

8.5.2 Post-Closure Care Plan

Because the Laboratory intends to perform a clean closure under interim status requirements, a detailed post-closure care plan is not required at this time. Should the Laboratory be unable to perform a clean closure, a detailed post-closure care plan will be submitted to NMED, pursuant to 40 CFR §265.112. The revised plan will provide the following:

a. A description of final cover placement, i.e. a multimedia cap designed and constructed in accordance with RCRA landfill requirements

b. A description of planned monitoring, maintenance and inspection activities and the frequencies at which they will be performed to ensure containment system integrity.

c. The name, address, and phone number of the person or office to contact about the facility during the post-closure care period

d. Any additional information regarding the facility or planned activities for the facility that may be required to address post-closure care. This may include but may not be limited to information regarding post-closure notices and documentation, deed and access restrictions, signs and security, etc.

8.6 NOTIFICATION IN DEED TO PROPERTY

This section is not applicable because a closure by removal exempts the impoundment per 40 CFR § 228(a)(1).

8.7 CLOSURE AND POST-CLOSURE CARE COST ESTIMATES

This section is not applicable because federal facilities are exempt from this section per 40 CFR §265.140(c). In addition, the Laboratory intends to perform a clean closure, precluding the need for post-closure care.

8.8 FINANCIAL ASSURANCE MECHANISMS FOR CLOSURE AND POST-CLOSURE CARE

This section is not applicable because federal facilities are exempt from this section per 40 CFR §265.140(c).

8.9 LIABILITY REQUIREMENTS

This section is not applicable because federal facilities are exempt from this section per 40 CFR §265.140(c).

9.0 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 14, will commence upon receipt of a notice of approval of this Amended Closure Plan from NMED; the dates shown in Figure 14 assumed 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 14 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).

NMED considers 180 days from the closure plan approval to the submittal of the Closure Certification Report and Engineer's Certification more than sufficient. This is based on the history of this closure plan application and the amount of work done at risk by LANL prior to approval. A finalized Closure Certification Report will include **all** lab data and a detailed explanation of the QA/QC methods of the certified laboratory doing the analysis. NMED will not accept laboratory data "validated/verified" by any source other than the certified laboratory's (that performed the analysis) own QA/QC program. The 180 days is more than adequate for the completion of any new sampling and analysis to verify closure standards and/or develop a ground water monitoring system and post closure care permit application for review.

10.0 REFERENCES

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Table 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[a]	Cool to 4°C[b]
Metals Compounds	Glass, silica/teflon Septa	250 ml[a]	Cool to 4°C[b]

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

Table 2

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

Acetone
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
Freon
4-Isopropyltoluene
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-Trichloroethane
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

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 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
Polychlorinated biphenyls
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 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 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
Acetone		8260
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		
Benzyl chloride		
Beryllium	Beryllium	6000/7000
Beryllium compounds, NOS	Beryllium compounds, NOS	6000/7000

See footnotes at end of table.

Table 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
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		
Copper cyanide		
Creosote		
Cresols, NOS	Cresols, NOS	8270
Crotonaldehyde		
Cyanides, NOS		
Cyanogen		
Cyanogen bromide		

See footnotes at end of table.

Table 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
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		
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		

See footnotes at end of table.

Table 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
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
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		

See footnotes at end of table.

Table 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
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		
Freon		8260
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		
Indeno{1,2,3-cd}pyrene	Indeno{1,2,3-cd}pyrene	8270
Isobutyl alcohol	Isobutyl alcohol	8260
Isodrin		8270
Isopropyltoluene		8260
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

See footnotes at end of table.

Table 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
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		
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		

See footnotes at end of table.

Table 6

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

EM-9 Analytical Appendix VIII Capabilities	*SW-846* Method
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
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	
Phenylthlourea	
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	

See footnotes at end of table.

Table 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
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		
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		

See footnotes at end of table.

Table 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
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
1,1,1-Trichloroethane		8260
1,1,2-Trichloroethane	1,1,2-Trichloroethane	8260
Trichloroethylene	Trichloroethylene	8260
Trichloromethanethiol		
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."

Table 7

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

Appendix VIII	EM-9 Analytical Capabilities	*SW-846* Method
Acetone		8260
Acetophenone		8270
2-Acetaminefluorene		8270
Acetyl chloride		
1-Acetyl-2-thiorurea		8270
Acrylamide		
Aflatoxins		
Aldicarb		
Allyl alcohol		
Aluminum phosphide		
4-Aminobiphenyl		8270
5-(Aminomethyl)-3-isooxazolol		
4-Aminopyridine		
Amitrole		
Ammonium vanadate		
Aramite		8270
Auramine		
Azaserine		
Benz(c)acridine		
Benzal chloride		
Benzenearsonic acid		
Benzo(j)fluoranthene		
p-Benzoquinone		
Benzotrichloride		
Benzyl chloride		
Bromoacetone		
Bricine		
Cacodylic acid		
Carbon oxyfluoride		
Chloral		
Chlordane (a and g isomers)		
Chlorinated benzenes, NOS		
Chlorinated fluorocarbons, NOS		
Chlorinated phenol, NOS		
Chlornaphazin		
Chloroacetaldehyde		
Chloroalkyl ethers, NOS		
Chlorobenzilate		8270
Chloromethyl methyl ether		
1-(o-Chlorophenyl)thiourea		
Chloroprene		
3-Chloropropionitrile		
Citrus red No. 2		
Coal tar creosote		
Copper cyanide		
Creosote		
Crotonaldehyde		
Cyanides, NOS		
Cyanogen		
Cyanogen bromide		

See footnotes at the end of this Table.

Table 7

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
Cyanogen chloride		
Cycasin		
2-Cyclohexyl-2,6-dinitrophenol		
Cyclophosphamide		
Daunomycin		
Diallate		8270
Dibenz(a,h)acridine		
Dibenz(a,j)acridine		8270
Dibenzo carbazole		
Dibenzo(a,e)pyrene		
Dibenzo(a,h)pyrene		
Dibenzo(a,i)pyrene		
Dichloroethyl ether		
Dichloroisopropyl ether		
Dichloromethoxy ethane		
Dichloromethyl ether		
2,6-Dichlorophenol		8270
Dichlorophenylarsine		
Dichloropropanol, NOS		
1,2,3,4-Diepoxybutane		
Diethylarsine		
1,4-Diethyleneoxide		
N,N-Diethyl hydrazine		
O,O-Diethyl s-methyl dithiophosphate		
Diethyl-p-nitrophenyl phosphate		
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
Dimethyl sulfate		
Dinitrobenzene, NOS		8270
4,6-Dinitro-o-cresol salts		
Diphenylamine		8270
1,2-Diphenylhydrazine		8270
Di-n-propyinitrosamine		
Disulfoton		8270
Dithiobiuret		
Endothall		
Epichlorohydrin		

See footnotes at the end of this Table.

Table 7

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
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 methanesulfonate		8270
Famphur		8270
Fluorine		
Fluoroacetamide		
Fluoroacetic acid sodium salt		
Formaldehyde		
Formic acid		
Freon		8260
Glycidyaldehyde		
Halomethanes, NOS		
Hexachlorodibenzo-p-dioxin		8280
Hexachlorodibenzofurans		8280
Hexachlorophene		8270
Hexachloropropene		8270
Hexaethyl tetraphosphate		
Hydrazine		
Hydrogen cyanide		
Hydrogen fluoride		
Hydrogen sulfide		
Isodrin		8270
Isopropyltoluene		8260
Isosafrole		8270
Kepone		8270
Lasiocaprine		
Maleic anhydride		
Maleic hydrazide		
Malononitrile		
Melphalan		
Mercury compounds, NOS		
Mercury fulminate		
Methapyrilene		8270
Methomyl		
Methyl chlorocarbonate		
Methylcholanthrene		8270
Methylenebis(2-chloroaniline)		8270
Methylethyl ketone peroxide		

See footnotes at the end of this Table.

Table 7

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
Methyl hydrazine		
Methyl isocyanate		
Methyl methacrylate		8260
Methyl methanesulfonate		8270
Methyl parathion		8270
Methylthiouracil		
Mitomycin C		
MNNG		
Mustard gas		
1,4-Napthoquinone		8270
a-Napthylamine		8270
b-Napthylamine		8270
a-Naphthylthiourea		
Nickel carbonyl		
Nicotine		
Nicotine salts		
Nitrogen dioxide		
Nitrogen mustard		
Nitrogen mustard, hydrochloric acid salt		
Nitrogen mustard n-oxide		
Nitrogen mustard, n-oxide, hydrochloride salt		
Nitroglycerin		
2-Nitropropane		
Nitrosoamines, NOS		8270
N-Nitrosodi-n-butylamine		8270
N-Nitrosodiethanolamine		
N-Nitrosodiethylamine		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
Pentachlorobenzene		8270
Pentachlorodibenzo-p-dioxins		8280
Pentachlorodisbezofurans		8280
Pentachloroethane		8260/8270
Pentachloronitrobenzene		8270

See footnotes at the end of this Table.

Table 7

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
Phenacetin		8270
Phenylenediamine		8270
Phenylmercury acetate		
Phenylthlourea		
Phosgene		
Phosphine		
Phorate		8270
Phthalic anhydride		8270
2-Picoline		8270
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
Selenourea		
Sodium cyanide		
Streptozotocin		
Strychnine		
Strychnine salts		
2,3,7,8-TCDD		8280
1,2,4,5-Tetrachlorobenzene		8270
Tetrachlorodibenzo-p-dioxins		8280
Tetrachlorodibenzofurans		8280
2,3,4,6-Tetrachlorophenol		8270
Tetraethyldithiopyrophosphate		
Tetraethyl lead		
Tetraethyl pyrophosphate		
Tetranitromethane		
Thioacetamide		
Thiofanox		
Thiomethanol		
Thiophenol		8270
Thiosemicarbizide		
Thiourea		
Thiram		
Toluenediamine		
Toluene-2,4-diamine		
Toluene-2,6-diamine		
Toluene-3,4-diamine		

See footnotes at the end of this Table.

Table 7

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
Toluene diisocyanate		
o-Toluidine		8270
o-Toluidine hydrochloride		
p-Toluidine		
1,1,1-Trichloroethane		8260
Trichloromethanethiol		
Tris(1-aziridinyl)phosphine sulfide		
Tris(2,3-dibromopropyl)phosphate		8270
Trypan blue		
Uracil mustard		
Vanadium pentoxide		
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."

Table 8

RESULTS OF VOLATILE ORGANIC ANALYSES[1] FOR LIQUID AND SLUDGE SAMPLES COLLECTED AT THE TA-35-TSL-85 SURFACE IMPOUNDMENT JUNE 9, 1988

PARAMETER	LIQUID RESULTS (ppb)	LIQUID/SLUDGE RESULTS[2] (ppb)
Acetone	ppm range	ppm range
2-Butanone	D>200.0	D>200.0
2-Hexanone	42.9 ± 4.3	42.8 ± 4.3
Methylene Chloride	D>5.0[3] (TIC)[4]	D>5.0 (TIC)
1,1,2-Trichloro-1,2,2-trifluoroethane	D>200.0	ppm range

(1) Modified EPA Method 524. Analytical methods are taken from Test Methods for Evaluating Solid Waste, EPA SW 846.
(2) Intermixed liquids and solids; analyzed liquid fraction only.
(3) D = Detected at a concentration greater than the limit stated in the above table.
(4) TIC indicates a tentatively-identified compound.

Table 9

PERCENT SURROGATE SPIKE RECOVERIES FOR VOLATILE ORGANIC ANALYSES OF LIQUID AND SLUDGE SAMPLES COLLECTED AT THE TA-35-TSL-85 SURFACE IMPOUNDMENT JUNE 9, 1988

COMPOUND	LIQUID RESULTS (%)	SLUDGE RESULTS (%)	CLP ACCEPTABLE RANGE (%)(1)
1,2-Dichloroethane d4	127	88.5	76-114
Toluene d8	93.8	91.0	88-110
p-Bromofluorobenzene	91.1	85.8	86-115

(1) U.S. Environmental Protection Agency Contract Laboratory Program (CLP) acceptable range of percent recovery.

Table 10

RESULTS OF EP TOXIC METALS ANALYSES FOR LIQUID AND SLUDGE SAMPLES COLLECTED AT THE TA-35-TSL-85 SURFACE IMPOUNDMENT

JUNE 9, 1988

EPA HAZARDOUS WASTE NUMBER	PARAMETER	LIQUID RESULTS (mg/1)	SLUDGE RESULTS (mg/kg)	EP TOXIC MINIMUM CONCENTRATIONS(1) (mg/1)
D004	Arsenic	0.0055	0.30	5.0
D005	Barium	0.21	12.0	100.0
D006	Cadmium	0.0026	0.18	1.0
D007	Chromium	0.006	2.40	5.0
D008	Lead	0.027	5.20	5.0
D009	Mercury	ND<.0005(2)	.011	0.2
D010	Selenium	ND<0.001	0.027	1.0
D011	Silver	ND<0.003	0.31	5.0

(1)40 CFR 261.24
(2)ND = Not Detected; the limit of detection is the amount stated in the table above.

NOTE: Total metals results for liquid samples are equivalent to results that would be obtained through the EP toxicity extraction procedure, and therefore a direct comparison of liquid results to EP toxic minimum concentrations is possible. For sludge samples, results obtained through the extraction procedure are a fraction representing the leachable portion of the total metals present.

Table 11

RESULTS OF POLYCHLORINATED BIPHENYLS (PCBs) ANALYSES FOR LIQUID SAMPLES COLLECTED AT THE TA-35-TSL-85 SURFACE IMPOUNDMENT

SAMPLE NUMBER	DATE SAMPLED	SAMPLE TYPE	SAMPLE METHOD	SAMPLE LOCATION	ANALYTICAL RESULTS (µg/g)
86.05275	09/08/86	Oil/water	Grab	Surface Impoundment	ND<2.0[1]
87.01843	07/29/87	Oil	Grab	Surface Impoundment	ND<1.1

[1]ND = Not Detected; the limit of detection is the amount stated in the above table.

Table 12

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).

Table 13

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 14

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

Constituent	Class[b]	Oral SF[c] (mg/kg-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 (milligrams per kilogram-day)$^{-1}$. This data was obtained from the EPA's Integrated Risk Information System (IRIS) database (June 1991 ed.).
[d] "RfD" refers to a reference dose for a systemic toxicant. Units are milligrams per kilogram-day. This data was obtained from the EPA's Integrated Risk Information System (IRIS) database (June 1991 ed.).
[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 15

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.

301625.03.01 A7

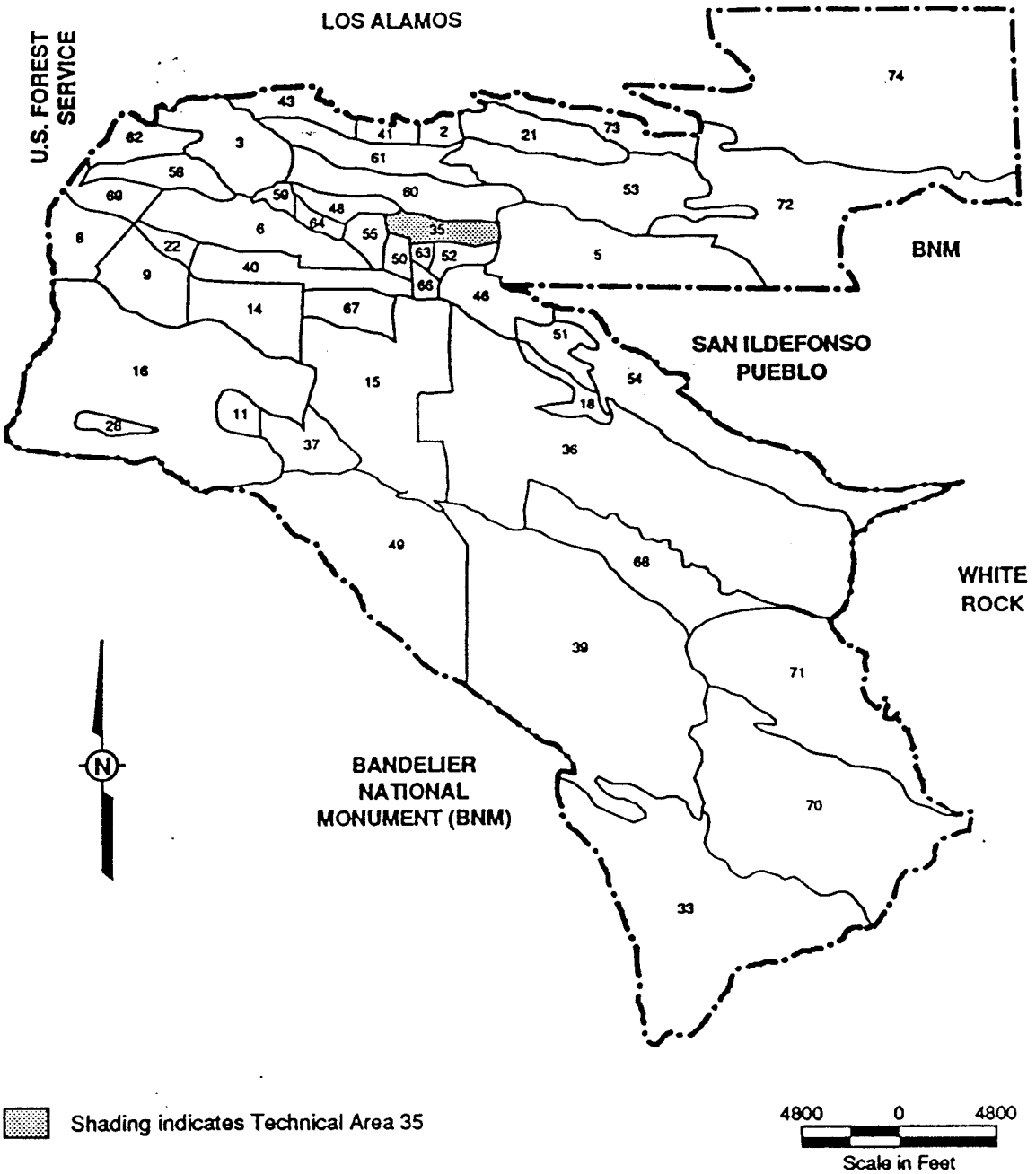
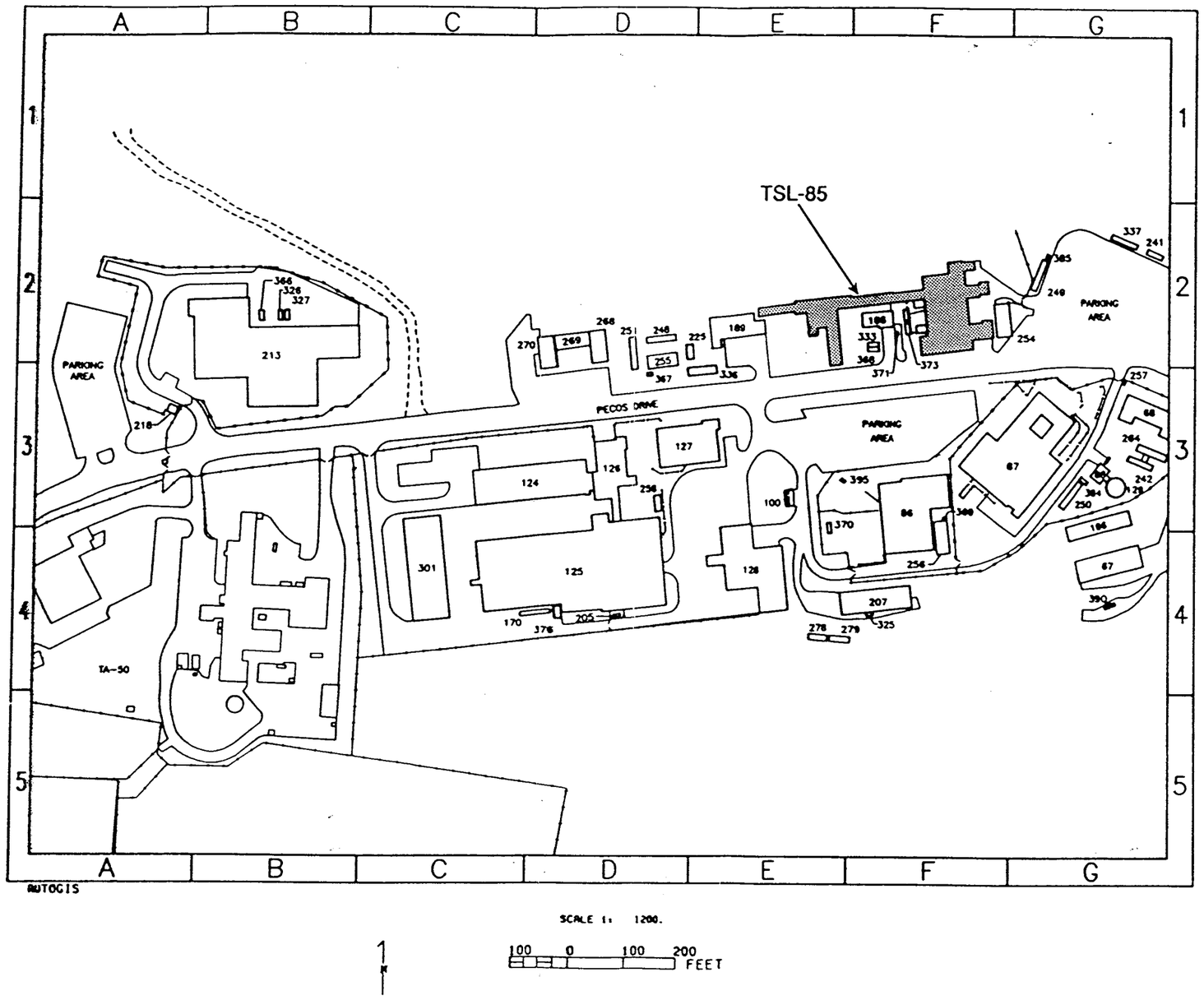
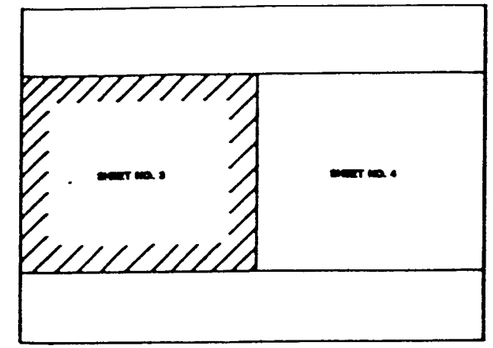


Figure 1

Location Map of Los Alamos National Laboratory Technical Areas

TA-35





TA-35 MAP GUIDE

Figure 2

Technical Area 35 Structure Location Map for TA-35 West

UNIVERSITY OF CALIFORNIA
Los Alamos
FACILITIES ENGINEERING DIVISION
STRUCTURE LOCATION MAP
C. BARDONI
B. COHEN
ENG- 5117

301625 A2

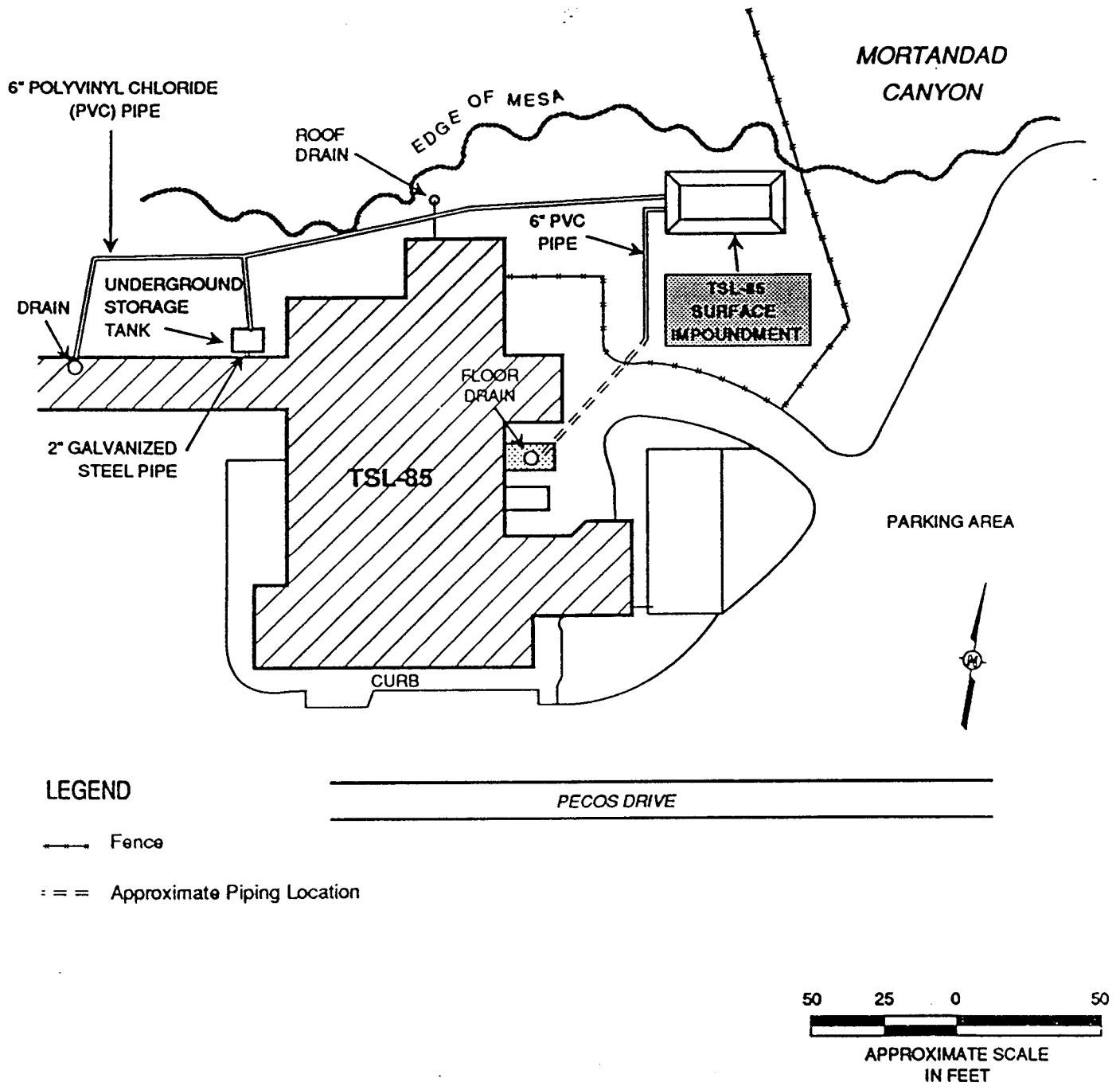
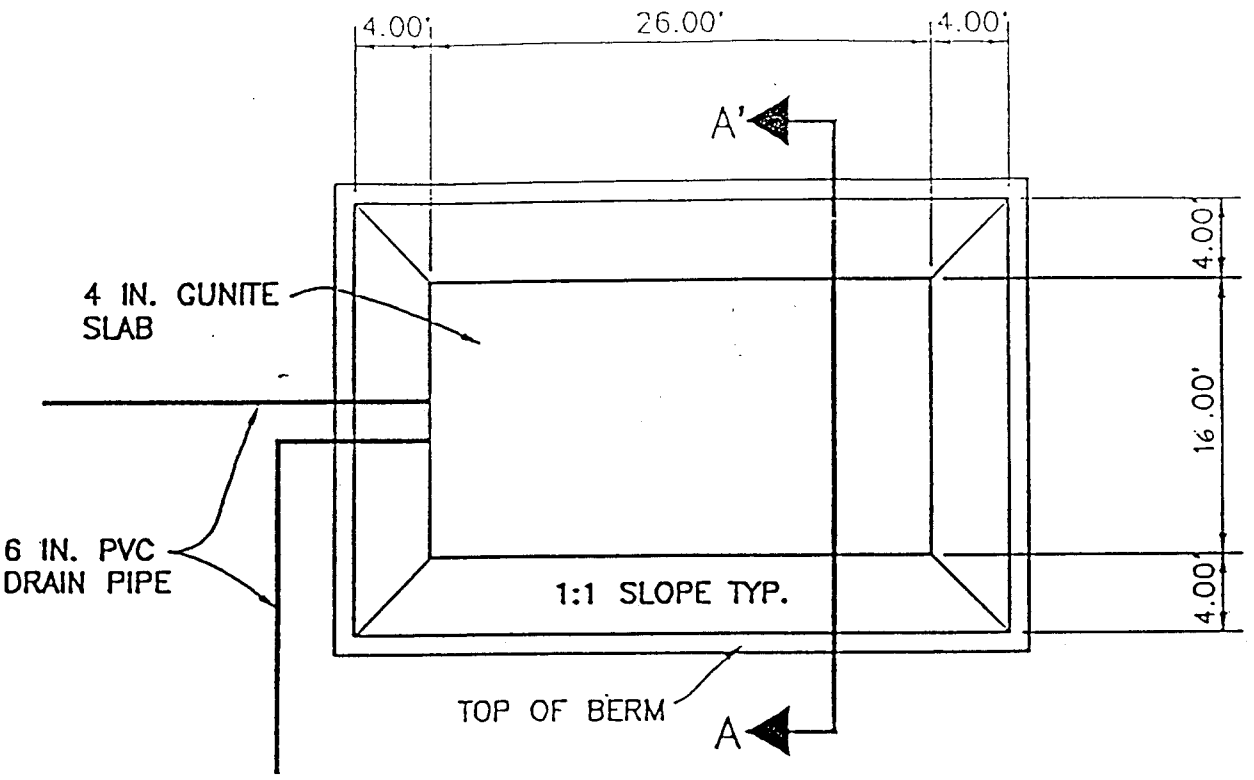
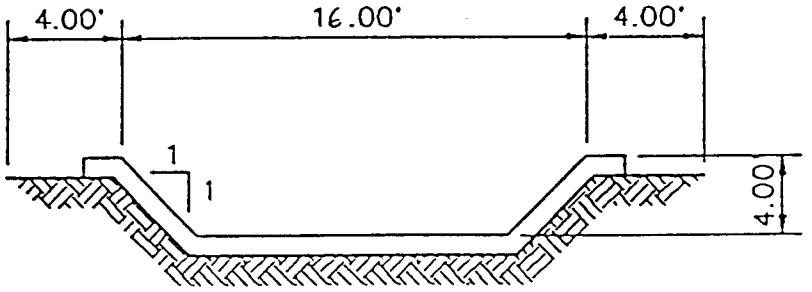


Figure 3

Location Map of the Technical Area 35, TSL-85 Surface Impoundment and Associated Piping Prior to Phases I through V



PLAN VIEW



CROSS SECTIONAL VIEW
A – A'

DRAWING NO.

CHECKED BY SAJ
APPROVED BY

SBH

DRAWN BY

ENGINEERING DRAWING
TA–35–TSL–85
SURFACE IMPOUNDMENT

PREPARED FOR

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

N

Figure 4

10 5 0 10 FEET
APPROXIMATE SCALE

BENCHMARK
ENVIRONMENTAL CORPORATION

301625 A8

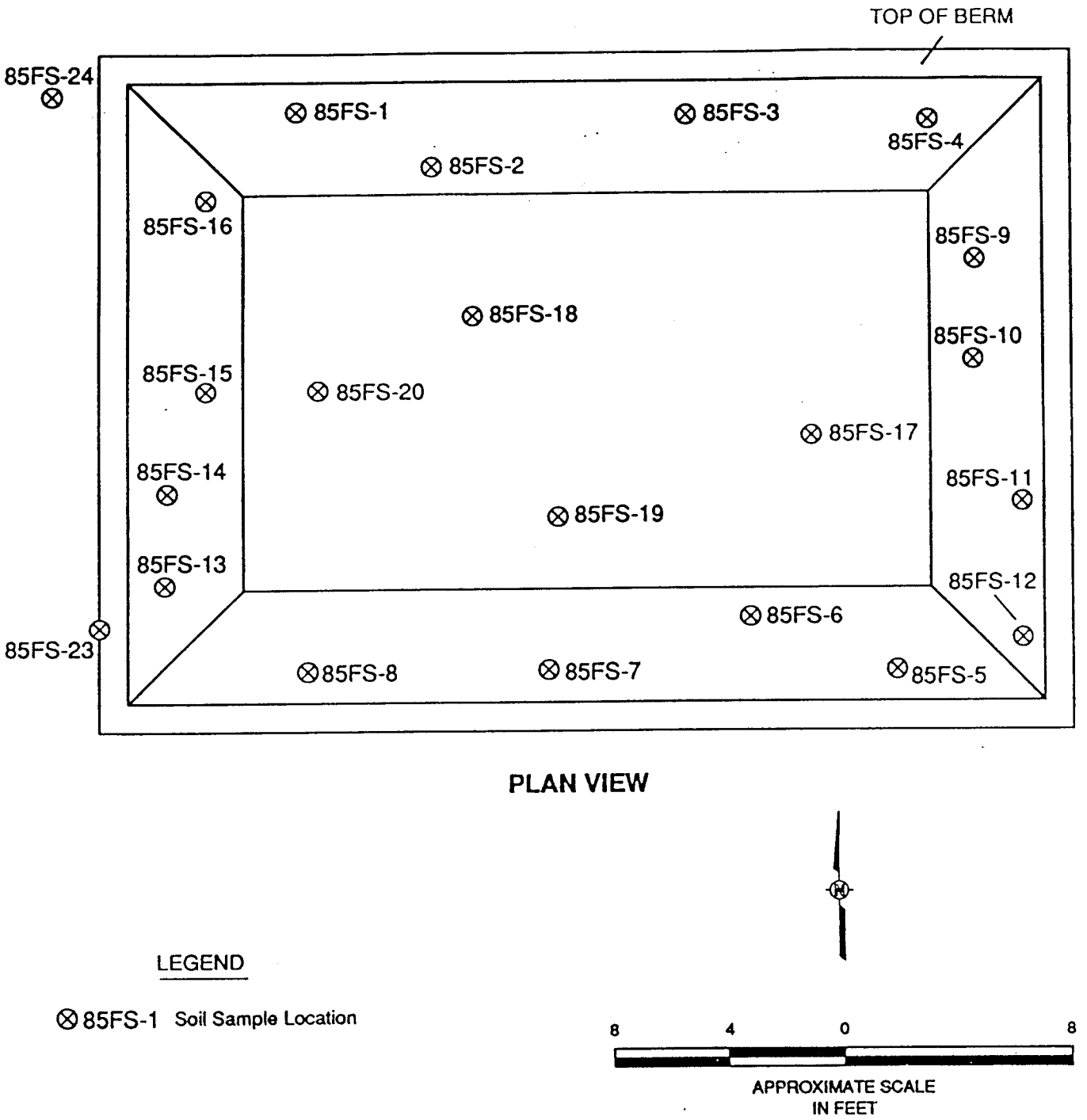


Figure 5

Phase I Soil Sample Locations
at the Technical Area 35, TSL-85 Surface Impoundment Site

301625 A3

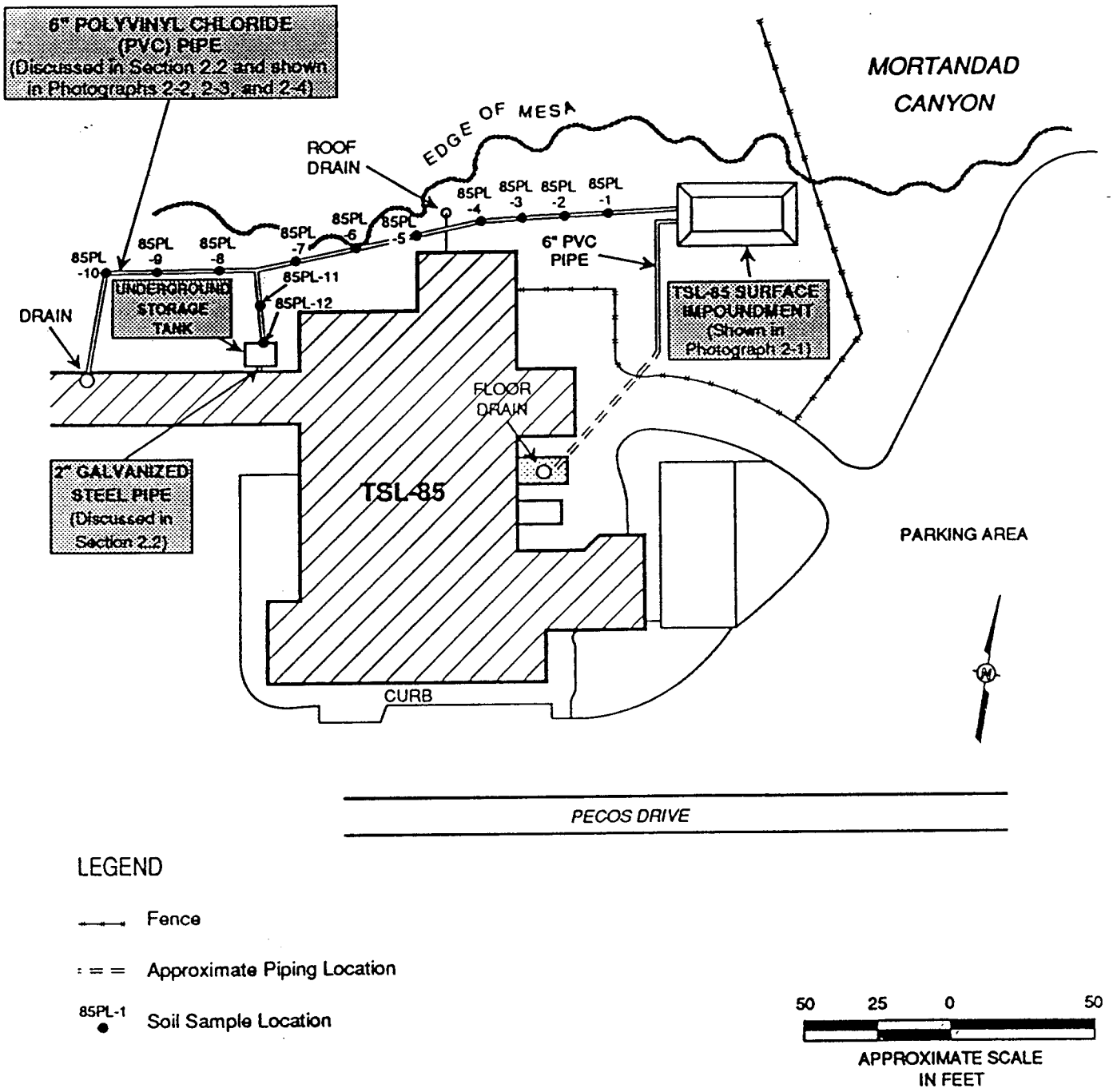


Figure 6

Phase III Soil Sample Locations Below the Underground Storage Tank and Associated Piping at the Technical Area 35, TSL-85 Surface Impoundment

301625 A1

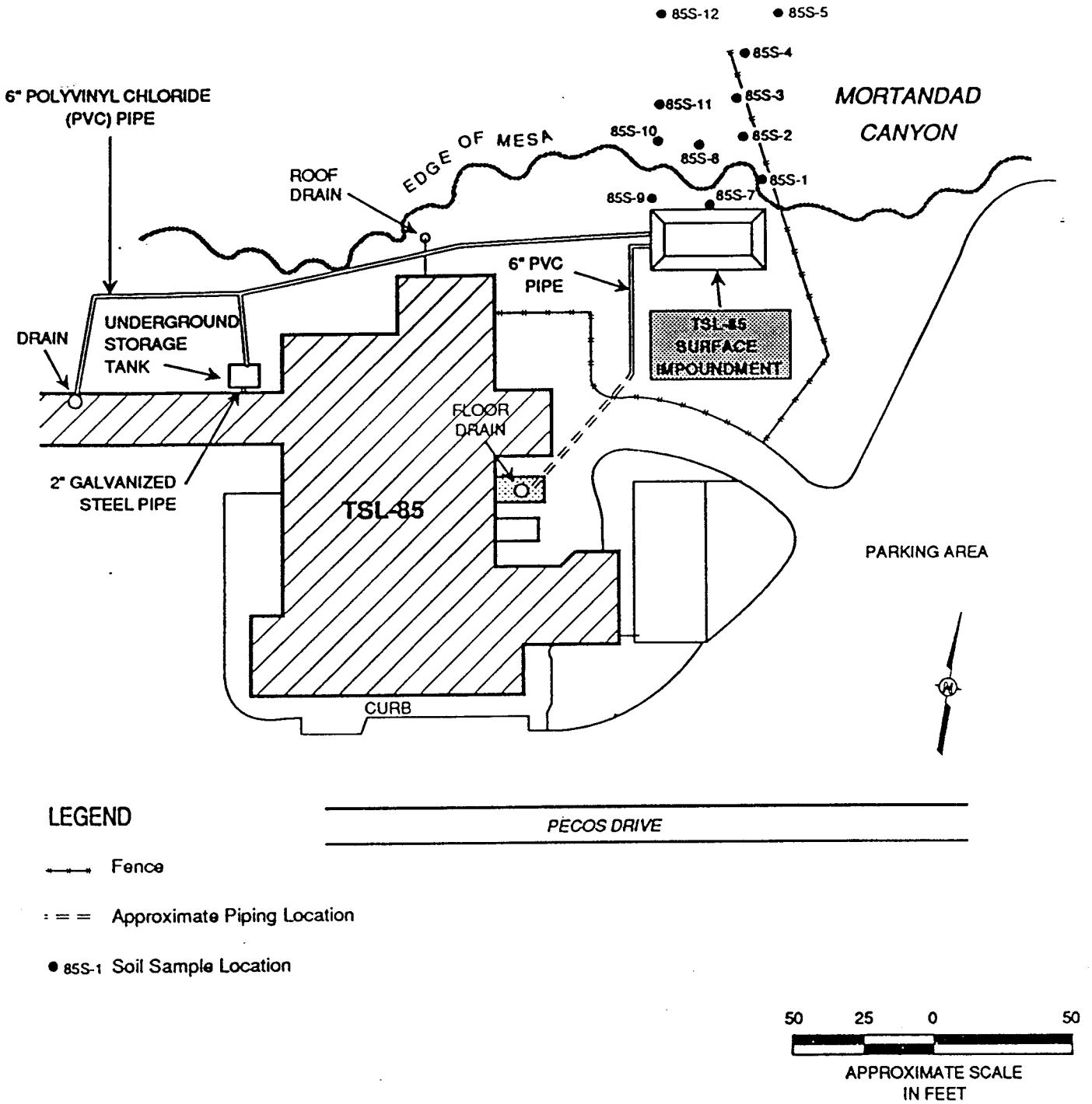


Figure 7

Phase IV Soil Sample Locations Along the Mortandad Canyon Spill Path at the Technical Area 35, TSL-85 Surface Impoundment

301625 A6

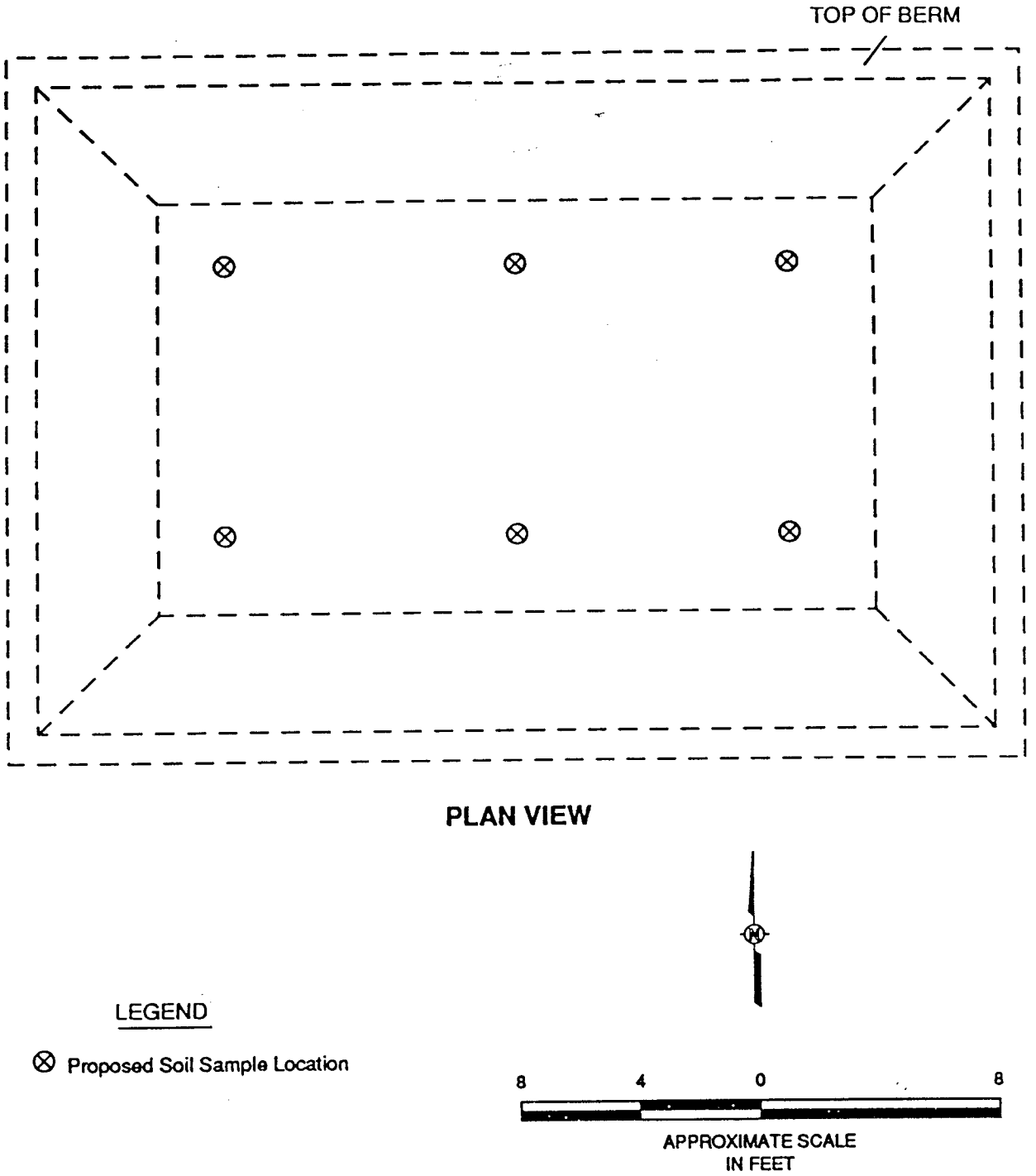


Figure 8

Proposed Phase VI Soil Sample Locations at the Site of
the Former Technical Area 35, TSL-85 Surface Impoundment

301625 A4

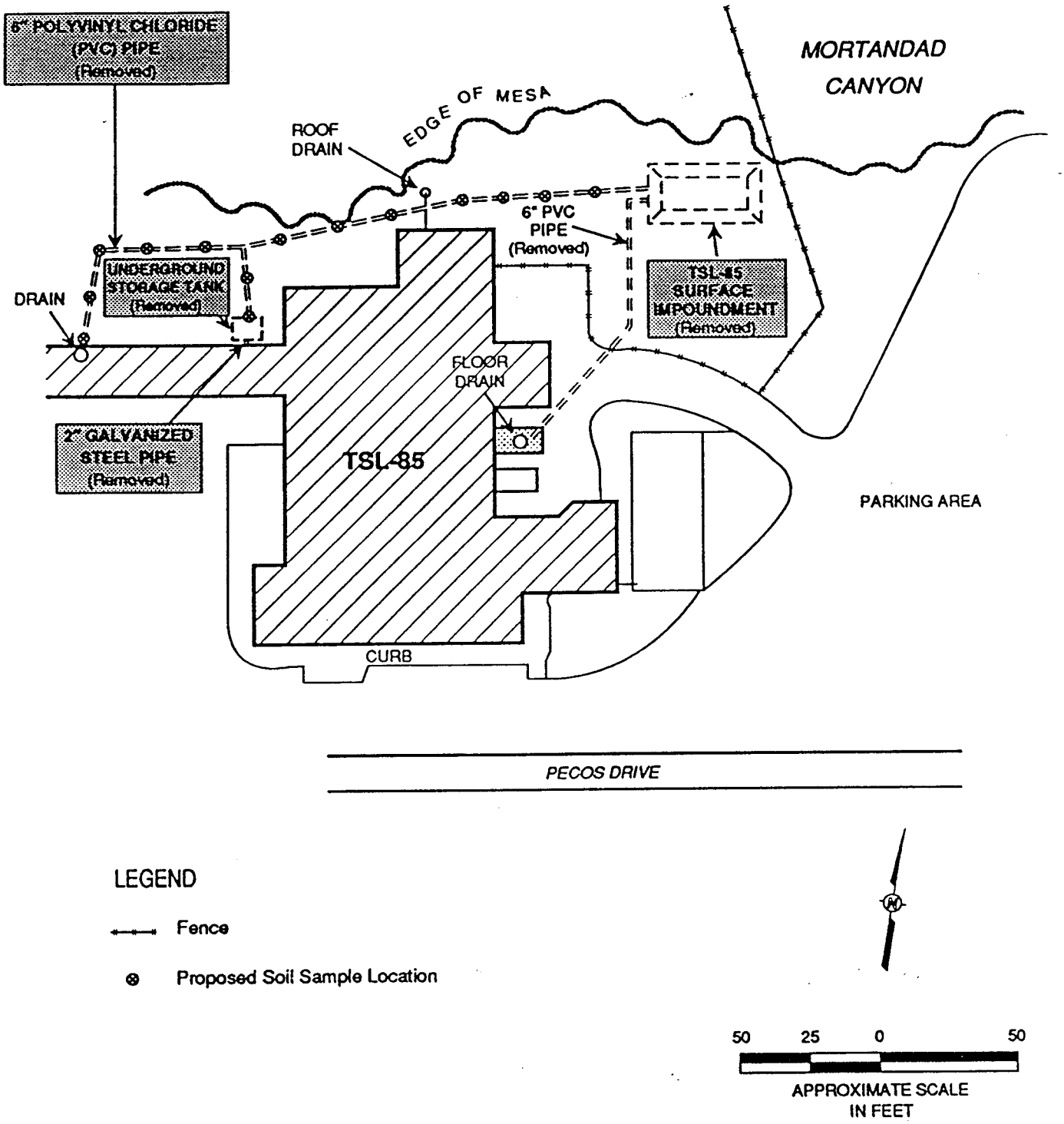


Figure 9

Proposed Phase VI Soil Sample Locations Below the Former Underground Storage Tank and Associated Piping at the Technical Area 35, TSL-85 Surface Impoundment

301625 A5

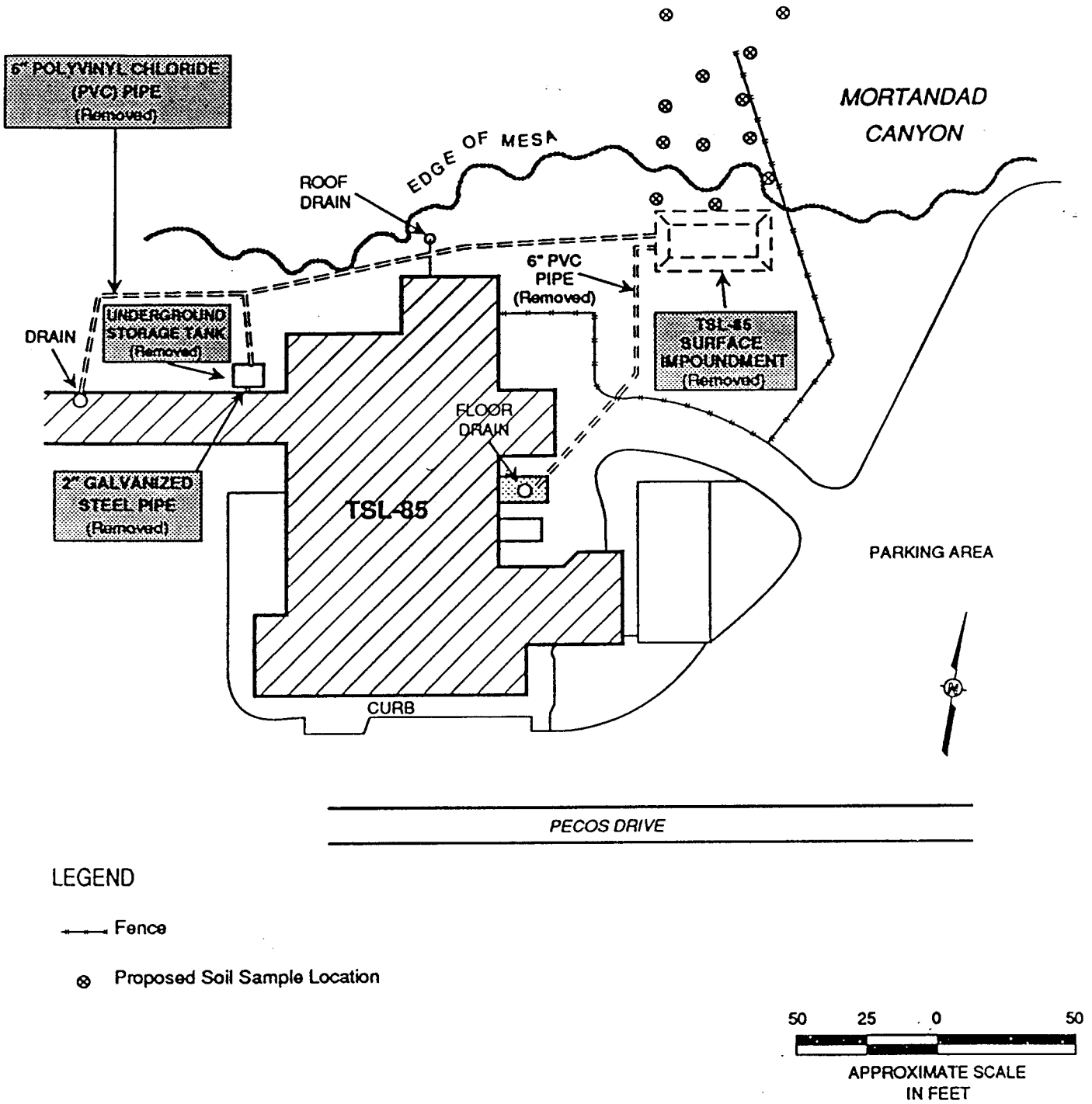
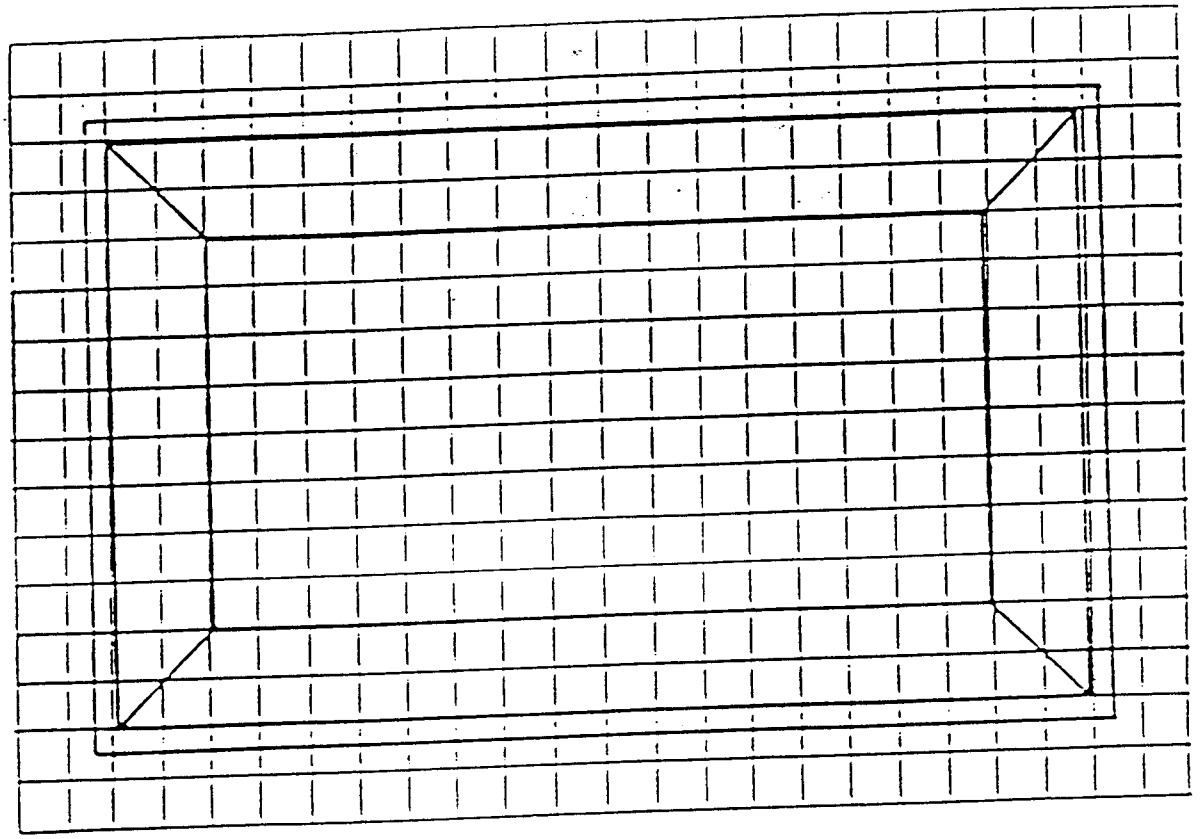


Figure 10

Proposed Phase VI Soil Sample Locations Along the Mortandad Canyon Spill Path at the Technical Area 35, TSL-85 Surface Impoundment



PLAN VIEW

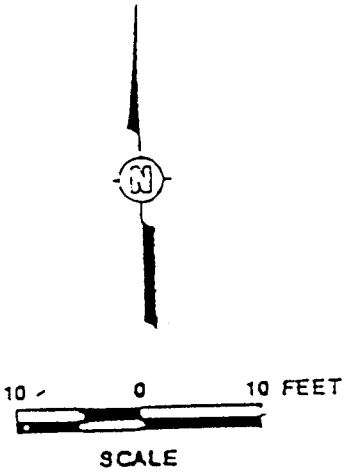


Figure 11

Grid Used For
DECONTAMINATION VERIFICATION
SAMPLING LOCATIONS AT
TA-35-TSL-85
PREPARED FOR
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

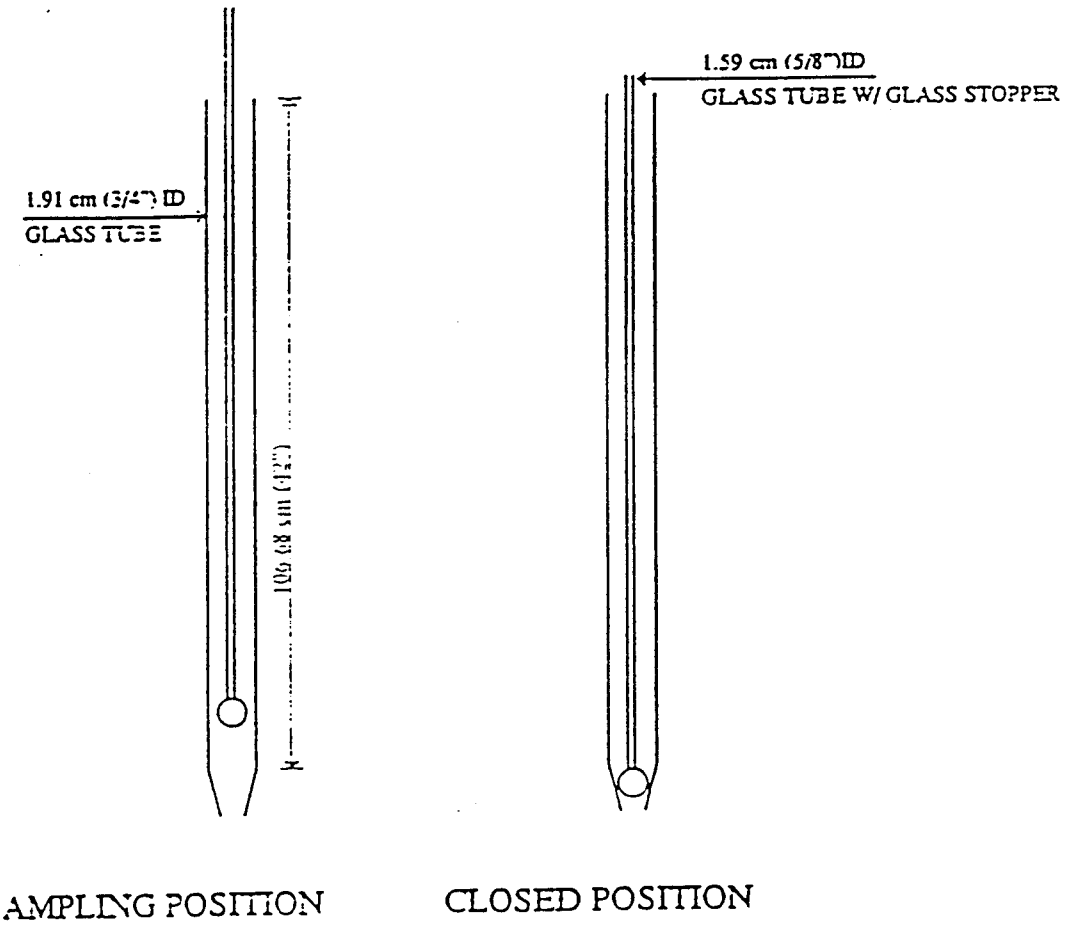


Figure 12

COMPOSITE LIQUID WASTE SAMPLER
(COLIWASA)

PREPARED FOR

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

Figure 13

Hazardous Materials Sample Analysis Request

PART I: FIELD SECTION

Collector: _____ Date Sampled: _____ Time: _____ hours

Location of Sampling: _____
name of company, disposal site, etc.

Address: _____
number street city state zip

Telephone: ( ) Company Contact: _____

HML No. (Lab only)	Collector's Sample No.	Type of Sample*	Field Information**

Analysis Requested: _____

Special Handling and/or Storage: _____

PART II: LABORATORY SECTION

Received by: _____ Title: _____ Date: _____

Sample Allocation: _____ HML _____ LBL _____ SRL Date: _____

Analysis Required: _____

* Indicate whether sample is sludge, soil, etc.
** Use back of page for additional information.

ACTIVITY ID	EARLY START	EARLY FINISH	ORIG DUR
10100100	1NOV93		0
10100200	1NOV93	30DEC93	40
10100300	3JAN94	31MAR94	63
10100400	1APR94	28APR94	20
10100500	29APR94	25JUL94	60
10100600	26JUL94	22AUG94	20
10100700	23AUG94	5SEP94	10
10100800	7SEP94	4OCT94	20
10100900	5OCT94	1NOV94	20
10101000	2NOV94	1DEC94	20
10101100	2DEC94	28FEB95	60
10101200	1MAR95	28MAR95	20
10101300	29MAR95	11APR95	10
10101400	12APR95	7JUN95	40
10101500	8JUN95	6JUL95	20
10101600	7JUL95	20JUL95	10
10101700	21JUL95	3AUG95	10
10101800		3AUG95	0

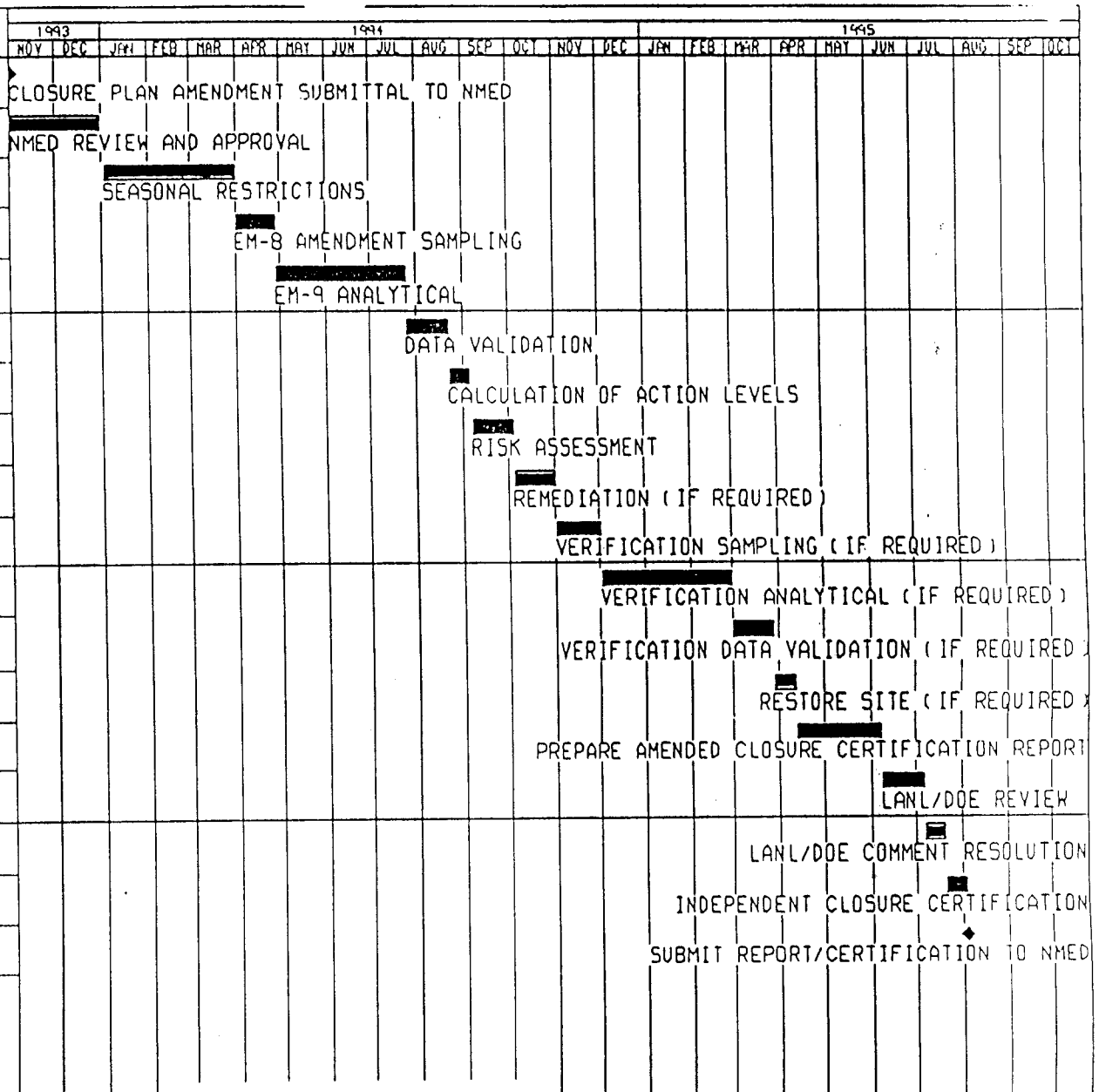


Figure 14

First Date 28OCT93
Data Date 1NOV93
Project Start 1NOV93
Project Finish 3AUG95

Primavera Systems, Inc

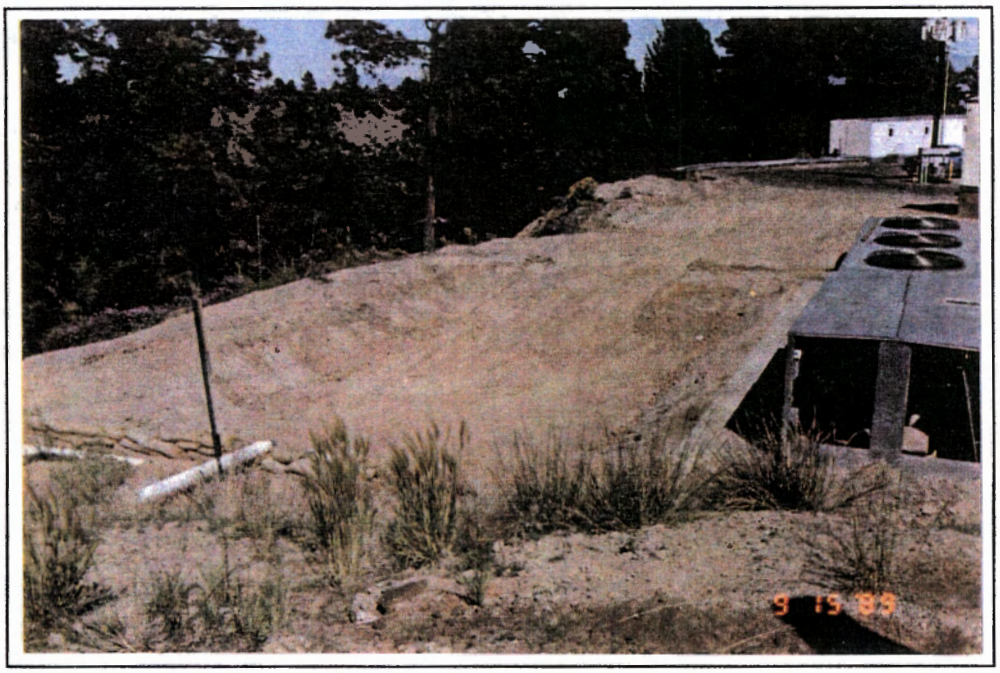
Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

LANL

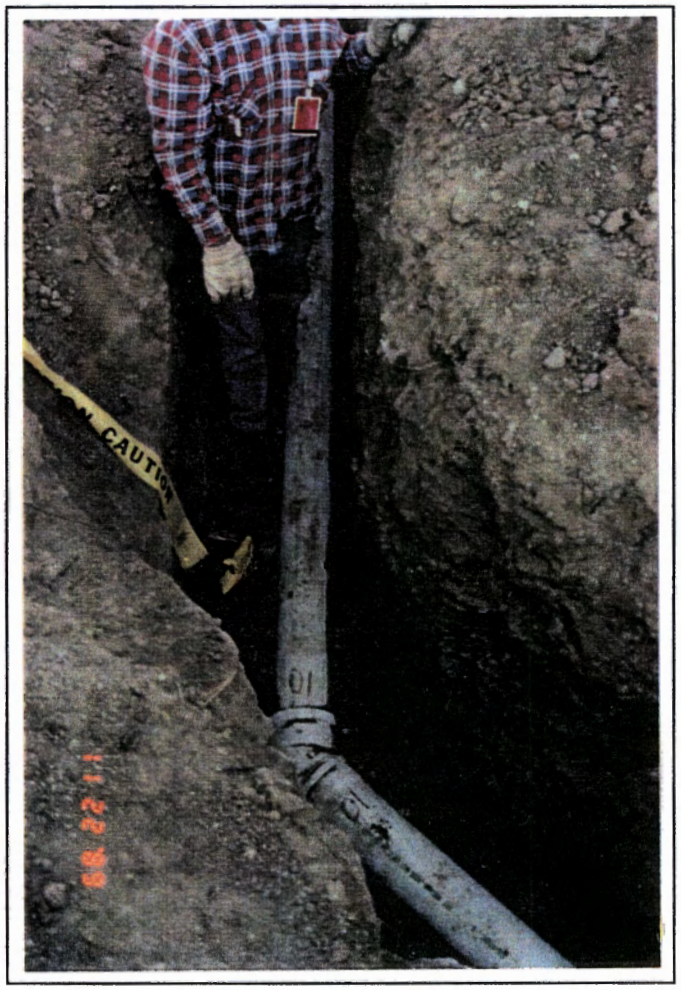
Sheet 1 of 1

LOS ALAMOS NATIONAL LABORATORY
AMENDED CLOSURE CERTIFICATION REPORT
TA-35 (TSL-85) SCHEDULE - NO 301625

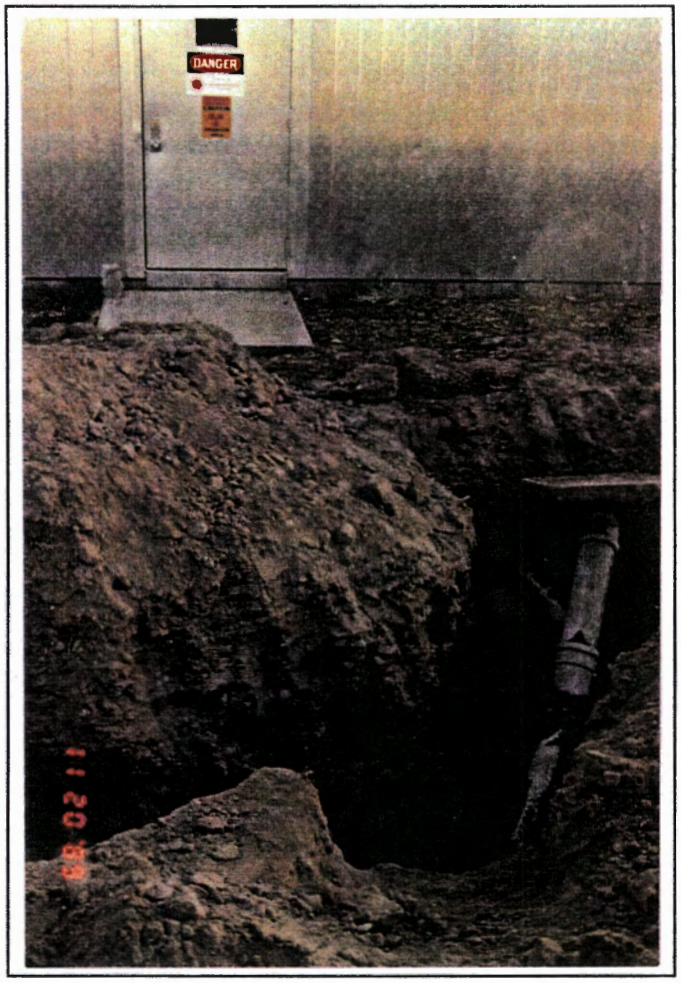
Date	Revision	Checked	Approved



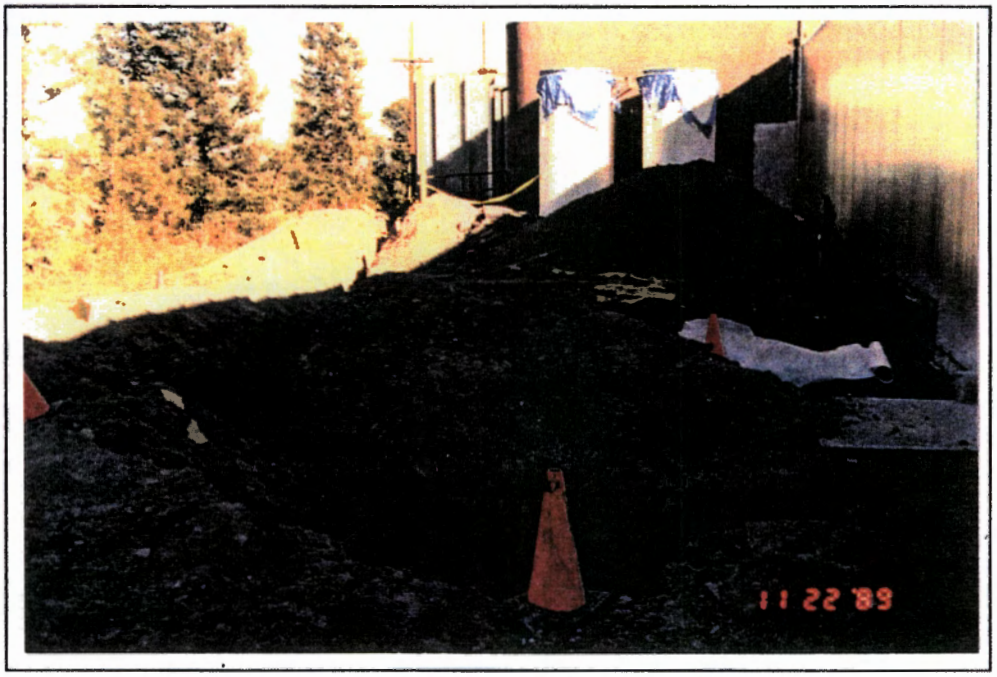
Photograph 2-1
Technical Area 35 (TA-35), TSL-85 Surface Impoundment
After Removal of Liner



Photograph 2-2
Excavation of 6" Polyvinyl Chloride (PVC) Pipe During Closure
of the TA-35, TSL-85 Surface Impoundment (corresponds to Figure 2-1)



Photograph 2-3
6" PVC Pipe During Excavation; View Looking South at the North Side of Building TSL-85 (corresponds to Figure 2-1)



Photograph 2-4
Excavation of 6" PVC Pipe; View Looking East Along North Side of Building TSL-85 (corresponds to Figure 2-1)

APPENDIX A

LANL BACKGROUND SOIL CHEMICAL DATA USING EPA SW-846 PROCEDURES

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Date: March 21, 1994

Mail Stop: J534
Telephone: 665-6493, 665-1264
Fax: 665-9118

memorandum

To: Distribution

From: Patrick Longmire, CST-10, Earth Sciences Technical Team

Subject: **BACKGROUND SOIL CHEMICAL DATA USING EPA SW846 PROCEDURES**

Attached are more recent background chemical data for soils collected at Los Alamos (Tables I and II). These data are collected from "true soils", which may have application for fill or reworked unconsolidated material found at the townsites and other disturbed areas of the Laboratory. Table I contains chemical data for all soils and fracture fill material sampled at the Laboratory. Table II contain chemical data from A horizons, which typically are the uppermost soil horizons found on the Pajarito Plateau. These A horizons are probably comparable to surface soil samples, excluding fill material, collected at operable units (OUs). Clearly, more Laboratory-wide background soil samples need to be collected from A horizons.

Nitric acid (HNO_3) was used to partly dissolve the soil samples. Atomic absorption (AA) and inductively coupled plasma spectroscopy (ICP) were the analytical methods used. Analytes of most concern include arsenic (As) and beryllium (Be) because background soil concentrations exceed screening action levels (SALs) for these two elements (Be, 0.16 ppm; As, 0.40 ppm). A seminar will be given in early May discussing details of these background data. Thank you for your interest in these background soil data.

TABLE I. Background Elemental Concentrations in Soils at Los Alamos, New Mexico

	Nitric Acid Dissolution (SW846)			INAA or DNAA (Uranium Only)		
Element[a]	Number of Samples	Mean	Range	Number of Samples	Mean	Range
As	72	4.9	0.5 - 13.6	67	5.04	1.20 - 10.81
Ba	72	176	24 - 730	75	459	125 - 829
Be	72	1.23	0.18 - 4.00		-	-
	75	[b]2.37	1.00 - 4.40			
Co	72	15.2	5.5 - 34	75	7.14	0.44 - 23.35
Cr	72	12.2	1.9 - 37.0	74	34.74	2.03 - 71.07
Cu	67	6.6	0.6 - 16.0		-	-
Fe (wt.%)	72	1.51	0.33 - 3.60	75	2.37	1.09 - 4.86
Ni	70	10.3	2.0 - 28.0		-	-
Pb	69	16.7	4.0 - 37.0		-	-
		[b]28.36	18.00 - 56.00			
Se	41	0.75	0.30 - 2.40		-	-
Th	72	7.1	0.6 - 15.0	75	16.06	10.09 - 27.30
Tl	40	0.42	0.20 - 0.90		-	-
U	72	0.94	0.20 - 2.40	75	3.41	1.54 - 6.73
V	72	26.6	4.0 - 56.0	72	48.95	11.54 - 113.10

[a]Data are reported in parts per million (ppm) unless otherwise noted.
[b]Hydrofluoric acid used in sample dissolution.

TABLE II. Background Elemental Concentrations in A Horizons of Soils at Los Alamos, New Mexico

	Nitric Acid Dissolution (SW846)		
Element[a]	Number of Samples	Mean	Range
As	9	3.1	0.8 - 5.4
Ba	9	123	27 - 220
Be	9	0.71	0.31 - 1.00
Co	9	16.7	10.0 - 29.0
Cr	9	8.1	1.9 - 16.0
Cu	7	6.5	3.3 - 9.5
Fe (wt.%)	9	1.21	0.33 - 2.80
Ni	9	6.7	2.0 - 12.0
Pb	9	15.8	4.0 - 38.0
Se	2	0.58	0.50 - 0.65
Th	9	5.8	2.0 - 8.0
Tl	2	0.2	0.2 - 0.2
U	9	0.9	0.5 - 2.4
V	9	19.8	4.6 - 37.0

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

Note: A horizon is uppermost soil horizon characterized during background investigation.

APPENDIX B

Sigma Mesa Background Elemental Concentrations in Soil and Vegetation, 1979

LA-11941-MS

UC-902
Issued: October 9

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	

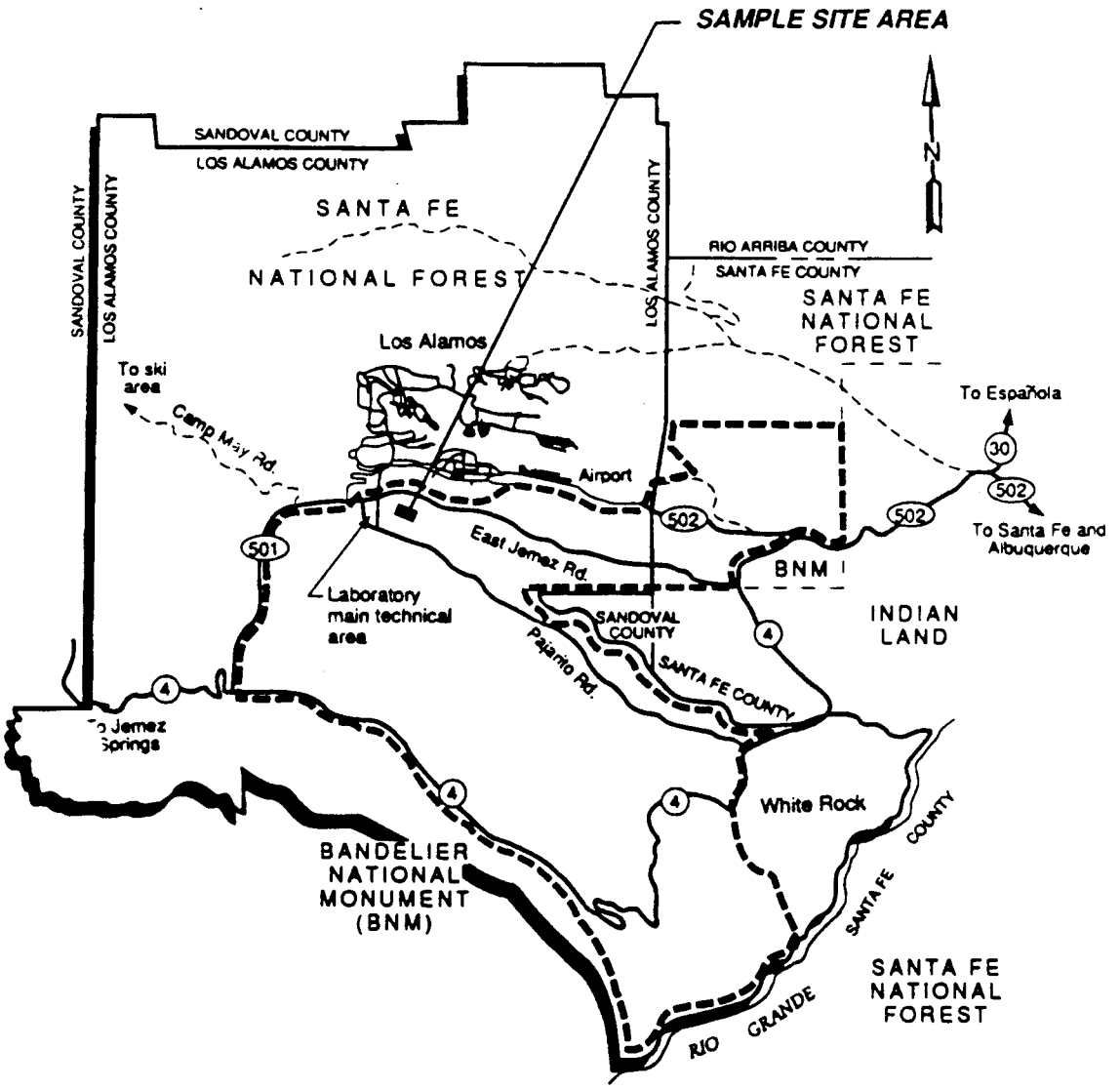


Fig. 1. Location of sampling area.

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

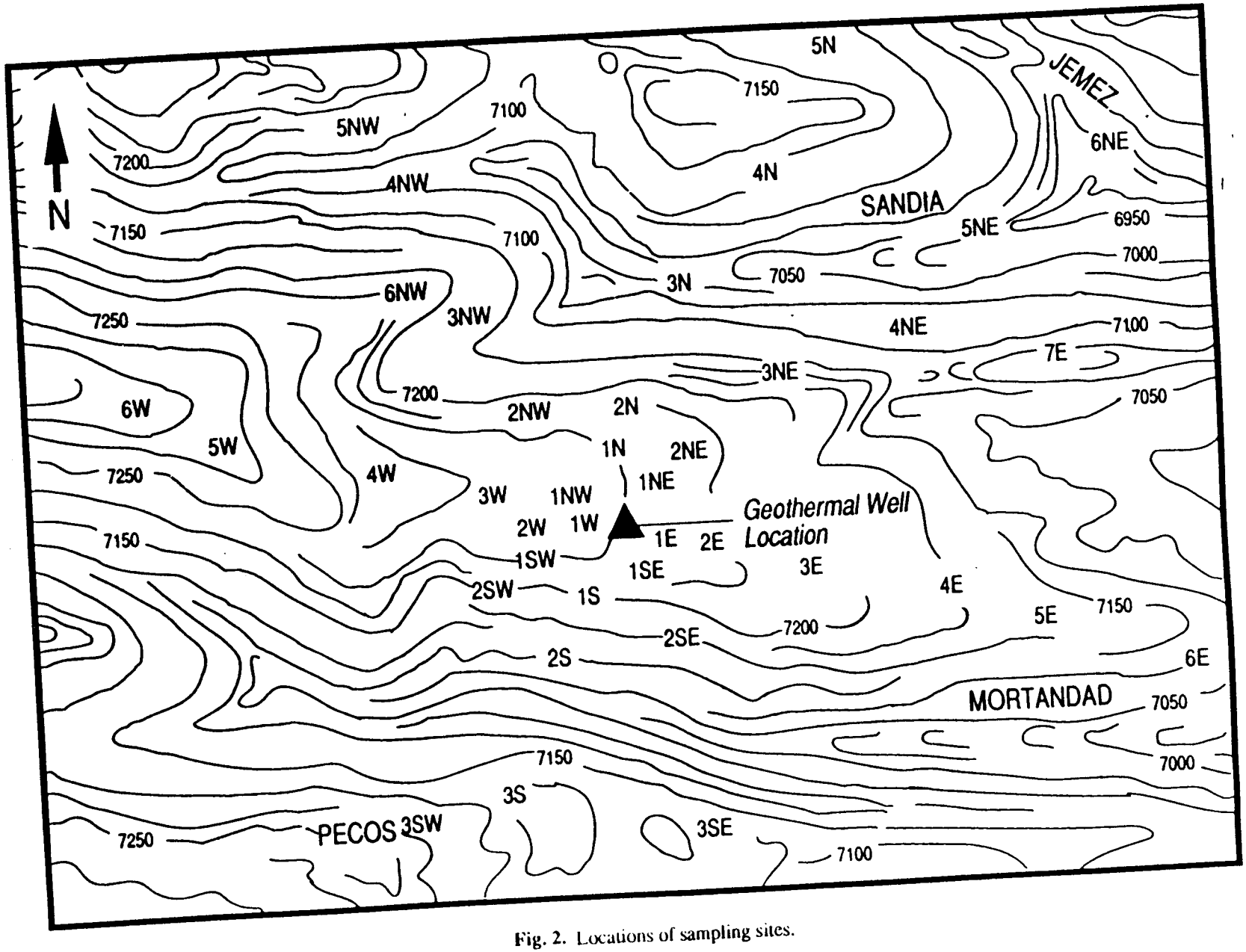


Fig. 2. Locations of sampling sites.

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	0	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	[illegible]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	[illegible]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-I (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

EPA RISK ASSESSMENT GUIDANCE DOCUMENTS

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_ds), which might cause adverse

APPENDIX D

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PROPOSED SUBPART S RULES

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^{-4} 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, 34006, 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 fo 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 greate 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 th Integrated Risk Information System (IRIS), a computer-housed, electronica communicated catalogue of Agency ris 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 ar IRIS account, call Dialcom at (202) 488 0550.) The risk assessment informatior (*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 Agency consensus. As EPA working groups continue to review and verify risk assessment values, additional chemicals and data components will b added to IRIS. IRIS hardcopy will be available through the National Technical Information Service (NTIS). addition, EPA will routinely update appendix A as new data on hazardou constituents are developed.

c. *Action Levels for Ground Water.* Proposed § 264.521(a) establishes acti levels for ground water in aquifers. By specifying the term "aquifer" in this context, the Agency intends to defi 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 determine 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−08	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−08	(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	8E−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 (ug/m³)	Water (mg/L)	Soils (mg/kg)
Cadmium	B1	6E−04	(1)	4E+01
Calcium cyanide	D		1E−00	3E+03
Carbon disulfide	D		4E−00	8E+03
Carbon tetrachloride	B2	3E−02	3E−04	5E−00
Chloral	D		7E−02	2E+02
Chlordane	B2	3E−00	3E−05	5E−01
Chlorine cyanide	D		2E−00	4E+03
Chlorobenzene	D	2E+01	7E−01	2E+03
Chloroform (3)	B2	4E−02	6E−03	1E+02
2-Chlorophenol	D		2E−01	4E+02
Chromium (VI)	A	9E−05	(1)	4E+02
Copper cyanide	D		2E−01	4E+02
m-Cresol	D		2E−00	4E+03
o-Cresol	D		2E−00	4E+03
p-Cresol	D		2E−00	4E+03
Cyanide	D		7E−01	2E+03
Cyanogen	D		1E−00	3E+03
Cyanogen bromide	D		3E−00	7E+03
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−03	1E−01
3,3'-Dichlorobenzidine	B2		6E−05	2E−00
Dichlorodifluoromethane	D	2E+02	7E−00	2E+04
1,2-Dichloroethane	B2	4E−02	(1)	8E−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	8E+02
1,3-Dichloropropene	B2		1E−02	2E+01
Dieldrin	B2	3E−04	2E−05	4E−02
Diethyl phthalate	D		3E+01	6E+04
Diethylnitrosamine	B2	3E−05	2E−07	5E−03
Dimethoate	D		7E−01	2E+03
Dimethylnitrosamine	B2	7E−05	7E−07	1E−02
m-Dinitrobenzene	D		4E−03	8E−00
2,4-Dinitrophenol	D		7E−02	2E+02
2,3-Dinitrotoluene (and 2,6-, mixture)	B2		6E−05	1E−03
1,4-Dioxane	B2		3E−00	6E+01
Diphenylamine	D		9E−04	2E+03
1,2-Diphenylhydrazine	B2	4E−03	4E−05	9E−01
Disulfoton	D		1E−03	3E−00
Endosulfan	D		2E−00	4E−03
Endothall	D		7E−01	2E+03
Endrin	D		(1)	2E+01
Epichlorohydrin	B2	9E−01	4E−03	7E+01
Ethylbenzene	D		4E-00	8E+03
Ethylene dibromide	B2	5E−03	4E−07	8E−03
Formaldehyde	B1	9E−02		
Formic acid	D		7E+01	2E+05
Glycidylaldehyde	D		1E−02	3E+01
Heptachlor	B2	9E−04	8E−05	2E−01
Heptachlor epoxide	B2	4E−04	4E−05	9E−02
Hexachlorobenzo-p-dioxin	B2	6E−07	1E−08	1E−04
Hexachlorobutadiene	C	4E−01	4E−03	9E+01
alpha-Hexachlorocyclohexane	B2	9E−04	6E−05	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	3E−04	1E−05	3E−01
Hydrogen cyanide	D		7E−01	2E+03
Hydrogen sulfide	D		1E−01	2E+02
Isobutyl alcohol	D		1E+01	2E+04
Isophorone	C		9E−02	2E+03
Lead	B2		(1)	
Lindane (gamma-hexachlorocyclohexane)	B2/C		(1)	8E−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−03	8E-00
Methomyl	D		9E−01	2E+03
Methyl chlorocarbonate	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−03	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−06	1E−01
n-Nitroso-n-ethylurea	B			
n-Nitroso-n-methylethylamine	B2		2E−06	3E−02
n-Nitrosodi-n-propylamine	B2		5E−06	1E−01
n-Nitrosodiethanolamine	B2		1E−05	3E−01
n-Nitrosodiphenylamine	B2		7E−03	1E+02
n-Nitrosopyrrolidine	B2	2E−03	2E−05	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−06	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−00	1E−02	3E+02
1,2,4,5-Tetrachlorobenzene	D		1E−02	2E+01
1,1,1,2-Tetrachloroethane	C	1E−00	1E−02	3E+02
1,1,2,2-Tetrachloroethane	C	2E−01	2E−03	4E+01
Tetrachloroethylene	B2	1E−00	7E−04	1E+01
2,3,4,6-Tetrachlorophenol	D		1E−00	2E+03
Tetraethyl lead	D		4E−00	8E−03
Tetraethyldithiopyrophosphate	D		2E−02	4E+01
Thallic oxide	D		2E−00	6E−00
Thallium acetate	D		3E−00	7E−00
Thallium carbonate	D		3E−00	6E−00
Thallium chloride	D		3E−00	6E−00
Thallium nitrate	D		3E−00	7E−00
Thallium sulfate	D		3E−00	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-09	2E-06	2E-06	2E-07	3E-01	3E-03
Beryllium	B2	4E-02	4E-04	8E-04	8E-06	2E+01	2E-01
Bis(2-ethylhexyl)phthlate	B2			3E-01	3E-03	5E+03	5E+
Bis(chloroethyl)ether	B2	3E-01	3E-03	3E-06	3E-08	6E+01	6E
Bromodichloromethane	B2			3E-06	3E-08	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
Chlorat	D						
Chlordane	B2	3E-01	3E-03	3E-06	3E-08	5E+01	5E-01
Chlorine cyanide	D						
Chlorobenzene	D						
Chloroform	B2	4E-00	4E-02	6E-01	6E-03	1E+04	1E+02
2-Chlorophenol	D						
Chromium (VI)	A	9E-08	9E-06				
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-00	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			6E-06	6E-08	2E+02	2E-00
Dichlorodifluoromethane	D						
1,2-Dichloroethane	B2	4E-00	4E-02	4E-06	4E-04	8E+02	8E-00
1,1-Dichlorothylene	C	3E-01	3E-03	6E-06	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-05	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-05	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-05	4E-07	8E-01	8E-03
Formaldehyde	B1	8E-00	8E-02				
Formic acid	D						
Glycidyaldehyde	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
Hexachlordibenzo-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-06	1E-08	3E+01	3E-01
n-Nitrosodiphenylamine	B2			7E-01	7E-03	1E+04	1E+02
n-Nitrosopyrrolidine	B2	2E-01	2E-03	2E-06	2E-08	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-Tetrachloroethane	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						
Thioacetamide	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:

$C_m = [0.002\ (mg/kg/d) \cdot 1000\ (\mu g/mg) \cdot 70(kg)]/[20\ (m^3/d) \cdot 1] = 7.0\ \mu g/m^3$

where:

C_m = 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:

$C_m = [10^{-6} \cdot 1000\ (\mu g/mg) \cdot 70\ (yrs) \cdot 70\ (kg)]/[0.20\ (mg/kg/day)^{-1} \cdot 20\ (m^3/day) \cdot 1 \cdot 70\ (yrs)] = .175\ \mu g/m$

where:

C_m = 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 e.	
		Oral RFD (mg/kg/d)	Inhalation RFD (mg/kg/d)	Oral slope factor (mg/kg/d)-1	Inhala. slope fa. (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	7.6E−01
Formaldehyde	B1				4.5E−02
Formic acid	D	2.0E−00			
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−08	2.0E−06		
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−06			
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)phthlate	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	8.0E-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.