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Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes

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United States Department of Energy

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A1.0 INTRODUCTION

Provided herein is supporting information on the criteria used to select the soil sampling sites in the context of the Hanford Sitewide soil background project objectives and the conceptual model. This information is supplemental to that provided in the *Characterization and Use of Soil and Groundwater Background for the Hanford Site* (WHC 1991a) and the *Site-wide Background Soil Sampling Plan* (WHC 1991c). This information focuses both on the general and site-specific geologic characteristics of the sampling sites, which served as the basis for their selection.

Section 2.0 addresses the selection of specific sampling sites. This section includes discussions on sampling activity objectives, soil background sampling sites, compositional integrity of the sampling sites, and the coverage associated with these sampling sites.

Section 3.0 contains photographs and a brief geological summary of each of the 14 soil sampling sites. The accompanying text addresses specific factors considered in selection of the sampling sites.

A2.0 SAMPLING OBJECTIVES AND SUPPLEMENTAL SOIL SAMPLING INFORMATION

This section contains an overview of sampling activities, and includes a general description of the Sitewide soil background sampling sites, a discussion regarding lead contamination at sampling sites, and representativeness of the outcrop and excavation sites in terms of the Hanford formation stratigraphy.

A2.1 SAMPLING ACTIVITY OBJECTIVES

The DQO process recommended by the EPA (EPA 1987) has been used as guidance for all activities associated with determination of the Sitewide background (Chapter 1.0, Section 1.2). The objectives of the soil background sampling and analysis effort are summarized briefly in the context of the soil background conceptual model as these and other DQOs have served as the basis for guiding the selection of the sampling sites.

The primary objective of the Sitewide soil background sampling and analysis effort is to obtain a more complete and representative characterization of the range of inorganic and organic chemical constituents that occur naturally in the vadose zone soil, and also to obtain a more complete understanding of the nature of the soils and sediments and the factors that affect their chemical composition. These background data are to be used in establishing and justifying the use of a single Sitewide soil background data set for defining contamination, in establishing cleanup goals, and in baseline risk assessments for environmental restoration on the Hanford Site.

The following sections provide further information regarding the siting and selection criteria for the primary inorganic sampling sites as support for the discussion of these issues in Chapter 5.0, Section 5.3.

A2.2 PRIMARY INORGANIC SOIL BACKGROUND SAMPLING SITES

The primary sites identified in the soil sampling plan (Appendix E) for sampling and analysis of background soils for inorganic analytes were selected from over 30 locations on the Hanford Site. Samples from three offsite localities also were collected for analysis of inorganic analytes (two excavation sites and one borehole site). All of the non-borehole sites are excavated sites or natural outcrops. The samples from these sites and one of the boreholes (Yakima Barricade borehole) are regarded as the primary inorganic soil background sampling localities because the main Sitewide soil background data set is derived from the analysis of soils from these sites. These sampling sites were evaluated in the context of the conceptual model as well as the criteria outlined in the *Characterization and Use of Soil and Groundwater Background for the Hanford Site* (WHC 1991a) and Appendix D. The main selection criteria included the following:

- Areas free of contamination or influences from waste generation activities
- Type and quality of exposure
- Sediment type and/or range of sediment types exposed
- Extent of vertical exposure
- Lateral coverage and spatial distribution
- Relative stratigraphic position
- Logistical and/or regulatory considerations.

The main objective in the selection of sampling sites was the acquisition of samples representing the range of sediment types and compositions encountered in environmental restoration and closure activities across the Hanford Site. The sampling sites identified in the soil sampling plan (Appendix E) were chosen as the sites that expose the most representative variety of soil types within the stratigraphic sequence of the vadose zone with a minimum redundancy or bias of soil types, and that provide a reasonable degree of lateral coverage. These sites also were chosen because the sites expose sediments analogous to those found in the subsurface at various WMUs. The range of sedimentary facies found in these exposures and outcrops correlates directly to those found in the subsurface because the facies represent exhumed parts of the vadose zone.

Many of the vadose zone exposures are excavation sites, also referred to as borrow pits, that have served as quarries of clean sand and gravel for building material use on the Hanford Site. The borrow pits, quarries, and areas excavated in conjunction with construction activities (e.g., the Fast Flux Test Facility) constitute a majority of the sampling sites. The remaining sampling sites are locations of opportunity that are natural outcrop exposures (e.g., river bank and stream gully exposures, road cuts), and those that exist because of vadose zone excavations for construction purposes (e.g., Grout Treatment Facility). All of these sampling sites also have undergone screening for cultural resource impacts and environmental protection, including radioactivity surveys in conjunction with the excavation permits. Thus, the excavation and outcrop locations are preferred sampling sites for the following reasons:

- These locations meet all or most of the selection criteria
- These locations represent 'windows' into the upper vadose zone on and off the Hanford Site
- Thicknesses of up to about 100 feet (30 meters) of the vadose zone both onsite and offsite are exposed at these excavation sites
- The upper few feet (meters) of the vadose zone are generally the soils of concern for most environmental restoration, permitting, and closure activities.

One of the advantages of using these excavations and outcrops as primary inorganic sampling sites is that these 'windows' into the vadose zone are available and reliable sources of information on geologic relationships of the vadose zone. Sampling at these sites of opportunity also is more cost effective and yields more overall information than other types of vadose zone sampling because the sites require no new drilling or excavation. Data obtained from samples in these exposures are superior to other types of vadose zone samples because the chemical composition of soil samples can be combined with geologic relationships that are directly observable (e.g., soil type, stratigraphic relationships, etc.), and also because the sample type and integrity are known. Based on the present understanding of the vadose zone, these sampling sites also are interpreted as exposing representative samples of the lithologic types expected to occur in the subsurface on the Hanford Site (Section A2.4).

Sampling from these sites also is preferred in many ways over borehole sampling because the samples from these sites are capable of providing much more of the information necessary to meet the objectives of this study than a comparable number of samples from boreholes. Only two vadose zone boreholes would produce the number of samples obtained in this study [for 5-foot (1.5-meter) sampling intervals] because of the thickness of the vadose zone in parts of the Hanford Site. Minimal information would, therefore, be available on lateral variability in physical and chemical composition, which is an important aspect of the Sitewide background conceptual model. Borehole samples also would introduce compositional bias from drilling fluids because even water would affect the concentration of analytes that occur in the soils

as soluble mineral species. Moreover, the physical and compositional integrity of soil samples obtained from boreholes also can be compromised by the drilling process or sediment characteristics (e.g., loss of fine matrix materials, sample recovery problem, drilling through boulder beds). These are potentially more important concerns for compositional bias than any associated with sampling from excavation and outcrop sites. These factors and the amounts and types of information obtainable for the same cost by both these sampling approaches were carefully evaluated. Based on the geological relationships regarding the stratigraphic coverage associated with the excavation and outcrop sites (Section A2.5), together with the aforementioned considerations, sampling from these sites together with a limited number of samples from boreholes was chosen as the preferred option. Brief geological descriptions of the individual soil sampling sites are provided in Chapter 5.0, Section 5.3.1.

Sampling from the excavation and outcrop sites was supplemented with samples from two boreholes that traverse the entire thickness of the vadose zone. Splits of about 35 vadose zone soil samples from a deep borehole near the Yakima Barricade and about 12 samples from an offsite borehole on Savage Island were submitted for analysis as part of this effort. These samples were collected by PNL in conjunction with other projects. Supporting information on bulk chemistry, mineral types, well logs, etc., generated by PNL in conjunction with these projects also was provided.

A2.3 EFFECTS OF LEAD CONTAMINATION AT EXCAVATION AND OUTCROP SAMPLING SITES

The natural lead content of soil is inherited from parent rocks. However, soils in anthropogenically influenced areas of lead pollution are likely to be enriched in lead, especially in the top horizon. The combustion of leaded gasolines by motor vehicles is the most common source of lead contamination in soils. The concentrations of lead originating from this source vary systematically with distance from highways, depth, and also are directly correlated with traffic volume (Smith 1976; Yassoglou et al. 1987).

Studies of lead concentrations in soils adjacent to highways indicate that lead contamination in soil decreases sharply with distance to the highway and that the concentrations drop to levels of background at distances of about 65 to 100 feet (20 to 30 meters) for high-volume highways (Smith 1976; Yassoglou et al. 1987; Deroanne-Bauvin et al. 1987). Most of this lead is concentrated in the upper 0 to 2 inches (0 to 5 centimeters) of soil (Yassoglou et al. 1987), and soils adjacent to highways can reach levels over 30 times greater than those in nonroadside soils and extend to depths of 8 inches (20 centimeters). However, the depth of lead contamination also decreases sharply with distance from roadways (Smith 1976; Yassoglou et al. 1987). Factors such as road age (accumulation over time), prevailing wind direction, soil type, vehicle types, topography, and vegetative cover also can be important in affecting these correlations. Lead contamination in soil from automobile exhaust is associated with carbonates and crystalline oxides, and possibly with relatively insoluble lead sulfate. Lesser amounts of cadmium and zinc also are correlated with this source of lead contamination.

Based on the patterns of the extent of lead contamination in soils laterally and vertically with distance from roadways reported in the literature (e.g., Smith 1976; Yassoglou et al. 1987; Deroanne-Bauvin et al. 1987), lead contamination at the soil background sampling sites is not expected to be detectible. Consideration of distances of sampling sites from roadways and the small traffic volumes on roadways on the Hanford Site alone indicate that lead contamination at the background sites is unlikely. Other factors such as the nature of the steep sampling sites (topography), and the fact that most of the sampling surfaces were freshly excavated, freshened, or otherwise cleaned also contribute to this conclusion.

The most compelling evidence for the lack of anthropogenic lead contamination from vehicular activity, however, is the lack of any difference in the lead concentrations in soils at sites with some proximity to vehicular traffic to other soils. No correlation or trend was seen in the lead concentrations of soils nearest to roads compared to the lead concentrations in soils farthest from roads or in samples collected at depths of up to 250 feet (76 meters) below the surface (Chapter 6.0, Section 6.4).

A2.4 STRATIGRAPHIC COVERAGE OF EXCAVATION AND OUTCROP SAMPLING SITES

The extent to which the excavation and outcrop sampling sites represent the range of sediment types in the vadose zone is addressed in this section. As noted in Section A2.2, an important consideration in the selection of these sites was that the sites expose the most representative variety of soil types within the stratigraphic sequence of the vadose zone with a minimum redundancy or bias of soil types, and also provide lateral coverage.

The Hanford Site geoscientists informally have recognized at least four major flood sequences within the Hanford formation (Chapter 3.0, Figure 3-10). These major flood sequences are recognized on the basis of their relative stratigraphy and lithology observed in excavations and boreholes, and also on paleomagnetics and isotopic age dating.

The excavation and outcrop sampling sites where the different soil types within the Hanford formation are exposed are shown in Chapter 3.0, Figure 3-10. As shown by the vertical dashed lines in Figure 3-10, the range of sedimentary facies found in these exposures and outcrops correlates directly to those in the subsurface.

Based on information from excavations and boreholes, the thickness of similar facies of the Hanford formation varies greatly across the Hanford Site. The presence or absence of whole stratigraphic sections also varies. Except for volcanic ashes, stratigraphic correlations laterally across the Hanford Site generally are not possible at this time because there are no adequate criteria for correlations, and also because of facies changes that occur on the scale of feet (meters) to tens of feet (meters). However, the relative stratigraphy of the sediments exposed at many of these sites is recognizable based the geologic relationships seen in the exposure. For example, the oldest parts of the Hanford formation are exposed at the surface at sampling site number 10 (described in Section A3.0), and the middle parts

of the stratigraphic sequence of the Hanford formation are exposed in the excavations at other sites (e.g., sampling sites number 6 and 7). Thus, the type of depositional facies exposed in each outcrop at the sampling sites was evaluated for physical characteristics and the observed relationship to lateral and vertical changes in the outcrop.

A3.0 SITEWIDE SAMPLING SITE DESCRIPTIONS

The following photographs provide visual details of the sampling sites.

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SAMPLING SITE NO. 1. Port of Benton Off-loading Ramp (located south of 300 Area adjacent to the Columbia River). (one photograph). Two sets of Hanford formation flood gravels overlain by Quaternary loess are shown. High-energy flood gravels with a relatively dark (basaltic sand) matrix are overlain by a sandy gravel unit with a higher proportion of quartz/feldspar matrix. These sediments are believed to belong stratigraphically to the middle part of the Hanford formation. These two units represent a transition from a depositional environment of relatively higher energy flood waters to somewhat lower energy. The overlying younger fine-grained sediments are typical of loess deposits found throughout the Hanford Site. The uppermost few inches (centimeters) to few feet (meters) above the loess deposits have been locally disturbed by construction activities and were not sampled.

SAMPLING SITE NO. 2. Excavation Exposures Upgrade from the Washington Public Power Supply System Solid Waste Pit. (one photograph). A thick section of dark-colored clast-free basalt-rich sands are overlain and locally intercalated with light-colored quartz/feldspar-rich sediments. The darker sands represent one of the best exposures found of a basalt-rich sand end member. These sands were deposited in the late stages of a flooding event with a rapid transition to a slack water environment from which the quartz/feldspar-rich sand/silts were deposited. The overlying light-colored sands/silts are typical of those found at the margins of the old flood channels (e.g., Sampling Site No. 11). These deposits are interpreted to be the early middle part of the stratigraphic sequence of the Hanford formation. The holes in the overlying light-colored sediments are swallow nests that were avoided during sampling. The white colored areas in the upper part of the basaltic sands appear to be concentrations of calcium carbonate; perhaps from replacement of old animal burrowings. These areas are restricted to the uppermost part of the basaltic sand unit, and some of these areas were included in the sampling effort. Red flags mark locations of samples.

SAMPLING SITE NO. 3. Hanford Site Gravel Pit No. 9. (one photograph). Thirty to 40 feet (9.1 to 12.2 meters) of the Hanford formation are exposed here in which several high-energy (channel) gravel units of varying types can be distinguished. The sediment types range from very coarse, nearly open-framework gravels to finer grained gravels with matrices of both basalt-rich material and of quartz/feldspar-rich material. This sampling site was selected because the site represents one of the best sequences of high-energy (channel) gravels with several transitions from high-energy to lower energy within a flood channel environment. The sampling site is believed to represent both the early and the middle parts of the Hanford formation channel facies. Some excavation was performed on this site before sampling.

SAMPLING SITE NO. 4. Alluvial Overbank Flood Deposits Adjacent to the Columbia River (south of the old Hanford townsite). (one photograph). These fine-grained silts and sands ±clay originate from Quaternary Columbia River floods that are younger than and stratigraphically overlie the Hanford formation. Several paleosol horizons are visible in the overbank exposures. This site was selected because these sediments represent an important type of material in the vadose zone, i.e., non-Hanford formation alluvial deposits. These sediments are ubiquitous throughout the 100 Areas of the Hanford Site. Sampling at this site also represents an opportunity to characterize the chemical variations associated with an obvious soil-development profile.

Recent stabilized sand dunes also occur about 30 to 60 feet (9.1 to 18.3 meters) from the Columbia River at this location. These sand dunes are locally draped over the overbank deposits and/or Hanford formation sediments. Eolian deposits of this type have somewhat different characteristics from loess in that there is locally a high degree of small scale segregation of light and dark colored material. Samples of these stabilized dune deposits also were collected at this location as this type of eolian material commonly comprises the upper few inches (centimeters) to upper few feet (meters) of the vadose zone at the Hanford Site. Red flags mark locations of samples.

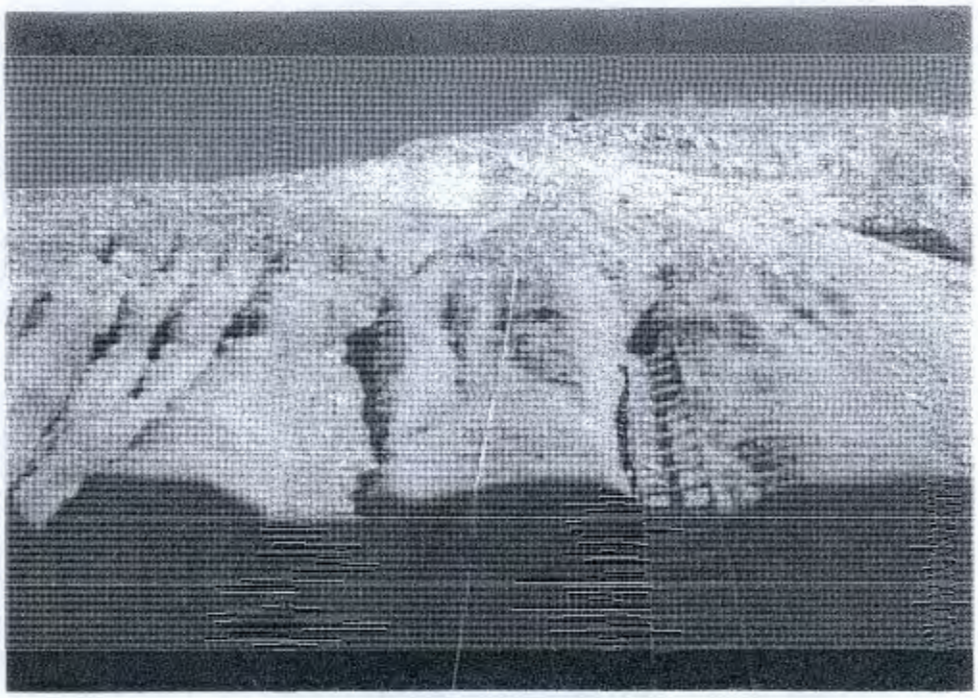
SAMPLING SITE NO. 5. Hanford Site Gravel Pit No. 21 (located in the 100 Areas of the Hanford Site). (one photograph). Four different lithologic types are exposed in this quarry. The finer grained facies of the middle Hanford formation are well exposed at this site, as well as a sequence of eolian sand layers above and below Mount Mazama ash (6,800 to 6,600 years old). The Hanford formation deposits range from open framework gravels to transitional flood sands and gravels that are typical of the lower energy depositional regimes found in the 100 Areas; these were deposited away from the main channel. Plane-laminated glaciofluvial sands also are exposed at the base of the quarry. Red flags mark locations of samples.

SAMPLING SITE NO. 6. Vadose Zone Exposed in Grout Treatment Facility Vault Pit (located in the 200 East Area). (three photographs). This site is one of the best continuous exposures of Hanford formation sediments that exists on the Hanford Site. These outcrops are exposures of opportunity resulting from the excavations for the Grout Treatment Facility. Exposed at this location is a thick section of interbedded basalt-rich and quartz/feldspar-rich sands that contain only a few cobbles and/or pebbles. These deposits are representative of the finer grained transition facies found in the 200 Area Plateau. These sediments were deposited on the lee side of a bar between the flood channels and the lower energy environments in back of the bar. This sequence of bar deposits forms a slight topographic high in the 200 Areas where sediments accumulated as the flood waters flowed from the north-northwest to the southeast. Several unconformities, manifested as horizontal layers truncating foreset bedding, are evident at this location. These represent successive flood episodes and changes in the energy regime within flood episodes

Also, the compositional diversity of the finer grained material in the Hanford formation is well illustrated, and includes clastic dikes, a well developed caliche horizon with calcified root casts in the upper part of the section, and paleosol development in the upper parts of eolian deposits that overlie the Hanford formation deposits. This sampling site was selected because of the unusually good continuous exposure of many tens of feet (meters) of the vadose zone in the 200 Area Plateau, the variety of soil types and depositional environment, and the uncontaminated nature of the site. This sampling site also afforded the opportunity to sample units laterally for tens of feet (meters) for the evaluation of lateral variability. Red flags mark locations of samples.

1 SAMPLING SITE NO. 6

SAMPLING SITE NO. 7. Burial Ground 218-E-12B - Trench 94 (located in the northeast corner of the 200 East Area). (two photographs). This site and the Vault Pit (Sampling Site No. 6) are two of the best continuous exposures of the vadose zone that exist on the Hanford Site. Several gravel and sand facies are exposed here, ranging from high-energy open framework gravels to transition facies sands and sandy gravels. The close proximity of this sampling site to the Vault Pit, located 0.9 mile (1.5 kilometers) to the south, provides insight into the scale of lateral variability of the Hanford formation. Sediments were deposited contemporaneously in both locations, but differ significantly in grain size over this short distance owing to local differences in the sedimentary environment. The Hanford formation in the area of Trench 94 represents sediments deposited in the vicinity of a bar on the side closest to the flood channel (medium-high energy environment), whereas the Vault Pit sediments were deposited on the lee side of the bar. These relationships provide information on the scale of variability in depositional environments and facies in the Hanford formation. This sampling site also is one of the best 'windows' into the upper 30 to 50 feet (9 to 15 meters) of the vadose zone on the Hanford Site. Sampling sites such as this contribute much to understanding the geology and physical composition of the Hanford Site vadose zone. Red flags mark locations of samples.

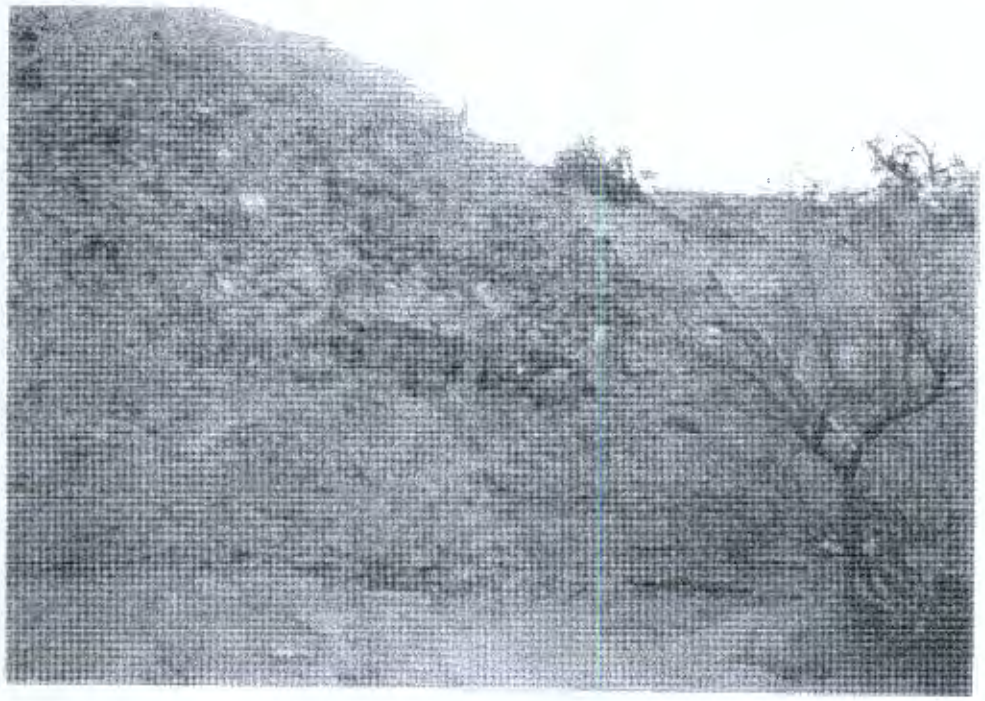


SAMPLING SITE NO. 7

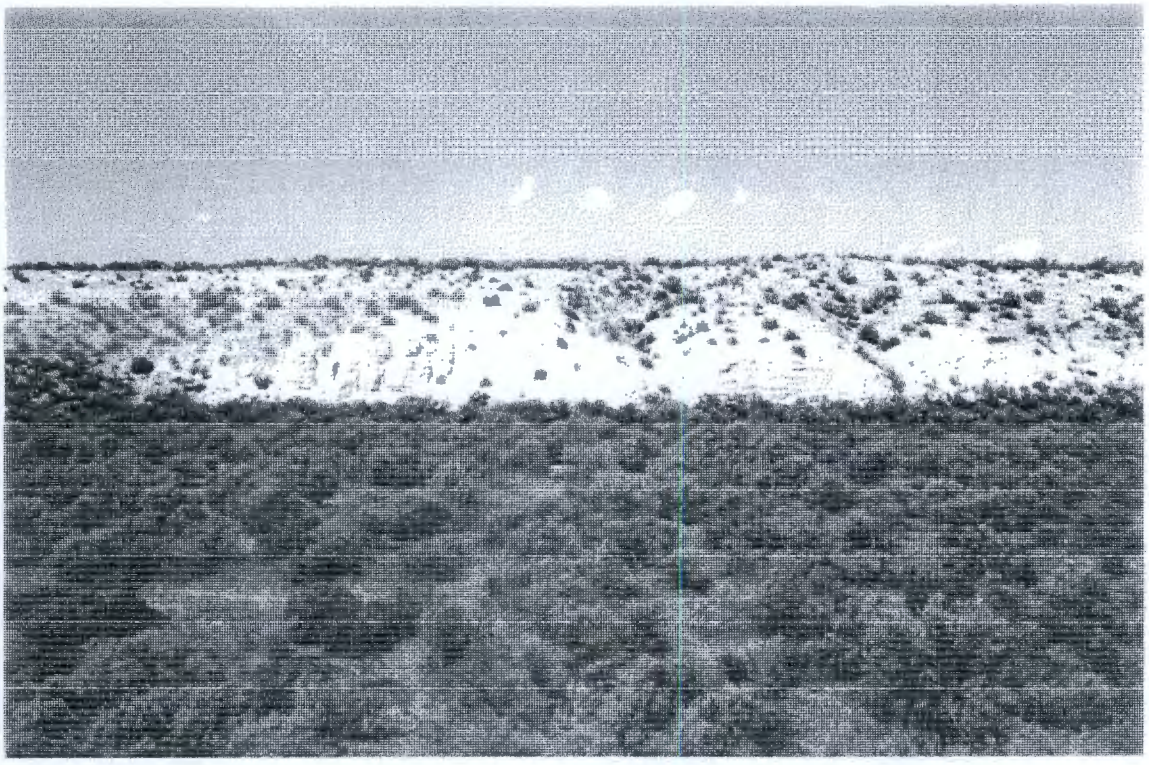
SAMPLING SITE NO. 8. Gravel Pit West of the 200 East Area (located just outside of the 200 East Area fence). (one photograph). At this sampling site, two to three high-energy regime flood gravel units are exposed. These units are locally intercalated with discontinuous lenses and layers of finer grained quartz/feldspar-rich sand. The gravels are laminated and show cyclic concentrations of dark and light colored material in their matrices. This deposit is a good example of transitional depositional facies that range from gravels deposited under flood conditions to finer, light-colored sands deposited under slack water conditions. Red flags mark locations of samples.

SAMPLING SITE NO. 9. Old Batch Plant Sand and Gravel Quarry (for cement). (one photograph). The deposits exposed at this sampling site are similar in type to those exposed at Sampling Site No. 8, (i.e., high-energy main channel gravels with some late stage, lower-energy sandy interbeds). However, the gravels at this location differ from those at Sampling Site No. 8 in that these deposits reflect more highly variable environments of deposition. The gravels exposed here are highly structured, i.e., foreset- and cross-bedding truncated by successive depositional episodes or flood surges. Both the structure of these sediments and the repetition of relatively closely spaced sequences of coarse dark-colored gravels transitional to finer grained quartz/feldspar-rich sands attest to a high degree of variability in the energy of the depositional environment.

SAMPLING SITE NO. 10. Exposure of Lower Hanford formation Sediments (located just east of Highway 25 on the Vernita grade near mile marker 41). (one photograph). This outcrop exposes the basal part of the Hanford formation. Flood gravels in this area have an usually high basalt clast content and overlie a pre-Hanford formation orange-colored loess unit deposited unconformably on 15 to 10 million year old Columbia River basalt (not shown in photograph). This basal flood gravel is well exposed and is characterized by a relatively high degree of calcite cementation throughout the angular gravels. This is one of the only known locations where the lower part of the Hanford formation is exposed. This part of the Hanford formation is reversely polarized and is determined to be as old as 750,000 years. Although exposed here, this part of the Hanford formation occurs at depths of over 200 feet (61 meters) below the surface elsewhere on the Hanford Site. Red flags mark locations of samples.



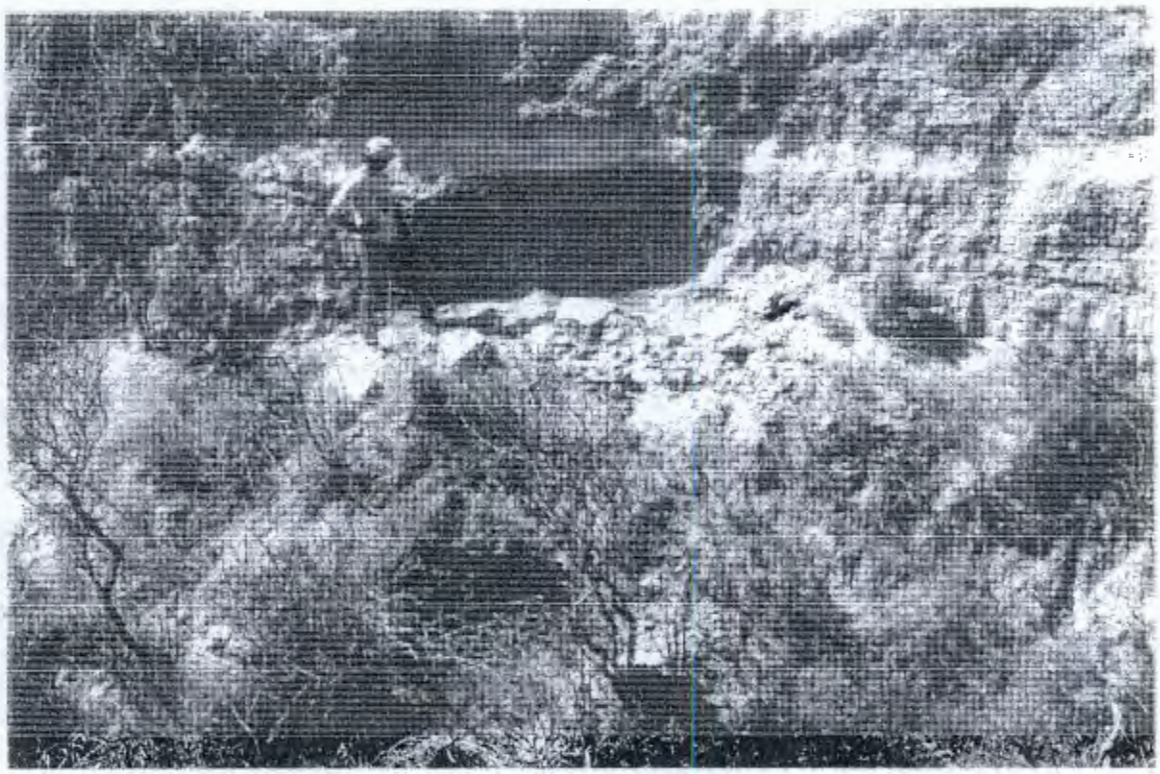
SAMPLING SITE NO. 11. Cold Creek Slack Water Facies of the Hanford formation on the Flank of Rattlesnake Mountain (located in the vicinity of Cold Creek, west of Highway 240 on the Arid Lands Ecology Reserve). (three photographs). The fine-grained quartz/feldspar-rich sand, silt, and clay sediments exposed in this stream gully represent sediment deposited at the distal margins of the flood channels contemporaneously with the Pasco gravels. These slack water facies of the Hanford formation (Touchet beds) also represent one of the two compositional end member materials that comprise the matrix of the Hanford formation deposits. Good vertical and lateral exposures of the rhythmically layered and finely laminated sediments exist at this sampling site, which reflect slack water deposition from successive flood events. Clastic dikes of similar composition also occur at this location.



SAMPLING SITE NO. 11

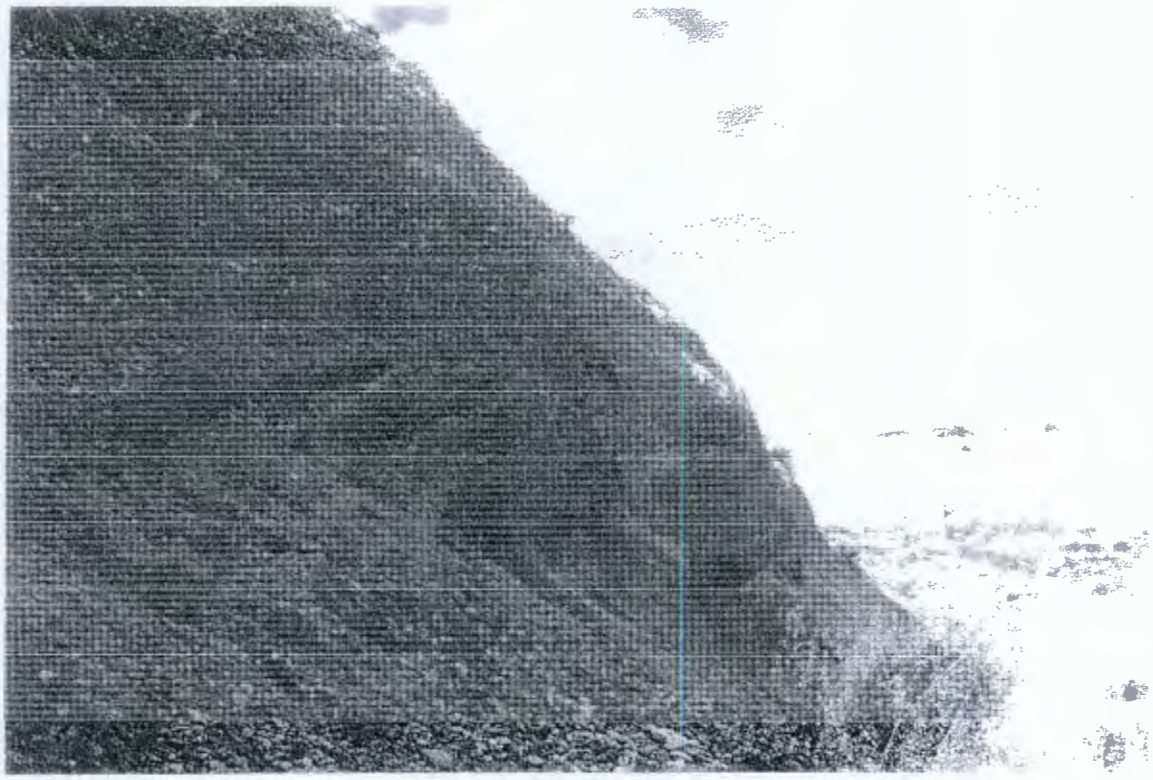
SAMPLING SITE NO. 12. Dry Creek Alluvial Deposits in Dry Creek Canyon Area (located west of Highway 240 on the Arid Lands Ecology Reserve). (one photograph). These sediments represent Touchet bed material from the marginal facies of the Hanford formation that has been remobilized by local stream processes and is interbedded with volcanic ash (white colored layers). This material is very similar in appearance and composition to the fine-grained quartz/feldspar-rich sandy-silty deposits exposed in Cold Creek. However, these deposits are younger because they are remobilized and are interbedded with volcanic ash from Mount Mazama (6,800 to 6,600 years old).

These alluvial deposits are typical of one source of sediment that is transported across the Hanford Site and deposited as loess by eolian processes. The composition of these sediments was compared and contrasted to those of the parental Touchet bed material, the eolian loess, and other fine-grained quartz/feldspar-rich sediments in the Hanford vadose zone. The Mazama ash was collected and analyzed as one type of natural outlier that can be expected to deviate from the population of other Hanford Site soil background compositions.



SAMPLING SITE NO. 13. Offsite Gravel Quarry Exposures of the Hanford formation. (three photographs). Excellent exposures of predominantly high-energy gravels and subordinate amounts of sandy interbed transitional facies of the Hanford formation occur in an abandoned gravel quarry on the east side of the Columbia River across from the 300 Area. Quaternary loess deposits overlie the Hanford formation deposits. Good vertical and lateral exposures of several successive flood deposit sequences exist at this site.

This location was selected as a good soil background sampling site because it is one of the best offsite exposures of Hanford formation deposits known to exist. These deposits also represent the upper part of the Hanford formation sediments that exist elsewhere on the Hanford Site.



SAMPLING SITE NO. 13

SAMPLING SITE NO. 14. Offsite Exposure of Hanford formation Deposits (located at the mouth of Ringold Coulee, east side of the Columbia River across from the dune fields on the Hanford Site). (three photographs). The exposures of Hanford formation deposits at this location are perhaps the most variable of all sampling sites. Soils with both basaltic and quartz/feldspar rich fine-grained components occur in the same section. The lower to middle part of this exposed section consists of dark-colored high-energy main channel gravels and cross-bedded sands with a high proportion of basaltic matrix material. The upper part of the section consists of a succession of lighter colored gravels transitional to fine-grained light colored quartz/feldspar-rich slack water sands and silts that show evidence of soft sediment deformation. One of the most distinctive features of the deposits at this sampling site is the difference between the dark and light-colored gravels. The lower gravels are dominated by basaltic clasts and matrix material. The upper gravels, however, appear to be dominated by reworked material from the Ringold Formation. Another variety of channel gravels also is exposed stratigraphically below the basalt-rich gravels elsewhere at this location (not shown in photographs). This sampling site was selected because of the excellent lateral and vertical exposure of the Hanford formation deposits, its offsite location, and because the sampling site represents one of the most diverse stratigraphic section of Hanford formation sediments that has been observed to date in the Pasco Basin.

SAMPLING SITE NO. 14

APPENDIX B

SAMPLING NARRATIVE

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B1.0 INTRODUCTION

This appendix describes the collection of field samples performed in accordance with the *Site-wide Background Soil Sampling Plan* (Appendix F). E

Field work was divided into two phases: (1) systematic random and judgment sampling for the analysis of inorganic analytes at the 14 primary excavation and outcrop sites and (2) judgment sampling of topsoils for inorganic and organic analytes. All of the 14 inorganic sampling sites had vertical exposures from which multiple samples were collected. This work was performed from September through November of 1991. Sampling for organic constituents was conducted in late February and March of 1992, at 12 locations different from those used for inorganic sampling. Samples from the topsoil sites were submitted for laboratory organic and inorganic analyses. Supplementary organic field screening measurements were made during this phase on fresh soil samples from both the initial 14 and the latter 9 sites. The inorganic sampling sites identified in the sampling plan are described in detail in Appendix A. Raw data for selected analytes obtained from these samples are presented in Appendix C. Splits of all samples are archived at the Hanford Site Geotechnical Sample Library.

B1.1 INORGANIC SAMPLING

The 14 primary sites selected for the characterization of inorganic analytes in soil were chosen with attention to the following: (1) size and type of geological exposure, (2) lack of known contamination, (3) geographic location, and (4) practical considerations (Chapter 5.0, Sections 5.7 and Appendix A2.2). Samples were not collected in sloughed material or in areas where there was evidence that the soil had been moved. Only in situ, native geologic material was collected. Samples were collected in accordance with onsite procedures (WHC 1988).

At each sampling site, a series of systematic random samples were collected along the fall line of the chosen slope. These samples were spaced at approximately 3-foot (0.9-meter) vertical intervals from a random starting point. The top of the sampling line was marked with a stake before leaving the site.

Additional judgment samples were collected to supplement the systematic samples. These samples were chosen by the field geologist when important lithologic features were not represented by the systematic samples.

At least one position at each site was selected randomly for multiple sampling. One sample was submitted for analysis as a regular sample, another sample was sent to an alternate laboratory as a split sample, and a third sample was divided into two portions, given separate identification numbers, and submitted to a laboratory for grain size analysis.

All samples were collected with stainless steel trowels or spoons. Stainless steel bowls and screens also were used for some samples. Separate,

clean equipment was used for each sample. Only laboratory cleaned, stainless steel collection equipment was used. Samples were placed in new, manufacturer-cleaned glass sample jars. Samples for laboratory chemical analysis were cooled on collection, and maintained on ice during shipment to the analytical laboratory.

Before shipment offsite, portions of all samples were laboratory-screened for radioactive content in accordance with routine onsite requirements. Most samples were screened for total activity at the 222-S Laboratory Complex (WHC 1993). Samples from some sites (Sites No. 4 and No. 6) were screened for release from radiological controls by the onsite mobile health physics counting organization. The results of screening were the same in all cases. Laboratory testing showed no aliquots exceeded the criteria for release as nonradioactive in accordance with applicable requirements (WHC 1993). This was consistent with all observed radiological field instrument readings.

The location of each of the sites is presented on Figure B1. A narrative of the sampling procedures for each site is presented as follows in the order of assigned number. Numbers associated with gravel pits follow the Hanford Site numbering scheme.

B1.1.1 Site No. 1

This site lies along the north side of a little-used gravel road leading to a heavy equipment off-load ramp on the Columbia River, owned by the Port of Benton, Richland, Washington. Sampling commenced on September 12, 1991. A vertical section of the hill was exposed when the road was built. A rocky, 32-foot- (9.8-meter-) wide section was selected as eligible for sampling.

Three sample locations represented the full height of the exposure. Samples were collected from the bottom upward to avoid the possibility of any cross-contamination from the sampling process. Split samples for chemical analysis and grain size analysis were collected at the uppermost location, about 1 foot (0.3 meter) below the top edge of the exposed slope. No judgment samples were collected from this site.

B1.1.2 Site No. 2

This site, currently leased to the Washington Public Power Supply System (Supply System), was sampled on September 26, 1991, the third of 14 sites. The area is adjacent to other Supply System operations in the southeast section of the Hanford Site. Access to the area is restricted by the Supply System.

The systematic samples were collected from four locations on an excavated, coarse sand hillside. Multiple samples from the uppermost location, about 1 foot (0.3 meter) below the top of the exposure, were submitted as regular, split, or grain size analysis samples.

Two judgment samples were chosen to supplement the systematic data set. Several carbonate-rich masses were visible on the eligible area, and one of these was sampled. Another dark, basalt-rich sand sample was collected over 40 yards (36.6 meters) northeast of the line of systematic samples, stratigraphically lower in the section.

B1.1.3 Site No. 3

This site is slightly over 1 mile (1.6 kilometer) north of the Wye Barricade on the Hanford Site, about 49 to 98 feet (15 to 30 meters) east of Route 2 South. Two separate sampling events occurred at this site because the basis for selection of this site was the vertical extent and exposure of two varieties of Hanford formation material on the west-facing side of the borrow pit. Between the time of site selection and sampling, however, the steep vertical section chosen for sampling had been reclaimed (i.e., bulldozed over and sloped), and the opposite east-facing side had been exposed by excavation activities. Thus, the first sampling effort occurred on the then existing east-facing exposure about 49 to 82 feet (15 to 25 meters) east of the original site. It was subsequently determined that the original west-facing exposure should be reexcavated and sampled for consistency with the original criteria for selection of this site, because the east-facing slope exposed less vertical section than the original west-facing section and because the geologic relationships seen in the east-facing exposure differed somewhat from those in the west-facing exposure in terms of soil type and characteristics. Because of the apparent facies changes between these two exposures [only 82 feet (25 meters) apart], both sets of samples were analyzed and were used to evaluate compositional variability on the scale of a few tens of meters.

A continuous 12-foot- (4-meter-) high exposure was sampled on October 24, 1991. This site was later terraced, exposing 25 vertical feet (7.6 vertical meters) in a stairstep manner. Resampling was performed on November 21, 1991 to take advantage of this larger exposure. Although all other sites were sampled after a prolonged period of no significant precipitation, both sampling events at Site No. 3, particularly the latter, occurred when soil was moist from recent rain. Weather for background sampling, beginning the second week of September, generally was pleasant. Weather in the latter part of October changed abruptly from sunny, warm, and dry to overcast, cool, and rainy.

On October 24, 1991, samples were collected during light wind and rain from four systematic and six judgment locations. The line of systematic samples was chosen at random from a 40-foot (12-meters) horizontal section of gravelly exposure. There were 12 feet (3.7 meters) of exposure at this location, from which multiple samples were collected 2 feet (0.61 meter) from the top. This was the location of the uppermost systematic sample.

Two judgment samples were collected from this area. These were located about 4 feet (1.2 meters) apart vertically, 30 feet (9.1 meters) north of the systematic line. Screens were used to help separate rocks from the finer fraction for all the samples.

Field sieving was performed only to aid in the removal of large rocks, and not to precisely separate the less than 2-millimeter-size fraction from site material. Screen mesh sizes varied. Laboratories performing chemical analysis were instructed to use the less than 2-millimeter-size fraction of submitted samples. This size fraction is recommended by WAC 173-340-740.

Four judgment samples were collected from eolian sand deposits near this site. Sample B014G8 was removed from the vertical face of a sandy hill, located about 10.5 feet (3.2 meters) southwest of the systematic line, outside the defined zone. The three other samples were collected near the top edge of the sandy hill northwest of the pit. The sample locations lie in a line 27 feet (8.2 meters) and 43 feet (12.8 meters) from the lowest location as measured along the hill's slope. The hill changed pitch over the length of the transect. The sand composition was visibly different at each location. The lowest site was chosen for multiple sampling.

After excavation, approximately five 5-foot- (1.52-meter-) vertical slopes were exposed, separated by horizontal terraces 15 to 20 feet (4.6 to 6.1 meters) wide. New sites were marked and geologic observations were made on November 15, 1991. The systematic line of samples was selected from a defined 60-foot- (18.3-meter-) horizontal section of the embankment. The top 2 feet (0.61 meter) of the vertical section was not trusted to be original in situ material, and so was excluded from consideration for sampling.

On November 20, 1991, the pit area was resampled. Samples were collected from a single line perpendicular to the stepped terraces of the new excavation. Old systematic sampling sites were obliterated when the new area was cleared. Eight locations were sampled; multiple samples were collected at the 14-foot (4.3-meter) depth. No additional judgment samples were collected at this time. The earlier exposed sand lens had been obliterated, and no similar lens was exposed.

B1.1.4 Site No. 4

This site was the first of two sampled on October 3, 1991. The other was Site No. 10, near Vernita. Site No. 4 is south of the old Hanford townsite along the shore of the Columbia River. Samples were collected from a thick river overbank deposit. A line down the natural vertical bluff was chosen at random from a 46-foot- (14-meter-) horizontal section. Three sample locations represented the full height of the exposure. An additional split sample and samples for grain size analysis were collected at the lowest sampled location, 7 feet (2.1 meters) below the well-defined top edge.

B1.1.5 Site No. 5

This site is further north than any other background site. The site was located in Pit 21 near the 100-D and DR Areas. Some preparation of this site was necessary because sand and wind blown tumbleweeds had accumulated at the base of the target area. Project personnel arranged for a backhoe to reexcavate the desired face. This was completed October 16, 1991.

On October 18, 1991, the site was visited in the late afternoon. Locations were flagged for sampling and observations were made by the project geologist. A systematic line of samples was chosen at random from a 59-foot- (17.9-meter-) wide section of the embankment. Multiple samples were collected 4 feet (1.2 meters) from the top. Other systematic locations (four) were at approximately 3-foot (0.9-meter) intervals to the top and bottom of the exposure. Four additional judgmental sites were selected to supplement the data set, two within and two southeast of the above defined zone.

Sampling was performed on October 21, 1991. Although the weather was pleasant when sampling began, winds steadily increased during sampling. Sampling at the 4-foot (1.2-meters) level intercepted a small animal burrow tunnel. Visible associated nonsoil remnants (vegetation, fur, food, bones, feces, etc.) were not apparent. All samples collected from Site No. 5 were fine grained.

B1.1.6 Site No. 6

This site, where the greatest number of systematic samples were collected, is a large pit excavated for placement of the grout disposal vaults. A series of systematic samples were collected from a 200-foot- (60.9-meter-) wide section comprising the majority of the south end of the pit. Fifteen sites were sampled. The slope of the sampled face was roughly 35 degrees. Vertical measurements were made using a marked pole and sighting to the next higher sample point.

A berm had been formed along the top edge of the pit; sampling was avoided in this area because the soil was not original in situ material. Samples were collected on October 8, 1991. The uppermost sample was collected approximately 6.5 vertical feet (2.0 vertical meters) below the top of the berm. The lowest systematic sample was approximately 8.5 feet (2.6 meters) above the existing pit bottom. Material below this point was sloughed from above.

The samples generally were sandy, with few rocks, and were collected easily with trowels. Extra sample material reserved from this site showed condensation when placed in plastic bags. This was unusual; before the late October rains, most sample sites contained only very dry material.

B1.1.7 Site No. 7

This site is located in Trench 94 of the Low-Level Burial Grounds. The site lies at the far northeast corner of the 200 East Area.

The line of systematic samples was selected from a 16-foot- (4.9-meter-) wide zone on the northwest wall of the trench. Ten systematic sample locations were collected from a random starting point within the eligible zone. Multiple samples were collected at the second lowest location.

Three additional judgment samples were collected from the west extension of the trench. Samples originated above, in, and below a narrow, moist silt/clay lens near the base of the trench. This moisture is because of very fine-grain size and/or clay content in the lens. Two judgment samples also were collected in the general vicinity of the systematic samples, one on each side of the area from which the line was chosen.

B1.1.8 Site No. 8

This site is located at Pit No. 29, east of Route 4 North and west of the 200 East Area. The site was sampled on October 9, 1991, after Site No. 9. Only small vertical exposures were present. Two samples in high-energy flood gravel deposits comprised the systematic samples. These sample locations were located along the east face of the pit at 2 feet (0.61 meter) and 5 feet (1.5 meters) below the top of the existing exposure. Both samples were collected using bowls and screens because of the preponderance of rocks.

Several judgment samples were collected at this site. A zone of fine-grained sediment between the two systematic samples was collected as judgment sample B014B5. This material was collected over a large lateral area, about 15 feet (4.6 meters), because of the narrowness of the layer and sample volume requirements. Material in the sample was predominantly from the finer zone, but some slight mixing with upper and lower zone material was unavoidable.

Another judgment sample was collected from the north side of the pit. Multiple samples (regular, split, and grain size aliquots) were collected at this location. The sampled media consisted predominantly of sand, with some coarser material. Material was chipped from the face into a stainless steel bowl; rocks were removed with trowels and sample bottles filled. The process was repeated until all jars were full.

B1.1.9 Site No. 9

This site is located north of Route 3, between the 200 West and 200 East Areas. An old cement batch plant was once located nearby. Gravel and fill have been quarried from the surrounding vicinity. Samples were collected from this site on October 9, 1991.

The sampled exposure was on the south-facing vertical slope, where a 20-foot- (6.1-meter-) wide section was chosen for sampling and an initial systematic point was selected at random. The exposure was approximately 12 feet (3.6 meters) tall, but the top 3 feet (0.9 meters) was not eligible for sampling. Evidence suggested the upper soil was mechanically moved in the past.

Three systematic locations were sampled at Site No. 9. Multiple samples were collected 10 feet (3.0 meters) down from the top of the embankment. Three judgment samples also were selected from this exposure.

This was the first site at which sieves were employed (in the field) to assist in separating rocks from the smaller soil fractions. Screens were used when collecting material from the 7-foot (2.1-meter) and 10-foot (3.0-meter) level, and in the coarse-grained judgment sample B01499.

B1.1.10 Site No. 10

This site is located east of State Highway 240, on the grade south of the Vernita Bridge. Access to the site is on foot, a short distance from the highway. This is a small exposure, which might have been a quarry in the past.

On the day of sampling, October 3, 1991, an overhang on the upper central portion of the exposure was observed, which was fractured and apparently unstable. This presented a potential and unacceptable hazard to sampling personnel. The western edge of the north-facing exposure was judged by the onsite geologist to be fully representative of material at this outcrop. Because the eligible area for systematic sampling was very narrow with no visible lateral variability, randomization was done only along the vertical axis to locate the initial systematic sampling point at this site. The top edge of the exposure was rounded, and not obviously defined.

Five systematic sample locations were marked over the full height of the exposure. Samples were located 1, 4, 7, 10, and 13 feet (0.3, 1.2, 2.1, 3.0, and 4.0 meters) from the top. All samples were chipped from the exposed face into a stainless steel bowl. This sediment generally was well cemented. Sample jars were filled after discarding much coarse material from the sampling bowl. Multiple samples were collected at the 7 foot (2.1 meter) level. These samples included the regular sample, a split, and aliquots for grain size analysis. No judgment samples were chosen at this site.

B1.1.11 Site No. 11

This site is located in fine-grained silt (Touchet beds) in the upper Cold Creek Valley. This was the most remote of all sampled sites. This natural exposure lies less than 0.5 mile (0.8 kilometer) north of a high voltage power line approximately 2.5 miles (4.0 kilometers) west of the nearest paved road, State Highway 240. Access was by four-wheel drive vehicle to the powerline road, and then by foot to the site. This site is located in the Arid Lands Ecology Reserve, which is a natural area set aside for ecological studies.

A line of samples was chosen from an eligible 23-foot (7.0-meter) section of exposed sediments on the north bank of a ravine. Sampling took place on October 15, 1991. Three samples represented the vertical height of the selected eligible area. The exposed slope was similar to Site No. 10 in that no clear feature distinguished the precise top of the vertical embankment. The height of the selected area was about 9 feet (2.7 meters). Samples were located 1, 4, and 7 feet (0.3, 1.2, and 2.1 meters) below the selected top

reference point. Multiple samples were collected from the 1 foot (0.3 meter) level.

Two judgment samples supplemented the data set. Both samples originated from clastic dikes--one about 3 yards (2.7 meters) east, and one about 55 yards (50.3 meters) east of the systematic samples. All samples were fine-grained and very dry.

B1.1.12 Site No. 12

This site is located along Dry Creek near Rattlesnake Springs on the Hanford Site. The sampled face of this site is part of a small canyon formed by Dry Creek. Dry creek is fed by springs draining remote areas west and upgradient of onsite activities. This site also is part of the Arid Lands Ecology Reserve and was sampled on September 24, 1991.

A 90-foot- (27.4-meter-) horizontal section of the south-facing embankment was marked, and a random point was chosen for the line of systematic samples. The eligible slope was 22 feet (6.7 meters) tall at the selected location. The lowest sampling point was outside the zone of heavy vegetation lining the base of the canyon. Samples were all very fine grained and dry. There was substantial cohesive strength to the material forming the canyon wall, but it was very dusty when crumbled. Multiple samples from the 5 foot (1.5 meters) level were collected in a stainless steel bowl and packaged for shipment.

Systematic samples were supplemented by two judgment samples, one from an ash layer and one from a carbonate-rich layer. These samples originated approximately 10 feet (3.0 meters) downstream from the vertical line of samples at the 7 and 12.5 foot (2.1 and 3.8 meter) level, respectively.

B1.1.13 Site No. 13

This site is a small gravel pit in Franklin County near the intersection of Sagemoor Road and Road 68 was sampled on October 1, 1991. The top edge of the sampled area was poorly defined. The stake marking the position of the vertical line for systematic sampling was placed well up the hill from the referenced edge. All four sample locations contained predominantly coarse-grained sediments. The third location from the top was also the origin of split and grain size samples. No judgment samples were collected at this site.

B1.1.14 Site No. 14

This site is located in a large gravel pit southeast of the Ringold fish hatchery that was sampled on October 1, 1991. This location offered accessible Hanford formation deposits at an offsite location. The deposits are located east of the Hanford Site across the Columbia River at the mouth of the Ringold coulee.

Because of the sheer size and steep pitch of the exposure, samples were taken in a vertical line down the slope only to a certain point, then shifted laterally and continued downslope to the floor of the pit. This was to ensure the safety of sampling personnel.

A 37-foot- (11.3-meter-) horizontal section of the exposure was selected as representative of the upper zone of the exposed material. A random point was chosen in the upper unit, and a systematic series of samples were collected. When talus was reached on the upper section, easily traceable strata were followed laterally to a second random point above the lower unit. Systematic sampling points on the lower line were continued at 3-foot- (0.9-meter-) vertical intervals determined by the initial series. Those sample 'depths' thus were referenced with respect to the original line. Multiple samples were collected from the 12 foot (3.6 meter) depth on the upper section. Some sample points at Site No. 14 were so coarse grained that it was difficult to find material less than two millimeters.

One judgment sample was collected at Site No. 14. This sample was from an area 38 feet (11.5 meters) further north of the second line where a stratagraphically lower unit could be sampled.

B1.2 TOPSOIL SAMPLING

Representative samples of the primary types of topsoils that occur in the main floral ecosystems on the Hanford Site were collected to further develop an understanding of baseline natural levels of organic and inorganic compounds detectable by CLP standard methods (EPA 1989c). Fewer samples were collected in this phase of the project than the previously described inorganic phase. This partly reflects a premise that measurable concentrations of naturally occurring regulated organic compounds are far less likely to occur in natural soils than inorganic elements. Furthermore, where 'natural' concentrations of regulated organic compounds do occur, the importance of localized biogenic processes must be recognized for proper interpretation. Thus, this phase of sampling focused on localities where the concentrations of naturally occurring organic compounds and biologically concentrated inorganic analytes should be largest. This phase of the background study focused on widely separated sample collection points occupied by characteristic vegetation.

This phase of sampling began on February 27, 1992. All sites were located on the Hanford Site; sampling sites were selected based on professional judgment and were collected in accordance with onsite procedures (WHC 1988). Samples were submitted for CLP volatile organic analysis, semivolatile analysis, pesticide and polychlorinated biphenyl analysis, and total organic carbon analysis. Inorganic analyses also were requested. Analytical method reference numbers can be found in Chapter 3.0.

In addition to these laboratory analyses, an organic vapor monitor was used to monitor air at the point of sample collection, and to perform supplementary headspace screening at a field laboratory. The monitor uses a photoionization detector with a 10.6 eV lamp, and commonly is employed for safety monitoring at dangerous waste sites. Headspace screening measures the

concentration of detectable vapors in the air (headspace) above the sample in a sealed container.

Before collecting the organic samples, a silica sand volatile organic analysis blank was prepared. This sample accompanied field samples from collection through shipment to the offsite laboratory, but was never opened in the field.

Soil samples were collected with stainless steel trowels or spoons after removal of surface debris. Samples were collected from the top 6 inches (15.2 centimeters) of soil. Separate, clean equipment was used for each sample. Only laboratory cleaned, stainless steel collection equipment was used. Samples were placed in new, manufacturer-cleaned glass sample jars. Samples for laboratory chemical analysis were cooled on collection, and maintained on ice during shipment to the analytical laboratory. Samples were not sieved in the field, nor was the analytical laboratory instructed to use sieved soil aliquots.

All samples were surveyed in the field for radioactivity. No detectable contamination was found. Consistent with onsite shipping requirements, aliquots of all samples also were submitted for a laboratory radioactivity analysis. Results were consistent with field surveys, and all samples qualified for unconditional release from radiologic controls. Each sample location was marked with a post or flag after collection. Each of the sites is described in the following sections in the order in which the sites were visited.

B1.2.1 Site No. E-1

The first background site, sampled on February 27, 1992, was on a southeast facing slope near the crest of Rattlesnake Mountain. Samples were collected 105 feet (32 meters) west of the access road to the radio telescope structure, midway between the structure and the main road (T11N R26E S32). This site is on the Arid Lands Ecology Reserve. Elevation at Site No. E-1 is 3,400 feet (1,036 meters).

Two sample types were associated with this location; a sample that would be submitted for a full suite of analyses, and a duplicate for volatile organic analysis. Aliquots of each sample were reserved for later headspace concentration measurements. Onsite air measurements with an organic vapor monitor showed no detectable organic compounds. Fog and light rain were present.

Samples were taken from under the canopy of three-tip Sage (*Artemisia tripartita*). Sparse shrubs and bunchgrass populate the site, and evidence of a recent range fire was visible. Associated primary bunchgrasses were Sandberg's bluegrass (*Poa sandbergii*) and bluebunch wheatgrass (*Agropyron spicatum*). Other identifiable species include grey rabbitbrush (*Chrysothamnus nauseosus*), big sagebrush (*Artemisia tridentata*), yarrow (*Achillea millefolium*), balsamroot (*Balsamorhiza careyana*), narrowleaf goldenweed (*Haplopappus stenophyllus*), Cusick's sunflower (*Helianthus cusickii*),

thymeleaf buckwheat (*Eriogonum thymoides*), Russian thistle (*Salsola kali*), cheatgrass (*Bromus tectorum*), and wildrye (*Elymus sp.*). Soil in this area had a high natural organic content. It is believed to be a Lickskillet silt loam.

B1.2.2 Site No. E-2

This site is several miles (kilometers) southwest of State Highway 240 on the Arid Lands Ecology Reserve. It is located at Rattlesnake Springs, about 300 yards (274 meters) southwest of the 648 Building (T12N R25E S29). Elevation at Site No. 2 is 700 feet (213 meters).

One sample was collected from beneath the canopy of a large greasewood (*Sarcobatus vermiculatus*). Large, separated shrubs, primarily greasewood with a few scattered grey rabbitbrush and spiny hopsage (*Grayia spinosa*), are present in the immediate vicinity. The understory consists primarily of saltgrass (*Distichlis stricta*) and cheatgrass. Other identifiable species include gray ryegrass (*Elymus cinereus*), rose (*Rosa woodsii*), bluebunch wheatgrass, bottlebrush squirreltail (*Sitanion hystrix*), small big sagebrush, a large bluegrass (perhaps *Poa nevadensis*), several winterfat (*Cerotoides lanata*), and scattered Russian thistle. The soil sample was moist dark brown silty sand, very fine, nonplastic, 10 to 20 percent nonplastic fines with much organic matter. It might be classified as Hezel sand or Esquatzel Silt loam.

B1.2.3 Site No. E-3 and No. E-4

Two sites were sampled along the south shore of the Columbia River, approximately River Mile 385 (T13N R25E S3). Both sites are over a hundred yards from the Columbia River on level to gently sloping land. These sites are upstream from all 100 Areas reactors. Elevation is approximately 400 feet (121 meters).

Sample E-3 was taken amid a healthy stand of thickspike wheatgrass (*Agropyron dasystachyum*). Several inches (meters) of plant matter were cleared before the sampled soil was exposed. Identifiable species in the area include grey rabbitbrush, Russian knapweed (*Centaurea repens*), common mullein (*Verbascum thapsus*), needle-and-thread (*Stipa comata*), gray ryegrass, Sandberg's bluegrass, cheatgrass, yarrow, cocklebur (*Xanthium strumarium*), plantain (*Plantago lanceolata*), miners lettuce (*Montia perfoliata*), Russian thistle, prairie sage (*Artemisia ludoviciana*), pacific sage (*Artemisia campestris*), baltic rush (*Juncus balticus*), hoary aster (*Machaeranthera canescens*), spring whitlowgrass (*Draba verna*), horsetail (*Equisetum sp.*), goldenrod (*Solidago sp.*), and cudweed (*Gnaphalium sp*).

Onsite air measurements taken at the soil surface while the first sample was collected appeared to be slightly elevated, about 1.6 parts per million with a maximum reading of 3 parts per million (isobutlyene equivalent).

Sample E-4 was collected approximately 400 yards (366 meters) upstream of Sample E-3, and roughly equidistant from the Columbia River. Sample E-3 was just outside the drip zone of a Rocky Mountain juniper (*Juniperus scopulorum*).

Other species present include sand dropseed (*Sporobolus cryptandrus*), Gray's lomatium (*Lomatium grayi*), Cranesbill (*Erodium cicutarium*), thickspike wheatgrass, clover fern (*Marsilea vestita*), Canada thistle (*Cirsium arvense*), cheatgrass, spring Whitlowgrass, Russian thistle, and sneezeweed (*Helenium autumnale*). Topsoil here is a brown gravelly silty sand, containing well-rounded gravel and cobbles, about 10 to 20 percent. Topsoil at sampling Site E-3 was a medium brown sandy silt. Most soil in the area appeared to be Ephrata sandy loam and/or Pasco silt loam.

B1.2.4 Site No. E-5

The fifth sample was taken slightly more than 1 mile (1 kilometer) east-northeast of the 200 East Area, south of Route 11A near the former BWIP well DB-15 (T13N R27E S31). A soil sample was taken adjacent to the northwest corner of a fenced ecological study site. The area is a mature sagebrush steppe community. Elevation is approximately 470 feet (143 meters).

The sample was collected beneath big sagebrush. The understory was cheatgrass. The soil type is Burbank loamy sand. There is some Sandberg's bluegrass in the area. Other species present include spiny hopsage, grey rabbitbrush, bottlebrush squirreltail, needle-and-thread, thickspike wheatgrass, balsamroot, spring Whitlowgrass, and longleaf phlox (*Phlox longifolia*).

The observation was made that the organic vapor monitor very easily could detect volatile compounds released from crushed sagebrush leaves. Readings could be made to exceed the display capabilities of the instrument, greater than 2,000 parts per million (isobutlyene equivalent).

B1.2.5 Site No. E-6

This site is a former agricultural field northwest of the old Hanford townsite (T13N R27E S23). The site lies over 1 mile (1 kilometer) north of the intersection of Route 11A with Route 2 North, about 35 yards (32 meters) north of the pistol range access road.

One sample was collected from within the cheatgrass dominated field. Other common field vegetation includes Russian thistle and tumble mustard (*Sisymbrium altissimum*). Near the access road are several specimens of Russian knapweed, needle-and-thread, and hoary aster. Soil in the upper 6 inches (15.2 centimeters) was damp, brown silty sand, mostly uniform, and very fine. The soil contained about 10 percent nonplastic fines, and a few percent well-rounded gravel. Soil type is probably Rupert sand, possibly Ephrata sandy loam.

B1.2.6 Site No. E-7 and No. E-8

These samples were collected north of Army Loop Road across from Goose Egg Hill (T12N R26E S28). This area is at the edge of a large 1984 wildfire. Elevation is 600 feet (182 meters).

Soil sample E-7 was collected beneath big sagebrush, 285 feet (86.8 meters) from the edge of the road. Sample E-8 was collected 65 feet (19.8 meters) further north under grey rabbitbrush. Other dominant plant species include green rabbitbrush (*Chrysothamnus viscidiflorus*), cheatgrass, Sandberg's bluegrass, and Indian ricegrass (*Oryzopsis hymenoides*). Additional species present include balsamroot, pale evening primrose (*Oenothera pallida*), wallflower (*Erysimum asperum*), sand beardtongue (*Penstemon acuminatus*), and tumble mustard. Understory was sparse. Soil in this area could be described as a coarse Burbank loamy sand. The soil was yellow brown sand, uniform, very fine, damp, with few nonplastic fines.

Onsite air measurements taken at the soil surface during collection near the rabbitbrush location appeared to be slightly elevated, about 1.4 parts per million (isobutlyene equivalent).

B1.2.7 Site No. E-9 and No. E-10

This site is near the Site No. E-6, lying west of Goose Egg Hill almost midway between Army Loop Road and State Highway 240 (T12N R26E S29).

This site was approached on foot from Army Loop Rd. On reaching the site, there is a distinct ecological change from the dry sandy environment, similar to the former Site No. E-6, to a moist, less diverse, brown silty desert playa.

Spiny hopsage is the major plant species present. Sandberg's bluegrass and a suspected woolly sunflower (*Eriophyllum lanatum*) were among the very few other higher plant species. There was an pronounced cryptogamic crust at the site. Duplicate soil samples were collected from a common excavation beneath a hopsage. As usual, loose organic debris was removed from the surface per applicable procedures before collecting the soil sample (WHC 1988). Soil type is uncertain, perhaps Esquatzel silt loam.

B1.2.8 Site No. E-11

This site is southwest of the 200 West area in the Cold Creek Valley (T12N R25E S10). The site is located approximately 100 feet (30 meters) north of a seldom-used road extending due west from Army Loop Road. A soil sample was collected outside the southeast corner of a fenced ecological study area, adjacent to big sagebrush. An additional sample consisting of clean silica sand also was prepared at the same site and submitted as a control sample. This site is best described as a mature sagebrush/Sandberg's bluegrass community. The community is not very diverse, and has good cryptogamic cover. In addition to large, healthy sagebrush, this area contains cheatgrass,

Russian thistle, spiny hopsage and scarlet globemallow (*Sphaeralcea munroana*). Soil from the site was a brown silty sand--uniform, very fine, estimated 5 to 10 percent nonplastic fines, damp, loose topsoil.

B1.2.9 Site No. E-12

The final site, on the 200 Area Plateau (T13N R25E S34) was sampled on February 27, 1992. The site is located west of the 200 West area, about 0.75 mile (1.2 kilometer) south of the intersection of Army Loop Road and Route 11A. A soil sample was removed from beneath a large big sagebrush, outside the southeast corner of a fenced area containing an ecological study site. This area consists of a mature sagebrush/cheatgrass/Sandberg's bluegrass plant community, and also includes hoary aster, threadleaf fleabane (*Erigeron filifolius*), and turpentine springparsley (*Cymopteris terebinthinus*). Soil from this location was a brown sand. The soil was uniform, very fine, estimated less than 5 percent fines, damp, and loose. Soil classification likely would be Rupert sand.

B2.0 VAPOR HEADSPACE MEASUREMENTS

Vapor headspace analysis is a method to rapidly and reliably detect volatile organic compounds in soil samples in the low parts per million range. This method was used to further validate background conditions, and to build baseline knowledge for future cost-effective waste site work. Organic vapors were measured in the air (headspace) above background soils in sealed glass containers. The following summarizes the activity and results of these field headspace measurements.

B2.1 METHOD

Samples were collected with stainless steel trowels and/or spoons as previously described. Samples were not sieved during collection. New, clean, wide-mouth, quart jars were swiftly filled half full with soil, immediately sealed, and transported to a field laboratory. The samples remained sealed until analysis later the same day. Before analysis, samples were equilibrated to room temperature for a minimum of one-half hour.

Analysis was performed using a closed loop system whereby vapors could be circulated from the sample headspace through a portable organic vapor monitor and exhausted back to the headspace. The system used a 10.6-eV light source to ionize compounds for measurement. A current proportional to the number of ions produced was amplified and converted to a displayed numeric concentration. The instrument usually was set to display 5 second averages. Each sample was monitored for a series of readings for at least 5 minutes. Values were autologged into the instrument memory. Bar codes were used to mark data sets. A single reading also was recorded manually as a backup record after adequate time for equilibration.

The system was calibrated using a manufacturer-supplied 101 parts per million (±2 percent) isobutylene gas. The same gas cylinder was used in all calibration work for this project. Ambient air filtered through an organic vapor respirator cartridge provided a zero reference. A separate 9.51 parts per million isobutylene gas was used as a low range instrument check. Instrument check, filtered zero, and calibration gases were not recirculated. Between all recorded observations, ambient air was circulated through the instrument until readings returned to ambient levels. Successive check standard readings were made at least at the beginning and end of each sample process batch.

Numerous auxiliary measurements also were recorded. These measurements included ambient volatile organic chemicals readings, collection and analysis times, gross and tare sample jar weights, ambient temperatures, headspace temperatures, and other observations. One clean sample jar without soil was included in each analysis batch as a blank. This 'sample' was monitored for the same prescribed time as a sample.

Further information regarding the equilibrium headspace method can be found in the Plan supplement, Engineering Change Notice 164706 (WHC 1991c).

B2.2 IMPLEMENTATION

Headspace sample measurements commenced on February 27, 1992. Fresh aliquots of each sample submitted for various organic measurements were transported to a field laboratory and analyzed. All the organic site samples were analyzed in a single batch on the day of collection. Extra check standards were run between each sample as well as at multiple times at the beginning, middle, and end of the batch. The date and origin of all these samples are contained in Table B1. Uninterpreted measurements and observations are compiled as data sheets Table B2.

Subsequent measurements were made on March 5, 6, 9, and 17, 1992, on batches of new, fresh samples gathered from the 14 inorganic sites. At least two fresh samples from each of the inorganic-only sites were screened for volatile organic chemicals. Soil at the top and bottom of each former systematic line was sampled with the exception of the Grout Pit (Site No. 6). The pit had been backfilled, burying the lower half of the former sample locations. At Site No. 6, samples were collected 1 vertical foot (0.3 vertical meter) above the uppermost former site (B01491), slightly above the new existing pit bottom [19 vertical feet (5.8 vertical meters) from B01491], and midway between the two points. Only the uppermost old location was still visible, others locations had been obscured by erosion. In addition to samples taken along the previously established systematic sampling lines, samples were collected in the west extension of Trench 94, Site No. 7. These originated from the moist silt/clay lens associated with the former inorganic sample B014D5. Two samples were collected as batch duplicates from this location.

One analysis batch was processed each sampling day with the exception of March 17, 1992, when measurements were performed in morning and afternoon

batches. Samples collected on February 27, 1992 were measured in a field laboratory trailer located in the 300 Area. Other samples were measured (by a separate analyst) at field locations in a truck-mounted field laboratory.

Quality control checks were performed for each batch of samples. Control parameter specifications were as follows:

Calibration check	±2 percent
Instrument check	9.5 ±2 parts per million
Ambient measurements	<1 part per million
Blank	<1 part per million

Quality control parameters were 10 percent for replicate sequential measurements and 25 percent for field duplicate measurements. Scale measurement checks were performed, where a weight standard periodically was used to check the accuracy of the scale. To minimize the potential effects of repositioning the scale, both tare and gross sample weights were made on a sample before moving the truck to a new location.

One of the sources of variability in this method is deciding which instrument reading to record. The instrument displays readings to the nearest 0.1 part per million. The Plan instructed the analyst to record the organic vapor monitor reading when a change of less than 10 percent was observed over three successive readings. However, a certain amount of judgment was necessary regarding which value to record even after deciding on an equilibration period. Because readings were often less than 1 part per million and the display was limited to tenths of a part per million, background noise alone was greater than 10 percent (±0.1 part per million). Recorded values were checked against electronic files for verification.

B2.3 SUMMARY OF RESULTS

The raw data shown in Table B2 are summarized as follows:

Range of calibration standard check	100 - 102
Range of instrument check	8.8 - 10.6
LOD from field blanks (n=6)	0.9
LOQ from field blanks (n=6)	2.0
Range of ambient observations	0.0 - 1.2
Maximum observed sample headspace concentration	0.5

Performance on the low-level instrument check standard was one of the best indicators available for assessing system capabilities. The sample standard deviation of all check standards separated by more than the minimum sample measurement time is 0.41 part per million. A method detection limit calculated using the 33 observations yields 1.0 part per million. This is in good agreement with the limit of detection estimated from the six batch blanks.

A Kruskal-Wallis test was used to assess if the batch means differed significantly from each other based on check standard performance. Check

standards used for comparison were those whose measurement times were separated by at least the minimum sample equilibration time, 5 minutes. No statistically significant difference between batches was found. This test assumes the data in each batch are drawn from distributions of similar shape, but not necessarily normal or even symmetric distributions. The statistic would indicate whether at least one batch mean is significantly larger or smaller than at least one other batch at the chosen level of confidence.

Close examination of the data suggests that trends in the method exist. The total number of runs above or below the median of original order data can be used as a test of randomness. When this is applied to instrument check observations, the results show significant deviations from that expected if there were no trends or cyclical patterns. This statistic was significant when the February 27, 1992 batch was considered individually or when all batches were combined chronologically. Because of the small number of separated observations in the other batches, no runs test was applied to any other individual batch.

It appears that values for check standards trend downward throughout a batch. Batches having far fewer instrument check observations are consistent with the trends present in the February 27, 1992 batch. Overall, five of the six batches have a final check observation lower than the initial check observation. The binomial probability of five successes out of six trials, given an equal likelihood of two events, is 0.094. This means that, on the average, this result would happen only 9.4 times out of 100 given no upward or downward trend. This comparison makes use of only the first and last observations of the six batches.

The ambient measurement associated with sample B06140 exceeded the Plan criteria of 1 part per million. A short time before this measurement, ambient air was drawn through an respirator filter and a reading made. The filter was designed to remove organic vapors. The result suggests the system might have been biased slightly high. The reported observation (0.6 part per million) is close to the demonstrated capabilities of the measurement system. Nevertheless, sealed samples that were opened only very briefly before analysis did not reflect any elevated concentration.

Sample comparisons between batches cannot reliably be made because all sample observations are well below the normal 'noise' between batches. For instance, the fact that all February 27, 1992 observations are 0.0 and almost all March 9, 1992 observations are 0.3 does not allow one to conclude that there are real differences in the headspace concentrations of the two sets of samples. Both numbers are below levels that can be reliably assessed for interbatch comparisons. Sub-limit of detection measurements might largely reflect transitory measurement conditions. Soil headspace concentration comparisons between batches must consider the limitations of the measurement system. Otherwise, nonrandom errors easily can confound interbatch comparisons.

B2.4 CONCLUSION

Concentrations of detectable compounds in the sample headspace were so low as to be unquantifiable by this method. All samples were consistent in this respect. The method is capable of detecting low parts per million concentrations of volatile compounds. These results support the premise that the soil at each site is uncontaminated by volatile dangerous waste.

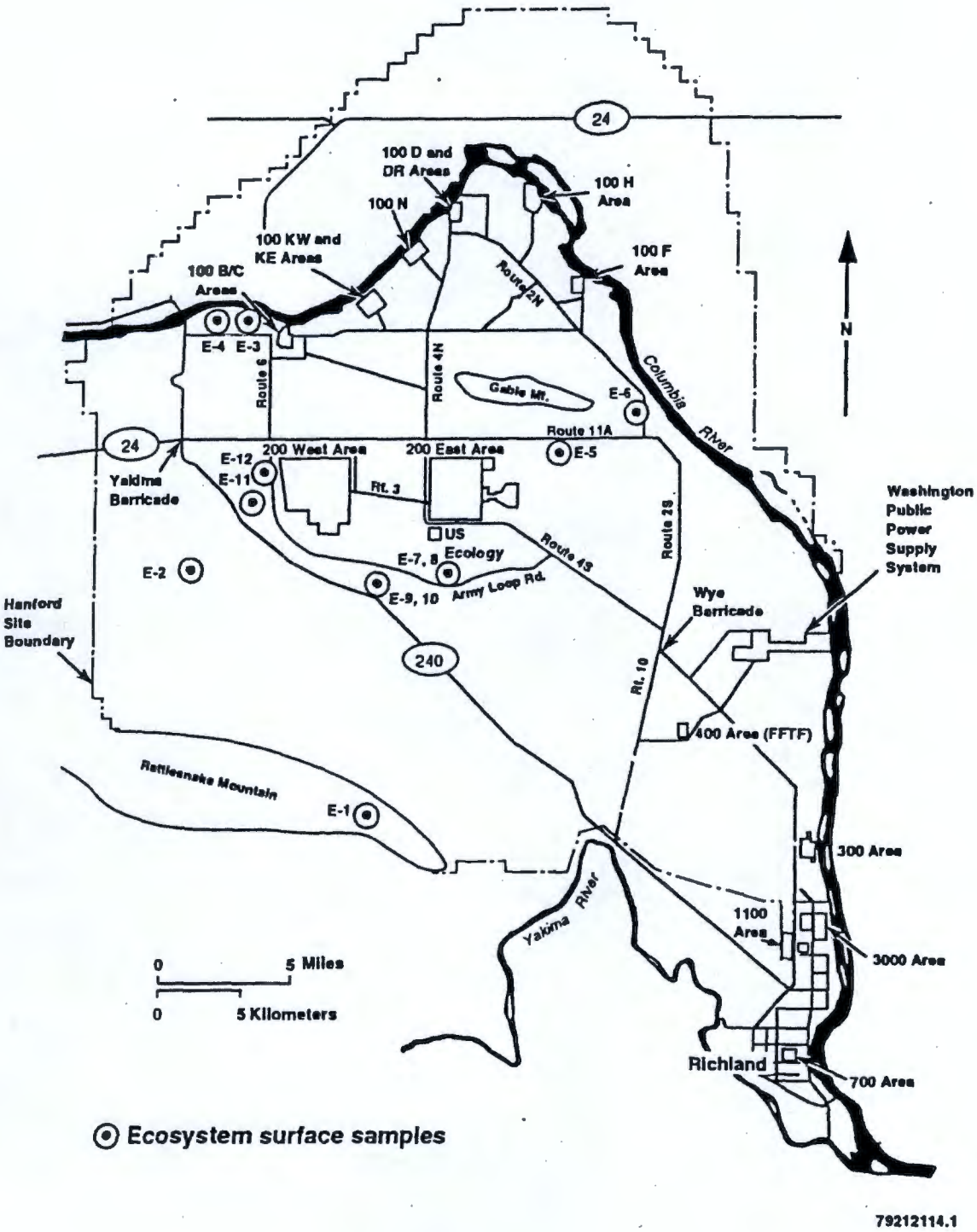

Figure B-1. Sampling Site Locations.

Table B-1. Headspace Screening Sample Key. (sheet 1 of 3)

Sample ID	Date	Origin
B06136	02/27/92	Equipment Store Room (VOA Trip Blank--unopened in the field)
B06137	02/27/92	Organic Site No. 1
B06138	02/27/92	Organic Site No. 1
B06139	02/27/92	Organic Site No. 2
B06140	02/27/92	Organic Site No. 3 (grass)
B06141	02/27/92	Organic Site No. 4 (juniper)
B06142	02/27/92	Organic Site No. 5
B06143	02/27/92	Organic Site No. 6
B06144	02/27/92	Organic Site No. 7 (sagebrush)
B06145	02/27/92	Organic Site No. 8 (rabbitbrush)
B06146	02/27/92	Organic Site No. 9
B06147	02/27/92	Organic Site No. 10 (field duplicate of B06146)
B06148	02/27/92	Organic Site No. 11
B06149	02/27/92	Organic Site No. 11 (blank)
B06150	02/27/92	Organic Site No. 12
B06151	03/05/92	Inorganic Site No. 13 (bottom)
B06152	03/05/92	Inorganic Site No. 13 (top)
B06154	03/05/92	Inorganic Site No. 14 (bottom)
B06155	03/05/92	Inorganic Site No. 14 (top)
B06156	03/05/92	Inorganic Site No. 14 (top--field duplicate of B06155)
B06157	03/05/92	Inorganic Site No. 14 (blank)
B06158	03/06/92	Inorganic Site No. 2 (top)
B06159	03/06/92	Inorganic Site No. 2 (bottom)
B06160	03/06/92	Inorganic Site No. 2 (bottom--field duplicate of B06159)
B06161	03/06/92	Inorganic Site No. 6 (top)
B06162	03/06/92	Inorganic Site No. 6 (existing bottom--refer to Section B1.1.6)

Table B-1. Headspace Screening Sample Key. (sheet 2 of 3)

Sample ID	Date	Origin
B06163	03/06/92	Inorganic Site No. 6 (midway between B06161 and B06162--refer to Section B.1.1.6)
B06164	03/06/92	Inorganic Site No. 9 (top)
B06165	03/06/92	Inorganic Site No. 9 (bottom)
B06166	03/06/92	Inorganic Site No. 8 (top)
B06167	03/06/92	Inorganic Site No. 8 (bottom)
B06168	03/06/92	Inorganic Site No. 8 (blank)
B06169	03/09/92	Inorganic Site No. 1 (bottom)
B06170	03/09/92	Inorganic Site No. 1 (top)
B01B83	03/09/92	Inorganic Site No. 10 (top)
B01B84	03/09/92	Inorganic Site No. 10 (bottom)
B01B85	03/09/92	Inorganic Site No. 11 (bottom)
B01B86	03/09/92	Inorganic Site No. 11 (top)
B01B87	03/09/92	Inorganic Site No. 12 (top)
B01B88	03/09/92	Inorganic Site No. 12 (bottom)
B01B89	03/09/92	Inorganic Site No. 12 (bottom--field duplicate of B01B88)
B01B90	03/09/92	Yakima Barricade, site of 03/09 measurements (blank)
B01B91	03/17/92	Inorganic Site No. 3 (bottom)
B01B92	03/17/92	Inorganic Site No. 3 (top)
B01B93	03/17/92	Inorganic Site No. 7 (bottom)
B01B94	03/17/92	Inorganic Site No. 7 (top)
B01B95	03/17/92	Inorganic Site No. 7 (west extension at former judgment site of B014D5)
B01B96	03/17/92	Inorganic Site No. 7 (field duplicate of B01B95)
B064G1	03/17/92	Inorganic Site No. 7 (blank)

Table B-1. Headspace Screening Sample Key. (sheet 3 of 3)

Sample ID	Date	Origin
B064G2 ✓	03/17/92	Inorganic Site No. 4 (bottom)
B064G3	03/17/92	Inorganic Site No. 5 (bottom)
B064G4	03/17/92	Inorganic Site No. 5 (top)
B064G5 ✓	03/17/92	Inorganic Site No. 4 (bottom--field duplicate of B064G2)
B064G6 ✓	03/17/92	Inorganic Site No. 4 (top)
B064G7	03/17/92	Inorganic Site No. 4 (blank)

Table B-2. Equilibrium Headspace Method – Field Data Sheet. (sheet 1 of 17)

Date: February 27, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight (g)		Soil Description	Time	VOC conc (ppm)		Temp (°C)		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					2030		102			Calibration Check (101 ppm isobutlyene std)
					2032		10.1			Instrument Check (9.51 ppm isobutlyene std)
					2033		10.0			Instrument Check
					2033		10.0			Instrument Check
					2034		9.8			Instrument Check
					2035		10.0			Instrument Check
					2036		9.8			Instrument Check
					2039		10.3			Instrument Check
B06137	0920	478.0	913.6	Dark brown sandy silt, 10% very fine sand, non-plastic, moist	2041	0.1	0	20	19 1/4	
					2048		10.6			Instrument Check
B06138	0920	480.6	820.9	As above	2051	0.9	0	20	19 1/2	Field duplicate of B06138

Sampler: R. McCain Date: 2/27/92

Analyst: R. McCain Date: 2/27/92 Reviewed by: C. Kramer Date: 4/3/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 2 of 17)

Date: February 27, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight (g)		Soil Description	Time	VOC conc (ppm)		Temp (°C)		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					2057		10.1			Instrument Check
					2059	1.2*	0.6			Zero -- Ambient air thru organic vapor respirator
B06139	1121	476.9	892.9	Dark brown silty sand, very fine, moist, 10-20% non-plastic fines	2102	0.9	0	20	19 3/4	
					2107		10.0			Instrument Check
B06140	1200	482.9	921.4	Medium brown sandy silt, damp, loose 5-10% very fine sand	2110	1.1*	0	20 1/4	19 3/4	
					2116		9.8			Instrument Check
B06141	1220	479.5	946.2	Brown gravelly silty sand - mostly fine to very fine, ~10% non- plastic fines, 10-20% well rounded gravel	2120	0.9	0	20	19 3/4	
					2126		10.0			Instrument Check

Sampler: R. McCain Date: 2/27/92

Analyst: R. McCain Date: 2/27/92 Reviewed by: C. Kramer Date: 4/3/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 3 of 17)

Date: February 27, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight (g)		Soil Description	Time	VOC conc (ppm)		Temp (°C)		Comments
		tare	tot			amb	hdspc	amb	hdspc	
B06142	1345	481.2	1050.4	Brown silty sand, very fine to fine, damp	2129	0.9	0	20 1/4	20	
					2152		9.8			Instrument Check
					2153		9.6			Instrument Check
					2154		9.6			Instrument Check
					2155		9.8			Instrument Check
					2156		9.8			Instrument Check
B06143	1410	479.4	1084.3	Brown silty sand, mostly uniform very fine, <10% non-plastic fines, damp	2158	0.4	0	20	19 1/2	(Forgot to turn on auto log)
					2211		9.6			Instrument Check
B06144	1450	479.5	954.9	Yellow brown sand, uniform, very fine, damp, trace fines	2213	0.7	0	20	19 1/2	
					2218		9.6			Instrument Check

Sampler: R. McCain Date: 2/27/92

Analyst: R. McCain Date: 2/27/92 Reviewed by: C. Kramer Date: 4/3/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 4 of 17)

Date: February 27, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight (g)		Soil Description	Time	VOC conc (ppm)		Temp (°C)		Comments
		tare	tot			amb	hdspc	amb	hdspc	
B06145	1455	483.0	1093.0	Yellow brown sand, uniform, very fine, damp	2220	0.7	0	20	19 3/4	
					2225		9.2			Instrument Check
B06146	1510	477.9	885.7	Dark brown silt, damp, non-plastic to slightly plastic	2229	0.7	0	20 1/4	19 3/4	
					2235		9.5			Instrument Check
B06147	1510	482.9	1015.8	Duplicate of B06146	2239	0.7	0	20	20	Field Duplicate
					2245		9.2			Instrument Check
B06148	1545	476.5	998.1	Brown silty sand, uniform, very fine, 5-10% non-plastic fines, damp	2246	0.7	0	20	20	
					2251		9.5			Instrument Check

Sampler: R. McCain Date: 2/27/92

Analyst: R. McCain Date: 2/27/92 Reviewed by: C. Kramer Date: 4/3/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 5 of 17)

Date: February 27, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight (g)		Soil Description	Time	VOC conc (ppm)		Temp (°C)		Comments
		tare	tot			amb	hdspc	amb	hdspc	
B06150	1605	476.4	1058.7	Brown sand, uniform, very fine, <5% fines, damp	2253	0.7	0	20 1/4	20	
					2258		9.5			Instrument Check
B06149				Blank - no soil	2300	0.6	0.4	20	19 3/4	
					2307		9.3			Instrument Check
					2307		9.3			Instrument Check
					2308		9.2			Instrument Check
					2309		9.3			Instrument Check
					2310		9.3			Instrument Check

* Exceeds plan goal of maintaining ambient < 1 ppm

Sampler: R. McCain Date: 2/27/92

Analyst: R. McCain Date: 2/27/92 Reviewed by: C. Kramer Date: 4/3/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 6 of 17)

Date: March 5, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					1313		101			Calibration Check (101 ppm isobutylene std)
					1315		9.7			Instrument Check (9.51 isob. std)
					1316		9.7			Instrument Check
					1317		9.5			Instrument Check
					1318		9.7			Instrument Check
					1318		9.7			Instrument Check
B06151	1140	482.7	1130.3	Coarse, moist sand, rocky	1323	0.0	0.5	21	22	Sample range to 0.7-- (Forgot to autolog)
B06151	"	"	"	"	1339	0.1	0.1	21	22	RE-RAN sample w/autolog, range 0.0 to 0.7
B06152	1146	476.3	1311.5	Coarse, moist sand, rocky	1333	0.0	0.3	21	22	Sample range to 0.5
					1347	0.1	9.3			Instrument Check (Ambient to 0.3)
					1347		9.3			Instrument Check

Sampler: C. Kramer Date: 3/5/92

Analyst: D. Jacques Date: 3/5/92 Reviewed by: C. Kramer Date: 4/3/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 7 of 17)

Date: March 5, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
B06154	1315	483.1	1297.6	Moist, finer grain sand w/small rocks	1355	0.0	0.1	22	22.5	
B06155	1330	477.8	1090.7	Finer sand w/small rocks, moist	1401	0.0	0.1	22	22.5	
B06157	1408	476.5	476.5	Blank	1409	0.0	0.1	22	23	New, unused jar
B06156	1340	475.8	1100.4	Finer, moist sand w/small rocks	1416	0.0	0.0	22	23.5	Field duplicate of B06155
					1421		9.0			Instrument Check
					1422		9.2			Instrument Check
					1423		9.2			Instrument Check
					1423		9.0			Instrument Check
					1424		9.0			Instrument Check

Sampler: C. Kramer Date: 3/5/92

Analyst: D. Jacques Date: 3/5/92 Reviewed by: C. Kramer Date: 4/3/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 8 of 17)

Date: March 6, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					1109		100			Calibration Check (101 ppm isobutylene std)
					1112		9.9			Instrument Check (9.51 isob. std)
					1113		9.9			Instrument Check
					1114		9.9			Instrument Check
					1115		9.9			Instrument Check
					1116		9.9			Instrument Check
B06158	0953	477.2	1037.4	Moist sand/silt, some roots & organic material	1121	0.3	0.4	20	21	
B06159	0947	480.0	1171.1	Moist sand	1128	0.3	0.4	20	21	
B06160	0947	477.1	1175.9	Moist sand	1135	0.3	0.4	20	21	Field duplicate
					1246		101			Calibration Check
					1247		10.0			Instrument Check
					1248		10.0			Instrument Check
					1251		10.0			Instrument Check

Sampler: C. Kramer Date: 3/6/92

Analyst: D. Jacques Date: 3/6/92 Reviewed by: C. Kramer Date: 4/4/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 9 of 17)

Date: March 6, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					1252		10.0			Instrument Check
					1253		9.9			Instrument Check
B06161	1112	478.8	1087.5	Moist sand/silt	1258	0.4	0.3	21	22.5	
B06162	1117	482.6	1101.4	Moist, fine sand	1305	0.3	0.3	21	22	
B06163	1121	483.0	1158.7	Moist, coarse sand	1312	0.4	0.3	22	22.5	
B06164	1213	477.6	1272.9	Fine sand/silt, dry	1319	0.4	0.4	22	22.5	
					1324		9.9			Instrument Check
					1325		9.9			Instrument Check
					1327		9.9			Instrument Check
					1328		9.9			Instrument Check
					1328		9.9			Instrument Check
B06165	1210	480.0	1440.6	Dry sand w/rocks	1332	0.5	0.2	23	24	
B06166	1243	479.5	1354.0	Sand, moist w/large rocks	1339	0.4	0.3	23	24	
B06167	1240	483.3	1427.5	Rocks w/some sand	1346	0.5	0.3	23	23.5	
B06168				Field blank	1352	0.4	0.6	23	24	Empty jar
					1357		9.3			Instrument Check

Sampler: C. Kramer Date: 3/6/92

Analyst: D. Jacques Date: 3/6/92 Reviewed by: C. Kramer Date: 4/4/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet.
(sheet 10 of 17)

Date: March 6, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					1358		9.3			Instrument Check
					1358		9.3			Instrument Check
					1359		9.3			Instrument Check
					1359		9.3			Instrument Check

Sampler: C. Kramer Date: 3/6/92

Analyst: D. Jacques Date: 3/6/92 Reviewed by: C. Kramer Date: 4/4/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 11 of 17)

Date: March 9, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					1241		100.8			Calibration Check (101 ppm isobutylene std)
					1243		9.8			Instrument Check (9.51 isob. std)
					1244		9.8			Instrument Check
					1244		9.8			Instrument Check
					1245		9.8			Instrument Check
					1246		9.8			Instrument Check
					1247		9.8			Instrument Check
B06169	0953	475.5	1506.9	Coarse basaltic sand, large rocks, dry	1251	0.3	0.5	21	22.5	Tare & Gross wt @ collection--Std weight (1219.1g) = 1217.2 g
B06170	0955	479.2	1109.5	Fine silt/sand, moist	1258	0.3	0.3	22	22.5	"
B01B83	1128	479.4	1119.0	Light, clumps, silt/sand slightly moist	1305	0.3	0.3	22	22.5	Tare & Gross wt @ collection--Std weight (1219.1g) = 1217.7 g
B01B84	1125	477.5	1209.1	Very coarse sand & rock	1311	0.3	0.4	22	23	"

Sampler: C. Kramer Date: 3/9/92

Analyst: D. Jacques Date: 3/9/92 Reviewed by: C. Kramer Date: 4/10/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 12 of 17)

Date: March 9, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
B01B90				Blank	1318	0.3	0.4	23	23	Clean, empty jar
					1322	0.3	9.6			Instrument Check
					1325		9.6			Instrument Check
					1326		9.6			Instrument Check
					1326		9.6			Instrument Check
					1327		9.6			Instrument Check
B01B85	1225	478.7	1092.5	Dry, fine sand	1334	0.4	0.4	23	23	Tare & Gross wt @ collection--Std weight (1219.1g) = 1218.8 g
B01B85					1349	0.3	0.3	23	24.5	Sample rerun with autolog on.
B01B86	1229	476.6	1009.2	Slightly moist, fine silt/sand	1344	0.3	0.3	23	24.5	Wts @ collection --Turned on autolog after 3 min., went 5 additional min.
B01B87	1307	477.8	1066.8	Dry silt loess	1356	0.3	0.3	23	24.5	
B01B88	1310	477.5	1035.0	Dry silty loess	1402	0.3	0.3	23	24	

Sampler: C. Kramer Date: 3/9/92

Analyst: D. Jacques Date: 3/9/92 Reviewed by: C. Kramer Date: 4/10/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 13 of 17)

Date: March 9, 1992 Project: Sitewide Background Instrument: OVM 580B, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
B01B89	1311	478.7	1096.5	Slightly moist, silty loess	1408	0.3	0.3	23	23.5	Field Duplicate of B01B88
					1414		8.8			Instrument Check
					1414		8.8			Instrument Check
					1415		8.8			Instrument Check
					1415		8.8			Instrument Check
					1416		8.8			Instrument Check

Sampler: C. Kramer Date: 3/9/92

Analyst: D. Jacques Date: 3/9/92 Reviewed by: C. Kramer Date: 4/10/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 14 of 17)

Date: 3-17-92 Project: Sitewide Background - VOA Headspace Instrument: 580B OVM, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					0917		100			Calibration Check (101 ppm isobutylene std)
					0918		9.5			Instrument Check (9.51 isob. std)
					0919		9.5			Instrument Check
					0920		9.5			Instrument Check
					0921		9.5			Instrument Check
					0921		9.5			Instrument Check
B01B91	0817	478.0	1296.4	Coarse sand/gravel, some fine silt, moist	0926	0.3	0.5	19	20	Standard Weight (1219.1 g) = 1218.5 g @ Site No. 3
B01B92	0820	481.7	1323.5	Gravel, rocks, sand w/ fine silt material, dry	0933	0.4	0.5	19	20	-91 & -92 Tare and total wt @ Site No. 3
B064G1				Equipment Blank	0940	0.4	0.4	20	21	Empty, clean jar
					0945		9.5			Instrument Check
					0945		9.5			Instrument Check

Sampler: C. Kramer Date: 3/17/92

Analyst: D. Jacques Date: 3/17/92 Reviewed by: C. Kramer Date: 4/4/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 15 of 17)

Date: 3-17-92 Project: Sitewide Background - VOA Headspace Instrument: 580B OVM, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					0946		9.5			Instrument Check
					0946		9.5			Instrument Check
					0947		9.5			Instrument Check
B01B93	0910	476.6	1193.3	Sand, moist	0951	0.5	0.4	20	21.5	Standard Weight (1219.1 g) = 1218.3 g @ Site No. 7
B01B94	0912	477.1	1302.3	Fine sand w/ small rocks, slightly moist	0957	0.4	0.4	20	21.5	-93 thru -96 Tare and total wt @ Site No. 7
B01B95	0919	477.7	1106.8	Silt loam, moist, some sand	1004	0.4	0.3	20	22	"
B01B96	0920	478.2	1186.9	Silt loam w/ sand, moist	1010	0.4	0.4	20	22	Field duplicate of B01B95
					1015		9.5			Instrument Check
					1016		9.5			Instrument Check
					1016		9.5			Instrument Check
					1017		9.5			Instrument Check
					1017		9.5			Instrument Check

Sampler: C. Kramer Date: 3/17/92

Analyst: D. Jacques Date: 3/17/92 Reviewed by: C. Kramer Date: 4/4/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 16 of 17)

Date: 3-17-92 Project: Sitewide Background - VOA Headspace Instrument: 580B OVM, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					1218		100			Calibration Check (101 ppm isobutylene std)
					1219		10.1			Instrument Check (9.51 isob. std)
					1220		10.1			Instrument Check
					1221		10.1			Instrument Check
					1221		10.1			Instrument Check
					1221		10.1			Instrument Check
B064G3	1055	477.1	1115.5	Medium grade sand, moist	1226	0.3	0.4	21	22.5	Standard Weight (1219.1 g)= 1219.2 g @ Site No. 9
B064G4	1057	481.8	1126.0	Fine sand, dry	1233	0.4	0.3	22	22.5	"
B064G7				Equipment Blank	1240	0.3	0.4	22	22.5	Empty jar
					1244	0.3	10.1			Instrument Check
					1246		10.1			Instrument Check
					1247		8.9			Instrument Check
					1248		8.9			Instrument Check

Sampler: C. Kramer Date: 3/17/92

Analyst: D. Jacques Date: 3/17/92 Reviewed by: C. Kramer Date: 4/4/92

Table B-2. Equilibrium Headspace Method - Field Data Sheet. (sheet 17 of 17)

Date: 3-17-92 Project: Sitewide Background - VOA Headspace Instrument: 580B OVM, 10.6 eV lamp

Sample Data					Headspace Data					
Sample	Time	Weight, g		Soil Description	Time	VOC conc, ppm		Temp, °C		Comments
		tare	tot			amb	hdspc	amb	hdspc	
					1248		8.9			Instrument Check
B064G2	1239	477.3	963.6	Silt loam, moist	1315	0.3	0.4	22	23	Standard Weight (1219.1 g)= 1219.2 g @ Site No. 4
B064G5	1240	479.5	994.1	"	1322	0.3	0.4	22	22.5	Duplicate of B064G2
B064G6	1245	481.5	866.7	Silt loam w/ roots, moist	1329	0.3	0.3	23	22.5	
					1334		8.9			Instrument Check
					1335		8.9			Instrument Check
					1335		8.9			Instrument Check
					1336		8.9			Instrument Check
					1336		8.9			Instrument Check

Sampler: C. Kramer Date: 3/17/92

Analyst: D. Jacques Date: 3/17/92 Reviewed by: C. Kramer Date: 4/4/92

APPENDIX C

RAW DATA SOIL BACKGROUND

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Table C-1. Summary Description of Systematic Random and Judgment Samples. (sheet 1 of 6)

VALIDATED DATA: March 4, 1992

Detection limits added March 24, 1993

QUALIFIER DEFINITIONS, column "Q" in data tables

UPDATED September 29, 1992

LABORATORY QUALIFIER DEFINITIONS

x/y	In column headed by "Q": Lab QA review / OSM QA review
(1)	Calculated by peak height
<	Less than the reported value
U	Analyzed for but not detected. Detection limit stated
N	Spiked sample recovery not within control limits
W	Post digestion spike for Furnace AA is out of control limits, while sample absorbance is less than 50% of spike absorbance
B	Reading greater than IDL, less than Contract Required Detection Limit
*	Duplicate analysis not within control limits
E	Estimated value due to interferences
S	Determined by the Method of Standard Additions

OSM QUALIFIER DEFINITIONS

J	Estimated
UJ	Undetected + estimated
U	Undetected
R	Rejected

Key to Laboratories:

S^3 = Maxwell S-Cubed
DC = DataChem

LAB	LAB ID	HEIS ID	SITE	COLLECTION DATE	TYPE	SELECTION	RELATIVE POSITION (YDS)	DEPTH (FT)	COMMENTS
S^3	2597-3	B01413	1	9/12/91	REG.	SYSTEMATIC	0	1	
DC	8384	B01414	1	9/12/91	SPLIT	SYSTEMATIC	0	1	
S^3	2597-2	B01412	1	9/12/91	REG.	SYSTEMATIC	1	4	
S^3	2597-1	B01411	1	9/12/91	REG.	SYSTEMATIC	2	7	
S^3	2628-4	B01433	2	9/26/91	REG.	SYSTEMATIC	0	1	
DC	8581	B01434	2	9/26/91	SPLIT	SYSTEMATIC	0	1	
S^3	2628-3	B01431	2	9/26/91	REG.	SYSTEMATIC	1	4	
S^3	2628-2	B01430	2	9/26/91	REG.	SYSTEMATIC	2	7	
S^3	2628-1	B01429	2	9/26/91	REG.	SYSTEMATIC	3	10	
S^3	2663-5	B01B58	3	10/24/9	REG.	SYSTEMATIC	0	2	
S^3	9026	B01B64	3	10/24/9	SPLIT	SYSTEMATIC	0	2	
S^3	2722	B01B78	3	11/20/9	REG.	SYSTEMATIC	0	2	
DC	2663-4	B01B57	3	10/24/9	REG.	SYSTEMATIC	1	5	
S^3	2723	B01B77	3	11/20/9	REG.	SYSTEMATIC	1	5	
S^3	2663-3	B014G9	3	10/24/9	REG.	SYSTEMATIC	2	8	
S^3	2724	B01B76	3	11/20/9	REG.	SYSTEMATIC	2	8	

Table C-1. Summary Description of Systematic Random and Judgment Samples. (sheet 2 of 6)

LAB	LAB ID	HEIS ID	SITE	COLLECTION DATE	TYPE	SELECTION	RELATIVE POSITION (YDS)	DEPTH (FT)	COMMENTS
S^3	2663-1	B014G7	3	10/24/9	REG.	SYSTEMATIC	3	11	
S^3	2725	B01B75	3	11/20/9	REG.	SYSTEMATIC	3	11	
S^3	2726	B01B74	3	11/20/9	REG.	SYSTEMATIC	4	14	
S^3	9385	B01B79	3	11/20/9	SPLIT	SYSTEMATIC	4	14	
S^3	2727	B01B73	3	11/20/9	REG.	SYSTEMATIC	5	17	
DC	2728	B01B72	3	11/20/9	REG.	SYSTEMATIC	6	20	
S^3	2729	B01B71	3	11/20/9	REG.	SYSTEMATIC	7	23	
S^3	2633-1	B01457	4	10/3/91	REG.	SYSTEMATIC	0	1	
S^3	2633-2	B01458	4	10/3/91	REG.	SYSTEMATIC	1	4	
S^3	2633-3	B01459	4	10/3/91	REG.	SYSTEMATIC	2	7	
S^3	8779	B01460	4	10/3/91	SPLIT	SYSTEMATIC	2	7	
S^3	2652-5	B014G2	5	10/21/9	REG.	SYSTEMATIC	0	1	
S^3	2652-4	B014G0	5	10/21/9	REG.	SYSTEMATIC	1	4	
S^3	9025	B014G1	5	10/21/9	SPLIT	SYSTEMATIC	1	4	
S^3	2652-3	B014F7	5	10/21/9	REG.	SYSTEMATIC	2	7	
S^3	2652-2	B014F6	5	10/21/9	REG.	SYSTEMATIC	3	10	
S^3	2652-1	B014F5	5	10/21/9	REG.	SYSTEMATIC	4	13	
S^3	2633-23	B01491	6	10/8/91	REG.	SYSTEMATIC	0	7	
S^3	2633-22	B01490	6	10/8/91	REG.	SYSTEMATIC	1	10	
DC	2633-21	B01489	6	10/8/91	REG.	SYSTEMATIC	2	13	
S^3	2633-20	B01488	6	10/8/91	REG.	SYSTEMATIC	3	16	
S^3	2633-19	B01487	6	10/8/91	REG.	SYSTEMATIC	4	19	
DC	2633-18	B01486	6	10/8/91	REG.	SYSTEMATIC	5	22	
S^3	2633-17	B01485	6	10/8/91	REG.	SYSTEMATIC	6	25	
S^3	2633-16	B01484	6	10/8/91	REG.	SYSTEMATIC	7	28	
S^3	2633-15	B01483	6	10/8/91	REG.	SYSTEMATIC	8	31	
S^3	2633-14	B01482	6	10/8/91	REG.	SYSTEMATIC	9	34	
S^3	2633-13	B01473	6	10/8/91	REG.	SYSTEMATIC	10	37	
S^3	8780	B01480	6	10/8/91	SPLIT	SYSTEMATIC	10	37	
S^3	2633-12	B01472	6	10/8/91	REG.	SYSTEMATIC	11	40	
S^3	2633-11	B01471	6	10/8/91	REG.	SYSTEMATIC	12	43	

Table C-1. Summary Description of Systematic Random and Judgment Samples. (sheet 3 of 6)

LAB	LAB ID	HEIS ID	SITE	COLLECTION DATE	TYPE	SELECTION	RELATIVE POSITION (YDS)	DEPTH (FT)	COMMENTS
S^3	2633-10	B01470	6	10/8/91	REG.	SYSTEMATIC	13	47	
S^3	2633-9	B01469	6	10/8/91	REG.	SYSTEMATIC	14	50	
S^3	2641	B014B9	7	10/11/9	REG.	SYSTEMATIC	9	NA	LOWEST SAMPLE APPROX 5-1/2' ABOVE CORE PAD
S^3	2640	B014C0	7	10/11/9	REG.	SYSTEMATIC	8	NA	
S^3	2639	B014C1	7	10/11/9	REG.	SYSTEMATIC	7	NA	
S^3	2638	B014C2	7	10/11/9	REG.	SYSTEMATIC	6	NA	
S^3	2637	B014C3	7	10/11/9	REG.	SYSTEMATIC	5	NA	
S^3	2636	B014C4	7	10/11/9	REG.	SYSTEMATIC	4	NA	
S^3	2635	B014C5	7	10/11/9	REG.	SYSTEMATIC	3	NA	
S^3	2634	B014C6	7	10/11/9	REG.	SYSTEMATIC	2	NA	
DC	2633	B014C7	7	10/11/9	REG.	SYSTEMATIC	1	NA	
S^3	2632	B014C8	7	10/11/9	REG.	SYSTEMATIC	0	NA	TOP EDGE NOT WELL DEFINED AT THIS SITE
S^3	8894	B014D3	7	10/11/9	SPLIT	SYSTEMATIC	8	NA	
S^3	2644	B014B4	8	10/10/9	REG.	SYSTEMATIC	0	2	EAST SIDE OF PIT# 29
S^3	2646-1	B014B3	8	10/10/9	REG.	SYSTEMATIC	1	5	EAST SIDE OF PIT# 30
S^3	2646-27	B01496	9	10/10/9	REG.	SYSTEMATIC	0	4	
S^3	2646-26	B01495	9	10/10/9	REG.	SYSTEMATIC	1	7	
S^3	2646-25	B01494	9	10/10/9	REG.	SYSTEMATIC	2	10	
S^3	8895	B014B0	9	10/10/9	SPLIT	SYSTEMATIC	2	10	
S^3	2633-8	B01468	10	10/3/91	REG.	SYSTEMATIC	0	1	
S^3	2633-7	B01467	10	10/3/91	REG.	SYSTEMATIC	1	4	
S^3	2633-6	B01464	10	10/3/91	REG.	SYSTEMATIC	2	7	
S^3	8781	B01465	10	10/3/91	SPLIT	SYSTEMATIC	2	7	
S^3	2633-5	B01463	10	10/3/91	REG.	SYSTEMATIC	3	10	
S^3	2633-4	B01462	10	10/3/91	REG.	SYSTEMATIC	4	13	TOP EDGE NOT WELL DEFINED AT THIS SITE
S^3	2622	B014F1	11	10/15/9	REG.	SYSTEMATIC	0	1	
S^3	8896	B014F2	11	10/15/9	SPLIT	SYSTEMATIC	0	1	
DC	2625	B014D8	11	10/15/9	REG.	SYSTEMATIC	1	4	
S^3	2626	B014D7	11	10/15/9	REG.	SYSTEMATIC	2	7	
S^3	2618-7	B01425	12	9/24/91	REG.	SYSTEMATIC	0	2	
S^3	2618-6	B01422	12	9/24/91	REG.	SYSTEMATIC	1	5	

Table C-1. Summary Description of Systematic Random and Judgment Samples. (sheet 4 of 6)

LAB	LAB ID	HEIS ID	SITE	COLLECTION DATE	TYPE	SELECTION	RELATIVE POSITION (YDS)	DEPTH (FT)	COMMENTS
S^3	8488	B01423	12	9/24/91	SPLIT	SYSTEMATIC	1	5	
S^3	2618-5	B01421	12	9/24/91	REG.	SYSTEMATIC	2	8	
S^3	2618-4	B01420	12	9/24/91	REG.	SYSTEMATIC	3	11	
S^3	2618-3	B01419	12	9/24/91	REG.	SYSTEMATIC	4	14	
S^3	2618-2	B01418	12	9/24/91	REG.	SYSTEMATIC	5	17	
S^3	2618-1	B01417	12	9/24/91	REG.	SYSTEMATIC	6	20	
DC	2630-12	B01451	13	10/1/91	REG.	SYSTEMATIC	0	2	TOP EDGE NOT WELL DEFINED AT THIS SITE
S^3	2630-13	B01452	13	10/1/91	REG.	SYSTEMATIC	1	5	
S^3	2630-14	B01453	13	10/1/91	REG.	SYSTEMATIC	2	8	
S^3	8583	B01454	13	10/1/91	SPLIT	SYSTEMATIC	2	8	
DC	2630-15	B01456	13	10/1/91	REG.	SYSTEMATIC	3	11	
S^3	2630-6	B01445	14	10/1/91	REG.	SYSTEMATIC	0	0	LINE #1
S^3	2630-5	B01444	14	10/1/91	REG.	SYSTEMATIC	1	3	LINE #2
S^3	2630-4	B01443	14	10/1/91	REG.	SYSTEMATIC	2	6	LINE #3
S^3	2630-3	B01442	14	10/1/91	REG.	SYSTEMATIC	3	9	LINE #4
S^3	2630-2	B01439	14	10/1/91	REG.	SYSTEMATIC	4	12	LINE #5
S^3	8582	B01440	14	10/1/91	SPLIT	SYSTEMATIC	4	12	LINE #6
DC	2630-1	B01438	14	10/1/91	REG.	SYSTEMATIC	5	15	LINE #7
S^3	2630-7	B01446	14	10/1/91	REG.	SYSTEMATIC	6	18	LINE #2 -DEPTH FROM TOP OF #1
S^3	2630-8	B01447	14	10/1/91	REG.	SYSTEMATIC	7	21	LINE #2 -DEPTH FROM TOP OF #0
S^3	2630-9	B01448	14	10/1/91	REG.	SYSTEMATIC	8	24	LINE #2 -DEPTH FROM TOP OF #1
DC	2630-10	B01449	14	10/1/91	REG.	SYSTEMATIC	9	27	LINE #2 -DEPTH FROM TOP OF #1
S^3	2628-7	B014K0	15	10/4/91	REG.	SYSTEMATIC	NA	10	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-8	B014K1	15	10/4/91	REG.	SYSTEMATIC	NA	15	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-9	B014K2	15	10/4/91	REG.	SYSTEMATIC	NA	23	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-10	B014K3	15	10/4/91	REG.	SYSTEMATIC	NA	30	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-11	B014K4	15	10/4/91	REG.	SYSTEMATIC	NA	34	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-12	B014K5	15	10/4/91	REG.	SYSTEMATIC	NA	39	YAKIMA BARRICADE, ARCHIVED AT 2101-M
DC	2628-13	B014K6	15	10/4/91	REG.	SYSTEMATIC	NA	70	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-14	B014K7	15	10/4/91	REG.	SYSTEMATIC	NA	80	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-15	B014K8	15	10/4/91	REG.	SYSTEMATIC	NA	85	YAKIMA BARRICADE, ARCHIVED AT 2101-M

Table C-1. Summary Description of Systematic Random and Judgment Samples. (sheet 5 of 6)

LAB	LAB ID	HEIS ID	SITE	COLLECTION DATE	TYPE	SELECTION	RELATIVE POSITION (YDS)	DEPTH (FT)	COMMENTS
S^3	2628-16	B014K9	15	10/4/91	REG.	SYSTEMATIC	NA	90	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2628-17	B014L0	15	10/4/91	REG.	SYSTEMATIC	NA	110	YAKIMA BARRICADE, ARCHIVED AT 2101-M
S^3	2618-10	B014H9	15	9/20/91	REG.	SYSTEMATIC	NA	115	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
S^3	2618-11	B014J0	15	9/20/91	REG.	SYSTEMATIC	NA	120	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
S^3	8489	B014J8	15	9/20/91	SPLIT	SYSTEMATIC	NA	120	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
S^3	2618-12	B014J1	15	9/20/91	REG.	SYSTEMATIC	NA	130	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
S^3	2618-13	B014J2	15	9/20/91	REG.	SYSTEMATIC	NA	135	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
S^3	2618-14	B014J3	15	9/20/91	REG.	SYSTEMATIC	NA	183	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
DC	2618-15	B014J4	15	9/20/91	REG.	SYSTEMATIC	NA	195	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
S^3	2618-16	B014J5	15	9/20/91	REG.	SYSTEMATIC	NA	230	YAKIMA BARRICADE, ARCHIVED AT SIGMA V
S^3	2628-5	B01435	2	9/26/91	REG.	JUDGEMENT	NA	5	
S^3	2628-6	B01436	2	9/26/91	REG.	JUDGEMENT	NA	NA	OPPOSITE BASE OF LANDFILL
S^3	2663-2	B014G8	3	10/24/9	REG.	JUDGEMENT	NA	NA	SAND, 10-1/2' S OF SYST. LINE, 1' BELOW B01B59
S^3	2663-6	B01B59	3	10/24/9	REG.	JUDGEMENT	NA	NA	LOWERMOST DUNE SAND LOCATION
S^3	2663-7	B01B60	3	10/24/9	REG.	JUDGEMENT	NA	NA	MIDDLE DUNE SAND LOCATION
DC	2663-8	B01B61	3	10/24/9	REG.	JUDGEMENT	NA	NA	UPPERMOST DUNE SAND LOCATION, DARK SAND
S^3	2663-9	B01B62	3	10/24/9	REG.	JUDGEMENT	NA	NA	30' N OF SYST. LINE, 1' BELOW FINE DARK SECTIO
S^3	2663-10	B01B63	3	10/24/9	REG.	JUDGEMENT	NA	NA	APPROX. 4' HIGHER THAN B01B62
S^3	9027	B01B67	3	10/24/9	SPLIT	JUDGEMENT	NA	NA	LOWERMOST DUNE SAND LOCATION
S^3	2652-6	B014G3	5	10/21/9	REG.	JUDGEMENT	NA	NA	42' S OF B014G5, 4' FROM TOP EDGE HERE
S^3	2652-7	B014G4	5	10/21/9	REG.	JUDGEMENT	NA	NA	2' BELOW B014G3
S^3	2652-8	B014G5	5	10/21/9	REG.	JUDGEMENT	NA	NA	4' FURTHER S, ABOUT 3' LOWER THAN B014G6
S^3	2652-9	B014G6	5	10/21/9	REG.	JUDGEMENT	NA	NA	26' LATERALLY S, ABOUT 6' BELOW TOP EDGE
S^3	2633-24	B01492	6	10/8/91	REG.	JUDGEMENT	NA	NA	CLASTIC DIKE IN LOWER PART OF PIT
S^3	2633-25	B01493	6	10/8/91	REG.	JUDGEMENT	NA	NA	PALEOSOL
S^3	2631	B014C9	7	10/11/9	REG.	JUDGEMENT	NA	NA	8 DEG. NNE, 41' FROM NW PILING, CORE 8912-1
S^3	2630	B014D0	7	10/11/9	REG.	JUDGEMENT	NA	NA	334 DEG. NNW, 43' FROM NE PILING, CORE 6945-2
S^3	2629	B014D4	7	10/11/9	REG.	JUDGEMENT	NA	NA	IN WEST EXTENSION, 6' UP FROM PRESENT FLOOR
S^3	2628	B014D5	7	10/11/9	REG.	JUDGEMENT	NA	NA	IN WEST EXTENSION, 7' UP FROM PRESENT FLOOR
S^3	2627	B014D6	7	10/11/9	REG.	JUDGEMENT	NA	NA	IN WEST EXTENSION, 10' UP FROM PRESENT FLOOR
S^3	2643	B014B5	8	10/10/9	REG.	JUDGEMENT	NA	NA	THIN CLAY/SILT LAYER BISECTING SYST. LOCATIONS

Table C-1. Summary Description of Systematic Random and Judgment Samples. (sheet 6 of 6)

LAB	LAB ID	HEIS ID	SITE	COLLECTION DATE	TYPE	SELECTION	RELATIVE POSITION (YDS)	DEPTH (FT)	COMMENTS
S^3	2642	B014B6	8	10/10/9	REG.	JUDGEMENT	NA	NA	FROM SAND LENS ON N SIDE OF PIT
S^3	8893	B014B7	8	10/10/9	SPLIT	JUDGEMENT	NA	NA	FROM SAND LENS ON N SIDE OF PIT
S^3	2646-28	B01497	9	10/10/9	REG.	JUDGEMENT	NA	NA	UPPERMOST & EAST OF SYSTEMATIC SAMPLES
S^3	2646-29	B01498	9	10/10/9	REG.	JUDGEMENT	NA	NA	MIDDLE & EAST OF SYSTEMATIC SAMPLES
DC	2646-30	B01499	9	10/10/9	REG.	JUDGEMENT	NA	NA	LOWERMOST & WEST OF SYSTEMATIC SAMPLES
S^3	2624	B014D9	11	10/15/9	REG.	JUDGEMENT	NA	NA	
S^3	2623	B014F0	11	10/15/9	REG.	JUDGEMENT	NA	NA	
S^3	2618-9	B01427	12	9/24/91	REG.	JUDGEMENT	NA	7	
S^3	2618-8	B01426	12	9/24/91	REG.	JUDGEMENT	NA	12.5	
S^3	2630-11	B01450	14	10/1/91	REG.	JUDGEMENT	NA	NA	STRATA EQUIVALENT TO 6' LOWER THAN B01449

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 1 of 21)

Refer to Table C-1 for description of qualifiers (Q). Max detection limit (DL) is the maximum detection limit reported by the laboratory. ACTUAL is computed DL based on prep blank standards (refer to Appendix D). USED is the largest of MAX and ACTUAL detection limits.

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	18.1	11.1	3	4.1	0.46
CRDL:	40	12	1	40	1
ACTUAL:	21.8	15.7	N/A	0.9	N/C
USED:	21.8	15.7	3	4.1	0.46

		Aluminum		Antimony		Arsenic		Barium		Beryllium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01411	1	*	5960	UN/UJ	15.7	/J	4.1		99.9		1.2
B01412	1	*	11000	UN/UJ	15.7	/J	5.2		118		1.3
B01413	1	*	8670	UN/UJ	15.7	/J	3		83.4		1.2
B01414	1	E/J	8630	BN/J	15.7	/U	3	E/J	77.6	U	0.46
B01429	2		5900	UN/UJ	15.7	N/J	4		75.3		1.4
B01430	2		5480	UN/UJ	15.7	N/J	3.6		80.3		1.2
B01431	2		4940	UN/UJ	15.7	N/J	3		70.4		1.2
B01433	2		8360	UN/UJ	15.7	N/J	3.6		97		1.2
B01434	2		9580	UN/R	N/D	BW	3		96.8	U	0.46
B014G7	3	*	7940	UN/RN	N/D	N/J	3.2		87.7		1.3
B014G9	3	*	11900	N/RN	N/D	N/J	6.9		87.9		1.2
B01B57	3	*/J	6070	UN/RN	N/D	N/J	3.9		96.5		1.2
B01B58	3	*/J	7780	UN/RN	N/D	N/J	4.6		72.8		1.3
B01B64	3	*/J	4800	/R	N/D	/R	N/D		73.6	/R	N/D
B01B71	3	/J	7540	/UJ	15.7	/B	3		74.1		1.2
B01B72	3	/J	6310	/UJ	15.7	/B	3		78.3		0.97
B01B73	3	/J	5850	/UJ	15.7	/B	3		78.8		1.3
B01B74	3	/J	4190	/UJ	15.7	/B	3		63.1		0.93
B01B75	3	/J	6230	/UJ	15.7	/B	3		73		1.2
B01B76	3	/J	6480	/UJ	15.7	/B	3.2		81.4		0.87
B01B77	3	/J	9720	/J	15.7	/J	5.9		102		1.2
B01B78	3	/J	6670	/UJ	15.7	/B	3.1		80.3		1
B01B79	3		4310	UN/J	15.7	BW/J	3		65	U	0.46
B01457	4		9640	UN/J	15.7	N/J	6.3	*	92.5		0.92
B01458	4		14100	UN/J	15.7	N/J	5	*	139		1.3
B01459	4		14900	UN/J	15.7	N/J	5	*	143		1.3
B01460	4		15900	UN	15.7		4.1	*	146	U	0.46
B014F5	5	/J	6420	/UJN	15.7	/J	4.1	/J	47.4	/J	0.71
B014F6	5	/J	8600	/UJN	15.7		5.2	/J	78	/J	0.92
B014F7	5	/J	7210	/UJN	15.7		5.3	/J	70.1	/J	0.72
B014G0	5	/J	7600	UJN	15.7		4.3	/J	65.2	/J	0.71
B014G1	5	/J	6520	J	15.7	/R	N/D	/J	64.6	/R	N/D
B014G2	5	/J	6590	UJN	15.7		3	/J	55.3	/J	0.6
B01469	6		4520	UN/J	15.7	UN/J	3	*	77.3		1
B01470	6		6610	UN/J	15.7	N/U	3	*	114		1.3
B01471	6		4840	N/J	15.7	N/U	3	*	78.3		1.1
B01472	6		4860	UN/J	15.7	N/U	3	*	81.6		1.2
B01473	6		5170	UN/J	15.7	N/U	3	*	79.6		1.2
B01480	6		6580	UN	15.7	B	3	*	156	U	0.46
B01482	6		6590	UN/J	15.7	N/J	3.1	*	98.5		1.3
B01483	6		5160	UN/J	15.7	UN	3	*	90.2		1.2
B01484	6		5890	UN/J	15.7	UN/J	3	*	96.6		1.5

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 2 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	18.1	11.1	3	4.1	0.46
CRDL:	40	12	1	40	1
ACTUAL:	21.8	15.7	N/A	0.9	N/C
USED:	21.8	15.7	3	4.1	0.46

		Aluminum		Antimony		Arsenic		Barium		Beryllium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01485	6		7890	UN/J	15.7	N/J	3.2	*	124		1.4
B01486	6		6150	UN/J	15.7	UN	3	*	101		1.4
B01487	6		4870	UN/J	15.7	N/J	4.1	*	82.3		1.1
B01488	6		5070	UN/J	15.7	N/J	3	*	95.1		1.1
B01489	6		5520	UN/J	15.7	UN	3	*	107		1.3
B01490	6		4100	UN/J	15.7	UN	3	*	57.4		1
B01491	6		6700	UN/J	15.7	N/J	9.9	*	84.6		1
B014B9	7		6530	UN/R	N/D	/J	3.9	N	61.5	N	0.92
B014C0	7		7770	UN/R	N/D	/J	3	N	85.1	N	1
B014C1	7		5870	UN/R	N/D	/J	3.1	N	64.7	N	0.81
B014C2	7		5570	UN/R	N/D	/J	3	N	49.5	N	0.81
B014C3	7		5690	UN/R	N/D	/J	3	N	98.6	N	1.3
B014C4	7		6520	UN/R	N/D	/J	4.6	N	102	N	1.3
B014C5	7		7110	UN/R	N/D	/J	3.7	N	85.4	N	1.4
B014C6	7		6990	UN/R	N/D	/J	3.1	N	115	N	1.5
B014C7	7		6290	UN/R	N/D	/J	3	N	73.4	N	1.3
B014C8	7		7120	UN/R	N/D	/J	6.1	N	80.6	N	1.2
B014D3	7		8110	/UJ	15.7	/J	3		61.2	/U	0.46
B014B3	8		8300	UN/R	N/D	/J	3.4	N	66.9	N	1
B014B4	8		13800	UN/R	N/D	/J	4	N	88.5	N	1.3
B01494	9		9950	UN/R	N/D	/J	3.3	N	193	N	1
B01495	9		12400	UN/R	N/D	/J	5.1	N	70.7	N	1.3
B01496	9		9350	UN/R	N/D	/J	4.6	N	95	N	1.1
B014B0	9		9760	/UJ	15.7	/J	4.4		187	/U	0.46
B01462	10		18100	UN	15.7	N/J	4.4	*	221		2.1
B01463	10		16400	N	15.7	N/J	5.6	*	169		1.8
B01464	10		14300	N	15.7	N/J	5	*	132		1.5
B01465	10		14800	UN	15.7		3.3	*	105	U	0.46
B01467	10		18000	UN/J	15.7	N/J	8	*	99.1		2
B01468	10		14800	UN/J	15.7	N/J	8.8	*	82.6		1.8
B014D7	11		9570	UN/R	N/D	/J	5.6	N	86.7	N	1
B014D8	11		13000	UN/R	N/D	/J	11	N	137	N	1.3
B014F1	11		17600	UN/R	N/D	/J	11.4	N	170	N	1.5
B014F2	11		16100	/UJ	15.7	/J	8.3		163	/U	0.46
B01417	12	*/J	11400	UN/R	N/D	W*	6.5		100		1.5
B01418	12	*/J	10300	UN/R	N/D	W*	5.2		110		1.3
B01419	12	*/J	5470	UN/R	N/D	W*	3.1		94		1.2
B01420	12	*/J	10000	UN/R	N/D	W*	3.6		133		1.2
B01421	12	*/J	9980	UN/R	N/D	W*	5		111		1.2
B01422	12	*/J	10300	UN/R	N/D	W*	5		116		1.2
B01423	12		14900	J	15.7		4.2		115	B	0.46
B01425	12	*/J	8560	UN/R	N/D	*	3.2		106		1.1

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 3 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	18.1	11.1	3	4.1	0.46
CRDL:	40	12	1	40	1
ACTUAL:	21.8	15.7	N/A	0.9	N/C
USED:	21.8	15.7	3	4.1	0.46

		Aluminum		Antimony		Arsenic		Barium		Beryllium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01451	13		7470	UN/R	N/D	/J	5.3	*/J	68.8		1.2
B01452	13		3940	UN/R	N/D		3	*/J	45.2		0.81
B01453	13		4930	UN/R	N/D		3	*/J	52.5		1.1
B01454	13		6340	UN/R	N/D	S	3		81.7	U	0.46
B01456	13		6440	UN/R	N/D	U/J	3	*/J	122		1.2
B01438	14		9500	UN/R	N/D	/J	4.7	*/J	121		1.4
B01439	14		7230	UN/R	N/D	/J	4.7	*/J	116		1.4
B01440	14		11300	BN/R	N/D	S	4.5		134	U	0.46
B01442	14		8140	UN/R	N/D	/J	4.3	*/J	107		1.3
B01443	14		7750	UN/R	N/D		7	*/J	66.8		1.2
B01444	14		9380	UN/R	N/D	/J	5.1	*/J	134		1.4
B01445	14		9120	UN/R	N/D	/J	3	*/J	111		1.1
B01446	14		8100	UN/R	N/D	/J	3.7	*/J	113		1.3
B01447	14		5040	UN/R	N/D	/J	4.1	*/J	114		1.1
B01448	14		11500	UN/R	N/D	/J	7.5	*/J	118		1.6
B01449	14		8490	UN/R	N/D	/J	3.6	*/J	149		1.6
B014H9	15	*/J	6230	UN/R	N/D	W*	3.8		72.8		0.82
B014J0	15	*/J	8710	UN/R	N/D	U*	3		64.7		0.82
B014J1	15	*/J	8110	UN/R	N/D	*	3		83.6		0.82
B014J2	15	*/J	6800	UN/R	N/D	U*	3		55.5		0.61
B014J3	15	*/J	8000	UN/R	N/D	*	3.7		66		0.83
B014J4	15	*/J	7650	UN/R	N/D	*	3		46.2		0.82
B014J5	15	*/J	7150	UN/R	N/D	*	4.2		65.8		0.72
B014J8	15		10300	/J	15.7		3		67	/U	0.46
B014K0	15		9810	UN/UJ	15.7	N/J	5.1		112		1.5
B014K1	15		6300	UN/UJ	15.7	N/J	5.4		73.5		0.71
B014K2	15		7800	UN/UJ	15.7	N/J	4.9		97		1.3
B014K3	15		6200	UN/UJ	15.7	N/J	3.9		76.3		1.2
B014K4	15		7210	UN/UJ	15.7	N/J	3		80.7		0.96
B014K5	15		6430	UN/UJ	15.7	N/J	4.2		52.7		0.79
B014K6	15		7520	UN/UJ	15.7	N/J	3.3		102		0.94
B014K7	15		7170	UN/UJ	15.7	N/J	3.6		90.6		0.94
B014K8	15		7160	UN/UJ	15.7	N/J	3.3		84.1		0.94
B014K9	15		6260	UN/UJ	15.7	N/J	3		62.2		0.72
B014L0	15		5550	UN/UJ	15.7	N/J	3		66.4		0.94

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 4 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	0.66	189	1.8	1.6	1.8
CRDL:	1	1000	2	10	5
ACTUAL:	0.02	175	1.1	0.9	2.1
USED:	0.66	189	1.8	1.6	2.1

		Cadmium		Calcium		Chromium		Cobalt		Copper	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01411	1	U	0.66		5800		4.5		14.6		17.2
B01412	1	U	0.66		18700		17.6		13.3		21.3
B01413	1	U	0.66		3970		12.3		11.1		12
B01414	1	U	0.66	E/J	4060		10.7		13.1	N*	28.3
B01429	2	U	0.66		7710	/J	7.9		16		13.8
B01430	2	U	0.66		8360	/J	6.1		13.6		15
B01431	2	U	0.66		7510	/J	4.2		14.3		15.1
B01433	2	U	0.66		3980	/J	10.4		11.6		12.1
B01434	2	U	0.66	*/J	5060	*	14.3		15.7		12.2
B014G7	3	U	0.66		10100	*/J	10.7		13.6	*	18
B014G9	3	U	0.66		10100	*/J	18.1		12	*	18.5
B01B57	3	U	0.66		7840	*/J	7.1		15.4	*	13.6
B01B58	3	U	0.66		8900	*/J	12.4		16	*	14.9
B01B64	3	/R	N/D		7060	/J	7.8		17		17
B01B71	3	/UN	0.66		9880	*/J	9.6		12.7		16.5
B01B72	3	/UN	0.66		7270	*/J	7.4		10.6		15.7
B01B73	3	/UN	0.66		7600	*/J	6.5		15.2		14.7
B01B74	3	/UN	0.66		6710	*/J	6.5		11.2		14.2
B01B75	3	/UN	0.66		7560	*/J	11.1		14.3		14.2
B01B76	3	/UN	0.66		8340	*/J	12.1		10.5		16.5
B01B77	3	/UN	0.66		6520	*/J	12.2		12.6		21.1
B01B78	3	/UN	0.66		7480	*/J	8.7		11.1		14.7
B01B79	3	U	0.66	*	4780	*/J	3.9		11.6		15
B01457	4	U	0.66	*	6050	*/J	19		9	N*	17.2
B01458	4	U	0.66	*	5790	*/J	29.6		11.1	N*	22.8
B01459	4	U	0.66	*	5830	*/J	30.6		11.2	N*	22.8
B01460	4	U	0.66		6480		33.2		12.5		22.6
B014F5	5	/UJ	0.66	/J	8010	/J	14		6.7		9.8
B014F6	5	/UJ	0.66	/J	15500	/J	19		8.6		14.5
B014F7	5	/UJ	0.66	/J	10900	/J	16.8		7.3		14.5
B014G0	5	/UJ	0.66	/J	19300	/J	14.6		7.4		13.6
B014G1	5	/R	N/D		18100	/J	13.3	/R	N/D		14
B014G2	5	/UJ	0.66	/J	3820	/J	10.6		6.1		8.1
B01469	6	U	0.66	*	6610	*/J	2.9		13.9	N*	13.3
B01470	6	U	0.66	*	11000	*/J	4.5		14.9	N*	32.8
B01471	6	U	0.66	*	6500	*/J	4.2		13	N*	12.6
B01472	6	U	0.66	*	6840	*/J	4.8		14.4	N*	11.5
B01473	6	U	0.66	*	11800	*/J	4.1		14.8	N*	12.1
B01480	6	U	0.66		11100		5		17.4		13.6
B01482	6	U	0.66	*	12100	*/J	5.2		15.9	N*	14.1
B01483	6	U	0.66	*	9730	*/J	6.2		13.7	N*	14.2
B01484	6	U	0.66	*	13500	*/J	5		15.9	N*	12.3

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 5 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	0.66	189	1.8	1.6	1.8
CRDL:	1	1000	2	10	5
ACTUAL:	0.02	175	1.1	0.9	2.1
USED:	0.66	189	1.8	1.6	2.1

		Cadmium		Calcium		Chromium		Cobalt		Copper	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01485	6	U	0.66	*	12500	*/J	8.7		14.8	N*	13.6
B01486	6	U	0.66	*	13300	*/J	5		15.3	N*	12.8
B01487	6	U	0.66	*	10900	*/J	5		12.4	N*	11.9
B01488	6	U	0.66	*	10000	*/J	4.6		11.6	N*	12.4
B01489	6	U	0.66	*	8880	*/J	4.8		13.2	N*	13.3
B01490	6	U	0.66	*	6700	*/J	5.9		12.3	N*	12
B01491	6	U	0.66	*	14700	*/J	8.3		11	N*/J	13.5
B014B9	7	UN	0.66		8620	*/J	8.1	N	8.4	/J	10.1
B014C0	7	UN	0.66		6820	*/J	12.8	N	9.2	/J	22.8
B014C1	7	UN	0.66		13200	*/J	8.3	N	8	/J	11
B014C2	7	UN	0.66		6470	*/J	7	N	8.9	/J	10.7
B014C3	7	UN	0.66		7970	*/J	4.7	N	15.2	/J	12.9
B014C4	7	UN	0.66		8970	*/J	5.2	N	16.6	/J	13.8
B014C5	7	UN	0.66		7660	*/J	6.3	N	16.7	/J	10.5
B014C6	7	UN	0.66		8100	*/J	6.3	N	16.9	/J	11.5
B014C7	7	UN	0.66		10000	*/J	4.5	N	15.7	/J	11.5
B014C8	7	UN	0.66		11500	*/J	6	N	13.2	/J	15.2
B014D3	7	/U	0.66		8450		14.2		10.9		15
B014B3	8	UN	0.66		7790	*/J	11.8	N	8.1	/J	11.9
B014B4	8	UN	0.66		6050	*/J	17.7	N	13	/J	19.1
B01494	9	UN	0.66		11700	*/J	12.4	N	9	/J	13.6
B01495	9	UN	0.66		11600	*/J	14.5	N	11	/J	17.8
B01496	9	UN	0.66		4000	*/J	10.2	N	10.6	/J	11.4
B014B0	9	/U	0.66		10700		12.7		9.7		11.4
B01462	10	U	0.66	*	11200	*/J	17.3		16.5	N*	36.1
B01463	10	U	0.66	*	18000	*/J	21.7		14.7	N*	29.6
B01464	10	U	0.66	*	18600	*/J	22.5		14.5	N*	29.6
B01465	10	U	0.66		13100		20.8		17.3		26.5
B01467	10	U	0.66	*	13100	*/J	27		16.8	N*	35.9
B01468	10	U	0.66	*	25300	*/J	16.4		14.7	N*	30.7
B014D7	11	UN	0.66		13600	*/J	15.1	N	9	/J	13.3
B014D8	11	UN	0.66		14100	*/J	19.8	N	12	/J	22.1
B014F1	11	UN	0.66		16400	*/J	23.8	N	12.8	/J	23.5
B014F2	11	/U	0.66		15400		24.3		12.6		21.9
B01417	12	U	0.66		5660		12.4		14.5		13.2
B01418	12	U	0.66		5230		12.5		13.8		15.5
B01419	12	U	0.66		6100		7.6		13		9.4
B01420	12	U	0.66		10200		11.4		13.6		13.3
B01421	12	U	0.66		11200		11.1		12.6		14.9
B01422	12	U	0.66		10400		10.6		12.8		16.5
B01423	12	/U	0.66		10600		17.2	/J	15.9		19.9
B01425	12	U	0.66		7200		9.3		11.6		12.3

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 6 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	0.66	189	1.8	1.6	1.8
CRDL:	1	1000	2	10	5
ACTUAL:	0.02	175	1.1	0.9	2.1
USED:	0.66	189	1.8	1.6	2.1

		Cadmium		Calcium		Chromium		Cobalt		Copper	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01451	13	U	0.66	*/J	8540	N/J	9.5	*/J	11.2	*/J	16
B01452	13	U	0.66	*/J	5600	N/J	4	*/J	7.3	*/J	14
B01453	13	U	0.66	*/J	5870	N/J	5.2	*/J	10.4	*/J	16.2
B01454	13	U	0.66	*/J	6410	*	7.3		14.9		14.3
B01456	13	U	0.66	*/J	11100	N/J	6.7	*/J	11.7	*/J	15.9
B01438	14	U	0.66	*/J	10300	N/J	11.2	*/J	14	*/J	12.9
B01439	14	U	0.66	*/J	13500	N/J	7.6	*/J	9.9	*/J	13.9
B01440	14	U	0.66	*/J	17400	*	12		15.1		16.5
B01442	14	U	0.66	/J	39500	N/J	8.7	*/J	8.5	*/J	13.6
B01443	14	U	0.66	*/J	14800	N/J	9.6	*/J	9.7	*/J	13.4
B01444	14	U	0.66	*/J	27500	N/J	13.1	*/J	10.1	*/J	16.3
B01445	14	U	0.66	*/J	4280	N/J	11.7	*/J	9.8	*/J	11.9
B01446	14	U	0.66	*/J	10900	N/J	9.7	*/J	13.6	*/J	13
B01447	14	U	0.66	*/J	6870	N/J	5.7	*/J	10.2	*/J	10
B01448	14	U	0.66	*/J	13800	N/J	14.3	*/J	13.7	*/J	20.2
B01449	14	U	0.66	*/J	13100	N/J	6.7	*/J	15.2	*/J	18.6
B014H9	15	U	0.66		3820		8.5		7.4		10.3
B014J0	15	U	0.66		11100		13.2		7.8		14.5
B014J1	15	U	0.66		7790		16.6		7.9		17.2
B014J2	15	U	0.66		6140		11.7		6.5		13.6
B014J3	15	U	0.66		7320		12.7		7.7		14.3
B014J4	15	U	0.66		5930		19.8		8.5		13.4
B014J5	15	U	0.66		9340		24		8.5		17.3
B014J8	15	B	0.66		10800		16		8.5		17.1
B014K0	15	U	0.66		10900	*/J	10.8		14.2		20.1
B014K1	15	U	0.66		8140	*/J	10.6		5.7		8.5
B014K2	15	U	0.66		10700	*/J	9.7		12.6		16.2
B014K3	15	U	0.66		12700	*/J	7.3		12.2		18.9
B014K4	15	U	0.66		86600	*/J	8		8.4		14.6
B014K5	15	U	0.66		52900	*/J	12.6		7.7		13.9
B014K6	15	U	0.66		14500	*/J	15		8.2		13.8
B014K7	15	U	0.66		21600	*/J	8.9		9		11.9
B014K8	15	U	0.66		25500	*/J	10.7		8.7		13
B014K9	15	U	0.66		10700	*/J	10.6		7		11.5
B014L0	15	U	0.66		3900	*/J	5.9		7.6		12.9

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 7 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	7.1	1.1	249	0.6	0.16
CRDL:	20	0.6	1000	3	0.04
ACTUAL:	75.7	N/A	18.4	0.6	N/A
USED:	75.7	1.1	249	0.6	0.16

		Iron		Lead		Magnesium		Manganese		Mercury	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01411	1	*	26000	N/J	5		4680	/J	338	UN/UJ	0.16
B01412	1	*	26700	N/J	9		6800	/J	433	UN/UJ	0.16
B01413	1	*	25500	N/J	7.4		4870	/J	369	UN/UJ	0.16
B01414	1	E	22700	NS*	4.8	E/J	4610	E/J	323	U	0.16
B01429	2		32500	/J	4.1		5150		391	N*/J	1
B01430	2		27200	/J	3.6		4630		358	N*/J	0.43
B01431	2		29000	/J	3.3		4670		350	N*/J	0.16
B01433	2		24800	/J	4.7		4570		380	N*/J	0.16
B01434	2		28400	NS*	6		5660	N/J	427	U	0.16
B014G7	3		27600		6.8	*/J	5640	*/J	397	*/J	0.83
B014G9	3		23600		9.8	*/J	6710	*/J	423	U*/UJ	0.16
B01B57	3		29300		4.9	*/J	4970	*/J	392	U*/UJ	0.16
B01B58	3		30800		6	*/J	6060	*/J	455	U*/UJ	0.16
B01B64	3	/J	21100		2.6		3870	/J	445	/R	N/D
B01B71	3	*/J	26900	/J	5.7		5150		327	/U	0.16
B01B72	3	*/J	22700	/J	7.5		4500		282	/U	0.16
B01B73	3	*/J	30800	/J	5		5280		390	/U	0.16
B01B74	3	*/J	22700	/J	3.3		4030		285	/U	0.16
B01B75	3	*/J	28800	/J	4.2		4390		353	/U	0.16
B01B76	3	*/J	20100	/J	6.6		4780		318	/U	0.16
B01B77	3	*/J	23800	/J	11.5		6510		459	/U	0.16
B01B78	3	*/J	23000	/J	5.8		4690		330	/U	0.16
B01B79	3		20300	*	1.9		3130	N/J	221	U	0.16
B01457	4		18700	N/JN	26.6		5490		299	UN	0.16
B01458	4		24800	N	1.1		7090		397	UN	0.16
B01459	4		24400	N/JN	12.1		6820		407	UN	0.16
B01460	4		26300	NS	10.8		7610		426	U/J	0.16
B014F5	5		15900		5	/J	4730	/J	273	/UJN	0.16
B014F6	5		20100		5.4	/J	5520	/J	339	/UJN	0.16
B014F7	5		16700		7	/J	4750	/J	298	/UJN	0.16
B014G0	5		16300		4.2	/J	4410	/J	279	/UJN	0.16
B014G1	5	/J	13600	/S	2.1		4600	/J	253		0.16
B014G2	5		14100		4.3	/J	3020	/J	229	/UJN	0.16
B01469	6		25900	N/JN	3.3		2900		347	UN	0.16
B01470	6		29900	N/JN	5		4190		477	UN	0.16
B01471	6		26300	N/JN	3.2		3200		394	UN	0.16
B01472	6		26600	N/JN	4.8		3360		435	UN	0.16
B01473	6		29900	N/JN	3.5		3670		411	UN	0.16
B01480	6		34200	N	2.5		4110		491	U/J	0.16
B01482	6		30500	N/JN	4.2		4640		553	UN	0.16
B01483	6		29400	N/JN	4		4020		443	UN	0.16
B01484	6		33700	N/JN	4		4480		485	UN	0.16

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 8 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	7.1	1.1	249	0.6	0.16
CRDL:	20	0.6	1000	3	0.04
ACTUAL:	75.7	N/A	18.4	0.6	N/A
USED:	75.7	1.1	249	0.6	0.16

		Iron		Lead		Magnesium		Manganese		Mercury	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01485	6		30900	N/JN	4.9		4950		560	UN	0.16
B01486	6		34000	N/JN	3.8		4240		399	UN	0.16
B01487	6		27400	N/JN	3.3		3980		334	UN	0.16
B01488	6		26500	N/JN	2.8		4340		350	UN/N	0.16
B01489	6		30400	N/JN	3.4		4150		383	UN	0.16
B01490	6		25500	N/JN	2.6		4050		383	UN/JN	0.16
B01491	6		22400	N/JN	10.8		6840		379	UN	0.16
B014B9	7	*/J	21400	*/J	5.6		4120		323	UN*	0.16
B014C0	7	*/J	23500	*/J	9.2		4670		377	UN*	0.16
B014C1	7	*/J	18900	*/J	3.4		3720		414	UN*	0.16
B014C2	7	*/J	18400	*/J	3.4		4480		254	UN*	0.16
B014C3	7	*/J	32600	*/J	2.9		4360		409	UN*	0.16
B014C4	7	*/J	34000	*/J	5.5		5520		496	UN*	0.16
B014C5	7	*/J	34400	*/J	4.5		5380		456	UN*	0.16
B014C6	7	*/J	35000	*/J	4		5220		564	N*/J	0.43
B014C7	7	*/J	33700	*/J	3.6		4510		434	UN*	0.16
B014C8	7	*/J	28600	*/J	8.6		4950		388	UN*	0.16
B014D3	7		23200		2.5		4900		300	/U	0.16
B014B3	8	*/J	20600	*/J	7.5		4800		377	N*/J	0.37
B014B4	8	*/J	26300	*/J	7.9		6050		553	UN*	0.16
B01494	9	*	20800	*/J	5.2		5160		356	UN*	0.16
B01495	9	*/J	26700	*/J	5.8		7300		382	UN*	0.16
B01496	9	*/J	24100	*/J	7.9		4200		350	UN*	0.16
B014B0	9		20000		4.2		5580		359	/U	0.16
B01462	10		35000	N/JN	9.8		9090		556	UN	0.16
B01463	10		31000	N/JN	11.2		8620		466	UN	0.16
B01464	10		28400	N/JN	11.2		7950		473	UN	0.16
B01465	10		34500	NS	8.1		8370		518	U/J	0.16
B01467	10		35100	N/JN	14.4		9810		508	UN	0.16
B01468	10		30600	N/JN	11.4		10100		485	UN	0.16
B014D7	11	*/J	20300	*/J	7.1		5690		420	UN*	0.16
B014D8	11	*/J	24300	*/J	14.7		7380		502	UN*	0.16
B014F1	11	*/J	27000	*/J	14.8		8460		528	UN*	0.16
B014F2	11		24900		14.7		8500		478	/U	0.16
B01417	12		31300	/J	11.1		4540	/J	468	UN/UJ	0.16
B01418	12		27000	W/J	8.6		5100	/J	492	UN/UJ	0.16
B01419	12		27000	W/J	5.1		3210	/J	383	UN/UJ	0.16
B01420	12		26700	W/J	6.9		6910	/J	704	UN/UJ	0.16
B01421	12		23800	W/J	7.9		9790	/J	434	UN/UJ	0.16
B01422	12		23800	/J	8.3		9150	/J	506	UN/UJ	0.16
B01423	12		31600		5.8		10500		534		0.16
B01425	12		22500	/J	7.2		4260	/J	478	UN/UJ	0.16

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 9 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	7.1	1.1	249	0.6	0.16
CRDL:	20	0.6	1000	3	0.04
ACTUAL:	75.7	N/A	18.4	0.6	N/A
USED:	75.7	1.1	249	0.6	0.16

		Iron		Lead		Magnesium		Manganese		Mercury
		Q	Conc.	Q	Conc.	Q	Conc.	Q	Conc.	Q	Conc.
HEIS ID	SITE		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg
B01451	13		22900	N	5		4760	*/J	348	UN/UJ	0.16
B01452	13		16000	N	4.9		2930	*/J	196	N	0.33
B01453	13		22800	N	4.7		3620	*/J	253	UN/UJ	0.16
B01454	13		29700	N*	4.4		4820	N/J	378	U	0.16
B01456	13		23400	N	4.8		4650	*/J	594	N/J	0.23
B01438	14		28500	N/J	6.2		5990	*/J	439	UN/UJ	0.16
B01439	14		22400	N	6.9		3950	*/J	355	UN/UJ	0.16
B01440	14		33000	NS*	7.5		4800	N/JN	344	U	0.16
B01442	14		18900	N	8		4250	*/J	211	UN/UJ	0.16
B01443	14		21600	N	5.8		4810	*/J	277	UN/UJ	0.16
B01444	14		21000	N	7.1		4890	*/J	412	UN/UJ	0.16
B01445	14		20900	N	6.7		5120	*/J	404	UN/UJ	0.16
B01446	14		26900	N	8.1		5870	*/J	443	UN/UJ	0.16
B01447	14		21400	N	5.5		3940	*/J	371	UN/UJ	0.16
B01448	14		28400	N	12.3		7610	*/J	410	UN/UJ	0.16
B01449	14		32000	N	7.2		4280	*/J	322	N/J	0.26
B014H9	15		14800	/J	7.2		3820	/J	346	UN/UJ	0.16
B014J0	15		15900	/J	6.4		4960	/J	316	UN/UJ	0.16
B014J1	15		16400	/J	4.1		4780	/J	264	UN/UJ	0.16
B014J2	15		13200	/J	4.6		4120	/J	227	UN/UJ	0.16
B014J3	15		15100	/J	7.8		4700	/J	333	UN/UJ	0.16
B014J4	15		17700	/J	3.4		5480	/J	304	UN/UJ	0.16
B014J5	15		16500	/J	4.4		5850	/J	372	UN/UJ	0.16
B014J8	15		18400		5.8		5250		310	/U	0.16
B014K0	15		29000	/J	5.5		5450		460	N*/J	0.53
B014K1	15		14000	/J	4.9		4640		268	N*/J	0.16
B014K2	15		27500	/J	4.9		4690		357	N*/J	0.44
B014K3	15		26100	/J	4.3		4990		311	N*/J	0.16
B014K4	15		16200	/J	1.1		3830		219	N*/J	0.41
B014K5	15		15600	/J	4.8		5600		244	N*/J	0.22
B014K6	15		16400	/J	4.6		4780		332	N*/J	0.24
B014K7	15		17600	/J	3.8		4150		297	N*/J	0.82
B014K8	15		17600	/J	4.3		4880		317	N*/J	3
B014K9	15		14200	/J	4		3850		262	N*/J	0.22
B014L0	15		17900	/J	3.9		3890		247	N*/J	3.8

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 10 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	7.2	851	5	1.1	98.7
CRDL:	8	1000	0.5	2	1000
ACTUAL:	2.4	135	N/A	1.4	50.7
USED:	7.2	851	5	1.4	98.7

		Nickel		Potassium		Selenium		Silver		Sodium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01411	1		12.2		851	UN/UJ	5	U	1.4	B	265
B01412	1		18.5		1690	UN/UJ	5	U	1.4	B	264
B01413	1		12.7		1700	UN/UJ	5	U	1.4	B	361
B01414	1		10.9		1640	/U	5	U	1.4	B	405
B01429	2	*/J	13.5		938	UN/UJ	5	N/J	1.4		514
B01430	2	*/J	10		851	UN/UJ	5	UN/UJ	1.4	B	328
B01431	2	*/J	9.7		851	UN/UJ	5	UN/UJ	1.4	B	344
B01433	2	*/J	11.8		2190	UN/UJ	5	UN/UJ	1.4	B	190
B01434	2		19.9		2220	UN/UJ	5	U/UJ	1.4	B	294
B014G7	3	*/J	13.8	*/J	1510	UN/UJN	5	U	1.4	B	291
B014G9	3	*/J	23.8	*/J	2050	UN/UJN	5		1.4	B	255
B01B57	3	*/J	13.2	*/J	918	UN/UJ	5		1.6	B	381
B01B58	3	*/J	16.6	*/J	1330	UN/UJ	5		1.4	B	304
B01B64	3		11.3	/R	N/D	/R	N/D	/R	N/D	/R	N/D
B01B71	3		12.3		1210	/UJN	5		1.4	B	338
B01B72	3		10.7		974	/UJN	5		1.4	B	231
B01B73	3		11.5		851	/UJ	5		1.6	B	284
B01B74	3		9.6		851	/UJ	5		1.4	B	202
B01B75	3		10.7		877	/UN	5		1.5	B	361
B01B76	3		13.9		1030	/UJ	5	/U	1.4	B	193
B01B77	3		17.6		1760	/UJ	5	/U	1.4	B	165
B01B78	3		11.2		1030	/UJ	5		1.4	B	183
B01B79	3	B	7.2	B	851	U	5	B/U	1.4	B	278
B01457	4	*	18.6		2100	UN/UJ	5	U	1.4	B*	223
B01458	4	*	26.6		1950	UN/UJ	5	U	1.4	B*	295
B01459	4	*	28.2		1370	UN	5	U	1.4	B*	316
B01460	4	/J	28.4		1410	UW	5	U	1.4	BE	297
B014F5	5	/J	12.3	/J	901	/RN	N/D	/UJ	1.4	/J	276
B014F6	5	/J	13.9	/J	1550	/RN	N/D	/UJ	1.4	/J	785
B014F7	5	/J	13.4	/J	1180	/RN	N/D	/UJ	1.4	/J	535
B014G0	5	/J	11.5	*/J	1010	/RN	N/D	/UJ	1.4	/J	256
B014G1	5		9.6	*/R	N/D	/R	N/D	/R	N/D	/R	N/D
B014G2	5	/J	7.9	*/J	1090	/RN	N/D	/UJ	1.4	/J	178
B01469	6	*	7.2		851	UN	5		1.4	B*	254
B01470	6	*	9.8		851	UN/UJ	5		1.4	B*	298
B01471	6	*	7.2		851	UN	5		14.6	B*	254
B01472	6	*	7.8		851	UN	5	U	1.4	B*	212
B01473	6	*	7.8		851	UN	5		1.4	B*	251
B01480	6	UW/B	7.2	B	851	U	5	U	1.4	BE	237
B01482	6	*	9.3		865	UN/UJ	5		1.4	B*	288
B01483	6	*	15.3		851	UN	5		1.4	*	950
B01484	6	*	10.3		851	UN	5		1.9	B*	293

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 11 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	7.2	851	5	1.1	98.7
CRDL:	8	1000	0.5	2	1000
ACTUAL:	2.4	135	N/A	1.4	50.7
USED:	7.2	851	5	1.4	98.7

		Nickel		Potassium		Selenium		Silver		Sodium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01485	6	*	14.8		1070	UN	5		1.4	B*	277
B01486	6	*	9.3		851	UN	5		2.5	B*	327
B01487	6	*	9.3		851	UN	5		1.4	B*	288
B01488	6	*	9		851	UN	5		1.4	B*	335
B01489	6	*	11.7		851	UN	5		1.4	B*	397
B01490	6	*	11.2	B	851	UN	5		1.4	*	721
B01491	6	*	11.4		1210	UN	5		1.4	*/J	1030
B014B9	7	N	8.1	*/J	1110	UN	5	UN	1.4	B	234
B014C0	7	N	13.1	*/J	1370	N/J	5	UN	1.4	B	228
B014C1	7	N	7.2	*/J	1160	N/J	5	UN	1.4	B	176
B014C2	7	N	11.3	*/J	1010	UN/UJ	5	UN	1.4	B	197
B014C3	7	N	7.2	*/J	926	UN/UJ	5	N	1.4	B	366
B014C4	7	N	8.1	*/J	1090	N/J	5	N	1.4	B	306
B014C5	7	N	8.4	*/J	1130	UN/UJ	5	N	1.4	B	352
B014C6	7	N	9.3	*/J	1070	UN/UJ	5	N	1.4	B	294
B014C7	7	N	7.2	*/J	1040	UN/UJ	5	N	1.4	B	408
B014C8	7	N	10.3	*/J	1220	UN/UJ	5	UN	1.4	B	339
B014D3	7		14.9		1130	/UJ	5	/U	1.4	B	448
B014B3	8	N	9.2	*/J	1700	UN/UJ	5	UN	1.4	B	284
B014B4	8	N/J	17.3	*/J	2710	UN/UJ	5	UN	1.4	/J	566
B01494	9	N	10.7	*/J	1840	UN/UJ	5	UN	1.4	/J	511
B01495	9	N	12.7	*/J	2010	UN/UJ	5	N	1.4	/J	796
B01496	9	N	11.3	*/J	1760	UN/UJ	5	UN	1.4	B/J	217
B014B0	9		12.2		1880	/UJ	5	/U	1.4	B	561
B01462	10	*	22.7		2620	UN/UJ	5	U	1.4	*	970
B01463	10	*	22.9		2540	UN	5		1.7	*	976
B01464	10	*	25.1		2140	UN	5		1.4	*	717
B01465	10		24.4		2370	UW	5	U	1.4	BE	664
B01467	10	*	25.1		2340	UN/UJ	5		1.4	*	687
B01468	10	*	21		1670	UN	5		1.4	B*	457
B014D7	11	N	12.4	*/J	1760	UN/UJ	5	UN	1.4	B	331
B014D8	11	N/J	19.4	*/J	2450	UN/UJ	5	UN	1.4	/J	850
B014F1	11	N/J	20.4	*/J	2950	UN/UJ	5	UN	1.4	B	331
B014F2	11		21.9	*/J	2860	/UJ	5	/U	1.4	B	287
B01417	12		14.1		1580	UWN/R	N/D	UN/U	1.4	B	379
B01418	12		16		1920	UWN/R	N/D	UN/U	1.4	B	281
B01419	12		9.5		877	UWN/R	N/D	UN/U	1.4	B	268
B01420	12		14		1610	UWN/R	N/D	UN/U	1.4	B	312
B01421	12		14.6		1860	UWN/R	N/D	UN/U	1.4		782
B01422	12		14.1		3280	UWN/R	N/D	UN/U	1.4		5620
B01423	12		17.3		3780	/U	5	/U	1.4	E	6060
B01425	12		12.6		2020	UWN/R	N/D	N/J	1.4		3390

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 12 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	7.2	851	5	1.1	98.7
CRDL:	8	1000	0.5	2	1000
ACTUAL:	2.4	135	N/A	1.4	50.7
USED:	7.2	851	5	1.4	98.7

		Nickel		Potassium		Selenium		Silver		Sodium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01451	13	*/J	10.8		1450	UN/UJ	5	UN/UJ	1.4	B	376
B01452	13	*/J	7.2		851	UN/UJ	5	UN/UJ	1.4	B	309
B01453	13	*/J	7.7		939	UN/UJ	5	UN/UJ	1.4	B	341
B01454	13		10.3		1170	UW	5	U/J	1.4	B	277
B01456	13	*/J	9.4		1180	UN/UJ	5	UN/UJ	1.4	B	308
B01438	14	*/J	12		1820	UN/UJ	5	N/J	1.4	B	349
B01439	14	*/J	9.9		1160	UN/UJ	5	UN/UJ	1.4	B	336
B01440	14		12.1		1370	UW	5	U/UJ	1.4	B	424
B01442	14	*/J	8.8		1240	UN/UJ	5	UN/UJ	1.4	B	464
B01443	14	*/J	10.9		1370	UN/UJ	5	UN/UJ	1.4	B	433
B01444	14	*/J	13.4		1130	UN/UJ	5	UN/UJ	1.4	B	446
B01445	14	*/J	12.4		2260	UN/UJ	5	UN/UJ	1.4	B	244
B01446	14	*/J	12.9		1590	UN/UJ	5	UN/UJ	1.4	B	268
B01447	14	*/J	8.9		996	UN/UJ	5	UN/UJ	1.4	B	226
B01448	14	*/J	16.7		2380	UN/UJ	5	UN/UJ	1.4	B	296
B01449	14	*/J	10.6		1300	UN/UJ	5	UN/UJ	1.4	B	430
B014H9	15		9.5		1140	UN/R	N/D	UN/U	1.4	B	143
B014J0	15		13.4		1660	UN/R	N/D	UN/U	1.4	B	235
B014J1	15		17.8		1090	UN/R	N/D	UN/U	1.4	B	238
B014J2	15		16.8		888	UWN/R	N/D	UN/U	1.4	B	204
B014J3	15		13.5		2350	UN/R	N/D	UN/U	1.4	B	140
B014J4	15		20.5		1050	UN/R	N/D	UN/U	1.4	B	177
B014J5	15		26.6		851	UN/R	N/D	UN/U	1.4	U	101
B014J8	15		13.1		1860	/U	5	/U	1.4	BE	304
B014K0	15	*/J	13.1		1580	UN/UJ	5	UN/UJ	1.4		798
B014K1	15	*/J	10.7		1380	UN/UJ	5	UN/UJ	1.4	B	208
B014K2	15	*/J	12.7		1130	UN/UJ	5	UN/UJ	1.4	B	481
B014K3	15	*/J	11.7		897	UN/UJ	5	UN/UJ	1.4	B	351
B014K4	15	*/J	10.7		851	UN/UJ	5	UN/UJ	1.4	B	314
B014K5	15	*/J	13.3		851	UN/UJ	5	UN/UJ	1.4	B	320
B014K6	15	*/J	14.6		1690	UN/UJ	5	UN/UJ	1.4	B	190
B014K7	15	*/J	11.7		1090	UN/UJ	5	UN/UJ	1.4	B	260
B014K8	15	*/J	12.3		1190	UN/UJ	5	UN/UJ	1.4	B	216
B014K9	15	*/J	12.4		1180	N/J	6	UN/UJ	1.4	B	173
B014L0	15	*/J	9.2		851	UN/UJ	5	UN/UJ	1.4	B	175

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 13 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	3.7	2	5	2	34
CRDL:	1	10	4	N/G	N/G
CTUAL:	N/A	1.8	6.4	N/A	N/C
USED:	3.7	2	6.4	2	34

		Thallium		Vanadium		Zinc		Molybdenum		Lithium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01411	1	UN	3.7	*	59.9	*	49.2				
B01412	1	UN	3.7	*	66.6	*	55.4		N/D		N/D
B01413	1	UN	3.7	*	60.6	*	49.9		N/D		N/D
B01414	1	B	3.7		55.6	E	41.6	BNW	2		N/D
B01429	2	UN/UJ	3.7		93.1		70.6		N/D	UN	34
B01430	2	UN/UJ	3.7		73.7		70.5		N/D	UN	34
B01431	2	UN/UJ	3.7		77.7		99.8		N/D	UN	34
B01433	2	UN/UJ	3.7		59.7		62.3		N/D	UN	34
B01434	2	U	3.7		75	E/J	55.8		N/D		N/D
B014G7	3	U*/UJ	3.7		61.2		54.7	U	2		N/D
B014G9	3	U*/UJ	3.7		46.3		53.2	U	2		N/D
B01B57	3	U*/UJ	3.7		80.5		56.8	U	2		N/D
B01B58	3	U*/UJ	3.7		82.3		60.8	U	2		N/D
B01B64	3		3.7		51.8		39	/R	N/D		N/D
B01B71	3	/UJ	3.7	/J	62.1	*/J	53.1	/U	2		N/D
B01B72	3	/UJ	3.7	/J	43.3	*/J	45	/U	2		N/D
B01B73	3	/UJ	3.7	/J	78.9	*/J	61.1	/U	2		N/D
B01B74	3	/UJ	3.7	/J	48.7	*/J	48.6	/U	2		N/D
B01B75	3	UW	3.7	/J	79.3	*/J	57.2	/U	2		N/D
B01B76	3	/UJ	3.7	/J	34.2	*/J	45.1	/U	2		N/D
B01B77	3	/UJ	3.7	/J	42.4	*/J	57.1	/U	2		N/D
B01B78	3	UW/UJ	3.7	/J	50.2	*/J	49.2	/U	2		N/D
B01B79	3	U	3.7		53.4		37.2	B	2		N/D
B01457	4	U/J	3.7		38.2		58.1	U	2	U	34
B01458	4	U/J	3.7		47.9		73.3	U	2	U	34
B01459	4	U	3.7		49.7		70.5	U	2	U	34
B01460	4	B	3.7		54.3	/J	69.1	U	2		N/D
B014F5	5	/UJ	3.7	/J	34.4	/J	32.6	/UJ	2		N/D
B014F6	5	/UJ	3.7	/J	42.8	/J	44.1	/UJ	2		N/D
B014F7	5	/UJ	3.7	/J	37	/J	37.9	/UJ	2		N/D
B014G0	5	/UJ	3.7	/J	37.3	/J	35.5	/UJ	2		N/D
B014G1	5	/R	N/D		27.4		30.7	/R	N/D		N/D
B014G2	5	/U	3.7	/J	31.1	/J	32.2	/UJ	2		N/D
B01469	6	U	3.7		79.2		44.8	U	2	U	34
B01470	6	U	3.7		83.9		56.9	U	2	U	34
B01471	6	U	3.7		74.1		44.9	U	2	U	34
B01472	6	U	3.7		83.1		47.4		2	U	34
B01473	6	U/J	3.7		90.1		50.1	U	2	U	34
B01480	6	U	3.7		105	/J	51.4	UW	2		
B01482	6	U/J	3.7		77.5		50.9	U	2	U	34
B01483	6	U/J	3.7		81		50.2	U	2	U	34
B01484	6	U	3.7		94.9		59.1	U	2	U	34

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 14 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	3.7	2	5	2	34
CRDL:	1	10	4	N/G	N/G
CTUAL:	N/A	1.8	6.4	N/A	N/C
USED:	3.7	2	6.4	2	34

		Thallium		Vanadium		Zinc		Molybdenum		Lithium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01485	6	U	3.7		78.1		54.6	U	2	U	34
B01486	6	U	3.7		90.9		119	U	2	U	34
B01487	6	U	3.7		65.5		48.4	U	2	U	34
B01488	6	U	3.7		74.6		54	U	2	U	34
B01489	6	U	3.7		71		56.9	U	2	U	34
B01490	6	U	3.7		60.1		46.2	U	2	U	34
B01491	6	U	3.7		47.7		50.8	U	2	U	34
B014B9	7	UN	3.7	*/J	46.5	/J	42.4	U	2		N/D
B014C0	7	UN	3.7	*/J	53.1	/J	43.4	U	2		N/D
B014C1	7	UN	3.7	*/J	40.9	/J	39.8	U	2		N/D
B014C2	7	UN	3.7	*/J	40.5	/J	36.8	U	2		N/D
B014C3	7	UN	3.7	*/J	88.4	/J	59.7	U	2		N/D
B014C4	7	UN	3.7	*/J	88	/J	59.5	U	2		N/D
B014C5	7	UN/UJ	3.7	*/J	92.7	/J	61.5	U	2		N/D
B014C6	7	UN/UJ	3.7	*/J	92.2	/J	61.9	U	2		N/D
B014C7	7	UN/UJ	3.7	*/J	89.8	/J	59.8	U	2		N/D
B014C8	7	UN/UJ	3.7	*/J	63.4	/J	75		2		N/D
B014D3	7	/U	3.7		58.8		40.6	/U	4		N/D
B014B3	8	UN	3.7	*/J	36.6	/J	42.8	U	2		N/D
B014B4	8	UN	3.7	*/J	48.8	/J	54.1	U	2		N/D
B01494	9	UN/UJ	3.7	*/J	39.1	/J	45.6	U	2		N/D
B01495	9	UN/UJ	3.7	*/J	57.8	/J	52.4	U	2		N/D
B01496	9	UN/UJ	3.7	*/J	54.2	/J	45.1	U	2		N/D
B014B0	9	/U	3.7		38.6		41.1	/U	4		N/D
B01462	10	U/J	3.7		59.8		72.2	U	2	U	34
B01463	10	U/J	3.7		66.9		68.4	U	2	U	34
B01464	10	U	3.7		60.2		77.2	U	2	U	34
B01465	10	U	3.7		77	/J	62.4	BW	2		N/D
B01467	10	U	3.7		65.8		74.1	U	2	U	34
B01468	10	U	3.7		61.1		67.7	U	2	U	34
B014D7	11	UN/UJ	3.7	*/J	36.8	/J	45.5	U	2		N/D
B014D8	11	UN/UJ	3.7	*/J	40.2	/J	61.4	U	2		N/D
B014F1	11	UN/UJ	3.7	*/J	45.8	/J	68.2	U	2		N/D
B014F2	11	/U	3.7		42.3		59.9	/U	4		N/D
B01417	12	U	3.7		91.6		58.8		N/D		34
B01418	12	U	3.7		66.1		52.2		N/D		34
B01419	12	U	3.7		97.9		51.3		N/D	U	34
B01420	12	UW	3.7		74		50.2		N/D	U	34
B01421	12	U	3.7		54.1		46.4		N/D		34
B01422	12	U	3.7		80.7		46.9		N/D		34
B01423	12	B	3.7		104		54.4	/U	2		34
B01425	12	UW	3.7		52.3		46.6		N/D		34

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 15 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	3.7	2	5	2	34
CRDL:	1	10	4	N/G	N/G
CTUAL:	N/A	1.8	6.4	N/A	N/C
USED:	3.7	2	6.4	2	34

		Thallium		Vanadium		Zinc		Molybdenum		Lithium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01451	13	U/UJ	3.7		49.2		55.8		N/D	UN	34
B01452	13	U	3.7		28.7		44.1		N/D	UN	34
B01453	13	U	3.7		48.1		47.6		N/D	UN	34
B01454	13	U	3.7		76.2	E/J	53.7		N/D		N/D
B01456	13	U	3.7		52.1		53		N/D	UN	34
B01438	14	U	3.7		66.4		65.7		N/D	N/J	36.3
B01439	14	U/UJ	3.7		48.8		49.5		N/D	UN	34
B01440	14	U	3.7		86.3	E/J	66.2		N/D		N/D
B01442	14	U/UJ	3.7		40.4		50.2		N/D	N/J	34
B01443	14	U	3.7		50.3		48.3		N/D	N/J	34
B01444	14	U	3.7		43.8		51.9		N/D	N/J	34.9
B01445	14	U/UJ	3.7		41.7		55.1		N/D	N/J	35.5
B01446	14	U/UJ	3.7		60.7		55.2		N/D	N/J	34.1
B01447	14	U/UJ	3.7		51.3		47.3		N/D	UN	34
B01448	14	U/UJ	3.7		52.5		70.8		N/D	N/J	38.2
B01449	14	U/UJ	3.7		79.6		70.4		N/D	UN	34
B014H9	15	U	3.7		27.9		32.6		N/D		34
B014J0	15	U	3.7		31.6		39.8		N/D		34
B014J1	15	U	3.7		36.8		34		N/D		34
B014J2	15	U	3.7		29.7		30.9		N/D		34
B014J3	15	U	3.7		27.7		42		N/D		34
B014J4	15	U	3.7		38.5		41.8		N/D	U	34
B014J5	15	U	3.7		33.2		39.3		N/D	U	34
B014J8	15	B	3.7		36.7		41.8	/U	2		34
B014K0	15	UN/UJ	3.7		74.7		56.7		N/D	UN	34
B014K1	15	UN/UJ	3.7		24.3		40.6		N/D	UN	34
B014K2	15	UN/UJ	3.7		67.4		54.4		N/D	UN	34
B014K3	15	UN/UJ	3.7		57.3		52.3		N/D	UN	34
B014K4	15	UN/UJ	3.7		44.1		37.7		N/D	UN	34
B014K5	15	UN/UJ	3.7		34.5		39.5		N/D	UN	34
B014K6	15	UN/UJ	3.7		33.1		45		N/D	UN	34
B014K7	15	UN/UJ	3.7		45.4		46.2		N/D	UN	34
B014K8	15	UN/UJ	3.7		46.4		44.4		N/D	UN	34
B014K9	15	UN/UJ	3.7		33.5		40.7		N/D	UN	34
B014L0	15	UN/UJ	3.7		36		43.8		N/D	UN	34

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 16 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:		5		11		0.6		5		5.2
CRDL:		N/G		N/G		N/G		N/G		N/G
ACTUAL:		N/C		N/C		N/C		N/C		N/C
USED:		5		11		0.6		5		5.2

		Titanium		Zirconium			Ammonia		Alkalinity		Silicon
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01411	1		N/D		N/D	<	0.6		203		N/D
B01412	1		N/D		N/D		1.06		16460		N/D
B01413	1		N/D		N/D	<	0.6		804		N/D
B01414	1	N	1800	N/J	19.9	<	0.6		5		N/D
B01429	2		2890	*	27.6	/J	8.95		282	/J	10.98
B01430	2		2650	*	27.8	/J	0.94		735	/J	12.2
B01431	2		2760	*	27.5	/J	1.26		536	/J	8.74
B01433	2		1930	*	22.4	/J	2.99		379	/J	8.55
B01434	2	/R	N/D	N/R	N/D		1		N/D		N/D
B014G7	3	/J	1860		24.9		8.7		939		62.79
B014G9	3	/J	1310		19.2		2.25		1500		53.83
B01B57	3	/J	2720		29.5	<	0.6		772		30.11
B01B58	3	/J	2780		27.2	<	0.6		951		42.61
B01B64	3	/J	1650		20.6	<	0.6		N/D		N/D
B01B71	3	/J	1820	*	23.2	<	0.6	/J	1200		454
B01B72	3	/J	1330	*	20.8	<	0.6	/J	1720		583
B01B73	3	/J	2430	*	24.4	<	0.6	/J	204		211
B01B74	3	/J	1530	*	19.9	<	0.6	/J	98.8		69.8
B01B75	3	/J	2360	*	25.1	<	0.6	/J	573		74.5
B01B76	3	/J	1060	*	17.3	<	0.6	/J	1310		112
B01B77	3	/J	1200	*	20.6	<	0.6	/J	1550		66.3
B01B78	3	/J	1570	*	19	<	0.6	/J	1970		69.5
B01B79	3	N	1930	N	23.9	</UJ	0.6		N/D		N/D
B01457	4	*	957	UN/J	11		16.4	/J	2140		7.62
B01458	4	*	1130	UN/J	11		7.29	/J	2000		43.3
B01459	4	*	1110	N/J	15.1		14.1	/J	739		104
B01460	4		1330	N	15.3	<	0.6		N/D		N/D
B014F5	5	/J	723	UJ	11		1.25	/J	240		19.6
B014F6	5	/J	1050	UJ	11		1.85	/J	7190		20.4
B014F7	5	/J	716	UJ	11		1.64	/J	4730		24.8
B014G0	5	/J	743	/UJ	11		8.57	/J	2860		9.63
B014G1	5	/J	606		11		1.8		N/D		N/D
B014G2	5		729	/UJ	11		7.23	/J	800		14.9
B01469	6	*	2830	N/J	29.4		1.71	/J	205	<	5.2
B01470	6	*	2690	N/J	32.2	<	0.6	/J	665		7.48
B01471	6	*	2460	N/J	29.2	<	0.6	/J	366		5.2
B01472	6	*	2400	N/J	26.4	<	0.6	/J	310		32.6
B01473	6	*	2600	N/J	34.4		6.14	/J	225		7.96
B01480	6		3180	N	39.3	<	0.6		N/D		N/D
B01482	6	*	2120	N/J	34.4		7.85	/J	247		8.84
B01483	6	*	2300	N/J	31.8		9.34	/J	615		6.3
B01484	6	*	2940	N/J	38.4		1.28	/J	121		6.04

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 17 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	5	11	0.6	5	5.2
CRDL:	N/G	N/G	N/G	N/G	N/G
ACTUAL:	N/C	N/C	N/C	N/C	N/C
USED:	5	11	0.6	5	5.2

		Titanium		Zirconium		Ammonia		Alkalinity		Silicon	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01485	6	*	2230	N/J	33.3		1.94	/J	670		30.1
B01486	6	*	2630	N/J	37		1.71	/J	305		13.4
B01487	6	*	1870	N/J	28.6		1.18	/J	162		6.59
B01488	6	*	1730	N/J	26.3		1.61	/J	162		9.54
B01489	6	*	2130	N/J	29.8		0.79	/J	454		9.01
B01490	6	*	1940	N/J	25		12.8	/J	181		5.2
B01491	6	*	1510	N/J	20.5		21	/J	11000		13.7
B014B9	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	303		12.1
B014C0	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	179		15.1
B014C1	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	240		14.2
B014C2	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	229		8.97
B014C3	7	E/R	N/D	/R	N/D	/J	0.6	/J	507		10.9
B014C4	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	347		9.62
B014C5	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	500		22.1
B014C6	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	662		16.8
B014C7	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	448		11.1
B014C8	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	660		16
B014D3	7	/J	1590	/J	15.5	<	0.6		N/D		N/D
B014B3	8	E/R	N/D	U/R	N/D	/J	5.58	/J	1180		5.52
B014B4	8	E/R	N/D	/R	N/D	/J	0.89	/J	299		12.7
B01494	9	E/R	N/D	/R	N/D	/J	6.54	/J	299		6.59
B01495	9	E/R	N/D	/R	N/D	/J	6.43	/J	1240		10.4
B01496	9	E/R	N/D	/R	N/D	/J	1.03	/J	5350		9.74
B014B0	9	/J	1130	/J	12.5	<	0.6		N/D		N/D
B01462	10	*	1510	N/J	84.8		13.9	/J	408		22.3
B01463	10	*	1580	N/J	53.9		1.03	/J	4140		20.9
B01464	10	*	1730	N/J	48.8		1.27	/J	3270		15.1
B01465	10		1850	N	53.7		0.6		5		N/D
B01467	10	*	1700	N/J	65.7		1.31	/J	3320		15.2
B01468	10	*	1610	N/J	57.1		1.8	/J	3790		30.3
B014D7	11	E/R	N/D	/R	N/D	</UJ	0.6	/J	2790	<	5.2
B014D8	11	E/R	N/D	/R	N/D	</UJ	0.6	/J	4600		8.37
B014F1	11	E/R	N/D	/R	N/D	</UJ	0.6	/J	5920		22.1
B014F2	11	/J	1130	/J	14.6	<	0.6		N/D		N/D
B01417	12	/J	2010		31.6		0.91		510		19.6
B01418	12	/J	1530		25.5		0.64	/J	1520		31.4
B01419	12	/J	2080		29		1.94	/J	405		18.1
B01420	12	/J	1620		28.1		0.65	/J	18500		32
B01421	12	/J	1250		25.9	<	0.6	/J	13700		25.1
B01422	12	/J	1120		26.4	<	0.6	/J	15300		21.2
B01423	12	/R	N/D	/R	N/D	<	0.6		N/D		N/D
B01425	12	/J	1240		23.5		0.95	/J	10200		9.34

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 18 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	5	11	0.6	5	5.2
CRDL:	N/G	N/G	N/G	N/G	N/G
ACTUAL:	N/C	N/C	N/C	N/C	N/C
USED:	5	11	0.6	5	5.2

		Titanium		Zirconium		Ammonia		Alkalinity		Silicon	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01451	13		1580		18.2	/J	16.2		22800		26.3
B01452	13		972		13.9	/J	19		1090		27.6
B01453	13		1570		17.9	/J	19	/J	2250		24.3
B01454	13	/R	N/D	N	30.3	<	0.6		N/D		N/D
B01456	13		1680		21.4	/J	15	/J	1240		20.3
B01438	14		2060		18.2	/J	8.67		2030		14.9
B01439	14		1300		20.2	/J	12		31		10.3
B01440	14	/R	N/D	N/R	N/D	<	0.6		N/D		N/D
B01442	14		945		14.8	/J	1.58		691		21.4
B01443	14		1310		16.5	/J	1.88		2040		7.71
B01444	14		925	U	11	/J	2.04		22100		14
B01445	14		1350		15.2	/J	1.13		1090		20.4
B01446	14		1830		18	</UJ	0.6		3530		20.9
B01447	14		1600		17.3	</UJ	0.6		3410		17.1
B01448	14		1530		21.9	/J	25.6		25900		16.5
B01449	14		2400		39.4	/J	26.4		1200		32.4
B014H9	15	/J	652		14	<	0.6	/J	306		15.3
B014J0	15	/J	681	/U	11	<	0.6	/J	508		8.11
B014J1	15	/J	919		12.7	<	0.6	/J	611		9.91
B014J2	15	/J	832		11.8	<	0.6	/J	805		7.06
B014J3	15	/J	589	U	11	<	0.6	/J	1740		7.01
B014J4	15	/J	985		11.4	<	0.6	/J	1210		7.4
B014J5	15	/J	524	U	11	<	0.6	/J	508		5.64
B014J8	15	/R	N/D	/R	N/D	<	0.6		N/D		N/D
B014K0	15		2160	*	26.9	/J	1.8	/J	6710	/J	12.81
B014K1	15		613	U*	11	</UJ	0.6	/J	983	/J	5.2
B014K2	15		2090	*	22	</UJ	0.6	/J	1950	/J	21.58
B014K3	15		1630	*	25.8	</UJ	0.6	/J	3590	/J	19.41
B014K4	15		1190	*	15.6	/J	1.18	/J	37600	/J	12.32
B014K5	15		1010	*	13.8	/J	1.11	/J	28500	/J	17.23
B014K6	15		828	U*	11	/J	1.24	/J	2250	/J	15.34
B014K7	15		1320	*/J	18.3	/J	1.2	/J	2620	/J	19.95
B014K8	15		1250	*	16.7	/J	1.12	/J	5150	/J	15.78
B014K9	15		843	U*	11	</UJ	0.6	/J	1000	/J	5.2
B014L0	15		1170	*	17.6	</UJ	0.6	/J	288	/J	12.33

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 19 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:						
MAX:	1	1	21	0.6	2	1
CRDL:	N/G	N/G	N/G	N/G	N/G	N/G
ACTUAL:	N/C	N/C	N/C	N/C	N/C	N/C
USED:	1	1	21	0.6	2	1

		Fluoride		Chloride		Nitrite		Nitrate		O-Phosphate		Sulfate
		Q	Conc.	Q	Conc.	Q	Conc.	Q	Conc.	Q	Conc.	Q	Conc.
HEIS ID	SITE		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg		mg/kg
B01411	1		2.11		8.11	<	21	/J	5.36	/U	2		13.5
B01412	1		2.86		8.13	<	21	/J	30.2	/U	2		4.79
B01413	1		N/D		N/D	<	21	/J	7.47	/U	2		3.32
B01414	1	</UJ	1	/J	2	</UJ	21	/J	1.8	/J	2	/J	3
B01429	2		1.88	<	1	</UJ	21	/J	1.64	/J	2		3.36
B01430	2		1		1	</UJ	21	/J	1.88	/U	2		1
B01431	2		1		1	/J	21	/J	2.91	/U	2		1
B01433	2		1		1	</UJ	21	/J	5.51	/J	2		2.87
B01434	2	<	1	<	1	<	21	/J	0.7	</J	2		3
B014G7	3		1		6.34	</UJ	21	/J	87	/U	2		11
B014G9	3		1		2.77	</UJ	21	/J	3.78	/J	2		1.55
B01B57	3	<	1		2.2	<	21	/J	10.6	/U	2		2.25
B01B58	3	<	1		3.34	<	21	/J	2.23	/U	2		1
B01B64	3	<	1	<	1	</UJ	21	</UJ	0.6	/U	2	<	1
B01B71	3		3.46		8.22	</UJ	21	/J	53.1	/J	2		5.58
B01B72	3		1.79		7.05	</UJ	21	/J	48.8	/J	2		7.25
B01B73	3		3.04		4.89	</UJ	21	/J	8	/U	2		1.12
B01B74	3		1		4.86	</UJ	21	/J	10.5	/U	2		1.95
B01B75	3		1		2.8	</UJ	21	/J	3.22	/U	2		1
B01B76	3		1.15		3.16	</UJ	21	/J	3.05	/J	2		2.12
B01B77	3		1.03		3.49	</UJ	21	/J	2	/J	2		2.1
B01B78	3		1.33		2.63	</UJ	21	/J	1.94	/U	2		1.91
B01B79	3	</UJ	1	/J	2	/J	21	/J	1.3	/U	2	/J	1
B01457	4		1		2.37	</UJ	21	/J	1.81	/U	2		2.88
B01458	4		1.92		4.42	</UJ	21	/J	2.77	/J	2		45.2
B01459	4		2.03		3.65	</UJ	21	/J	3.46	/J	2		11.2
B01460	4		2		2	<	21	/J	0.6	/U	2		7
B014F5	5		1.37		2.41	</UJ	21	/J	2.9	/U	2		8.6
B014F6	5		5.45		8.51	</UJ	21	/J	1.7	/U	2		40.1
B014F7	5		1.08		11.6	/J	21	/J	3.13	/U	2		42.8
B014G0	5		1		13.4	</UJ	21	/J	6.76	/U	2		125
B014G1	5	<	1		13	</UJ	21	/J	1.8	/U	2	/J	140
B014G2	5		1		3.4	</UJ	21	/J	2.35	/J	3.14		11.6
B01469	6		1		2.49	</UJ	21	/J	1.34	/U	2		3.26
B01470	6		1		2.24	</UJ	21	/J	1.04	/U	2		1.89
B01471	6		1		2.35	</UJ	21	/J	1.16	/U	2		2.19
B01472	6		1.23		2.73	</UJ	21	/J	1.6	/U	2		4.51
B01473	6		1		2.75	</UJ	21	/J	1.16	/U	2		2.54
B01480	6	<	1	<	1	<	21	</UJ	0.6	/U	2		4
B01482	6		1		3.42	</UJ	21	/J	1.3	/U	2		3.87
B01483	6		1		3.45	</UJ	21	/J	1.25	/U	2		3.06
B01484	6		1		4	</UJ	21	/J	1.04	/U	2		3.87

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 20 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:						
MAX:	1	1	21	0.6	2	1
CRDL:	N/G	N/G	N/G	N/G	N/G	N/G
ACTUAL:	N/C	N/C	N/C	N/C	N/C	N/C
USED:	1	1	21	0.6	2	1

		Fluoride		Chloride		Nitrite		Nitrate		O-Phosphate		Sulfate
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01485	6		1		3.85	</UJ	21	/J	1.07	/U	2		7.21
B01486	6		1		9.03	</UJ	21	/J	0.71	/U	2		11.1
B01487	6		1		4.27	</UJ	21	/J	0.77	/U	2		11.9
B01488	6		1		3.81	</UJ	21	/J	0.99	/U	2		7.52
B01489	6		1		11.5	</UJ	21	/J	1.06	/U	2		24.6
B01490	6		1		46.4	</UJ	21	/J	1.64	/U	2		79.2
B01491	6		2.25		292	</UJ	21	/J	0.92	/U	2		430
B014B9	7		1		87.6	</UJ	21		5.6	/U	2		55
B014C0	7		1		3.77	</UJ	21		1.23	/U	2		4.82
B014C1	7		1		11.6	</UJ	21		1.9	/U	2		15
B014C2	7		1		10.3	</UJ	21		1.46	/J	2		13.7
B014C3	7		1		6.97	</UJ	21		1.95	/U	2		9.92
B014C4	7		1		5.97	</UJ	21		1.45	/U	2		9.1
B014C5	7		1		9.78	</UJ	21		2.76	/U	2		11.1
B014C6	7		1.07		8.18	</UJ	21		1.15	/U	2		19.4
B014C7	7		1		2.62	</UJ	21		5.83	/U	2		1.26
B014C8	7		1		2.67	</UJ	21		3.2	/U	2		4.02
B014D3	7		1		2	</UJ	21	</UJ	0.6	/U	2		6
B014B3	8		1		2.76	</UJ	21		1.05	/U	2		1.44
B014B4	8		1		2.84	</UJ	21		2.82	/U	2		1.18
B01494	9		1		30.7	</UJ	21		2.29	/U	2		28.5
B01495	9		1.76		19.1	</UJ	21		3.15	/J	2.37		22.9
B01496	9		1		11.2	</UJ	21		50.1	/J	2		5.4
B014B0	9		1		40	</UJ	21	/UJ	0.6	/U	2		62
B01462	10		20.1		212	</UJ	21	/J	328	<	2		4340
B01463	10		16.6		112	</UJ	21	/J	175	/J	225		4270
B01464	10		1		101	</UJ	21	/J	132	/J	43.8		1650
B01465	10	<	1		30	</UJ	21	/J	13	</J	2		550
B01467	10		73.3		723	/UJ	21	/J	206	/U	2		1920
B01468	10		1.6		39.9	</UJ	21	/J	60	/J	2		220
B014D7	11		1.72		450	</UJ	21		474	/U	2		43.2
B014D8	11		4.86		1480	</UJ	21		440	/U	2		108
B014F1	11		3.29		560	</UJ	21		29.2	/J	2		21
B014F2	11		3		3	</UJ	21	/J	5.6	/U	2		23
B01417	12		1.85		20.3	</UJ	21	/J	25.3	/J	2		50.9
B01418	12		1.73		6.81	</UJ	21	/J	8.14	/J	2		97.7
B01419	12		1		25.4	</UJ	21	/J	2.93	/J	2		13.1
B01420	12		1.52		10.3	</UJ	21	/J	3.6	/J	2		11.6
B01421	12	(1)	1.39		370	</UJ	21	/J	4.65	/J	2		102
B01422	12	(1)	3.97		889	</UJ	21	/J	10.3		14.4		1480
B01423	12		10		830	<	21	/J	2.4	/J	4.3		1400
B01425	12	<	1		601	</UJ	21	/J	11.9		7.7		2600

Table C-2. Chemical Composition of Systematic Random Samples.
(sheet 21 of 21)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:						
MAX:	1	1	21	0.6	2	1
CRDL:	N/G	N/G	N/G	N/G	N/G	N/G
ACTUAL:	N/C	N/C	N/C	N/C	N/C	N/C
USED:	1	1	21	0.6	2	1

HEIS ID	SITE	Q	Fluoride Conc. mg/kg	Q	Chloride Conc. mg/kg	Q	Nitrite Conc. mg/kg	Q	Nitrate Conc. mg/kg	Q	O-Phosphate Conc. mg/kg	Q	Sulfate Conc. mg/kg
B01451	13		1		1.71	</UJ	21	/J	31.1	/U	2		18.1
B01452	13		1		18.3	</UJ	21	/J	538	/U	2		266
B01453	13		1		2.44	</UJ	21	/J	4.14	/U	2		20.8
B01454	13	<	1		2	<	21	/J	0.6	/U	2		12
B01456	13		1		36.4	<	21	/J	6.9	/U	2		38.9
B01438	14		1.64		4.83	</UJ	21	/J	5.08	/U	2		14.2
B01439	14		1.44		25.1	</UJ	21	/J	14	/U	2		22.6
B01440	14	<	1		18	<	21	/J	1.9	/U	2		32
B01442	14		1.03		26	</UJ	21	/J	17.6	/U	2		61.3
B01443	14		1.84		146	</UJ	21	/J	2.94	/J	2		590
B01444	14		1.84		169	</UJ	21	/J	7.24	/U	2		229
B01445	14		2.91		1	</UJ	21	/J	2.4	/J	2		4.38
B01446	14		1.41		19.8	</UJ	21	/J	4.17	/U	2		59.6
B01447	14		1		25	</UJ	21	/J	8.1	/U	2		104
B01448	14		1.78		2.42	</UJ	21	/J	2.35	/U	2		46.7
B01449	14		1		1.63	</UJ	21	/J	4.61	</J	2		40.7
B014H9	15		1	<	1	</UJ	21	/J	1.39	/J	2.47		1.23
B014J0	15	<	1		1	</UJ	21	/J	1.62	/U	2		1.18
B014J1	15	<	1	<	1	</UJ	21	<UJ	0.6	/U	2		1
B014J2	15	<	1		1	/UJ	21	/J	2.75	/U	2		1.27
B014J3	15		1		1.99	</UJ	21	/J	3.45	/U	2		2.37
B014J4	15		1		1	</UJ	21	/J	1.32	/U	2		1.26
B014J5	15		1		1	</UJ	21	/J	1.18	/U	2		1
B014J8	15	<	1	<	1	<	21	</UJ	0.6	/U	2		2
B014K0	15	/J	1.51	/J	170	</UJ	21	/J	10.5	</J	2	/J	95.7
B014K1	15	/J	1	/J	17.3	</UJ	21	/J	22.4	/U	2	/J	103
B014K2	15	/J	1	/J	2.47	/UJ	21	/J	10.5	/U	2	/J	22.1
B014K3	15	/J	1	/J	2.24	</UJ	21	/J	8.12	/U	2	/J	14.1
B014K4	15	/J	2.32	/J	9	</UJ	21	/J	44.6	/U	2	/J	54.6
B014K5	15	/J	1.21	/J	3.13	</UJ	21	/J	13.2	/U	2	/J	13.6
B014K6	15	/J	1	/J	1.79	</UJ	21	/J	5.98	/U	2	/J	2.34
B014K7	15	/J	1	/J	2.85	</UJ	21	/J	9.03	/U	2	/J	5.69
B014K8	15	/J	1	/J	3.13	</UJ	21	/J	9.56	/U	2	/J	4.4
B014K9	15	/J	1	/J	3.38	</UJ	21	/J	8.32	/U	2	/J	2.3
B014L0	15	/J	1	/J	1	</UJ	21	/J	2.32	/U	2	/J	1.74

Table C-3. Chemical Composition of Judgment Samples.
(sheet 1 of 7)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	18.1	11.1	3	4.1	0.46
CRDL:	40	12	1	40	1
ACTUAL:	21.8	15.7	N/A	0.9	N/C
USED:	21.8	15.7	3	4.1	0.46

		Aluminum		Antimony		Arsenic		Barium		Beryllium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01435	2		4190	UN/UJ	15.7	N/J	4		84.6		1
B01436	2		5680	UN/UJ	15.7	N/J	4.9		70.6		1.3
B014G8	3	*	7420	UN/RN	N/D	N/J	4.7		69.5		0.83
B01B59	3	*/J	6330	UN/RN	N/D	N/J	4.7		68.7		0.75
B01B60	3	*/J	7890	UN/RN	N/D	N/J	3.6		60		0.97
B01B61	3	*/J	6490	UN/RN	N/D	N/J	3.7		65.2		0.77
B01B62	3	*/J	13100	UN/RN	N/D	N/J	6.3		100		1.5
B01B63	3	*/J	8000	UN/RN	N/D	N/J	3.7		78.4		1.4
B01B67	3	/J	5620	/R	N/D	/R	N/D		51	/R	N/D
B014G3	5	/J	6640	UJN	15.7	/U	3	/J	52.2	/J	0.7
B014G4	5	/J	6610	UJN	15.7	/U	3	/J	62.4	/J	0.72
B014G5	5	/J	9780	UJN	15.7		5.6	/J	106	/J	0.97
B014G6	5	/J	6900	UJN	15.7		3	/J	64.3	/J	0.72
B01492	6		8430	UN/J	15.7	N/J	4.2	*	152		1.4
B01493	6		7770	UN/J	15.7	UN/J	9	*	99.4		1.2
B014C9	7		6580	UN/R	N/D	/J	3	N	85	N	0.81
B014D0	7		7330	UN/R	N/D	/J	4.3	N	108	N	1.4
B014D4	7		7020	UN/R	N/D	/J	3	N	71.7	N	0.83
B014D5	7		7900	UN/R	N/D	/J	3.7	N	98.9	N	0.91
B014D6	7		6130	UN/R	N/D	/J	3	N	80.7	N	0.82
B014B5	8		12400	UN/R	N/D	/J	5.2	N	79.7	N	1.2
B014B6	8		8110	UN/R	N/D	/J	5.4	N	79.7	N	1
B014B7	8		11100	/UJ	15.7	/J	4.6		94.1	/U	0.46
B01497	9		23000	UN/R	N/D	/J	6.7	N	294	N	2.1
B01498	9		10600	UN/R	N/D	/J	4.2	N	120	N	1
B01499	9		10100	UN/R	N/D	/J	6.5	N	98.6	N	1
B014D9	11		15700	UN/R	N/D	/J	11.2	N	198	N	1.4
B014F0	11		15100	UN/R	N/D	/J	6	N	153	N	1.3
B01426	12	*/J	6770	UN/R	N/D	*	4		92.8		1.2
B01427	12	*/J	7200	UN/R	N/D	W*	4.5		83.4		0.62
B01450	14		6120	UN/R	N/D	/J	7	*/J	88.1		1.4

Table C-3. Chemical Composition of Judgment Samples.
(sheet 2 of 7)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	0.66	189	1.8	1.6	1.8
CRDL:	1	1000	2	10	5
ACTUAL:	0.02	175	1.1	0.9	2.1
USED:	0.66	189	1.8	1.6	2.1

		Cadmium		Calcium		Chromium		Cobalt		Copper	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01435	2	U	0.66		39300	/J	3.4		11.6		13.6
B01436	2	U	0.66		9840	/J	5.1		14.3		18.1
B014G8	3	U	0.66		6330	*/J	12.3		7.9	*	9.3
B01B59	3	U	0.66		5740	*/J	11.6		7.6	*	9
B01B60	3	U	0.66		8300	*/J	16.2		10.3	*	9.5
B01B61	3	U	0.66		6680	*/J	11.8		8.3	*	10.1
B01B62	3	U	0.66		12100	*/J	17.3		14.5	*	19.3
B01B63	3	U	0.66		9060	*/J	10.8		17.8	*	15
B01B67	3	/R	N/D		5280		9.9	/R	N/D		8.5
B014G3	5	/UJ	0.66	/J	8260	/J	14.3		6.4		13.1
B014G4	5	/UJ	0.66	/J	9040	/J	14.6		6.9		10.3
B014G5	5	/UJ	0.66	/J	13300	/J	20.1		10.6		28.4
B014G6	5	/UJ	0.66	/J	12200	/J	15.7		7.4		13.1
B01492	6	U	0.66	*	12900	*/J	6.8		17.3	N*/J	15.4
B01493	6	U	0.66	*	18500	*/J	9		12.6	N*/J	13.5
B014C9	7	UN	0.66		6660	*/J	7.7	N	7.1	/J	8.6
B014D0	7	UN	0.66		7790	*/J	6.4	N	14.8	/J	11
B014D4	7	UN	0.66		6440	*/J	9.3	N	7.1	/J	10.2
B014D5	7	UN	0.66		8900	*/J	11.3	N	8.5	/J	10.5
B014D6	7	UN	0.66		5640	*/J	6.7	N	9.7	/J	11.6
B014B5	8	UN	0.66		6900	*/J	17.5	N	10.3	/J	17.3
B014B6	8	UN	0.66		7250	*/J	13.1	N	7.6	/J	10.6
B014B7	8	/U	0.66		7110		14.4		9.3		11.9
B01497	9	UN	0.66		10600	*/J	22.7	N	16.8	/J	22.6
B01498	9	UN	0.66		10800	*/J	13.1	N	8.8	/J	16.2
B01499	9	UN	0.66		25400	*/J	10.3	N	9.7	/J	15.4
B014D9	11	UN	0.66		17000	*/J	23.1	N	12.4	/J	22.6
B014F0	11	UN	0.66		13800	*/J	20.1	N	11.2	/J	17.1
B01426	12	U	0.66		10800		8.2		15		9.7
B01427	12	U	0.66		37500		6.8		6.1		11.6
B01450	14	U	0.66	*/J	21600	N/J	3.6	*/J	12.2	*/J	17.6

Table C-3. Chemical Composition of Judgment Samples.
(sheet 3 of 7)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	7.1	1.1	249	0.6	0.16
CRDL:	20	0.6	1000	3	0.04
ACTUAL:	75.7	N/A	18.4	0.6	N/A
USED:	75.7	1.1	249	0.6	0.16

		Iron		Lead		Magnesium		Manganese		Mercury	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01435	2		23500	/J	3.2		4080		299	N*/J	0.27
B01436	2		29000	/J	4		5240		400	N*/J	0.71
B014G8	3		16600		4.8	*/J	4150	*/J	300	U*/UJ	0.16
B01B59	3		15200		4.2	*/J	4210	*/J	262	U*/UJ	0.16
B01B60	3		22100		4.6	*/J	5000	*/J	353	U*/UJ	0.16
B01B61	3		16200		4.1	*/J	4130	*/J	292	U*/UJ	0.16
B01B62	3		27500		8.9	*/J	7470	*/J	481	U*/UJ	0.16
B01B63	3		33700		8.2	*/J	6290	*/J	467	U*/UJ	0.16
B01B67	3		13000		3.1		3590	/J	227	/R	N/D
B014G3	5		15900		3.9	/J	4730	/J	263	/UJN	0.16
B014G4	5		15000		5	/J	4710	/J	273	/UJN	0.16
B014G5	5		22500		7.5	/J	6970	/J	506	/UJN	0.16
B014G6	5		16100		3.8	/J	4700	/J	282	/UJN	0.16
B01492	6		32900	N/JN	7.4		4980		602	UN	0.16
B01493	6		26700	N/JN	11.9		7450		420	UN	0.16
B014C9	7	*/J	17400	*/J	3.1		3920		262	UN*	0.16
B014D0	7	*/J	31200	*/J	5.4		5070		451	UN*	0.16
B014D4	7	*/J	17300	*/J	4.7		4440		280	N*/J	0.34
B014D5	7	*/J	19700	*/J	4.3		5110		361	UN*	0.16
B014D6	7	*/J	21000	*/J	2.7		4020		413	UN*	0.16
B014B5	8	*/J	24100	*/J	11.4		5840		409	N*/J	1.7
B014B6	8	*/J	19500	*/J	9.5		4830		364	UN*	0.16
B014B7	8		21400		7.6		6090		394	/U	0.16
B01497	9	*/J	37000	*/J	9.7		8920		814	UN*	0.16
B01498	9	*/J	19800	*/J	6.3		5660		403	UN*	0.16
B01499	9	*/J	21400	*/J	7.2		5600		326	UN*	0.16
B014D9	11	*/J	26900	*/J	19.1		8850		519	UN*	0.16
B014F0	11	*/J	26300	*/J	8.2		6670		444	UN*	0.16
B01426	12		26400	/J	6		3720	/J	385	UN/UJ	0.16
B01427	12		12300	/J	3.8		6250	/J	214	UN/UJ	0.16
B01450	14		27500	N	7.8		3420	*/J	309	UN/UJ	0.16

Table C-3. Chemical Composition of Judgment Samples.
(sheet 4 of 7)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	7.2	851	5	1.1	98.7
CRDL:	8	1000	0.5	2	1000
ACTUAL:	2.4	135	N/A	1.4	50.7
USED:	7.2	851	5	1.4	98.7

		Nickel		Potassium		Selenium		Silver		Sodium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B0143S	2	*/J	7.7		851	UN/UJ	5	UN/UJ	1.4	B	287
B01436	2	*/J	9.4		950	UN/UJ	5	UN/UJ	1.4	B	305
B014G8	3	*/J	11.6	*/J	1270	UN/UJN	5	U	1.4	B	196
B01B59	3	*/J	13	*/J	1140	UN/UJ	5		1.4	B	149
B01B60	3	*/J	14.3	*/J	1200	UN/UJ	5	U	1.4	B	194
B01B61	3	*/J	12.3	*/J	1170	UN/UJ	5	U	1.4	B	163
B01B62	3	*/J	22.8	*/J	2190	UN/UJ	5		1.4	B	349
B01B63	3	*/J	16.3	*/J	1330	UN/UJ	5		1.7	B	385
B01B67	3		8.9	/R	N/D	/R	N/D	/R	N/D	/R	N/D
B014G3	5	/J	11.7	*/J	910	/RN	N/D	/UJ	1.4	/J	330
B014G4	5	/J	14	*/J	1110	/RN	N/D	/UJ	1.4	/J	344
B014G5	5	/J	16.1	*/J	1600	/RN	N/D	/UJ	1.4	/J	721
B014G6	5	/J	12.5	*/J	1000	/RN	N/D	/UJ	1.4	/J	210
B01492	6	*	12.7		1300	UN	5		1.4	B*/J	332
B01493	6	*	11		1260	UN	5		1.4	*/J	748
B014C9	7	N	7.2	*/J	1160	UN/UJ	5	UN	1.4	B	142
B014D0	7	N	8	*/J	1220	UN/UJ	5	N	1.4	B	372
B014D4	7	N	8.5	*/J	1270	UN/UJ	5	UN	1.4	B	167
B014D5	7	N	10.4	*/J	1530	UN/UJ	5	UN	1.4	B	183
B014D6	7	N	8.2	*/J	1430	UN/UJ	5	UN	1.4	B	210
B014B5	8	N/J	14.7	*/J	2240	UN	5	UN	1.4	B	374
B014B6	8	N	9.3	*/J	1720	UN/UJ	5	UN	1.4	B	317
B014B7	8		12.6		2380	/UJ	5	/U	1.4	B	399
B01497	9	N/J	17	*/J	3630	UN/UJ	5	N	1.4		976
B01498	9	N	11.2	*/J	1920	UN/UJ	5	UN	1.4	B	477
B01499	9	N	10.3	*/J	1100	UN/UJ	5	UN	1.4	B	293
B014D9	11	N/J	21.8	*/J	2900	UN/UJ	5	UN	1.4	B	473
B014F0	11	N/J	17.8	*/J	2280	UN/UJ	5	N	1.4	/J	629
B01426	12		10.7		1030	UWN/R	N/D	N/J	1.4	B	309
B01427	12		7.7		1470	UWN/R	N/D	UN/U	1.4		2460
B01450	14	*/J	8		855	UN/UJ	5	UN/UJ	1.4	B	306

Table C-3. Chemical Composition of Judgment Samples.
(sheet 5 of 7)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	3.7	2	5	2	34
CRDL:	1	10	4	N/G	N/G
CTUAL:	N/A	1.8	6.4	N/A	N/C
USED:	3.7	2	6.4	2	34

		Thallium		Vanadium		Zinc		Molybdenum		Lithium	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01435	2	UN/UJ	3.7		63		52.5		N/D	UN	34
B01436	2	UN/UJ	3.7		79.6		60.9		N/D	UN	34
B014G8	3	U*/UJ	3.7		37		33.3	U	2		N/D
B01B59	3	U*/UJ	3.7		31.4		34.7	U	2		N/D
B01B60	3	U*/UJ	3.7		52.9		42.4	U	2		N/D
B01B61	3	U*/UJ	3.7		35.4		34	U	2		N/D
B01B62	3	U*/UJ	3.7		59.3		60.1	U	2		N/D
B01B63	3	U*/UJ	3.7		94.9		66.4	U	2		N/D
B01B67	3	/R	N/D		28.6		26.7	/R	N/D		N/D
B014G3	5	/UJ	3.7	/J	34.6	/J	32.5	/UJ	2		N/D
B014G4	5	/UJ	3.7	/J	29.4	/J	35.6	/UJ	2		N/D
B014G5	5	/UJ	3.7	/J	50.2	/J	52.8	/UJ	2		N/D
B014G6	5	/UJ	3.7	/J	37.4	/J	36.7	/UJ	2		N/D
B01492	6	U	3.7		72.6		54.4	U	2	U	34
B01493	6	U	3.7		62.8		58.1	U	2	U	34
B014C9	7	UN/UJ	3.7	*/J	36.4	/J	36.4	U	2		N/D
B014D0	7	UN/UJ	3.7	*/J	77.2	/J	56.4	U	2		N/D
B014D4	7	UN/UJ	3.7	*/J	35.8	/J	36.7	U	2		N/D
B014D5	7	UN/UJ	3.7	*/J	38.3	/J	43	U	2		N/D
B014D6	7	UN/UJ	3.7	*/J	41.4	/J	41.3	U	2		N/D
B014B5	8	UN	3.7	*/J	43.7	/J	55.2	U	2		N/D
B014B6	8	UN	3.7	*/J	35.4	/J	43.4	U	2		N/D
B014B7	8	/U	3.7		38.9		46.8	UW	2		N/D
B01497	9	UN/UJ	3.7	*/J	66.7	/J	79.9	U	2		N/D
B01498	9	UN/UJ	3.7	*/J	35.1	/J	47.6	U	2		N/D
B01499	9	UN/UJ	3.7	*/J	50.1	/J	45.2	U	2		N/D
B014D9	11	UN/UJ	3.7	*/J	45.4	/J	69	U	2		N/D
B014F0	11	UN/UJ	3.7	*/J	49.7	/J	57.1	U	2		N/D
B01426	12	UW	3.7		89		49.9		N/D		34
B01427	12	U	3.7		27.3		24.2		N/D		34
B01450	14	U/UJ	3.7		48.5		58		N/D	UN	34

Table C-3. Chemical Composition of Judgment Samples.
(sheet 6 of 7)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:					
MAX:	5	11	0.6	5	5.2
CRDL:	N/G	N/G	N/G	N/G	N/G
ACTUAL:	N/C	N/C	N/C	N/C	N/C
USED:	5	11	0.6	5	5.2

		Titanium		Zirconium		Ammonia		Alkalinity		Silicon	
HEIS ID	SITE	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg	Q	Conc. mg/kg
B01435	2		2190	*	20	/J	16.6		13900	/J	10.87
B01436	2		2700	*	25.2	/J	1.39		280	/J	9.56
B014G8	3	/J	962	U	11		1.59		536		59.94
B01B59	3		864	U	11		1.36		457		34.35
B01B60	3	/J	1260		11.3		0.7		1980		36.87
B01B61	3	/J	911	U	11		15.7		675		33.72
B01B62	3	/J	1720		26		11.6		1140		22.74
B01B63	3	/J	3180		31.7		5.57		1010		25.93
B01B67	3	/J	781		11	/U	0.6		N/D		N/D
B014G3	5	/J	757	/UJ	11	<	0.6	/J	257		5.53
B014G4	5	/J	701	/UJ	11	<	0.6	/J	569		20
B014G5	5	/J	823	/UJ	11		0.84	/J	2050		46.8
B014G6	5	/J	757	/UJ	11		0.96	/J	1990		8.82
B01492	6	*	2280	N/J	39.9		6.15	/J	2870		17.9
B01493	6	*	2070	N/J	23.5		16.6	/J	6660		15.7
B014C9	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	219		6.76
B014D0	7	E/R	N/D	/R	N/D	/J	0.92	/J	905		9.73
B014D4	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	225		20.7
B014D5	7	E/R	N/D	U/R	N/D	</UJ	0.6	/J	1540		9.34
B014D6	7	E/R	N/D	/R	N/D	</UJ	0.6	/J	171		8.22
B014B5	8	E/R	N/D	/R	N/D	</UJ	0.6	/J	1320		19.1
B014B6	8	E/R	N/D	/R	N/D	</UJ	0.6	/J	219		6.14
B014B7	8	/J	1130	/J	12.5	<	0.6		N/D		N/D
B01497	9	E/R	N/D	/R	N/D	/J	0.85	/J	3540		19.8
B01498	9	E/R	N/D	/R	N/D	/J	0.69	/J	2080		13.2
B01499	9	E/R	N/D	/R	N/D	/J	0.95	/J	7650		11.4
B014D9	11	E/R	N/D	/R	N/D	</J	1.65	/J	5320		8
B014F0	11	E/R	N/D	/R	N/D	</UJ	0.6	/J	4010		10.9
B01426	12	/J	1980		29.6	<	0.6	/J	4980		21.5
B01427	12	/J	587		14.7		1.32	/J	27500		31.3
B01450	14		1380		32.5	/J	1.31		288		15.7

Table C-3. Chemical Composition of Judgment Samples.
(sheet 7 of 7)

N/G: Not given in CLP SOW
N/C: Not calculated, due to lack of lab data
N/A: Not applicable
N/D: Not determined

DETECTION LIMIT (DL) VALUES, mg/kg:

MAX:	1	1	21	0.6	2	1
CRDL:	N/G	N/G	N/G	N/G	N/G	N/G
ACTUAL:	N/C	N/C	N/C	N/C	N/C	N/C
USED:	1	1	21	0.6	2	1

HEIS ID	SITE	Q	Fluoride Conc. mg/kg	Q	Chloride Conc. mg/kg	Q	Nitrite Conc. mg/kg	Q	Nitrate Conc. mg/kg	Q	O-Phosphate Conc. mg/kg	Q	Sulfate Conc. mg/kg
B01435	2		1.32		1	</UJ	21	/J	4.17	/U	2		2.71
B01436	2		1		1	</UJ	21	/J	0.9	/U	2		2.28
B014G8	3		1		2.38	</UJ	21	/J	18.5	/J	2		2.26
B01B59	3		1		1.9	</UJ	21	/J	2.97	/J	2		1.09
B01B60	3		1		3.46	</UJ	21	/J	55.7	/U	2		7.34
B01B61	3		1		1.82	</UJ	21	/J	2.05	/J	2		1
B01B62	3	<	1		4.65	</UJ	21	/J	299	/U	2		28.9
B01B63	3	<	1		1.79	</UJ	21	/J	2.48	/U	2		1
B01B67	3	<	1	<	1	</UJ	21	/J	0.6	/U	2	<	1
B014G3	5		1		2.07	</UJ	21	/J	1.07	/U	2		1.26
B014G4	5		1.19		1.8	</UJ	21	/J	1.06	/U	2		3.07
B014G5	5		1.22		3.2	</UJ	21	/J	1.3	/U	2		11.9
B014G6	5		1		2.01	</UJ	21	/J	2.02	/U	2		1.7
B01492	6		1		36.7	</UJ	21	/J	41.9	/U	2		101
B01493	6		1.93		87.7	</UJ	21	/J	10.7	/U	2		182
B014C9	7		1		3.97	</UJ	21		1.37	/U	2		4.77
B014D0	7		1		74.2	</UJ	21		1.2	/U	2		59.4
B014D4	7		1		63.2	</UJ	21		5	/U	2		75.1
B014D5	7		1		170	</UJ	21		14.9	/U	2		160
B014D6	7		1		2.93	</UJ	21		0.6	/U	2		2.59
B014B5	8		1		3.05	</UJ	21		3.08	/J	2		3.36
B014B6	8		1.3		365	</UJ	21		18	/U	2		91.1
B014B7	8		2		720	</UJ	21	/J	6.3	/U	2		120
B01497	9		1.37		39.8	</UJ	21		68.9	/J	2		340
B01498	9		1		5.79	</UJ	21		1.3	/J	2		10.6
B01499	9		2.94		3	/J	21		14.1	<	2		12.5
B014D9	11		4.81		170	</UJ	21		906	/U	2		97.7
B014F0	11		2.85		555	</UJ	21		778	/U	2		84.8
B01426	12	<	1		1.01	</UJ	21	/J	1.66		7.04		1.89
B01427	12	<	1		543	</UJ	21	/J	3.39	/U	2		833
B01450	14		1		1	</UJ	21	/J	62.5	/U	2		11.7

Table C-4. Inorganic Composition of Ecosystem Samples.
(sheet 1 of 3)

B06139

HEIS #:	B06137	B061379	B06140	B06141	B06142
Site #:	E-1	E-2	E-3	E-4	E-5
Location:	Rattlesnake Mountain	Rattlesnake Spring			
Sample Type:		Greaswood	Riparian grass	Riparian juniper	DC Well
Analyte					
Aluminum	14400	7600	9940	10200	6170
Antimony	29.1	17.4	13.7	14.2	12.6
Arsenic	4	3.1	7.7	27.7	2.4
Barium	144	190	88.8	90.8	76
Beryllium	1.7	0.9	0.94	0.98	0.87
Cadmiun	1.2	0.9	3.1	2.9	0.65
Calcium	4980	105000	5650	5820	3590
Chromium	21.6	7.2	19.6	20.4	7.1
Cobalt	17.5	8.1	10.1	10.6	9.5
Copper	24.8	19.5	31.8	32.9	8.9
Iron	29600	14800	20300	20800	20900
Lead	38.2	12	67.4	74.1	8.4
Magnesium	5050	32300	5110	5250	3550
Manganese	668	518	297	304	333
Mercury	0.12	0.15	0.12	0.12	0.11
Nickel	24	12.3	20	19.9	10.8
Potassium	3610	6410	2020	2100	1440
Selenium	0.96	1.2	0.94	0.98	0.87
Silver	6	3	2.4	2.5	2.2
Sodium	272	5120	273	263	214
Thallium	0.72	0.9	0.71	0.74	0.65
Vanadium	64.7	30.5	43.6	44.7	50
Zinc	60.6	50	356	366	43.3
Molybdenum	4.3	4.2	3.3	3.4	3
Titanium	1520	808	1010	1000	1730
Lithium					
Zirconium	27.2	29.9	23.6	24.5	21.6
Ammonia	13.4	9.8	0.71	0.96	1.14
Alkalinity	1100	150000	9.7	1580	673
Silicon	53.1	94.5	110.9	11.2	75.4
Fluoride	0.94	<2	0.94	1.2	0.84
Chloride	3.07	1	0.88	1.06	0.39
Nitrite	0.54	36.5	<.3	0.54	<.3
Nitrate	10.3	585	12.4	7.11	2.7
O-Phosphate	20.7	18.8	3.13	4.51	7.36
Sulfate	1.7	12600	13.5	4.67	1.12
Tot Organic Carbon	21442	51635/63832	19774	13742	6991

Table C-4. Inorganic Composition of Ecosystem Samples.
(sheet 2 of 3)

HEIS #:	B06143	B06144	B06145	B06146	B06147
Site #:	E-6	E-7	E-8	E-9	E-10
Location:	Old Field	Columbia River Plain	Columbia River Plain		
Sample Type:	ECA	sagebrush	rabbitbrush	Playa	Duplicate Playa
Analyte					
Aluminum	10400	6610	6390	28800	22900
Antimony	13.3	12.4	12.6	16.4	17.9
Arsenic	7	3.1	3.7	5	5.4
Barium	113	62	66.5	241	241
Beryllium	1.2	0.64	0.65	2.5	2.3
Cadmiun	0.69	0.64	0.65	0.85	0.85
Calcium	4210	3490	5110	13900	12300
Chromium	13.6	12.8	12.4	26.5	22.7
Cobalt	11.3	6.4	6.9	26	25.3
Copper	12.4	10.3	11.1	40.3	39.8
Iron	26900	14100	14400	53600	48300
Lead	35.4	8.1	5.4	26.5	19.9
Magnesium	4510	4110	4270	9960	9120
Manganese	463	289	288	1100	1110
Mercury	0.12	0.11	0.11	0.14	0.14
Nickel	14.3	13.5	14.3	31.3	28.7
Potassium	2550	1790	1680	7900	7130
Selenium	0.92	0.86	0.87	1.1	1.1
Silver	2.3	2.1	2.2	2.8	2.8
Sodium	227	211	214	33.6	284
Thallium	0.69	0.64	0.65	0.85	0.85
Vanadium	61.4	25.9	26	90.3	82.1
Zinc	62.8	38.3	38.8	103	95.5
Molybdenum	3.2	3	3	3.9	4
Titanium	1930	642	633	2550	2040
Lithium					
Zirconium	26.2	21.4	21.7	73.3	59.7
Ammonia	2.24	2.57	1.68	<.2	<.2
Alkalinity	768	686	1910	15100	11300
Silicon	119.9	34.6	33.3	682	1202.9
Fluoride	1	0.72	0.68	0.95	1.19
Chloride	0.53	1.28	0.56	0.52	0.55
Nitrite	<.3	0.6	<.3	<.3	<.03
Nitrate	3.13	66.3	6.12	21	30.5
O-Phosphate	9.21	21.3	3.4	23.4	18.2
Sulfate	5.81	29.1	6.18	5.05	6.44
Tot Organic Carbon	12327	7452	5328	16886	23690

ECA = Ecological Control Area

Table C-4. Inorganic Composition of Ecosystem Samples.
(sheet 3 of 3)

HEIS #:	B06148	B061349	B06150
Site #:	E-11	E-11	E-12
Location:	Columbia River Plain	Columbia River Plain	200 Area Plateau
Sample Type:	ECA	ECA (Blank)	ECA
Analyte			
Aluminum	9980	16.2	6340
Antimony	12.8	0	12.6
Arsenic	2.5	0.6	2.6
Barium	118	7	86.9
Beryllium	1.1	0.4	0.87
Cadmiun	0.66	0.6	0.65
Calcium	4240	213	3570
Chromium	12.4	1.4	7.4
Cobalt	12.1	2	10
Copper	12.4	3.6	10
Iron	24900	12.4	20900
Lead	9.9	4.2	7.8
Magnesium	4190	498	3420
Manganese	459	1.2	381
Mercury	0.11	0.1	0.11
Nickel	13.9	6.4	9.6
Potassium	2320	260	1530
Selenium	0.88	0.8	0.87
Silver	2.2	2	2.2
Sodium	218	197	215
Thallium	0.66	0.3	0.65
Vanadium	58.1	4	47.1
Zinc	50.8	10	44.4
Molybdenum	3.1	2.8	3.1
Titanium	1670	2.2	1560
Lithium			
Zirconium	27.2	20	22.4
Ammonia	<.2		<.2
Alkalinity	1200		434
Silicon	226.1		113.4
Fluoride	1.79		0.87
Chloride	0.71		2.52
Nitrite	<.3		<.3
Nitrate	53.9		2.6
O-Phosphate	18.3		6.75
Sulfate	12.7		2.06
Tot Organic Carbon	9294		3702

ECA = Ecological Control Area

Table C-5. Organic Composition of Ecosystem Samples Showing Laboratory Qualifiers. (sheet 1 of 8)

Table C-1 contains description of qualifiers.

HEIS Number:	B06137	B06138	B061379	B06140	B06141	B06142	B06143
Site Number:	1	1	2	3	4	5	6
Location:	Rattlesnake Mountain	Rattlesnake Mountain	Rattlesnake Springs	Riparian grass	Riparian juniper	DC Well	Old Field
		VOA Dup.					ECA
Analyte							
alpha-BHC	U		U	U	U	U	U
beta-BHC	U		U	U	U	U	U
delta-BHC (Lindane)	U		U	U	U	U	U
Heptachlor	U		U	U	U	U	U
Lldrin	U		U	U	U	U	U
Heptachlor epoxide (endo)	U		U	U	U	U	U
Heptachlor epoxide (exo)	U		U	U	U	U	U
Endosulfan I	U		U	U	U	U	U
Dieldrin	U		U	U	U	U	U
4,4'-DDE	U		U	U	U	U	U
Endrin	U		U	U	U	U	U
Endosulfan II	U		U	U	U	U	U
4.4'-DDD	U		U	U	U	U	U
Endosulfan sulfate	U		U	U	U	U	U
4,4'-DDT	U		U	U	U	U	U
Methoxychlor	U		U	U	U	U	U
Endrin ketone	U		U	U	U	U	U
Endrin Aldehyde	U		U	U	U	U	U
alpha-Chlordane	U		U	U	U	U	U
gamma-Chlordane	U		U	U	U	U	U
Toxaphene	U		U	U	U	U	U
Aroclor-1016	U		U	U	U	U	U
Aroclor-1221	U		U	U	U	U	U
Aroclor-1232	U		U	U	U	U	U
Aroclor-1242	U		U	U	U	U	U
Aroclor-1248	U		U	U	U	U	U
Aroclor-1254	U		U	U	U	U	U
Aroclor-1260	U		U	U	U	U	U
Phenol	U		U	U	U	U	U
Bis (2-Chloroethyl) ether	U		U	U	U	U	U
2-Chlorophenol	U		U	U	U	U	U
1,3-Dichlorobenzene	U		U	U	U	U	U
1,4-Dichlorobenzene	U		U	U	U	U	U

Table C-5. Organic Composition of Ecosystem Samples. (sheet 2 of 8)

HEIS Number:	B06137	B06138	B061379	B06140	B06141	B06142	B06143
Site Number:	1	1	2	3	4	5	6
Location:	Rattlesnake Mountain	Rattlesnake Mountain	Rattlesnake Springs	Riparian grass	Riparian juniper	DC Well	Old Field
		VOA Dup.					ECA
Analyte							
1,2-Dichlorobenzene	U		U	U	U	U	U
2-Methylphenol	U		U	U	U	U	U
2,2'-oxybis (1-Chloropropane)	U		U	U	U	U	U
4-Methylphenol	U		U	U	U	U	U
N-Nitroso-di-n-propylamine	U		U	U	U	U	U
Hexachloroethane	U		U	U	U	U	U
Nitrobenzene	U		U	U	U	U	U
Isophorone	U		U	U	U	U	U
2-Nitrophenol	U		U	U	U	U	U
2,4-Dimethylphenol	U		U	U	U	U	U
Bis (2-Chloroethoxy) methane	U		U	U	U	U	U
2,4-Dichlorophenol	U		U	U	U	U	U
1,2,4-Trichlorobenzene	U		U	U	U	U	U
Naphthalene	U		U	U	U	U	U
4-Chloroaniline	U		U	U	U	U	U
Hexachlorobutadiene	U		U	U	U	U	U
4-Chloro-3-methylphenol	U		U	U	U	U	U
2-Methylnaphalene	U		U	U	U	U	U
Hexachlorocyclopentadiene	U		U	U	U	U	U
2,4,6-Trichorophenol	U		U	U	U	U	U
2,4,5-Trichorophenol	U		U	U	U	U	U
2-Chloronaphthalene	U		U	U	U	U	U
2-Nitroaniline	U		U	U	U	U	U
Dimethylphthalate	U		U	U	U	U	U
Acenaphthylene	U		U	U	U	U	U
2,6-Dinitrotoluene	U		U	U	U	U	U
3-Nitroaniline	U		U	U	U	U	U
Acenaphthene	U		U	U	U	U	U
2,4-Dinitrophenol	U		U	U	U	U	U
4-Nitrophenol	U		U	U	U	U	U
Dibenzofuran	U		U	U	U	U	U
2,4-Dinitrotoluene	U		U	U	U	U	U
Diethylphthalate	U		U	U	U	U	U

Table C-5. Organic Composition of Ecosystem Samples.
(sheet 3 of 8)

HEIS Number:	B06137	B06138	B061379	B06140	B06141	B06142	B06143
Site Number:	1	1	2	3	4	5	6
Location:	Rattlesnake Mountain	Rattlesnake Mountain	Rattlesnake Springs	Riparian grass	Riparian juniper	DC Well	Old Field
		VOA Dup.					ECA
Analyte							
4-Chlorophenyl-phenyl-ether	U		U	U	U	U	U
Fluorene	U		U	U	U	U	U
4-Nitroaniline	U		U	U	U	U	U
4,6-Dinitro-2-methylphenol	U		U	U	U	U	U
N-Nitrosodiphenylamine (1)	U		U	U	U	U	U
4-Bromophenyl-phenylether	U		U	U	U	U	U
Hexachlorobenzene	U		U	U	U	U	U
Pentachlorophenol	U		U	U	U	U	U
Phenanthrene	U		U	U	U	U	U
Anthracene	U		U	U	U	U	U
Carbazole	U		U	U	U	U	U
Di-n-butylphthalate	U		U	U	U	U	U
Fluoranthene	U		U	U	U	U	U
Pyrene	UR		UR	UR	UR	UR	UR
Butylbenzylphthalate	U		U	U	U	U	U
3,3'-Dichlorobenzidine	U		U	U	U	U	U
Benzo (a) anthracene	U		U	U	U	U	U
Chrysene	U		U	U	U	U	U
Bis (2-Ethylhexyl) phthalate	U		U	U	U	U	U
Di-n-octylphthalate	U		U	U	U	U	U
Benzo (b) fluoranthene	U		U	U	U	U	U
Benzo (k) fluoranthene	U		U	U	U	U	U
Benzo (a) pyrene	U		U	U	U	U	U
Indeno (1,2,3-cd) pyrene	U		U	U	U	U	U
Dibenz (a,h) anthracene	U		U	U	U	U	U
Benzo (g,h,i) perylene	U		U	U	U	U	U
Chloromethane	U	U	UJ	U	U	U	U
Bromomethane	U	U	UJ	U	U	U	U
Vinyl Chloride	U	U	UJ	U	U	U	U
Chloroethane	U	U	UJ	U	U	U	U
Methylene Chloride	13 U	8 U	13 UJ	12 U	12 U	14 U	12 U
Acetone	75 U	81 U	110 J	12 U	12 U	50 U	21 U
Carbon Disulfide	U	U	UJ	U	U	U	U

Table C-5. Organic Composition of Ecosystem Samples. (sheet 4 of 8)

HEIS Number:	B06137	B06138	B061379	B06140	B06141	B06142	B06143
Site Number:	1	1	2	3	4	5	6
Location:	Rattlesnake Mountain	Rattlesnake Mountain VOA Dup.	Rattlesnake Springs	Riparian grass	Riparian juniper	DC Well	Old Field ECA
Analyte							
1,1-Dichloroethene	U	U	UJ	U	U	U	U
1,1-Dichloroethane	U	U	UJ	U	U	U	U
1,2-Dichloroethene (total)	U	U	UJ	U	U	U	U
Chloroform	U	U	UJ	U	U	U	U
1,2-Dichloroethane	U	U	UJ	U	U	U	U
2-Butanone	29 U	29 U	15 UJ	12 U	12 U	23 U	31 U
1,1,1-Trichloroethane	U	U	UJ	U	U	U	U
Carbon Tetrachloride	U	U	UJ	U	U	U	U
Bromodichloromethane	U	U	UJ	U	U	U	U
1,2-Dichloropropane	U	U	UJ	U	U	U	U
Cis-1,3-Dichlorpropene	U	U	UJ	U	U	U	U
Trichloroethene	U	U	UJ	U	U	U	U
Dibromochloromethane	U	U	UJ	U	U	U	U
1,1,2-Trichlorethane	UR	UR	UR	UR	UR	UR	UR
Benzene	U	U	UJ	U	U	U	U
Trans-1,3-Dichlorpropene	U	U	UJ	U	U	U	U
Bromoform	U	U	UJ	U	U	U	U
4-Methyl-2-pentanone	U	U	UJ	U	U	U	U
2-Hexanone	U	U	UJ	U	U	U	U
Tetrachloroethene	U	U	UJ	U	U	U	U
Toluene	4 J	U	UJ	U	U	U	U
1,1,2,2-Tetrachlorethane	U	U	UJ	U	U	U	U
Chlorobenzene	U	U	UJ	U	U	U	U
Ethyl Benzene	U	U	UJ	U	U	U	U
Styrene	U	U	UJ	U	U	U	U
Xylene (total)	U	U	UJ	U	U	U	U
	ECA = Ecological Control Area						

Appendix C – Raw Data Soil Background

Table C-5. Organic Composition of Ecosystem Samples. (sheet 5 of 8)

HEIS Number:	B06144	B06145	B06146	B06147	B06148	B061349	B06150
Site Number:	7	8	9	10	11	11	12
Location:	Col. R Plain	Col. R Plain	Playa	Playa	Col. R Plain	Col. R Plain	200 Plat
	sagebrush	rabbitbrush	duplicate			blank	
					ECA	ECA	ECA
Analyte							
alpha-BHC	U	U	U	UR	U	U	U
beta-BHC	U	U	U	UR	U	U	U
delta-BHC (Lindane)	U	U	U	UR	U	U	U
Heptachlor	U	U	U	UR	U	U	U
Lldrin	U	U	U	UR	U	U	U
Heptachlor epoxide (endo)	U	U	U	UR	U	U	U
Heptachlor epoxide (exo)	U	U	U	UR	U	U	U
Endosulfan I	U	U	U	UR	U	U	U
Dieldrin	U	U	U	UR	U	U	U
4,4'-DDE	U	U	U	UR	U	U	U
Endrin	U	U	U	UR	U	U	U
Endosulfan II	U	U	U	UR	U	U	U
4.4'-DDD	U	U	U	UR	U	U	U
Endosulfan sulfate	U	U	U	UR	U	U	U
4,4'-DDT	U	U	U	UR	U	U	U
Methoxychlor	U	U	U	UR	U	U	U
Endrin ketone	U	U	U	UR	U	U	U
Endrin Aldehyde	U	U	U	UR	U	U	U
alpha-Chlordane	U	U	U	UR	U	U	U
gamma-Chlordane	U	U	U	UR	U	U	U
Toxaphene	U	U	U	UR	U	U	U
Aroclor-1016	U	U	U	UR	U	U	U
Aroclor-1221	U	U	U	UR	U	U	U
Aroclor-1232	U	U	U	UR	U	U	U
Aroclor-1242	U	U	U	UR	U	U	U
Aroclor-1248	U	U	U	UR	U	U	U
Aroclor-1254	U	U	U	UR	U	U	U
Aroclor-1260	U	U	U	UR	U	U	U
Phenol	U	U	U	U	U	U	U
Bis (2-Chloroethyl) ether	U	U	U	U	U	U	U
2-Chlorophenol	U	U	U	U	U	U	U
1,3-Dichlorobenzene	U	U	U	U	U	U	U
1,4-Dichlorobenzene	U	U	U	U	U	U	U

Table C-5. Organic Composition of Ecosystem Samples. (sheet 6 of 8)

HEIS Number:	B06144	B06145	B06146	B06147	B06148	B061349	B06150
Site Number:	7	8	9	10	11	11	12
Location:	Col. R Plain	Col. R Plain	Playa	Playa	Col. R Plain	Col. R Plain	200 Plat
	sagebrush	rabbitbrush	duplicate			blank	
					ECA	ECA	ECA
Analyte							
1,2-Dichlorobenzene	U	U	U	U	U	U	U
2-Methylphenol	U	U	U	U	U	U	U
2,2'-oxybis (1-Chloropropane)	U	U	U	U	U	U	U
4-Methylphenol	U	U	U	U	U	U	U
N-Nitroso-di-n-propylamine	U	U	U	U	U	U	U
Hexachloroethane	U	U	U	U	U	U	U
Nitrobenzene	U	U	U	U	U	U	U
Isophorone	U	U	U	U	U	U	U
2-Nitrophenol	U	U	U	U	U	U	U
2,4-Dimethylphenol	U	U	U	U	U	U	U
Bis (2-Chloroethoxy) methane	U	U	U	U	U	U	U
2,4-Dichlorophenol	U	U	U	U	U	U	U
1,2,4-Trichlorobenzene	U	U	U	U	U	U	U
Naphthalene	U	U	U	U	U	U	U
4-Chloroaniline	U	U	U	U	U	U	U
Hexachlorobutadiene	U	U	U	U	U	U	U
4-Chloro-3-methylphenol	U	U	U	U	U	U	U
2-Methylnaphalene	U	U	U	U	U	U	U
Hexachlorocyclopentadiene	U	U	U	U	U	U	U
2,4,6-Trichorophenol	U	U	U	U	U	U	U
2,4,5-Trichorophenol	U	U	U	U	U	U	U
2-Chloronaphthalene	U	U	U	U	U	U	U
2-Nitroaniline	U	U	U	U	U	U	U
Dimethylphthalate	U	U	U	U	U	U	U
Acenaphthylene	U	U	U	U	U	U	U
2,6-Dinitrotoluene	U	U	U	U	U	U	U
3-Nitroaniline	U	U	U	U	U	U	U
Acenaphthene	U	U	U	U	U	U	U
2,4-Dinitrophenol	U	U	U	U	U	U	U
4-Nitrophenol	U	U	U	U	U	U	U
Dibenzofuran	U	U	U	U	U	U	U
2,4-Dinitrotoluene	U	U	U	U	U	U	U
Diethylphthalate	U	U	U	U	U	U	U

Table C-5. Organic Composition of Ecosystem Samples.
(sheet 7 of 8)

HEIS Number:	B06144	B06145	B06146	B06147	B06148	B061349	B06150
Site Number:	7	8	9	10	11	11	12
Location:	Col. R Plain	Col. R Plain	Playa	Playa	Col. R Plain	Col. R Plain	200 Plat
	sagebrush	rabbitbrush	duplicate			blank	
					ECA	ECA	ECA
Analyte							
4-Chlorophenyl-phenyl-ether	U	U	U	U	U	U	U
Fluorene	U	U	U	U	U	U	U
4-Nitroaniline	U	U	U	U	U	U	U
4,6-Dinitro-2-methylphenol	U	U	U	U	U	U	U
N-Nitrosodiphenylamine (1)	U	U	U	U	U	U	U
4-Bromophenyl-phenylether	U	U	U	U	U	U	U
Hexachlorobenzene	U	U	U	U	U	U	U
Pentachlorophenol	U	U	U	U	U	U	U
Phenanthrene	U	U	U	U	U	U	U
Anthracene	U	U	U	U	U	U	U
Carbazole	U	U	U	U	U	U	U
Di-n-butylphthalate	U	U	U	U	U	U	U
Fluoranthene	U	U	U	U	U	U	U
Pyrene	UR	UR	UR	UR	UR	UR	UR
Butylbenzylphthalate	U	U	U	U	U	U	U
3,3'-Dichlorobenzidine	U	U	U	U	U	U	U
Benzo (a) anthracene	U	U	U	U	U	U	U
Chrysene	U	U	U	U	U	U	U
Bis (2-Ethylhexyl) phthalate	U	U	U	U	U	U	U
Di-n-octylphthalate	U	U	U	U	U	U	U
Benzo (b) fluoranthene	U	U	U	U	U	U	U
Benzo (k) fluoranthene	U	U	U	U	U	U	U
Benzo (a) pyrene	U	U	U	U	U	U	U
Indeno (1,2,3-cd) pyrene	U	U	U	U	U	U	U
Dibenz (a,h) anthracene	U	U	U	U	U	U	U
Benzo (g,h,i) perylene	U	U	U	U	U	U	U
Chloromethane	U	U	U	U	U	U	U
Bromomethane	U	U	U	U	U	U	U
Vinyl Chloride	U	U	U	U	U	U	U
Chloroethane	U	U	U	U	U	U	U
Methylene Chloride	15 U	11 U	14 U	14 U	11 U	10 U	11 U
Acetone	37 U	11 U	33 U	14 U	15 U	13 U	15 U
Carbon Disulfide	U	U	U	U	U	U	U

Table C-5. Organic Composition of Ecosystem Samples. (sheet 8 of 8)

HEIS Number:	B06144	B06145	B06146	B06147	B06148	B061349	B06150
Site Number:	7	8	9	10	11	11	12
Location:	Col. R Plain	Col. R Plain	Playa	Playa	Col. R Plain	Col. R Plain	200 Plat
	sagebrush	rabbitbrush	duplicate			blank	
					ECA	ECA	ECA
Analyte							
1,1-Dichloroethene	U	U	U	U	U	U	U
1,1-Dichloroethane	U	U	U	U	U	U	U
1,2-Dichloroethene (total)	U	U	U	U	U	U	U
Chloroform	U	U	U	U	U	U	U
1,2-Dichloroethane	U	U	U	U	U	U	U
2-Butanone	11 U	11 U	42 U	33 U	24 U	20 U	11 U
1,1,1-Trichloroethane	U	U	U	U	U	U	U
Carbon Tetrachloride	U	U	U	U	U	U	U
Bromodichloromethane	U	U	U	U	U	U	U
1,2-Dichloropropane	U	U	U	U	U	U	U
Cis-1,3-Dichlorpropene	U	U	U	U	U	U	U
Trichloroethene	U	U	U	U	U	U	U
Dibromochloromethane	U	U	U	U	U	U	U
1,1,2-Trichlorethane	UR	UR	UR	UR	UR	UR	UR
Benzene	U	U	U	U	U	U	U
Trans-1,3-Dichlorpropene	U	U	U	U	U	U	U
Bromoform	U	U	U	U	U	U	U
4-Methyl-2-pentanone	U	U	U	U	U	U	U
2-Hexanone	U	U	U	U	U	U	U
Tetrachloroethene	U	U	U	U	U	U	U
Toluene	U	U	U	U	U	U	U
1,1,2,2-Tetrachlorethane	U	U	U	U	U	U	U
Chlorobenzene	U	U	U	U	U	U	U
Ethyl Benzene	U	U	U	U	U	U	U
Styrene	U	U	U	U	U	U	U
Xylene (total)	U	U	U	U	U	U	U

Table C-6. Chemical Composition of Unit Background Samples for 1324-N. (sheet 1 of 2)

	Area:	1324-N	1324-N	1324-N	1324-N	1324-N	1324-N	1324-N	1324-N	1324-N
	Sample Number:	1NN	2NN	3JF	4JF	5JF	6JF	8JF	9JF	10JF
	Well Number:	1324N-1	1324N-2	1324N-3	1324N-4	1324N-5	1324N-6	1324N-7	1324N-8	1324N-9
	Depth:	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Analytes	Thresholds									
Aluminum	15100	5480	5030	3720	4680	4450	4690	4870	5070	4710
Arsenic	9	0.86	0.80	1.15	1.18	1.33	1.78	0.90	0.86	0.69
Barium	175	47.8	58.2	44.7	52.5	47.4	44.1	45.1	52.9	49.4
Beryllium	1.8	0.8	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5
Cadmium	0.66	7.1	7.4	6.1	7.0	6.4	6.5	6.6	7.5	7.1
Calcium	24600	8120	7440	5700	7110	7230	5710	5440	6810	7060
Chromium	28	4.2	4.3	2.3	3.2	3.2	2.7	2.8	3.5	3.6
Cobalt	18.9	8.9	9.7	8.1	9.7	8.4	8.5	8.3	9.3	9.1
Copper	30	17.6	16.9	16.4	17.1	16.0	16.5	15.1	16.5	17.2
Iron	38200	28100	29000	21900	24700	24000	24100	28300	27800	27200
Lead	14.9	3.15	2.90	2.67	2.79	2.89	2.58	N/D	N/D	N/D
Magnesium	9160	5310	5390	4590	5020	4630	5090	5700	4990	4980
Manganese	583	294	350	227	291	262	248	249	323	285
Nickel	24.7	7.6	8.7	5.7	8.8	6.7	6.3	6.1	7.3	7.3
Potassium	3090	777	675	455	689	590	544	614	739	684
Silver	2.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sodium	1390	363.0	326.0	238.0	267.0	272.0	308.0	268.0	345.0	298.0
Strontium	N/A	16.6	20.4	22.5	27.4	19.4	20.0	26.6	16.3	17.3
Vanadium	107	58.7	61.0	41.7	45.4	42.5	43.4	47.7	58.8	57.1
Zinc	79	40.7	40.4	33.6	37.0	33.4	36.2	36.1	39.5	38.2
Ammonia	27.4	N/D	N/D	N/D	N/D	N/D	N/D	2.5	1.5	0.8
Fluoride	13	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sulfate	931	2.51	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Appendix C – Raw Data Soil Background

Table C-6. Chemical Composition of Unit Background Samples for 1324-N. (sheet 2 of 2)

	Area:	1324-N	1324-N	1324-N	1324-N
	Sample Number:	11JF	12JF	13JF	14JF
	Well Number:	1324N-10	1324N-11	1324N-12	1324N-13
	Depth:	10.5	10.5	10.5	10.5
Analytes	Thresholds				
Aluminum	15100	5040	4620	6240	5130
Arsenic	9	0.88	0.77	0.94	0.74
Barium	175	54.1	46.0	55.1	55.5
Beryllium	1.8	<0.5	<0.5	<0.5	<0.5
Cadmium	0.66	7.9	6.5	7.6	7.7
Calcium	24600	8040	7920	7530	7680
Chromium	28	4.9	2.5	5.0	4.2
Cobalt	18.9	9.2	8.0	9.7	9.7
Copper	30	16.3	15.3	17.0	19.1
Iron	38200	27800	25500	28300	25800
Lead	14.9	N/D	N/D	N/D	N/D
Magnesium	9160	4940	5100	5640	4730
Manganese	583	290	246	313	321
Nickel	24.7	8.1	6.7	8.7	8.3
Potassium	3090	660	628	931	875
Silver	2.1	<1.0	<1.0	<1.0	<1.0
Sodium	1390	270.0	226.0	370.0	329.0
Strontium	N/A	24.0	26.1	17.9	17.8
Vanadium	107	56.6	43.4	61.1	64.6
Zinc	79	38.7	35.6	41.9	44.8
Ammonia	27.4	<0.5	<0.5	<0.5	<0.5
Fluoride	13	<1.0	<1.0	<1.0	<1.0
Sulfate	931	<1.0	<1.0	<1.0	<1.0

Table C-7. Chemical Composition of Unit Background Samples for 2101-M. (sheet 1 of 2)

	Area:	2101-M	2101-M	2101-M	2101-M	2101-M	2101-M	2101-M	2101-M
	Sample Number:	M131	M132	M133	M134	M135	M136	M137	M138
	Well Number:	2101M-1	2101M-1	2101M-1	2101M-1	2101M-2	2101M-2	2101M-2	2101M-2
	Depth:	1.0	3.5	6.0	8.5	11.0	5.0	10.0	15.0
Analytes	Thresholds								
Aluminum	15100	10100	8870	5770	5060	6570	7210	5920	6290
Arsenic	9	1.70	3.30	8.10	1.20	1.40	2.60	1.30	1.60
Barium	175	61.7	88.8	205.0	63.0	55.9	77.0	96.1	81.5
Beryllium	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	0.66	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Calcium	24600	3770	4750	4540	2770	2800	3050	2790	7040
Chromium	28	16.6	15.5	8.0	5.9	8.3	7.5	6.8	8.6
Cobalt	18.9	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Copper	30	3.3	5.5	<1.0	<1.0	11.9	<1.0	<1.0	1.5
Iron	38200	26900	23100	25400	16400	18600	19500	16700	15300
Lead	14.9	12.7	8.9	3.9	3.1	3.7	4.9	3.8	4.5
Magnesium	9160	4700	5310	4030	3550	4680	4930	3990	4780
Manganese	583	164	268	2870	264	237	361	383	234
Nickel	24.7	9.2	12.7	13.0	5.7	9.1	6.8	6.3	6.6
Potassium	3090	1620	1290	643	547	723	910	723	746
Silver	2.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sodium	1390	937.0	1170.0	991.0	820.0	848.0	852.0	814.0	838.0
Strontium	N/A	22.7	31.6	22.4	15.0	18.3	18.9	17.2	26.9
Vanadium	107	59.0	65.2	65.3	35.1	35.0	38.0	33.4	24.6
Zinc	79	112.0	61.8	48.8	30.9	31.4	33.9	30.4	28.9
Ammonia	27.4	2.6	0.9	1.2	1.5	1.6	1.2	1.5	2.0
Fluoride	13	3.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sulfate	931	19.1	7.8	6.1	1.9	1.7	4.6	2.3	1.3

Table C-7. Chemical Composition of Unit Background Samples for 2101-M. (sheet 2 of 2)

	Area:	2101-M	2101-M	2101-M	2101-M	2101-M	2101-M	2101-M	2101-M
	Sample Number:	M139	M140	M141	M142	M143	M144	M145	M146
	Well Number:	2101M-3	2101M-3	2101M-3	2101M-3	2101M-4	2101M-4	2101M-4	2101M-4
	Depth:	1.0	3.5	6.0	8.5	11.0	5.0	10.0	15.0
Analytes	Thresholds								
Aluminum	15100	8560	6050	7230	7740	7260	8910	7960	8710
Arsenic	9	1.10	1.90	2.10	1.70	1.10	1.60	3.60	1.30
Barium	175	85.9	46.3	97.3	65.6	117.0	80.4	57.9	46.6
Beryllium	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	0.66	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Calcium	24600	3550	8340	14000	10600	8440	10700	5890	9700
Chromium	28	8.5	8.3	6.6	9.0	8.3	8.1	8.6	10.1
Cobalt	18.9	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Copper	30	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Iron	38200	25500	18800	29200	20000	23600	28300	21800	23200
Lead	14.9	7.1	5.0	6.8	3.9	3.6	4.8	3.3	4.2
Magnesium	9160	4660	4430	5110	5860	4980	5980	5420	6910
Manganese	583	380	252	393	279	533	392	272	243
Nickel	24.7	7.8	6.2	6.8	7.4	7.1	7.2	7.2	6.7
Potassium	3090	1810	833	1120	1340	924	916	1250	1670
Silver	2.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sodium	1390	827.0	1430.0	1170.0	1640.0	1620.0	1710.0	1280.0	1130.0
Strontium	N/A	20.3	22.7	27.3	39.2	29.3	36.9	25.6	28.7
Vanadium	107	55.1	42.2	69.8	42.5	53.8	66.3	47.0	36.2
Zinc	79	44.7	32.3	44.9	33.8	39.7	43.4	37.2	34.4
Ammonia	27.4	1.9	1.9	2.0	2.0	2.0	1.6	1.4	2.2
Fluoride	13	<1.0	1.2	1.4	1.1	<1.0	1.4	<1.0	<1.0
Sulfate	931	1.0	1.2	9.6	5.0	1.5	34.5	25.5	17.3

Table C-8. Chemical Composition of Unit Background Samples for 1100-EM. (sheet 1 of 3)

	Area:	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM
	Sample Number:	AH217	AH218	AH222	AH223	AH224	AH225	A0302
	Well Number:	1100EM/NS	1100EM/NS	1100EM/NS	1100EM/NS	1100EM/NS	1100EM/NS	HRL-1
	Depth:	0.5	0.5	0.5	0.5	0.5	0.5	7.5
Analytes	Thresholds							
Aluminum	15100	6050	6930	6180	6600	5480	6410	4730
Arsenic	9	0.74	1.60	1.60	1.60	0.15	1.60	1.40
Barium	175	71.2	81.4	69.0	67.5	52.3	65.2	73.5
Beryllium	1.8	0.34	0.47	0.39	0.42	0.23	0.42	0.24
Cadmium	0.66	0.32	0.44	0.35	0.50	0.32	0.29	0.35
Calcium	24600	3380	3370	2930	2840	2000	2460	4170
Chromium	28	8.3	10.0	7.9	9.7	7.8	8.6	11.2
Cobalt	18.9	9.8	11.0	9.5	10.7	6.1	7.3	10.1
Copper	30	12.1	11.8	10.2	10.6	6.9	9.1	15.6
Iron	38200	19000	20500	18400	20100	13200	15200	17800
Lead	14.9	4.1	8.1	4.4	6.2	0.25	6.5	3.8
Magnesium	9160	4200	4580	3680	3640	2780	3190	3450
Manganese	583	325	367	308	309	211	252	250
Nickel	24.7	9.6	10.8	8.7	9.9	5.9	5.9	10.1
Potassium	3090	1260	1550	1290	1240	1040	1200	609
Silver	2.1	0.71	1.30	1.30	1.50	0.48	1.00	0.41
Sodium	1390	153.0	164.0	142.0	155.0	133.0	190.0	360.0
Strontium	N/A	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Vanadium	107	43.9	46.6	42.1	52.1	29.6	24.4	49.5
Zinc	79	37.4	42.3	36.8	39.8	27.2	32.1	35.1
Ammonia	27.4	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Fluoride	13	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Sulfate	931	N/D	N/D	N/D	N/D	N/D	N/D	N/D

Table C-8. Chemical Composition of Unit Background Samples for 1100-EM. (sheet 2 of 3)

	Area:	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM	1100-EM
	Sample Number:	A0306	A0101	A0104	A0105	A0109	A0201	A0203	A0204	A0206
	Well Number:	HRL-1	DP-7	DP-7	DP-7	DP-7	BAP-2	BAP-2	BAP-2	BAP-2
	Depth:	12.9	1.4	12.9	17.3	29.2	1.3	9.0	12.3	18.3
Analytes	Thresholds									
Aluminum	15100	5510	7440	4040	3630	3600	8530	5540	4130	3760
Arsenic	9	2.60	2.10	0.90	0.74	0.83	2.70	1.80	0.69	0.63
Barium	175	143.0	79.7	67.1	61.5	229.0	102.0	90.3	68.3	66.3
Beryllium	1.8	0.20	0.16	0.14	0.13	0.16	0.24	0.17	0.16	0.18
Cadmium	0.66	0.36	0.32	0.28	0.26	0.32	0.31	0.34	0.31	0.36
Calcium	24600	4130	3610	5710	4870	5690	3990	5430	6070	5180
Chromium	28	8.9	10.4	10.2	9.5	5.1	10.8	18.3	11.3	7.3
Cobalt	18.9	10.3	12.3	12.5	12.4	13.2	13.4	13.1	13.7	13.5
Copper	30	14.2	13.4	16.7	16.1	17.2	14.9	18.6	15.7	14.9
Iron	38200	18400	22800	21800	21300	23400	24600	23300	23200	23000
Lead	14.9	2.4	4.3	2.8	2.6	2.4	6.5	4.5	2.3	2.1
Magnesium	9160	4200	4710	3910	3630	4020	5090	4180	3690	3810
Manganese	583	303	357	277	259	294	443	325	285	285
Nickel	24.7	10.4	10.3	6.8	7.5	8.9	13.2	15.2	9.8	9.1
Potassium	3090	618	1350	632	562	549	1610	891	721	557
Silver	2.1	0.35	0.48	0.41	0.39	0.48	0.47	0.51	0.47	0.54
Sodium	1390	238.0	135.0	312.0	319.0	251.0	125.0	261.0	360.0	322.0
Strontium	N/A	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Vanadium	107	46.3	58.6	85.9	91.5	96.0	58.0	60.6	68.7	65.4
Zinc	79	37.6	46.1	38.4	38.5	41.3	49.8	42.7	43.3	42.6
Ammonia	27.4	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Fluoride	13	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Sulfate	931	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D

Table C-8. Chemical Composition of Unit Background Samples for 1100-EM. (sheet 3 of 3)

	Area:	1100-EM	1100-EM	1100-EM	1100-EM
	Sample Number:	A0207	A0208	A0209	A0210
	Well Number:	BAP-2	BAP-2	BAP-2	BAP-2
	Depth:	18.3	20.3	26.2	34.9
Analytes	Thresholds				
Aluminum	15100	3760	3980	3780	4270
Arsenic	9	0.67	0.64	0.31	0.91
Barium	175	65.6	64.1	64.9	68.8
Beryllium	1.8	0.18	0.16	0.18	0.18
Cadmium	0.66	0.36	0.33	0.36	0.36
Calcium	24600	5430	6100	5510	7020
Chromium	28	12.7	48.3	9.0	9.0
Cobalt	18.9	14.2	14.6	13.1	14.2
Copper	30	16.7	15.7	15.3	17.0
Iron	38200	23200	24000	25200	25500
Lead	14.9	2.4	2.4	1.3	2.4
Magnesium	9160	3840	3810	3560	4340
Manganese	583	281	296	292	323
Nickel	24.7	10.4	25.3	5.9	10.0
Potassium	3090	639	579	547	806
Silver	2.1	0.54	0.49	0.54	0.54
Sodium	1390	305.0	316.0	304.0	321.0
Strontium	N/A	N/D	N/D	N/D	N/D
Vanadium	107	62.2	74.6	65.6	70.2
Zinc	79	41.8	44.1	41.8	46.5
Ammonia	27.4	N/D	N/D	N/D	N/D
Fluoride	13	N/D	N/D	N/D	N/D
Sulfate	931	N/D	N/D	N/D	N/D

Table C-9. Chemical Composition of Unit Background Samples for 183-H.

	Area:	183H	183H	183H	183H	183H	183H	183H	183H	183H
	Sample Number:	AB-044	AB-045	AB-046	AB-047	AB-050	AB-051	AB-052	AB-053	AB-054
	Well Number:									
	Depth:									
Analytes	Thresholds									
Aluminum	15100	11000	10900	13100	12400	13300	10500	11500	10700	10900
Arsenic	9	2.40	2.50	2.60	2.60	2.60	2.20	2.00	2.50	2.40
Barium	175	97.7	91.2	93.5	94.5	96.3	90.2	89.8	89.5	87.7
Beryllium	1.8	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	0.66	5.2	5.1	5.7	5.7	6.0	5.9	5.9	4.7	5.1
Calcium	24600	3290	3620	4100	3860	4000	4730	3980	3430	3500
Chromium	28	11.9	11.2	14.1	13.1	14.0	10.5	13.6	11.5	11.8
Cobalt	18.9	8.1	7.4	8.6	8.5	9.2	8.2	8.8	7.5	7.3
Copper	30	16.9	13.1	17.4	16.1	18.2	19.8	16.5	15.0	14.7
Iron	38200	23000	20800	23700	23200	24900	24000	23500	20700	21200
Lead	14.9	4.4	5.1	6.1	4.9	6.3	4.2	4.2	4.7	5.2
Magnesium	9160	5590	5100	5960	5730	6120	5730	5740	5050	5150
Manganese	583	336	330	363	361	371	332	360	321	327
Nickel	24.7	12.4	12.8	14.9	14.3	15.3	14.0	15.4	12.2	12.3
Potassium	3090	2490	2320	2580	2590	2600	1850	2010	2290	2440
Silver	2.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sodium	1390	187.0	229.0	238.0	221.0	225.0	246.0	212.0	210.0	229.0
Strontium	N/A	27.8	28.0	31.2	29.4	29.9	28.1	29.1	27.8	28.3
Vanadium	107	40.7	39.2	44.5	42.1	45.0	47.3	44.7	38.0	38.9
Zinc	79	35.1	36.2	40.6	40.5	40.8	39.7	39.7	34.2	35.3
Ammonia	27.4	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Fluoride	13	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sulfate	931	2.2	2.2	3.3	4.0	3.7	3.8	5.0	5.4	5.9

APPENDIX D

BACKGROUND DATA ANALYSIS

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D1.0 STATISTICAL ANALYSIS

This appendix describes the statistical analyses performed on the data from the soil sampling activities. The following objectives directed these analyses:

1. Demonstrate the validity of the Hanford Sitewide background concepts as described in *Characterization and Use of Soil and Groundwater Background for the Hanford Site* (WHC 1991a)

2. Determine summary statistics and distribution parameters

3. Determine if the DQOs specified as part of Appendix E were achieved.

D1.1 DATA ANALYSIS METHODS

Data analyses were performed to support these objectives. The individual analyses are described in the following paragraphs.

D1.1.1 Data Validation

On receipt, the data packages were reviewed for conformance to the requirements of CLP analyses. These checks included reviews of: (1) chain-of-custody records, (2) instrument calibration, (3) internal control standards, (4) blanks analyses, (5) matrix spikes, (6) duplicate analyses, (7) serial dilutions, and (8) holding times. These checks ensured that the measurement process was consistent and within the specified control limits.

D1.1.2 Data Transcription and Verification

After the data packages were validated, the data were transcribed into computer spreadsheets. For verification of data input, a printout of the spreadsheet was checked against the original hardcopy (received from the laboratory) by a second party. Corrections similarly were input and verified. These steps ensured that the validated data received from the vendor were transferred correctly to the data analysis software.

D1.1.3 Detection Limit Analysis

Reagent blank analyses, performed concurrently with the soil analyses, were used to determine the minimum limit of detection and the limit of quantitation. The limit of detection is defined as the lowest concentration level that can be determined to be statistically different from a blank. The limit of quantitation is the level above which quantitative results might be obtained with a specified degree of confidence (ACS 1983). The results of the blank analyses contain all measurement error effects, excluding sample preparation errors. For this reason, the limit of detection and limit of

quantitation values are considered minimums. Estimates of the sample preparation errors are made as part of the analysis described in the following sections. This analysis provides a basis for determining if the required detection limits were achieved and screens out data dominated by noise in the measurement process.

D1.1.4 Factor Analysis

The factor analysis provides a determination of representative analytes for further statistical analysis in support of the DQOs. Factor analysis is a statistical method used for attempting to reveal patterns within a set of multivariate observations. For example, strong correlations between nickel and chrome, identified as part of the factor analysis, can be used to identify possible outlier data as related to the natural sediments.

D1.1.5 Variogram Analysis

A variogram is a graphical tool for displaying the correlation structure of a spatially distributed variable. The classical statistics method, on which most background comparisons are based, assumes that the data are independent and identically distributed. The variogram analysis determines the range over which this assumption is valid. Sampling at intervals that are less than the correlation range can introduce errors into the classical statistics. Constructing a variogram for selected, representative analytes demonstrates that the sampling intervals and locations have been appropriately determined.

D1.1.6 Analysis of Field Duplicate Samples

Field duplicate samples were routed to separate laboratories for independent analysis. Field duplicate samples provide a quality check on the performance of the primary laboratory. These results serve to reveal any consistent laboratory bias or scaling errors in the data.

Because soil duplicate samples, unlike water split samples, cannot be considered identical, individual sample comparisons are difficult to evaluate. Variation in the percentage mixture of end members, especially for the minor and trace analytes, can cause variations in the results that are significantly larger than the accuracy of the measurement process. Therefore, the duplicate samples are considered as a group and analyzed for similarity between the groups.

D1.1.7 Distribution and Outlier Analysis

The analysis for the best fit distribution is based on Weibull and lognormal forms. Section D2.10 describes the Weibull distribution and the equations necessary for working with the distribution. Suspect outliers were determined based on the data points lying outside double-sided confidence

intervals of the distribution of the data. Suspension of the outliers was used to provide a more accurate estimate of the distribution parameters.

D1.1.8 Threshold Analysis and Tolerance Interval

A threshold is used as the statistical upper bound of the naturally occurring concentrations. There are a number of possible thresholds that can be calculated depending on the requirements for the use of the data. Several typical thresholds have been calculated and are presented.

D1.1.9 Subordinate End Member Analysis

A suite of samples was collected and analyzed to identify the characteristics of volumetrically minor soils. These judgment samples were chosen by the field geologist. Criteria for the judgment samples included selected end member samples, potential outlier samples, and samples that represent typical local lithology. These samples could include subordinate end members such as caliche, ash beds, and paleosols.

One way to analyze the judgment sample data is to compare the data to the 95/95 threshold. Data that significantly exceed the threshold would be further analyzed to determine if the data represent subordinate end members that must be considered separately from the randomly sampled data.

D2.0 DATA ANALYSIS

The soil data were analyzed according to the previously described analytical methods. Background threshold values for the analytes were determined and are presented in the following sections.

D2.1 DATA DESCRIPTION

A complete description of the data types is presented in Chapter 5.0. The data were grouped into four main types: (1) systematic random data, (2) judgment samples, (3) quality assurance and quality control data set, and (4) data to support the conceptual model (e.g., grain size, bulk rock analysis, modes).

The systematic random data set provides the basis for computing the statistical parameters associated with the Hanford Site vadose zone. The judgment data are used to test whether or not the systematic random data set is representative and complete. The quality assurance and quality control data set establishes the detection limits and uncertainty limits on the systematic random data set. The last data set was used to determine if the conceptual model described in Chapter 4.0 was appropriate for the interpretation of the data.

D2.2 DATA VALIDATION

Validation of the data received from the Maxwell S-Cubed and DataChem laboratories was performed according to onsite procedures (WHC 1990). The validation procedure evaluates the following:

- Calibration
- Blanks
- Interference check sample
- Matrix spike
- Duplicate analysis
- Laboratory control sample
- Serial dilution
- Holding times
- Standard additions [graphite furnace atomic adsorption (GFAA)]
- Other quality control.

The conditions that the data must meet for each of these areas are summarized in the following sections. The results of the validation process are shown in the data tables in Appendix C. Information concerning the relative magnitude of an effect such as matrix interference is not preserved or carried forward in the analysis, only information that the effect is less than a stated amount.

D2.2.1 Calibration

Calibration requirements have been established to ensure that an instrument is capable of producing acceptable quantitative data. Initial calibration data demonstrate that the instrument is capable of acceptable performance at the beginning of the batch run, and continuing calibration data documents that the performance is maintained throughout the run.

The quantitative measure of calibration is based on the percent recovery of the true value of the calibration sample. The control limits and actions for the percent recovery are as follow:

Metals:	<75 percent	75-89 percent	111-125 percent	>125 percent
Mercury:	<65 percent	65-79 percent	121-135 percent	>135 percent
Cyanide:	<70 percent	70-84 percent	116-130 percent	>130 percent
Action:				
Results <IDL	R	UJ	Acceptable	Acceptable
Results >IDL	R	J	J	R

The action symbols are R = reject data as unsuitable, U = qualify data as less than the detection limit, and J = qualify data as estimated.

D2.2.2 Blanks

Assessment of blanks provides information on the existence and magnitude of any contamination problems that might occur in the laboratory. Detection of any contaminants in the initial calibration, continuing calibration, or preparation blank will cause samples measurements to be qualified as U if the sample measurement is greater than the instrumental detection limits, but less than five times the maximum concentration in any blank.

D2.2.3 Interference Check Sample

The inductively coupled plasma interference check sample verifies the laboratory's interelement and background correction factors. The check sample is a liquid sample of specified composition. Evaluation of the interference check sample is based on percent recoveries (%R) for each analyte. Control limits and actions for the interference check sample are as follow:

Analyte %R	<50 percent	50-79 percent	>120 percent
Results <IDL	R	UJ	Acceptable
Results >IDL	R	J	J

D2.2.4 Matrix Spike Samples

Matrix spike sample analysis provides information on the accuracy associated with a measurement method, and the effect of each sample matrix on the digestion and measurement methodology. The evaluation basis is percent recovery of the spiked amount. Control limits and actions are as follow:

Recovery (%R):	<30 percent	30-74 percent	>125 percent
Results <IDL	R	UJ	Acceptable
Results >IDL	J	J	J

D2.2.5 Duplicate Sample Analysis

Duplicate analysis is an indication of the laboratory precision based on each sample matrix. For soil, the duplicates are repeated subsamples of the soil material submitted to the laboratory for analysis. The duplicate analysis also allows for determination of the replicability of the data (Section D.6) in a manner similar to limit of detection calculations. The evaluation of the duplicate analysis for validation purposes is based on the relative percent difference (RPD). Control limits and actions are as follow:

RPD:	<65 percent	>135 percent
Sample less than 5 times contract required detection limit	UJ	UJ
Sample greater than 5 times contract required detection limit	J	J

D2.2.6 Laboratory Control Sample

The laboratory control sample is a monitor of the overall performance of the analytical method in all steps of the analysis including sample preparation. The basis for evaluation of the laboratory control sample is the percent recovery. Control limits are established on Form VII of the CLP data package and actions are as follow:

Analyte %R	<low limit	>high limit
Results <IDL	UJ	Acceptable
Results >IDL	J	J

Solid laboratory control samples do not exist for soils, therefore, this portion of the validation was not performed for the background data.

D2.2.7 Inductively Coupled Plasma Serial Dilution

Serial dilutions of the samples prepared for inductively coupled plasma analysis are another method used to indicate whether significant physical or chemical interferences exist because of the sample matrix. The evaluation of the serial dilution is based on the percent difference (%D) between the initial sample and the diluted sample. Control limits are that the %D be less than 10 percent when the initial sample concentration is greater than 50 times the instrumental detection limit. If the control limits are not met, then the data must be qualified. If the initial concentration is greater than the instrumental detection limit, then qualify the data as J; else qualify the data as UJ.

D2.2.8 Holding Times

At present, definite holding time criteria in onsite procedures (WHC 1990) apply only to water samples. Soil requirements are currently under investigation and it is left to the discretion of the reviewer (data validator) whether or not to apply the water-holding-time criteria to other media (e.g. soils). Onsite procedures recommend that the 6 month holding time for metals be applied to all media.

D2.2.9 Standard Additions For Graphite Furnace Atomic Adsorption

Graphite furnace atomic adsorption duplicate injections and post-digestion spikes establish the precision and accuracy of the analytical results. The basis for the evaluation of duplicate injections is the percent relative sample difference (%RSD), which must agree within ±20%. For values less than the contract required detection limit, no control limits apply. For data not meeting the 20 percent control limit (including 1 rerun of the sample), the data are qualified as estimated (J). The basis for evaluating the post-digestion spikes is the percent recovery (%R). The following control limits and actions apply:

Recovery (%R)	<10 percent	10-39 percent	40-84 percent	>115 percent
Results <IDL	R	UJ	UJ	Acceptable
Results >IDL	J	J	J	J

The method of standard additions also is used if the sample absorbance is greater than 50 percent of the spike absorbance. Qualification of the data is not done if the method of standard additions recovery is greater than 40 percent and the correlation coefficient is greater than 0.995.

D2.2.10 Validation Results

A summary of the data reporting statistics for the systematic random, judgment, and preparation blank samples is presented in Table D1. A total of 5,765 analyses were requested. A total of 5,405 results passed the validation criteria, giving an overall success rate of 94 percent.

The laboratories were inconsistent in performing analysis of molybdenum, lithium, alkalinity, and silicon. Additionally, antimony, selenium, titanium, and zirconium suffered from high rejection rates. The rejection basis for these analytes appears to be due to percent spike recovery failures. Additionally, one batch, consisting of one preparation blank and three duplicate samples, was rejected because of laboratory contamination.

D2.3 DETECTION LIMITS

Evaluation of the accuracy and precision of analyses reported by a laboratory is important in all efforts involving chemical data, especially when the samples contain low concentrations of analytes. In these cases, the quality of the data should be evaluated with respect to the detection limit for each analyte. The detection limit should serve as a filter for identifying those data that do not meet the specified criteria for quality assurance.

The detection limit can be determined in a number of ways. The CLP analyses report two different detection limits: instrumental detection limit and contract required detection limit. The instrumental detection limit

typically is determined quarterly by the laboratory, using procedures set up by the instrument manufacturer designed to establish the lowest detectable concentration of an analyte under ideal conditions (e.g., pure single-element samples, no matrix, multiple replicates). The instrumental detection limit is rarely, if ever, recognized as a practical detection limit for dissolved soil samples. A more conservative detection limit usually is specified in the contract between the laboratory and individual customers; this is referred to as the contract required detection limit. The contract required detection limit is specified by the CLP protocol (EPA 1989c).

The most representative method of quantifying a detection limit is to measure the variation in the background signal near or on the spectral line for each analyte. Ideally, these measurements should approach as closely as possible the conditions under which the actual samples are being analyzed. This would have the advantage of building in and thus negating biases produced by unique matrix effects. In practice, this approach is unreasonable because of nearly ubiquitous schedule constraints and lack of suitable samples for use as matrix blanks. The standard process for establishing detection limits based on spectral background is to use a preparation blank, which is an aliquot of analyte-free solution that has been subjected to the same processes as an unknown sample (i.e., digestion with acid, dilution with deionized water). These blanks are used to determine detection limits as well as the existence and magnitude of any laboratory contamination problems. There are several different definitions for detection limits other than those described previously. Some are qualitative and others are based on the standard deviation of sequential analyses (usually three) of a preparation blank. A few of these detections limits and their definitions are as follow:

- Limit of detection (LOD)--the concentration that produces a signal approximately three times the standard deviation above the mean of blank analyses (APHA 1989)

- Instrumental detection limit (IDL)--a concentration that produces a signal greater than five times the signal/noise ratio of the instrument; approximately 1.6 times the standard deviation of the preparation blank analyses (APHA 1989).

- Limit of quantitation (LOQ)--the concentration that produces a signal sufficiently greater than the blank that it can be detected within specified limits by laboratories during routine analysis; typically 10 times the standard deviation of the preparation blank analyses (APHA 1989).

The limit of quantitation is used as a minimum value to which a high degree of certainty can be attached. According to the American Chemical Society Committee on Environmental Improvement: "...quantitative interpretation, decision-making, and regulatory actions should be limited to data at or above the limit of quantitation" (ACS 1983).

Form 3 of the CLP data package describes the results of analysis for blanks in the laboratory. There are three different types of blanks typically reported: (1) internal calibration (ICB), (2) deionized water (DI), and (3) preparation blanks (PBS). The preparation blanks samples are samples that have been subjected to the complete sample preparation process, minus any solid sample material. Thus, the samples contain all likely laboratory contaminants and reagent impurities. These samples also incorporate any errors and biases associated with calibration, the digestion process, or the measurement process that are independent of concentration.

The preparation blank analyses for the time period covered by the project were retrieved from the data packages and consolidated (78 measurements). These data were analyzed by inductively coupled plasma. The mean and standard deviation of the blank measurements were computed, and the limit of detection and limit of quantitation were determined as the mean plus 3 and 10 standard deviations, respectively. Where the mean of the data was less than zero, it was reset to zero. Not all analytes in the target analyte list were reported by the laboratory. Analytes not covered were titanium, zirconium, mercury, lithium, ammonia, nitrite, silicon, alkalinity, fluorine, chlorine, O-phosphate, sulfate. For these analytes, the largest laboratory claimed detection limit has been used as the limit of detection. Additionally, data were reported for arsenic, lead, selenium, and thallium, even though the soil data for these analytes were analyzed with graphite furnace atomic adsorption. No preparation blank quality control data were reported for graphite furnace atomic adsorption analyses. These data have been retained in the table for completeness. The data from the preparation blanks are presented in Table D2; the limit of detection and limit of quantitation results are presented in Table D3.

The computation of actual detection limits over all the batches provides a basis for evaluating the reliability of data near the detection limit. Data less than the limit of quantitation are considered unreliable for making cleanup decisions at a waste site. The limit of detection calculated from the blanks provides a single censoring level for use in the statistical calculations. The detection limits determined on a daily basis are subject to large statistical scatter because of the low number of samples (3) included in the calculation. Basing the limit of detection calculation on the entire set of data, taken over the time period of interest, provides a more accurate and stable result. The combining of data over many batches is possible because of the demonstrated stable nature of the measurement process (Section D2.4). The limit of detections achieved represent the combined effect of all measurement errors as obtained from preparation blanks. Not included in the blanks are matrix effects and field sampling effects.

D2.4 MEASUREMENT PROCESS STABILITY

The stability of the measurement process was evaluated by constructing control charts for the Maxwell S-Cubed laboratory covering the time period over which the samples were analyzed. Because a solid control material of known composition was not available for inclusion in the analysis, the control charts were based on the preparation blanks described previously and used for

the limit of detection and limit of quantitation information. Two forms of the control chart were developed. The first was based on the average of all the preparation blanks run on a single day, the second was based on the standard deviation of the preparation blanks run on a single day. These results were plotted as function of the days following the first analysis for the background project. The warning and alarm limits were set at 2 and 3 standard deviations of the control variable. For the daily averages, these are two-sided limits. For the standard deviations, these are one-sided limits. The control charts are shown in Figures D1 and D2. The data for these control charts are presented in Table D2.

It must be noted that the number of days (batches) included in the control chart analysis is low and irregularly spaced over the period of interest. This limits the resolution of the charts and the ability to detect long-term trends. This is, however, the best available data for determining the long-term performance of the laboratory.

The daily average control charts provide an indication of the stability of the measurement process with respect to accuracy. Drift in the chart beyond the warning line indicates that the measurement process is moving out of control. Drift beyond the alarm line indicates that control of the measurement process has been lost and no further measurements should be taken until the control is reestablished. In the control charts shown, there is obviously some drift with respect to some analytes. Chromium is a good example of this. The average value of the blank steadily drifts towards the upper warning limit followed by an obvious correction to bring the measurement process back within limits.

Note that a data point above the warning limit does not, in itself, represent a loss of control of the measurement process. Isolated data points outside the warning limits can be expected based on the fact that the warning limits are statistically based. The primary observation to be considered is the overall trend exhibited by the data. The control charts for the daily averages do not show any significant trends beyond the warning limits, indicating that the measurement process was stable with respect to accuracy.

The controls charts with standard deviation as the control variable demonstrate that the measurement process is stable with respect to precision. As with the daily average control charts, there are no significant trends beyond the warning limits. The conclusion can be made that the precision of the analysis was stable during the period involved.

D2.5 ANALYSIS OF FIELD DUPLICATES

Field duplicate samples were taken during the sampling process. One sample from each sampling site was selected randomly for duplication. The duplicate sample was submitted to the DataChem laboratory for analysis. Figures D3 shows the regression of the DataChem results against the S-Cubed data. Also performed and reported in Table D4 are statistical comparisons of the data from the two laboratories. The comparison is based on the nonparametric Mann-Whitney U test.

The basis for the U test is a series of pairwise comparisons between the elements of two data sets, A and B. A comparison results in a 1 if $a_i > b_j$ and a 0 if $a_i < b_j$. Ties can be handled either by ignoring the comparison result, randomly assigning a 1 or 0 with equal probability, or by assignment of a 1 or 0 to the tie. The result is a set of NxM comparisons that can be treated as a series of Bernoulli trials. The null hypothesis is that the two data sets were drawn from the same distribution; therefore, the probability of $(a_i > b_j) = (a_i < b_j) = 0.5$. Ties for this test were handled by assignment of a 1 to the tie. This does introduce some bias into the test, but this is only significant for a large number of ties that would be obvious on inspection of the data sets. Furthermore, the data sets have been filtered by removing data pairs where both members of a pair were assigned the detection limit. This limits the test to those analytes for which data exist above the detection limit.

For the results shown in Figure D3 and Table D4, the only analytes for which a statistically significant bias existed between laboratories were cobalt, beryllium, and nitrate. The linear regression of the DataChem data against the Maxwell S-cubed data was examined. The cobalt regression shows that the Maxwell S-cubed data were biased low with respect to the DataChem data by approximately 2 parts per million. The beryllium regression shows a difference because DataChem reported only detection limit value for beryllium, while Maxwell S-cubed reported data above the detection limit. This indicates either a scaling error or a bias between the laboratories. Quantification and determination of the type of error is not possible at this time. The nitrate results indicate a scaling difference in which the Maxwell S-cubed results are approximately 10 times the Datachem results. These results address only differences between the primary and secondary laboratories and does not address the issue of which one is the 'correct' analysis.

The results of this analysis indicate that there is no statistically significant laboratory bias or scaling errors for most analytes. Differences between the two laboratories do exist for cobalt (bias), beryllium (unknown type), and for nitrate (scaling).

D2.6 REPLICABILITY

The replicability of the analytical data can be evaluated in two parts. The first is the replicability of the field sampling process. This is addressed as part of the variogram analysis (Section D2.9). The second part is the replicability of the measurements on samples delivered to the laboratory. This was evaluated by analyzing the results of the laboratory duplicate analysis reported on CLP Form 6. This analysis was done by taking a second sub-sample from the field sample and repeating the analysis. The analysis of the duplicates indicates the ability of the laboratory to replicate the analysis of the field sample.

The standard deviation of the differences between duplicates was computed and is provided in Table D5. As with the definition of limit of detection, the mean plus three standard deviations indicates the concentration at which the uncertainty, because of replicability of the data, is 100 percent. Data

below this concentration should be considered of limited usefulness because of the limitations in obtaining a representative sample. This limitation is attributable to the small (1 to 2 gram) subsamples used as part of the acid digestion procedures.

D2.7 SUMMARY OF QUALITY ASSURANCE AND QUALITY CONTROL ANALYSIS

The following conclusions can be reached regarding the data obtained from Maxwell S-cubed.

- The measurement process was stable and in control over the period of interest.

- There was no evidence for significant bias between the primary laboratory and the secondary laboratory, with the exception of cobalt, beryllium, and nitrate. Cobalt showed a consistent bias of 2 parts per million. Beryllium was not detected by the DataChem laboratory and was detected by Maxwell S-cubed. This leads to a conclusion of a difference between the laboratories, of unknown magnitude and type. Nitrate showed a consistent scaling difference of a factor of 10.

- Limit of detections and limit of quantitations have been computed for those analytes reported as part of the preparation blanks analysis. For other analytes, the largest reported detection limit has been used as the detection limit.

- The data have been validated and qualified according to established onsite procedures. Some data were rejected on the basis of laboratory contamination in the blanks and failure of the duplicate analysis to fall within the control limits. The remaining data are acceptable for further statistical analysis.

D2.8 FACTOR ANALYSIS

Factor analysis is a statistical method for determining related groups of variables. Factor analysis expresses a large number of variables as a function of a much smaller set of reduced variables. For the purposes of this study, grouping the analytes allows for the selection of analytes that are representative of each of statistical group. These analytes have been subjected to a more complete statistical analysis than the rest of the data set.

Factor analysis was performed on the CLP analysis of the systematic random samples. Tables D6 describes the results of the factor analysis of the systematic random data set.

The factoring procedure used was the principle components method. The number of factors determined was based on the greater of either the number of factors required to account for 75 percent of the matrix variance or the rank

order of the eigenvalue at the inflection point of the root curve. The number of factors determined for the systematic random data was 6 [Table D6(a)].

The measure of variable sampling adequacy [Table D6(b)] addresses the adequacy of homogeneity of the factors (i.e., that the data are drawn from the same statistical universe). Arguments have been made (Kaiser 1970) that for the assumption of homogeneity to hold, the total measure of sampling adequacy should be greater than 0.5. For the systematic random data, this measure was 0.81; therefore, the data are considered suitable for factor analysis.

The Bartlett Test of Sphericity is a multivariate analog of the Chi-square test for nonzero correlations. The systematic random data show significant values for the Chi-square statistic, indicating that the interelement correlations are significantly different from zero. The level of significance is 1 E-4.

The communality summary [Table D6(c)] indicates the total proportion of the variance of each variable that can be predicted by the factors. The lowest predictive ability is achieved for barium, lead, zinc, and fluorine. For these elements, less than 70 percent of the variance can be accounted for by the factor analysis.

The proportion of variance contributions [Table D6(d)] identifies the relative contributions of each of the factors to the total variance of the data set. For the systematic random data, the first factor accounts for 38 percent, while the second factor accounts for 28 percent of the total variance. This indicates that there are two major contributing factors to the variance of the data.

The solutions for the systematic random data show the loadings of the various analytes onto each of the factors. The factors are represented graphically in Figure D4. Table D6(e) describes the oblique factor correlations and Table D6(f) presents the variable complexity for the systematic random data set. The variable complexity table indicates how many factors are required to account for the variance of each analyte. The most simple structure is for each analyte to be represented by only one factor. The remainder of the analytes are represented by approximately two factors, with the exception of sodium and potassium. Both potassium and sodium readily form a wide variety of minerals. Additionally, sodium is readily dissolved and forms evaporites [sodium chloride (NaCl) and sodium sulfate ($NaSO_4$)], which is not expected to correlate well with factors attributable to mineralogy, deposition, or measurement processes.

The factor analysis indicates that calcium does not correlate well with any analyte except alkalinity. If soil formation processes have affected the Hanford formation it should be expected that other analytes would be correlated with high calcium measurements either through coprecipitation (e.g., $MgCO_2$) or as translocated elements affected by the same process that has created the caliche ($CaCO_2$) deposits in the Hanford formation. The lack of correlation between calcium and other analytes indicates that soil-forming processes generally do not occur, beyond the formation of evaporite deposits such as caliche.

Based on the described factor analysis, aluminum, iron, calcium, and sodium have been selected as representative of the first four factors of the systematic random data set. Additionally, lead and copper are included to represent the sulfides group and potential contaminants of interest. These elements will have further statistical testing performed in support of the conceptual model verification (i.e., variogram analysis).

D2.9 VARIOGRAMS

Variograms are statistical tools used to evaluate spatial correlations in a data set. Application of variogram analyses for the Sitewide soil data set is presented in the following sections.

D2.9.1 Variogram Construction

Many statistical tests assume the independence of data within a data set. The variogram provides a ready test of that assumption by determining if data that are closer together in space are more (or less) correlated than data further apart. The formula for computing a variogram is:

$$\gamma(\vec{h}) = \frac{1}{2n}\sum_{i=1}^{n}[C(\vec{x_i}) - C(\vec{x_i} + \vec{h})]^2 \qquad (1)$$

where

$C(\vec{x_i})$ = concentration at location $\vec{x_i}$

$\vec{h}$ = lag (i.e., distance between samples)

n = number of sample pairs separated by distance $\vec{h}$

The term gamma(h) represents the average variance of samples separated by a distance h (a data pair). Note that h is a vector indicating that the value for gamma is a function of direction in space. A plot of gamma(h) versus h shows whether or not there exists significant correlation between data.

To construct such a plot, several parameters need to be specified. The first of these is the vector representing h. This vector usually is specified as a direction (azimuth and elevation) plus or minus a tolerance range over which the vector will be allowed to vary (half-window). For example, a specification of 0 degrees azimuth and 0 degrees elevation will specify an east-west horizontal vector for the coordinate system used here. Specifying an azimuthal half-window of 90 degrees will include all data pairs regardless of horizontal orientation. A specification of 45 degrees will include only those data pairs whose connecting vector lies between northeast-southeast and

southwest-northwest. The same concept applies to the elevation vector. Because of the large separation distances horizontally compared to the depth distances, a small vertical half-window suffices to include all of the possible pairs in the vertical direction between different sampling sites.

The second parameter to be specified is the range of h to be included. This allows the variogram to be scaled for examining the variograms at different scales of resolution. The resolution depends on both the range of h and the number of intervals within the range. Intervals are used to group the data pairs to arrive at the average variance for a specified distance. This allows the variogram to be used on randomly scattered data in which a particular distance might only be represented by a single data pair.

Variograms were constructed for aluminum, iron, sodium, calcium, lead, and copper as being representative of the behavior of the major groups of analytes (Section D2.8). These variograms are shown in Figures D5 and D6 along with the input specification and output text. These variograms were constructed based on the following parameters.

1. An east-west orientation with a 90 degree horizontal half-window and a 30 degree elevation half-window--This includes all data pairs between sample sites and no data pairs within a sample site e.g., correlations in all horizontal directions but no vertical correlations.

2. An east-west window with a 45 degree horizontal half-window and a 30 degree vertical half-window--This includes all data pairs between sample sites that contain a dominant east-west trend to their orientation.

3. A north-south window with a 45 degree horizontal half-window and a 30 degree vertical half-window--This includes all data pairs between sample sites that contain a dominant north-south trend to their orientation.

4. A vertical window with a 90 degree horizontal half-window and a 15 degree vertical half-window--This includes all data pairs within a sample site and no data pairs between sample sites. The exclusion of data pairs between sample sites is done because the reference points for depth measurements were arbitrary at each sampling location, i.e., the depths were not tied to a universal reference point such as mean sea level, but instead were referenced from the local land surface. Two separate ranges for depth were used: 150 and 50 feet (46 and 15 meters).

Other sets of parameters were used on a case-by-case basis and are described along with the results for each analysis in the following sections.

The coordinate system used was based on the latitude and longitude positions of the sampling sites. The positions of the sampling sites were converted to distance measures in feet. Zero points for the x and y axes were

set respectively at the sites furthest east and south. The resulting coordinates are shown in Table D7.

The software used to construct the variograms contained some limitations that required compensation. Although the data are three dimensional and the software is written for three dimensional data, the variograms for the vertical window could not be constructed from the 3-dimensional data input. A coordinate transformation was employed to rotate the data so that the depth information lay along the y axis and the x axis was an arbitrary separation distance. The half-window was set to preclude comparisons between sample sites. The software plots a question mark for each data point involving less than 20 data pairs. This highlights those areas of the plot for which the statistical validity of the results can be considered questionable. This is an aid to the analyst to guard against over-interpreting the variogram.

The variance of the field duplicates is plotted on the vertical variograms to show the zero lag variance of the data. The variance of the field duplicates has been computed without including pairs containing detection limit values in the calculation.

D2.9.2 Horizontal Window Variogram Results

Results from the horizontal window variogram analysis show that there is no definite trend in the data. Details of the analysis for each element considered are presented in the following sections.

D2.9.2.1 Aluminum. The variograms for aluminum (Figure D5-1) show no definite trend with lag distance in either the 360 degree orientation or the east-west or north-south orientations. There does not appear to be any significant anisotropy in either direction. The horizontal variograms for aluminum can be classified as random, indicating that the data from different sampling sites are essentially independent and uncorrelated.

D2.9.2.2 Iron. The variograms for iron (Figure D5-2) show no definite trend with lag distance in either the 360 degree orientation or the east-west or north-south orientations. There does not appear to be any significant anisotropy in either direction. The horizontal variograms for iron can be classified as random, indicating that the data from different sampling sites essentially are independent and uncorrelated.

D2.9.2.3 Calcium. The variograms for calcium (Figure D5-3) show a definite and an approximate linear relationship between gamma(h) and h. Two possible causes exist for such a relationship. The first cause is a true correlation of random data with distance. The second cause is a trend in the data. The second possibility can be investigated by plotting the data with respect to a space coordinate. It was determined that a general trend existed in the east-west direction. The calcium data were treated to remove this trend. A linear regression was applied to the data, based on the east-west coordinates. The best-fit line was subtracted from the data and the variogram of the residuals constructed (Figure D5-3). The east-west plot shows a random variogram at distances greater than approximately 25,000 feet (approximately

7,620 meters). The north-south plot and the northwest-southeast plot show progressively larger scattering without a clear increase in the linearity of the data. From these plots, it is obvious that the linear relationship of gamma(h) with h has been removed, indicating that the variation in the data is caused by a trend in the calcium data. The trend most likely is associated with the process of caliche formation and the spatial correlation of rainfall and evapotranspiration patterns across the Hanford Site.

D2.9.2.4 Sodium. The variograms for sodium (Figure D5-4) show no definite trend with lag distance in either the 360 degree orientation or the east-west or north-south orientations. There does not appear to be any significant anisotropy in either direction. The horizontal variograms for sodium can be classified as random, indicating that the data from different sampling sites essentially are independent and uncorrelated.

D2.9.2.5 Copper. The variograms for copper (Figure D5-5) show no definite trend with lag distance in either the 360 degree orientation or the east-west or north-south orientations. There does not appear to be any significant anisotropy in either direction. The horizontal variograms for copper can be classified as random, indicating that the data from different sampling sites essentially are independent and uncorrelated.

D2.9.2.6 Lead. The variograms for lead (Figure D5-6) show no definite trend with lag distance in either the 360 degree orientation or the east-west or north-south orientations. There does not appear to be any significant anisotropy in either direction. The horizontal variograms for lead can be classified as random, indicating that the data from different sampling sites essentially are independent and uncorrelated.

D2.9.3 Vertical Window Variogram Results

The Yakima Barricade Borehole (Site No. 15) was the only site to supply data at depths greater than 50 feet (15 meters). Only Sites Nos. 6 and 15 supplied data at intervals greater than 27 feet (8 meters). This limits the ability to draw conclusion about the variogram at vertical lag distances greater than approximately 25 feet (7.6 meters).

D2.9.3.1 Aluminum. The vertical variograms for aluminum (Figure D6-1) show no definite correlation with distance. A possible short-range negative slope trend is evident, but a good portion of the trend involves low-accuracy data (less than 20 data pairs per interval). This trend also is contrary to most typical variograms, which start low and increase with lag distance, and is therefore interpreted as a random variogram.

The field duplicate variance is plotted on the variogram and is considered to be well within the range of values shown for larger lag distances. On this basis, it appears that the samples can be considered independent and uncorrelated in the vertical direction.

D2.9.3.2 Iron. The vertical variograms for iron (Figure D6-2) show no definite correlation with distance. The field duplicate variance is plotted

on the variogram and is considered as within the range of values shown for larger lag distances. On this basis, it appears that the samples can be considered independent and uncorrelated in the vertical direction.

D2.9.3.3 Calcium. The vertical variograms for calcium (Figure D6-3) show no definite correlation with distance. The field duplicate variance is plotted on the variogram and is generally lower than the values shown for larger lag distances. This indicates some correlation with distance that rapidly dies out with distance. The correlation range is estimated to be on the order of 5 feet (1.5 meters). This is similar to the sampling interval [3 feet (0.9 meter)] for the background data, and is the same as standard practice for borehole sampling [every 5 feet (1.5 meters) or change in lithology]. The short correlation range indicates that violation of the assumption of independence can be expected to be small. On this basis, it appears that the samples can be considered independent and uncorrelated in the vertical direction.

D2.9.3.4 Sodium. The vertical variograms for sodium (Figure D6-4) show no definite correlation with distance. The field duplicate variance is plotted on the variogram and is generally lower than the values shown for larger lag distances. This indicates some correlation with distance that rapidly dies out with distance. The correlation range is estimated to be on the order of 5 feet (1.5 meters). This is similar to the sampling interval [3 feet (0.9 meter)] for the background data, and is the same as standard practice for borehole sampling [every 5 feet (1.5 meters) or change in lithology]. The short correlation range indicates that violation of the assumption of independence can be expected to be small. On this basis, it appears that the samples can be considered independent and uncorrelated in the vertical direction.

D2.9.3.5 Copper. The vertical variograms for copper (Figure D6-5) show no definite correlation with distance. The field duplicate variance is not plotted on the variogram as the variance is above the scale of the plot at 8.7. On this basis, it appears that the samples can be considered independent and uncorrelated in the vertical direction.

D2.9.3.6 Lead. The vertical variograms for lead (Figure D6-6) show no definite correlation with distance. The field duplicate variance is plotted on the variogram and is considered to be within the range of values shown for larger lag distances. On this basis, it appears that the samples can be considered independent and uncorrelated in the vertical direction.

D2.9.4 Vertical Versus Horizontal Anisotropy

The vertical variograms were compared to the horizontal variograms to determine if a significant degree of anisotropy existed between the vertical and horizontal directions. 'Average' values were estimated from the 360 degree horizontal variograms and the 150-foot (45.7 meter) range vertical variograms for each of the 6 analytes. These estimates are shown in Table D8. As can be seen from Table D8, there is a definite anisotropy between the horizontal and vertical directions that ranges from nearly 1:1 to over 4:1.

D2.9.5 Variogram Analysis Summary

Variograms for six analytes were constructed and analyzed. With some exceptions described in the following paragraphs, all of the variograms could be classed as random. A random variogram indicates that the data can be considered as uncorrelated and independent, thus permitting the use of classical statistical methods. The exceptions to this were calcium in both the vertical and horizontal directions and sodium in the vertical direction.

The calcium data were shown to exhibit a horizontal spatial trend that accounted for virtually all of the apparent correlation with distance. Statistical analysis of the calcium data should be done properly by removing the trend from the data and dealing with the residuals. However, two factors operate against this approach. The first factor is that the trend explains only a small percentage of the variation in the data. The magnitudes of gamma(h) in the detrended variogram are of the same order as the gamma(h) of the original variogram. The second factor is that calcium is seldom expected to be an analyte of concern in any cleanup effort. As a result, the effort to deal with residuals is not justified.

The vertical correlations of calcium and sodium involved a very short correlation range, on the order of 5 feet (1.5 meters). This correlation most likely is due to formation of layered evaporite deposits. A PNL study (PNL 1991) indicates that the depth of such effects is limited to less than 10 feet (3 meters), consistent with the variograms developed. The effects of these short range correlations are expected to be minimal because the effect is limited to near-surface samples. It is expected that the data for sodium and calcium can be treated as independent and uncorrelated in the vertical direction.

The variogram analysis has shown that the variance of the data is anisotropic between horizontal and vertical directions. For example, a borehole of limited depth [<50 feet (15.2 meters)] can be expected to show a smaller variance than samples collected in the horizontal directions at distances greater than 5,000 feet (1,524 meters).

D2.10 WEIBULL DISTRIBUTION

This section describes the Weibull distribution [named after Waloddi Weibull (1951)] and its various parameters and calculational forms. One reason for its popularity is its great variety of shapes. This makes it extremely flexible and it empirically fits many kinds of data. Additional descriptions of the characteristics of the Weibull distribution are described in the following. These are summarized from Nelson (1982).

D2.10.1 Basic Form

The Weibull probability density function (PDF) is:

$$f(x) = \frac{\beta}{\eta^{\beta}}(x-t_o)^{\beta-1}\exp\left[-\left(\frac{x-t_o}{\eta}\right)^{\beta}\right] \tag{2}$$

The parameter β is called the shape parameter and is positive. The parameter η is called the scale parameter and also is positive. The parameter t_o is the location parameter and can be positive or negative. The value of t_o indicates a minimum value for the variable x and has the same units as x. The scale parameter also is called the characteristic value, because it is always the 63.2th percentile of the distribution. The parameter η carries the same units as x. β is the slope of the cumulative distribution when plotted on the appropriate probability paper. The distribution is only defined for $x > t_o$. Restricting t_o to >= 0 makes the distribution suitable for describing concentration data.

For the special case of $\beta = 1$, the Weibull distribution collapses to the simple exponential distribution. For $\beta = 2$, the Weibull distribution is known as the Rayleigh distribution, representative of multivariate joint normal distributions through the transform $z^2 = x_1^2 + x_2^2 + \ldots + x_n^2$. For values in the range $3 <= \beta <= 4$, the shape of the Weibull distribution closely approximates that of the normal distribution. For large β (>= 10), the Weibull distribution approximates the smallest extreme value distribution. For much data, the Weibull distribution is more suitable than the exponential, normal, and smallest extreme value distributions, and should be tried first (Nelson 1982).

The Weibull distribution is related to the simpler smallest extreme value distribution in the same way that the lognormal distribution is related to the normal distribution. The natural logarithm of a Weibull distributed variable behaves as a smallest extreme value variable. This fact will be used later to develop estimates of the distribution parameters.

The Weibull cumulative density function (CDF) is:

$$F(x) = 1 - \exp\left[-\left(\frac{x-t_o}{\eta}\right)^{\beta}\right] \tag{3}$$

The Weibull distribution parameters are sometimes expressed differently by different users. Some examples of different notations in common use are:

$$F(x) = 1 - \exp\left[-\lambda(x-t_o)^{\beta}\right]$$

$$F(x) = 1 - \exp\left[-\frac{(x-t_o)^{\beta}}{\theta}\right] \qquad (4)$$

$$\lambda = \frac{1}{\eta^{\beta}}$$

$$\theta = \frac{1}{\lambda} = \eta^{\beta}$$

Because the Weibull CDF exists in a closed form, the Weibull distribution can be inverted, something not possible with the normal and lognormal forms. The value of x_p corresponding to a particular percentile is:

$$x_p = \eta[-\ln(1 - p)]^{\beta} + t_o \qquad (5)$$

$$p = \text{percentile value}/100$$

The Weibull complementary cumulative distribution function (CCDF) describes the proportion of data exceeding x. For this reason, it also is known as the reliability function:

$$R(x) = \exp\left[-\left(\frac{x-t_o}{\eta}\right)^{\beta}\right] \qquad (6)$$

The Weibull mode, the most likely value, is:

$$x_m = \eta\left(1 - \frac{1}{\beta}\right)^{\frac{1}{\beta}} + t_o \quad \text{for } \beta \geq 1 \qquad (7)$$
$$x_m = t_o \quad \text{for } 0 < \beta < 1$$

The Weibull mean is:

$$E(x) = \eta\Gamma\left[1 + \left(\frac{1}{\beta}\right)\right] + t_o \qquad (8)$$

where

$$\Gamma(\nu) = \int_0^\infty z^{\nu-1}\exp[-z]dz$$

is the gamma function and

$$\Gamma(\nu+1) = \nu\Gamma(\nu)$$

$\Gamma(n) = (n-1)!$, for integer n

z = Dummy variable of integration.

For a value of $\beta = 1$ (exponential distribution), the mean = $\eta + t_o$.

The Weibull variance is:

$$Var(x) = \eta^2\left[\Gamma\left(1 + \frac{2}{\beta}\right) - \left[\Gamma\left(1 + \frac{1}{\beta}\right)\right]^2\right] \qquad (9)$$

The Weibull standard deviation is:

$$\sigma(x) = \eta\left[\Gamma\left(1 + \frac{2}{\beta}\right) - \left[\Gamma\left(1 + \frac{1}{\beta}\right)\right]^2\right]^{\frac{1}{2}} \qquad (10)$$

D2.10.2 Simple Parameter Estimation

Estimates for the parameters η and β can be performed by several methods. The simplest is based on the parameters of the corresponding extreme value distribution developed from the log (data) values. This estimate sequence is:

Extreme value scale parameter δ

$$\delta \approx D = 0.7797S \tag{11}$$

where

S = Standard deviation of Ln(data)

Extreme value location parameter λ

$$\lambda \approx L = \overline{X} + 0.5772D$$

where

$\overline{X}$ = Average Ln(data)

0.5772... = Eulers constant

Weibull scale parameter η

$$\hat{\eta} \approx A = \exp[L]$$

Weibull shape parameter β

$$\hat{\beta} \approx B = 1/D$$

L, A, B, and D are biased estimators, and their sampling distributions have not been derived. Menon (1963) shows that the large sample distribution of D is approximately normal with a mean of delta and a variance of $1.100\ \delta^2/n$. Menon (1963) also shows that the large sample distribution of L is approximately normal, with mean lambda and variance $1.168\ \delta^2/n$.

Confidence limits for the parameters η and β are based on the confidence limits for the smallest extreme value parameters:

Two-sided approximate 100γ % confidence limits for λ

$$\lambda_{-} \approx L - K_{\gamma} 1.081 \left[\frac{D}{n^{\frac{1}{2}}}\right] \qquad \lambda^{-} \approx L + k_{\gamma} 1.081 \left[\frac{D}{n^{\frac{1}{2}}}\right] \tag{12}$$

where

$$K_{\gamma} = 100\left[\frac{1+\gamma}{2}\right] \text{ percentile of the normal distribution}$$

$$\eta_{-} = \exp[\lambda_{-}] \qquad \eta^{-} = \exp[\lambda^{-}]$$

and for β

$$\delta_{-} \approx \frac{D}{\exp\left[\frac{1.049K_{\gamma}}{n^{\frac{1}{2}}}\right]} \qquad \delta^{-} \approx D \bullet \exp\left[\frac{1.049K_{\gamma}}{n^{\frac{1}{2}}}\right]$$

$$\beta_{-} = \frac{1}{\delta^{-}} \qquad \beta^{-} = \frac{1}{\delta_{-}}$$

and

X_{-} = Lower confidence limit on variable X

X^{-} = Upper confidence limit on variable X

The number of samples required to estimate β with approximately 100γ percent probability is:

$$n \approx 1.100\left[\frac{K_{\gamma}}{\ln(f)}\right]^{2} \tag{13}$$

where f is the desired accuracy factor (e.g., γ = 90 percent confidence, $K\gamma$ = 1.645 and f = 1.25 yields 60 samples).

The estimate of the $100P^{th}$ percentile (X_p) of the Weibull distribution is:

$$T_p = L + u_p D \tag{14}$$

where u_p is the $100P^{th}$ percentile of the standard extreme value distribution:

$$u_p = Ln(-Ln(1 - P))$$

$$X_p = \exp[T_p]$$

With two-sided approximate 100γ percent confidence limits of the following:

$$T_{p-} \approx T_p - K_\gamma D \left[\frac{(1.1680 - 0.1913u_p + 1.1000u_p^2}{n}\right]^{\frac{1}{2}}$$

$$T_p^- \approx T_p + K_\gamma D \left[\frac{(1.1680 - 0.1913u_p + 1.1000u_p^2}{n}\right]^{\frac{1}{2}} \tag{15}$$

and

$$X_{p-} = \exp[T_{p-}] , \qquad X_p^- = \exp[T_p^-]$$

These are estimates that can be performed by hand even though the estimates are biased estimators as indicated previously. More exact methods are available, either through regression fitting of the data on a plot or through maximum likelihood methods described in Nelson (1982).

D2.10.3 Maximum Likelihood Estimates

The Weibull log likelihood for a sample of n data is:

$$\mathcal{L} = \sum_{i=1}^{i=n}\left[\ln(\beta) + (\beta - 1)\ln(x_i) - \beta\ln(\eta) - \left(\frac{x_i}{\eta}\right)^{\beta}\right] \tag{16}$$

The values of η and β that maximize L for η_o and β_o also are solutions of the likelihood equations.

$$0 = \frac{\partial\mathcal{L}}{\partial\eta} = \sum_{i=1}^{i=n}\left[-\left(\frac{\beta}{\eta}\right) + \left(\frac{\beta}{\eta}\right)\left(\frac{x_i}{\eta}\right)^{\beta}\right]$$

$$0 = \frac{\partial\mathcal{L}}{\partial\beta} = \sum_{i=1}^{i=n}\left[\left(\frac{1}{\beta}\right) + \ln\left(\frac{x_i}{\eta}\right) - \left(\frac{x_i}{\eta}\right)^{\beta}\ln\left(\frac{x_i}{\eta}\right)\right] \tag{17}$$

These nonlinear equations must be iteratively solved by computer to obtain the estimates of η and β. Alternatively, Equations 19 can be reduced by eliminating η to yield the following single equation in β that is easier to solve:

$$\sum_{i=1}^{i=n}\frac{\ln(x_i)}{n} = \left[\sum_{i=1}^{i=n} x_i^{\beta}\ln(x_i)\right]\left[\sum_{i=1}^{i=n} x_i^{\beta}\right]^{-1} - \left[\frac{1}{\beta}\right] \tag{18}$$

The left hand sum runs just over the concentration data. It is easy to iteratively solve equation 20 to get an estimated β, because the right hand side is a monotonic function of β. The estimate of η is then derived from:

$$\hat{\eta} = \left(\sum_{i=1}^{i=n}\frac{x_i^{\beta}}{n}\right)^{\frac{1}{\beta}} \tag{19}$$

For large samples, the joint cumulative distribution function of the estimates of η and β is close to a joint normal distribution with means η_o and β_o and the covariance given below.

The variance in the estimates of the parameters are (for complete data):

$$\begin{aligned} Var(\hat{\eta}) &\approx \frac{1.1087}{n}\left[\frac{\eta_o}{\beta_o}\right]^2 \\ Var(\hat{\beta}) &\approx \frac{0.6079}{n}\beta_o^2 \\ Cov(\hat{\eta},\hat{\beta}) &\approx \frac{0.2570}{n}\eta_0 \end{aligned} \tag{20}$$

Because the true values remain unknown, it is common to use the estimated values in the above equations. The variance relationships described in Equation 22 can be used to construct two-sided 100γ percent confidence intervals on the distribution parameters:

$$\begin{aligned} \eta_- &= \frac{\hat{\eta}}{\exp\left[\frac{K_\gamma[Var(\hat{\eta})]^{\frac{1}{2}}}{\hat{\eta}}\right]}, \qquad \eta^- = \hat{\eta}\cdot\exp\left[\frac{K_\gamma[Var(\hat{\eta})]^{\frac{1}{2}}}{\hat{\eta}}\right] \\ \beta_- &= \frac{\beta}{\exp\left[\frac{K_\gamma[Var(\beta)]^{\frac{1}{2}}}{\beta}\right]}, \qquad \beta^- = \beta\cdot\exp\left[\frac{k_\gamma[var(\beta)]^{\frac{1}{2}}}{\beta}\right] \end{aligned} \tag{21}$$

For single sided confidence limits, replace K_γ with Z_γ = 100γ^{th} standard normal percentile.

The 100Pth percentile of the distribution is:

$$X_p = \hat{\eta}[-\ln(1-P)]^{\frac{1}{\beta}} \tag{22}$$

Confidence limits for X_p either can be calculated from the confidence limits for the corresponding smallest extreme value distribution or through the more general case of error propagation formula. This latter method is presented in the following section.

D2.10.4 Propagation of Error

An estimate for a function $h = f(c_1, \ldots, c_p)$ of $c_1, \ldots, c_p$ is desired. Percentiles are such functions. The maximum likelihood (ML) estimate of the function is:

$$\hat{h} = h(\hat{c}_1, \ldots, \hat{c}_p) \tag{23}$$

Under certain conditions and for large samples, the cumulative distribution of $\hat{h}$ is approximately normal with mean h and variance by propagation of error (Wilks 1962):

$$\mathrm{Var}(\hat{h}) = \hat{H}^T F^{-1} \hat{H} \tag{24}$$

where

$$\hat{H} = \left| \begin{matrix} \frac{\partial h}{\partial c_1} \\ \vdots \\ \frac{\partial h}{\partial c_p} \end{matrix} \right|_{c_p = \hat{c}_p}$$

$$F^{-1} = \left| \begin{matrix} Var(\hat{\eta}) & Cov(\hat{\eta}, \hat{\beta}) \\ Cov(\hat{\eta}, \hat{\beta}) & Var(\hat{\beta}) \end{matrix} \right|$$

The standard deviation of the parameter is:

$$s(\hat{h}) = [\mathrm{Var}(\hat{h})]^{\frac{1}{2}} . \tag{25}$$

This allows calculation of 100γ percent confidence interval for h as:

$$h_{-} = \hat{h} - K_{\gamma}s(\hat{h}) \quad , \qquad h^{-} = \hat{h} + K_{\gamma}s(\hat{h}). \tag{26}$$

These limits apply for h varying from minus to plus infinity. For the case of the Weibull distribution where h is restricted to positive values, approximate positive limits are:

$$h_{-} = \frac{\hat{h}}{\exp\left[\frac{K_{\gamma}s(\hat{h})}{\hat{h}}\right]} \quad , \qquad h^{-} = \hat{h}\bullet\exp\left[\frac{k_{\gamma}s(\hat{h})}{\hat{h}}\right] \tag{27}$$

D2.11 RANK REGRESSION FITTING OF DATA

This method of estimating the distribution coefficients is more versatile than the maximum likelihood estimate (MLE) methods described previously, in that this method allows computation of the third parameter in the distribution t_o. This method relies on the scale transformations used in plotting the data to fit a straight line to the data values. This method produces biased estimates of the parameters. Work with the soil data included in this report and the Weibull distribution indicates that for n > 100 samples, the bias is negligible (< 1 percent) and that for sample sizes of about 20, the results are biased low, typically about 5-10 percent depending on β. The equations that follow are for complete uncensored data.

The first step in the estimation procedure is to order the data and assign ranks 1 through n. The ith rank is converted to an estimated percentile of the distribution through Bernard's formula:

$$\hat{p}_i = \frac{(i - 0.3)}{(n + 0.4)}. \tag{28}$$

This formula has been demonstrated to provide a robust estimation of the true percentile, regardless of the underlying true distribution of the data.

The estimated percentiles provide the y coordinate data for the fitting of the distribution. The remaining preparatory step is to set up a coordinate transformation that converts the S-shaped cumulative distribution function into a straight line. The CDF described in Equation 3 is rearranged (assuming $t_o = 0$) and given a log transformation resulting in:

$$\log(x_i) = \log(\eta) + \frac{1}{\beta}\log[-\ln(1 - F)] \tag{29}$$

This is a linear relationship between $\mathrm{Log}(x_i)$ and the function $\mathrm{Log}(-\mathrm{Ln}(1-F))$. Therefore, the data scale (horizontal) is logarithmic and the vertical probability scale has the value F located at $\mathrm{Log}[-\ln(1-F)]$. β thus determines the slope of the straight line. From these considerations, the data transformations can be set up as:

$$\begin{aligned} x'_i &= \mathrm{Log}(x_i) \\ y'_i &= \mathrm{Log}(-\mathrm{Ln}[1-\hat{p}_i]) \end{aligned} \tag{30}$$

Given these transformed data, the values of $\mathrm{Log}(\eta)$ and $1/\beta$ can be determined by standard linear regression techniques.

The value of t_o is determined through optimization of the fit of the data to the straight line describing the two parameter distribuiton as above. The trial value of t_o is subtracted from the data before the linear regression procedure is applied. A goodness-of-fit measure such as the correlation coefficient is determined from the regression procedure and then is maximized by adjusting the value of t_o. The maximization procedure can be anything from manual trial and error to one of several nonlinear optimization techniques available in the literature.

D2.12 DISTRIBUTION ANALYSIS

An important consideration when applying statistical analyses to a data set is the distribution of the data. A discussion of specific influences on the distribution and comparing potentially different distributions is contained in the following sections.

D2.12.1 *A Priori* Considerations

When attempting to fit a statistical distribution to data, several considerations go into the choice of distributions attempted. One consideration is the nature of the process that generates the data. Process

knowledge might indicate that a certain form is more likely to be appropriate for the data than another form. The most common example is measurement error data in which the total error is a sum of many individual error terms. The resulting distribution of a sum of random numbers has been shown to be asymptotically equal to the normal distribution. Similarly, the product of a series of numbers can be represented by a lognormal distribution. Log transforming a multiplicative series results in an additive series, thus the common practice of transforming log-distributed data to use the wealth of normal distribution analysis methods.

There are several processes that contribute to the final measured values of the background data set. These processes are the erosion and breakup of the sediments from their parent material during the cataclysmic floods, the deposition of these sediments in the Pasco Basin, the physical sampling, and the actual measurement process itself. The erosion of the sediments during the cataclysmic floods is a classic example of the theory of breakage (Aitchison and Brown 1957). Large masses of rock are broken from the parent material and subsequently broken again and again as the mass is transported downgradient. This leads to a model in which the grain sizes are a result of a repeated process of multiplication of (random) percentages. Because this fits the model for a multiplicative series described previously, the grain sizes resulting from the erosion process can be represented by a lognormal distribution.

The depositional environment in the Pasco Basin provided a means for modifying the distribution of grain sizes after the sediments entered the basin. The deposition of a sediment grain depended directly on (1) grain size, (2) density and the energy of the flood waters at the point, and (3) time of deposition. The flood waters generally entered the basin with a high initial energy in the main channels followed by a period of spreading out to fill the basin, followed by a low-energy period as the event subsided and the waters flowed out through the Wallula Gap. A point near the main channels was exposed repeatedly to high-energy flows followed by low-energy flows, while points farther from the main channels were exposed to progressively lower maximum energies and all points were exposed to the low-energy regimes.

Therefore, the deposition process provided a sorting mechanism that operated to determine the range of grain sizes at a particular location on the Hanford Site. This sorting process is particularly evident in sampling site Nos. 6, 9, and 14 (Appendix A). The result is that the parent distribution of grain sizes has been differentiated across the Pasco Basin into a family of distributions that have the same minimum grain sizes (i.e., low-energy deposits), but a variable upper bound of grain sizes (i.e., high-energy deposits). This would yield distributions that have various degrees of right truncation (e.g., largest values eliminated). A process that truncates distributions by selecting only the smaller values leads, in the asymptotic limit, to a Weibull distribution. Thus, a Weibull distribution, described in Section D2.10, might be more suited for describing grain-size data in the Pasco Basin. The sampling process is also a sorting process in which only the material less than 2 millimeters is retained in the sample.

The measurement process that is applied to the sample (for cations) is based on a partial acid digestion step [method 3050 (EPA 1986)] followed by measurement in one of several instruments (inductively coupled plasma, graphite furnace atomic adsorption, ion chromatograph). The acid digestion step is designed to extract the most readily dissolved portions of the sample and to use this portion as the basis for further measurement. The amount of an analyte present in the digestate (fluid resulting from the digestion process) depends on several factors, notably, the initial amount in the solid sample, the rate at which the reaction proceeds, and the elapsed time of the reaction.

The digestion process can be viewed as a destructive test of the integrity of the bonds formed between a contaminant and the sediment grains, and of the grains in the sediment. 'Failure' of a contaminant bond or individual grain leads to an increase in the concentration of the digestate. The bonds that fail will be the weakest bonds. The grains that fail will be those with the highest free-surface energies and thus the lowest thermodynamic stability, again a 'weakest link' situation. The total number of failures, hence concentration, is a random function that should be describable by a distribution designed for 'weakest link' situations. The most common form of distribution used for this type of failure mode is the Weibull distribution.

D2.12.2 Data Constraints

The compositions of soil are nonnegative data. In theory, the minimum value for a particular analyte might equal zero. In practice, the minimum value will be the assigned detection limit or some larger censoring value such as limit of quantitation (Section D2.3). Although the censor value itself does not affect the choice of distribution as long as the distribution can deal with a lower bound, the presence of censoring can affect the methods used to determine a goodness of fit for a particular choice.

Concentration data also are bounded at the upper end by constraints on the stoichiometric and phase relationships of the minerals in the sample. This limit is not expected to be encountered in practice as it would require a complete dissolution of a pure mineral to generate the limit data. What could be encountered is a practical limit to the process of dissolution driven by either of the following limits: (1) solubility limits on a particular analyte or (2) time limits on the dissolution process. Both of these limits are undefined and therefore variable. The solubility limit depends on the physicochemical character of the sample. The time limit depends on the analyst's judging that certain reactions are complete (e.g., effervescence of peroxide in method 3050).

Any statistical distribution that is proposed to represent the background data set should contain a lower bound. Both the distributions discussed previously (lognormal, Weibull) are distributions with lower bounds. Further characterization of the background data set will be based on these distributions.

D2.12.3 Fitting Distributions to the Data

The process of determining the parameters of the distribution that best represent the data was based on a linear regression fit of the distribution equation to the data. This is described in Section D2.10 for the Weibull distribution. The procedure for the lognormal distribution is identical except that the vertical axis (percentiles) is scaled by the inverse of the cumulative normal distribution function. Software programs generally are available to perform this regression analysis. The software used was LogNormSmith*, commercially written software designed explicitly for Weibull and lognormal distribution analysis.

The data fitted to the distributions were first left censored according to the detection limit described in Section D2.3. An initial fit to the data was determined and the cumulative distribution plot inspected. Further left censoring of the data was performed as necessary to eliminate scatter at the noncritical low end of the distribution. Censored data is used in the regression fit only to establish the ranks and percentiles of noncensored data. Censored data is not used directly in the regression analysis itself. The censoring values used were compared with the analysis of the predigestion duplicates (Section D2.6) reported by the laboratory (CLP form 6) (Table D5). The censoring value was chosen based on the interpretation of the plot and was consistently approximately three times the standard deviation of the predigestion duplicates (i.e. 100 percent relative uncertainty in the replication of the data). This indicates that the low-end scatter in the plots is tied to the representativeness of the laboratory subsampling procedures. The subsamples used in the digestion process are 1 to 2 gram masses subsampled from an approximately 1 kilogram amount submitted to the laboratory.

After the left censoring was completed, the plot again was inspected. Potential outlier data at the right end of the plot were subjected to censoring by suspension. This removes the data from the regression fitting procedure without changing the rankings (percentile values) of smaller valued data. This supports the concept that outlier data should not be eliminated from the data set while increasing the accuracy of the estimation procedure for the percentiles of interest in the distribution. The plot also was inspected for general trends about the regression line, indicative of multiple or mixed distributions. The final plots are shown in Figures D7-1 through D7-30. After completing the analysis, the percentiles of the distribution were determined and recorded along with the distribution parameters shown in Table D9.

Two analytes, sodium and silicon, showed evidence of multiple distributions (Figure D7-16 and D7-25). These analytes were analyzed further to characterize the upper portion of the distribution under the assumption of multiple distributions. These results also are presented in the tables. It is of interest to note that the break in the distribution of sodium occurs at about 400 milligramsl per kilogram. This also is approximately three times

*LogNormSmith is a trademark of Fulton Findings, Torrance, California.

the standard deviation of the predigestion duplicates as described previously. Thus, the lower end of the curve appears to be dominated by the effects of subsampling and is not representative of the true distribution of sodium in the soils. Predigestion duplicate analyses were not performed by the laboratory for silicon so a similar conclusion only can be inferred and not directly supported for silicon.

D2.12.4 Distribution Comparison

The results of fitting the Weibull and lognormal distributions to the background data set are shown in Table D10. Comparisons are presented for correlation coefficient (goodness of fit) and several percentiles (80, 90, 95), as well as the upper tolerance intervals associated with each percentile. For each parameter, a comparison is made based on the relative magnitude of the parameter (i.e., is the lognormal derived value larger or smaller than the Weibull-derived parameter).

The goodness-of-fit criterion was based on the correlation coefficient. The correlation coefficient goodness-of-fit test is asymptotically equal to the Kolmogorov-Smirnov goodness-of-fit test. This test shows that either distribution provides an acceptable fit to the data for each analyte. Exceptions to this are the lognormal fits to copper, magnesium, sodium (single distribution) and silicon (single distribution). A basis for determining which distribution provides a better representation of the data can be constructed in several different ways. The first is a statistical test on the ensemble of correlation coefficients shown in Table D10-1. Under the assumption that both Weibull and lognormal forms provide equal representation of the data, a comparison between pairs of correlation coefficients can be performed. The null hypothesis is that the probability of the lognormal correlation coefficient ($_{RL}$) being larger than the Weibull correlation coefficient ($_{RW}$) is equal to 50 percent. The alternative hypothesis is that the probability is significantly different from 50 percent. This hypothesis can be tested via a sign test and the binomial distribution. There are 32 pairs with 1 tie. Discarding the tie leaves 31 pairs of which 5 occur with $_{RL} > _{RW}$. The limits for the number of successes, at 95 percent confidence levels, are 10 and 21 for lower and upper bounds, respectively. Because 5 < 10, it must be concluded that the probability is significantly less than 50 percent. The upper bound value for $P(_{RL} > _{RW})$ is 0.337 and the expected value is 0.181. Thus, a statistical based conclusion is that the Weibull distribution provides a consistently better representation of the data than does the lognormal distribution.

A second possible test is to repeat the first test (same hypothesis) only using the percentile values (e.g., 80th percentile) from each distribution type. For all of the parameters measured (80, 90, 95 percentiles and 80, 90, 95 upper tolerance intervals), there is no statistically significant difference between the two distribution forms for yielding either larger or smaller estimates of the percentiles and tolerance intervals. The final conclusion of this comparison is that either distribution can be used to describe the upper percentiles of the data, but that the Weibull distribution provides a consistently more accurate representation of the data. Tables D9-1

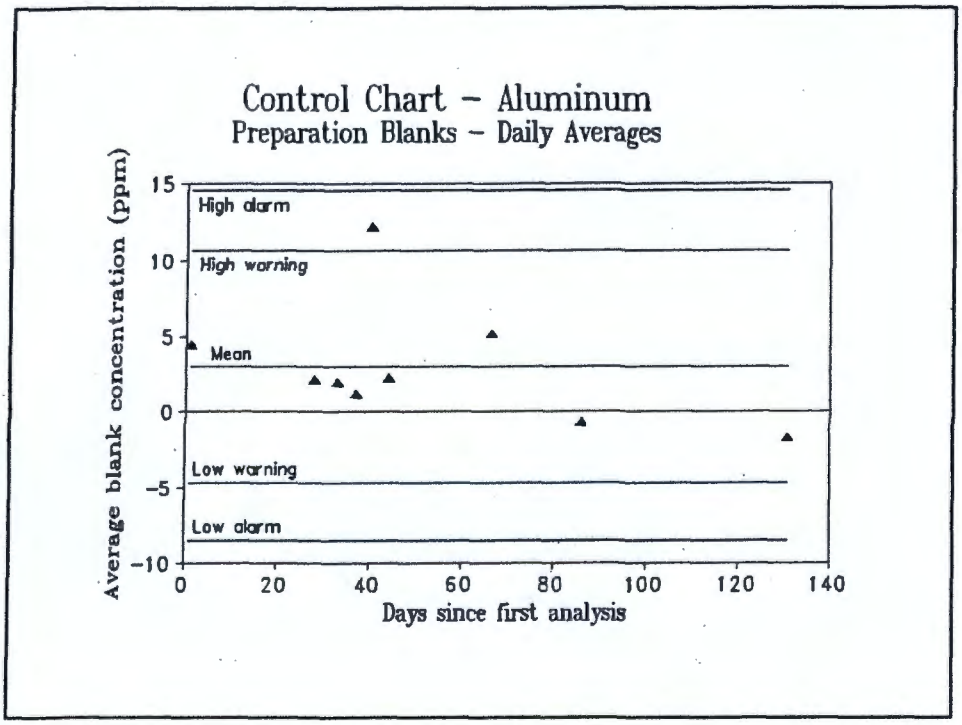
and D9-2 describe the best-fit parameters of the Weibull and lognormal distributions, respectively.

D2.13 LEAD NEAR ROADS

One issue of concern involves the possible contamination of the sample sites. The main issue is with the location of several of the sample sites near roads and the possibility of contamination of the sites with vehicle exhaust particulates, especially lead.

Sample sites selected as being 'near' roads are site Nos. 1, 5, 6, 7, 8, 9, 13, and 14. Site descriptions are provided in Appendix A. A number of the sites are located in and around the 200 Areas. The systematic random data were stratified as described previously. Additionally, aluminum data also were stratified. Aluminum and lead showed a definite positive correlation in all of the samples (r^2 = .55+). Therefore, it would be expected that if lead were added to the soil by vehicle exhaust, this correlation would not hold for the near-road sites. Figure D8 shows the variation diagram of lead versus aluminum. The straight line is the regression line using all of the systematic random data excluding the largest lead datum, which obviously does not follow the correlation trend. Figure D8 amply demonstrates that (1) the two data sets are not different with respect to the trend pattern and interelement correlations and (2) the near-road data set is obviously lower overall in both aluminum and lead.

The overall lower values for aluminum and lead can be attributed to the characteristics of the sites and the pattern of the stratification of the data sets. The near-road sites are all sites in which the pattern of depositions was primarily high-energy deposits (main channel) in which the sediment material can be expected to be coarser grained and denser than the overall site average. Aluminum and lead can be expected to be found as part of the less-dense aluminosilicate minerals. This, combined with the lower surface area resulting from coarse-grained materials, can be expected to generate lower values for both lead and aluminum in the near-road sites.



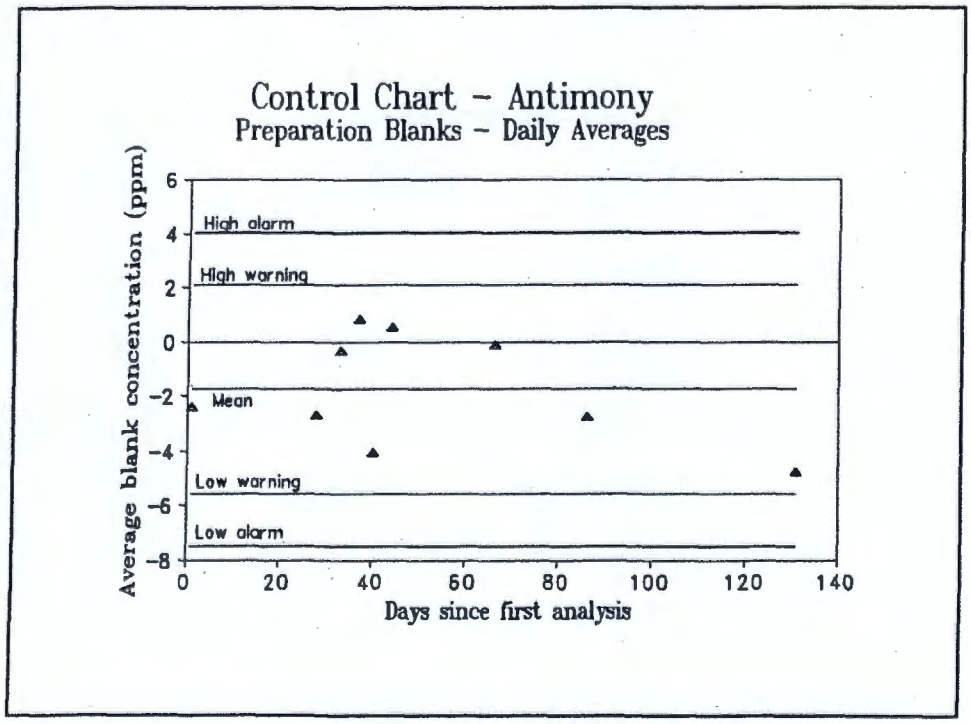
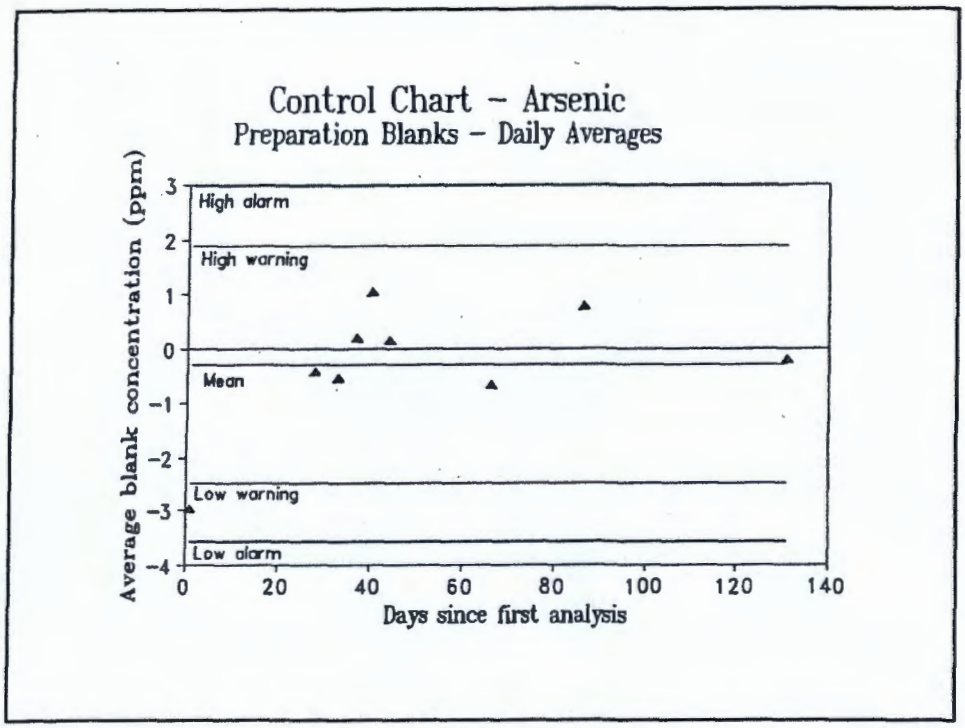


Figure D1-1. Daily Average Control Charts for Aluminum and Antimony.



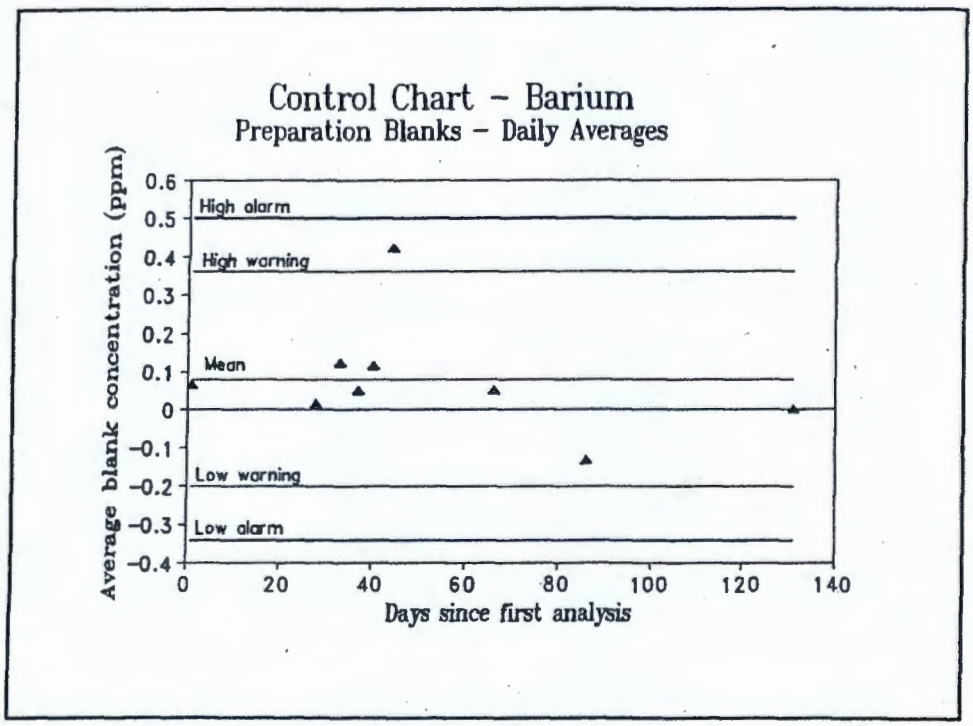
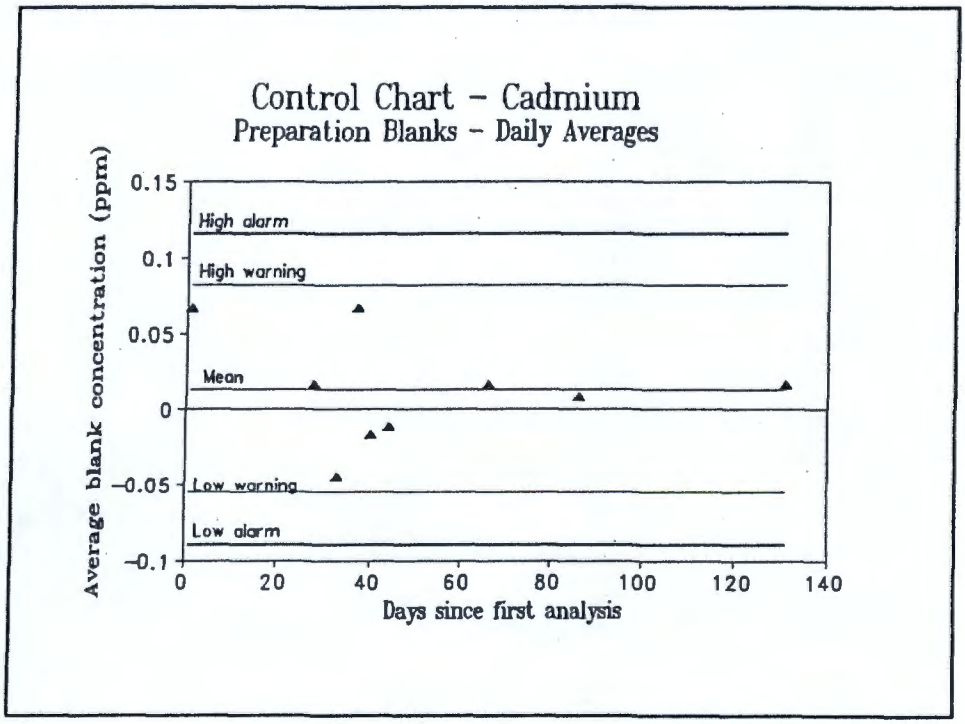


Figure DI-2. Daily Average Control Charts for Arsenic and Barium.



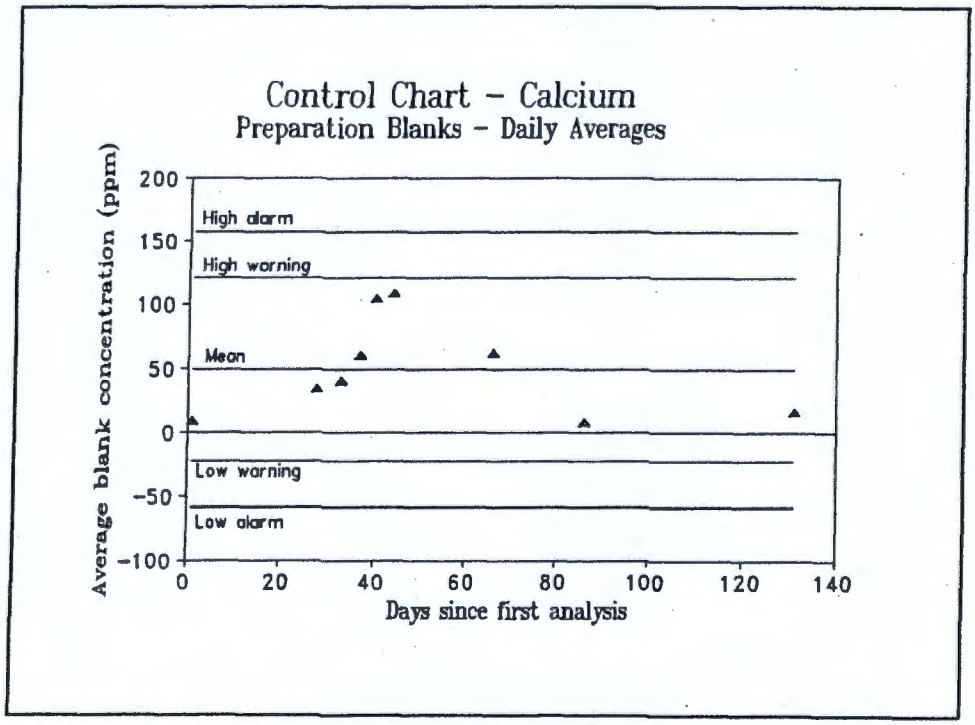
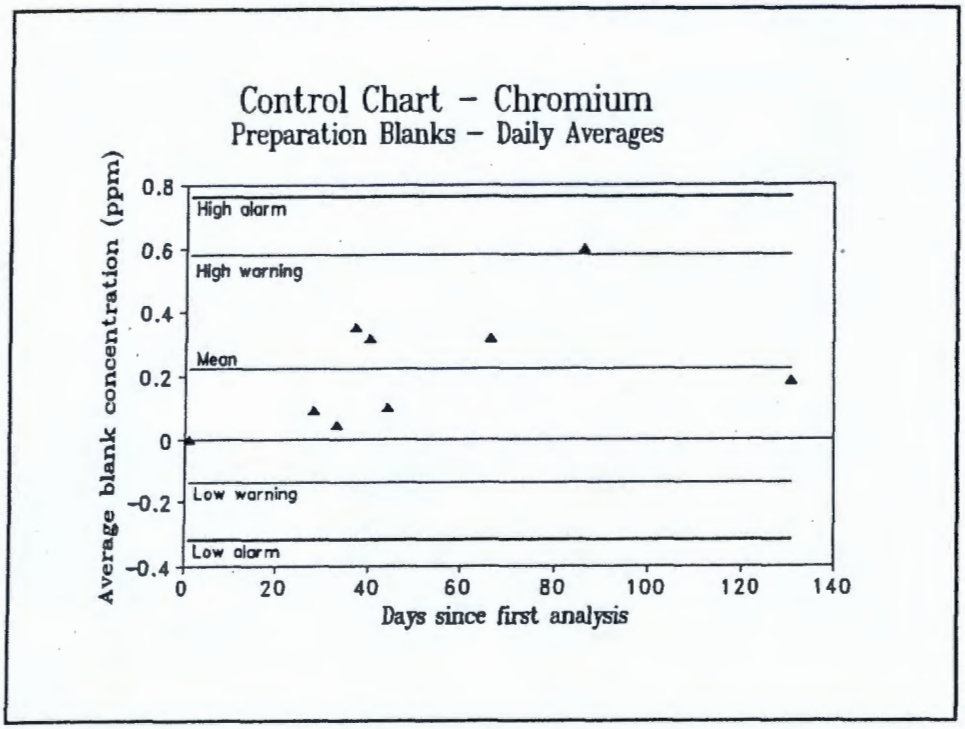


Figure D1-3. Daily Average Control Charts for Cadmium and Calcium.



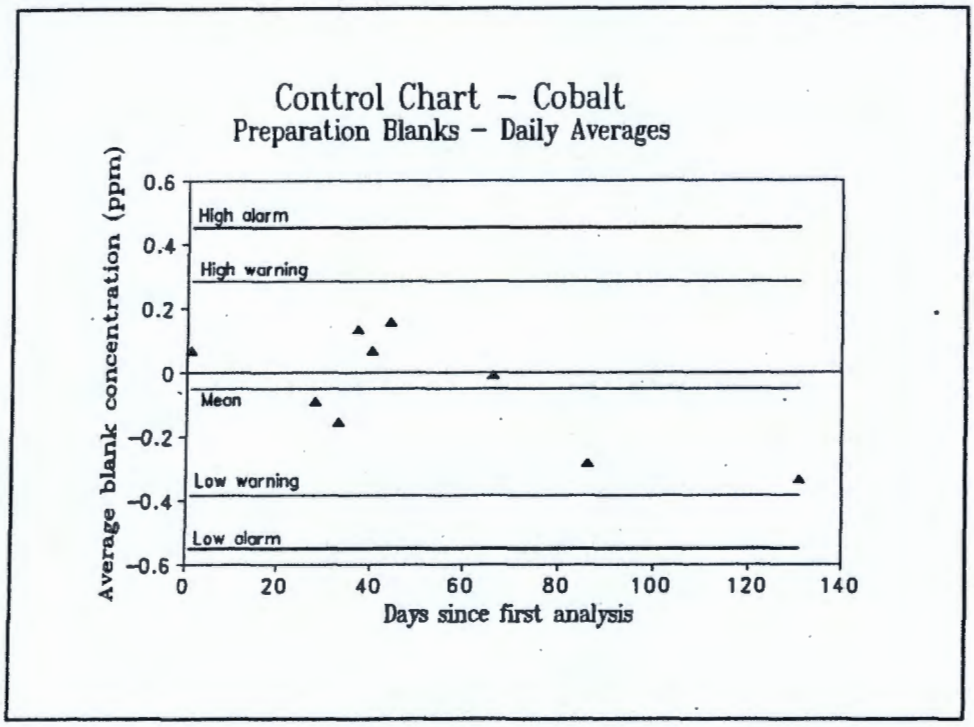
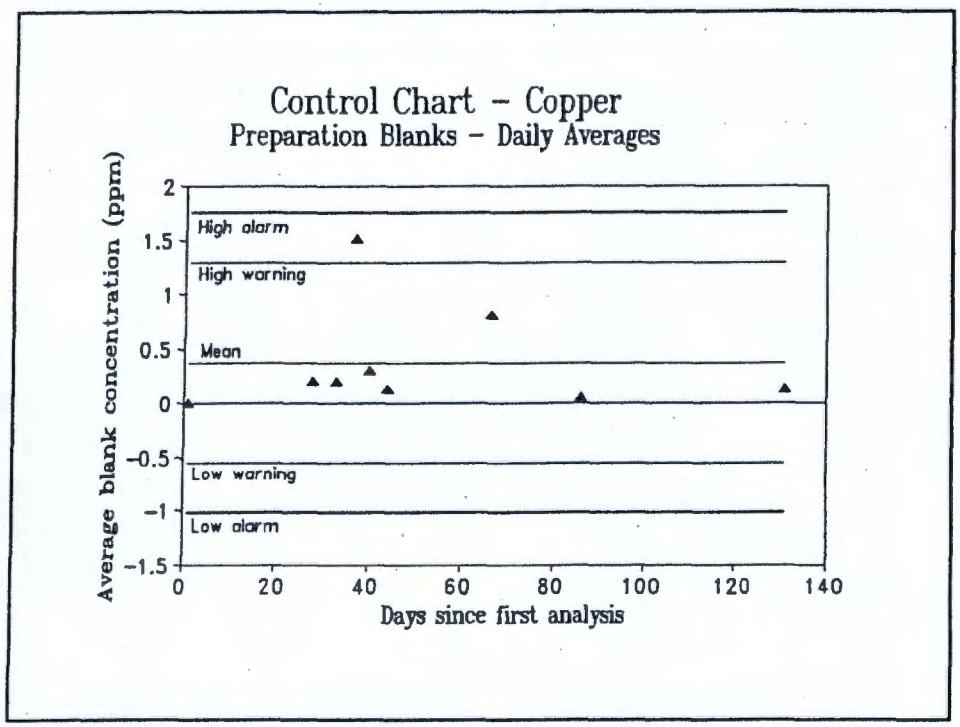


Figure D1-4. Daily Average Control Charts for Chromium and Cobalt.



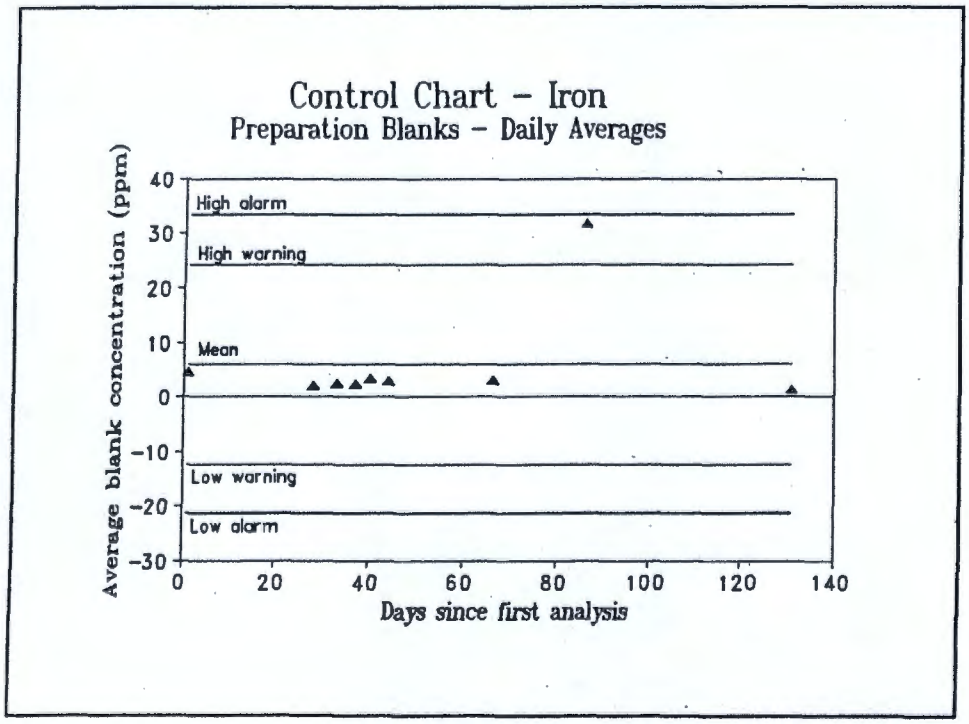
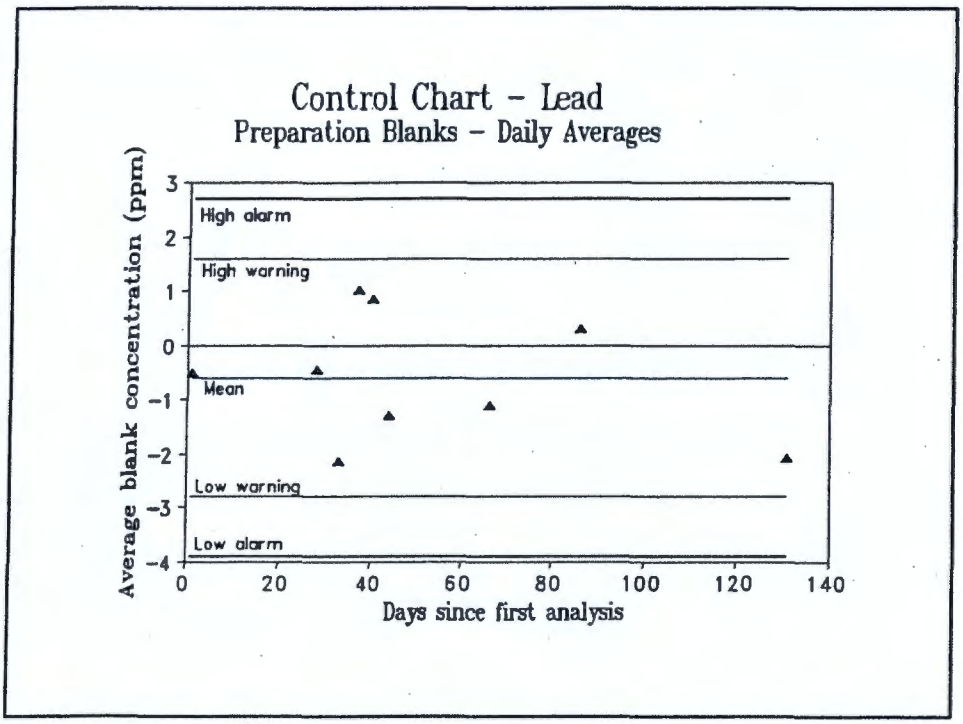


Figure D1-5. Daily Average Control Charts for Copper and Iron.



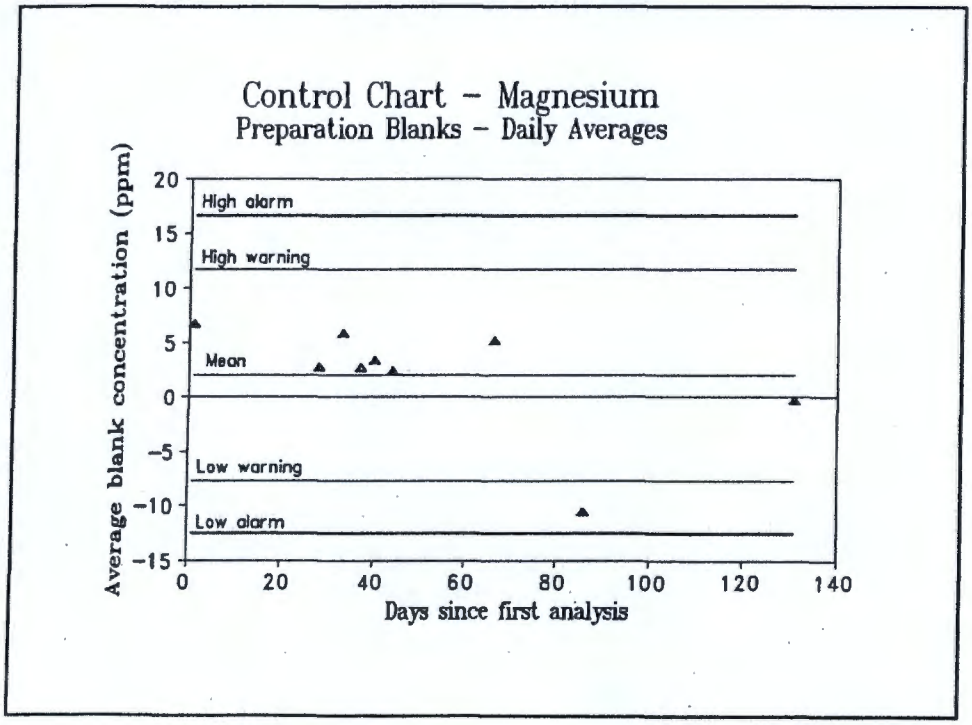
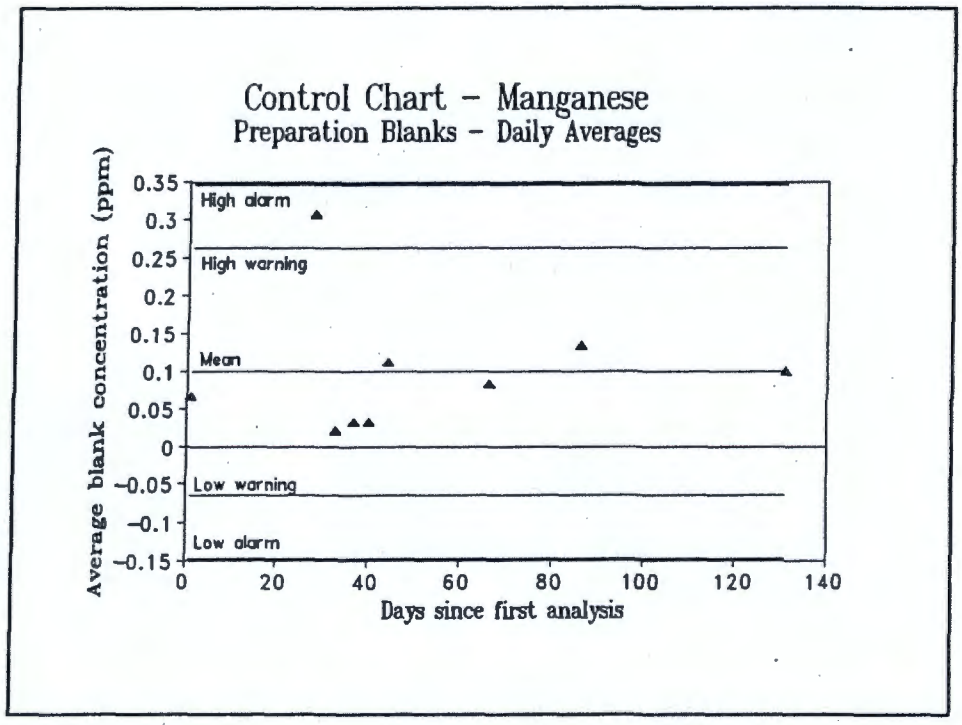


Figure D1-6. Daily Average Control Charts for Lead and Magnesium.



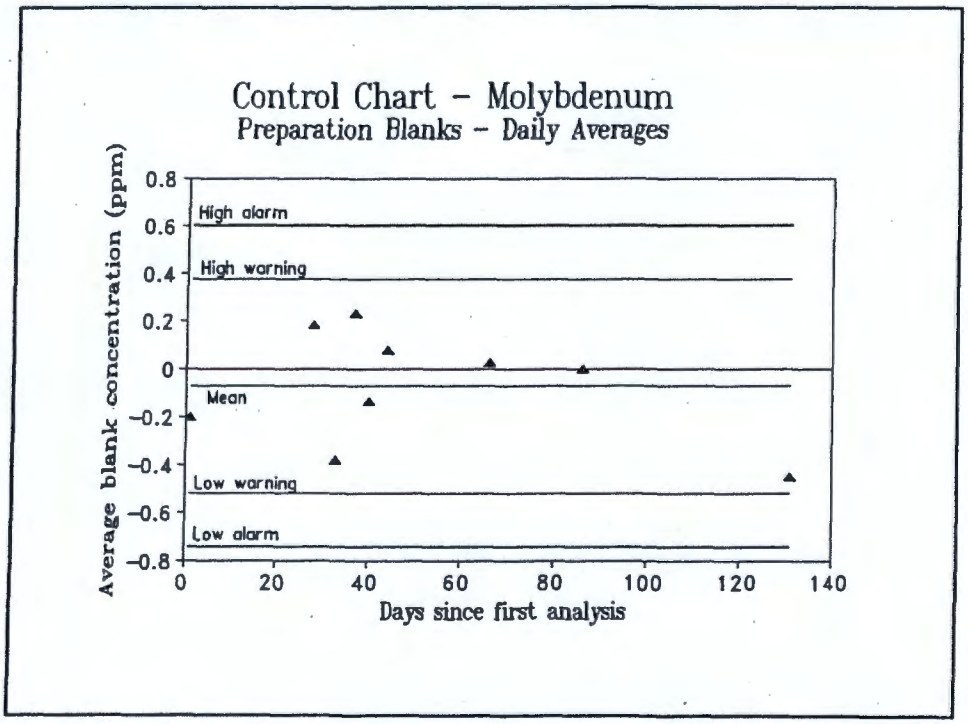
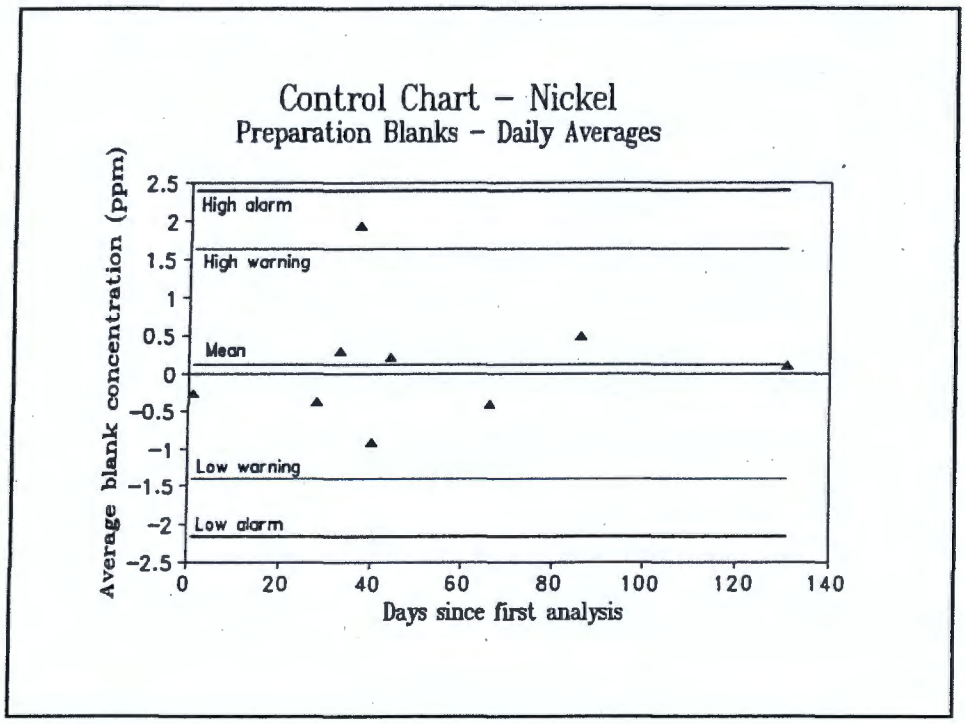


Figure D1-7. Daily Average Control Charts for Manganese and Molybdenum.



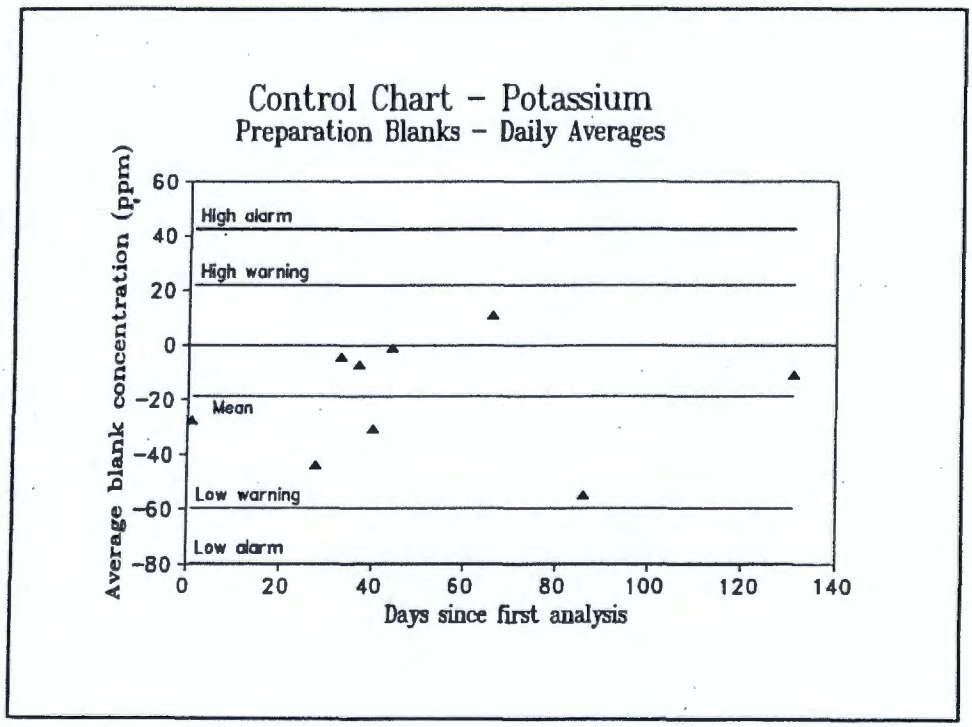
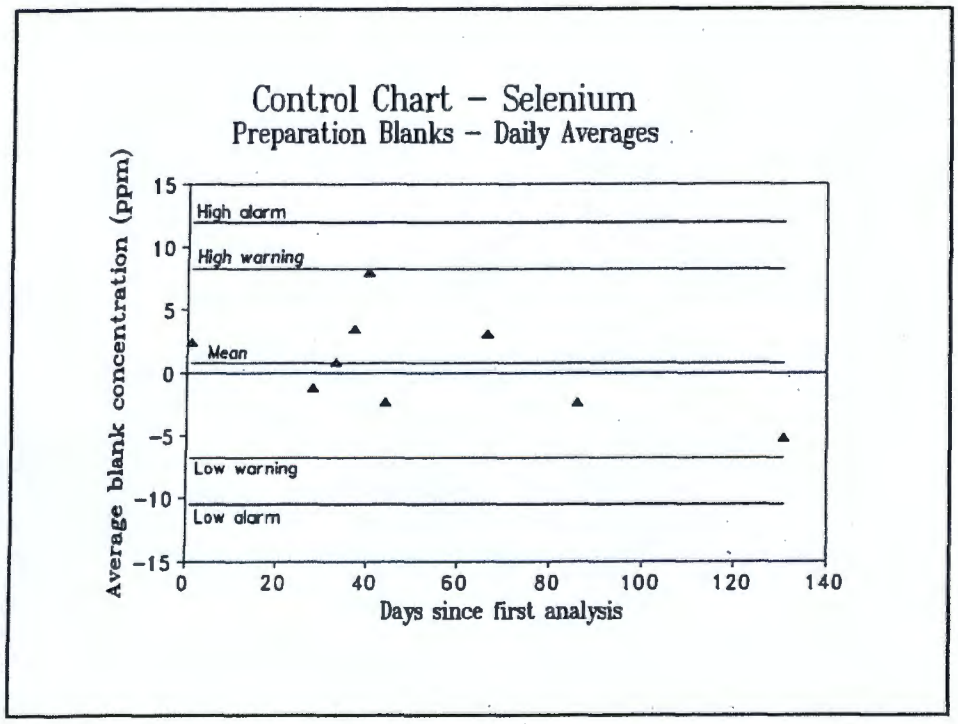


Figure D1-8. Daily Average Control Charts for Nickel and Potassium.



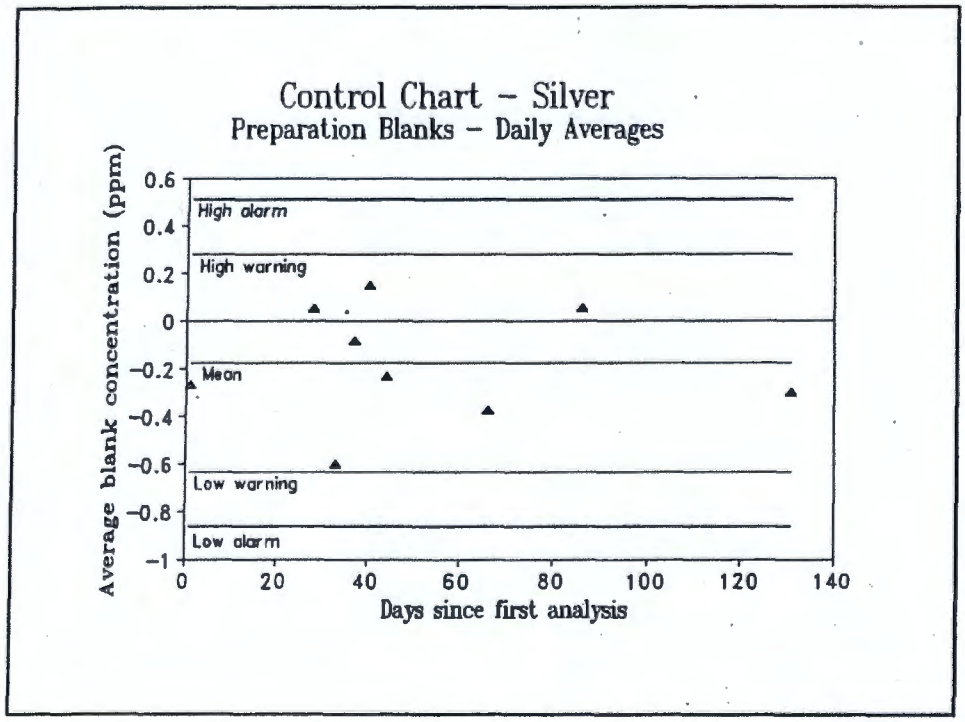
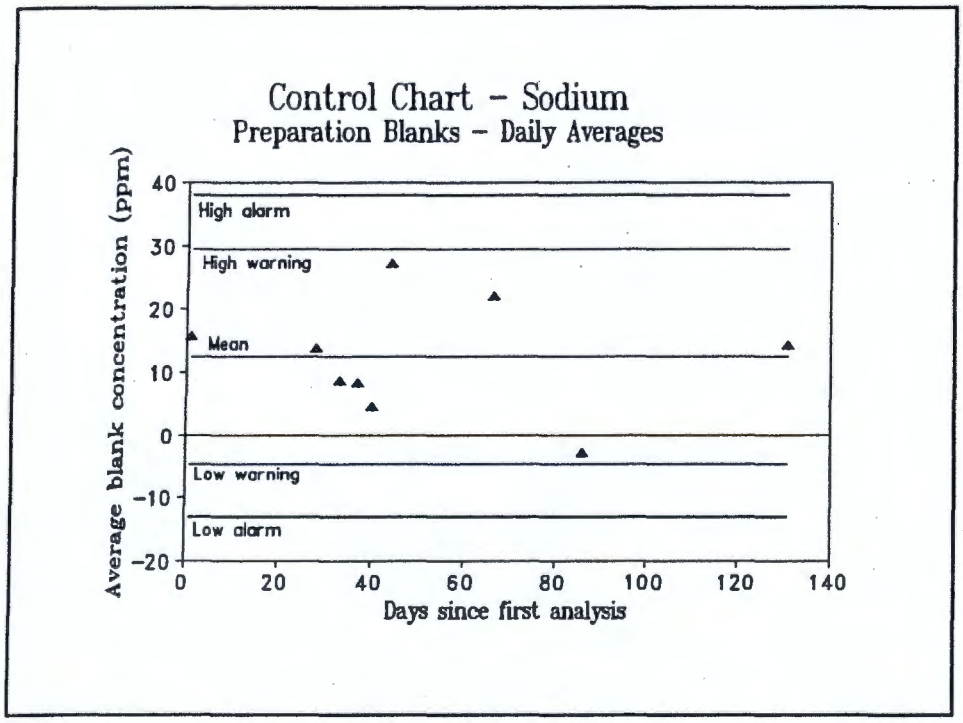


Figure D1-9. Daily Average Control Charts for Selenium and Silver.



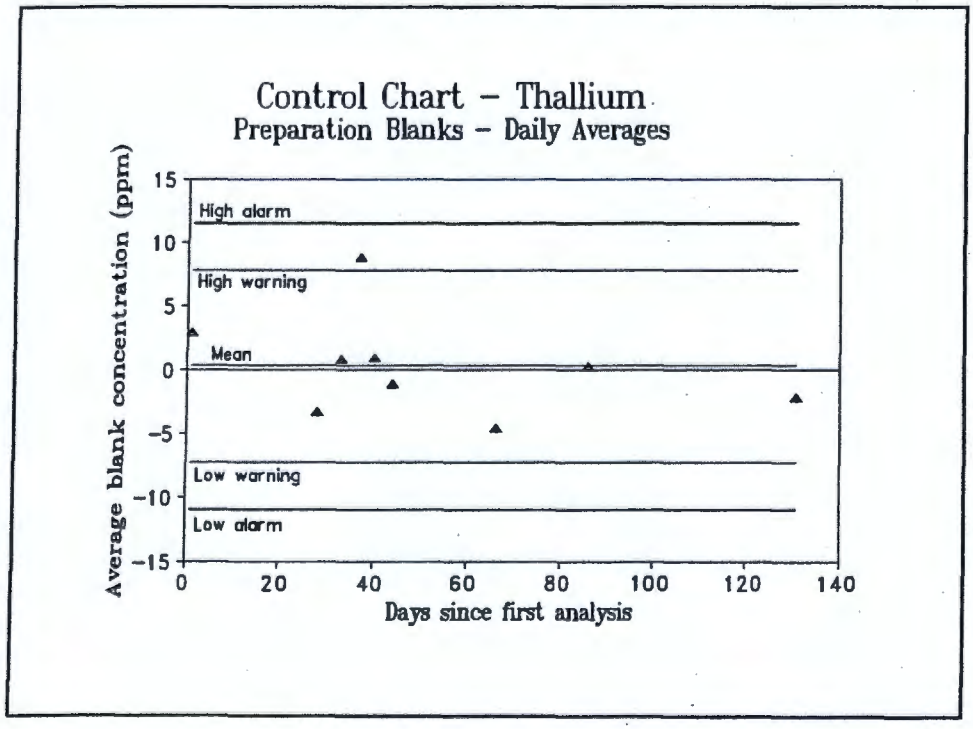
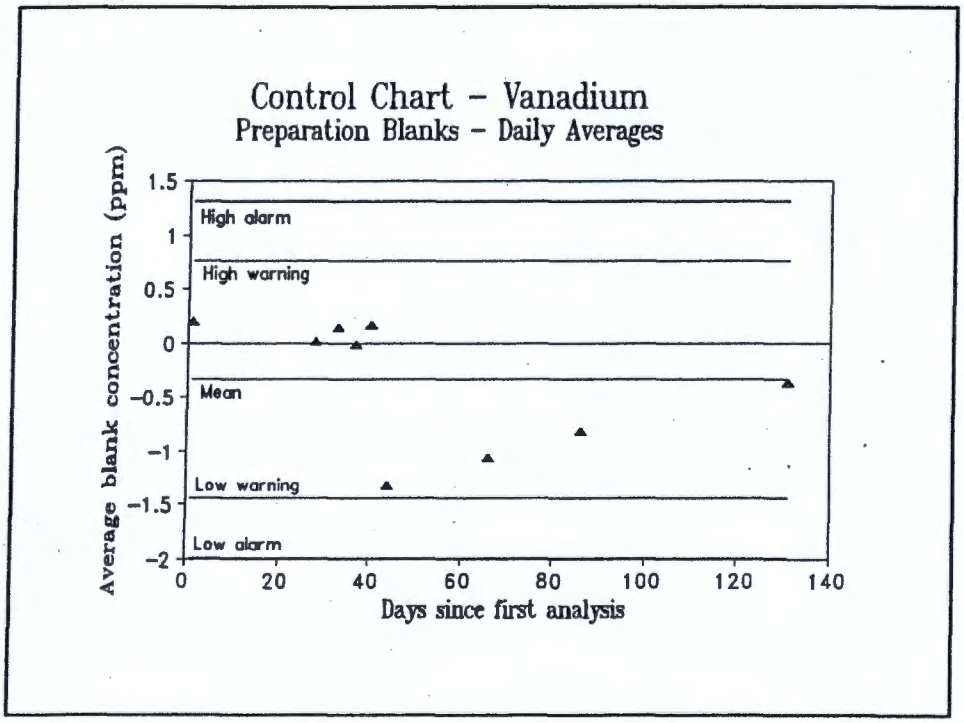


Figure D1-10. Daily Average Control Charts for Sodium and Thallium.



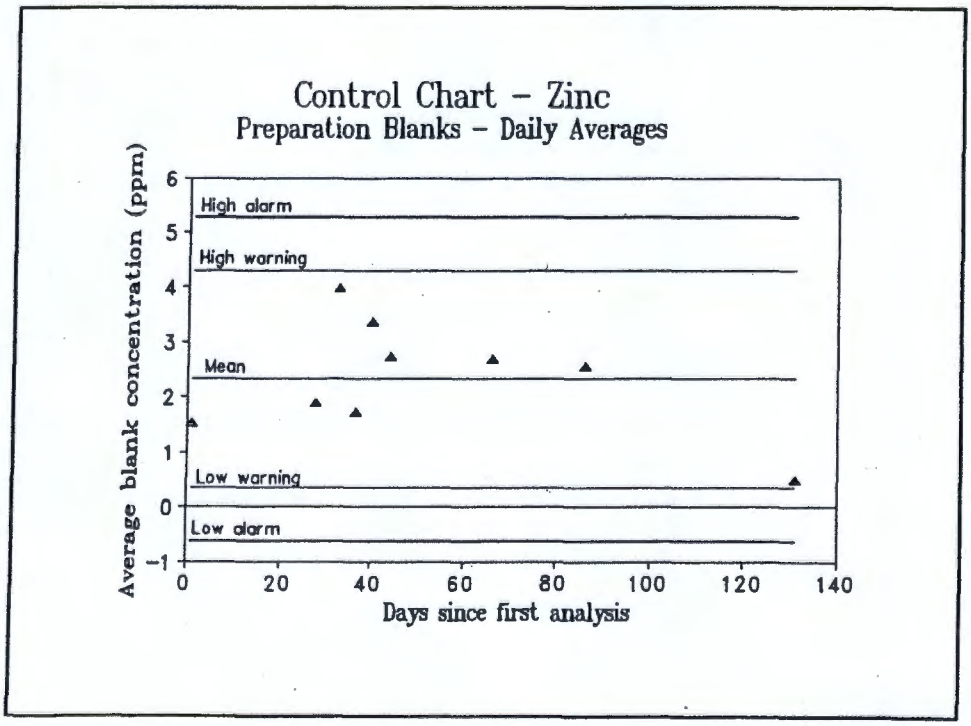
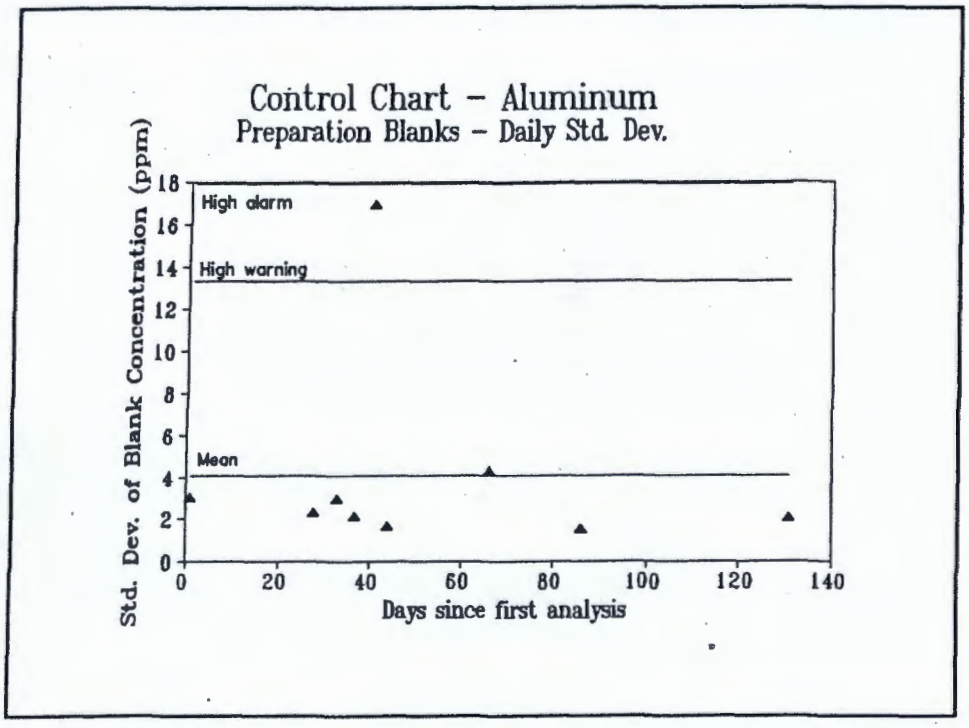


Figure D1-11. Daily Average Control Charts for Vanadium and Zinc.



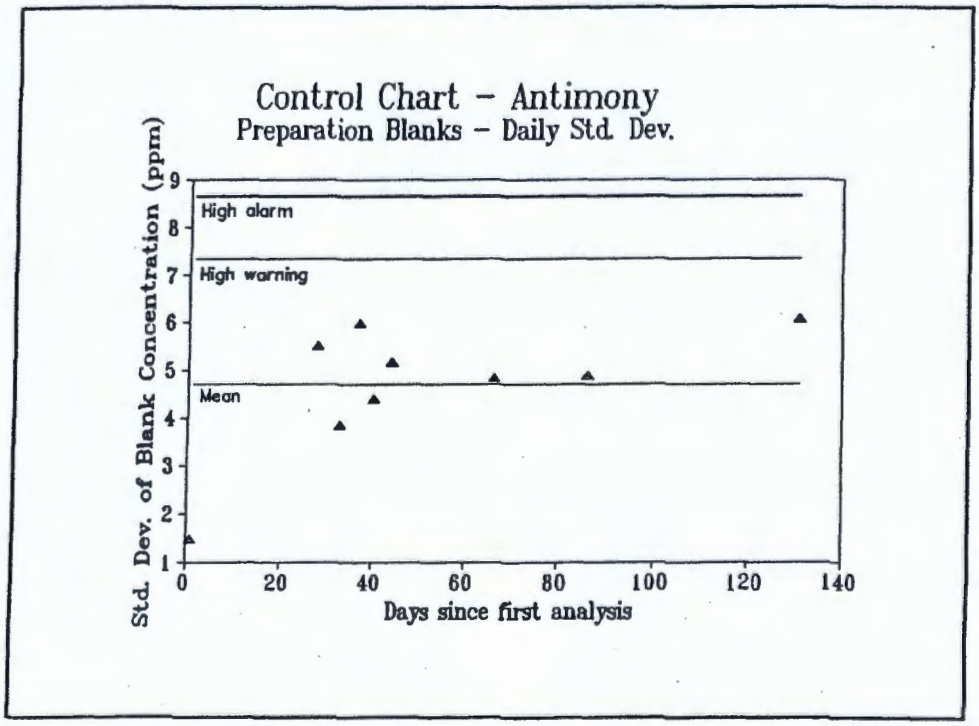
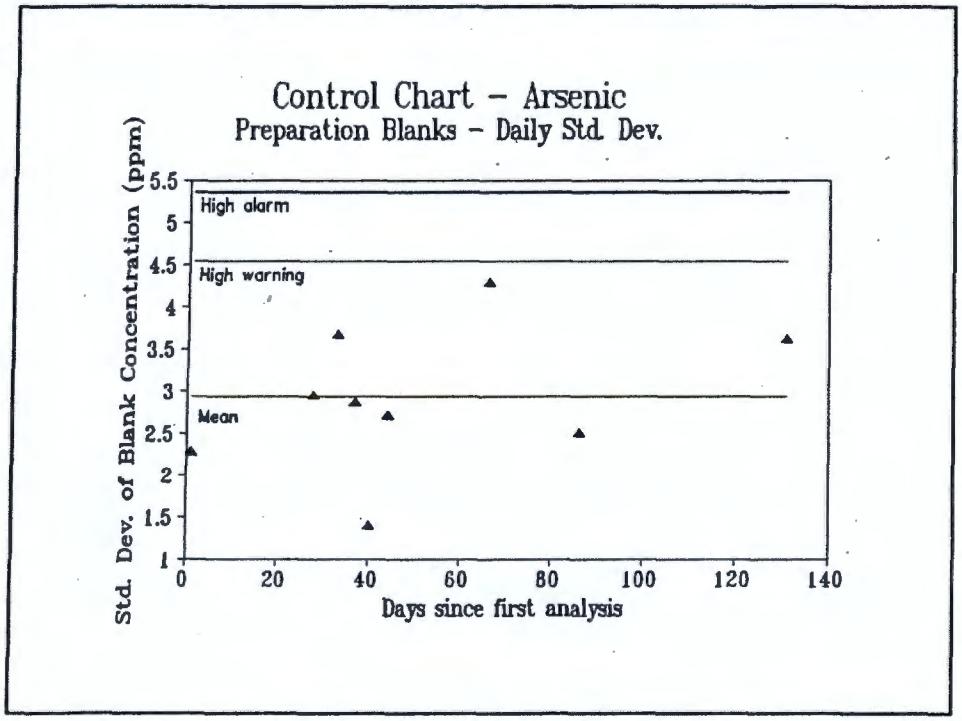


Figure D2-1. Daily Standard Deviation Control Charts for Aluminum and Antimony.



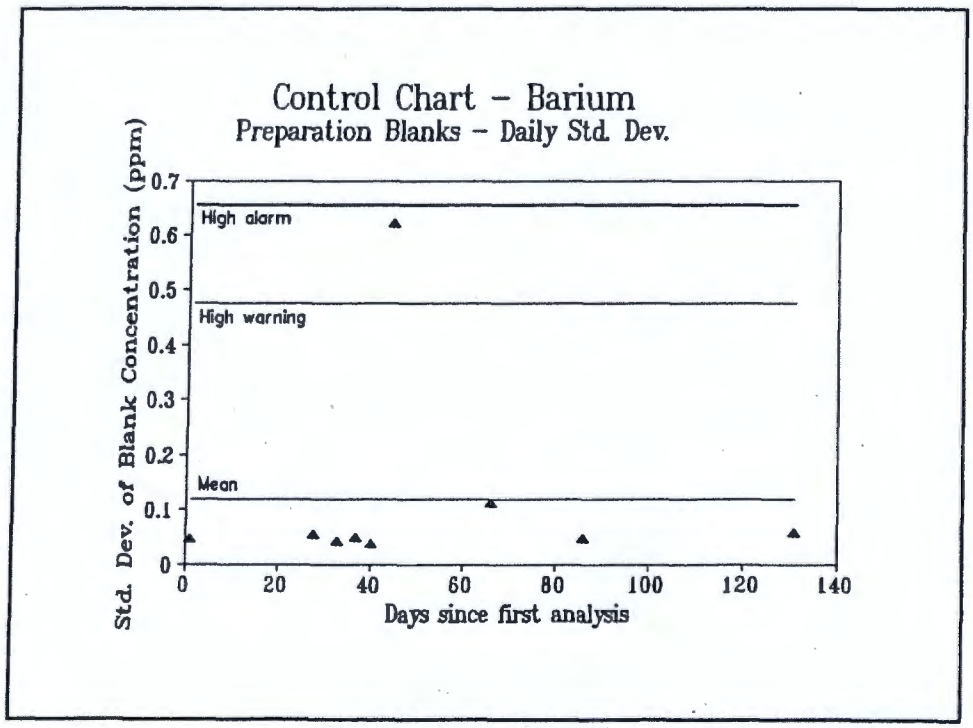
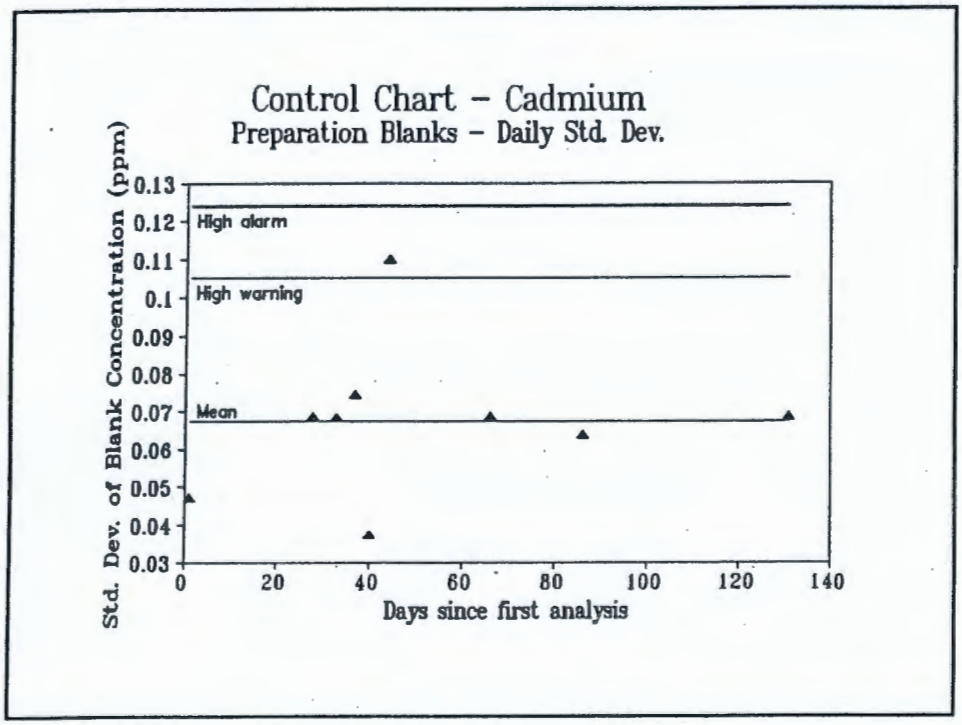


Figure D2-2. Daily Standard Deviation Control Charts for Arsenic and Barium.



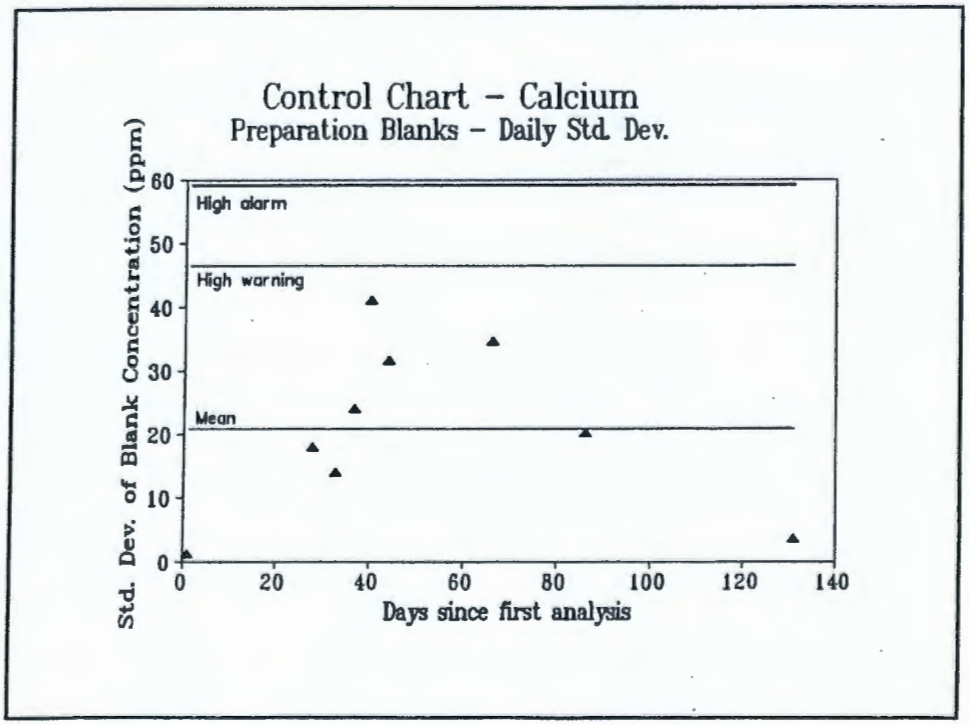
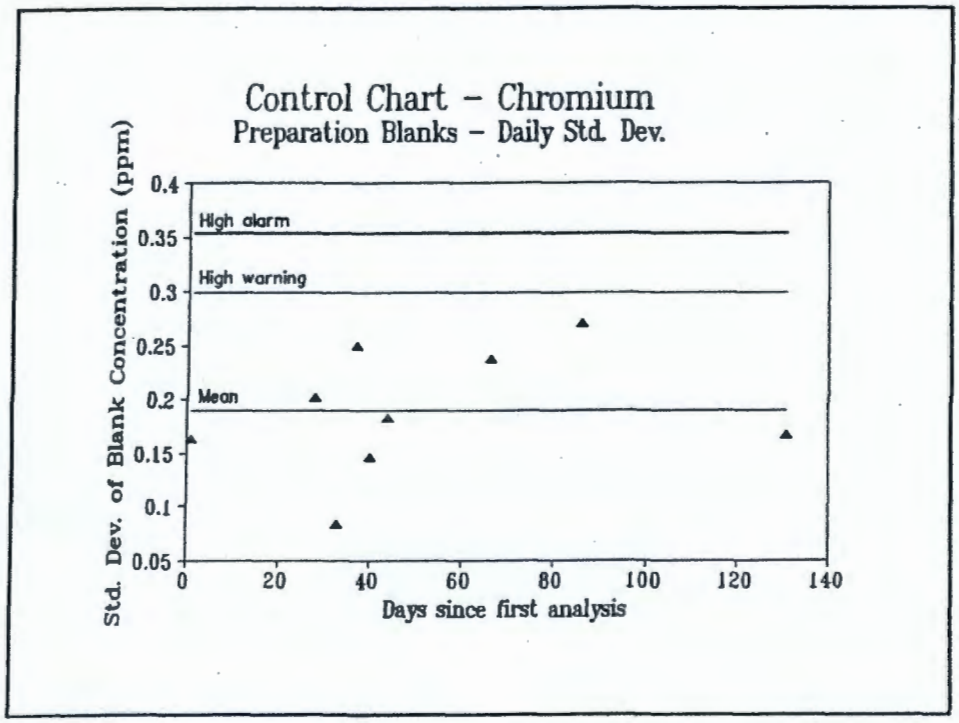


Figure D2-3. Daily Standard Deviation Control Charts for Cadmium and Calcium.



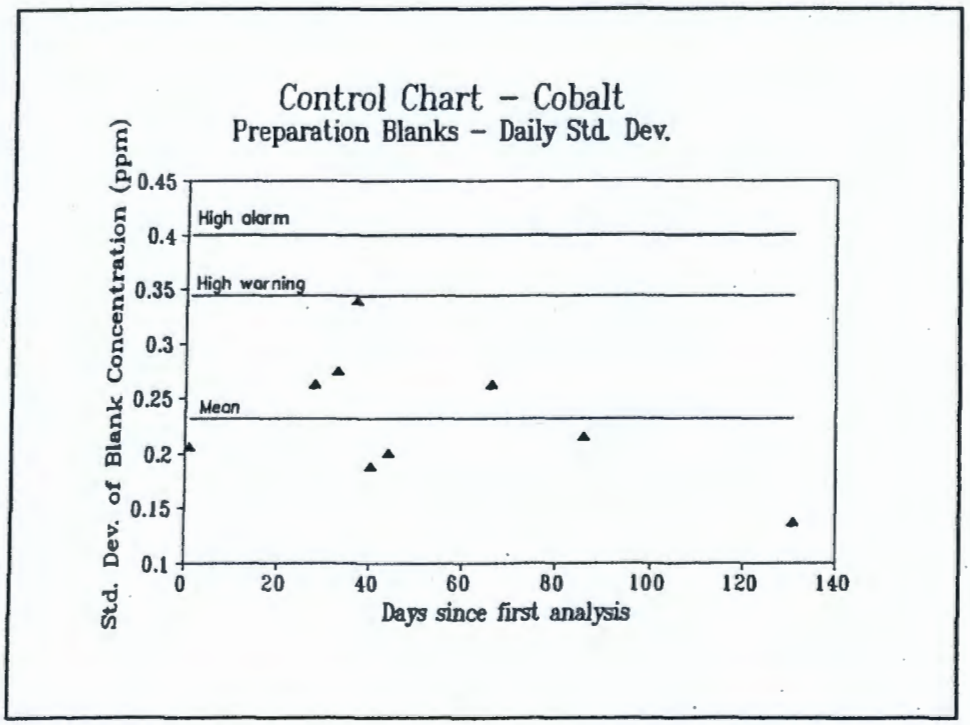
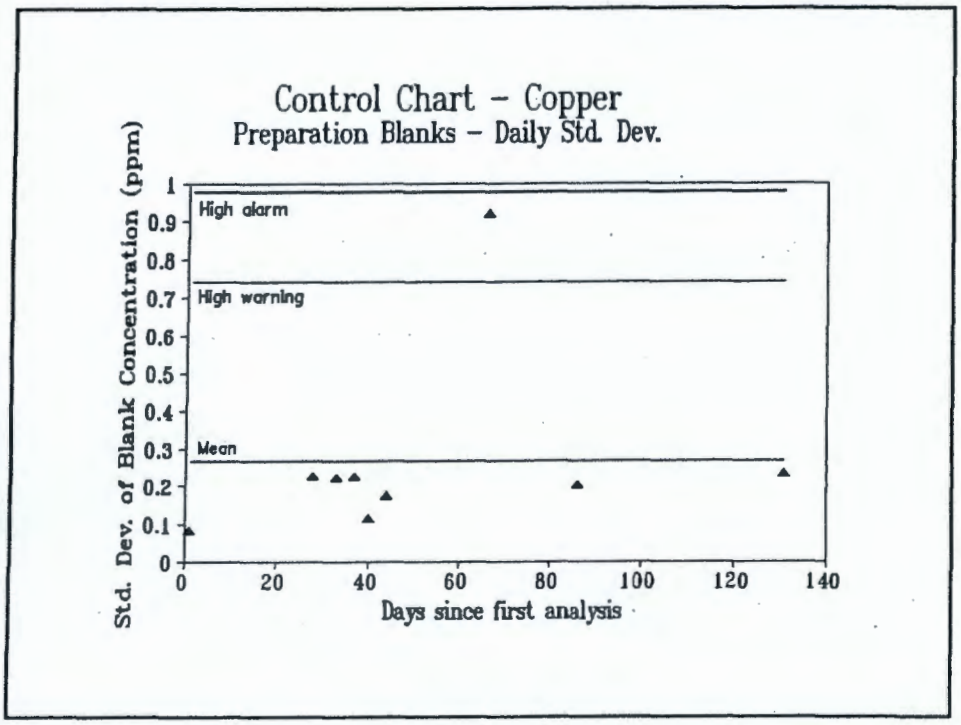


Figure D2-4. Daily Standard Deviation Control Charts for Chromium and Cobalt.



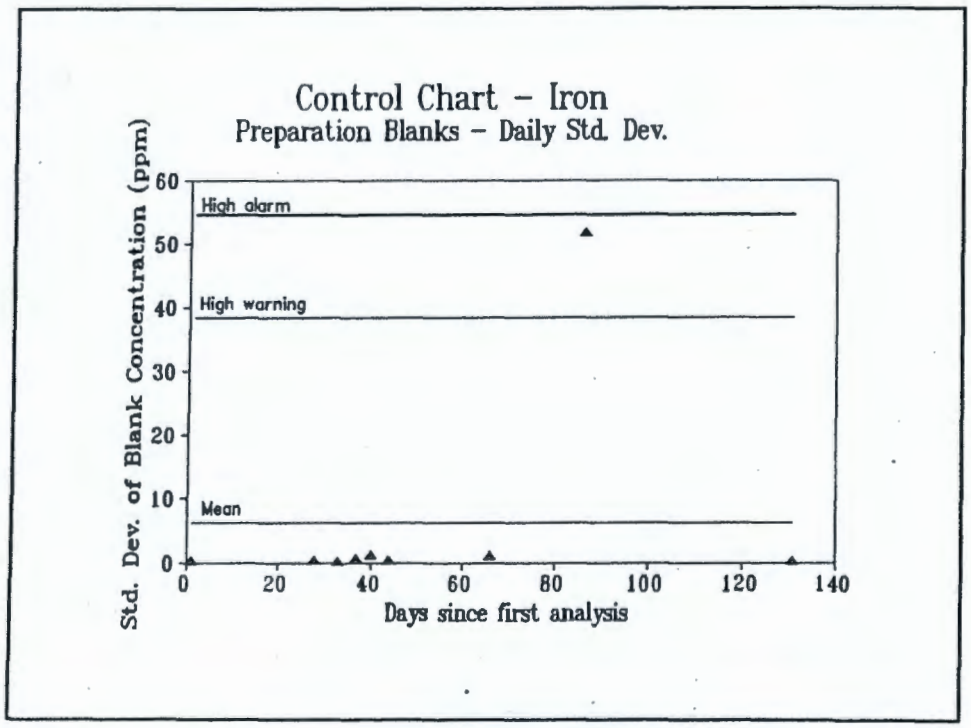
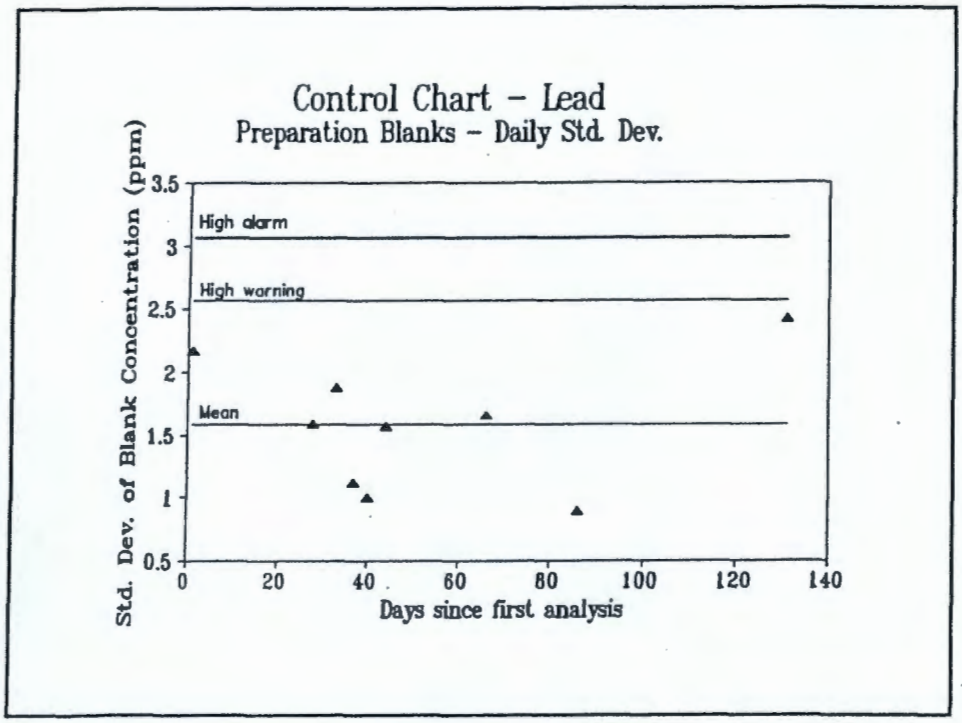


Figure D2-5. Daily Standard Deviation Control Charts for Copper and Iron.



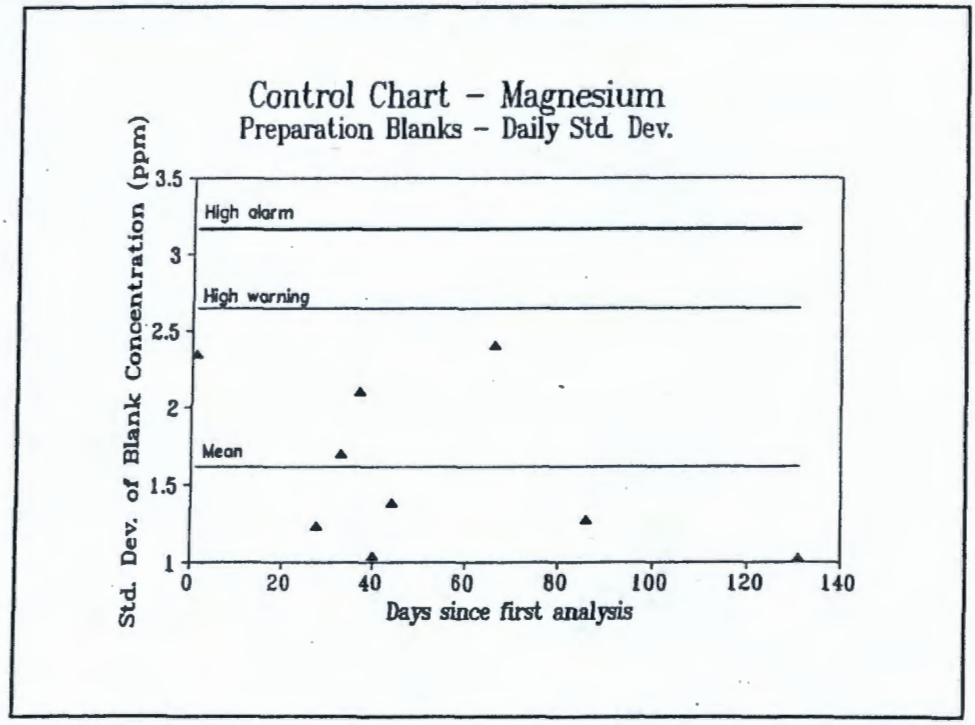
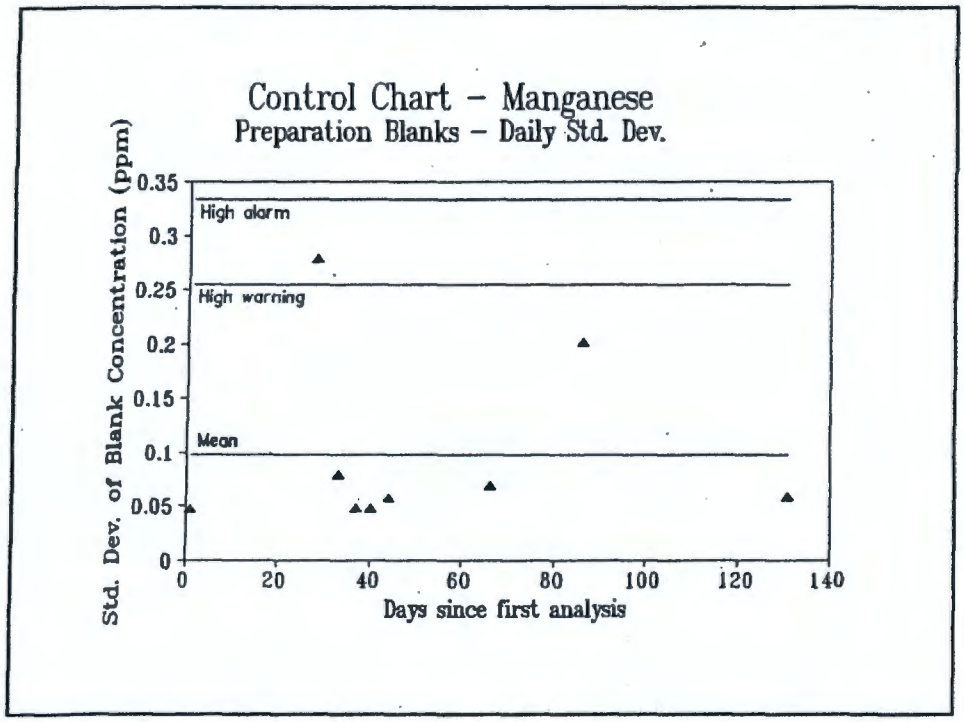


Figure D2-6. Daily Standard Deviation Control Charts for Lead and Magnesium.



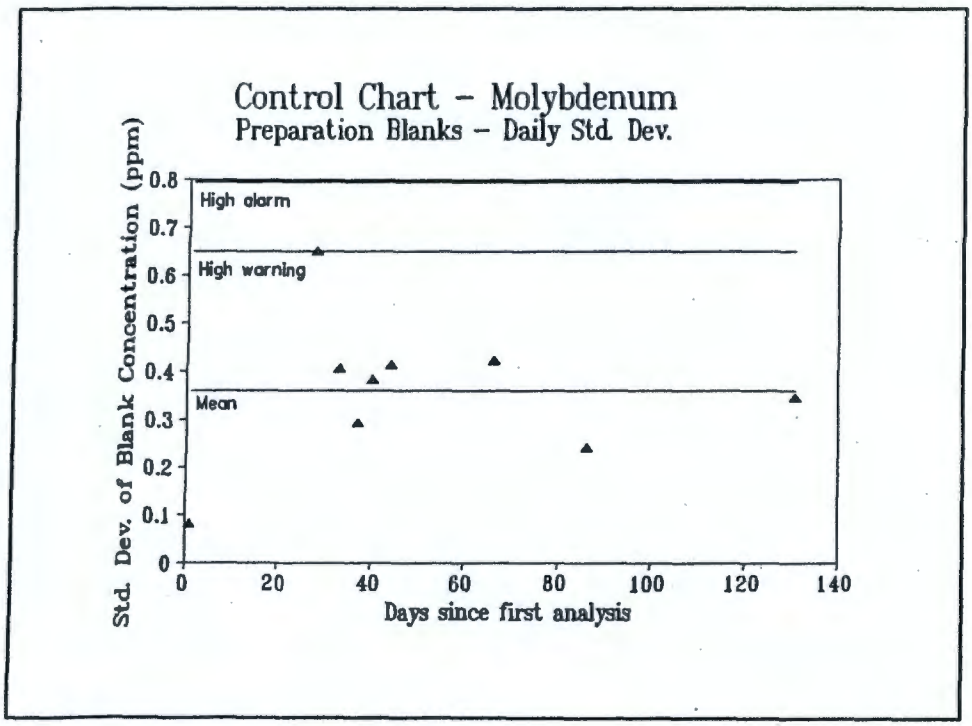
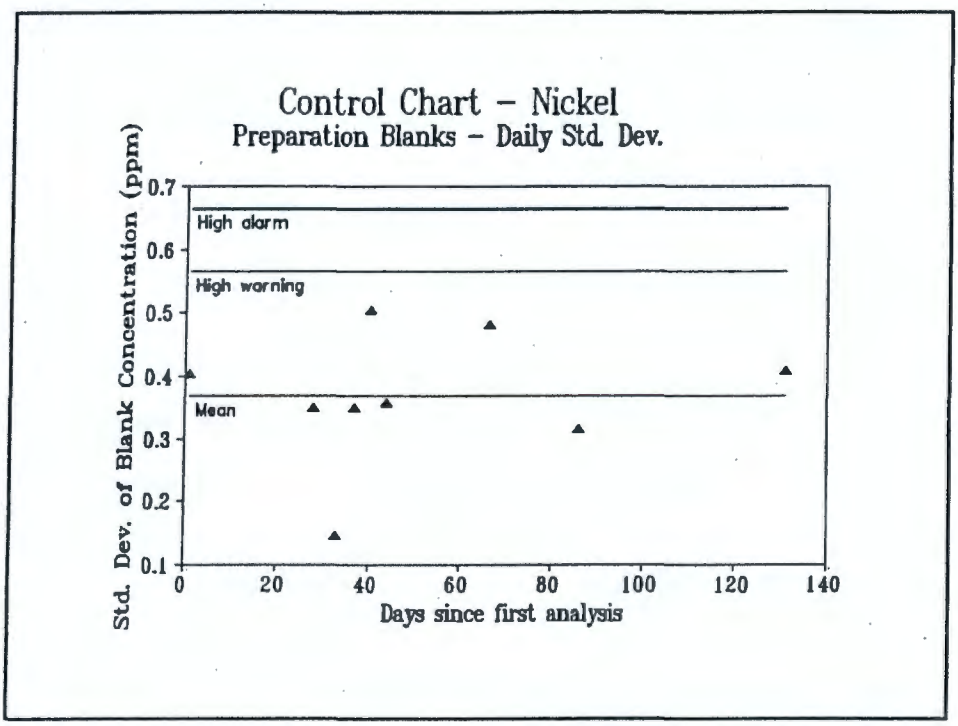


Figure D2-7. Daily Standard Deviation Control Charts for Manganese and Molybdenum.



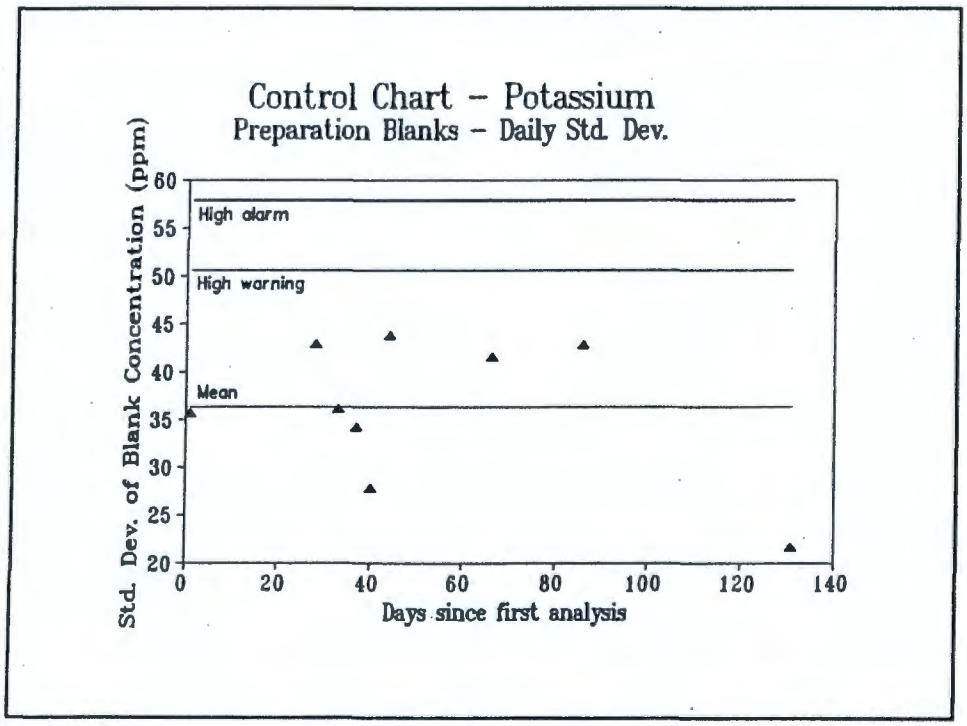
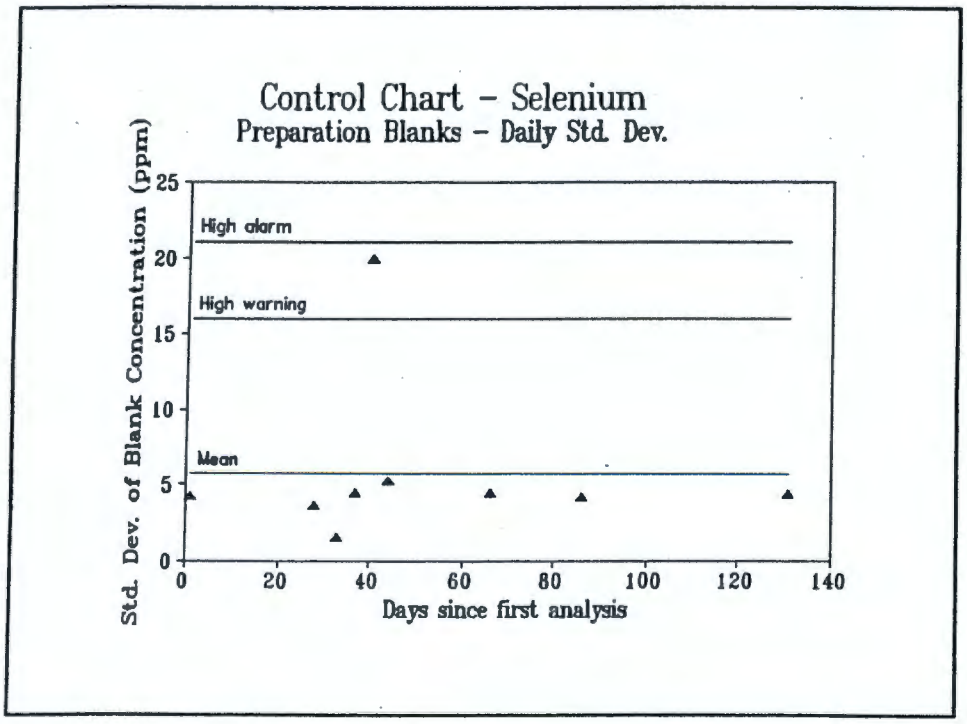


Figure D2-8. Daily Standard Deviation Control Charts for Nickel and Potassium.



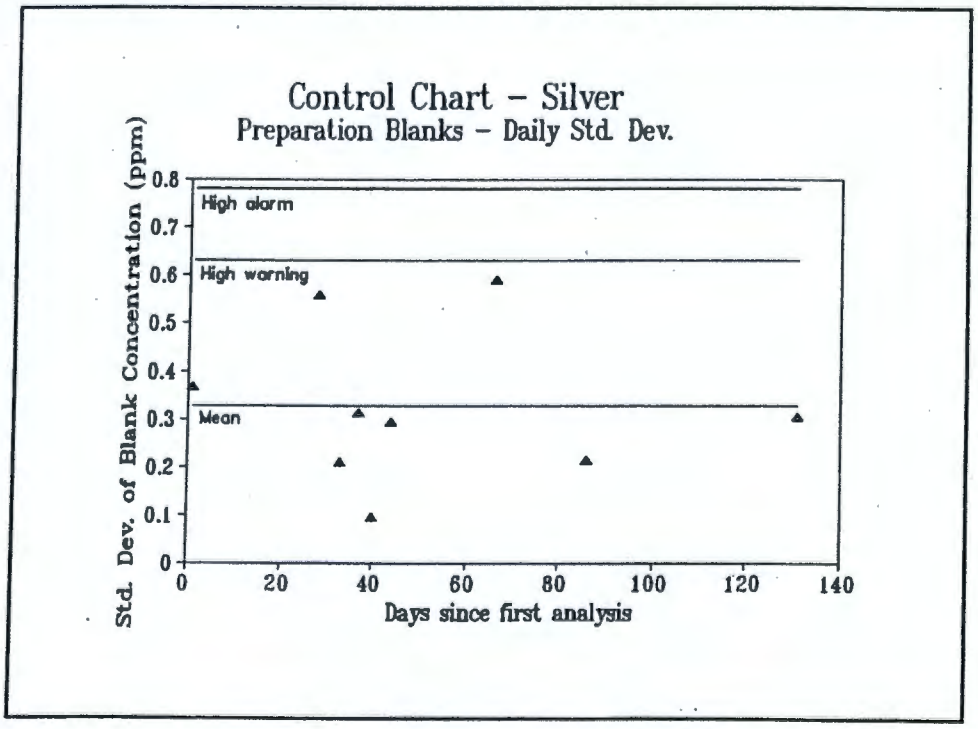
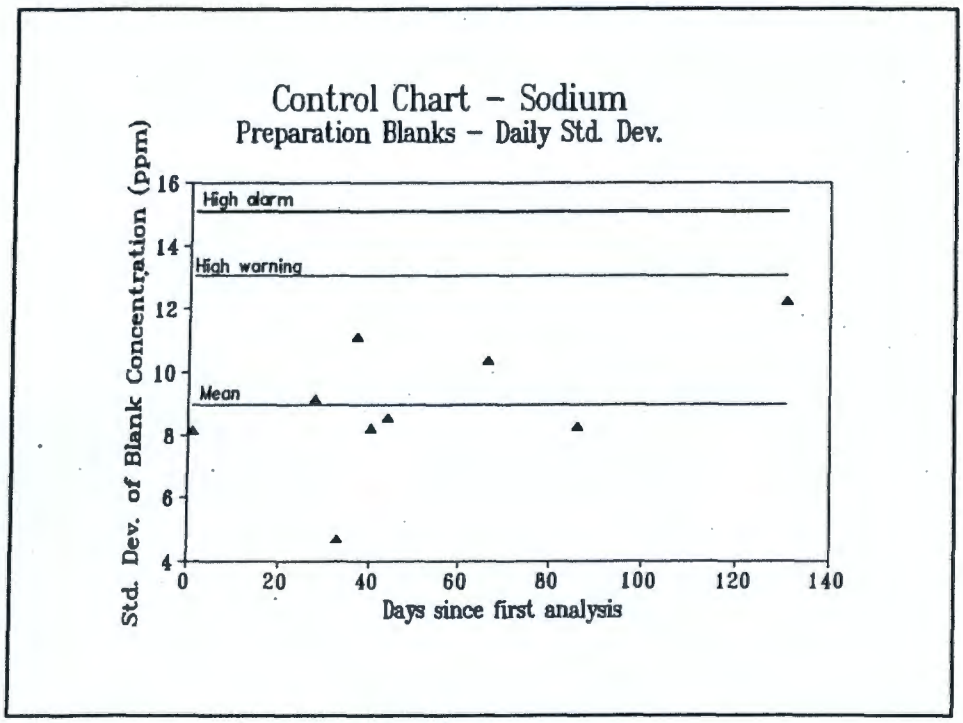


Figure D2-9. Daily Standard Deviation Control Charts for Selenium and Silver.



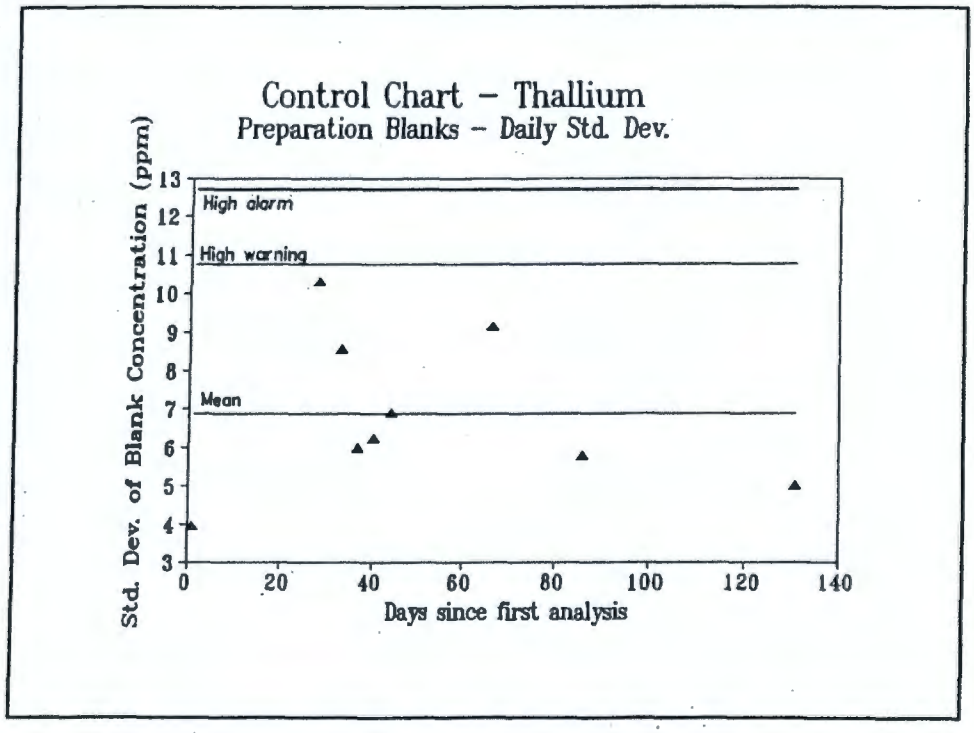
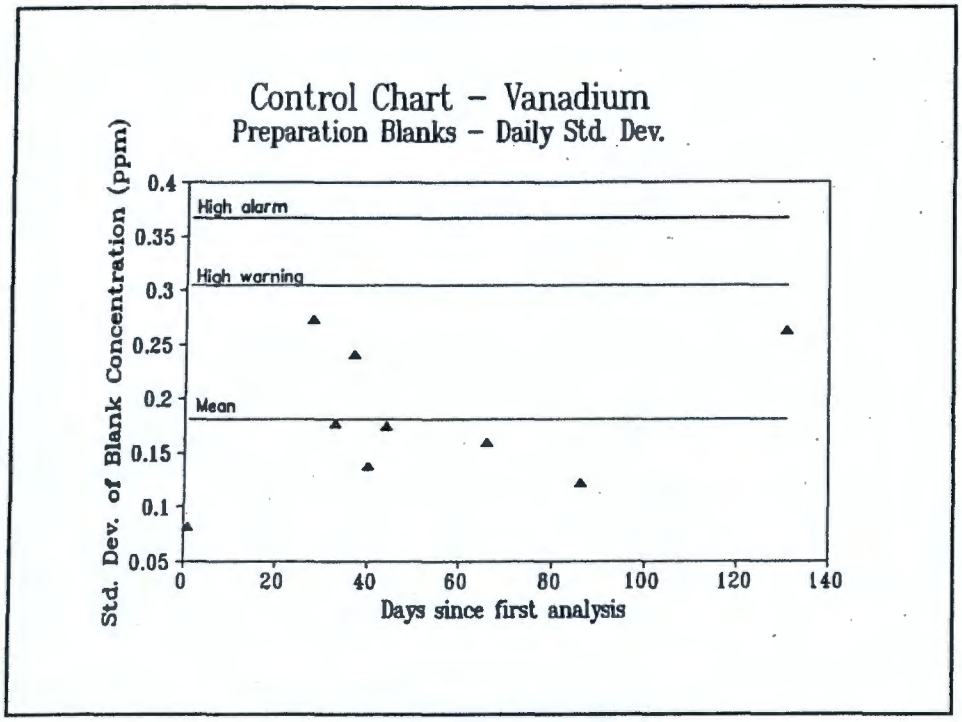


Figure D2-10. Daily Standard Deviation Control Charts for Sodium and Thallium.



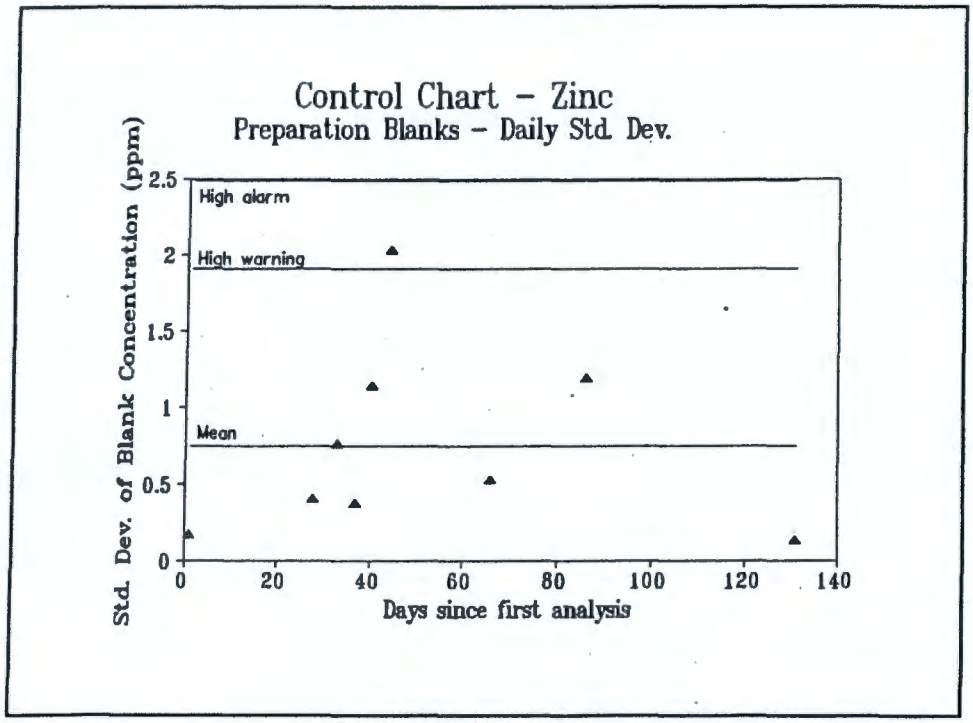
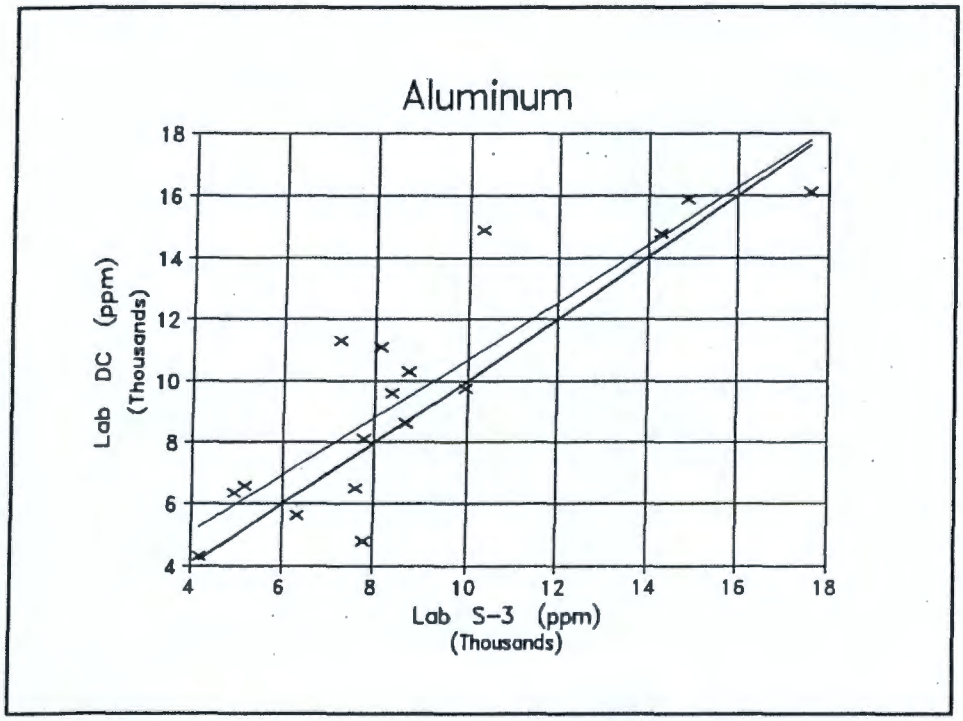


Figure D2-11. Daily Standard Deviation Control Charts for Vanadium and Zinc.



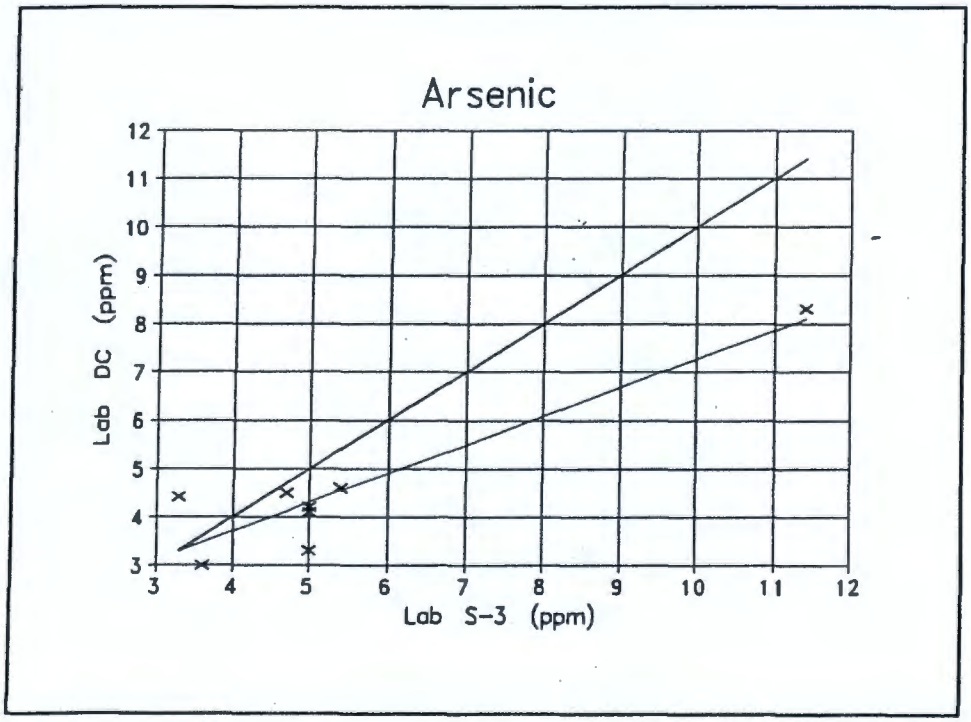
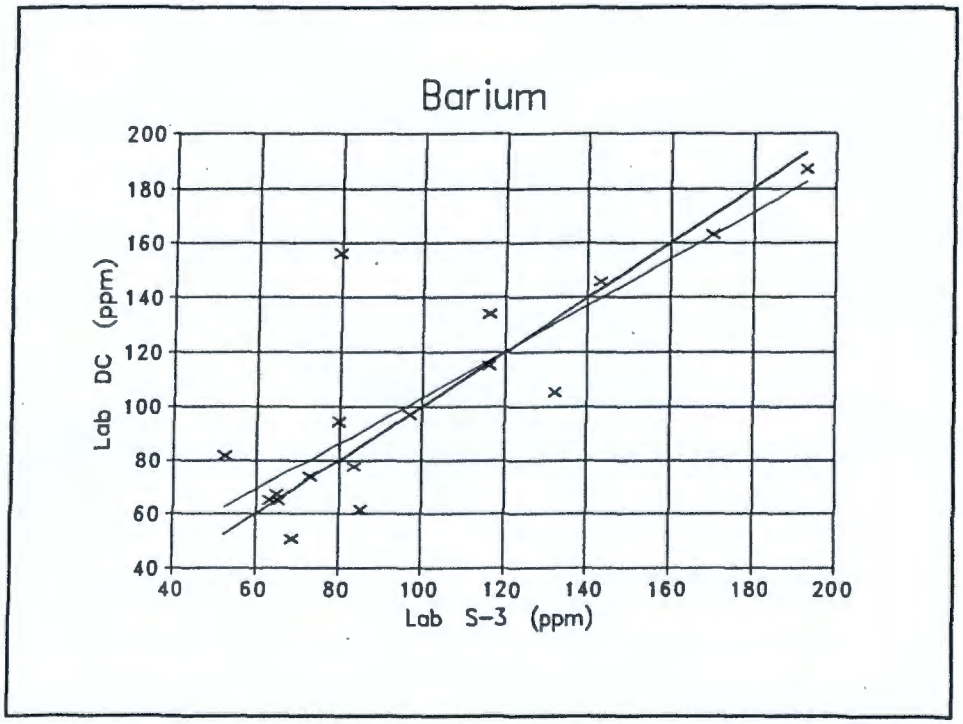


Figure D3-1. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Aluminum and Arsenic.



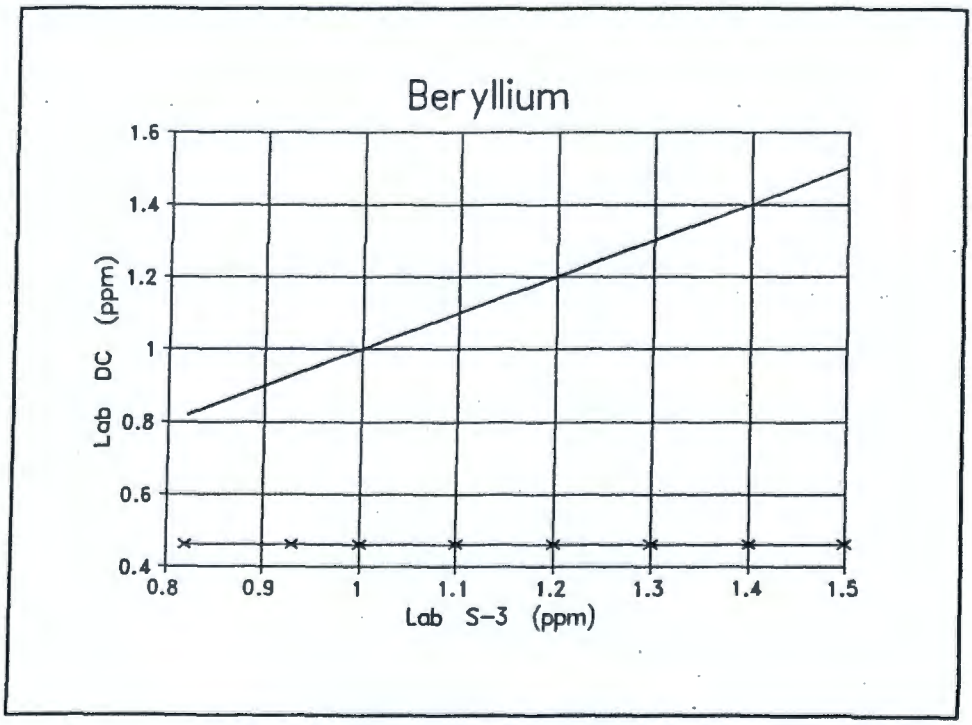
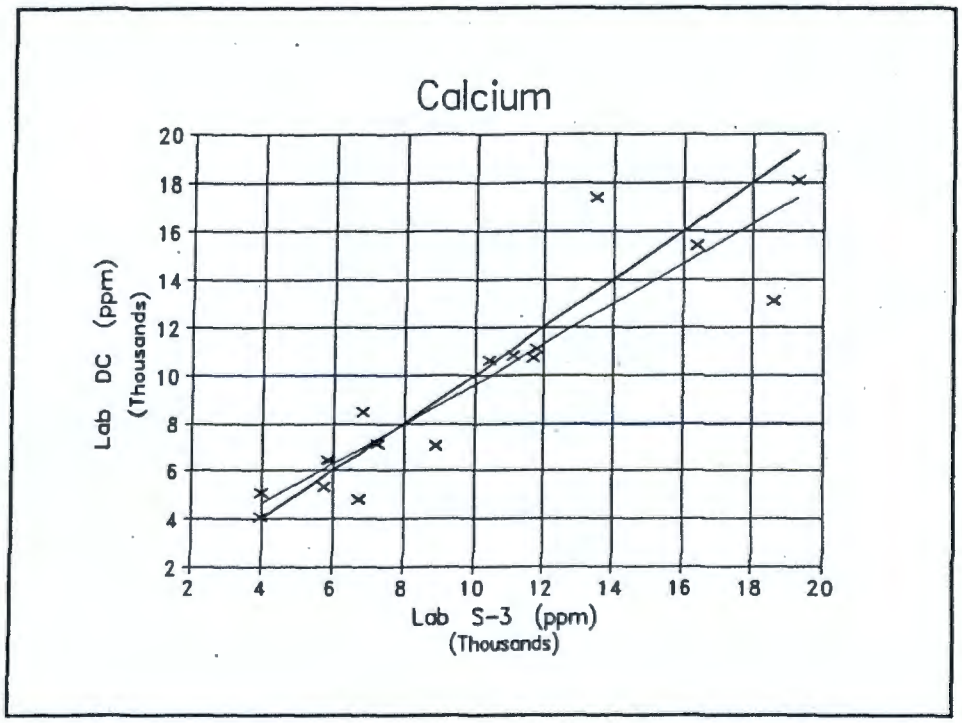


Figure D3-2. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Barium and Beryllium.



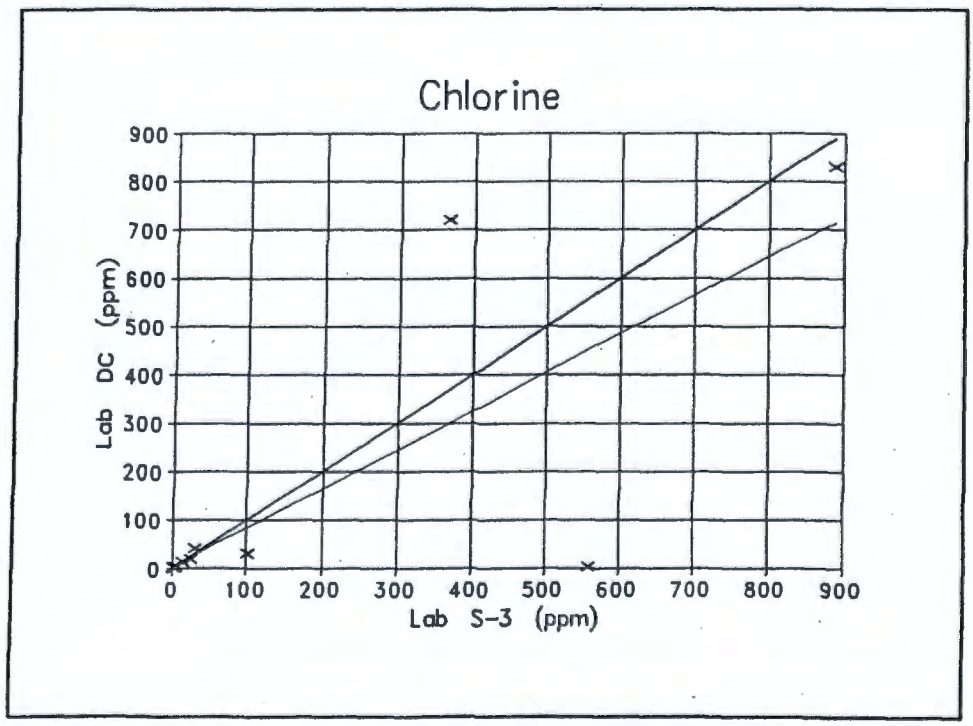
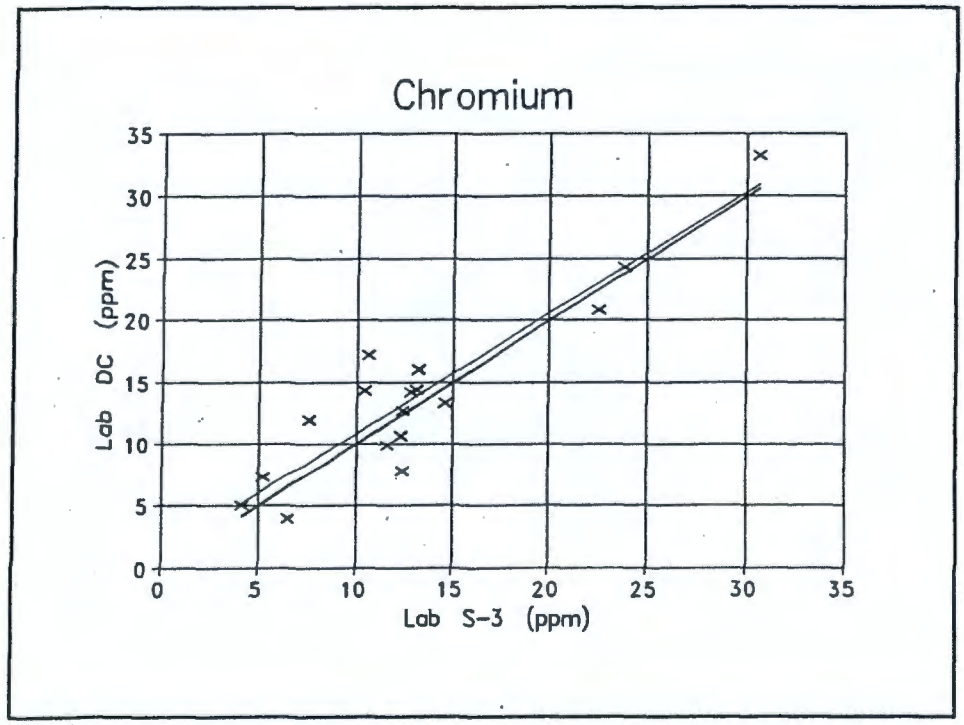


Figure D3-3. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Calcium and Chlorine.



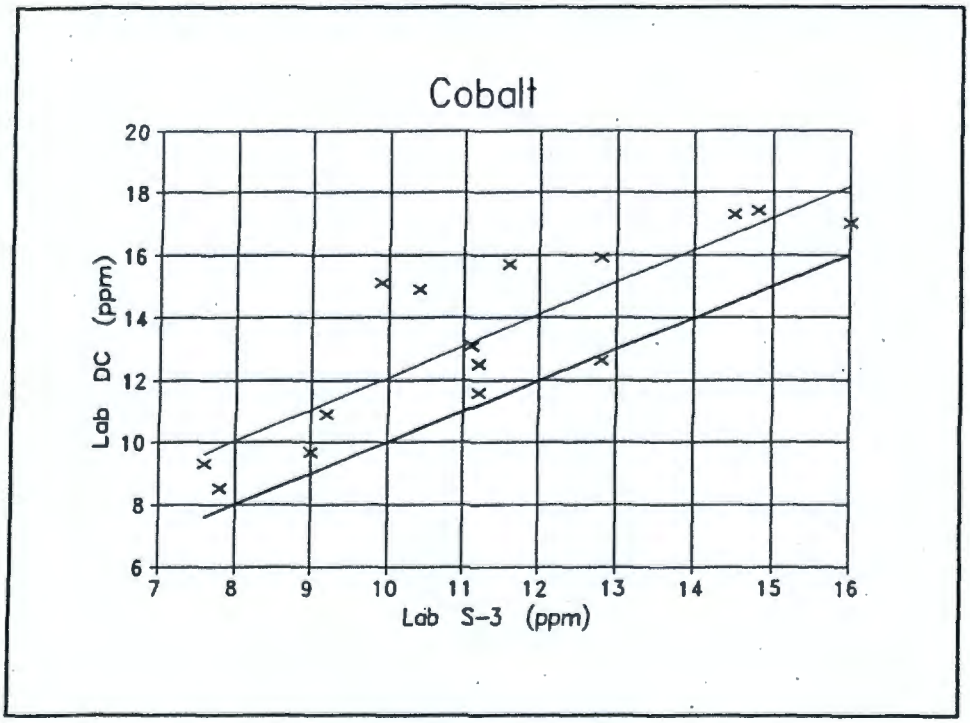
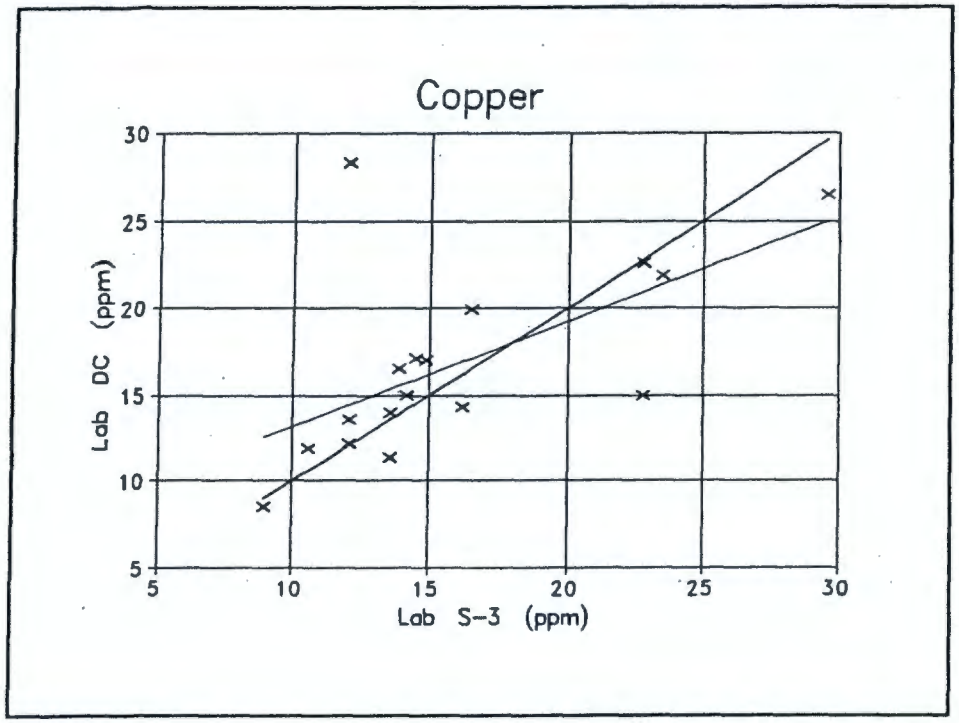


Figure D3-4. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Chromium and Cobalt.



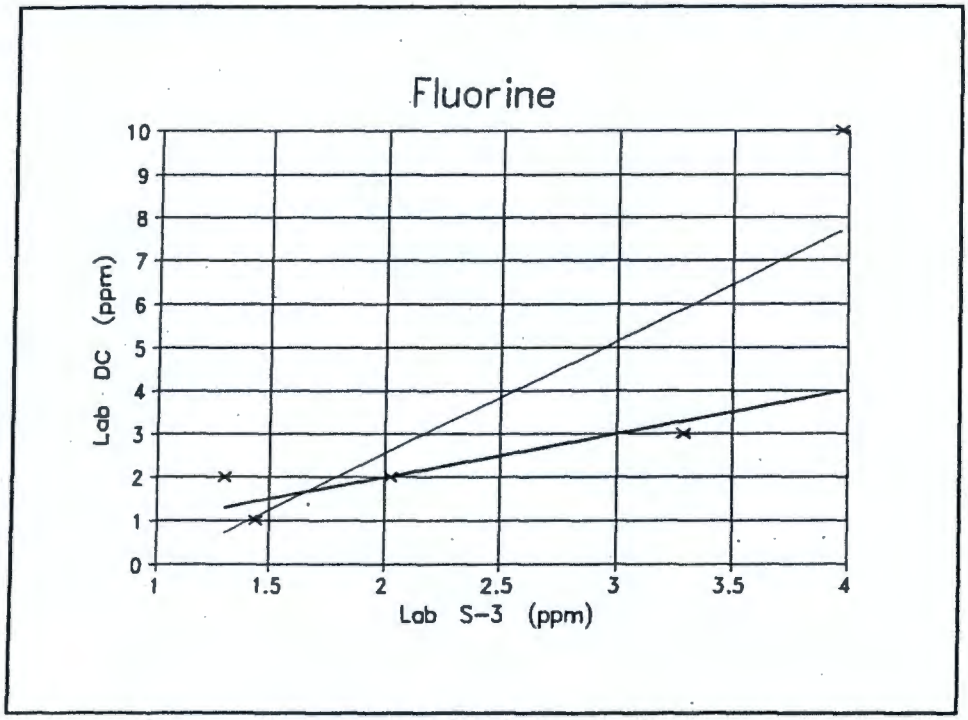
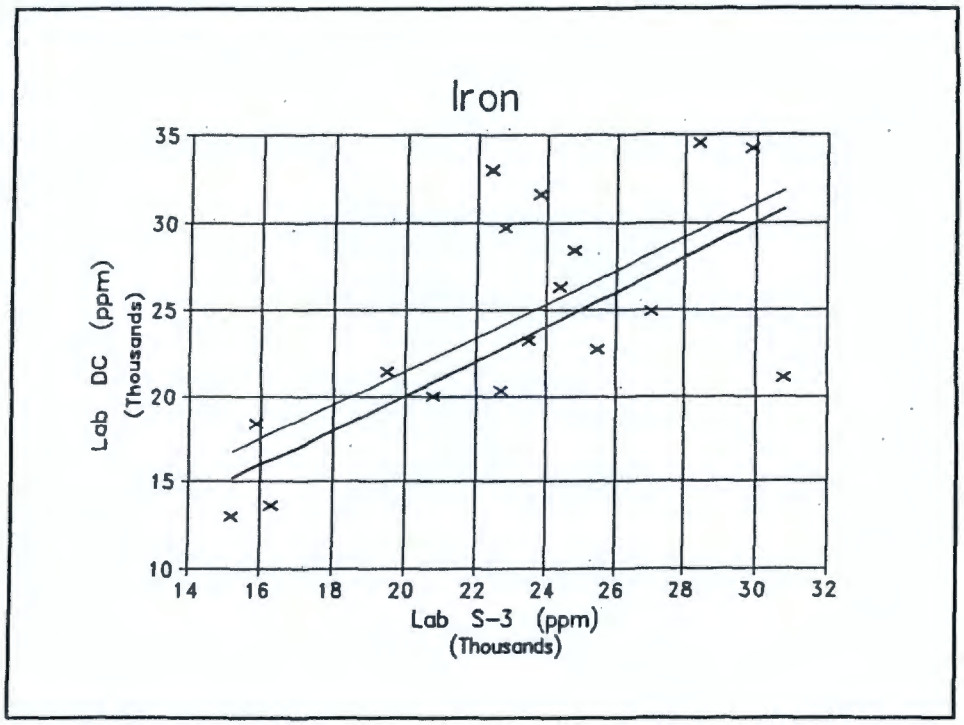


Figure D3-5. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Copper and Fluorine.



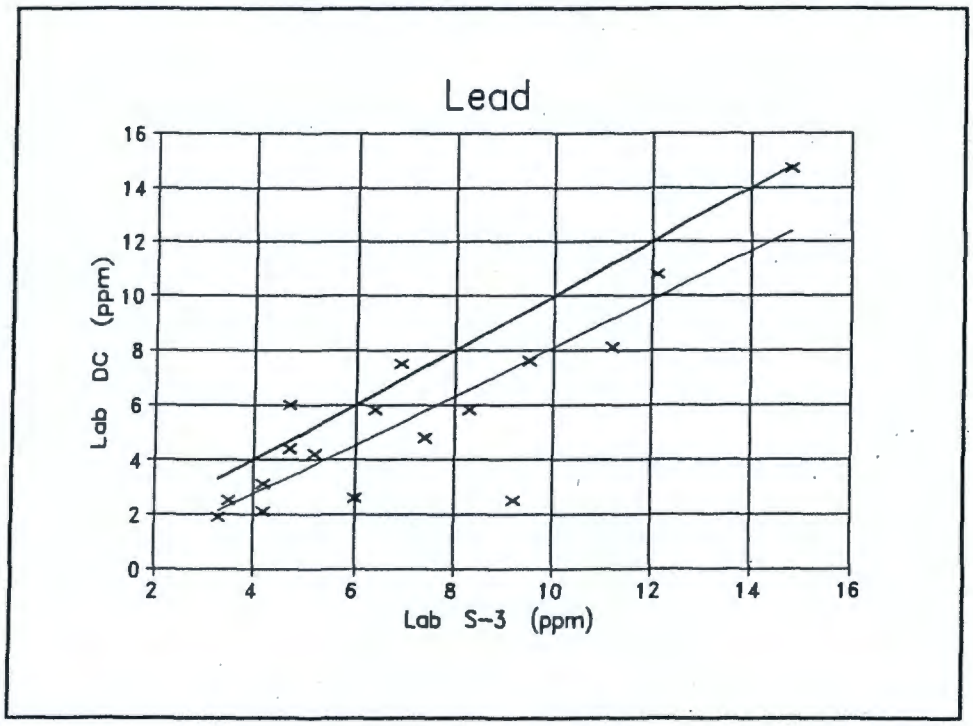
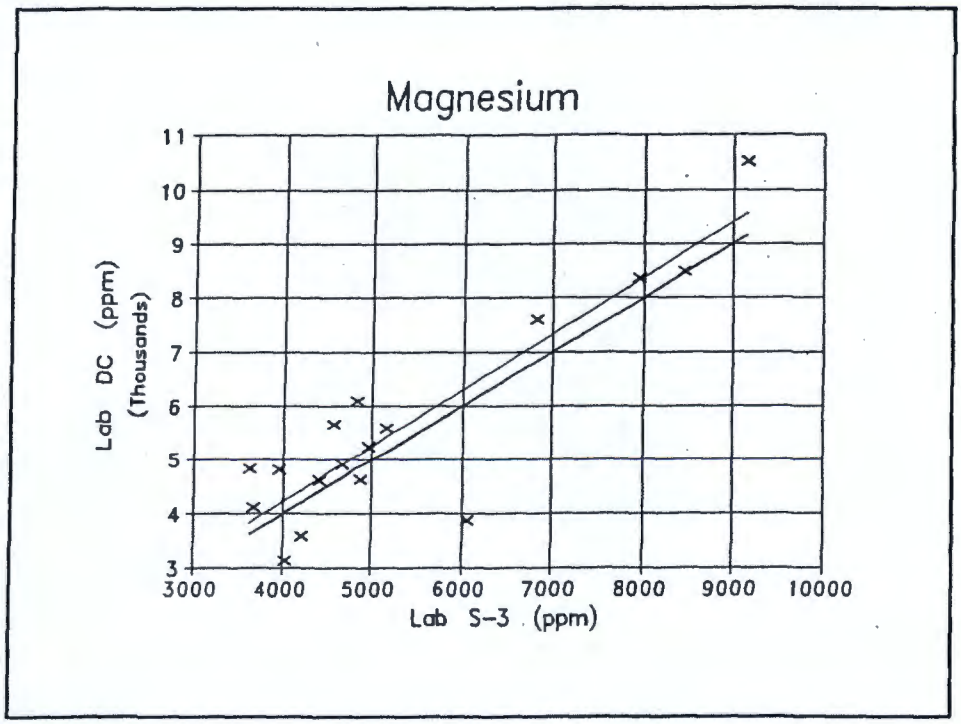


Figure D3-6. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Iron and Lead.



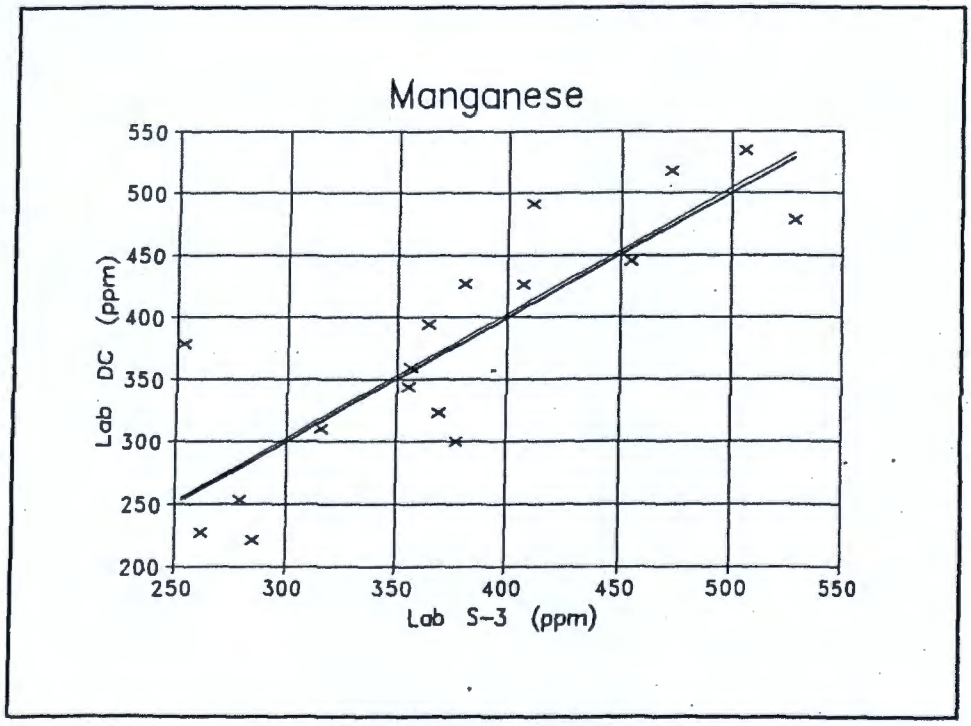
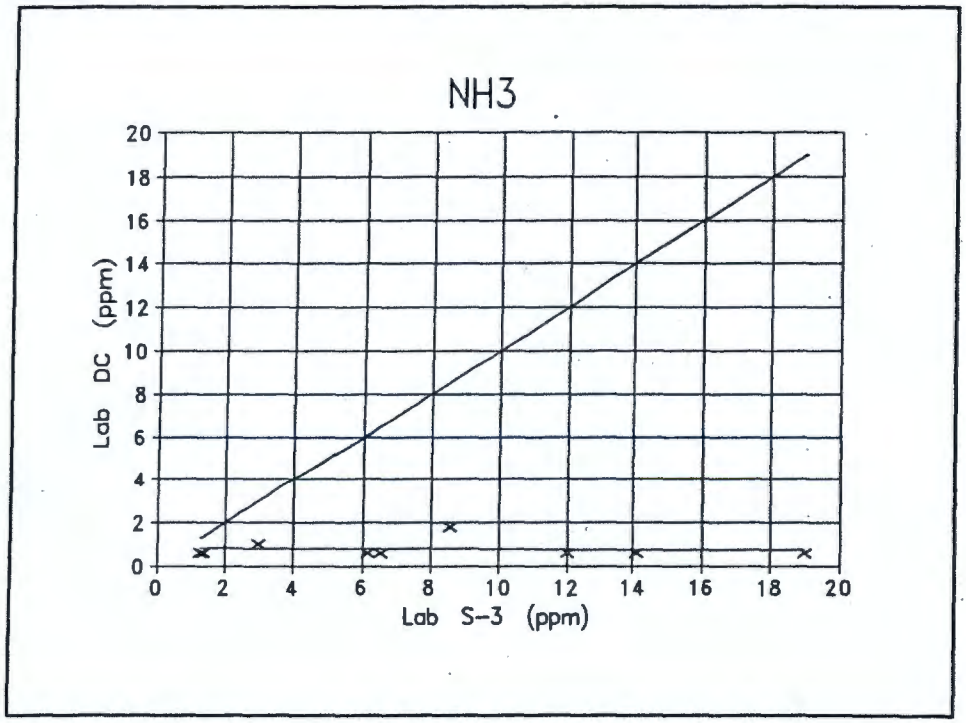


Figure D3-7. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Magnesium and Manganese.



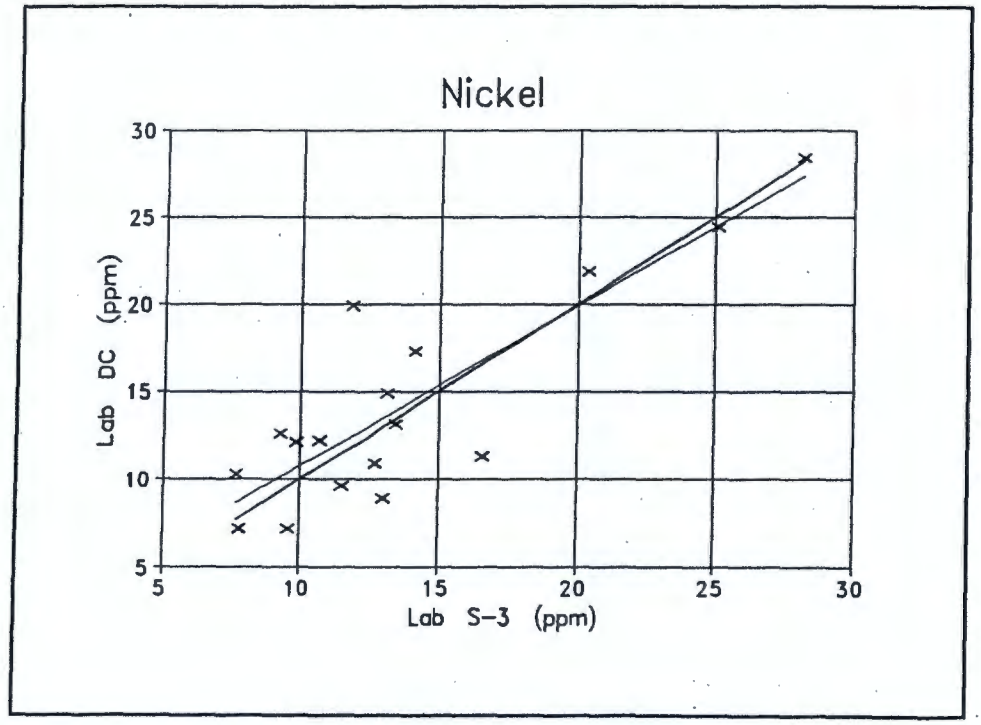
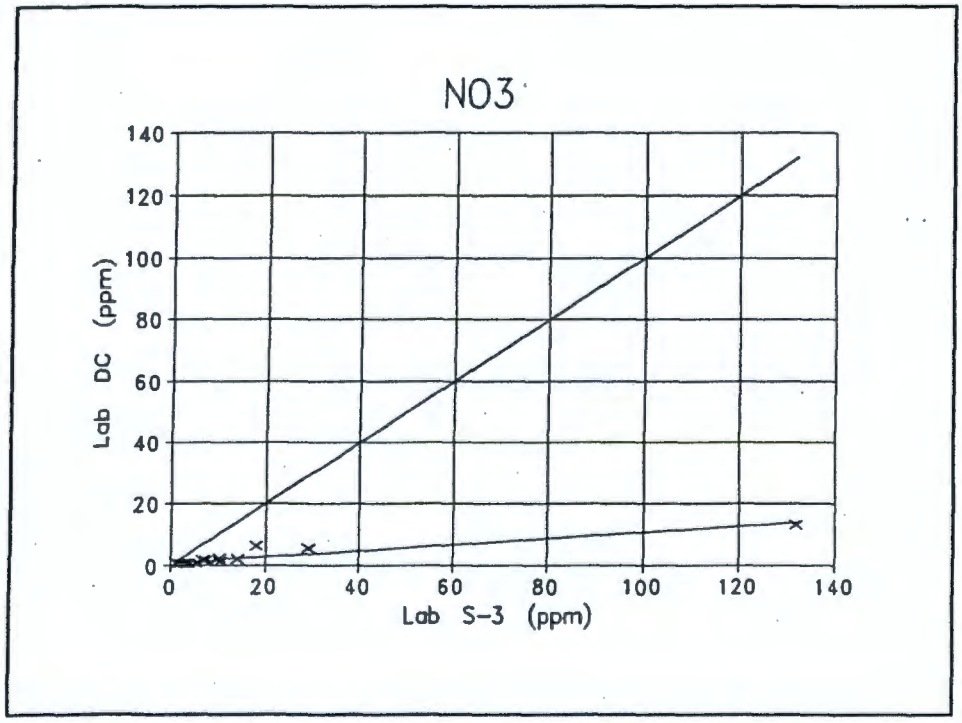


Figure D3-8. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Ammonia and Nickel.



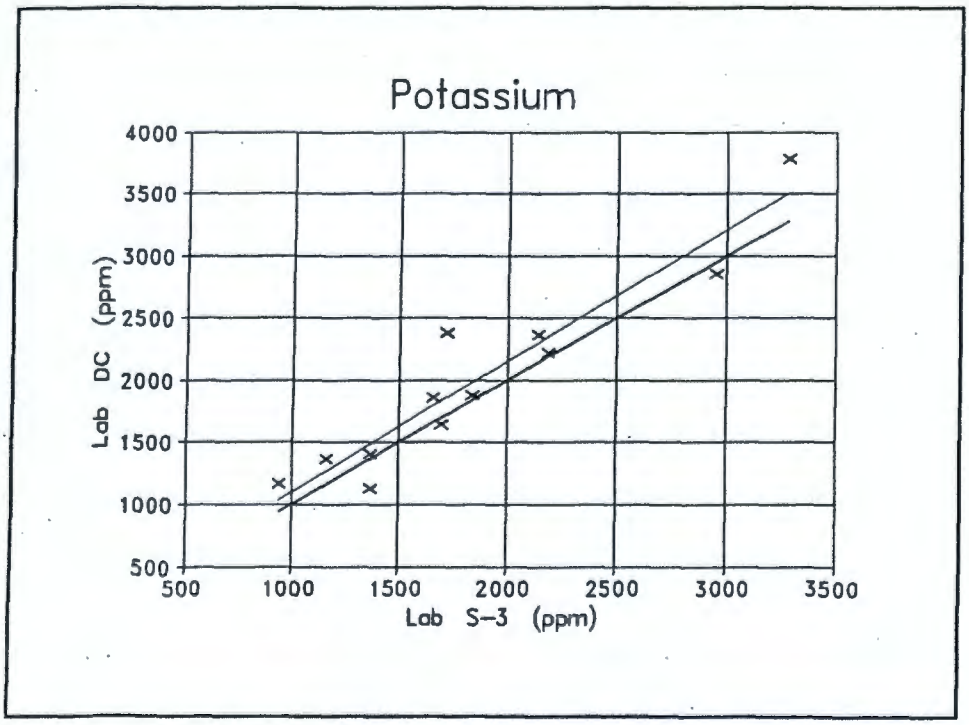
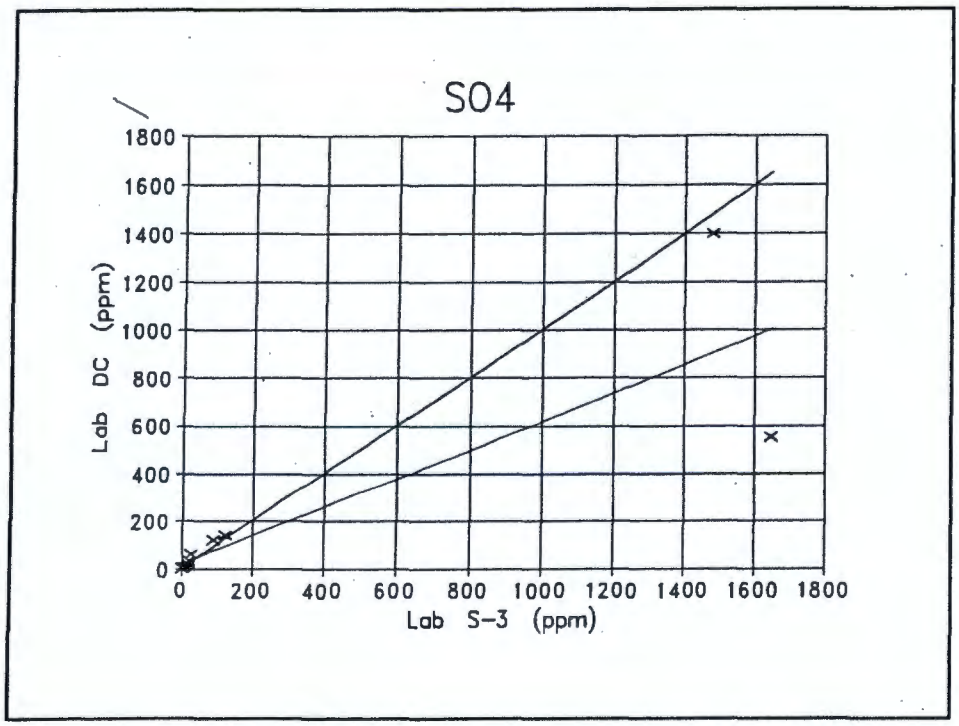


Figure D3-9. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Nitrate and Potassium.



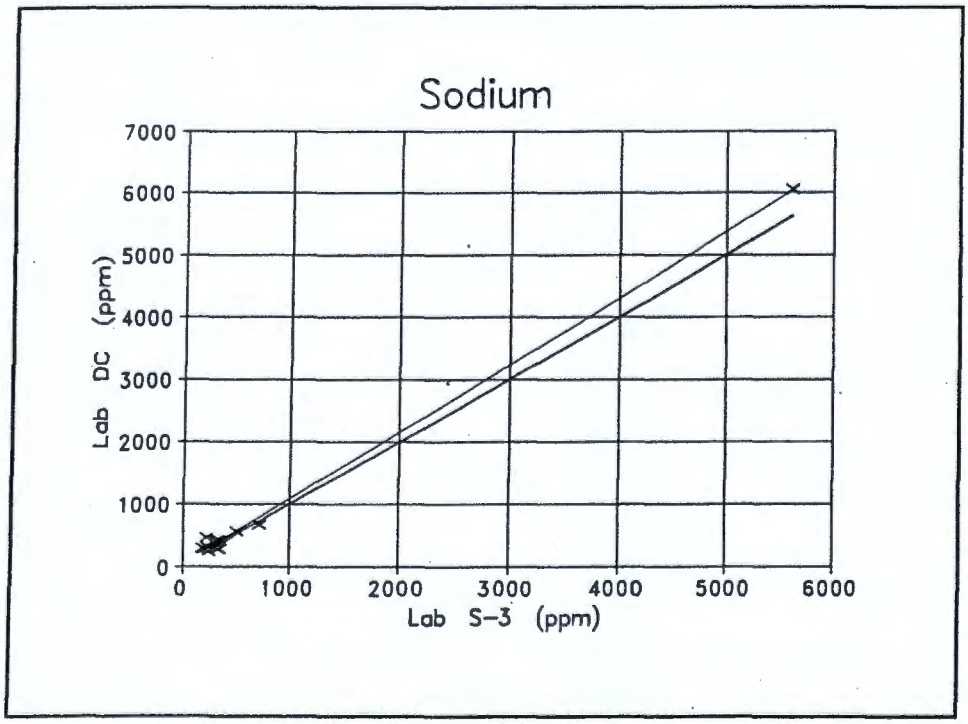
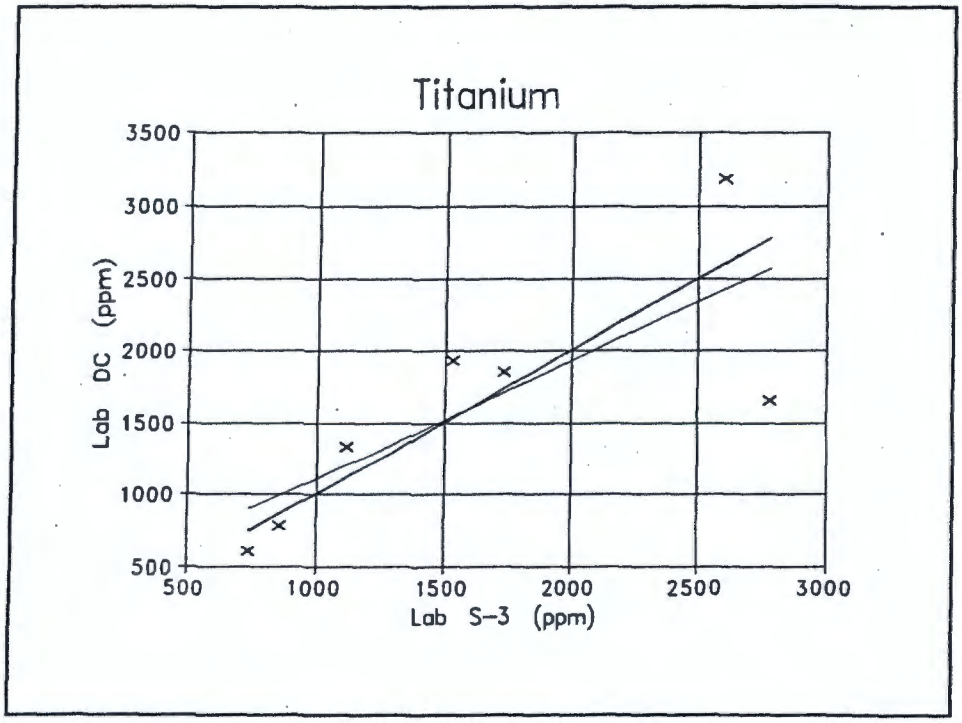


Figure D3-10. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Sulfate and Sodium.



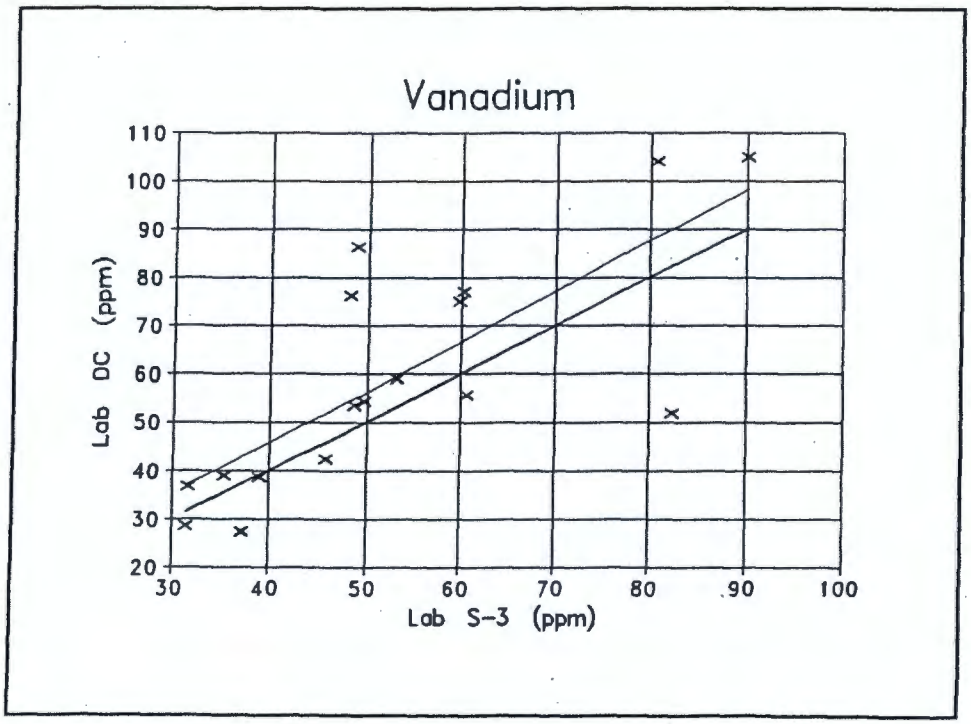
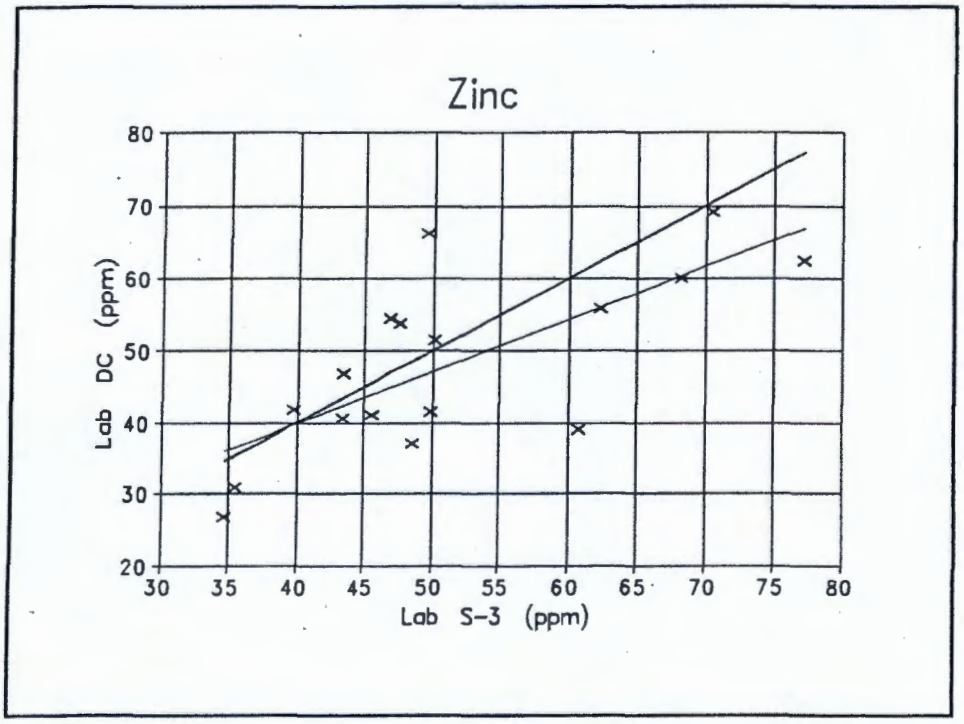


Figure D3-11. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Titanium and Vanadium.



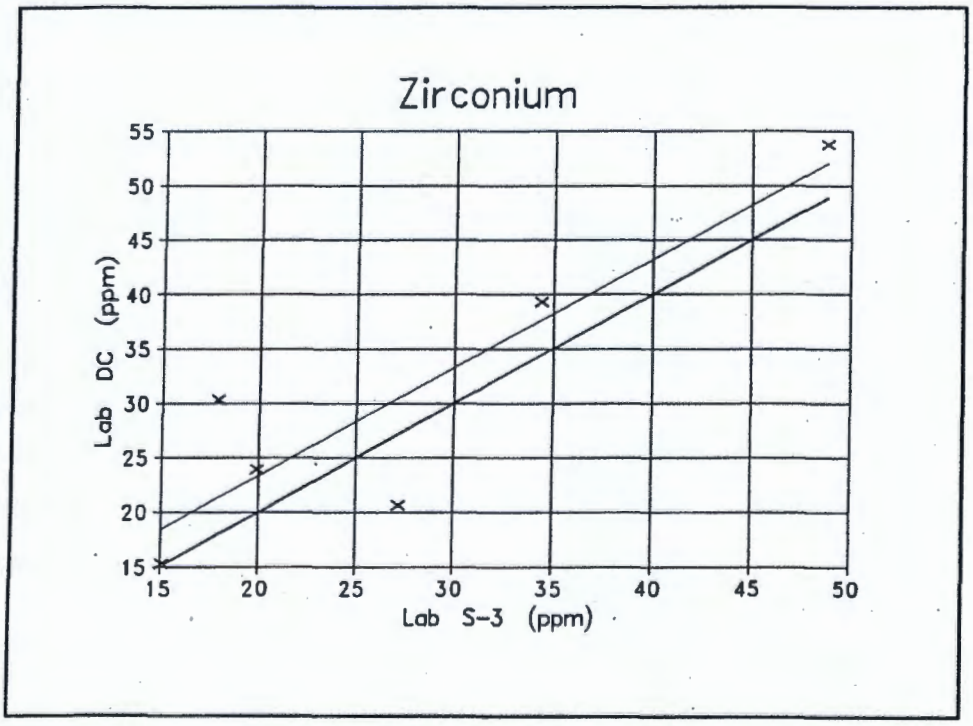


Figure D3-12. Paired Sample Regression of DataChem Results Against S-Cubed Results for Analytes Zinc and Zirconium.

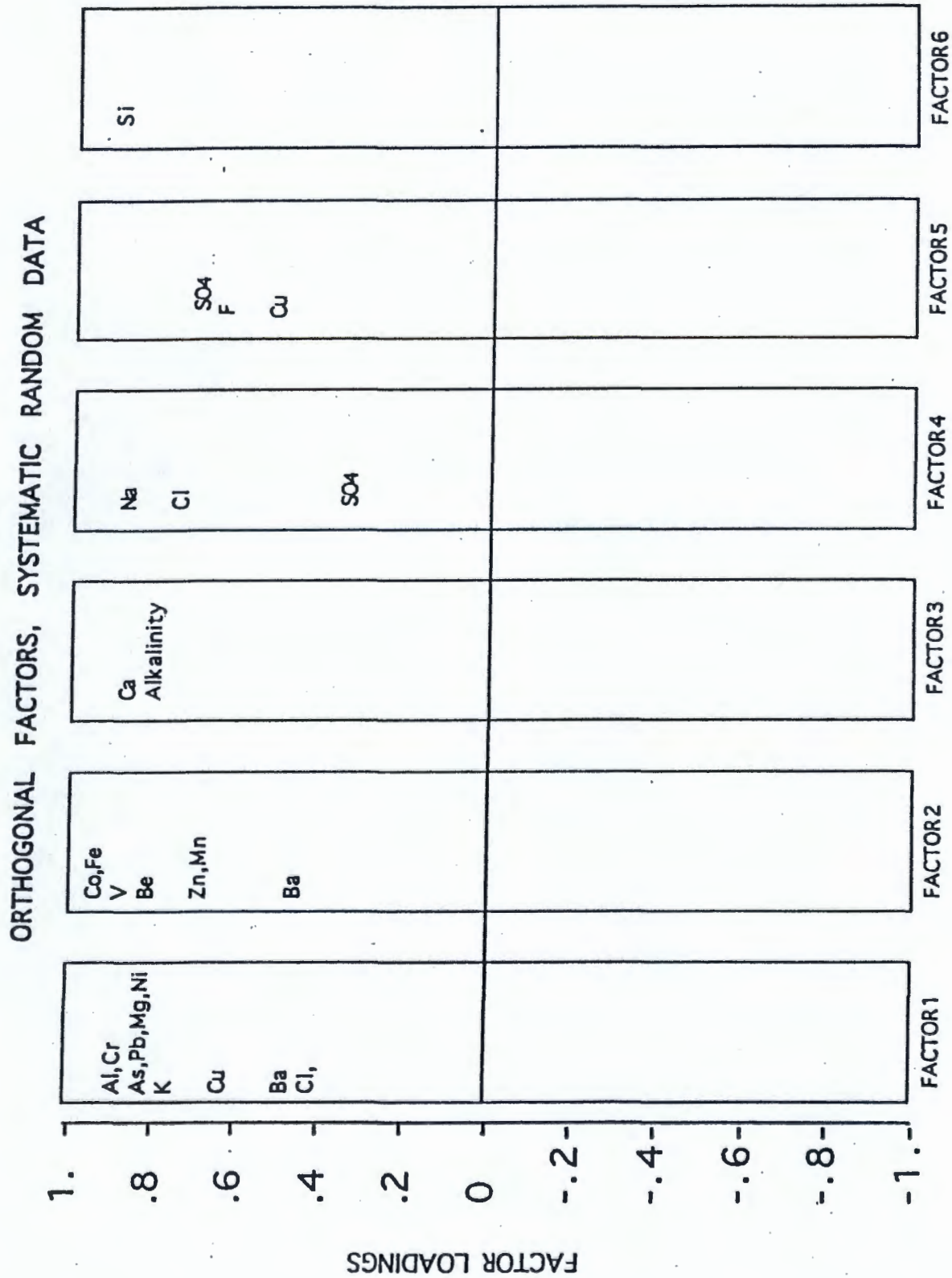


Figure D4-1. Factor Analysis, Orthogonal Factors for Digestate/Leachate Analyses.

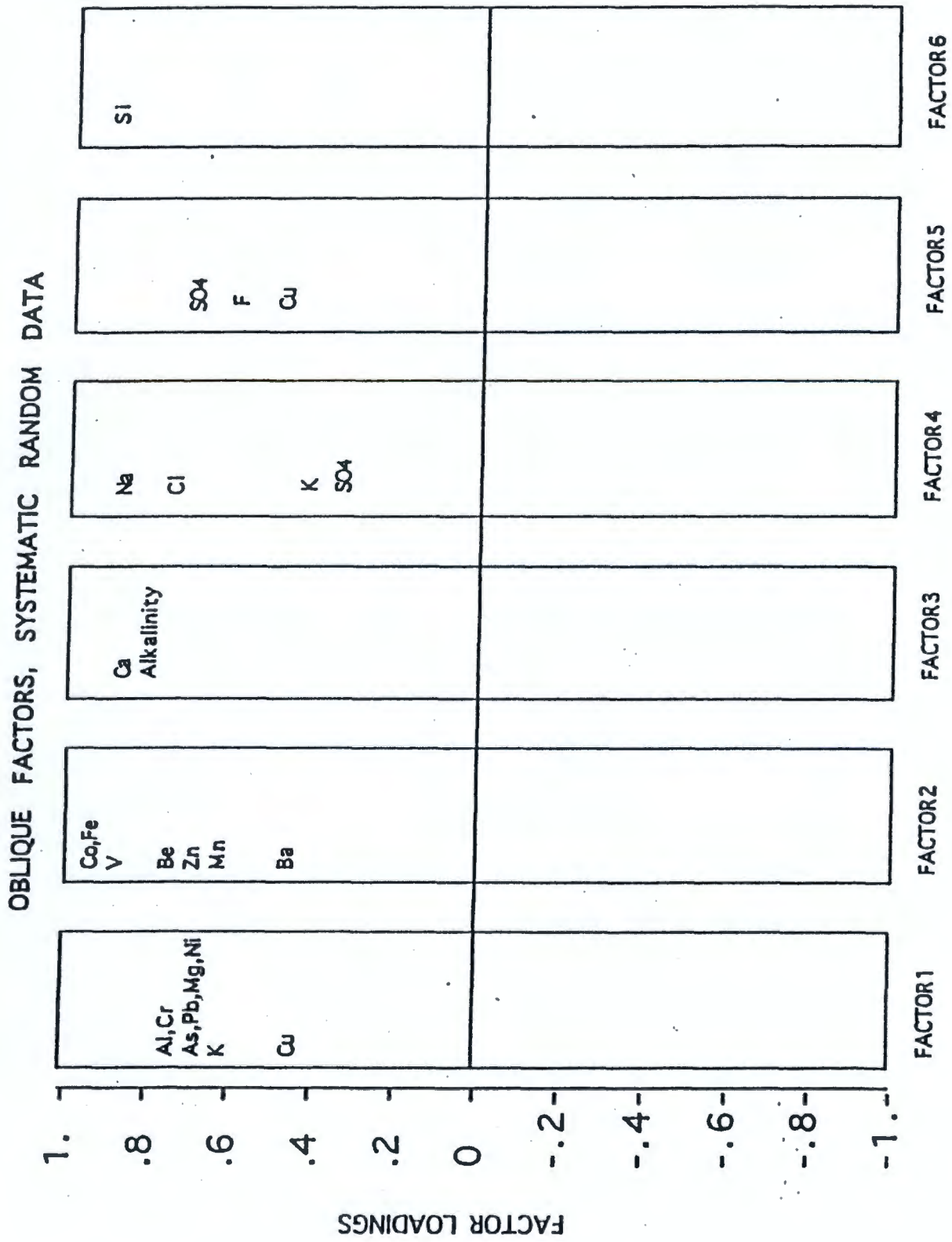


Figure D4-2. Factor Analysis, Oblique Factors for Digestate/Leachate Analyses.

ALUMINUM

DATA FILTER INFORMATION

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Minimum value used:	.00000
Maximum data value:	18100.
Maximum value used:	15100.

COORDINATE SELECTION INFORMATION

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Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	98

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	7667.4
Minimum value:	.00000
Maximum value:	15100.
Variance:	5.83101E+06
Standard deviation:	2414.7
Coeff. of variation:	.31493

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	90.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	176	11570.7	2.7635E+06
13688. - 27376.	269	19287.6	1.1801E+07
27376. - 41064.	72	37892.9	6.5327E+06
41064. - 54752.	738	48489.3	6.4259E+06
54752. - 68440.	746	60490.5	6.5758E+06
68440. - 82129.	160	73366.3	1.3931E+07
82129. - 95817.	487	88842.8	4.3092E+06
95817. - 109505.	595	100587.0	5.4500E+06
109505. - 123193.	138	117082.8	8.8130E+06
123193. - 136881.	72	124816.1	1.9235E+06
136881. - 150569.	393	142742.6	4.5762E+06
150569. - 164257.	155	156916.8	8.4125E+06
164257. - 177945.	115	170564.4	3.2773E+06
177945. - 191633.	86	186644.3	4.3694E+06
191633. - 205321.	54	194900.0	3.4792E+06
205321. - 219009.	14	212522.7	3.1635E+07
219009. - 232698.	0		
232698. - 246386.	20	238325.8	2.4904E+06
246386. - 260074.	15	251104.1	3.2021E+06
260074. - 273762.	0		

Figure D5-1a. Input Parameters for Horizontal Variogram of Aluminum. (sheet 1 of 2)

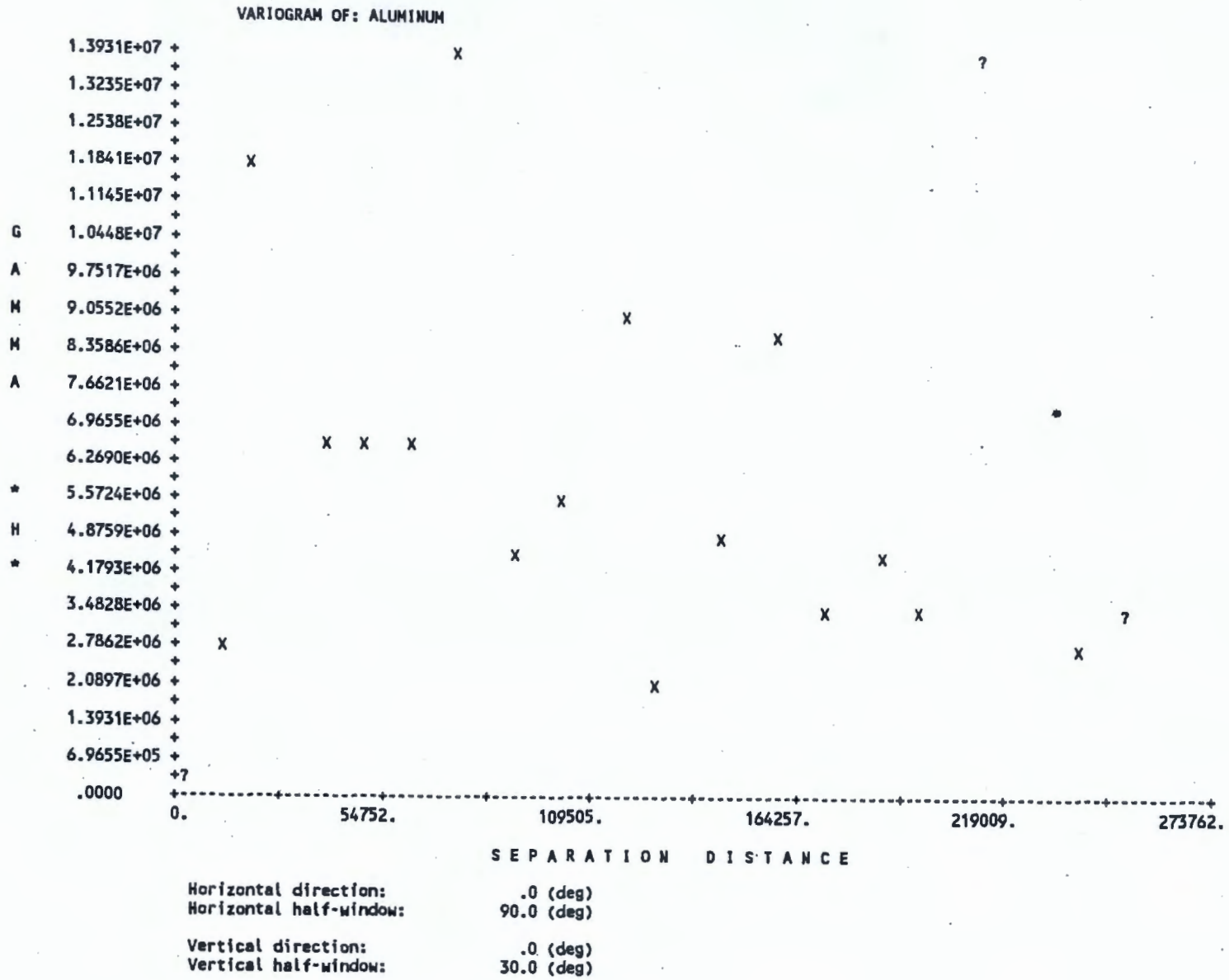


Figure D5-1a. Input Parameters for Horizontal Variogram of Aluminum. (sheet 2 of 2)

ALUMINUM

DATA FILTER INFORMATION

Minimum data value:	3940.0
Minimum value used:	.00000
Maximum data value:	18100.
Maximum value used:	15100.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	98

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	7667.4
Minimum value:	.00000
Maximum value:	15100.
Variance:	5.83101E+06
Standard deviation:	2414.7
Coeff. of variation:	.31493

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	26	9057.0	1.1986E+07
13688. - 27376.	145	17036.6	1.1405E+07
27376. - 41064.	54	38458.7	6.9609E+06
41064. - 54752.	411	47327.4	7.5563E+06
54752. - 68440.	560	59659.2	6.8913E+06
68440. - 82129.	30	69034.5	4.0604E+07
82129. - 95817.	220	88053.7	5.8542E+06
95817. - 109505.	365	101562.9	6.4865E+06
109505. - 123193.	98	119859.1	1.0001E+07
123193. - 136881.	72	124816.1	1.9235E+06
136881. - 150569.	236	143067.7	4.8379E+06
150569. - 164257.	20	159138.3	2.0066E+07
164257. - 177945.	0		
177945. - 191633.	0		
191633. - 205321.	0		
205321. - 219009.	0		
219009. - 232698.	0		
232698. - 246386.	0		
246386. - 260074.	0		
260074. - 273762.	0		

Figure D5-1b. Input Parameters for Horizontal Variogram of Aluminum. (sheet 1 of 2)

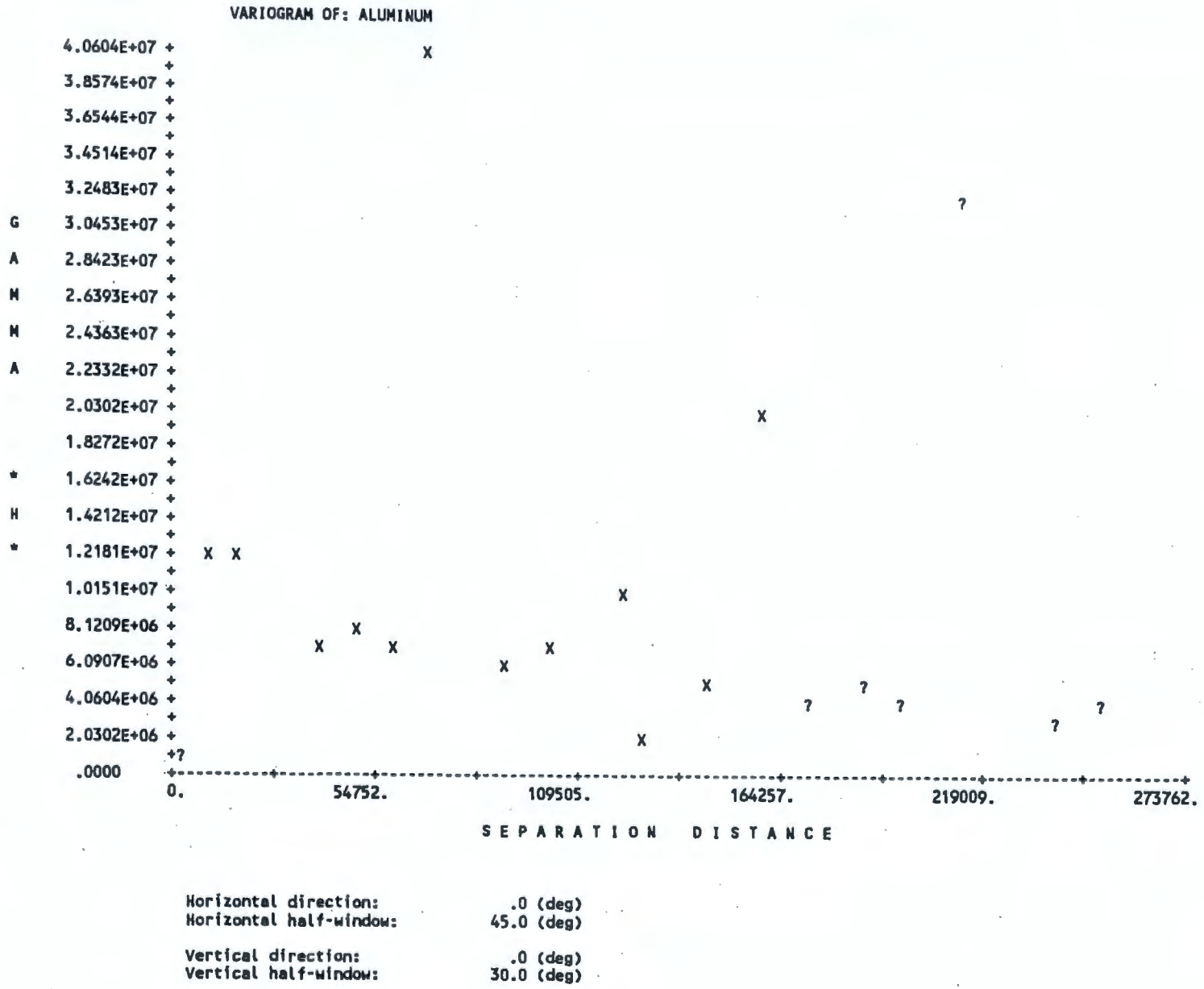


Figure D5-1b. Input Parameters for Horizontal Variogram of Aluminum. (sheet 2 of 2)

ALUMINUM

DATA FILTER INFORMATION

Minimum data value:	3940.0
Minimum value used:	.00000
Maximum data value:	18100.
Maximum value used:	15100.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	98

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	7667.4
Minimum value:	.00000
Maximum value:	15100.
Variance:	5.83101E+06
Standard deviation:	2414.7
Coeff. of variation:	.31493

VARIOGRAM DIRECTION INFORMATION

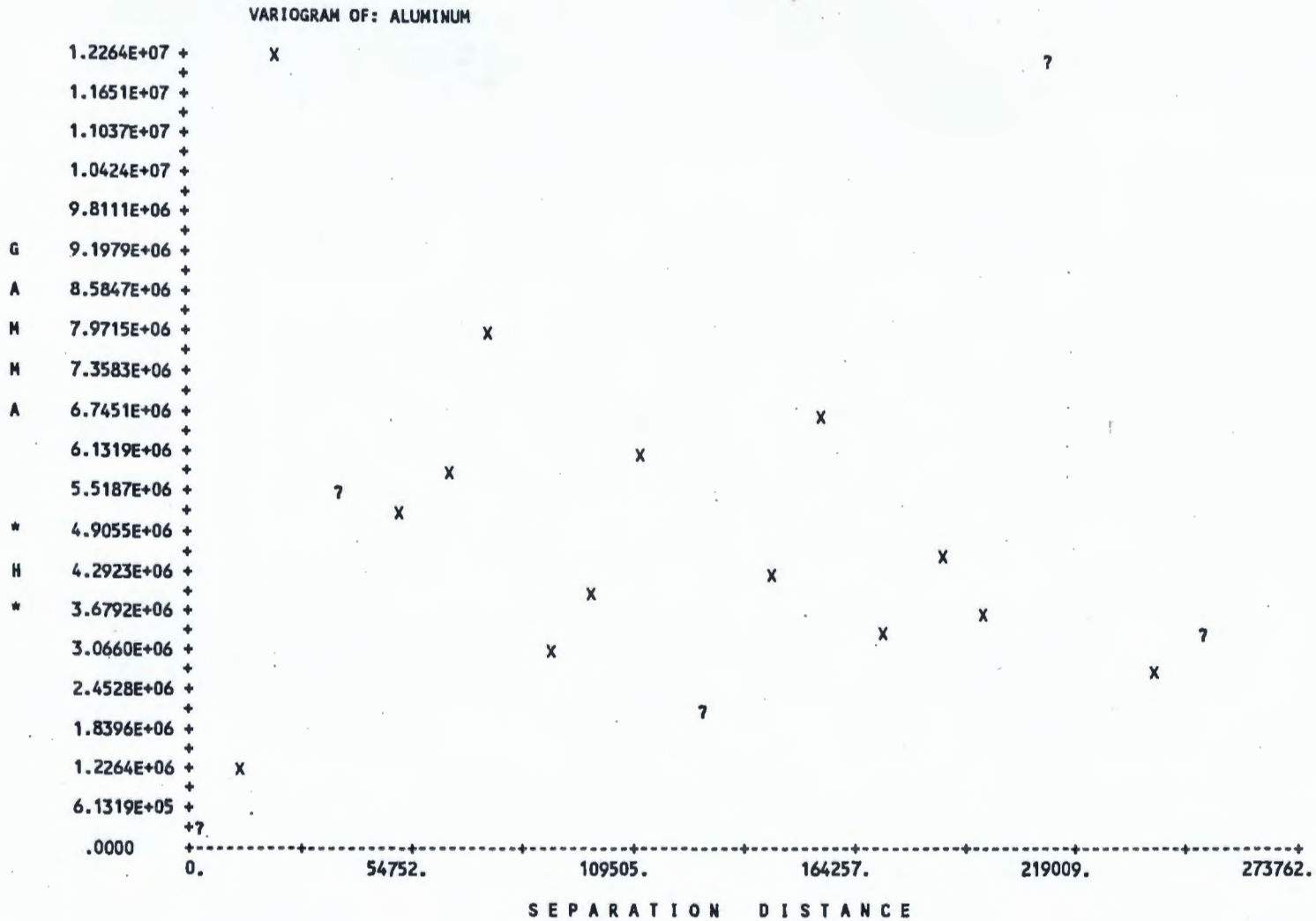
Horizontal direction:	90.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	150	12006.4	1.1649E+06
13688. - 27376.	124	21919.9	1.2264E+07
27376. - 41064.	18	36195.7	5.2480E+06
41064. - 54752.	327	49949.3	5.0051E+06
54752. - 68440.	186	62992.9	5.6258E+06
68440. - 82129.	130	74365.9	7.7757E+06
82129. - 95817.	267	89492.0	3.0361E+06
95817. - 109505.	230	99036.9	3.8051E+06
109505. - 123193.	40	110281.4	5.9022E+06
123193. - 136881.	0		
136881. - 150569.	157	142253.9	4.1827E+06
150569. - 164257.	135	156587.7	6.6861E+06
164257. - 177945.	115	170564.4	3.2773E+06
177945. - 191633.	86	186644.3	4.3694E+06
191633. - 205321.	54	194900.0	3.4792E+06
205321. - 219009.	14	212522.7	3.1635E+07
219009. - 232698.	0		
232698. - 246386.	20	238325.8	2.4904E+06
246386. - 260074.	15	251104.1	3.2021E+06
260074. - 273762.	0		

Figure D5-1c. Input Parameters for Horizontal Variogram of Aluminum. (sheet 1 of 2)



Horizontal direction: 90.0 (deg)
Horizontal half-window: 45.0 (deg)

Vertical direction: .0 (deg)
Vertical half-window: 30.0 (deg)

Figure D5-1c. Input Parameters for Horizontal Variogram of Aluminum. (sheet 2 of 2)

IRON

DATA FILTER INFORMATION

Minimum data value:	13200.
Minimum value used:	.00000
Maximum data value:	35100.
Maximum value used:	38200.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	102

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	24454.
Minimum value:	.00000
Maximum value:	38200.
Variance:	3.36025E+07
Standard deviation:	5796.8
Coeff. of variation:	.23705

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	90.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	176	11570.7	2.6294E+07
13688. - 27376.	341	20073.5	4.6851E+07
27376. - 41064.	90	38015.3	2.7737E+07
41064. - 54752.	758	48553.9	3.9546E+07
54752. - 68440.	801	60457.3	3.8808E+07
68440. - 82129.	241	72839.8	2.6980E+07
82129. - 95817.	487	88842.8	2.5291E+07
95817. - 109505.	617	100642.4	3.9188E+07
109505. - 123193.	177	117136.2	1.8244E+07
123193. - 136881.	72	124816.1	6.9375E+07
136881. - 150569.	415	142652.9	3.6191E+07
150569. - 164257.	185	157277.0	2.7254E+07
164257. - 177945.	115	170564.4	3.7822E+07
177945. - 191633.	93	186281.0	1.8163E+07
191633. - 205321.	54	194900.0	3.8158E+07
205321. - 219009.	35	212522.7	4.9919E+07
219009. - 232698.	0		
232698. - 246386.	20	238325.8	1.7407E+07
246386. - 260074.	15	251104.1	3.9668E+07
260074. - 273762.	0		

Figure D5-2a. Input Parameters for Horizontal Variogram of Iron. (sheet 1 of 2)

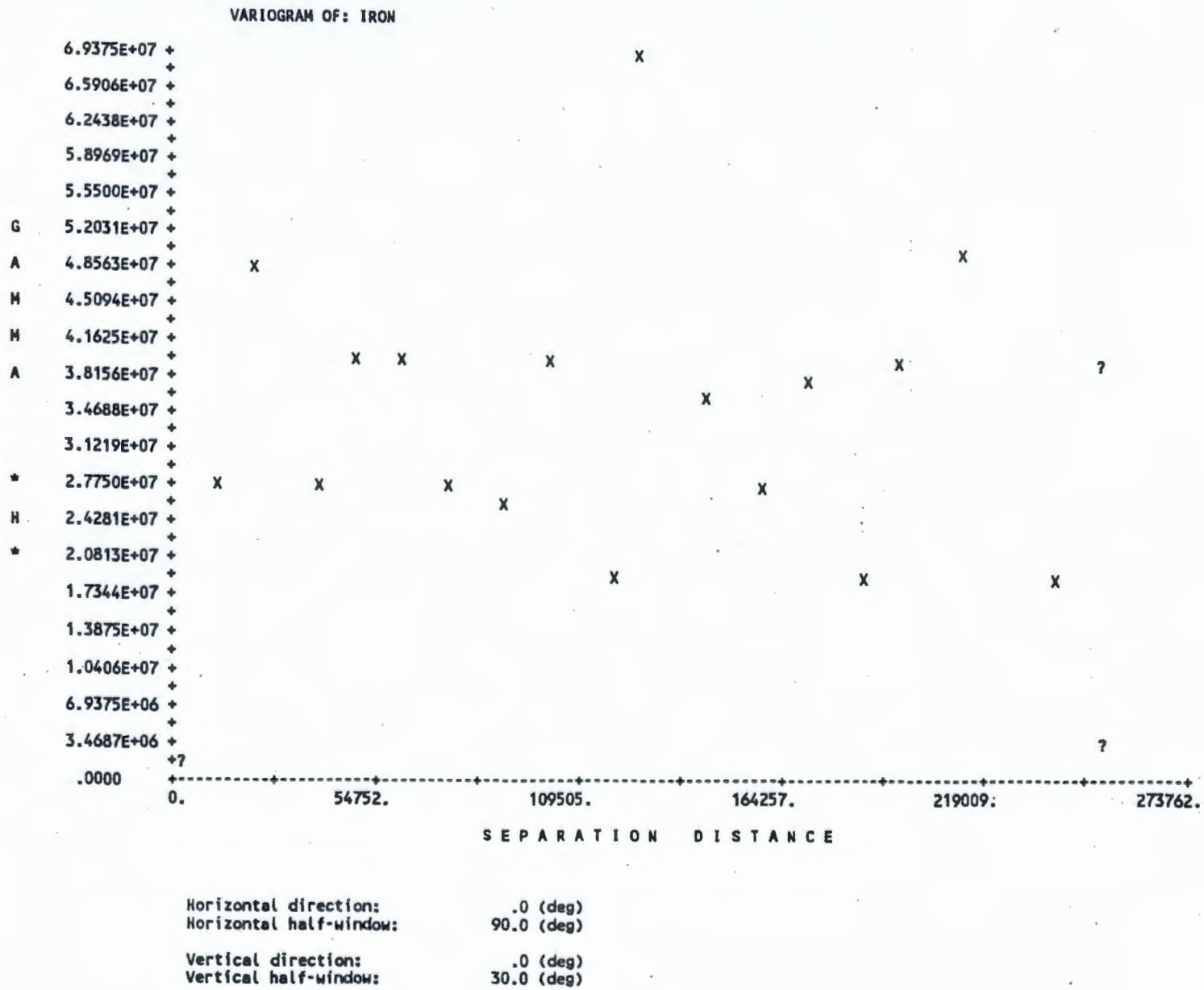


Figure D5-2a. Input Parameters for Horizontal Variogram of Iron. (sheet 2 of 2)

IRON

DATA FILTER INFORMATION

Minimum data value:	13200.
Minimum value used:	.00000
Maximum data value:	35100.
Maximum value used:	38200.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	102

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	24454.
Minimum value:	.00000
Maximum value:	38200.
Variance:	3.36025E+07
Standard deviation:	5796.8
Coeff. of variation:	.23705

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	26	9057.0	2.8997E+07
13688. - 27376.	145	17036.6	2.3061E+07
27376. - 41064.	54	38458.7	3.1156E+07
41064. - 54752.	431	47495.0	4.9349E+07
54752. - 68440.	615	59690.0	4.3519E+07
68440. - 82129.	75	69034.5	1.3960E+07
82129. - 95817.	220	88053.7	1.8977E+07
95817. - 109505.	387	101595.8	3.4298E+07
109505. - 123193.	132	119444.9	1.8859E+07
123193. - 136881.	72	124816.1	6.9375E+07
136881. - 150569.	258	142895.8	3.1776E+07
150569. - 164257.	50	159138.4	4.2595E+07
164257. - 177945.	0		
177945. - 191633.	0		
191633. - 205321.	0		
205321. - 219009.	0		
219009. - 232698.	0		
232698. - 246386.	0		
246386. - 260074.	0		
260074. - 273762.	0		

Figure D5-2b. Input Parameters for Horizontal Variogram of Iron. (sheet 1 of 2)

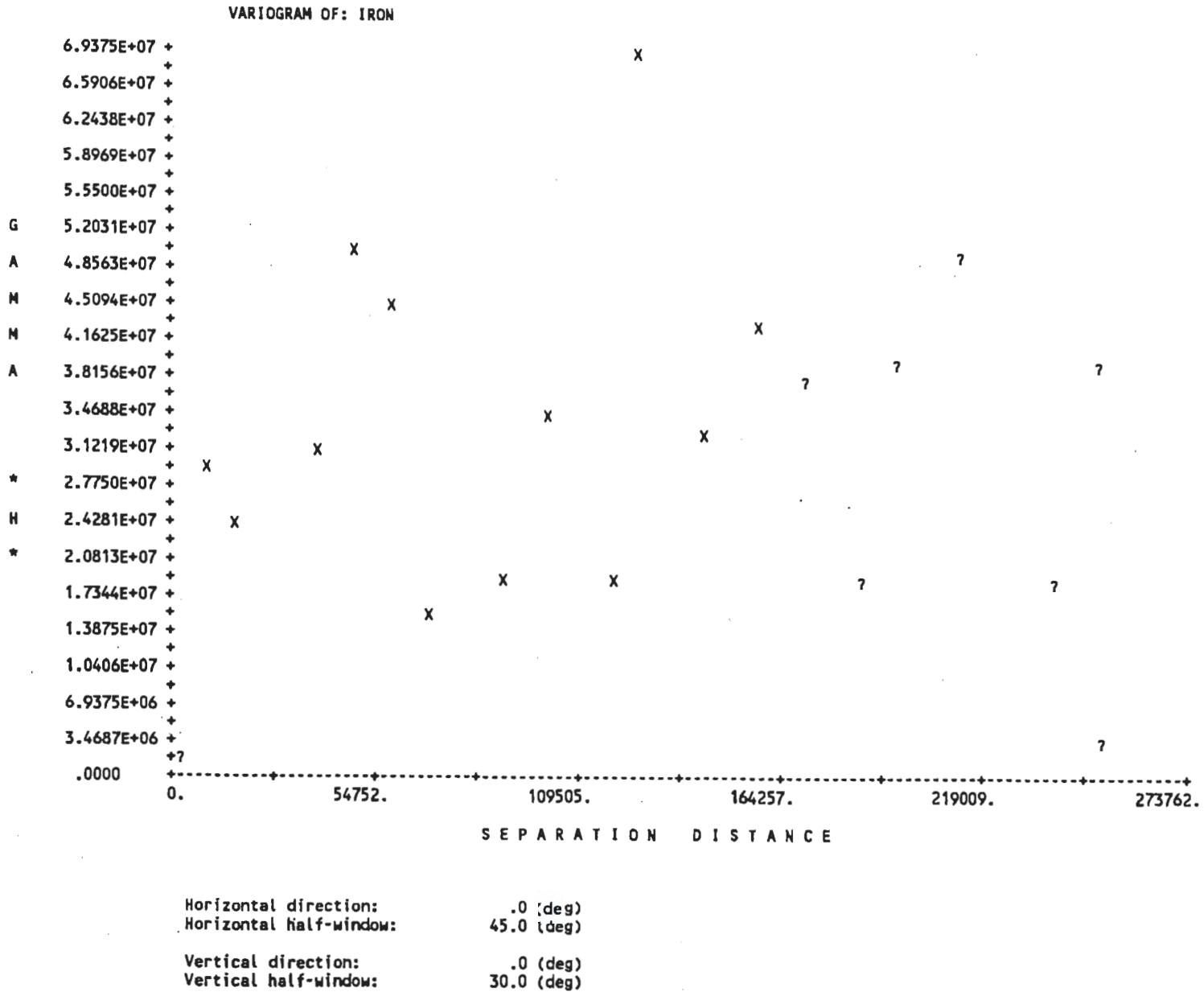


Figure D5-2b. Input Parameters for Horizontal Variogram of Iron. (sheet 2 of 2)

IRON

DATA FILTER INFORMATION

Minimum data value:	13200.
Minimum value used:	.00000
Maximum data value:	35100.
Maximum value used:	38200.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	102

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	24454.
Minimum value:	.00000
Maximum value:	38200.
Variance:	3.36025E+07
Standard deviation:	5796.8
Coeff. of variation:	.23705

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	150	12006.4	2.5826E+07
13688. - 27376.	196	22320.2	6.4451E+07
27376. - 41064.	36	37350.3	2.2609E+07
41064. - 54752.	327	49949.3	2.6626E+07
54752. - 68440.	186	62992.9	2.3232E+07
68440. - 82129.	166	74558.9	3.2863E+07
82129. - 95817.	267	89492.0	3.0493E+07
95817. - 109505.	230	99036.9	4.7415E+07
109505. - 123193.	45	110363.8	1.6438E+07
123193. - 136881.	0		
136881. - 150569.	157	142253.9	4.3447E+07
150569. - 164257.	135	156587.7	2.1572E+07
164257. - 177945.	115	170564.4	3.7822E+07
177945. - 191633.	93	186281.0	1.8163E+07
191633. - 205321.	54	194900.0	3.8158E+07
205321. - 219009.	35	212522.7	4.9919E+07
219009. - 232698.	0		
232698. - 246386.	20	238325.8	1.7407E+07
246386. - 260074.	15	251104.1	3.9668E+07
260074. - 273762.	0		

Figure D5-2c. Input Parameters for Horizontal Variogram of Iron. (sheet 1 of 2)

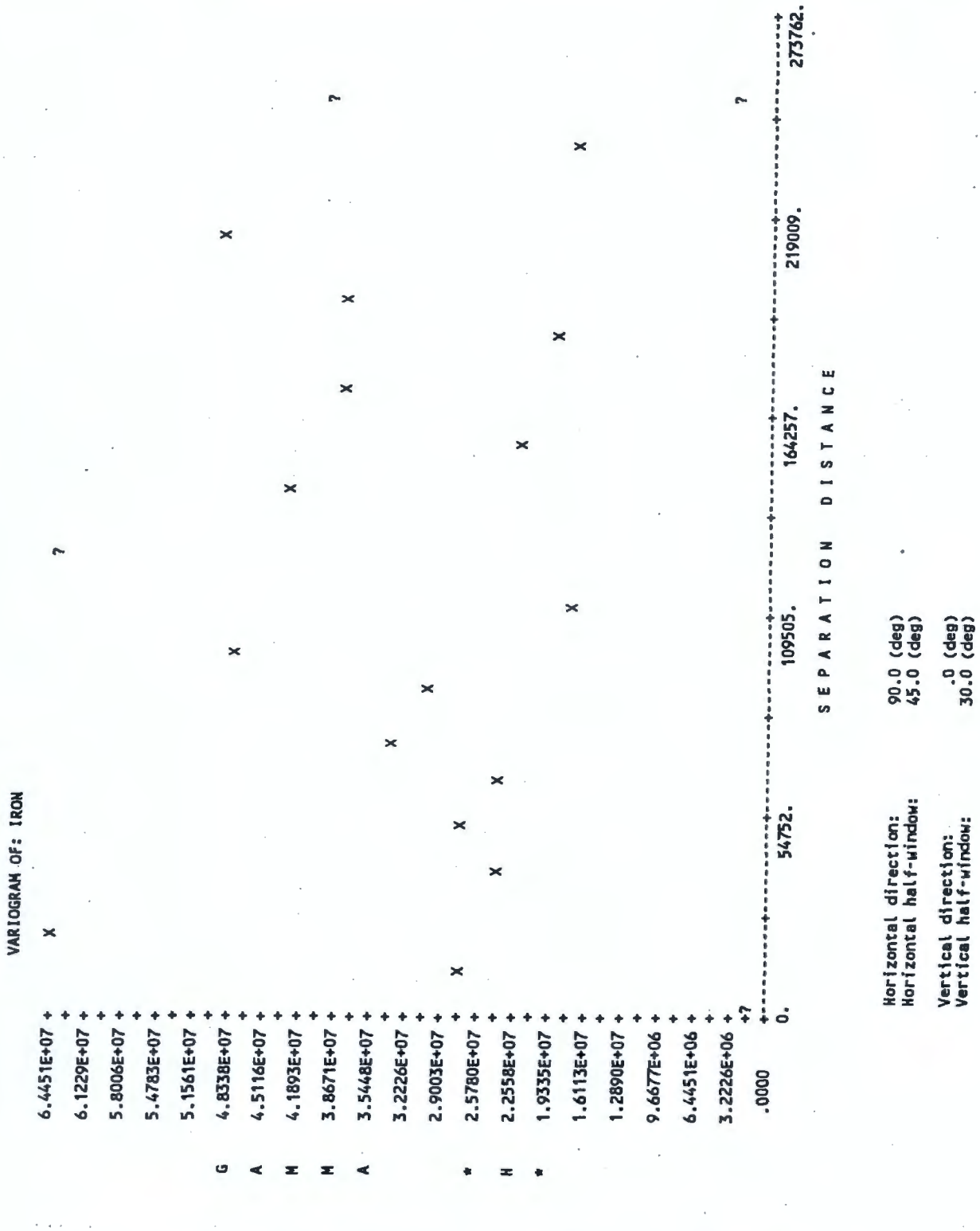


Figure D5-2c. Input Parameters for Horizontal Variogram of Iron. (sheet 2 of 2)

CALCIUM

DATA FILTER INFORMATION

Minimum data value:	3820.0
Minimum value used:	5600.0
Maximum data value:	86600.
Maximum value used:	22000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	88

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	10099.
Minimum value:	5600.0
Maximum value:	22000.
Variance:	1.24913E+07
Standard deviation:	3534.3
Coeff. of variation:	.34997

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	90.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	174	11642.9	6.3613E+06
13688. - 27376.	230	19721.5	1.3034E+07
27376. - 41064.	56	37811.9	1.2560E+07
41064. - 54752.	599	48516.0	1.0437E+07
54752. - 68440.	661	60559.5	9.8947E+06
68440. - 82129.	178	72691.5	1.6759E+07
82129. - 95817.	335	88433.3	1.1890E+07
95817. - 109505.	466	100427.1	1.4222E+07
109505. - 123193.	123	116988.0	2.1845E+07
123193. - 136881.	39	124816.1	1.1659E+07
136881. - 150569.	284	142923.9	1.3886E+07
150569. - 164257.	132	157266.0	1.5847E+07
164257. - 177945.	68	170401.6	2.1668E+07
177945. - 191633.	70	185951.5	1.7403E+07
191633. - 205321.	26	194900.1	3.0319E+07
205321. - 219009.	24	211729.0	3.3540E+07
219009. - 232698.	0		
232698. - 246386.	16	238325.8	2.7776E+07
246386. - 260074.	8	251104.1	3.0809E+07
260074. - 273762.	0		

Figure D5-3a. Input Parameters for Horizontal Variogram of Calcium. (sheet 1 of 2)

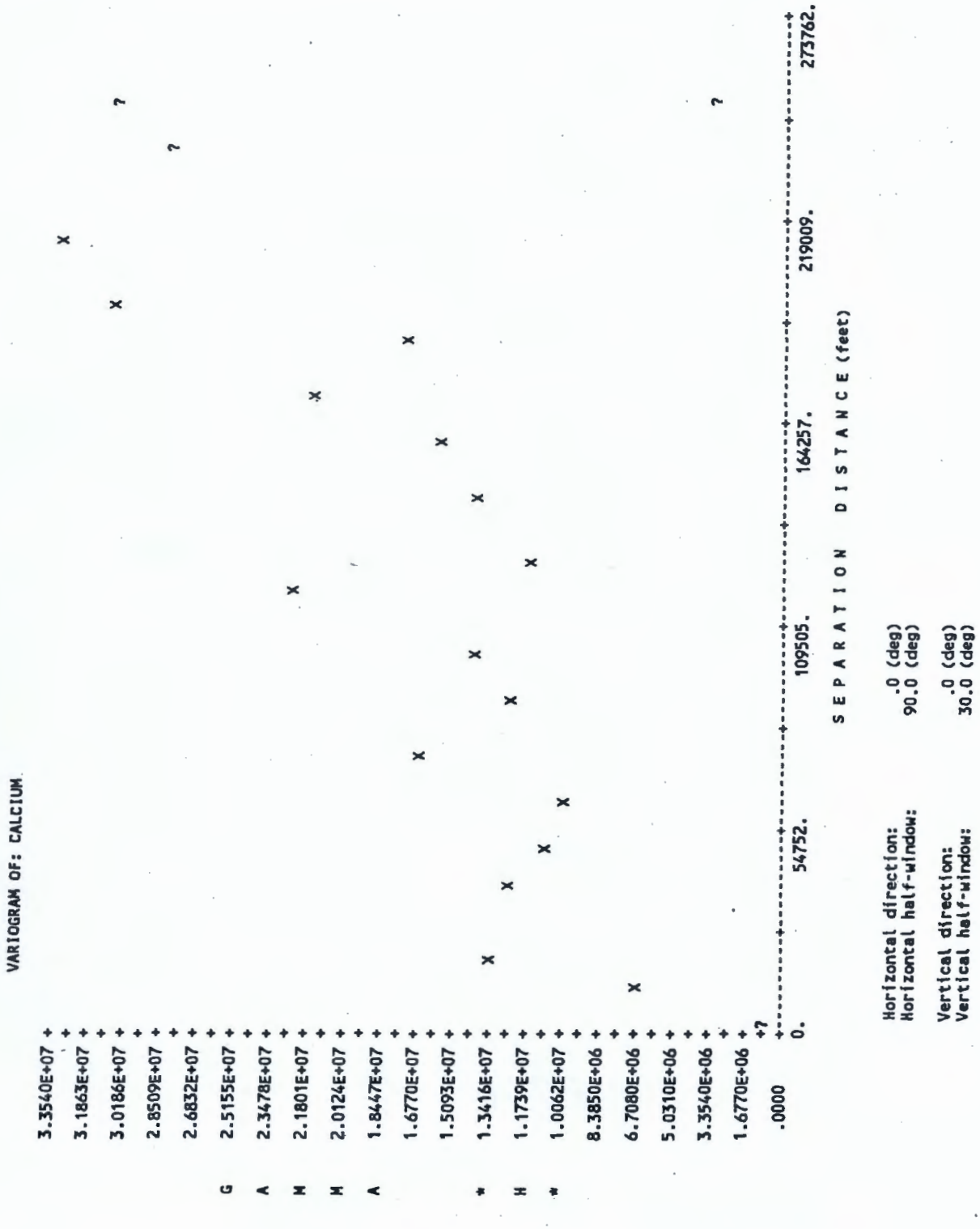


Figure D5-3a. Input Parameters for Horizontal Variogram of Calcium. (sheet 2 of 2)

CALCIUM

DATA FILTER INFORMATION

Minimum data value:	3820.0
Minimum value used:	5600.0
Maximum data value:	86600.
Maximum value used:	22000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	88

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	10099.
Minimum value:	5600.0
Maximum value:	22000.
Variance:	1.24913E+07
Standard deviation:	3534.3
Coeff. of variation:	.34997

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	24	9370.9	5.5868E+06
13688. - 27376.	101	16716.9	7.6856E+06
27376. - 41064.	26	38458.8	8.6659E+06
41064. - 54752.	329	47415.1	1.2379E+07
54752. - 68440.	492	59852.3	1.1664E+07
68440. - 82129.	60	69034.5	2.0427E+07
82129. - 95817.	165	87706.3	6.2059E+06
95817. - 109505.	284	101412.4	1.5207E+07
109505. - 123193.	91	119303.1	2.1455E+07
123193. - 136881.	39	124816.1	1.1659E+07
136881. - 150569.	148	143241.6	1.2052E+07
150569. - 164257.	28	159138.3	1.3724E+07
164257. - 177945.	0		
177945. - 191633.	0		
191633. - 205321.	0		
205321. - 219009.	0		
219009. - 232698.	0		
232698. - 246386.	0		
246386. - 260074.	0		
260074. - 273762.	0		

Figure D5-3b. Input Parameters for Horizontal Variogram of Calcium. (sheet 1 of 2)

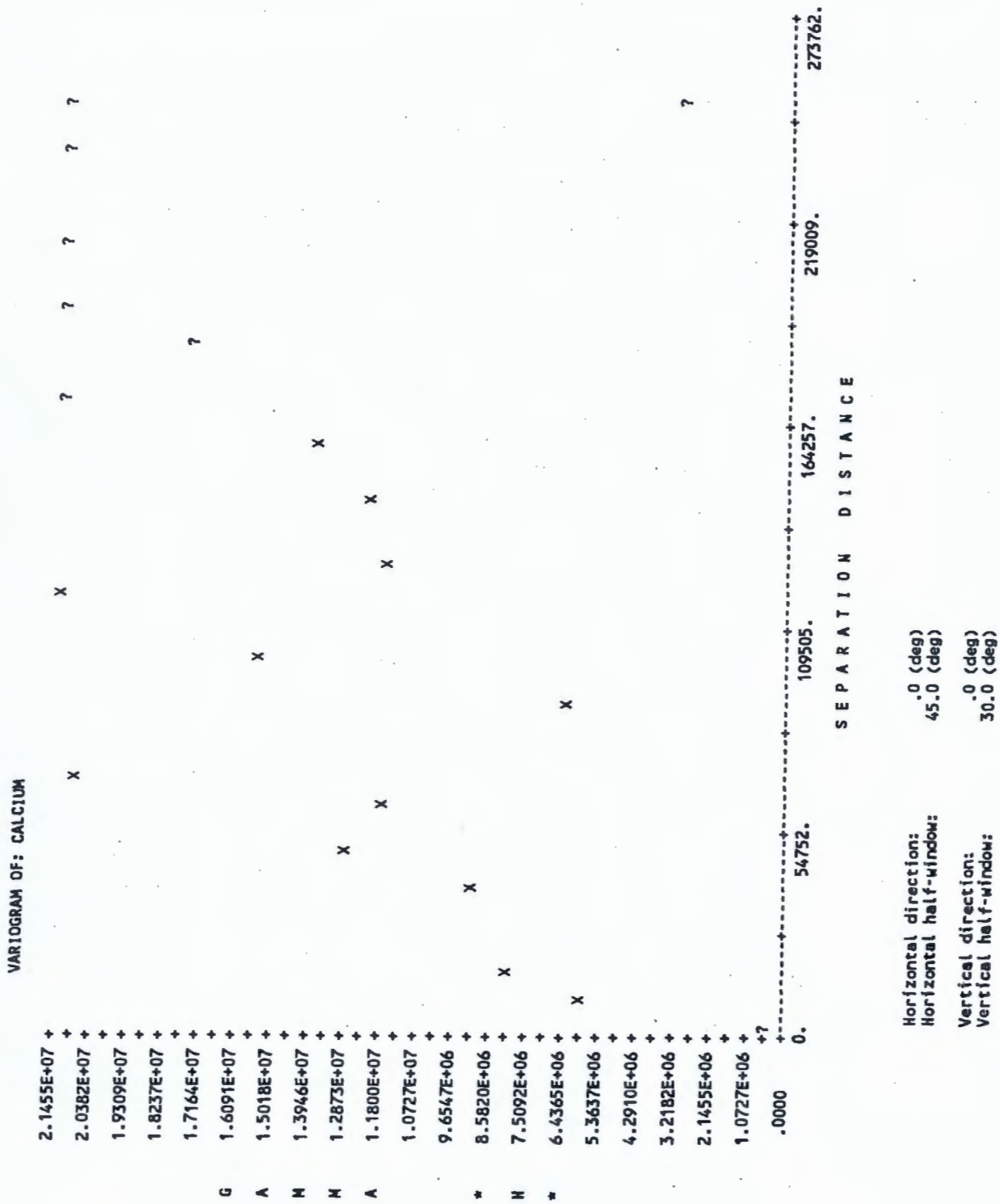


Figure D5-3b. Input Parameters for Horizontal Variogram of Calcium. (sheet 2 of 2)

CALCIUM

DATA FILTER INFORMATION

Minimum data value:	3820.0
Minimum value used:	5600.0
Maximum data value:	86600.
Maximum value used:	22000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	88

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	10099.
Minimum value:	5600.0
Maximum value:	22000.
Variance:	1.24913E+07
Standard deviation:	3534.3
Coeff. of variation:	.34997

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	150	12006.4	6.4852E+06
13688. - 27376.	129	22073.8	1.7221E+07
27376. - 41064.	30	37251.3	1.5935E+07
41064. - 54752.	270	49857.5	8.0700E+06
54752. - 68440.	169	62618.0	4.7436E+06
68440. - 82129.	118	74550.7	1.4894E+07
82129. - 95817.	170	89139.3	1.7407E+07
95817. - 109505.	182	98888.4	1.2685E+07
109505. - 123193.	32	110404.9	2.2956E+07
123193. - 136881.	0		
136881. - 150569.	136	142577.9	1.5883E+07
150569. - 164257.	104	156762.0	1.6419E+07
164257. - 177945.	68	170401.6	2.1668E+07
177945. - 191633.	70	185951.5	1.7403E+07
191633. - 205321.	26	194900.1	3.0319E+07
205321. - 219009.	24	211729.0	3.3540E+07
219009. - 232698.	0		
232698. - 246386.	16	238325.8	2.7776E+07
246386. - 260074.	8	251104.1	3.0809E+07
260074. - 273762.	0		

Figure D5-3c. Input Parameters for Horizontal Variogram of Calcium. (sheet 1 of 2)

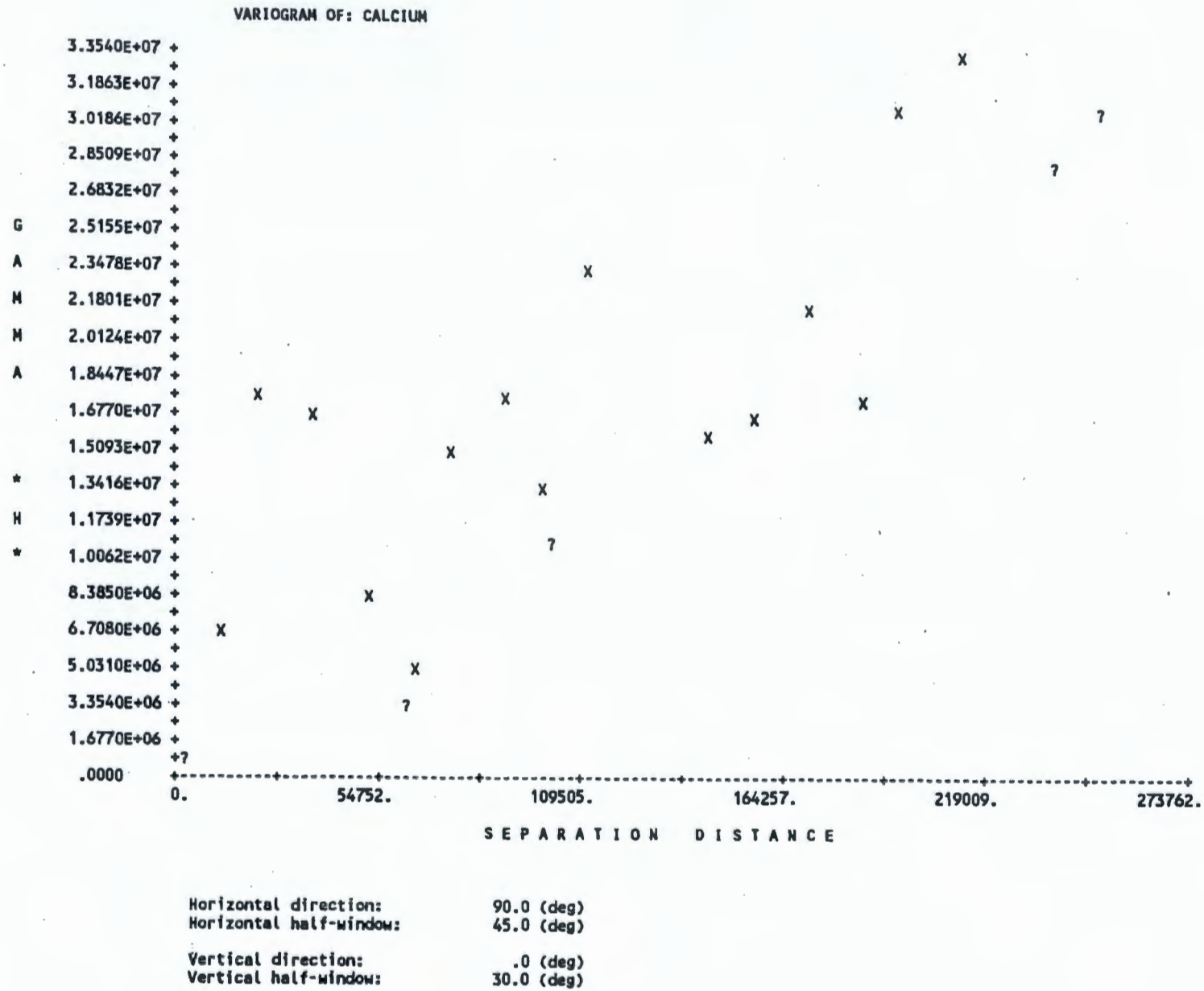


Figure D5-3c. Input Parameters for Horizontal Variogram of Calcium. (sheet 2 of 2)

CALCIUM RE

DATA FILTER INFORMATION

Minimum data value:	-7705.0
Minimum value used:	-8000.0
Maximum data value:	20000.
Maximum value used:	15000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	96

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	133.50
Minimum value:	-8000.0
Maximum value:	15000.
Variance:	1.45936E+07
Standard deviation:	3820.2
Coeff. of variation:	28.615

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	26	9057.0	6.0817E+06
13688. - 27376.	137	16915.5	1.2658E+07
27376. - 41064.	45	38458.8	1.6466E+07
41064. - 54752.	370	47464.3	1.2288E+07
54752. - 68440.	560	59961.7	1.3532E+07
68440. - 82129.	60	69034.5	1.2129E+07
82129. - 95817.	190	87669.7	1.2410E+07
95817. - 109505.	335	101550.7	1.2333E+07
109505. - 123193.	108	119473.8	2.4899E+07
123193. - 136881.	60	124816.1	1.1683E+07
136881. - 150569.	188	143183.8	2.5667E+07
150569. - 164257.	32	159138.3	1.1055E+07
164257. - 177945.	0		
177945. - 191633.	0		
191633. - 205321.	0		
205321. - 219009.	0		
219009. - 232698.	0		
232698. - 246386.	0		
246386. - 260074.	0		
260074. - 273762.	0		

Figure D5-3d. Input Parameters for Horizontal Variogram of Calcium RE. (sheet 1 of 2)

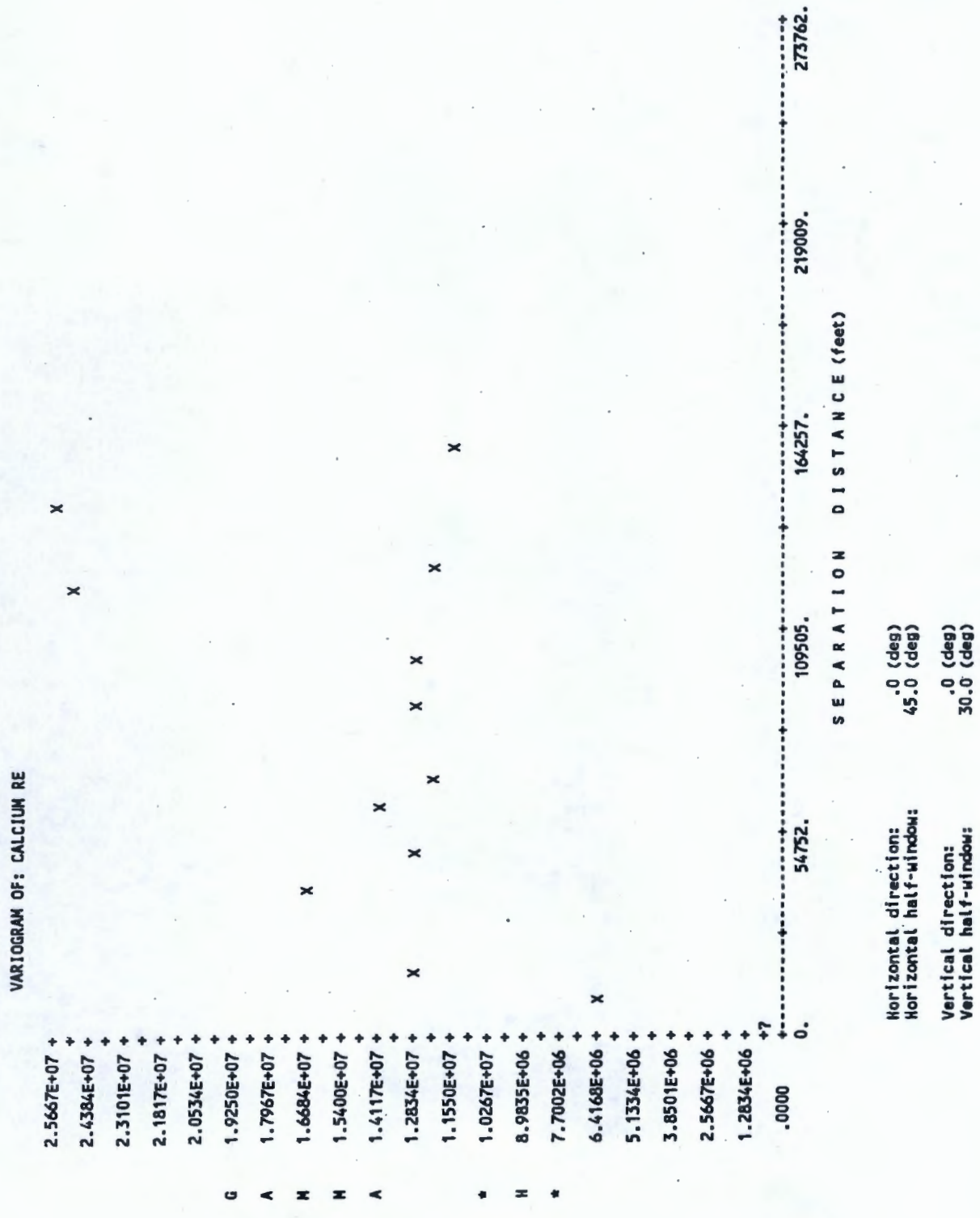


Figure D5-3d. Input Parameters for Horizontal Variogram of Calcium RE. (sheet 2 of 2)

CALCIUM RE

DATA FILTER INFORMATION

Minimum data value:	-7705.0
Minimum value used:	-8000.0
Maximum data value:	20000.
Maximum value used:	15000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	96

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	133.50
Minimum value:	-8000.0
Maximum value:	15000.
Variance:	1.45936E+07
Standard deviation:	3820.2
Coeff. of variation:	28.615

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	45.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	150	12006.4	6.5964E+06
13688. - 27376.	207	21112.8	1.6183E+07
27376. - 41064.	66	37318.8	1.8886E+07
41064. - 54752.	565	48800.6	1.0806E+07
54752. - 68440.	487	58985.4	1.1150E+07
68440. - 82129.	188	72691.1	1.4141E+07
82129. - 95817.	312	87238.5	1.2637E+07
95817. - 109505.	515	100304.3	1.4201E+07
109505. - 123193.	138	117421.7	2.4868E+07
123193. - 136881.	60	124816.1	1.1683E+07
136881. - 150569.	310	143156.0	1.9789E+07
150569. - 164257.	167	157076.4	1.8205E+07
164257. - 177945.	105	170159.0	2.5171E+07
177945. - 191633.	81	186088.0	1.4951E+07
191633. - 205321.	45	194900.1	3.9259E+07
205321. - 219009.	28	212522.7	1.8191E+07
219009. - 232698.	0		
232698. - 246386.	20	238325.8	1.7890E+07
246386. - 260074.	15	251104.1	3.6211E+07
260074. - 273762.	0		

Figure D5-3e. Input Parameters for Horizontal Variogram of Calcium RE. (sheet 1 of 2)

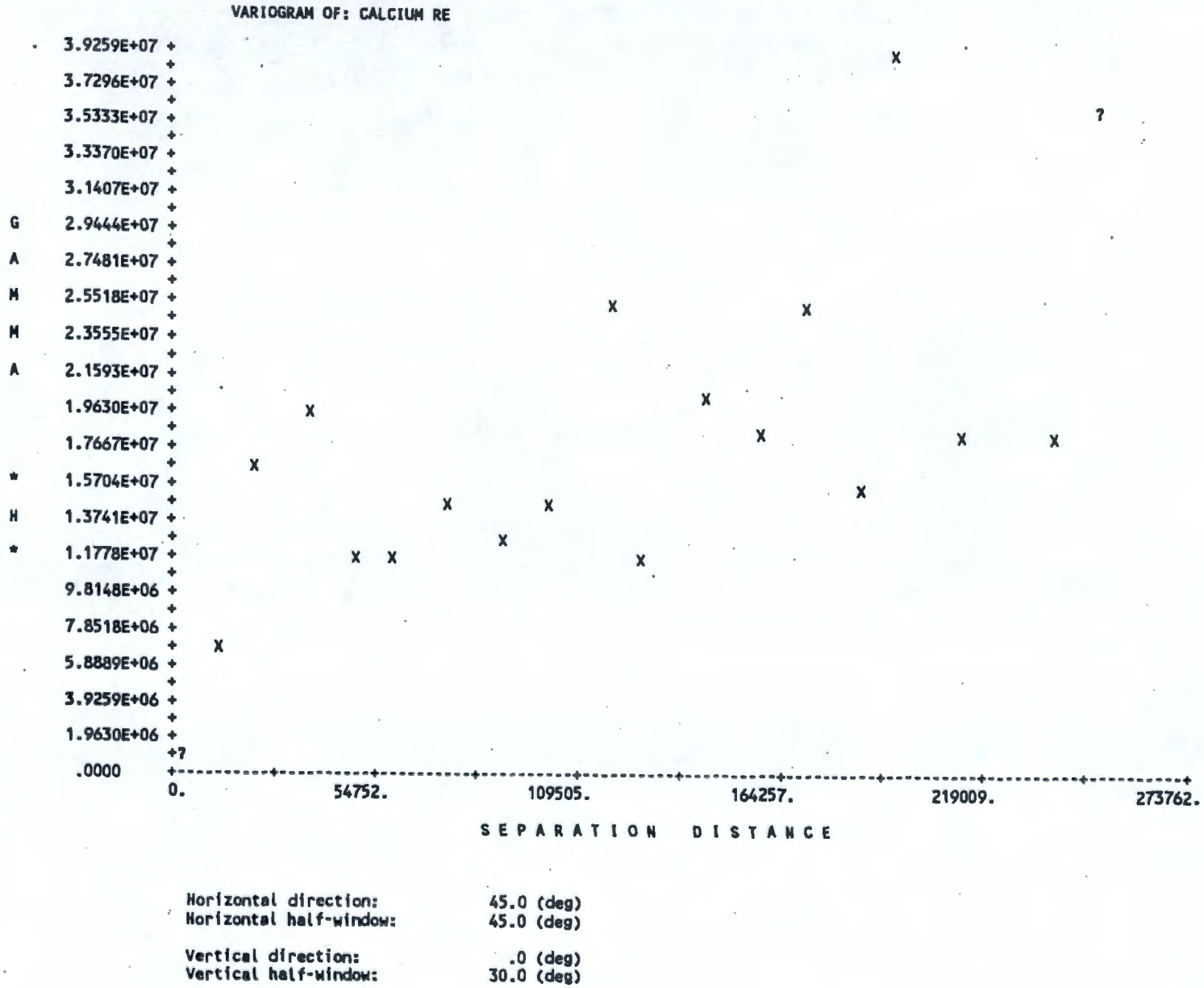


Figure D5-3e. Input Parameters for Horizontal Variogram of Calcium RE. (sheet 2 of 2)

CALCIUM RE

DATA FILTER INFORMATION

Minimum data value:	-7705.0
Minimum value used:	-8000.0
Maximum data value:	20000.
Maximum value used:	15000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	96

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	133.50
Minimum value:	-8000.0
Maximum value:	15000.
Variance:	1.45936E+07
Standard deviation:	3820.2
Coeff. of variation:	28.615

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	150	12006.4	6.5964E+06
13688. - 27376.	157	22107.0	2.0147E+07
27376. - 41064.	33	37035.4	1.7476E+07
41064. - 54752.	306	49965.6	7.9983E+06
54752. - 68440.	178	62755.7	4.9785E+06
68440. - 82129.	148	74585.9	1.5928E+07
82129. - 95817.	246	89278.0	2.1514E+07
95817. - 109505.	210	98907.3	1.6080E+07
109505. - 123193.	45	110363.8	2.1895E+07
123193. - 136881.	0		
136881. - 150569.	157	142253.9	1.5426E+07
150569. - 164257.	135	156587.7	1.9900E+07
164257. - 177945.	105	170159.0	2.5171E+07
177945. - 191633.	81	186088.0	1.4951E+07
191633. - 205321.	45	194900.1	3.9259E+07
205321. - 219009.	28	212522.7	1.8191E+07
219009. - 232698.	0		
232698. - 246386.	20	238325.8	1.7890E+07
246386. - 260074.	15	251104.1	3.6211E+07
260074. - 273762.	0		

Figure D5-3f. Input Parameters for Horizontal Variogram of Calcium RE. (sheet 1 of 2)

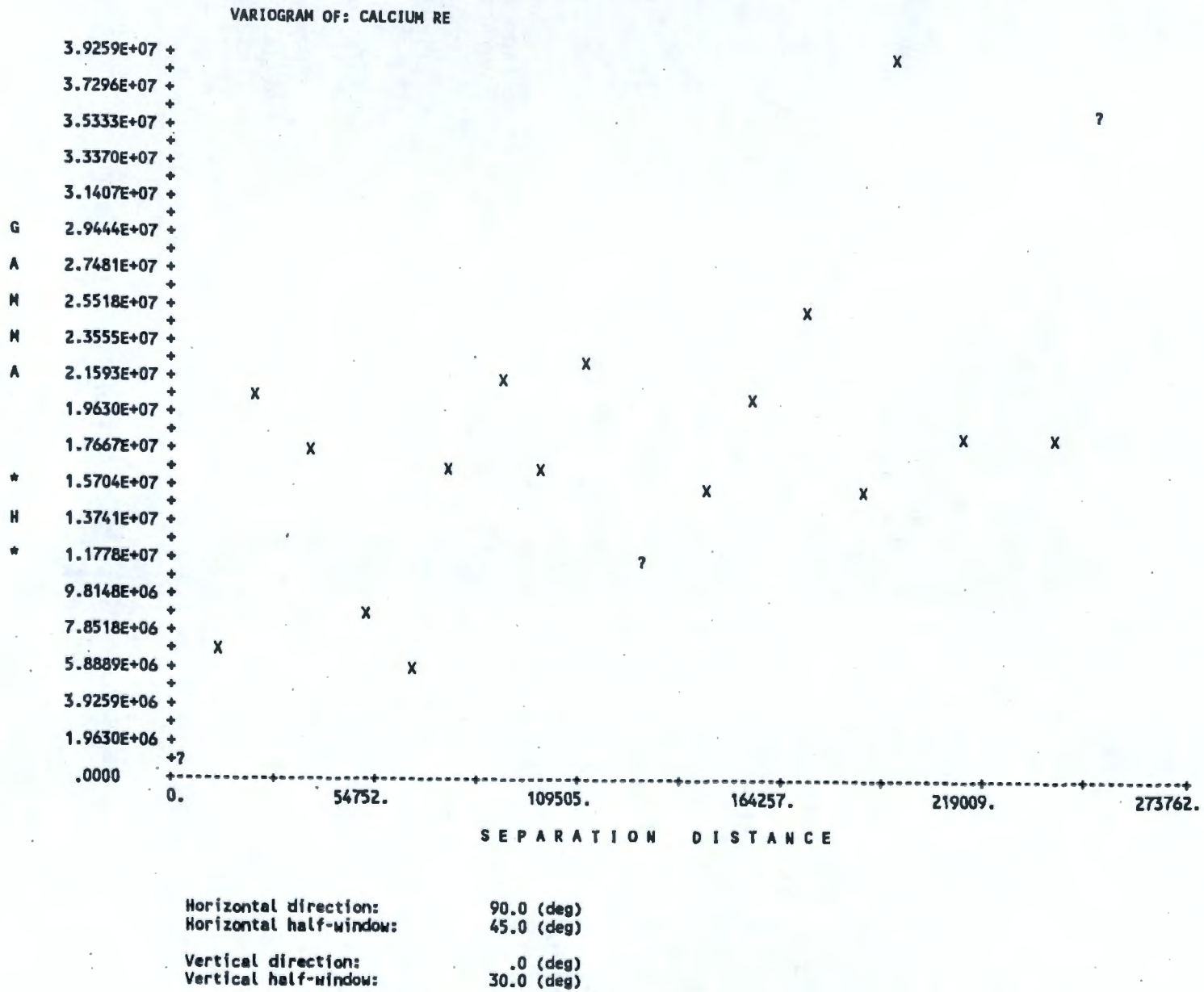


Figure D5-3f. Input Parameters for Horizontal Variogram of Calcium RE. (sheet 2 of 2)

SODIUM

DATA FILTER INFORMATION

Minimum data value:	101.00
Minimum value used:	190.00
Maximum data value:	5620.0
Maximum value used:	980.00

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	90

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	375.62
Minimum value:	190.00
Maximum value:	980.00
Variance:	35164.
Standard deviation:	187.52
Coeff. of variation:	.49922

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	90.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	150	11519.4	2.4541E+04
13688. - 27376.	281	19801.2	5.5376E+04
27376. - 41064.	66	38179.8	6.3307E+04
41064. - 54752.	559	48144.8	2.3726E+04
54752. - 68440.	600	60784.2	3.7982E+04
68440. - 82129.	217	72725.2	6.5734E+04
82129. - 95817.	387	88671.9	2.7204E+04
95817. - 109505.	474	100780.6	2.7156E+04
109505. - 123193.	146	116945.9	5.8568E+04
123193. - 136881.	48	124816.1	2.0558E+04
136881. - 150569.	314	142698.9	3.0972E+04
150569. - 164257.	172	157388.7	4.3821E+04
164257. - 177945.	98	170449.2	2.6596E+04
177945. - 191633.	69	185828.0	2.4234E+04
191633. - 205321.	36	194900.1	1.5824E+04
205321. - 219009.	35	212522.7	1.1586E+05
219009. - 232698.	0		
232698. - 246386.	16	238325.8	3.2110E+04
246386. - 260074.	12	251104.1	3.7031E+04
260074. - 273762.	0		

Figure D5-4a. Input Parameters for Horizontal Variogram of Sodium. (sheet 1 of 2)

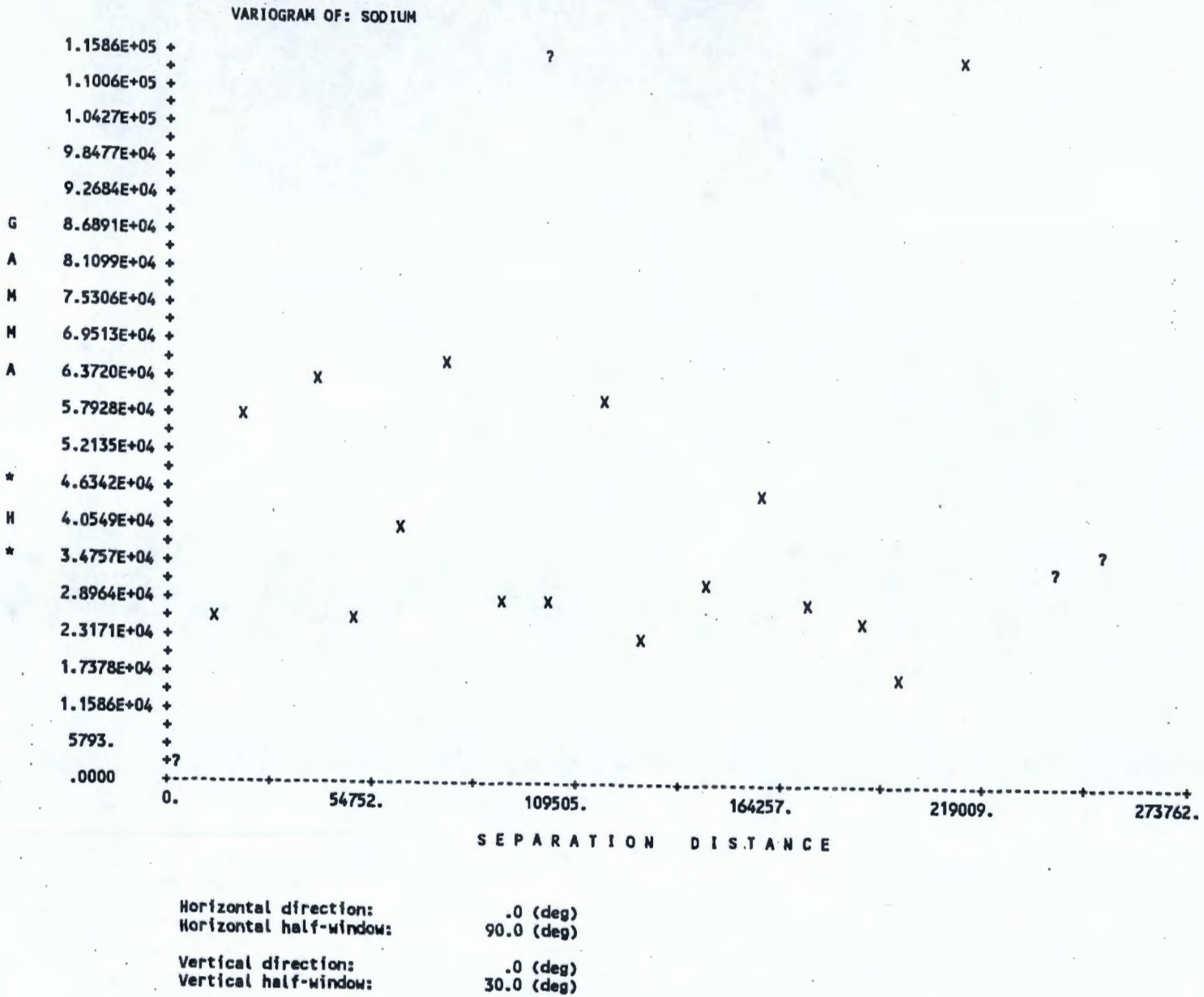


Figure D5-4a. Input Parameters for Horizontal Variogram of Sodium. (sheet 2 of 2)

SODIUM

DATA FILTER INFORMATION

Minimum data value:	101.00
Minimum value used:	190.00
Maximum data value:	5620.0
Maximum value used:	980.00

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	90

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	375.62
Minimum value:	190.00
Maximum value:	980.00
Variance:	35164.
Standard deviation:	187.52
Coeff. of variation:	.49922

VARIOGRAM DIRECTION INFORMATION

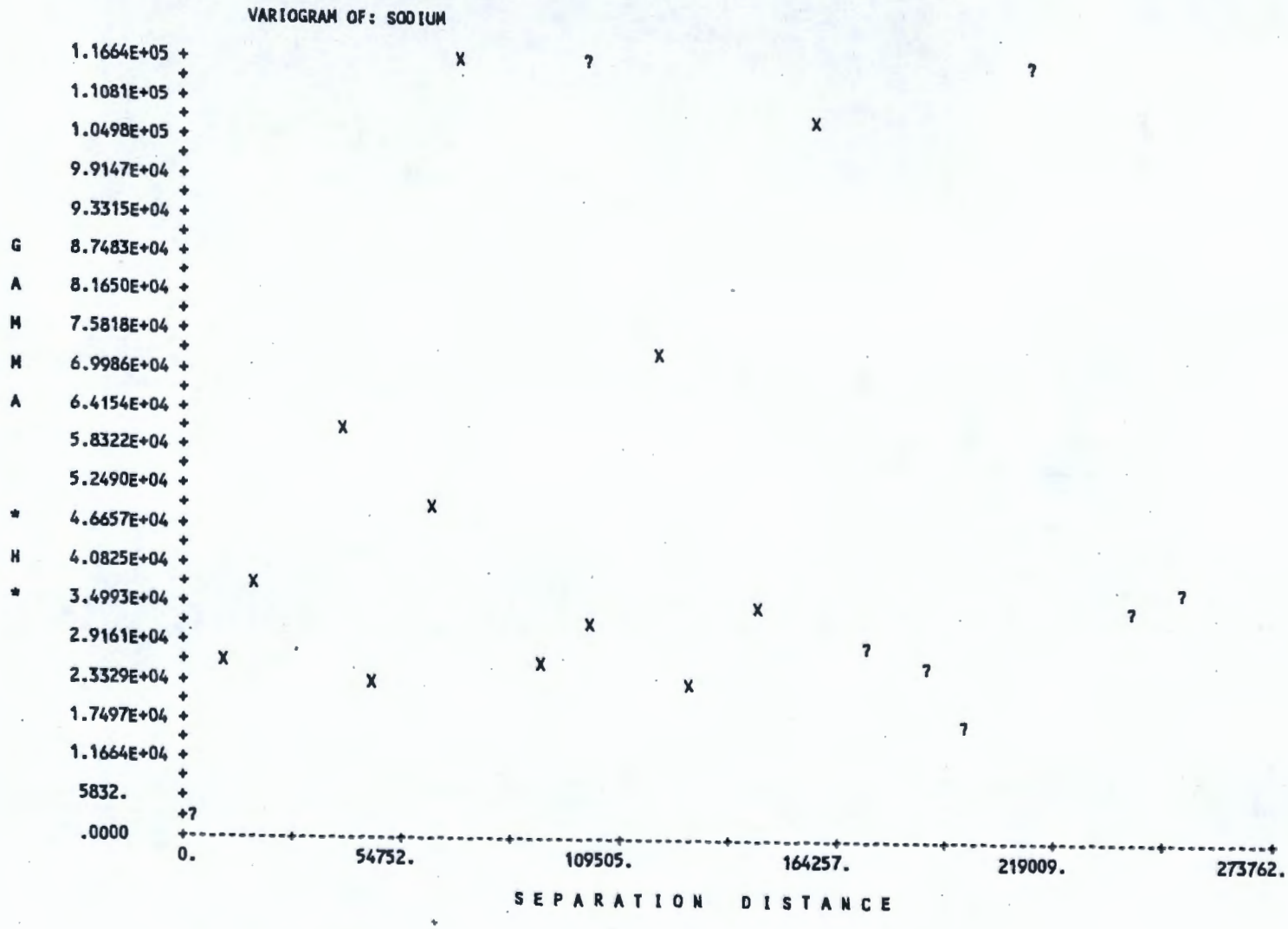
Horizontal direction:	.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	24	8962.8	2.5082E+04
13688. - 27376.	137	17089.2	3.7313E+04
27376. - 41064.	36	38458.7	5.9614E+04
41064. - 54752.	331	46911.9	2.1332E+04
54752. - 68440.	439	59849.8	4.8932E+04
68440. - 82129.	70	69034.5	1.1664E+05
82129. - 95817.	185	88626.6	2.4730E+04
95817. - 109505.	280	101937.8	3.1934E+04
109505. - 123193.	107	119354.2	7.2710E+04
123193. - 136881.	48	124816.1	2.0558E+04
136881. - 150569.	190	142740.8	3.2483E+04
150569. - 164257.	50	159138.4	1.0752E+05
164257. - 177945.	0		
177945. - 191633.	0		
191633. - 205321.	0		
205321. - 219009.	0		
219009. - 232698.	0		
232698. - 246386.	0		
246386. - 260074.	0		
260074. - 273762.	0		

Figure D5-4b. Input Parameters for Horizontal Variogram of Sodium. (sheet 1 of 2)



Horizontal direction: .0 (deg)
Horizontal half-window: 45.0 (deg)

Vertical direction: .0 (deg)
Vertical half-window: 30.0 (deg)

Figure D5-4b. Input Parameters for Horizontal Variogram of Sodium. (sheet 2 of 2)

COPPER

DATA FILTER INFORMATION

Minimum data value:	8.1000
Minimum value used:	13.000
Maximum data value:	36.100
Maximum value used:	32.200

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	69

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	16.723
Minimum value:	13.000
Maximum value:	32.200
Variance:	17.818
Standard deviation:	4.2211
Coeff. of variation:	.25241

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	90.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	23	11185.1	13.17
13688. - 27376.	165	20534.3	35.40
27376. - 41064.	50	37807.9	20.86
41064. - 54752.	332	47607.5	11.30
54752. - 68440.	270	61132.9	11.20
68440. - 82129.	93	73223.5	61.89
82129. - 95817.	197	88231.9	10.12
95817. - 109505.	356	100592.8	10.37
109505. - 123193.	113	116242.7	40.74
123193. - 136881.	39	124816.1	2.900
136881. - 150569.	222	142592.6	11.25
150569. - 164257.	87	156967.2	46.07
164257. - 177945.	48	170565.8	13.08
177945. - 191633.	73	185924.2	8.094
191633. - 205321.	39	194900.1	36.16
205321. - 219009.	21	212522.7	77.15
219009. - 232698.	0		
232698. - 246386.	12	238325.8	1.361
246386. - 260074.	9	251104.1	43.13
260074. - 273762.	0		

Figure D5-5a. Input Parameters for Horizontal Variogram of Copper. (sheet 1 of 2)

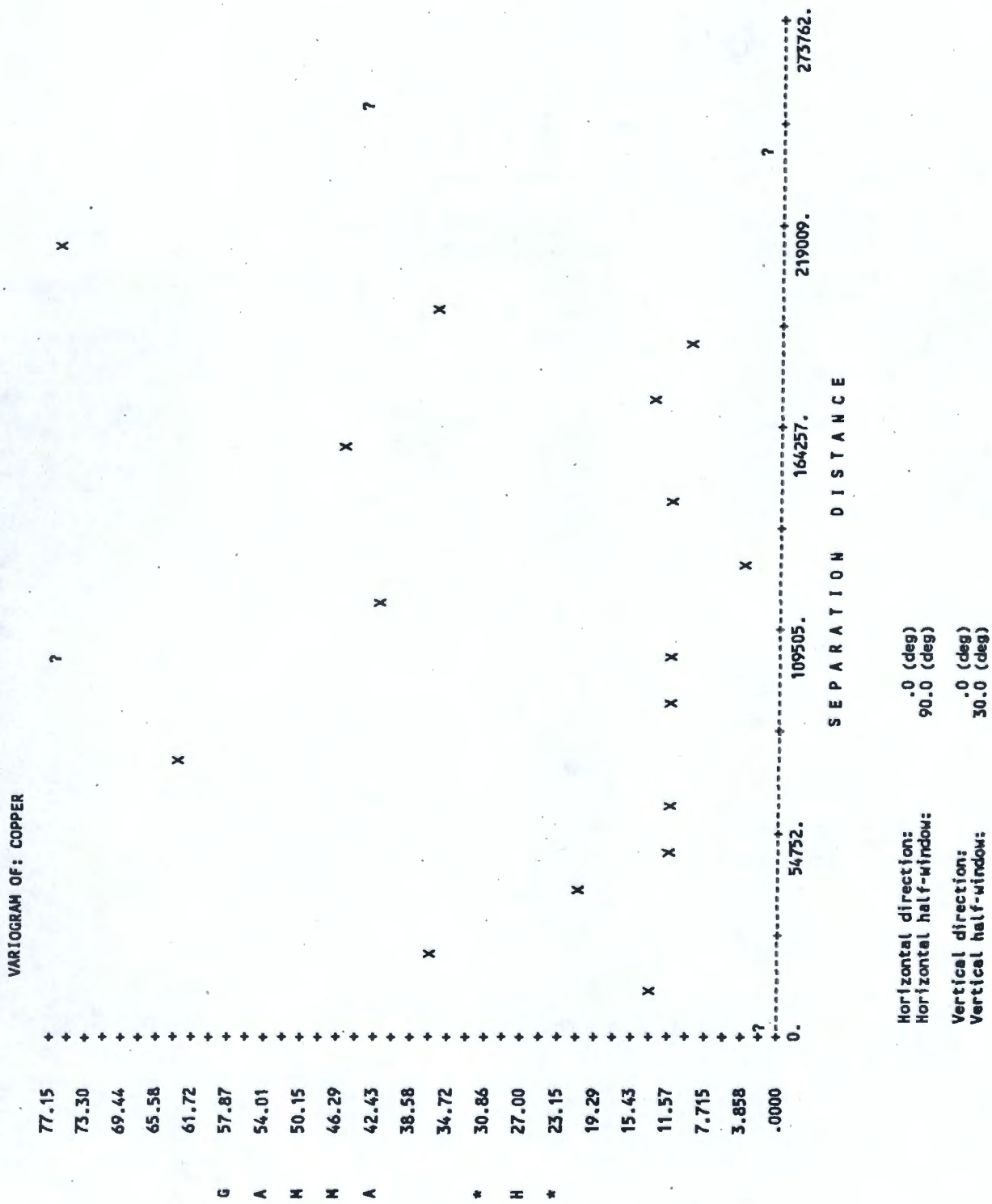


Figure D5-5a. Input Parameters for Horizontal Variogram of Copper. (sheet 2 of 2)

COPPER

DATA FILTER INFORMATION

Minimum data value:	8.1000
Minimum value used:	13.000
Maximum data value:	36.100
Maximum value used:	32.200

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	69

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	16.723
Minimum value:	13.000
Maximum value:	32.200
Variance:	17.818
Standard deviation:	4.2211
Coeff. of variation:	.25241

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	5	8228.3	8.893
13688. - 27376.	45	17678.4	6.558
27376. - 41064.	26	38458.8	4.632
41064. - 54752.	167	45490.9	15.85
54752. - 68440.	188	59777.9	11.96
68440. - 82129.	18	69034.5	133.0
82129. - 95817.	92	86331.6	4.575
95817. - 109505.	268	101222.2	11.46
109505. - 123193.	74	119394.6	45.88
123193. - 136881.	39	124816.1	2.900
136881. - 150569.	141	143050.8	14.83
150569. - 164257.	21	159138.3	107.3
164257. - 177945.	0		
177945. - 191633.	0		
191633. - 205321.	0		
205321. - 219009.	0		
219009. - 232698.	0		
232698. - 246386.	0		
246386. - 260074.	0		
260074. - 273762.	0		

Figure D5-5b. Input Parameters for Horizontal Variogram of Copper. (sheet 1 of 2)

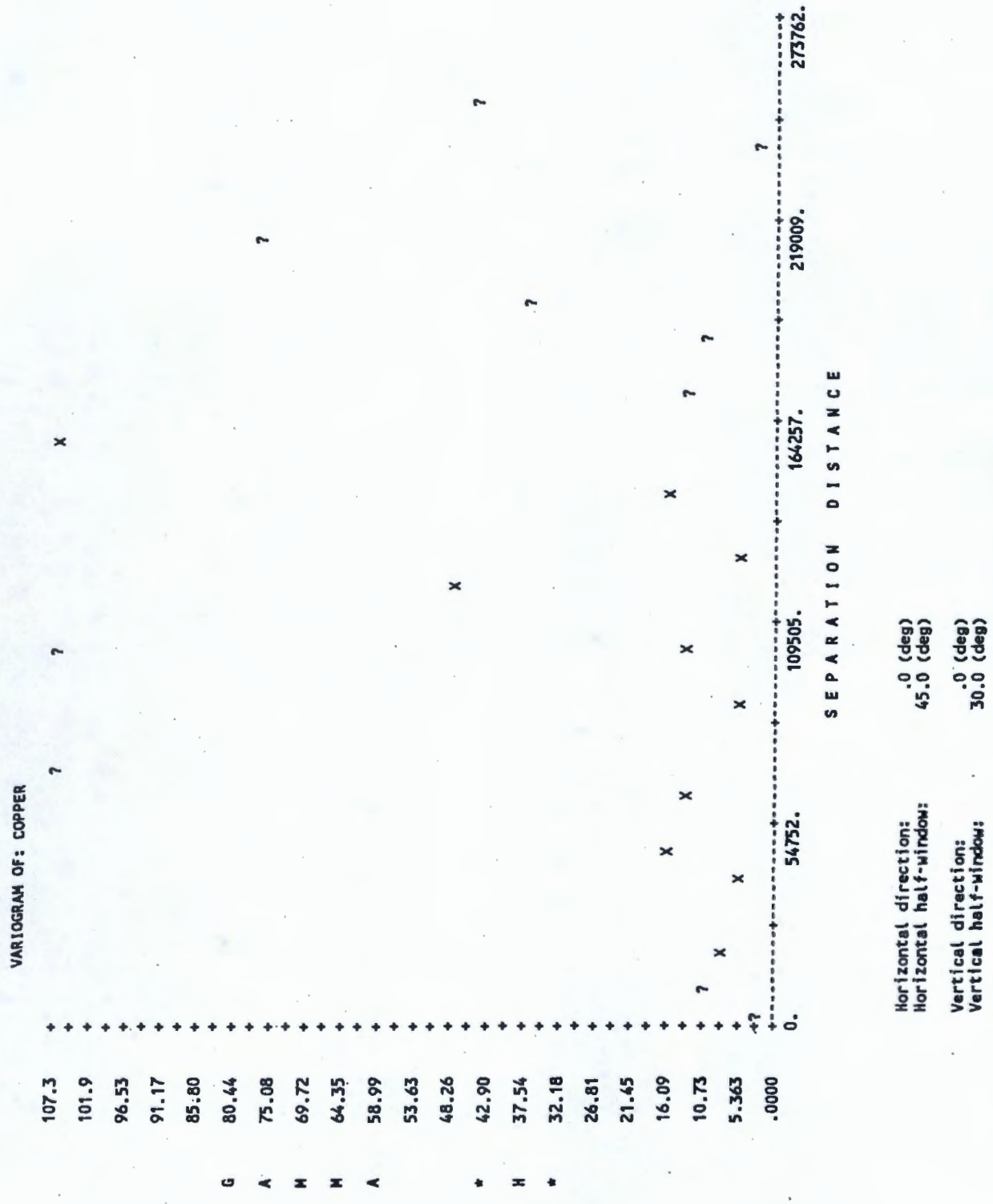


Figure D5-5b. Input Parameters for Horizontal Variogram of Copper. (sheet 2 of 2)

COPPER

DATA FILTER INFORMATION

Minimum data value:	8.1000
Minimum value used:	13.000
Maximum data value:	36.100
Maximum value used:	32.200

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	69

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	16.723
Minimum value:	13.000
Maximum value:	32.200
Variance:	17.818
Standard deviation:	4.2211
Coeff. of variation:	.25241

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	18	12006.4	14.36
13688. - 27376.	120	21605.2	46.21
27376. - 41064.	24	37102.9	38.44
41064. - 54752.	165	49749.5	6.704
54752. - 68440.	82	64239.8	9.464
68440. - 82129.	75	74228.9	44.81
82129. - 95817.	105	89897.4	14.97
95817. - 109505.	88	98675.4	7.047
109505. - 123193.	39	110262.4	31.01
123193. - 136881.	0		
136881. - 150569.	81	141794.4	5.017
150569. - 164257.	66	156276.5	26.60
164257. - 177945.	48	170565.8	13.08
177945. - 191633.	73	185924.2	8.094
191633. - 205321.	39	194900.1	36.16
205321. - 219009.	21	212522.7	77.15
219009. - 232698.	0		
232698. - 246386.	12	238325.8	1.361
246386. - 260074.	9	251104.1	43.13
260074. - 273762.	0		

Figure D5-5c. Input Parameters for Horizontal Variogram of Copper. (sheet 1 of 2)

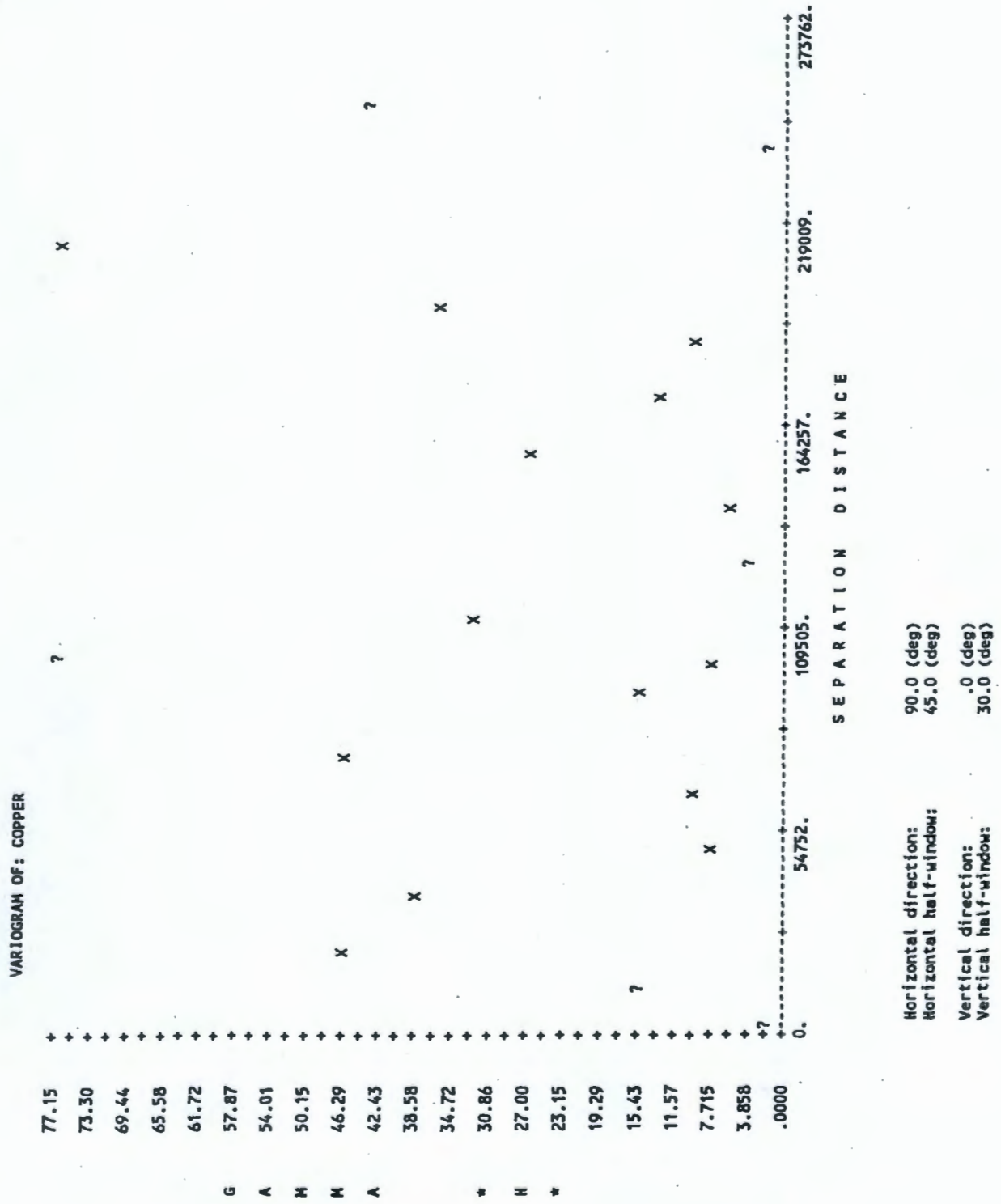


Figure D5-5c. Input Parameters for Horizontal Variogram of Copper. (sheet 2 of 2)

LEAD

DATA FILTER INFORMATION

Minimum data value:	1.1000
Minimum value used:	3.3000
Maximum data value:	26.600
Maximum value used:	15.400

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	95

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	6.2832
Minimum value:	3.3000
Maximum value:	15.400
Variance:	7.4475
Standard deviation:	2.7290
Coeff. of variation:	.43434

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	90.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	132	11453.0	4.313
13688. - 27376.	315	20237.1	15.09
27376. - 41064.	87	38000.0	6.919
41064. - 54752.	618	48602.2	6.520
54752. - 68440.	662	60747.3	9.044
68440. - 82129.	194	73034.6	14.43
82129. - 95817.	443	88730.3	4.419
95817. - 109505.	505	100564.5	6.614
109505. - 123193.	177	117136.2	12.61
123193. - 136881.	68	124816.1	1.281
136881. - 150569.	385	142643.9	7.452
150569. - 164257.	166	157448.3	6.396
164257. - 177945.	112	170625.1	3.750
177945. - 191633.	89	186222.4	7.677
191633. - 205321.	51	194900.0	3.525
205321. - 219009.	35	212522.7	21.06
219009. - 232698.	0		
232698. - 246386.	20	238325.8	.5735
246386. - 260074.	15	251104.1	2.974
260074. - 273762.	0		

Figure D5-6a. Input Parameters for Horizontal Variogram of Lead. (sheet 1 of 2)

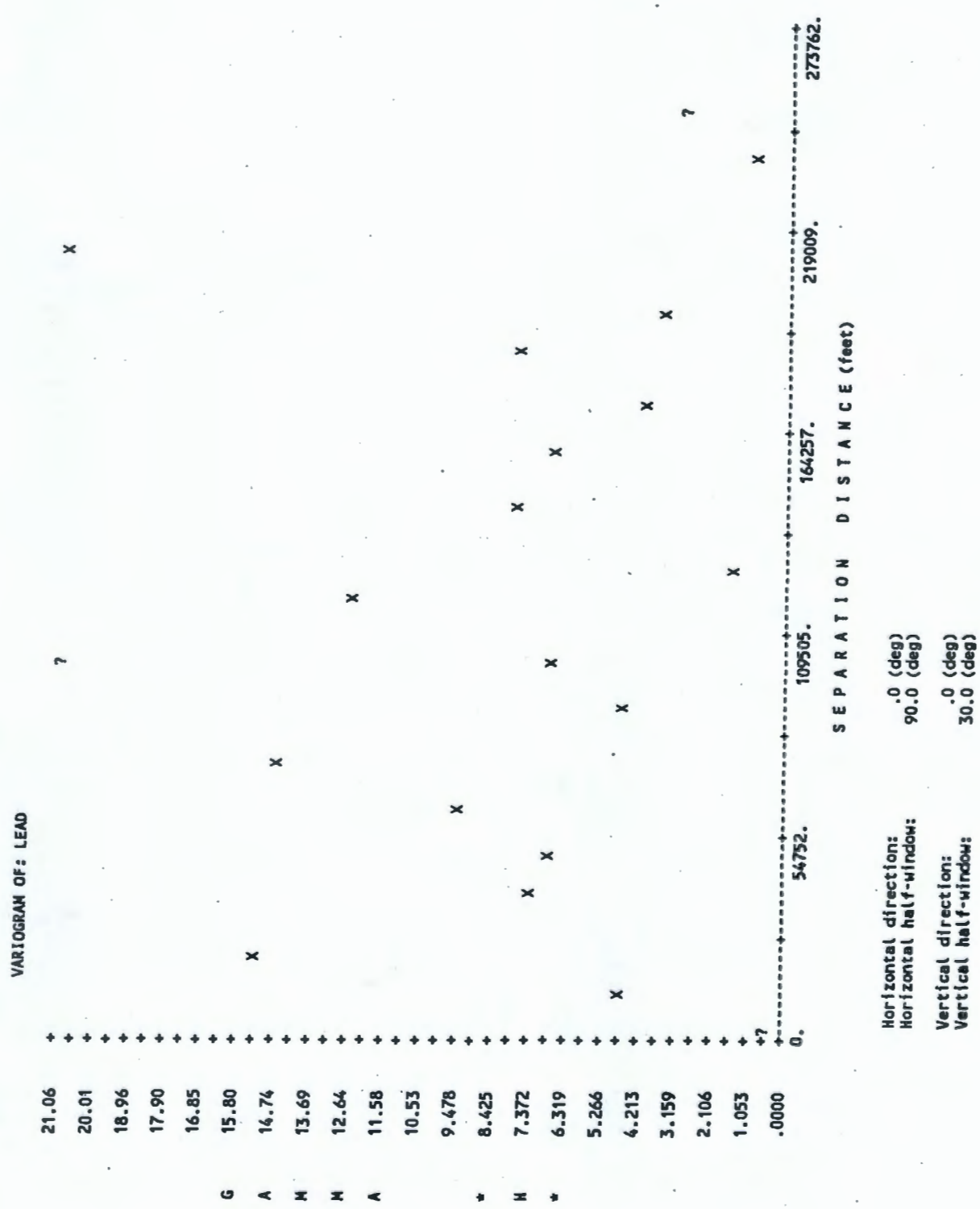


Figure D5-6a. Input Parameters for Horizontal Variogram of Lead. (sheet 2 of 2)

LEAD

DATA FILTER INFORMATION

Minimum data value:	1.1000
Minimum value used:	3.3000
Maximum data value:	26.600
Maximum value used:	15.400

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	95

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	6.2832
Minimum value:	3.3000
Maximum value:	15.400
Variance:	7.4475
Standard deviation:	2.7290
Coeff. of variation:	.43434

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	24	8962.8	4.184
13688. - 27376.	127	17127.6	5.592
27376. - 41064.	51	38458.7	2.371
41064. - 54752.	348	47440.5	6.656
54752. - 68440.	494	59982.2	10.39
68440. - 82129.	60	69034.5	27.69
82129. - 95817.	190	87669.7	6.668
95817. - 109505.	310	101621.2	7.737
109505. - 123193.	132	119444.9	12.36
123193. - 136881.	68	124816.1	1.281
136881. - 150569.	248	142916.3	9.313
150569. - 164257.	50	159138.4	11.71
164257. - 177945.	0		
177945. - 191633.	0		
191633. - 205321.	0		
205321. - 219009.	0		
219009. - 232698.	0		
232698. - 246386.	0		
246386. - 260074.	0		
260074. - 273762.	0		

Figure D5-6b. Input Parameters for Horizontal Variogram of Lead. (sheet 1 of 2)

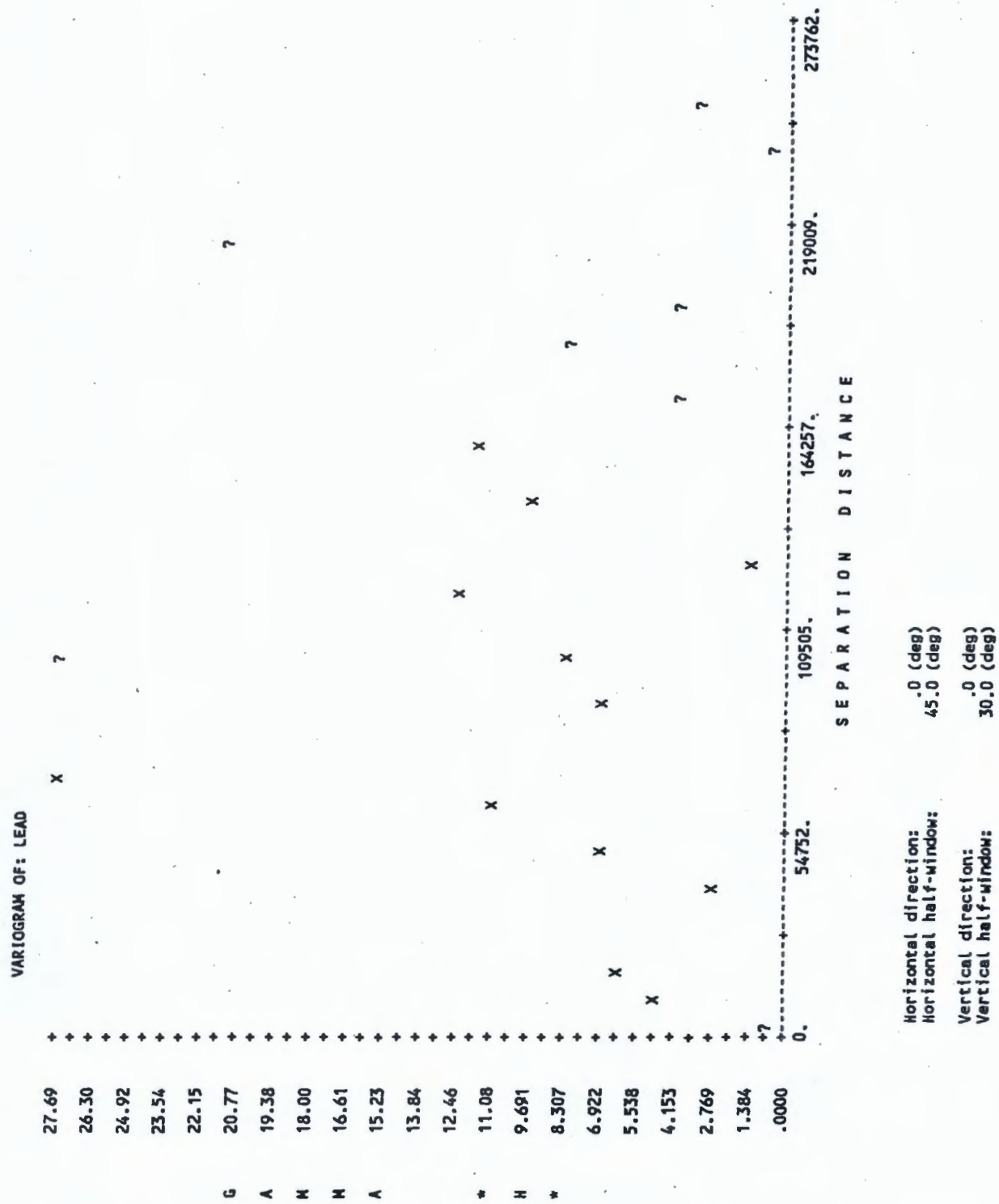


Figure D5-6b. Input Parameters for Horizontal Variogram of Lead. (sheet 2 of 2)

LEAD

DATA FILTER INFORMATION

Minimum data value:	1.1000
Minimum value used:	3.3000
Maximum data value:	26.600
Maximum value used:	15.400

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	124016.
Maximum X coordinate used:	124016.
Minimum Y coordinate:	1.00000
Minimum Y coordinate used:	1.00000
Maximum Y coordinate:	244062.
Maximum Y coordinate used:	244062.
Minimum Z coordinate:	.100000
Minimum Z coordinate used:	.100000
Maximum Z coordinate:	230.000
Maximum Z coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	95

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	6.2832
Minimum value:	3.3000
Maximum value:	15.400
Variance:	7.4475
Standard deviation:	2.7290
Coeff. of variation:	.43434

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	45.0 (deg)
Vertical direction:	.0 (deg)
Vertical half-window:	30.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	273762.
Number of intervals:	20
Length of interval:	13688.1

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 13688.	108	12006.4	4.341
13688. - 27376.	188	22337.7	21.50
27376. - 41064.	36	37350.3	13.36
41064. - 54752.	270	50099.3	6.344
54752. - 68440.	168	62996.4	5.077
68440. - 82129.	134	74825.5	8.489
82129. - 95817.	253	89526.1	2.731
95817. - 109505.	195	98883.2	4.829
109505. - 123193.	45	110363.8	13.34
123193. - 136881.	0		
136881. - 150569.	137	142150.7	4.083
150569. - 164257.	116	156720.0	4.103
164257. - 177945.	112	170625.1	3.750
177945. - 191633.	89	186222.4	7.677
191633. - 205321.	51	194900.0	3.525
205321. - 219009.	35	212522.7	21.06
219009. - 232698.	0		
232698. - 246386.	20	238325.8	.5735
246386. - 260074.	15	251104.1	2.974
260074. - 273762.	0		

Figure D5-6c. Input Parameters for Horizontal Variogram of Lead. (sheet 1 of 2)

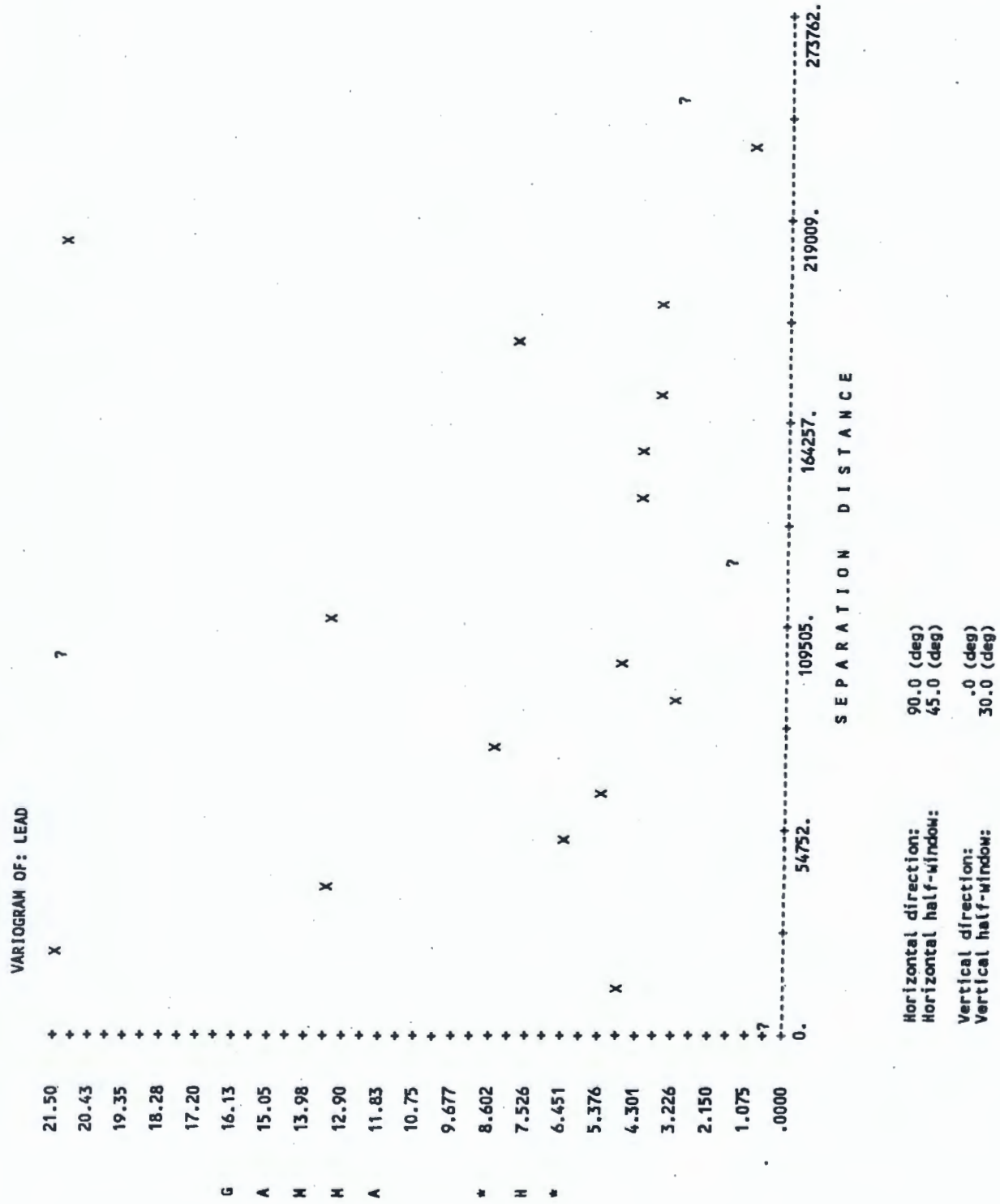


Figure D5-6c. Input Parameters for Horizontal Variogram of Lead. (sheet 2 of 2)

ALUMINUM

DATA FILTER INFORMATION

Minimum data value:	3940.0
Minimum value used:	.00000
Maximum data value:	18100.
Maximum value used:	15100.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	98

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	7667.4
Minimum value:	.00000
Maximum value:	15100.
Variance:	5.83101E+06
Standard deviation:	2414.7
Coeff. of variation:	.31493

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	150.000
Number of intervals:	30
Length of interval:	5.00000

INTERVAL	OF PAIRS	DISTANCE	GAMMA (H)
0. - 5.	68	3.0	2.5324E+06
5. - 10.	105	7.1	1.9282E+06
10. - 15.	44	11.9	1.4070E+06
15. - 20.	51	16.4	1.6082E+06
20. - 25.	31	22.0	1.2634E+06
25. - 30.	14	26.6	1.2580E+06
30. - 35.	13	31.3	8.4533E+05
35. - 40.	7	35.9	1.0280E+06
40. - 45.	8	40.5	1.0564E+06
45. - 50.	8	46.1	3.5210E+05
50. - 55.	7	50.7	2.4384E+05
55. - 60.	5	55.6	3.8463E+05
60. - 65.	6	60.8	6.0267E+05
65. - 70.	5	66.0	6.9914E+05
70. - 75.	4	71.0	1.8108E+06
75. - 80.	5	75.4	1.0943E+06
80. - 85.	5	80.4	2.1200E+06
85. - 90.	4	85.8	1.4654E+06
90. - 95.	4	91.5	1.8269E+06
95. - 100.	6	96.2	2.6380E+05
100. - 105.	6	100.7	1.9649E+06
105. - 110.	5	105.4	2.1013E+06
110. - 115.	5	111.0	5.1141E+05
115. - 120.	3	115.0	7.2548E+05
120. - 125.	3	120.0	9.5000E+05
125. - 130.	2	125.0	2.2693E+06
130. - 135.	0		
135. - 140.	0		
140. - 145.	2	142.0	8.1425E+05
145. - 150.	2	147.0	1.5605E+05

Figure D6-1a. Input Parameters for Vertical Variogram of Aluminum. (sheet 1 of 2)

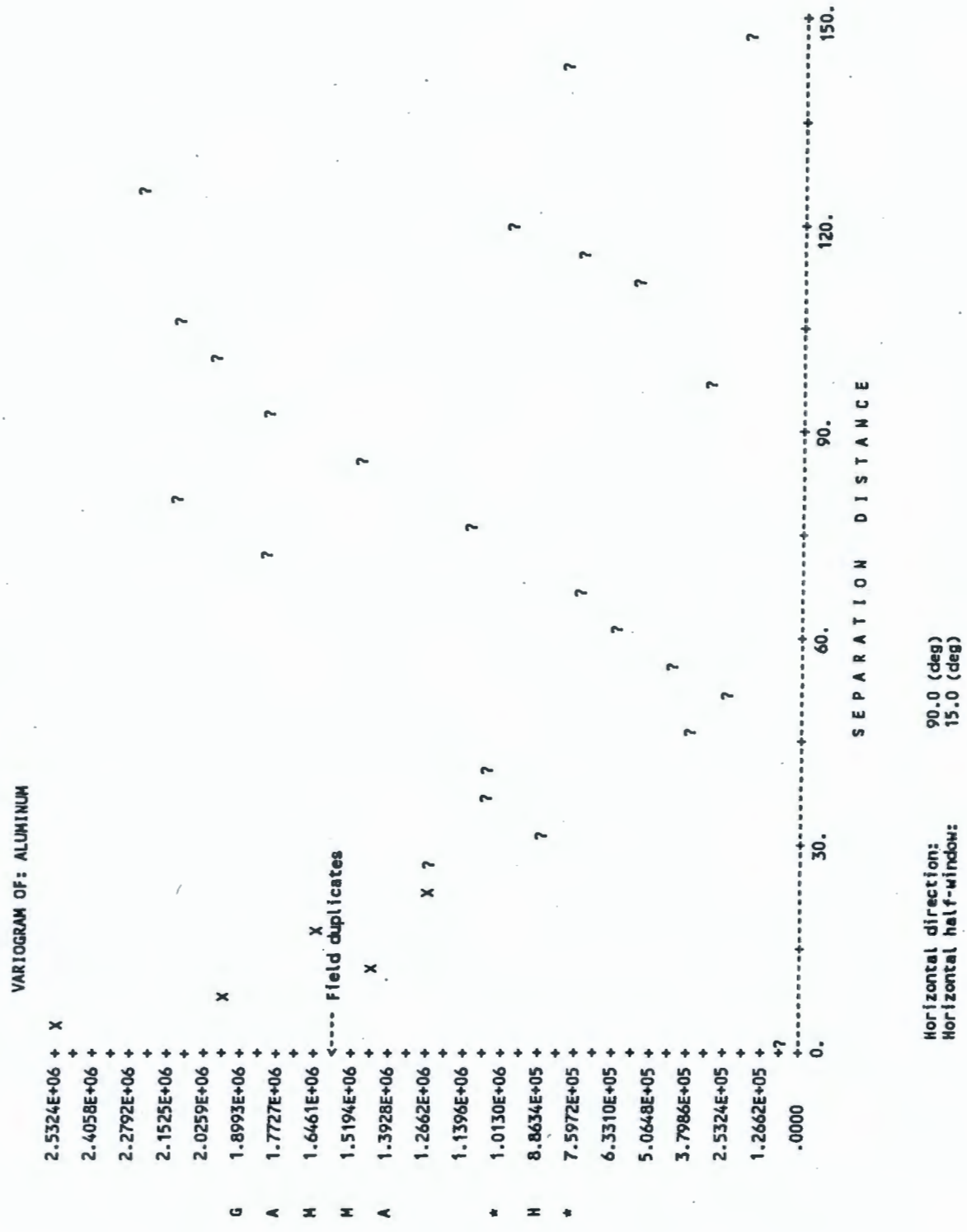


Figure D6-1a. Input Parameters for Vertical Variogram of Aluminum. (sheet 2 of 2)

ALUMINUM

DATA FILTER INFORMATION

Minimum data value:	3940.0
Minimum value used:	.00000
Maximum data value:	18100.
Maximum value used:	15100.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	98

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	7667.4
Minimum value:	.00000
Maximum value:	15100.
Variance:	5.83101E+06
Standard deviation:	2414.7
Coeff. of variation:	.31493

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	50.0000
Number of intervals:	20
Length of interval:	2.50000

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 3.	0		
3. - 5.	68	3.0	2.5324E+06
5. - 8.	63	5.9	2.1066E+06
8. - 10.	42	9.0	1.6607E+06
10. - 13.	39	11.7	1.5021E+06
13. - 15.	5	13.8	6.6523E+05
15. - 18.	29	15.1	1.5421E+06
18. - 20.	22	18.1	1.6954E+06
20. - 23.	20	20.8	1.3970E+06
23. - 25.	11	24.0	1.0206E+06
25. - 28.	11	26.1	8.2339E+05
28. - 30.	3	28.3	2.8515E+06
30. - 33.	9	30.3	9.1972E+05
33. - 35.	4	33.5	6.7798E+05
35. - 38.	7	35.9	1.0280E+06
38. - 40.	0		
40. - 43.	7	40.1	8.6782E+05
43. - 45.	1	43.0	2.3762E+06
45. - 48.	7	45.9	2.9954E+05
48. - 50.	1	48.0	7.2000E+05

Figure D6-1b. Input Parameters for Vertical Variogram of Aluminum. (sheet 1 of 2)

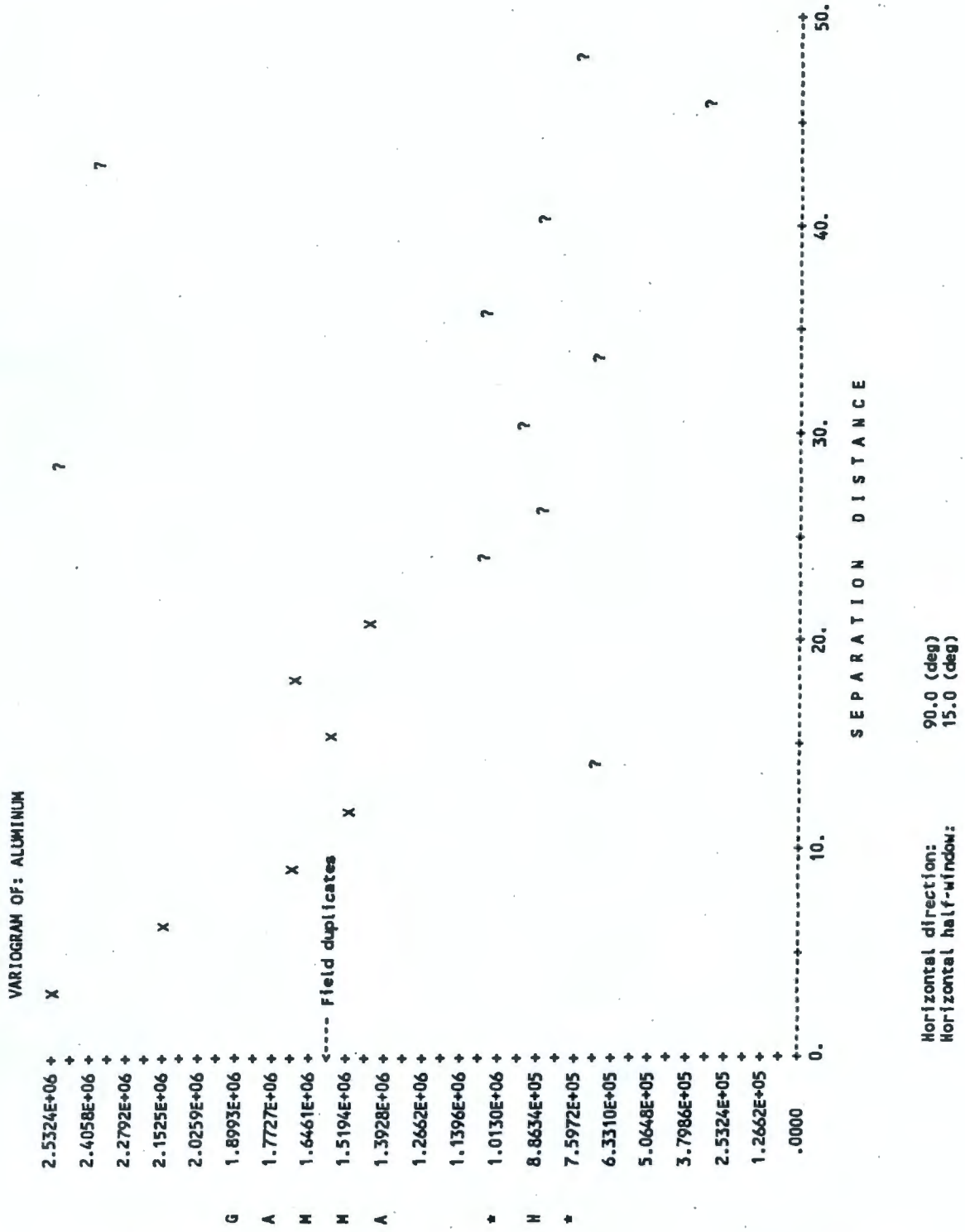


Figure D6-1b. Input Parameters for Vertical Variogram of Aluminum. (sheet 2 of 2)

IRON

DATA FILTER INFORMATION

Minimum data value:	13200.
Minimum value used:	.00000
Maximum data value:	35100.
Maximum value used:	38200.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	102

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	24454.
Minimum value:	.00000
Maximum value:	38200.
Variance:	3.36025E+07
Standard deviation:	5796.8
Coeff. of variation:	.23705

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	150.000
Number of intervals:	20
Length of interval:	7.50000

DISTANCE INTERVAL		NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. -	8.	139	4.4	1.2060E+07
8. -	15.	89	10.5	1.8229E+07
15. -	23.	71	17.7	2.7715E+07
23. -	30.	25	25.4	2.3734E+07
30. -	38.	20	32.9	4.6365E+06
38. -	45.	8	40.5	1.1046E+07
45. -	53.	14	47.9	8.4629E+06
53. -	60.	6	55.2	1.6756E+07
60. -	68.	10	62.7	3.1052E+07
68. -	75.	5	70.4	1.5614E+07
75. -	83.	10	77.9	2.1675E+07
83. -	90.	4	85.8	2.7498E+07
90. -	98.	9	93.9	2.4069E+07
98. -	105.	7	100.3	1.7104E+07
105. -	113.	9	107.7	4.9088E+07
113. -	120.	4	114.5	1.2938E+06
120. -	128.	5	122.0	4.1269E+07
128. -	135.	0		
135. -	143.	1	140.0	2.6450E+06
143. -	150.	3	146.0	4.4500E+05

Figure D6-2a. Input Parameters for Vertical Variogram of Iron. (sheet 1 of 2)

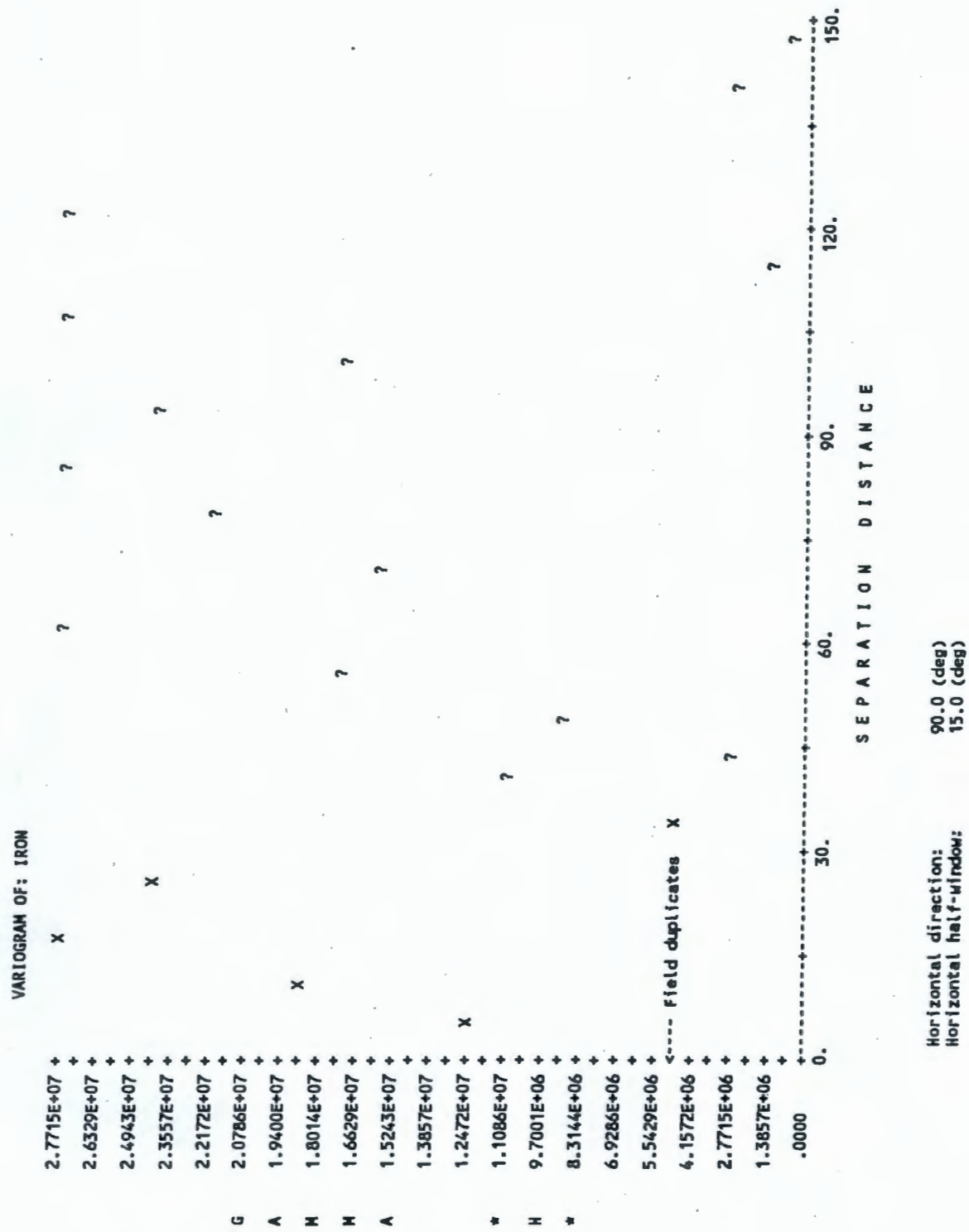


Figure D6-2a. Input Parameters for Vertical Variogram of Iron. (sheet 2 of 2)

IRON

DATA FILTER INFORMATION

Minimum data value:	13200.
Minimum value used:	.00000
Maximum data value:	35100.
Maximum value used:	38200.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	102

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	24454.
Minimum value:	.00000
Maximum value:	38200.
Variance:	3.36025E+07
Standard deviation:	5796.8
Coeff. of variation:	.23705

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	50.0000
Number of intervals:	20
Length of interval:	2.50000

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 3.	0		
3. - 5.	73	3.0	1.1061E+07
5. - 8.	66	5.9	1.3164E+07
8. - 10.	44	9.0	1.8336E+07
10. - 13.	40	11.7	1.9235E+07
13. - 15.	5	13.8	9.2370E+06
15. - 18.	29	15.1	3.0328E+07
18. - 20.	22	18.1	2.9703E+07
20. - 23.	20	20.8	2.1737E+07
23. - 25.	11	24.0	2.7110E+07
25. - 28.	11	26.1	1.5402E+07
28. - 30.	3	28.3	4.1903E+07
30. - 33.	9	30.3	5.5300E+06
33. - 35.	4	33.5	2.3613E+06
35. - 38.	7	35.9	4.7879E+06
38. - 40.	0		
40. - 43.	7	40.1	1.1749E+07
43. - 45.	1	43.0	6.1250E+06
45. - 48.	7	45.9	9.7236E+06
48. - 50.	1	48.0	1.8050E+06

Figure D6-2b. Input Parameters for Vertical Variogram of Iron. (sheet 1 of 2)

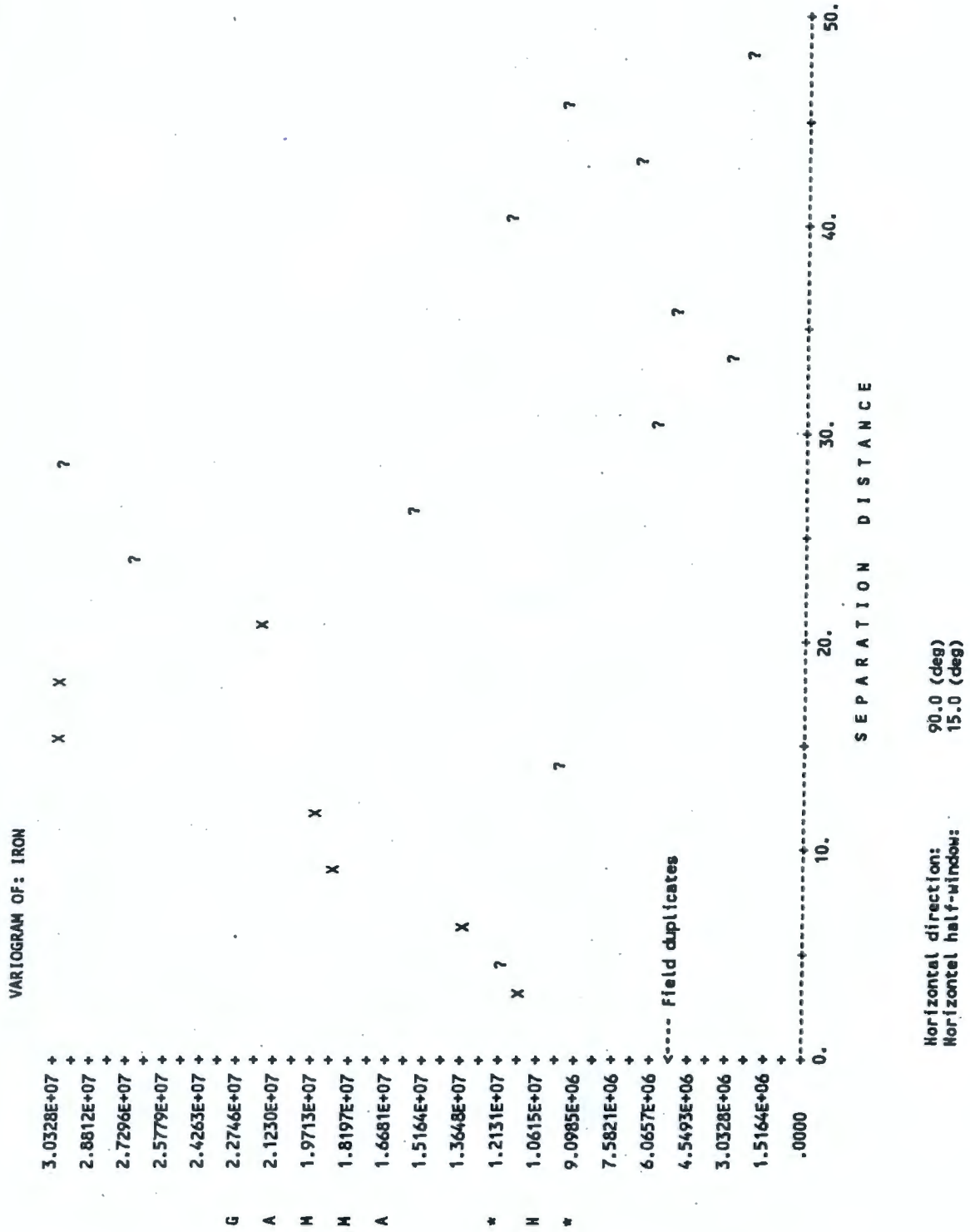


Figure D6-2b. Input Parameters for Vertical Variogram of Iron. (sheet 2 of 2)

CALCIUM

DATA FILTER INFORMATION

Minimum data value:	3820.0
Minimum value used:	5600.0
Maximum data value:	86600.
Maximum value used:	22000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	88

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	10099.
Minimum value:	5600.0
Maximum value:	22000.
Variance:	1.24913E+07
Standard deviation:	3534.3
Coeff. of variation:	.34997

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	150.000
Number of intervals:	20
Length of interval:	7.50000

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 8.	113	4.4	6.0364E+06
8. - 15.	72	10.4	6.5772E+06
15. - 23.	56	17.6	6.5219E+06
23. - 30.	16	25.5	8.0551E+06
30. - 38.	14	32.9	7.6420E+06
38. - 45.	6	40.5	1.6759E+07
45. - 53.	7	48.1	2.3014E+07
53. - 60.	4	55.0	4.9812E+07
60. - 68.	9	62.8	1.8380E+07
68. - 75.	1	70.0	5.7245E+07
75. - 83.	3	76.7	5.5538E+06
83. - 90.	0		
90. - 98.	4	93.8	3.0481E+06
98. - 105.	3	101.0	3.8405E+07
105. - 113.	7	107.7	7.6391E+06
113. - 120.	3	114.3	4.9537E+07
120. - 128.	4	122.5	1.3722E+07
128. - 135.	0		
135. - 143.	1	140.0	9.2480E+05
143. - 150.	0		

Figure D6-3a. Input Parameters for Vertical Variogram of Calcium. (sheet 1 of 2)

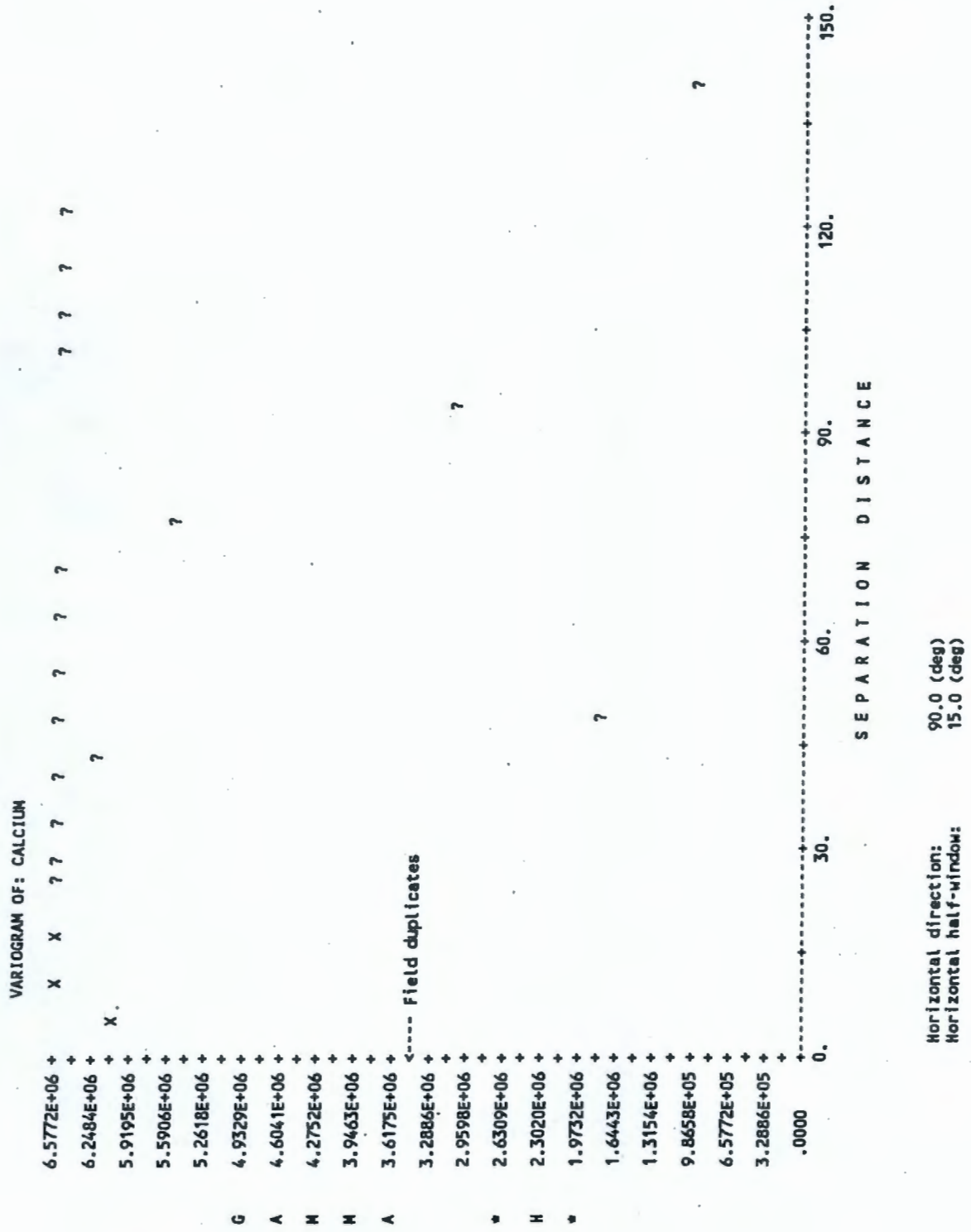


Figure D6-3a. Input Parameters for Vertical Variogram of Calcium. (sheet 2 of 2)

CALCIUM

DATA FILTER INFORMATION

Minimum data value:	3820.0
Minimum value used:	5600.0
Maximum data value:	86600.
Maximum value used:	22000.

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	88

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	10099.
Minimum value:	5600.0
Maximum value:	22000.
Variance:	1.24913E+07
Standard deviation:	3534.3
Coeff. of variation:	.34997

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	50.0000
Number of intervals:	20
Length of interval:	2.50000

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 3.	0		
3. - 5.	61	3.0	6.8656E+06
5. - 8.	52	6.0	5.0637E+06
8. - 10.	36	9.0	6.4678E+06
10. - 13.	32	11.7	6.8874E+06
13. - 15.	4	13.5	5.0809E+06
15. - 18.	23	15.1	7.5794E+06
18. - 20.	18	18.1	5.8422E+06
20. - 23.	15	21.0	5.7159E+06
23. - 25.	7	24.0	8.2528E+06
25. - 28.	7	26.4	6.9613E+06
28. - 30.	2	28.0	1.1192E+07
30. - 33.	6	30.3	2.8048E+06
33. - 35.	4	33.5	9.7258E+06
35. - 38.	4	36.3	1.2814E+07
38. - 40.	0		
40. - 43.	5	40.0	1.3566E+07
43. - 45.	1	43.0	3.2724E+07
45. - 48.	3	46.3	6.5523E+06
48. - 50.	1	48.0	6.9620E+05

Figure D6-3b. Input Parameters for Vertical Variogram of Calcium. (sheet 1 of 2)

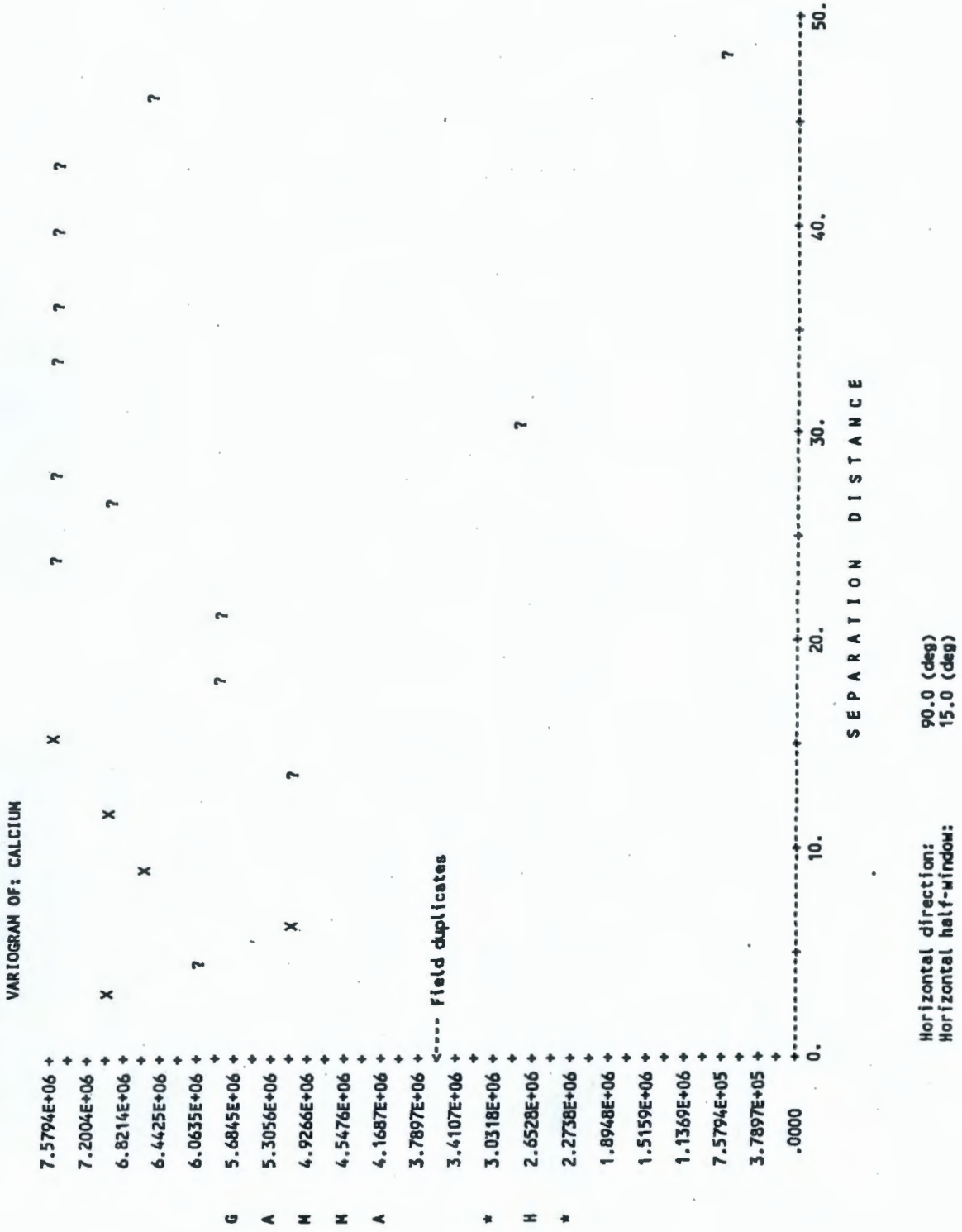


Figure D6-3b. Input Parameters for Vertical Variogram of Calcium.
(sheet 2 of 2)

SODIUM

DATA FILTER INFORMATION

Minimum data value:	101.00
Minimum value used:	190.00
Maximum data value:	5620.0
Maximum value used:	980.00

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	90

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	375.62
Minimum value:	190.00
Maximum value:	980.00
Variance:	35164.
Standard deviation:	187.52
Coeff. of variation:	.49922

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	150.000
Number of intervals:	20
Length of interval:	7.50000

DISTANCE INTERVAL		NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. -	8.	120	4.4	2.4209E+04
8. -	15.	74	10.4	2.7427E+04
15. -	23.	55	17.6	2.5030E+04
23. -	30.	20	25.5	2.6501E+04
30. -	38.	12	33.3	3.1188E+04
38. -	45.	4	40.3	3.1029E+04
45. -	53.	9	48.3	6635.
53. -	60.	4	55.5	8816.
60. -	68.	5	62.4	4.4509E+04
68. -	75.	2	70.0	7.2377E+04
75. -	83.	2	78.0	8.6487E+04
83. -	90.	1	86.0	3121.
90. -	98.	5	94.0	9993.
98. -	105.	2	100.5	6217.
105. -	113.	5	107.8	4.7509E+04
113. -	120.	1	115.0	450.0
120. -	128.	3	121.7	1.1108E+05
128. -	135.	0		
135. -	143.	0		
143. -	150.	0		

Figure D6-4a. Input Parameters for Vertical Variogram of Sodium. (sheet 1 of 2)

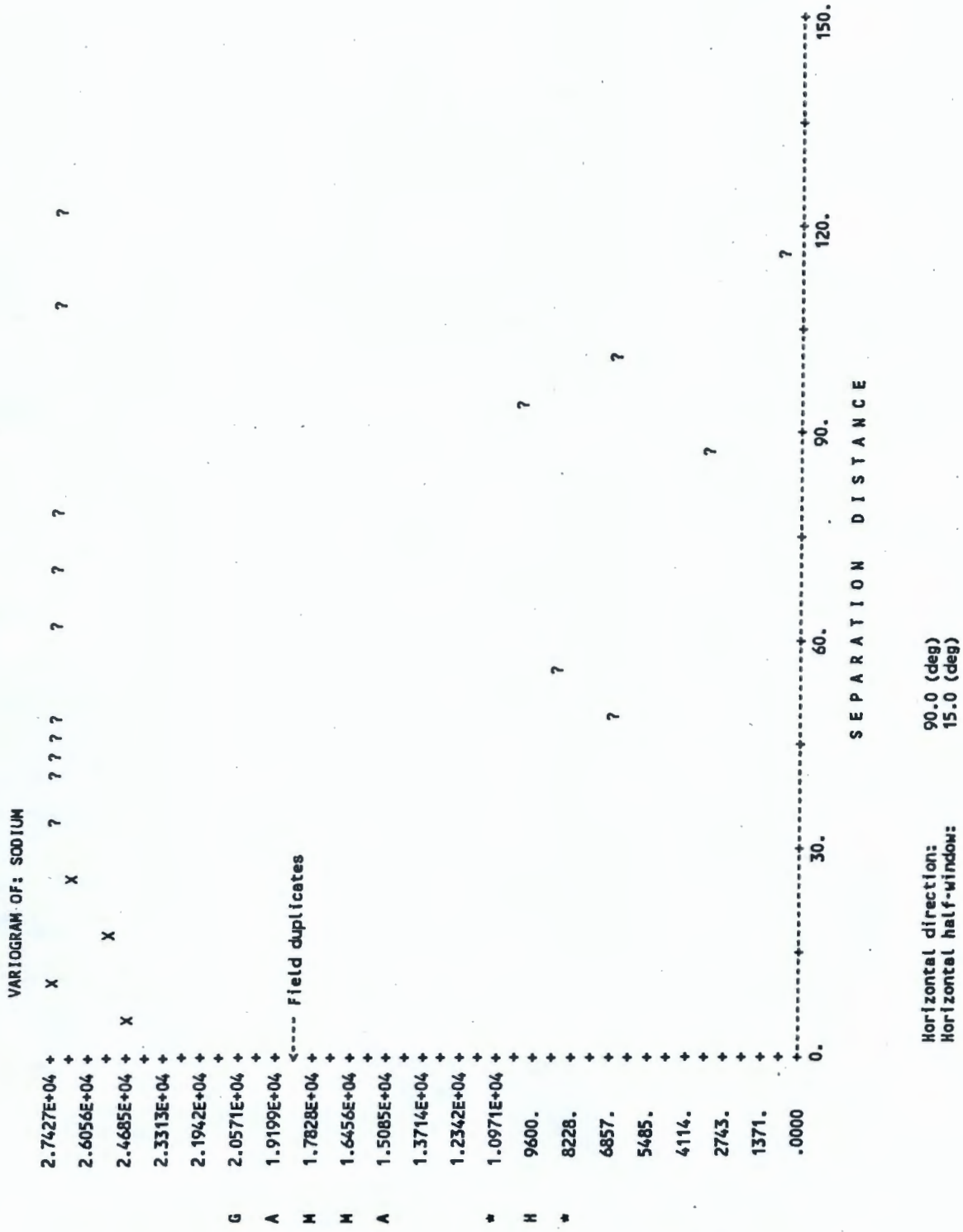


Figure D6-4a. Input Parameters for Vertical Variogram of Sodium. (sheet 2 of 2)

SODIUM

DATA FILTER INFORMATION

Minimum data value:	101.00
Minimum value used:	190.00
Maximum data value:	5620.0
Maximum value used:	980.00

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	90

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	375.62
Minimum value:	190.00
Maximum value:	980.00
Variance:	35164.
Standard deviation:	187.52
Coeff. of variation:	.49922

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	50.0000
Number of intervals:	20
Length of interval:	2.50000

DISTANCE INTERVAL		NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. -	3.	0		
3. -	5.	65	3.0	2.4245E+04
5. -	8.	55	6.0	2.4166E+04
8. -	10.	38	9.0	2.9106E+04
10. -	13.	31	11.7	2.7981E+04
13. -	15.	5	13.8	1.1235E+04
15. -	18.	23	15.1	2.8099E+04
18. -	20.	18	18.2	3.1015E+04
20. -	23.	14	21.1	1.2294E+04
23. -	25.	10	24.0	2.5872E+04
25. -	28.	7	26.4	2.2048E+04
28. -	30.	3	28.3	3.8986E+04
30. -	33.	5	30.6	2.9896E+04
33. -	35.	3	33.7	3.9075E+04
35. -	38.	4	36.3	2.6889E+04
38. -	40.	0		
40. -	43.	4	40.3	3.1029E+04
43. -	45.	0		
45. -	48.	4	46.0	1.2362E+04
48. -	50.	0		

Figure D6-4b. Input Parameters for Vertical Variogram of Sodium.
(sheet 1 of 2)

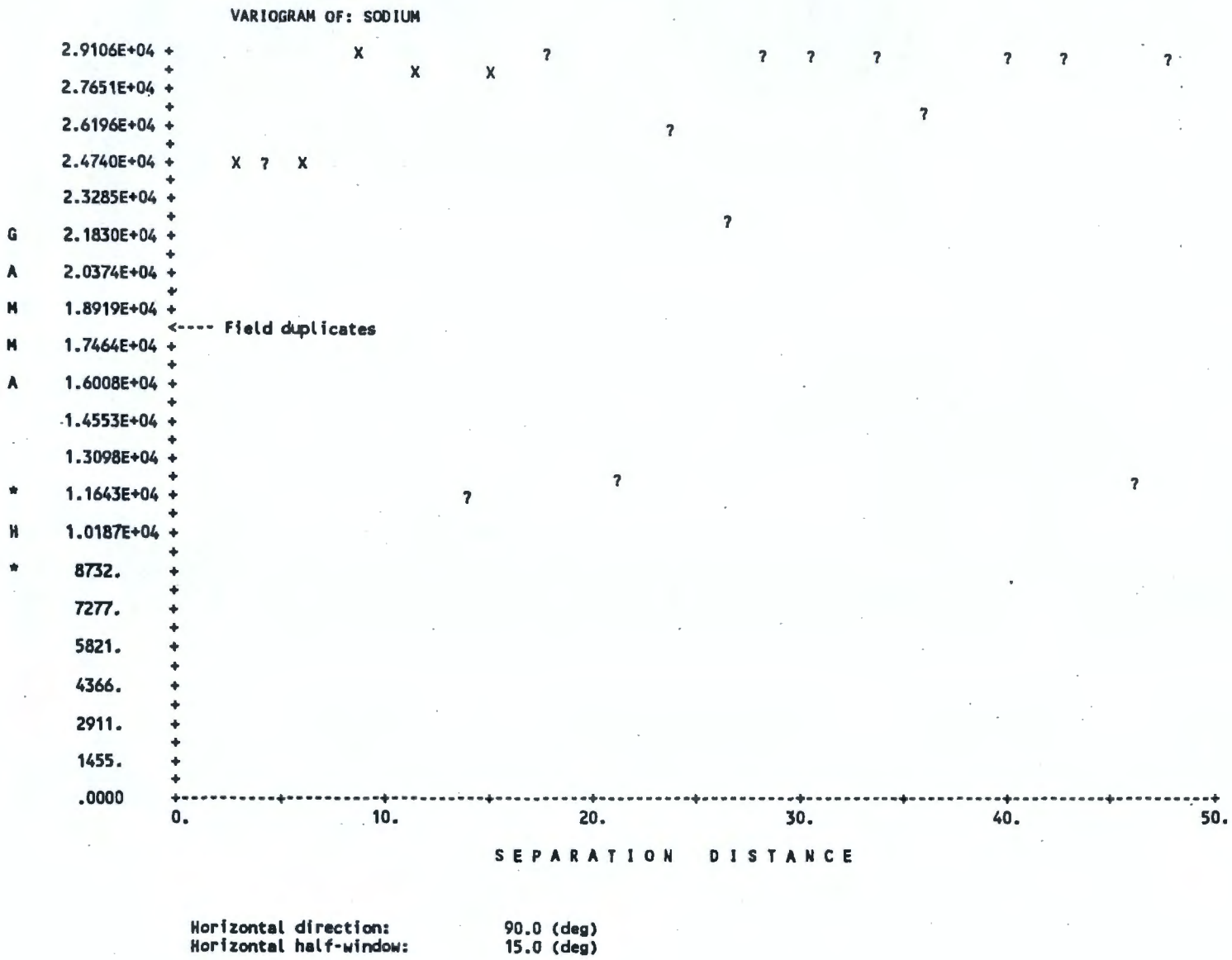


Figure D6-4b. Input Parameters for Vertical Variogram of Sodium. (sheet 2 of 2)

COPPER

DATA FILTER INFORMATION

Minimum data value:	8.1000
Minimum value used:	13.000
Maximum data value:	36.100
Maximum value used:	32.200

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation:	None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	69

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	16.723
Minimum value:	13.000
Maximum value:	32.200
Variance:	17.818
Standard deviation:	4.2211
Coeff. of variation:	.25241

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	150.000
Number of intervals:	20
Length of interval:	7.50000

DISTANCE INTERVAL	NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. - 8.	64	4.4	6.272
8. - 15.	34	10.4	5.029
15. - 23.	25	17.2	5.568
23. - 30.	7	25.3	9.477
30. - 38.	5	34.8	1.811
38. - 45.	2	41.5	6.512
45. - 53.	8	48.0	2.319
53. - 60.	2	54.0	10.80
60. - 68.	7	62.1	5.432
68. - 75.	0		
75. - 83.	3	77.0	8.663
83. - 90.	1	86.0	5.0000E-03
90. - 98.	6	94.2	4.473
98. - 105.	4	99.8	.6987
105. - 113.	6	109.0	6.267
113. - 120.	1	113.0	.1250
120. - 128.	3	123.3	8.470
128. - 135.	0		
135. - 143.	0		
143. - 150.	3	146.0	3.123

Figure D6-5a. Input Parameters for Vertical Variogram of Copper. (sheet 1 of 2)

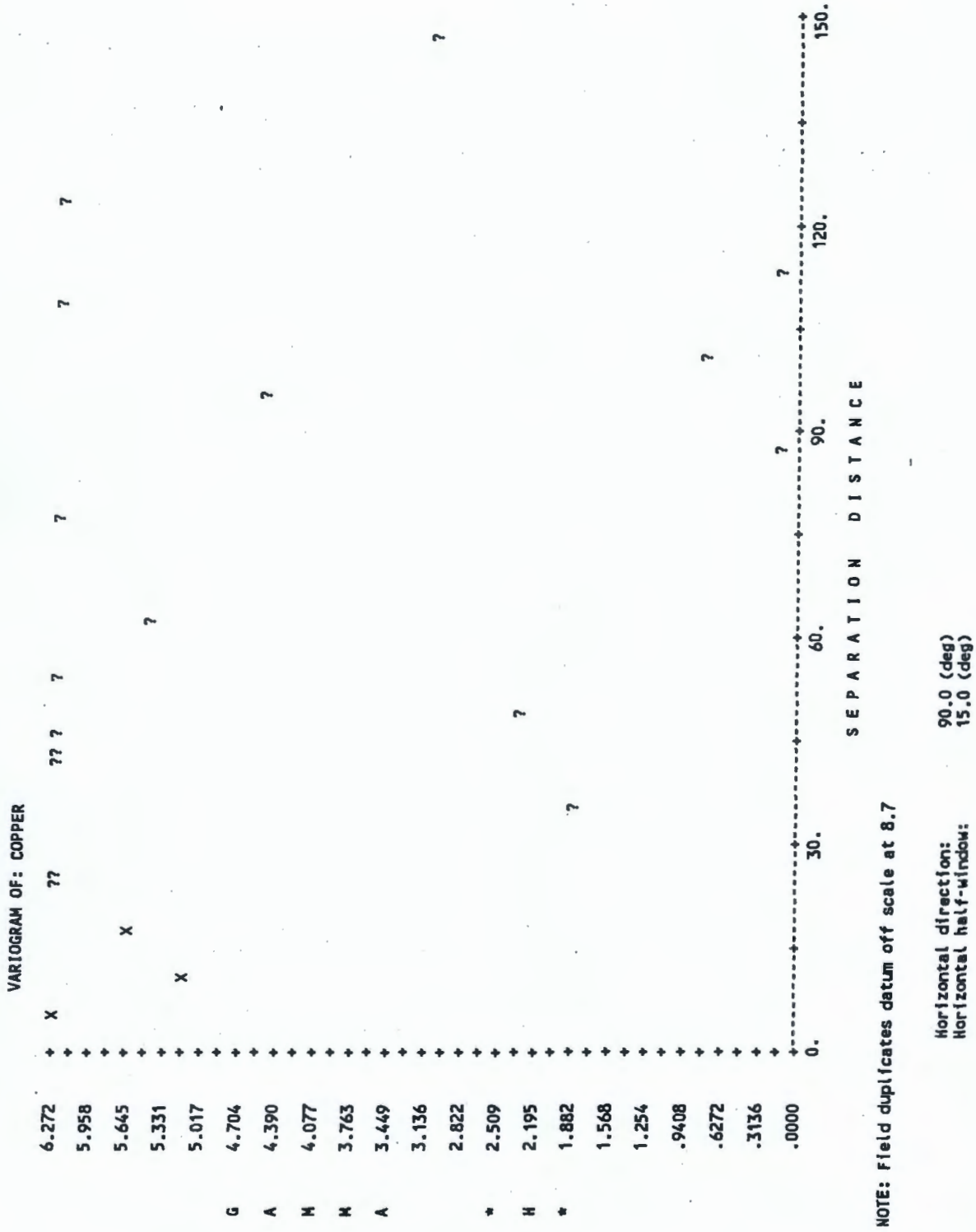


Figure D6-5a. Input Parameters for Vertical Variogram of Copper. (sheet 2 of 2)

COPPER

DATA FILTER INFORMATION

Minimum data value:	8.1000
Minimum value used:	13.000
Maximum data value:	36.100
Maximum value used:	32.200

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	69

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	16.723
Minimum value:	13.000
Maximum value:	32.200
Variance:	17.818
Standard deviation:	4.2211
Coeff. of variation:	.25241

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	50.0000
Number of intervals:	20
Length of interval:	2.50000

DISTANCE INTERVAL		NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. -	3.	0		
3. -	5.	35	3.0	4.843
5. -	8.	29	6.0	7.997
8. -	10.	17	9.0	4.072
10. -	13.	16	11.8	5.884
13. -	15.	1	13.0	7.605
15. -	18.	12	15.2	5.351
18. -	20.	8	18.1	6.443
20. -	23.	5	20.8	4.689
23. -	25.	4	24.0	11.72
25. -	28.	2	26.0	.1125
28. -	30.	1	29.0	19.22
30. -	33.	1	31.0	4.9999E-03
33. -	35.	0		
35. -	38.	4	35.8	2.262
38. -	40.	0		
40. -	43.	1	40.0	13.00
43. -	45.	1	43.0	2.0000E-02
45. -	48.	4	46.3	4.151
48. -	50.	1	48.0	.2450

Figure D6-5b. Input Parameters for Vertical Variogram of Copper. (sheet 1 of 2)

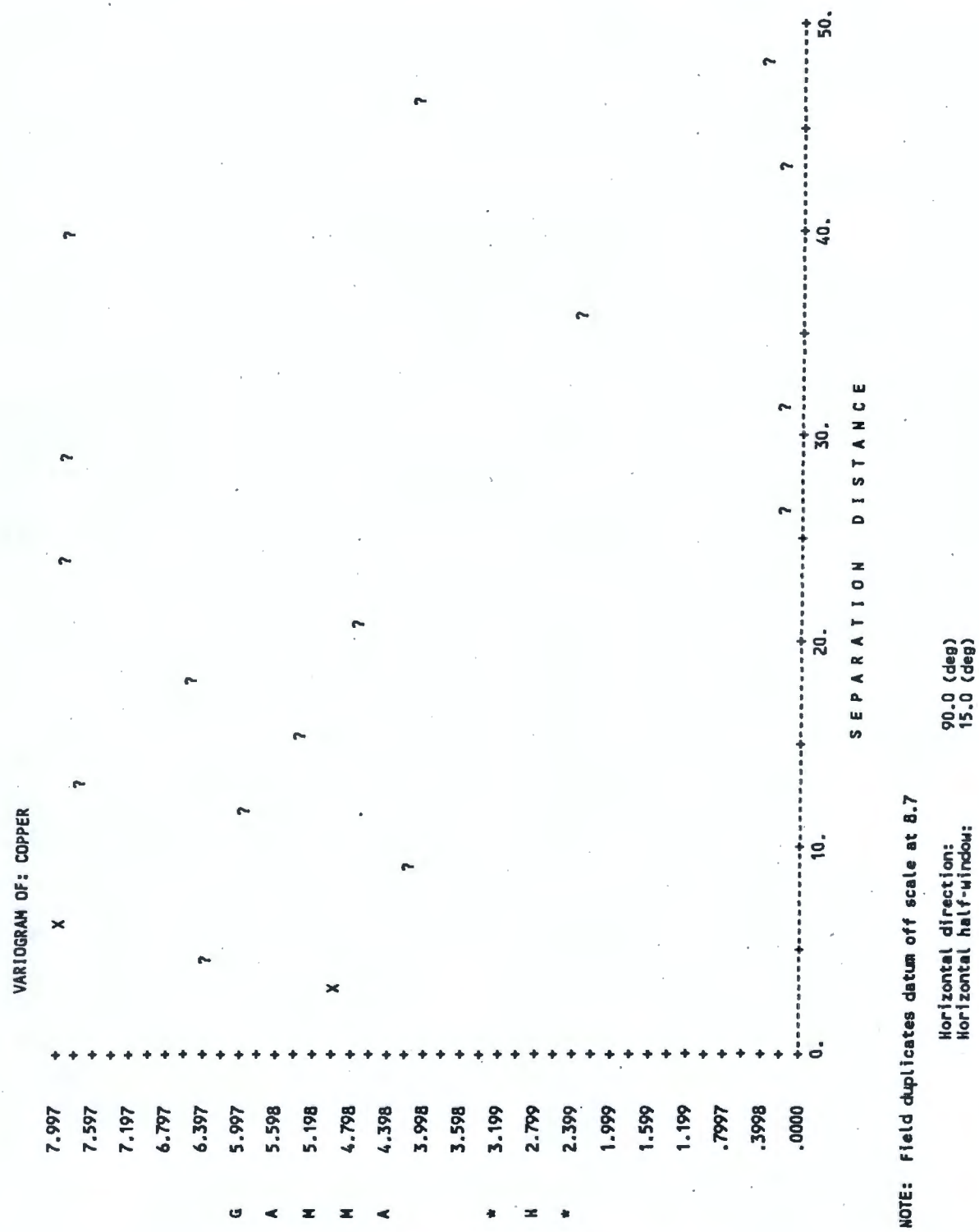


Figure D6-5b. Input Parameters for Vertical Variogram of Copper. (sheet 2 of 2)

LEAD

DATA FILTER INFORMATION

Minimum data value:	1.1000
Minimum value used:	3.3000
Maximum data value:	26.600
Maximum value used:	15.400

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	95

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	6.2832
Minimum value:	3.3000
Maximum value:	15.400
Variance:	7.4475
Standard deviation:	2.7290
Coeff. of variation:	.43434

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	150.000
Number of intervals:	20
Length of interval:	7.50000

DISTANCE INTERVAL		NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. -	8.	120	4.4	3.493
8. -	15.	76	10.4	3.017
15. -	23.	61	17.6	3.966
23. -	30.	19	25.6	4.086
30. -	38.	12	32.6	5.127
38. -	45.	7	40.6	7.017
45. -	53.	12	47.8	1.400
53. -	60.	5	55.0	1.563
60. -	68.	10	62.7	.3710
68. -	75.	5	70.4	1.963
75. -	83.	8	77.8	2.276
83. -	90.	3	85.7	1.610
90. -	98.	8	93.6	1.747
98. -	105.	6	100.2	3.019
105. -	113.	9	107.7	.6633
113. -	120.	4	114.5	2.360
120. -	128.	5	122.0	.4550
128. -	135.	0		
135. -	143.	1	140.0	8.0000E-02
143. -	150.	2	144.5	2.253

Figure D6-6a. Input Parameters for Vertical Variogram of Lead. (sheet 1 of 2)

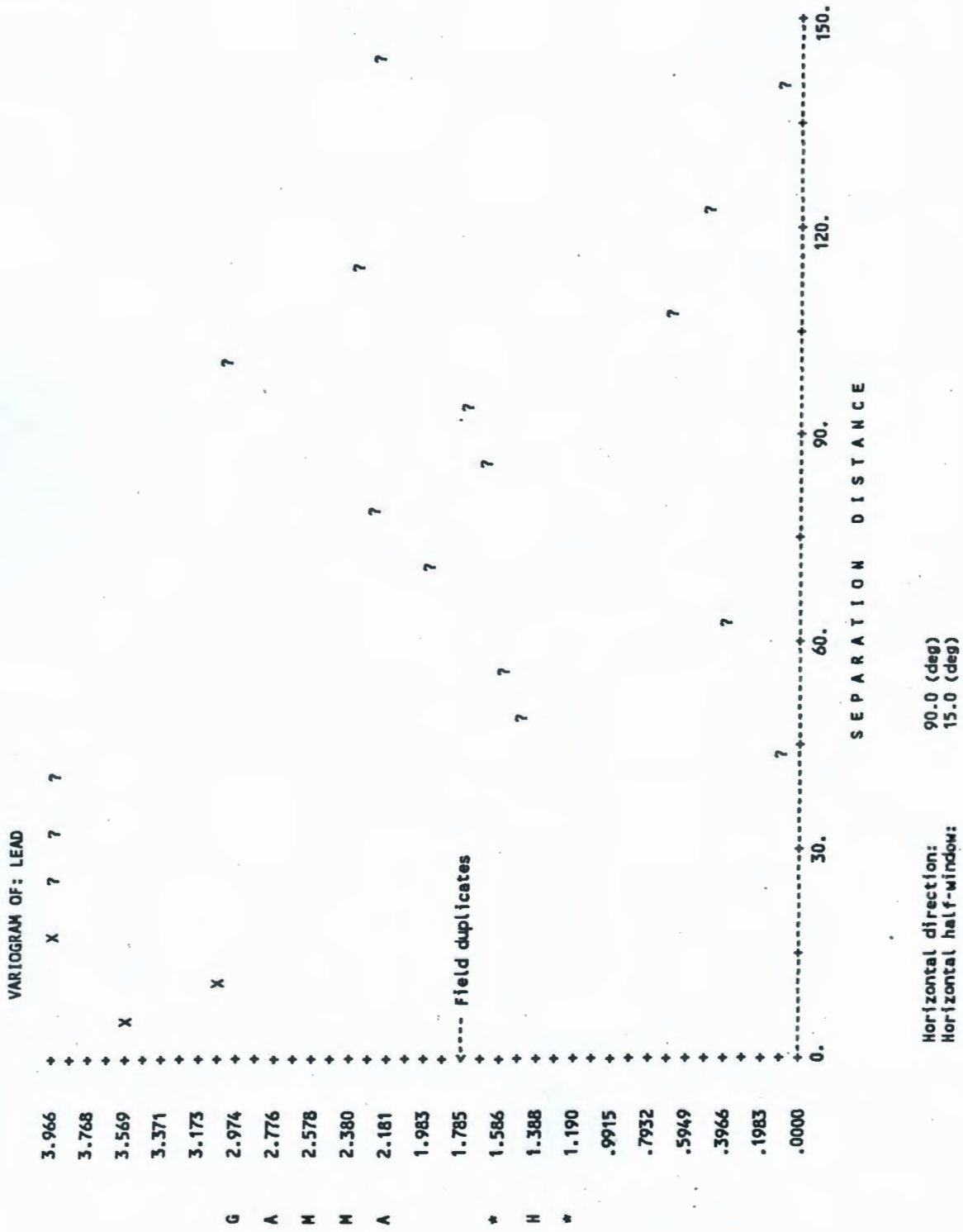


Figure D6-6a. Input Parameters for Vertical Variogram of Lead.
(sheet 2 of 2)

LEAD

DATA FILTER INFORMATION

Minimum data value:	1.1000
Minimum value used:	3.3000
Maximum data value:	26.600
Maximum value used:	15.400

COORDINATE SELECTION INFORMATION

Minimum X coordinate:	1.00000
Minimum X coordinate used:	1.00000
Maximum X coordinate:	1400.00
Maximum X coordinate used:	1400.00
Minimum Y coordinate:	.100000
Minimum Y coordinate used:	.100000
Maximum Y coordinate:	230.000
Maximum Y coordinate used:	230.000

TRANSFORMATION INFORMATION

Transformation: None Applied

SAMPLE USAGE INFORMATION

Total number of samples available:	102
Total number of samples used:	95

STATISTICAL SUMMARY FOR THE DATA USED

Average value:	6.2832
Minimum value:	3.3000
Maximum value:	15.400
Variance:	7.4475
Standard deviation:	2.7290
Coeff. of variation:	.43434

VARIOGRAM DIRECTION INFORMATION

Horizontal direction:	90.0 (deg)
Horizontal half-window:	15.0 (deg)

VARIOGRAM DISTANCE INFORMATION

Maximum distance:	50.0000
Number of intervals:	20
Length of interval:	2.50000

DISTANCE INTERVAL		NUMBER OF PAIRS	AVERAGE DISTANCE	GAMMA (H)
0. -	3.	0		
3. -	5.	62	3.0	3.351
5. -	8.	58	5.9	3.645
8. -	10.	38	9.0	2.900
10. -	13.	34	11.6	3.483
13. -	15.	4	13.5	.1613
15. -	18.	26	15.1	2.729
18. -	20.	18	18.1	5.338
20. -	23.	17	20.8	4.404
23. -	25.	7	24.0	5.856
25. -	28.	9	25.9	3.870
28. -	30.	3	28.3	.6050
30. -	33.	6	30.3	5.626
33. -	35.	2	33.5	9.640
35. -	38.	4	35.5	2.122
38. -	40.	0		
40. -	43.	6	40.2	3.499
43. -	45.	1	43.0	28.13
45. -	48.	6	45.8	1.588
48. -	50.	1	48.0	5.120

Figure D6-6b. Input Parameters for Vertical Variogram of Lead. (sheet 1 of 2)

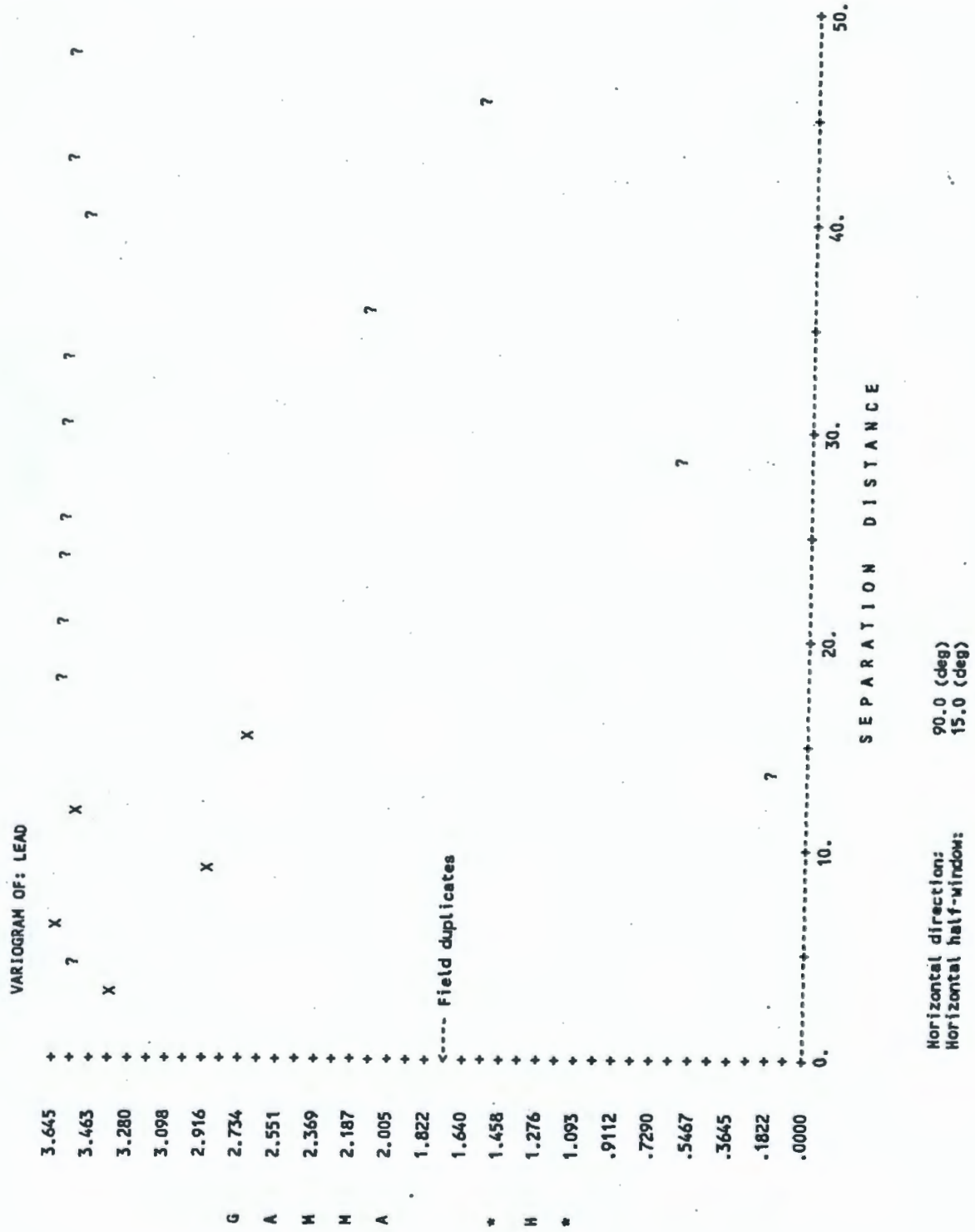
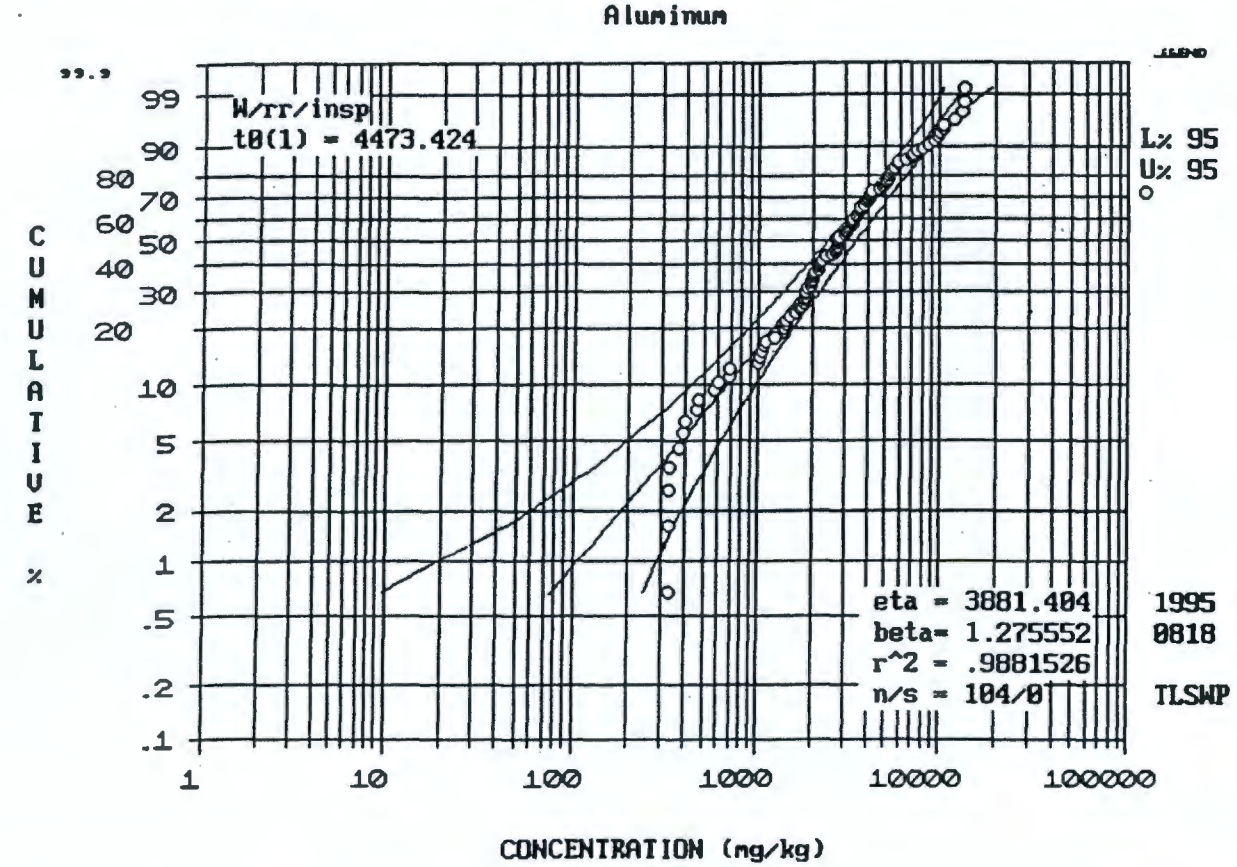


Figure D6-6b. Input Parameters for Vertical Variogram of Lead.
(sheet 2 of 2)



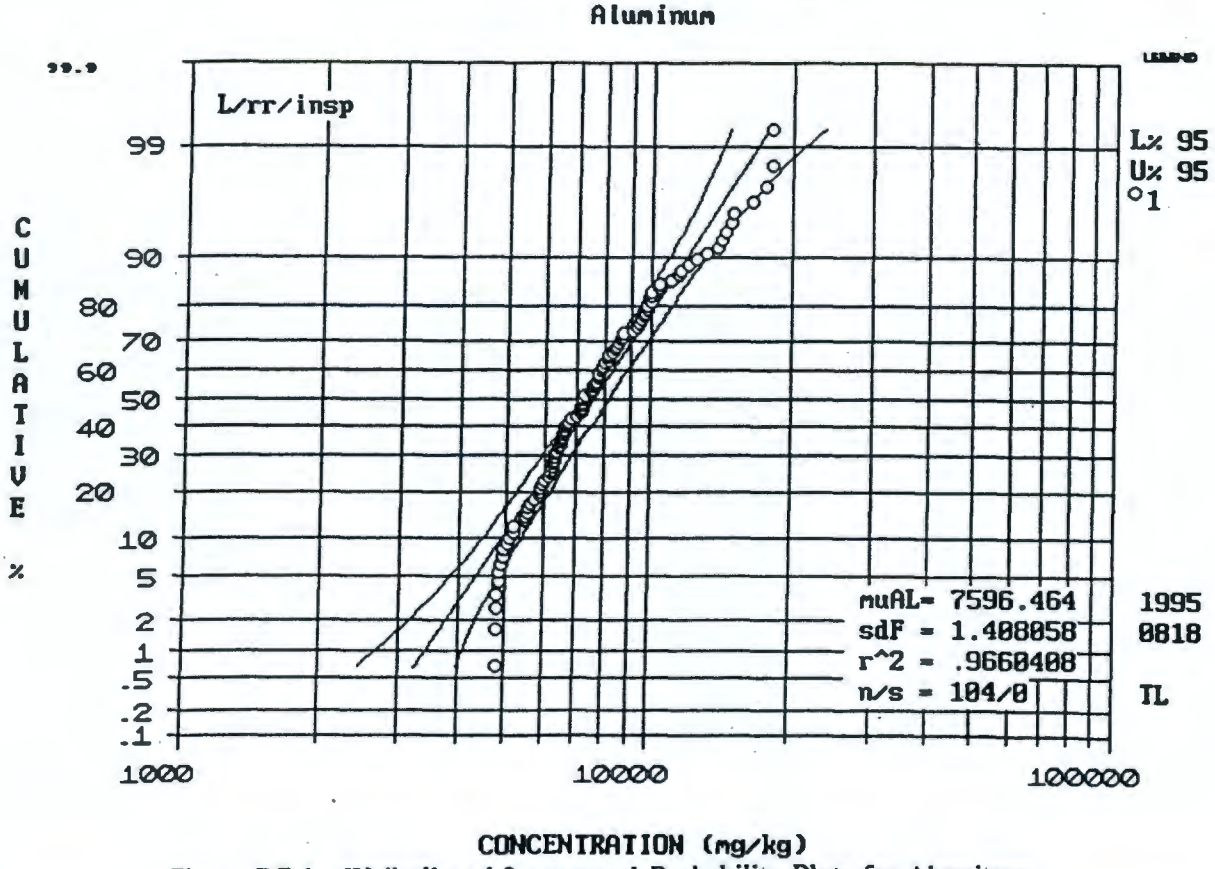


Figure D7-1. Weibull and Lognormal Probability Plots for Aluminum.

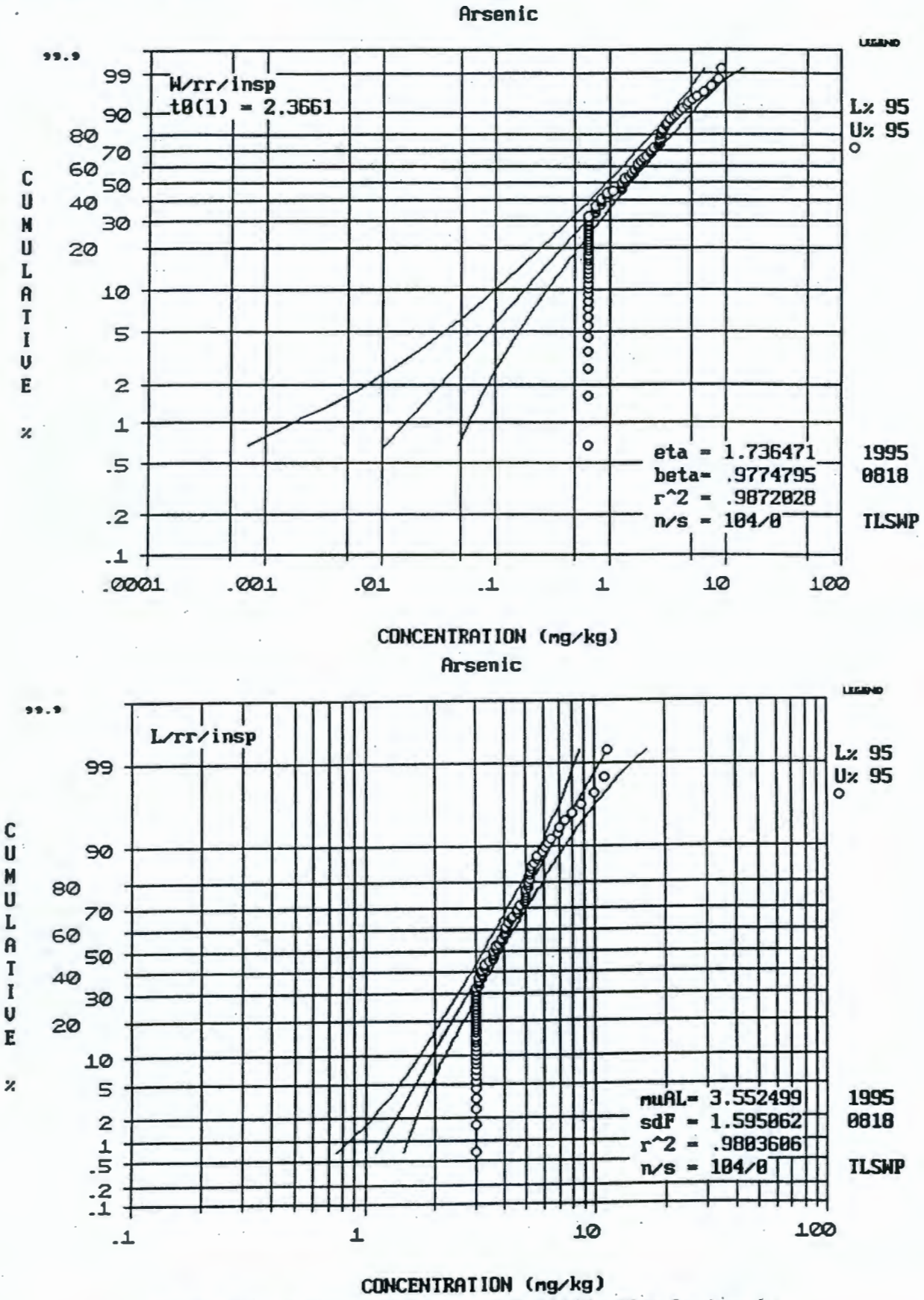
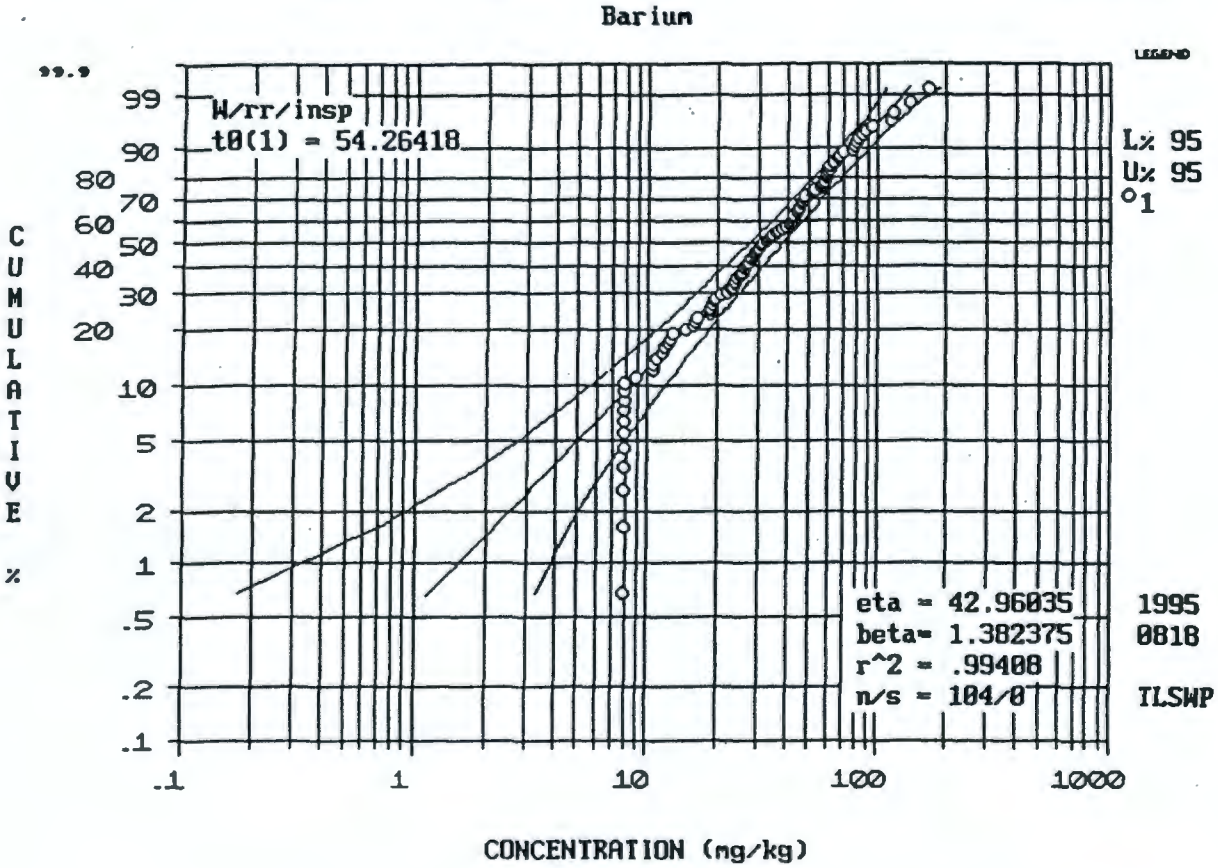


Figure D7-2. Weibull and Lognormal Probability Plots for Arsenic.



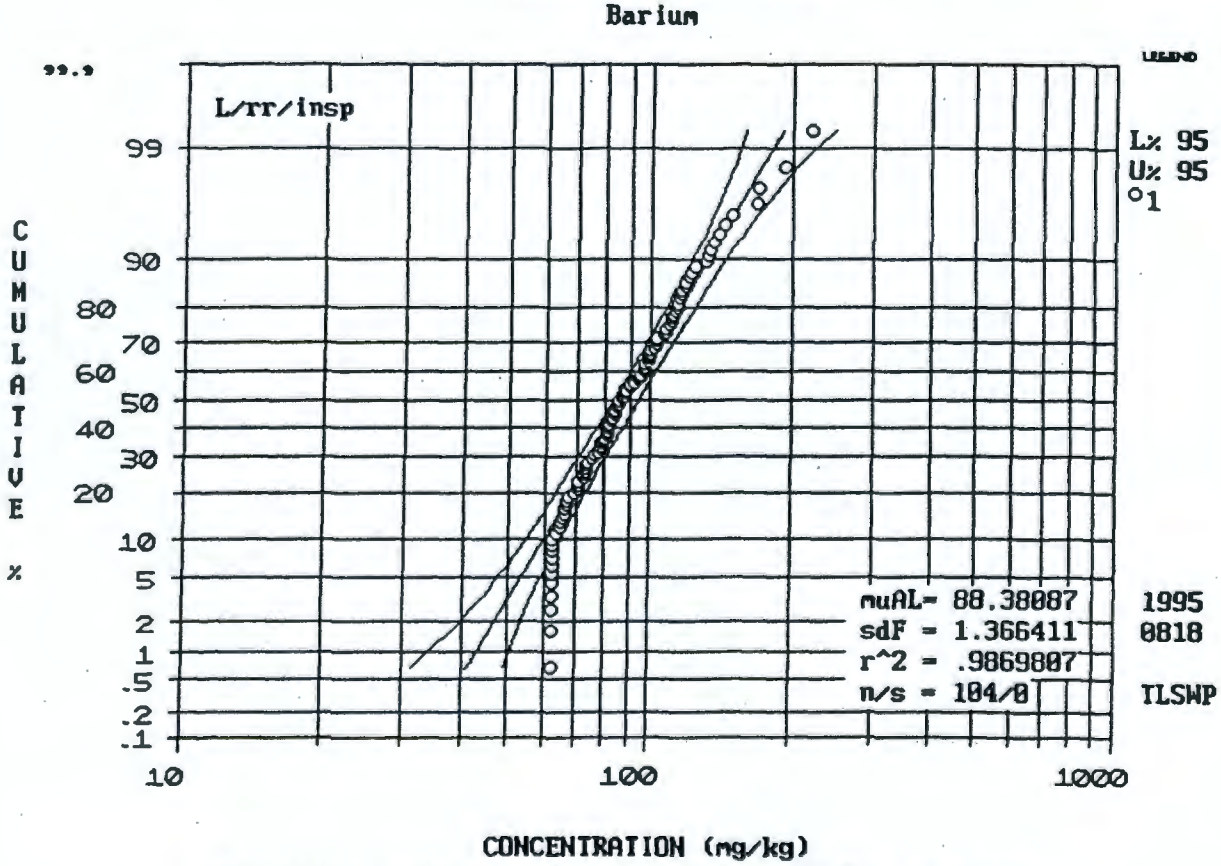
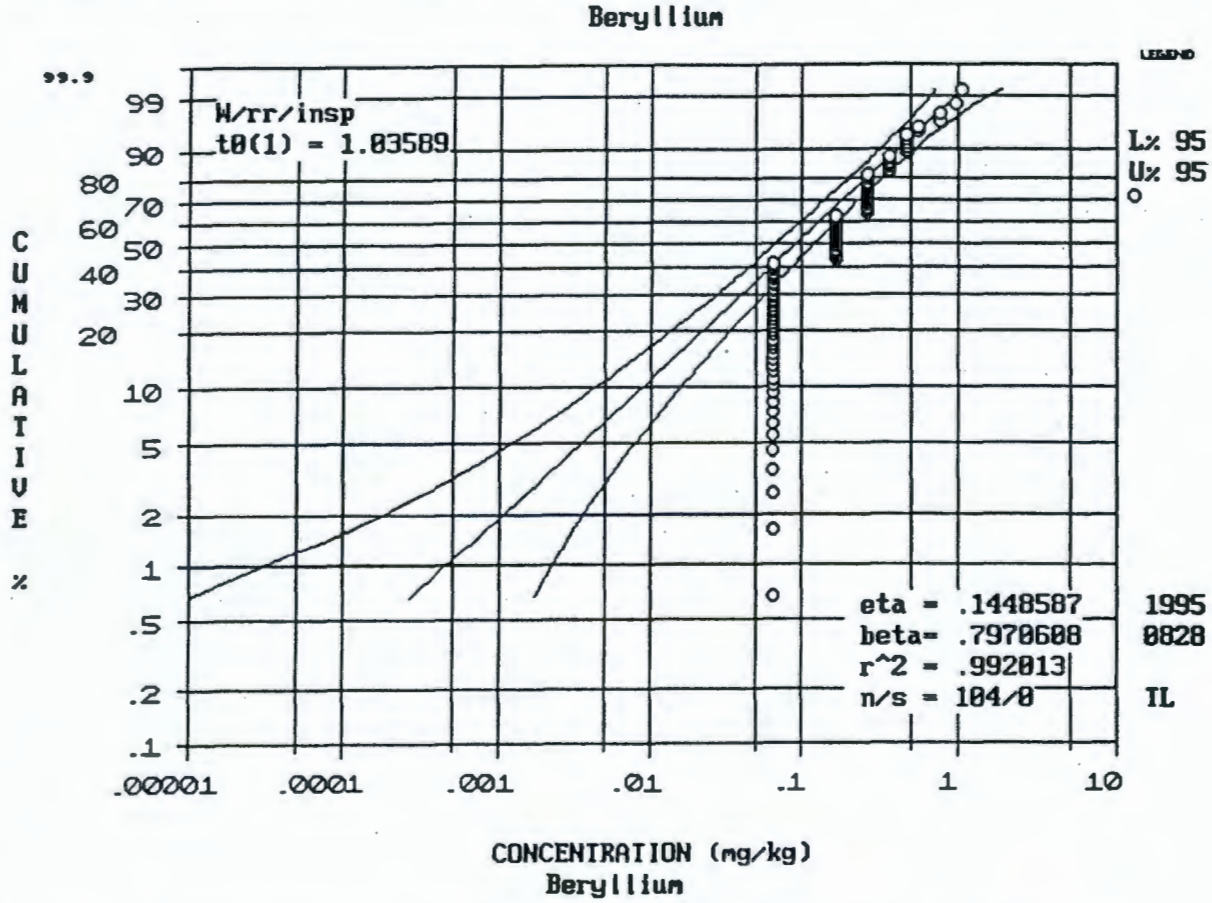


Figure D7-3. Weibull and Lognormal Probability Plots for Barium.



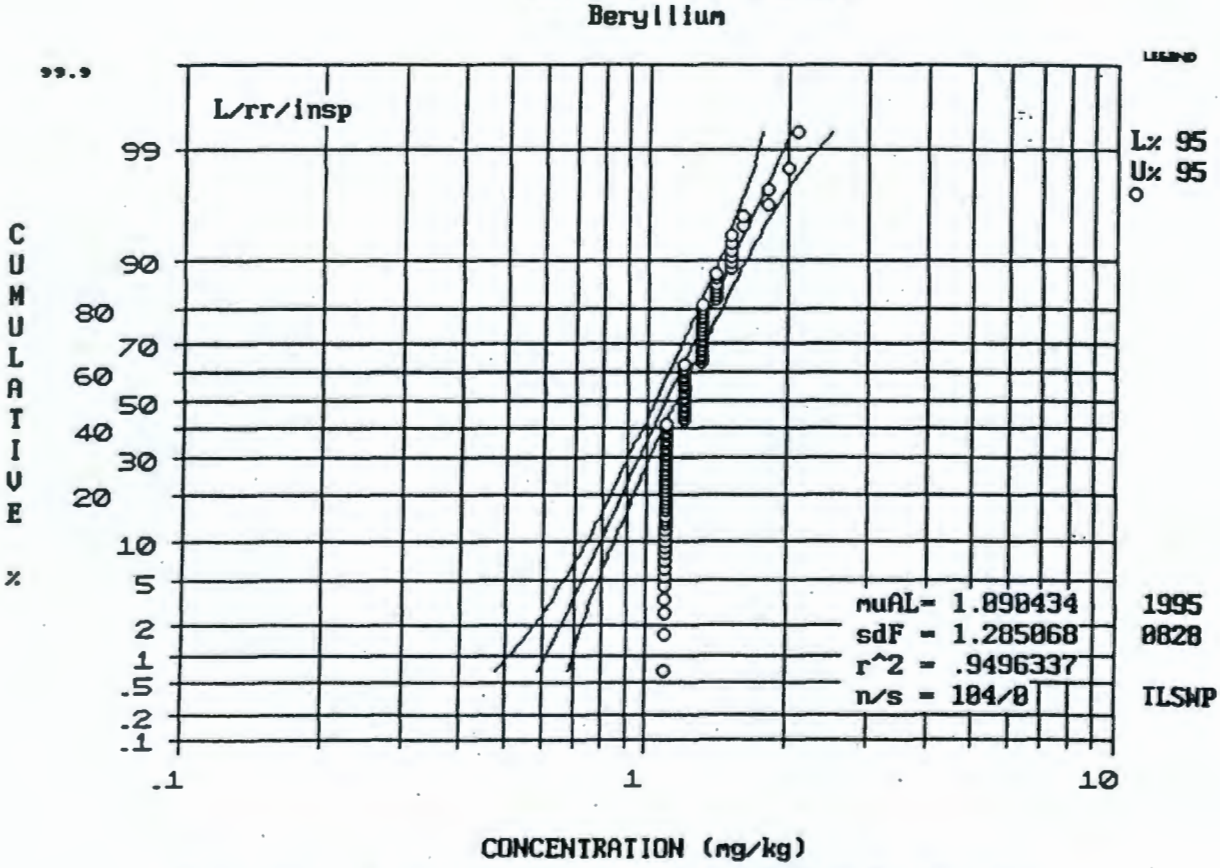
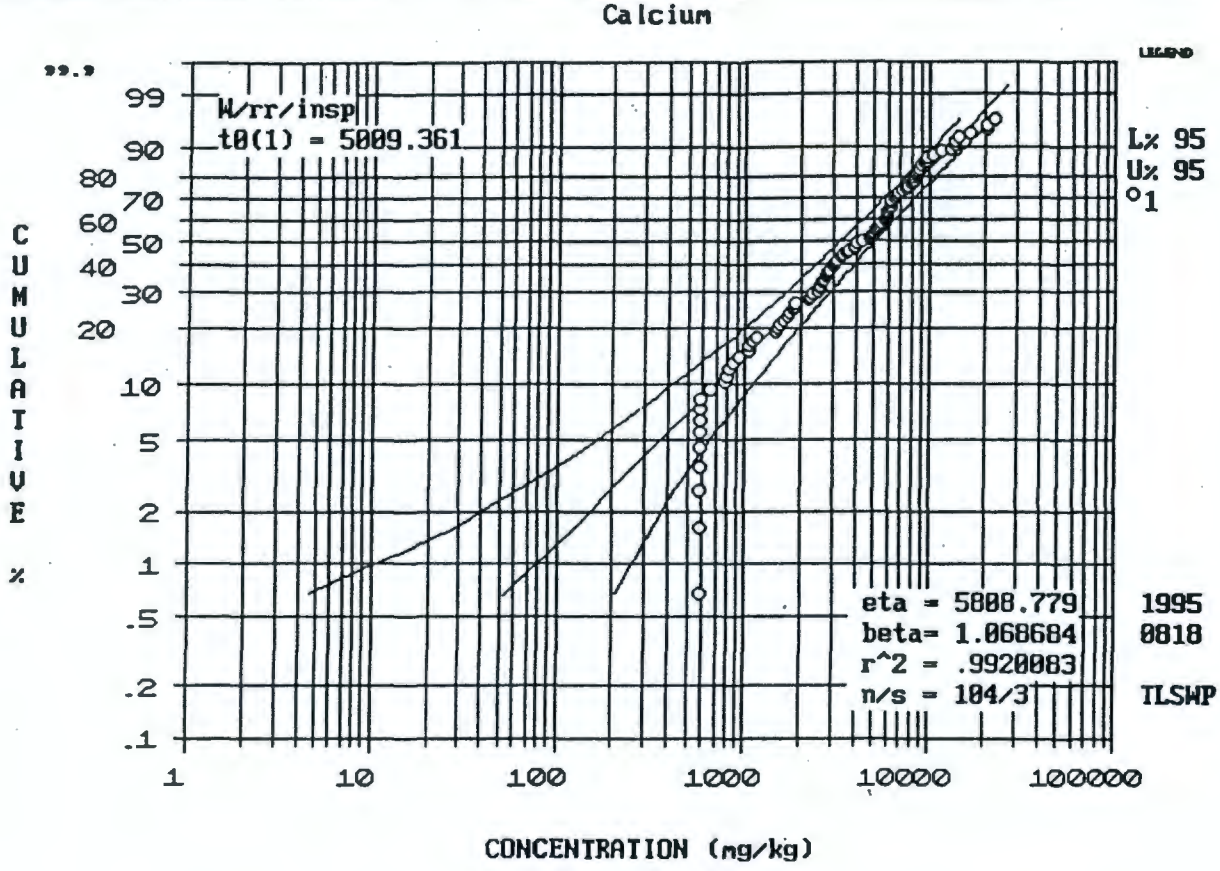


Figure D7-4. Weibull and Lognormal Probability Plots for Beryllium.



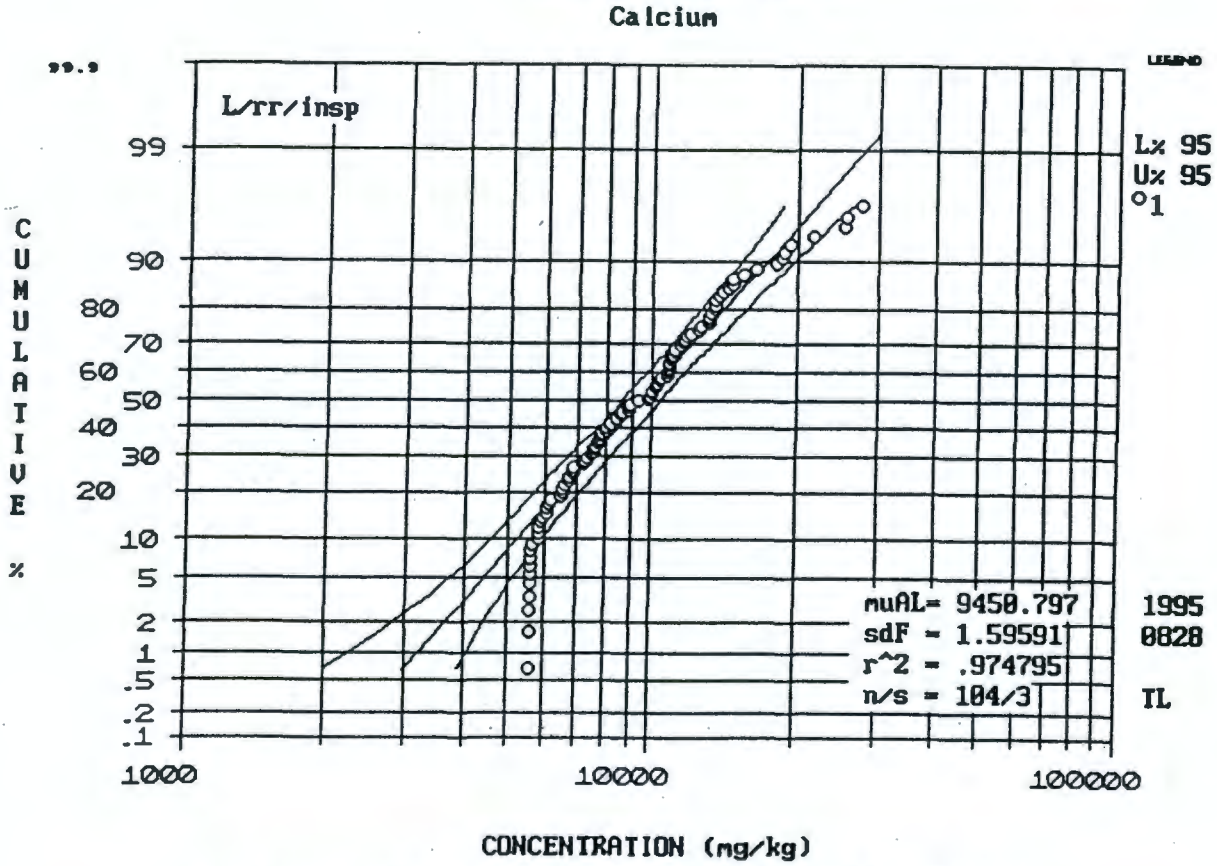
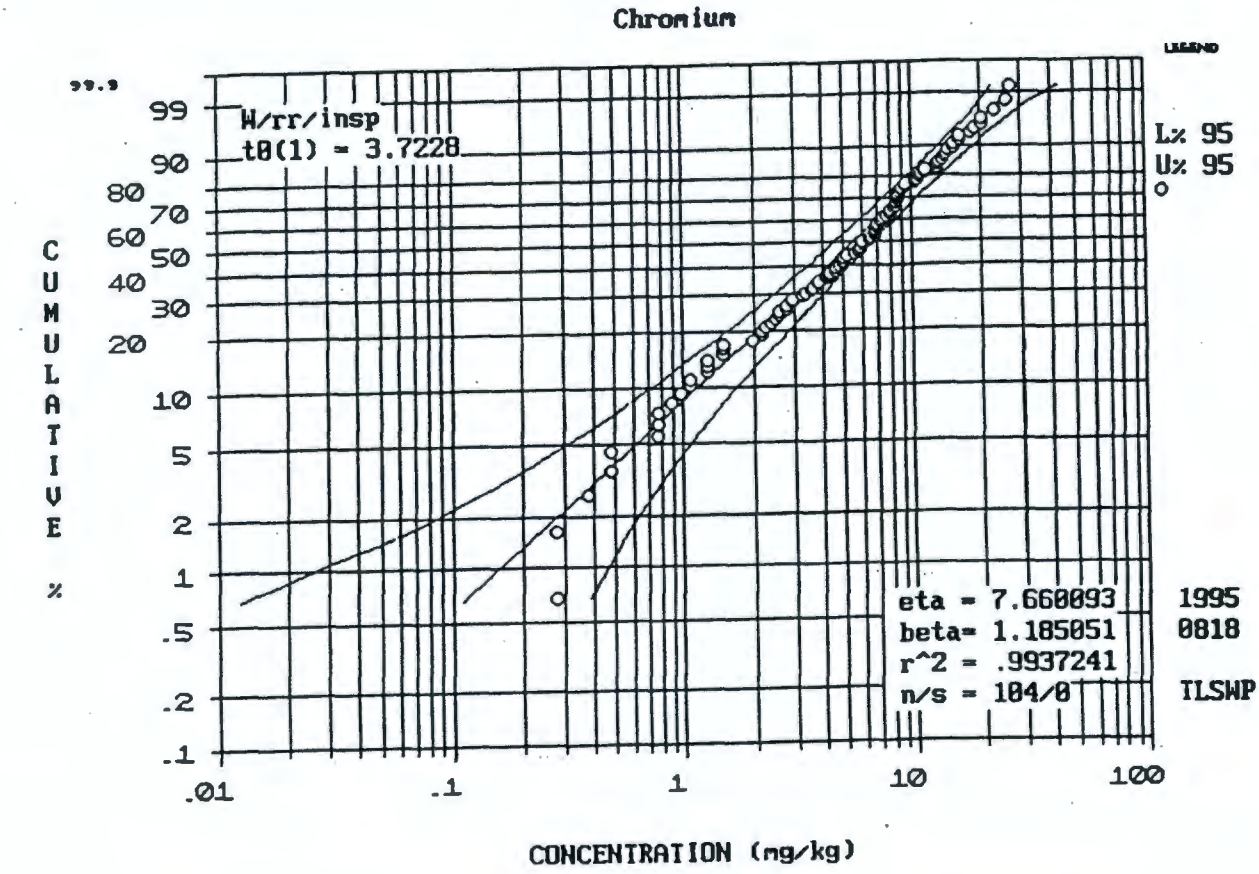


Figure D7-5. Weibull and Lognormal Probability Plots for Calcium.



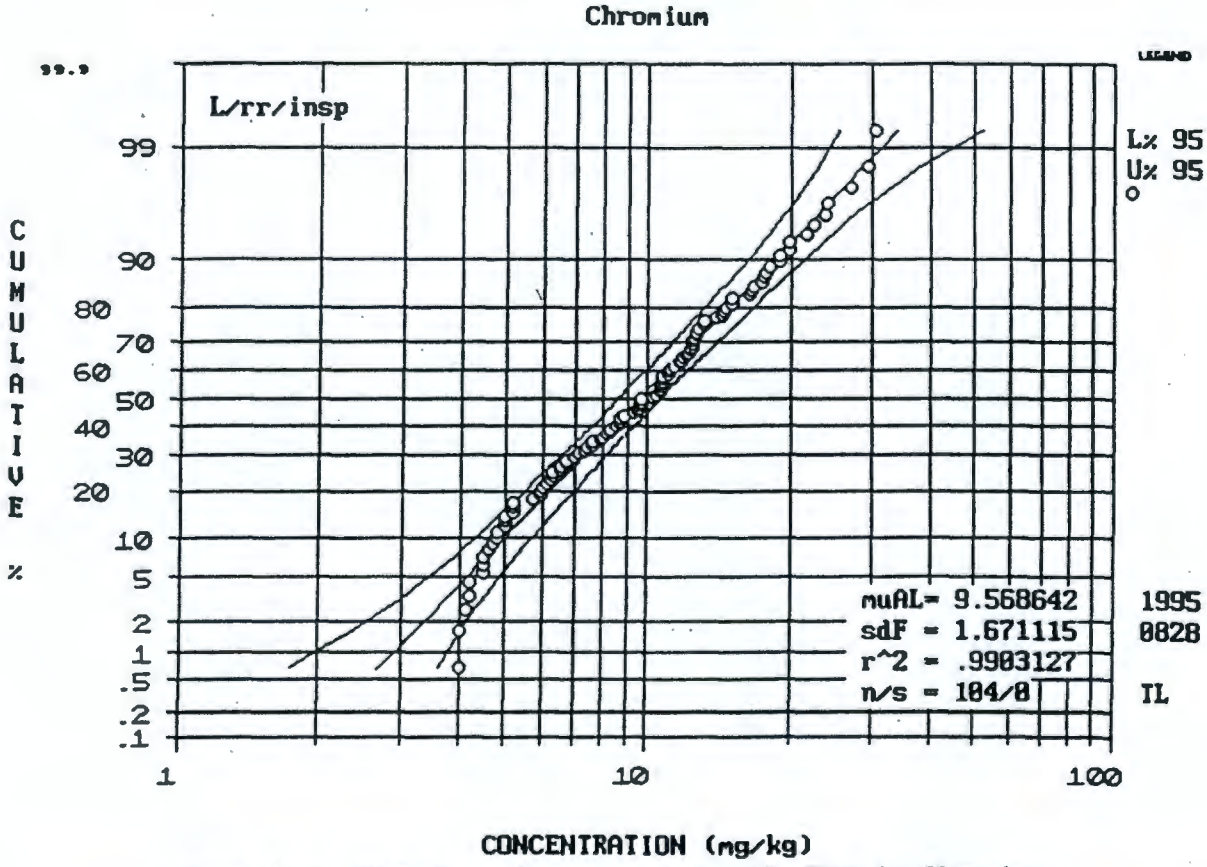


Figure D7-6. Weibull and Lognormal Probability Plots for Chromium.

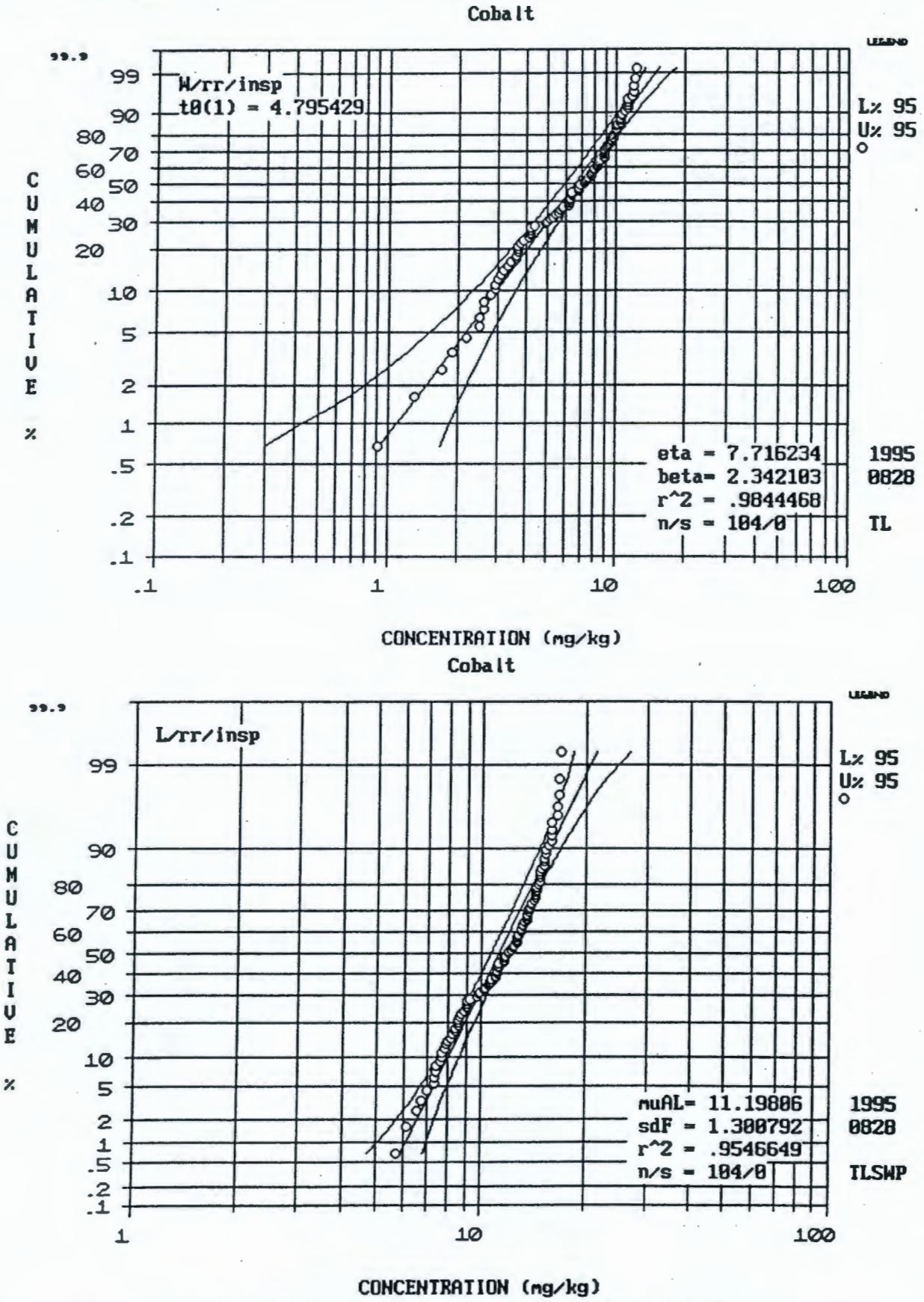
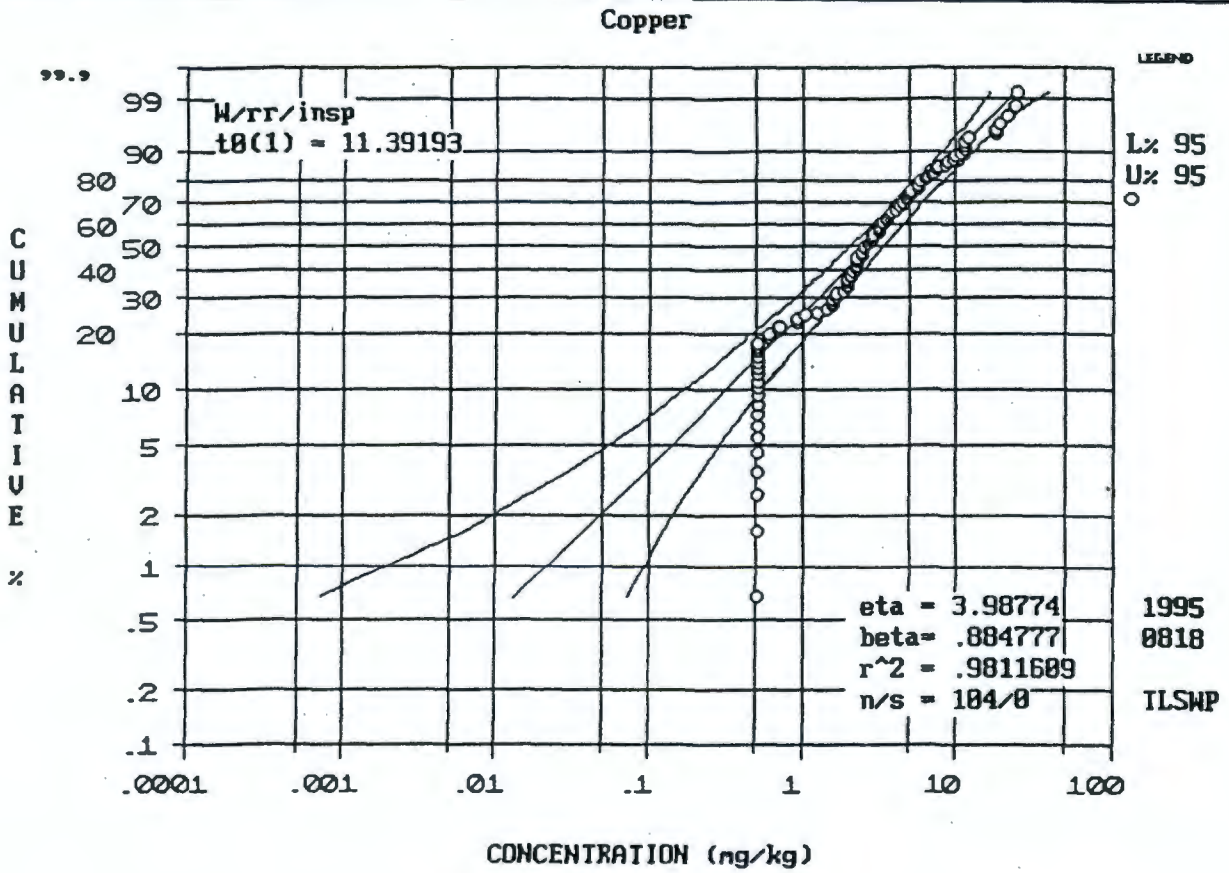


Figure D7-7. Weibull and Lognormal Probability Plots for Cobalt.



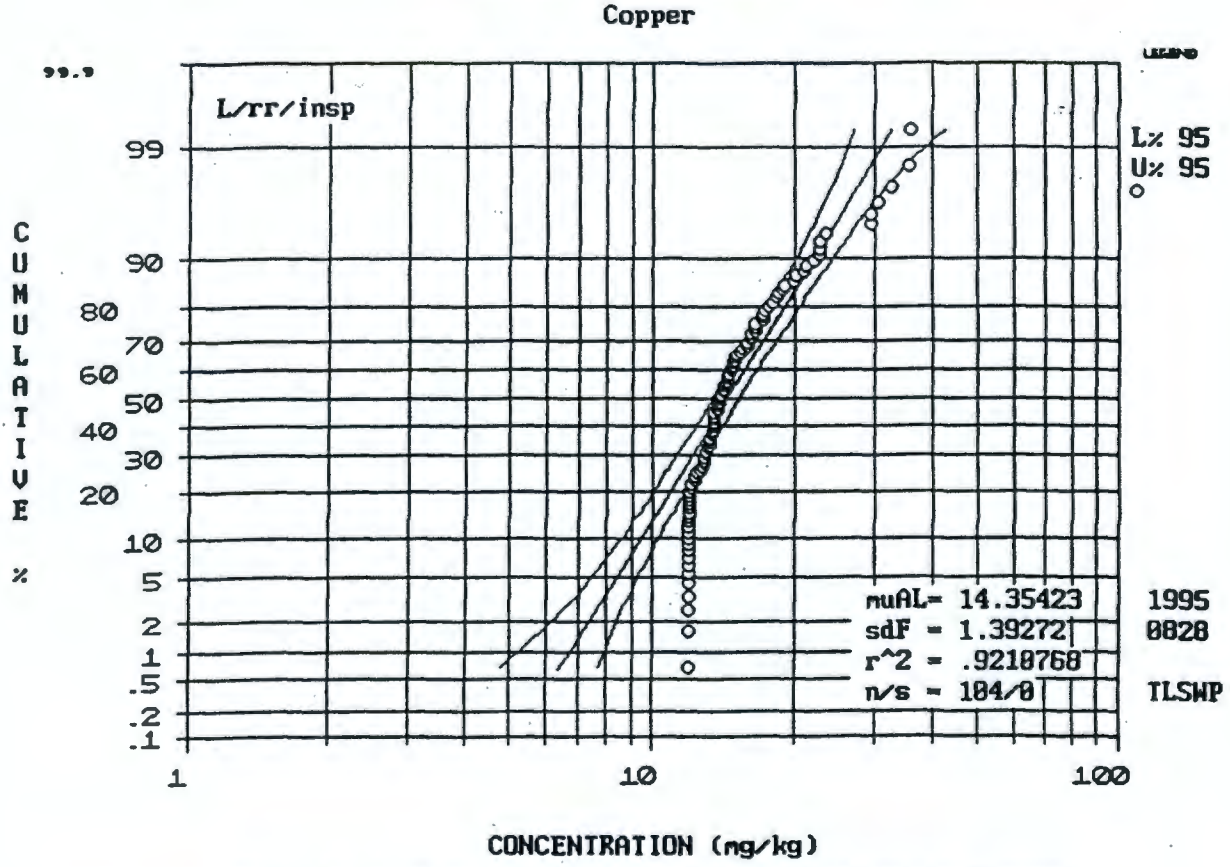
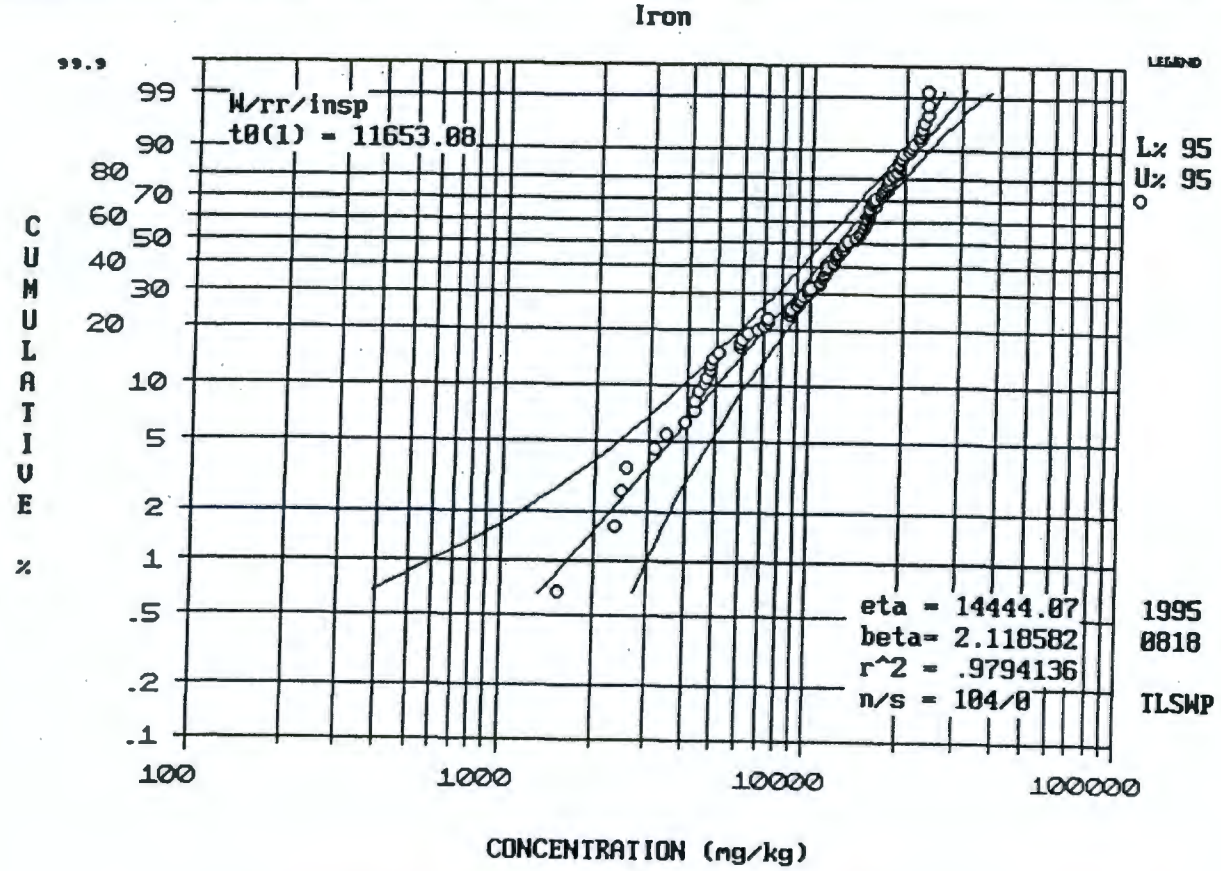


Figure D7-8. Weibull and Lognormal Probability Plots for Copper.



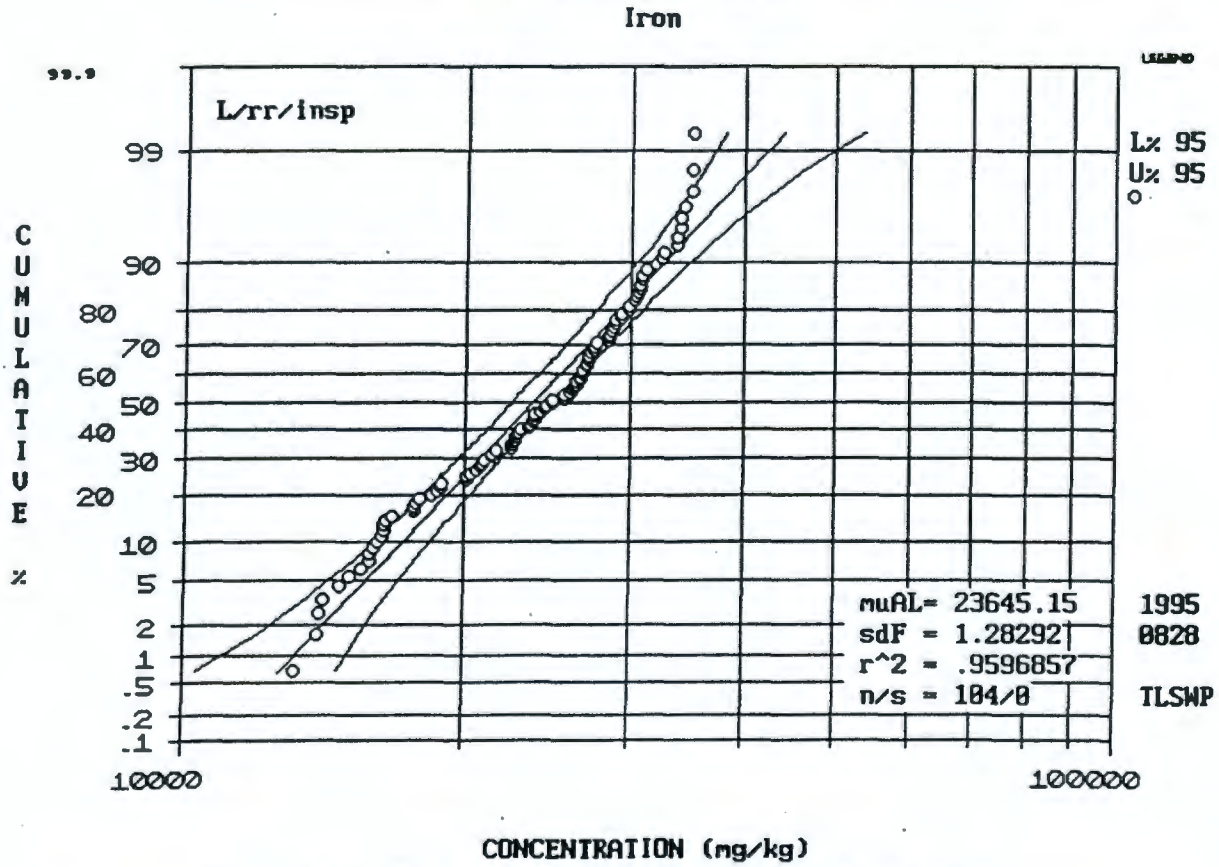
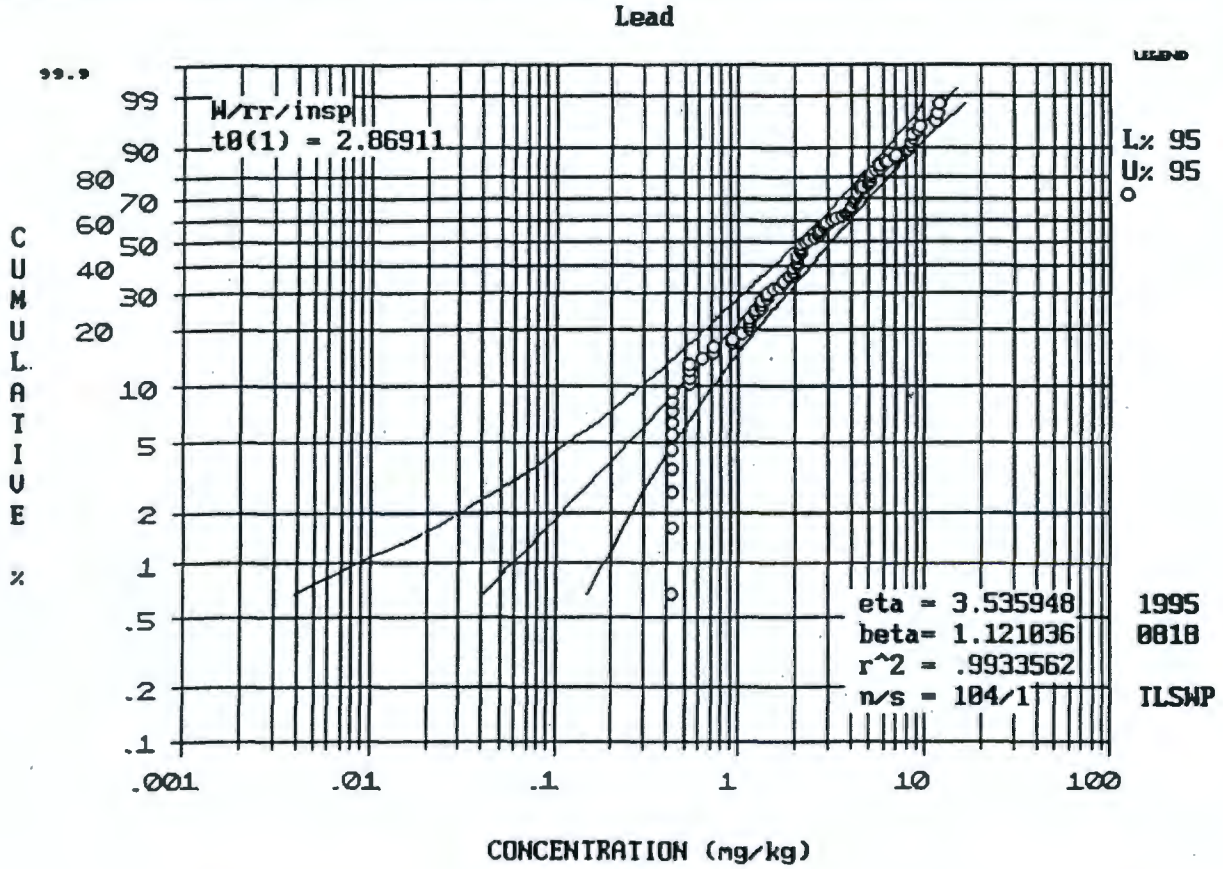


Figure D7-9. Weibull and Lognormal Probability Plots for Iron.



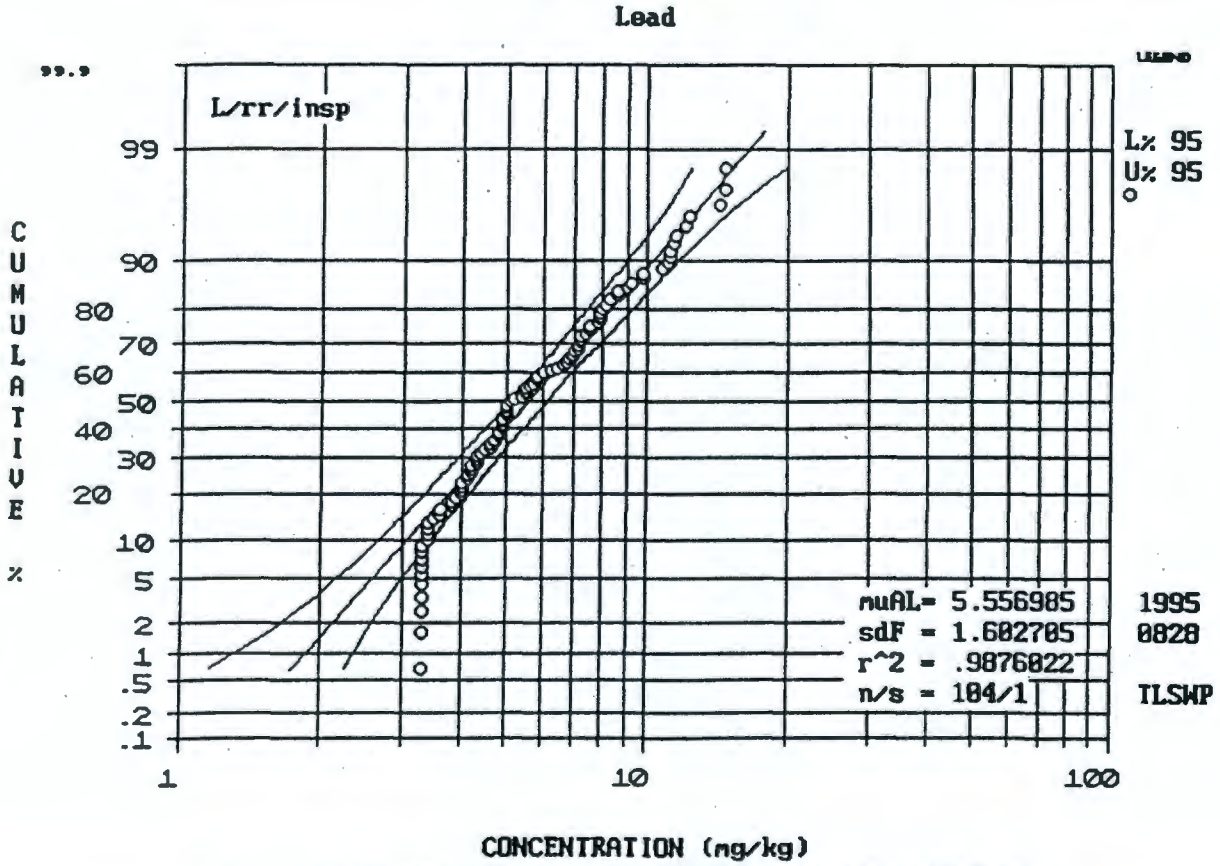
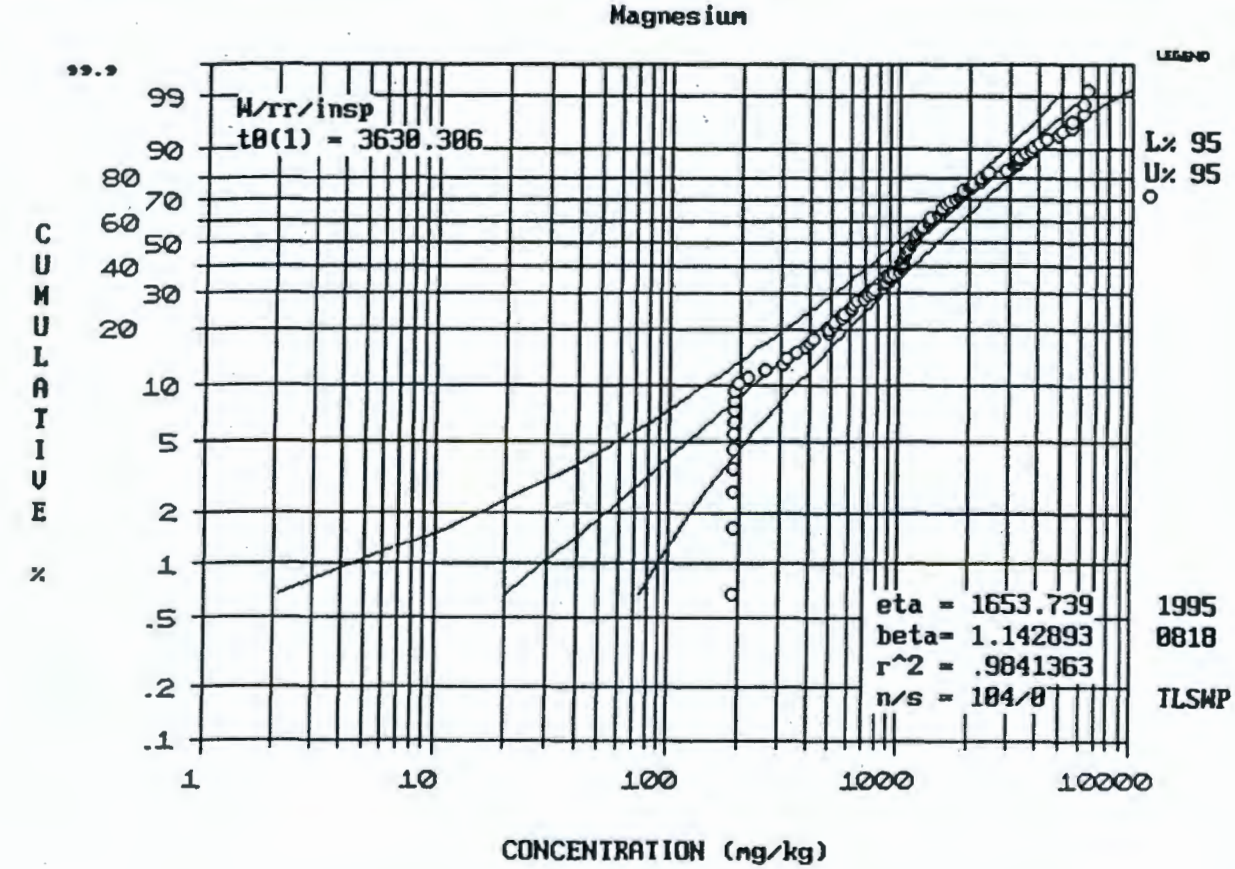


Figure D7-10. Weibull and Lognormal Probability Plots for Lead.



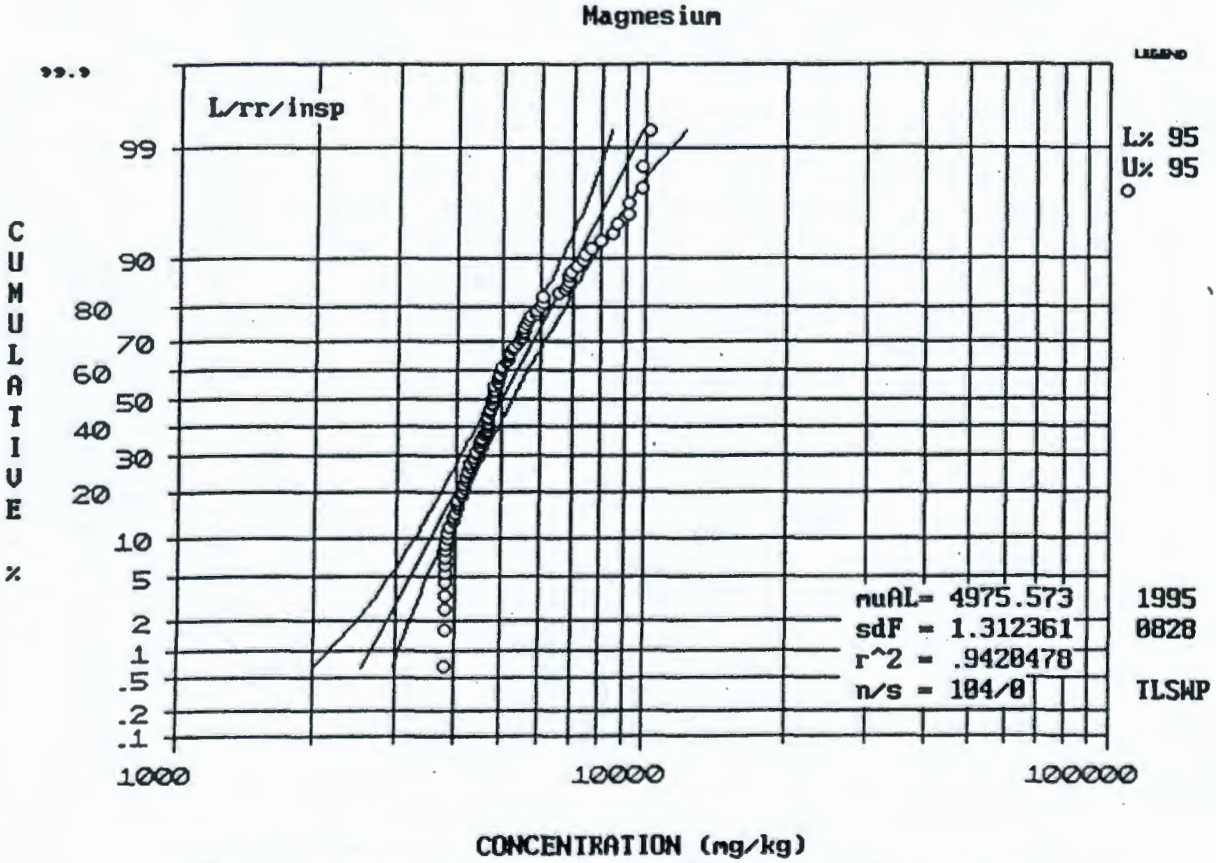


Figure D7-11. Weibull and Lognormal Probability Plots for Magnesium.

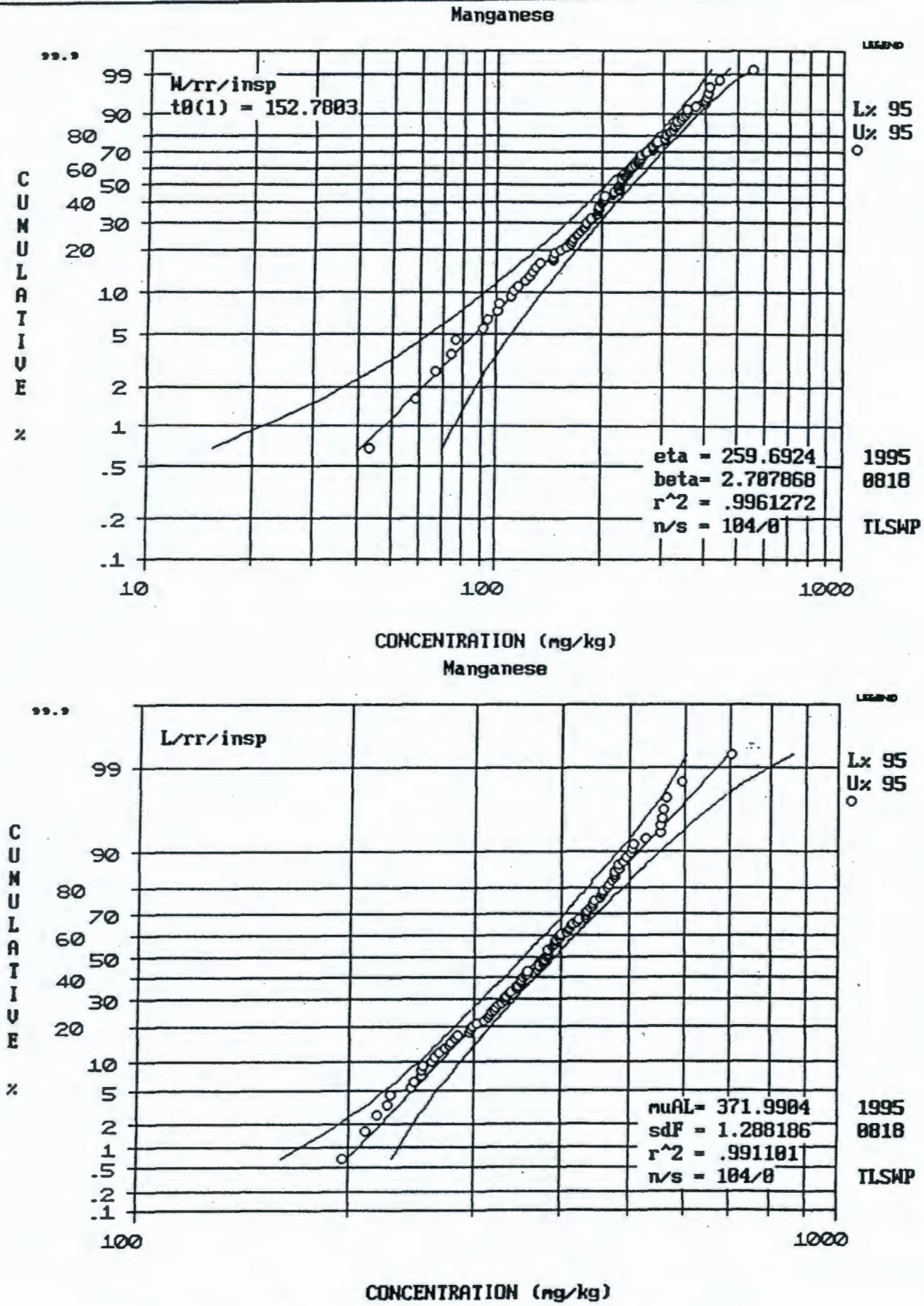
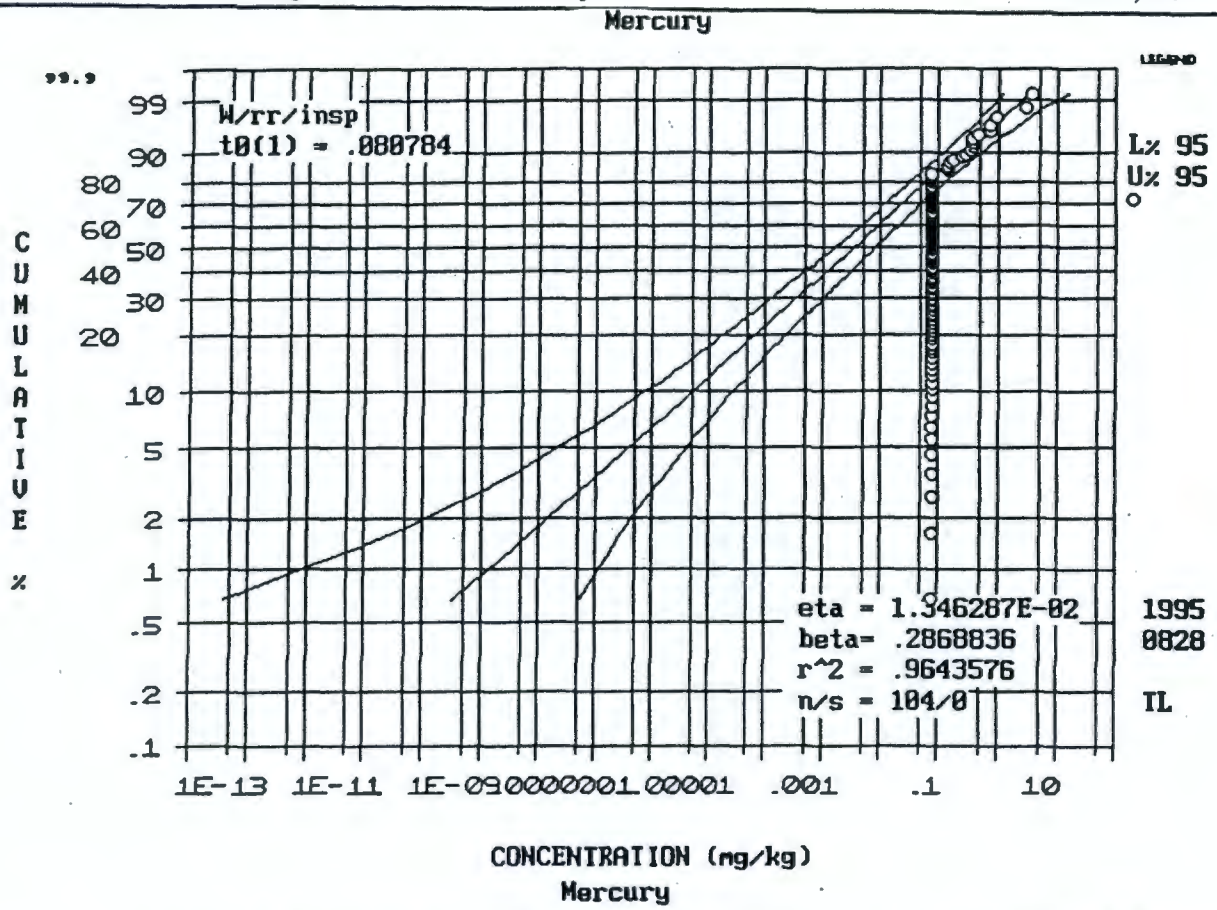


Figure D7-12. Weibull and Lognormal Probability Plots for Manganese.



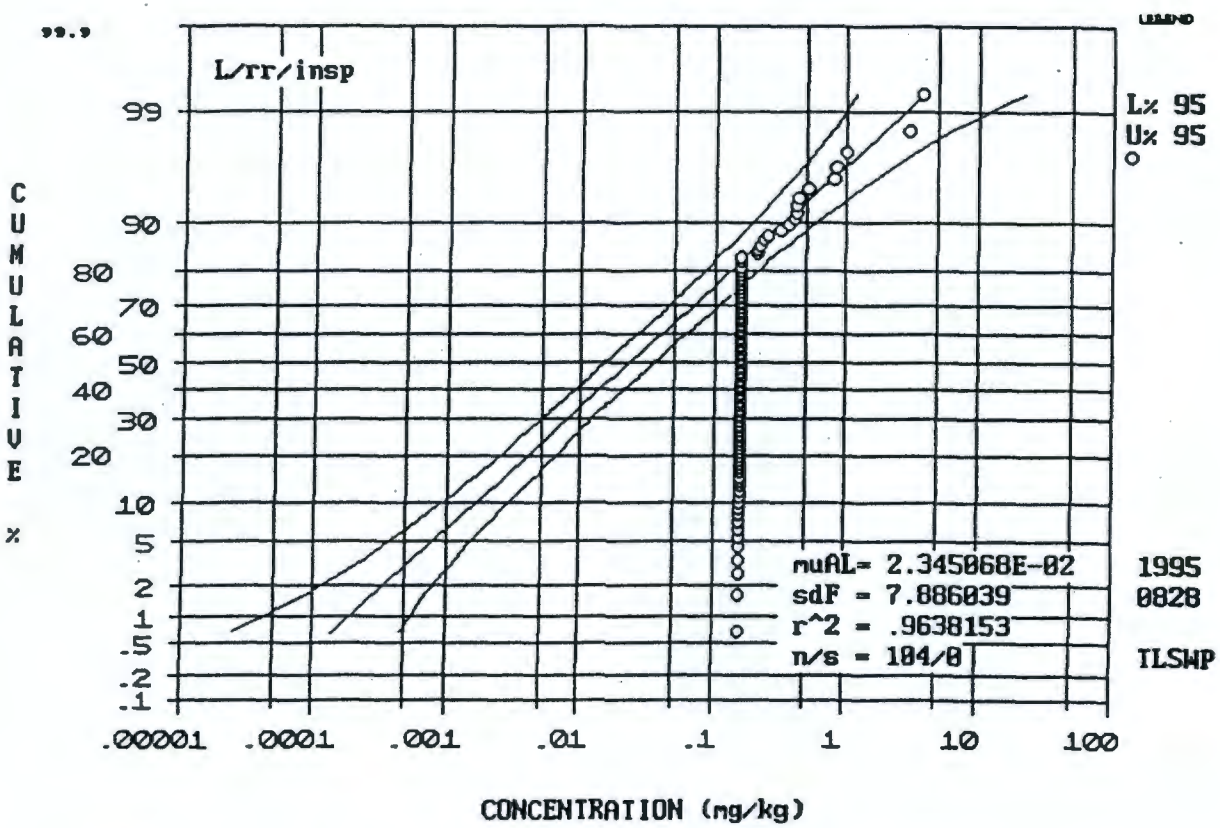
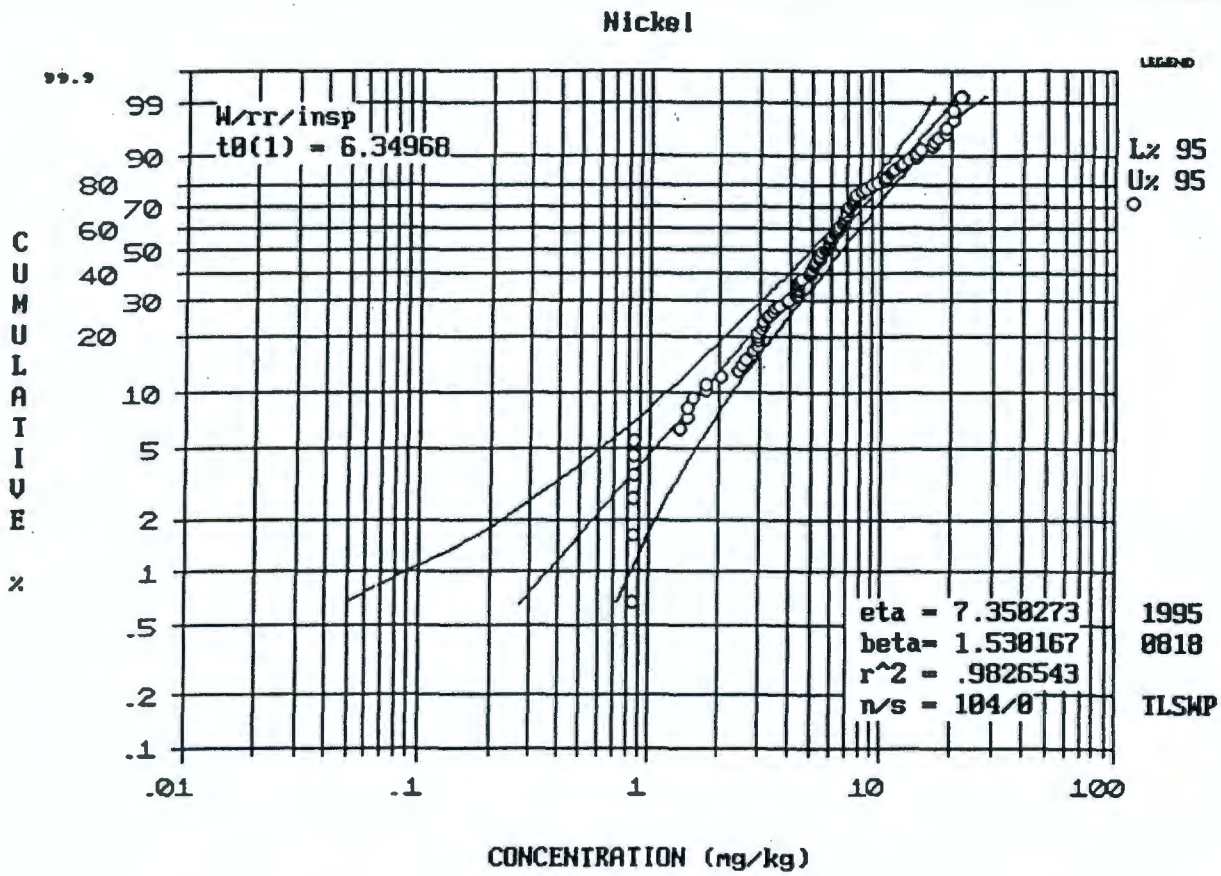


Figure D7-13. Weibull and Lognormal Probability Plots for Mercury.



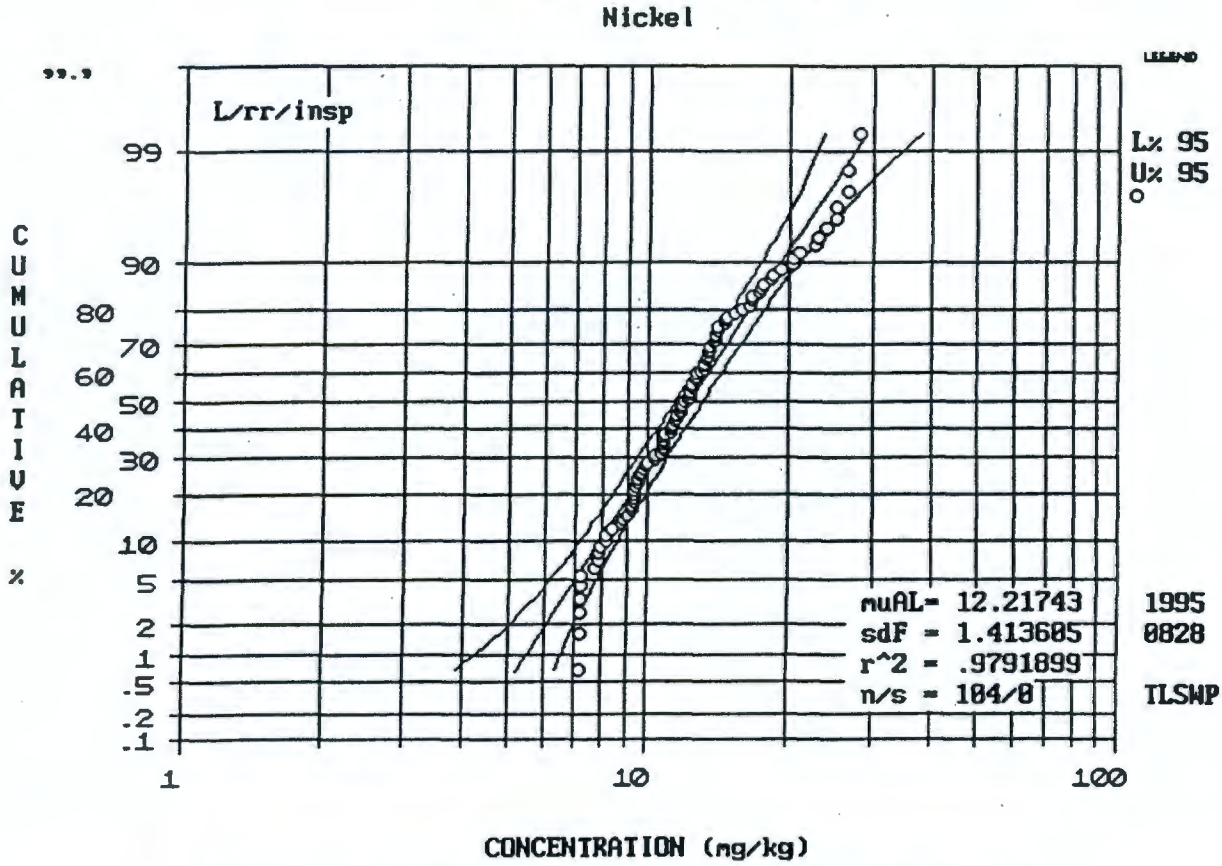
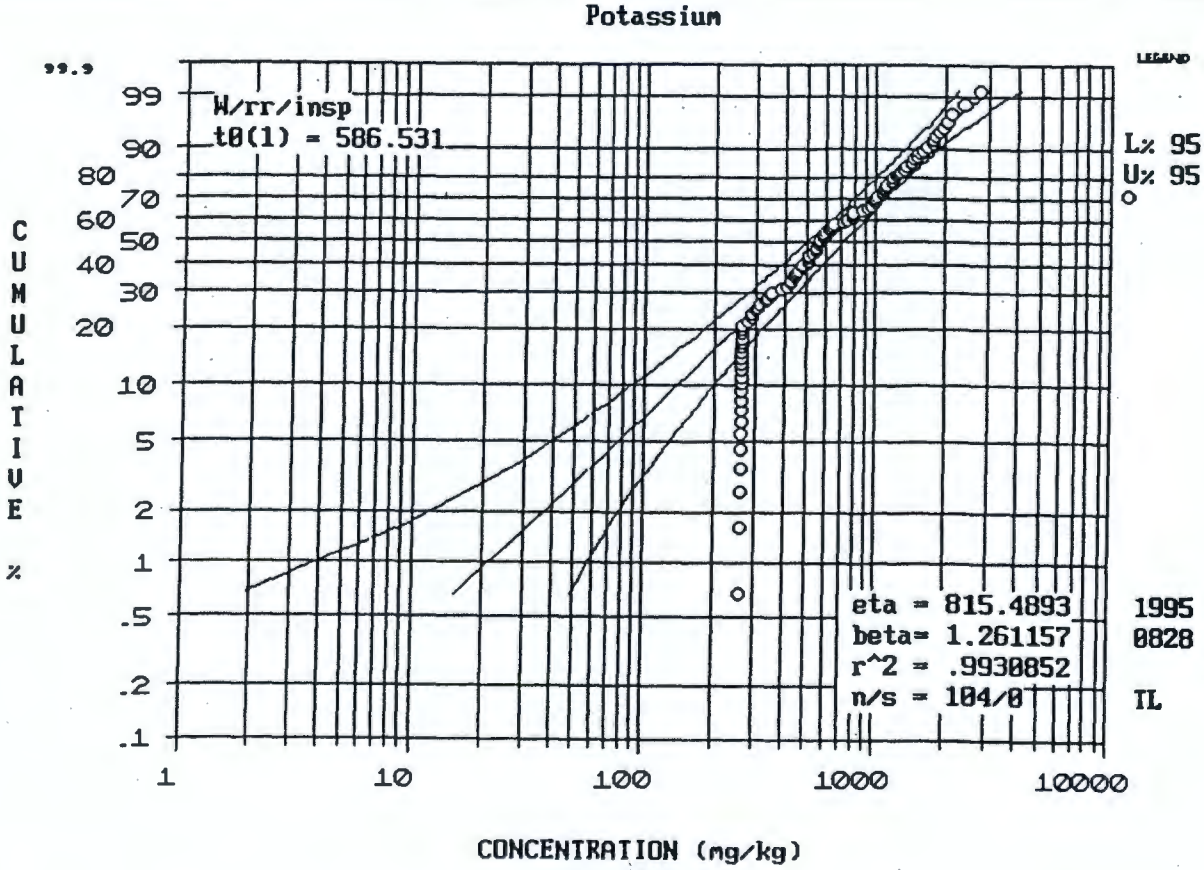


Figure D7-14. Weibull and Lognormal Probability Plots for Nickel.



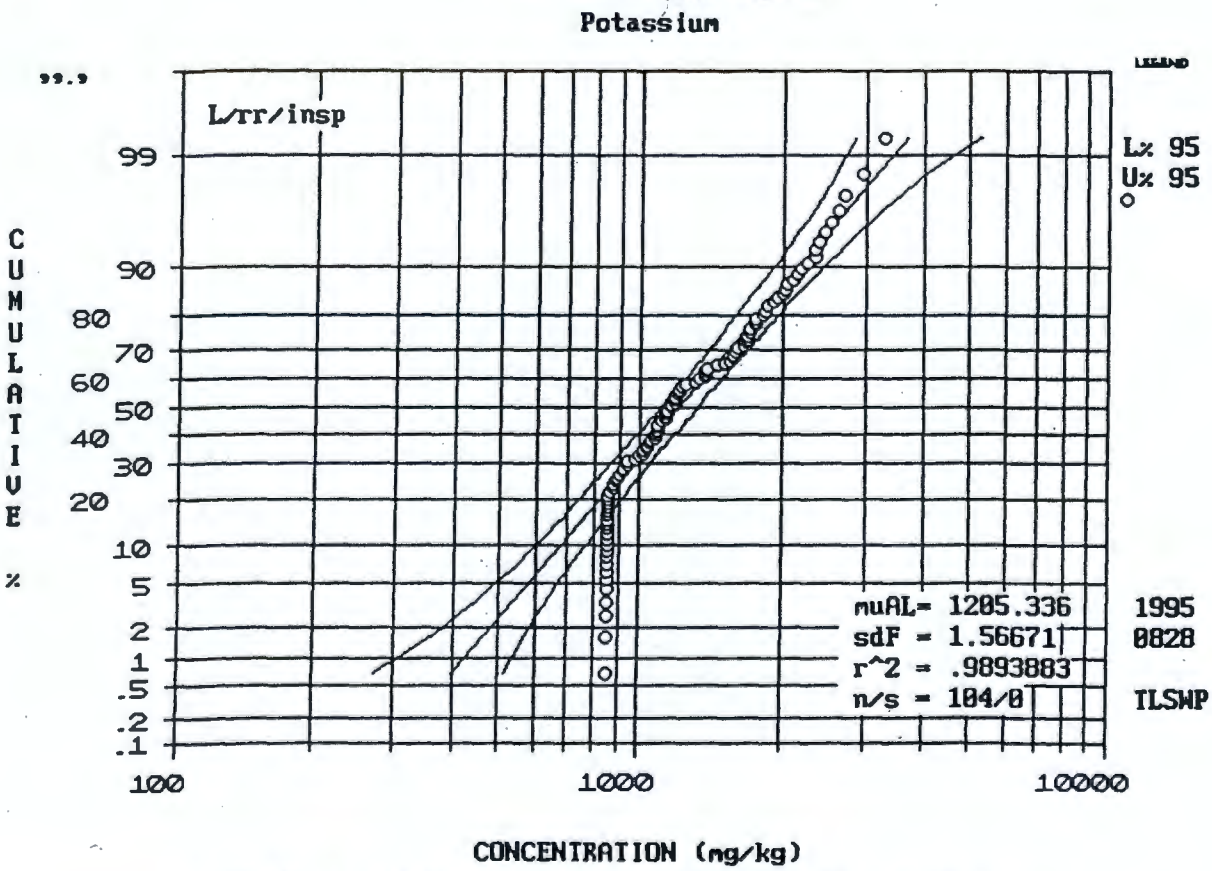
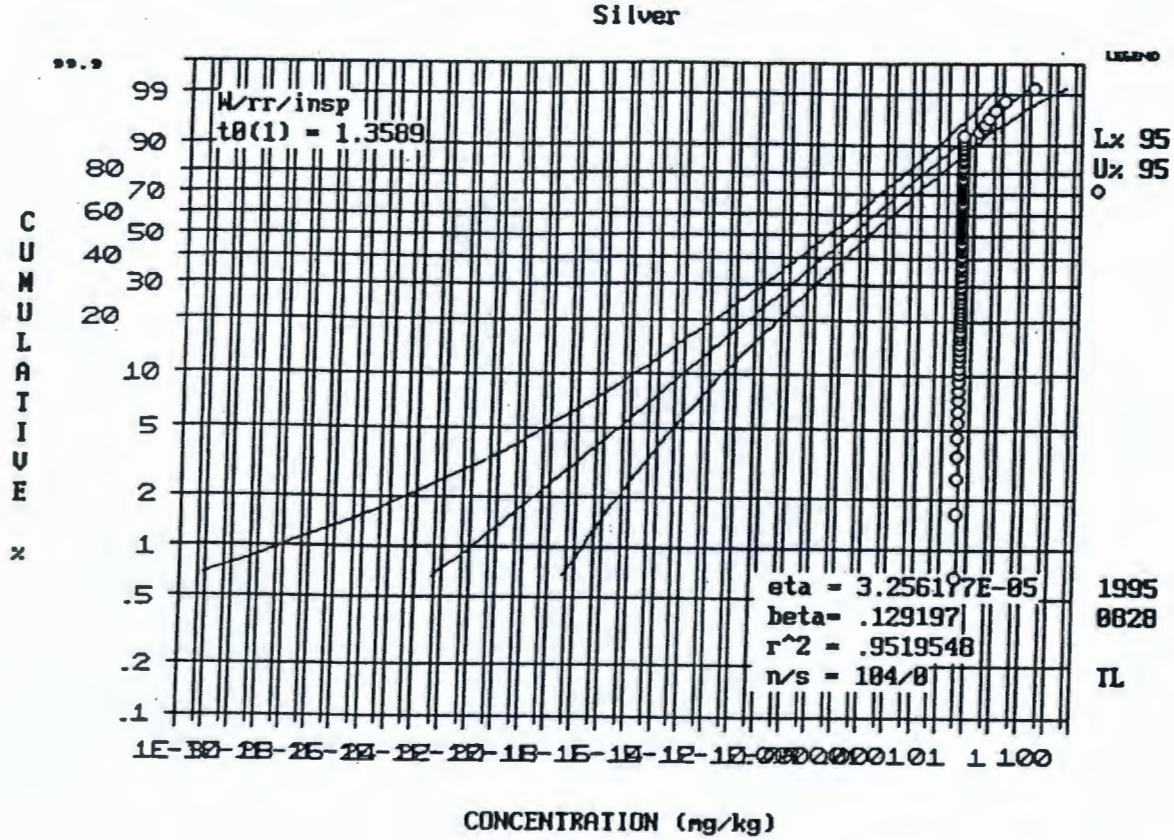


Figure D7-15. Weibull and Lognormal Probability Plots for Potassium.



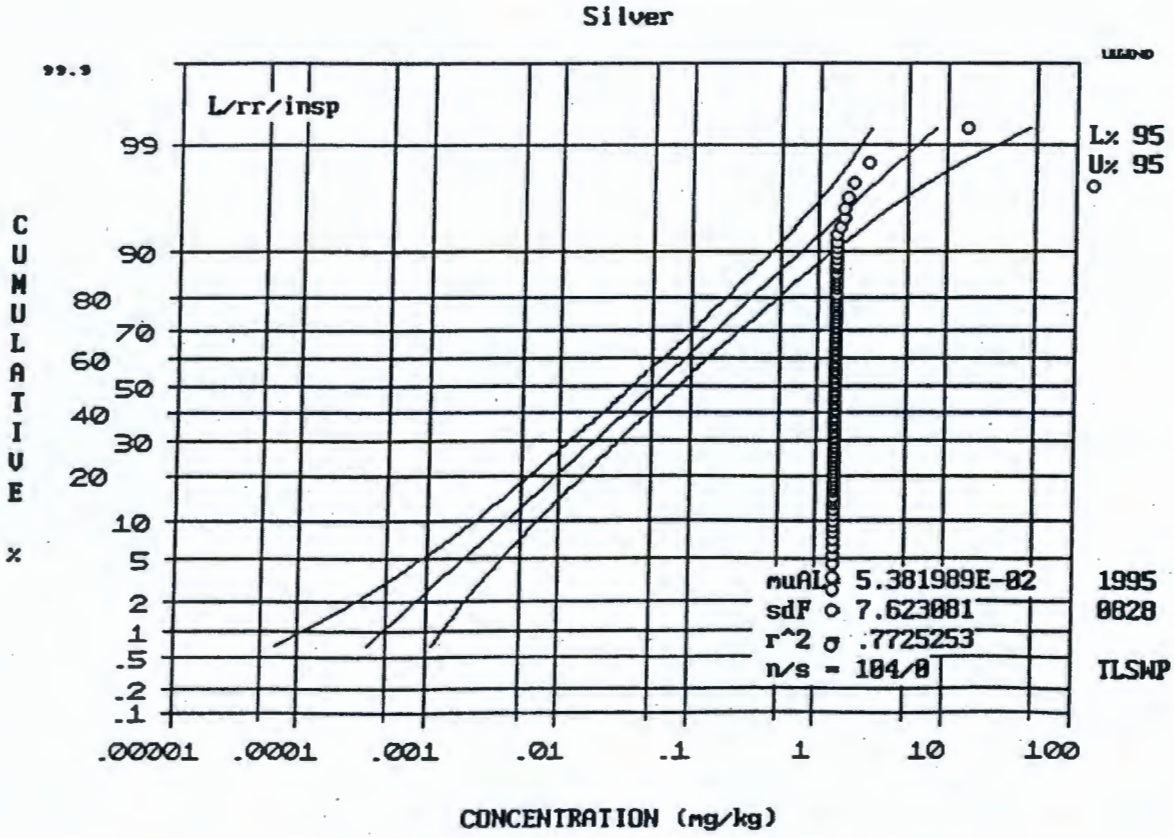
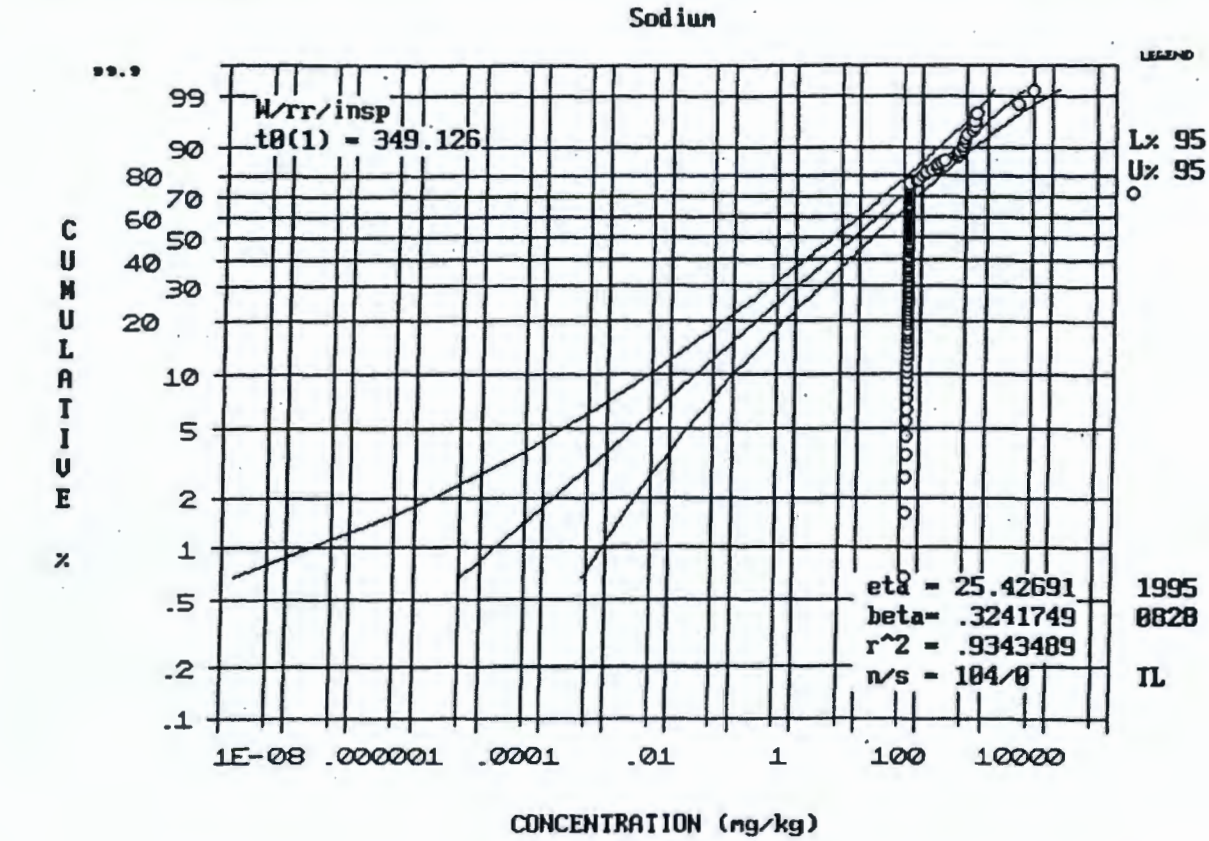


Figure D7-16. Weibull and Lognormal Probability Plots for Silver



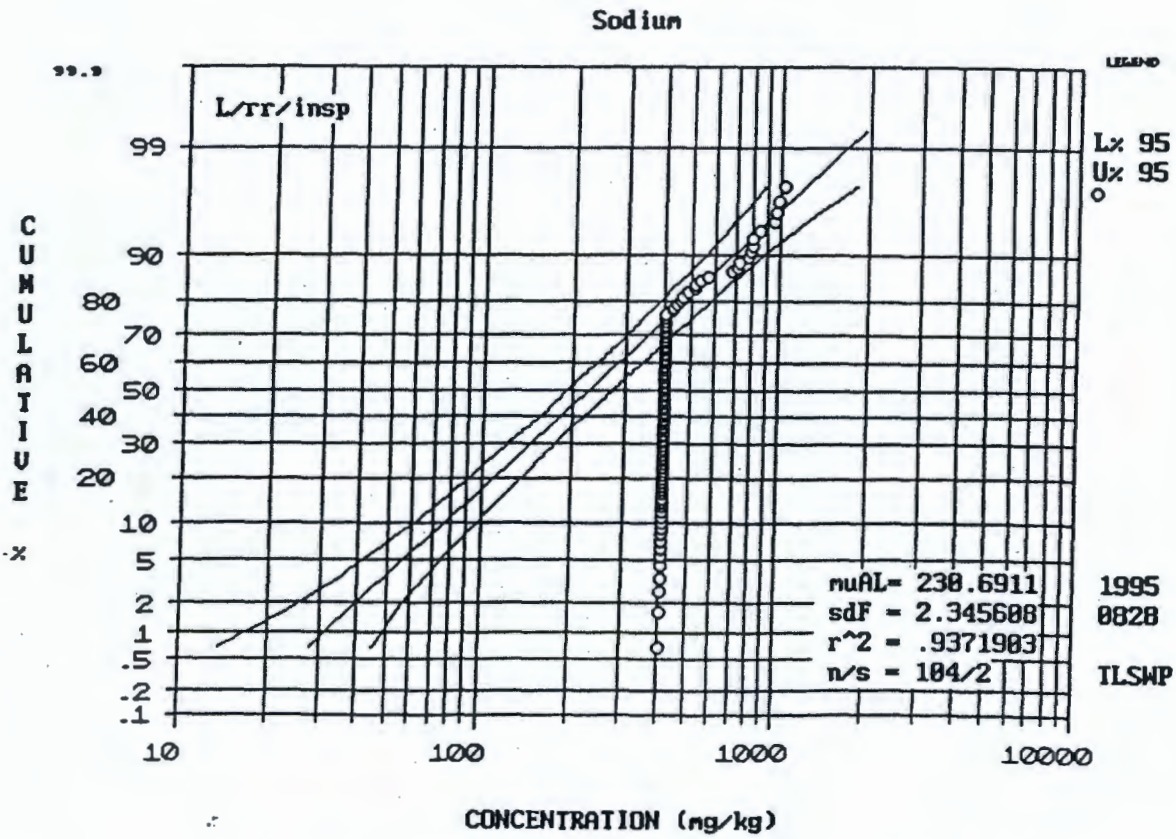
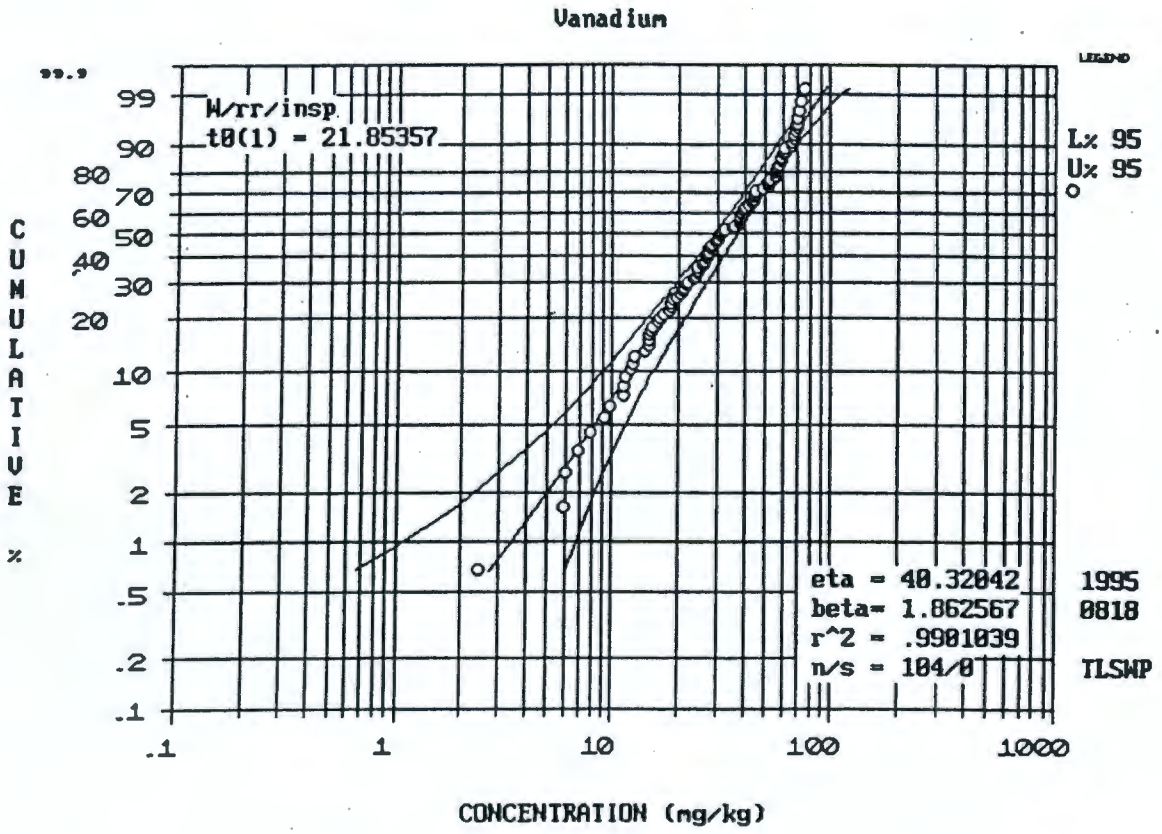


Figure D7-17. Weibull and Lognormal Probability Plots for Sodium



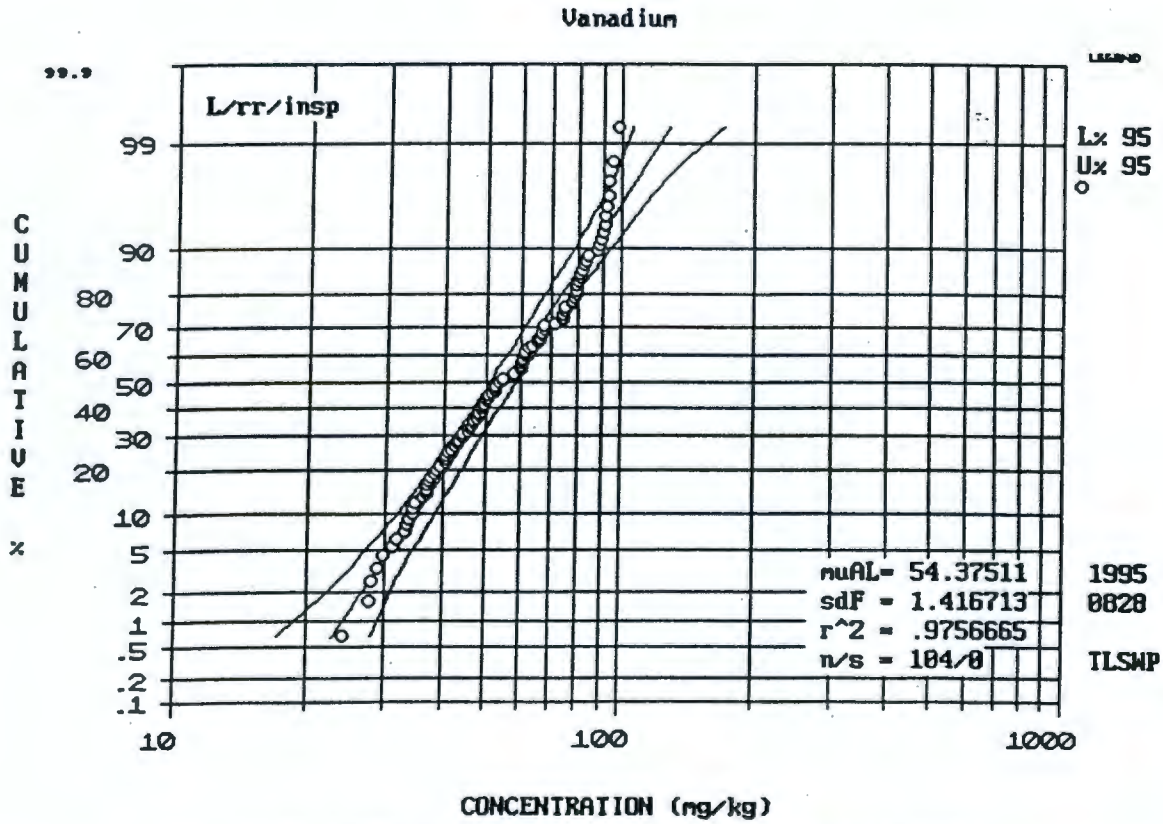
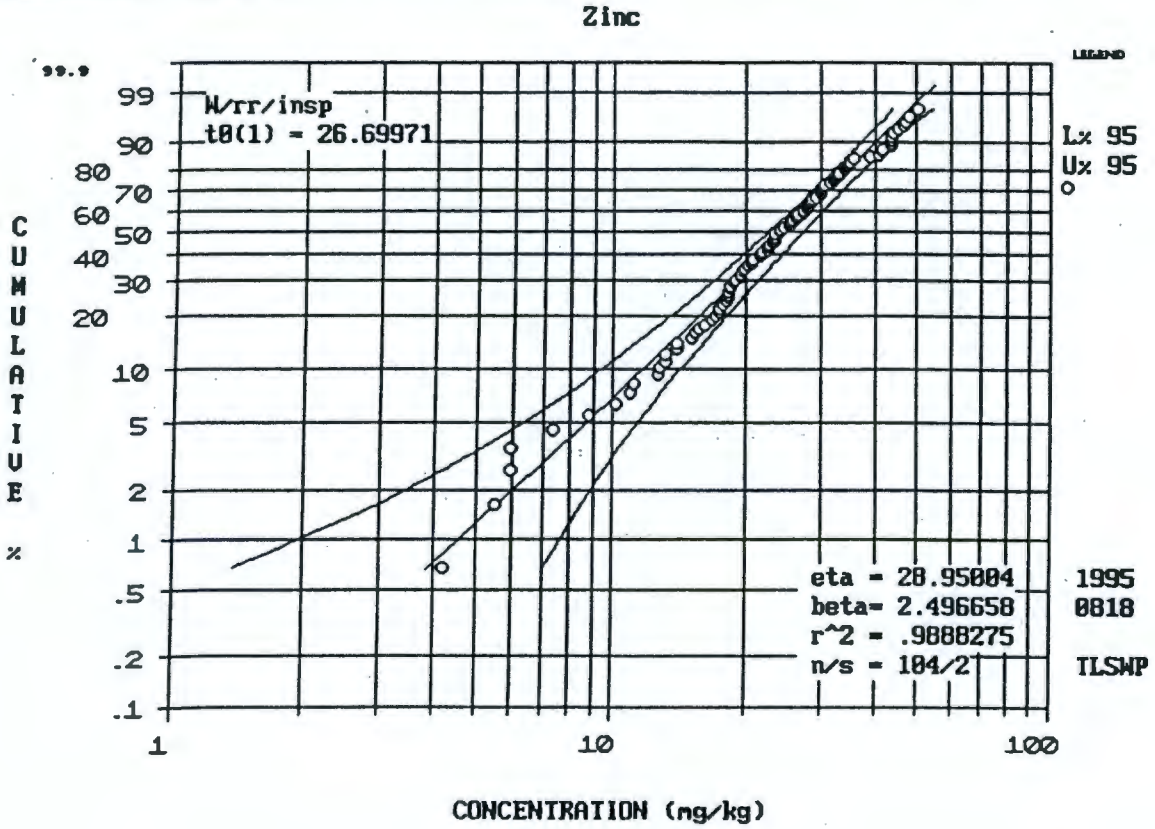


Figure D7-18. Weibull and Lognormal Probability Plots for Vanadium.



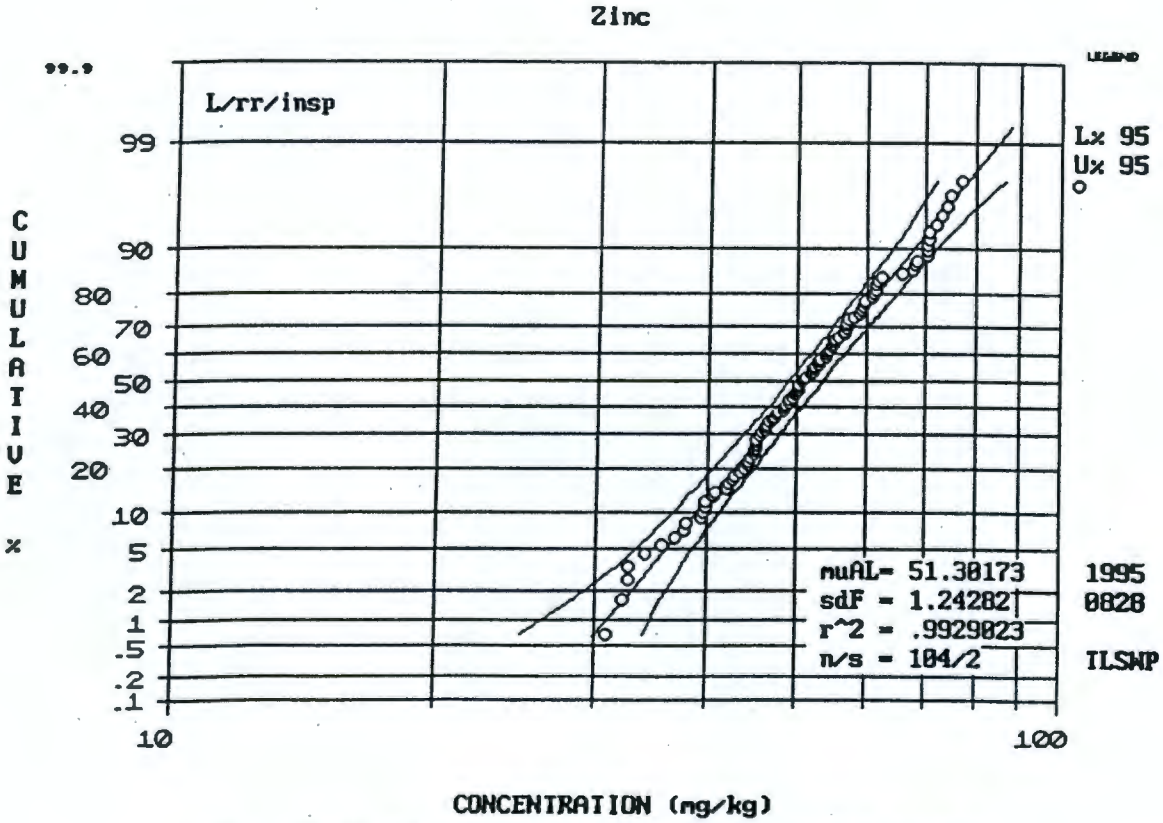
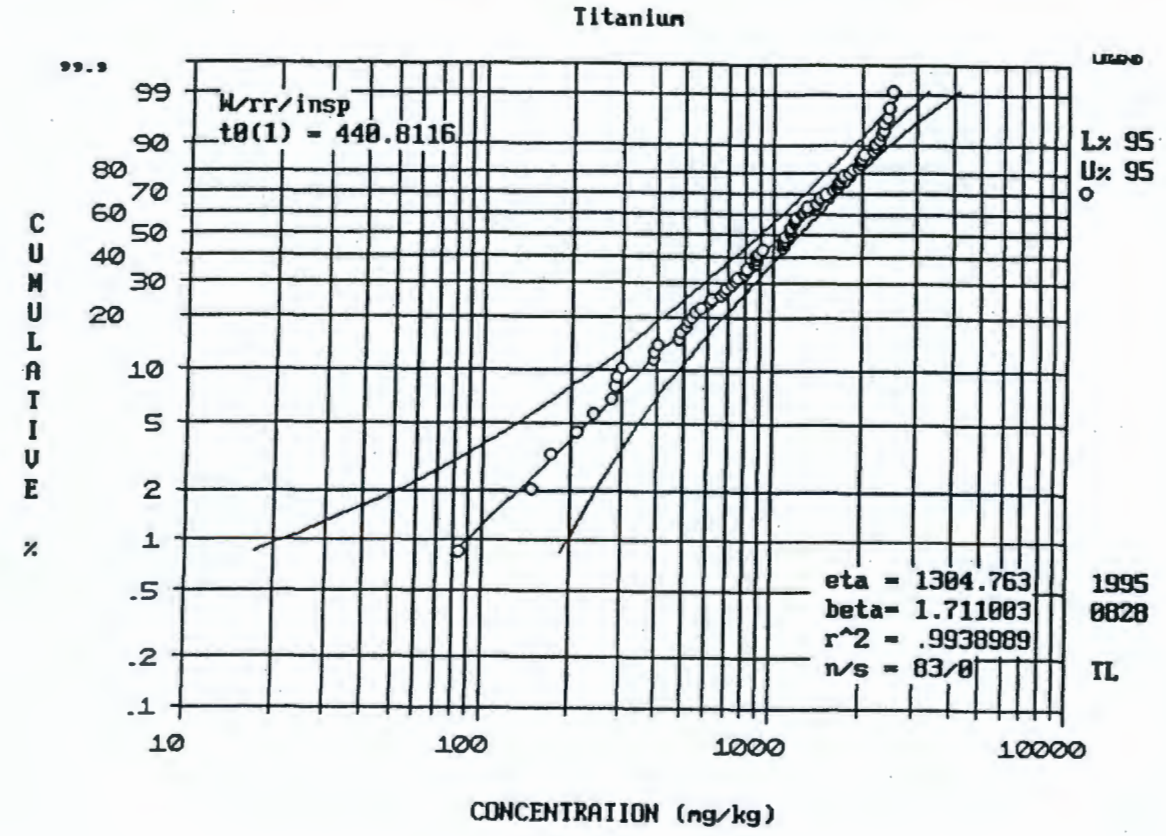


Figure D7-19. Weibull and Lognormal Probability Plots for Zinc.



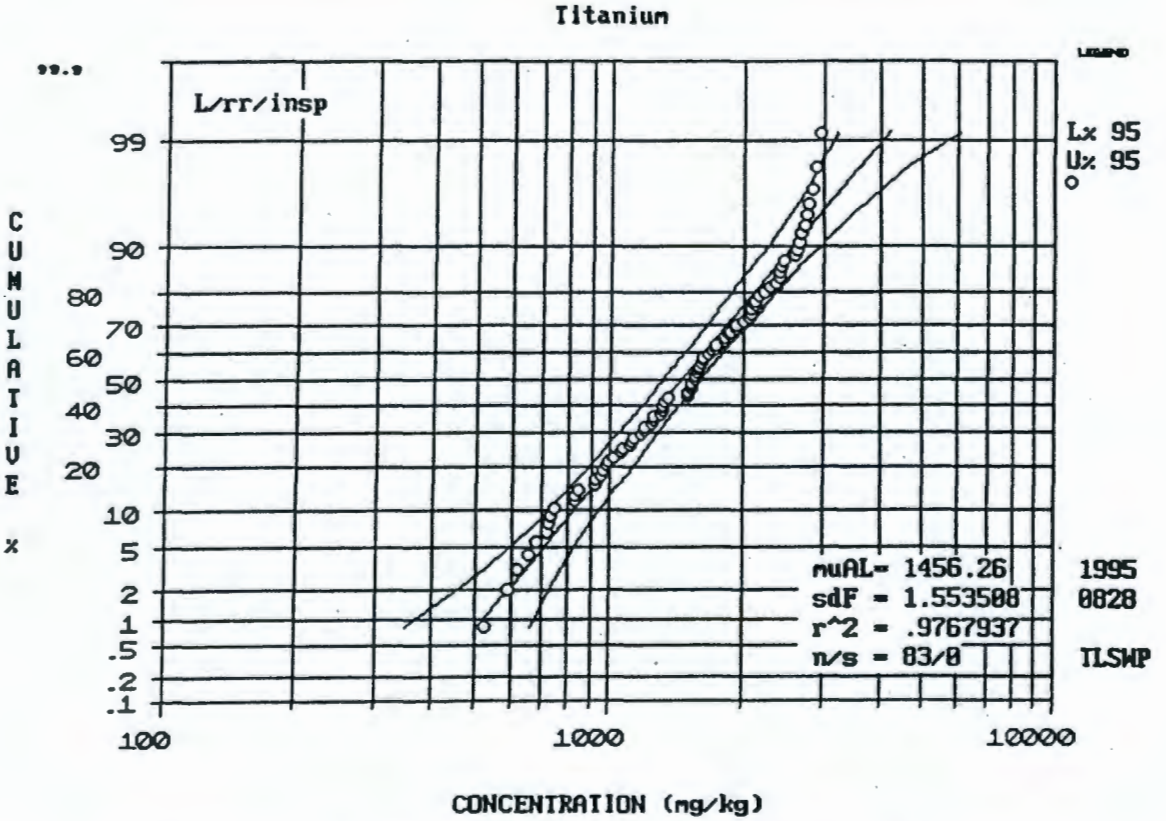
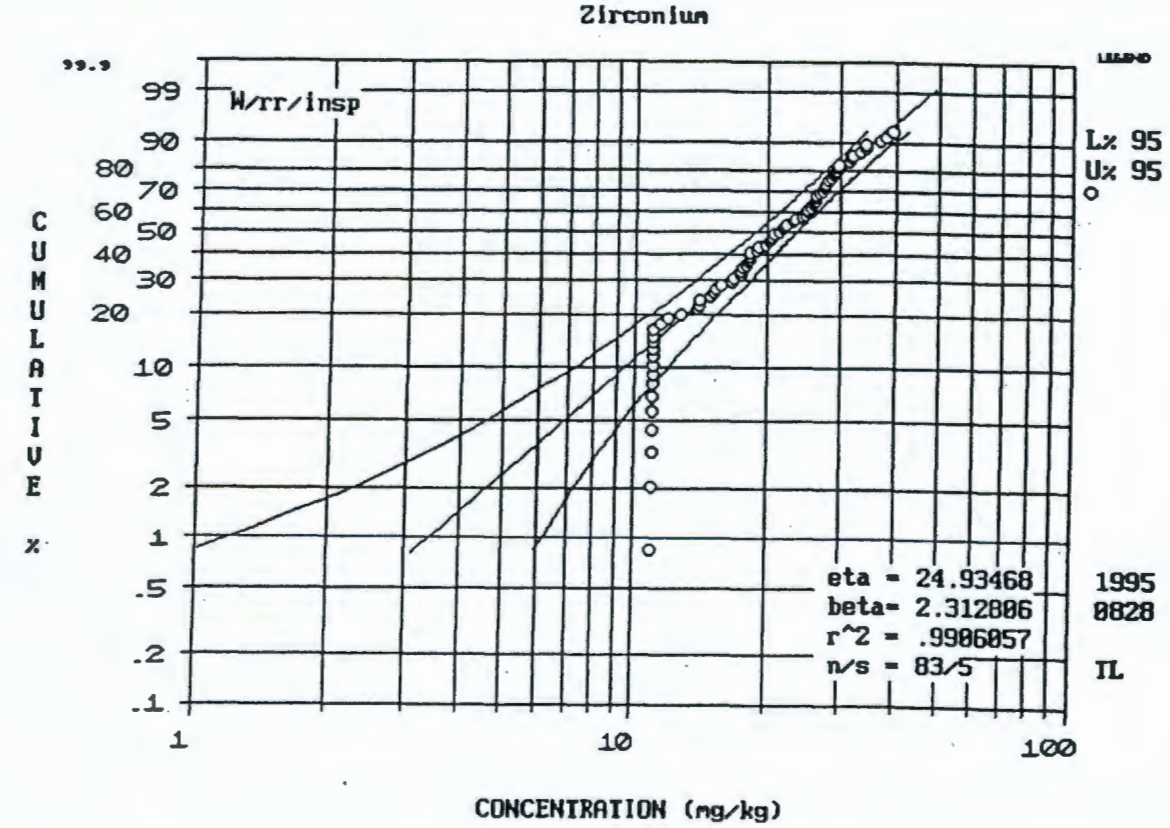


Figure D7-20. Weibull and Lognormal Probability Plots for Titanium.



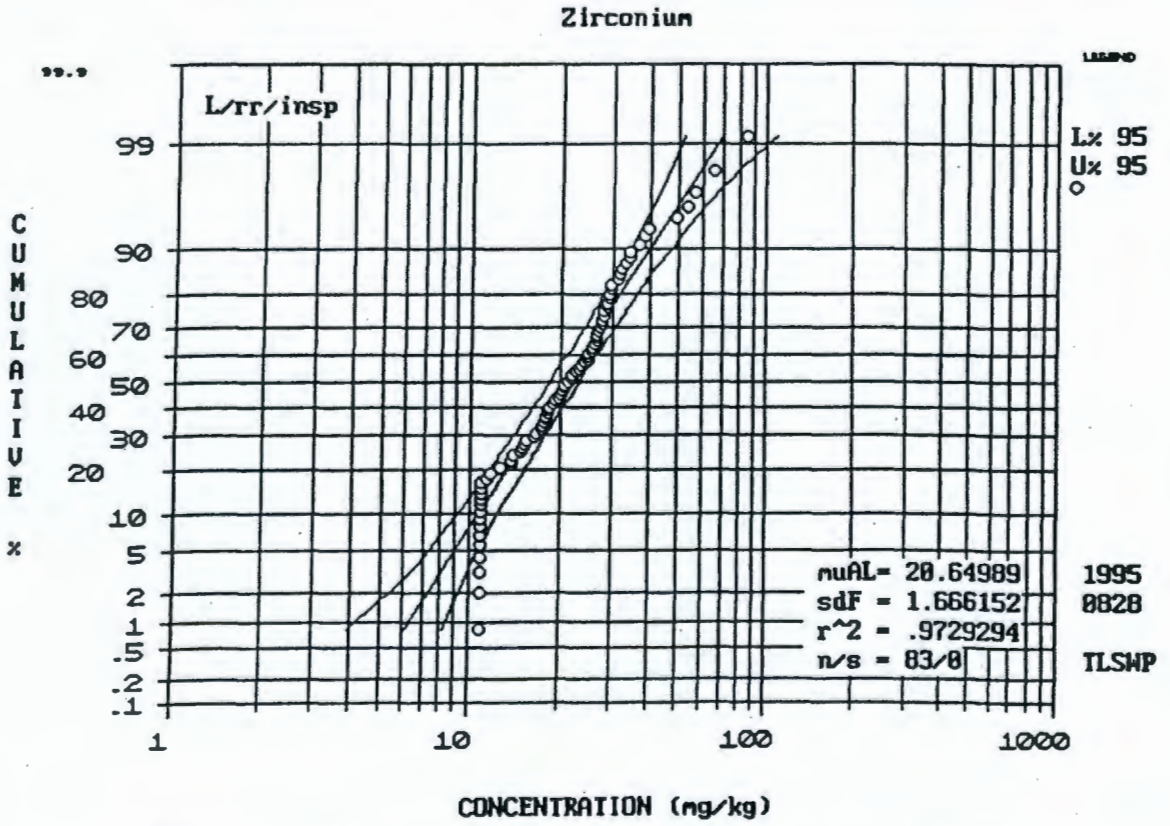
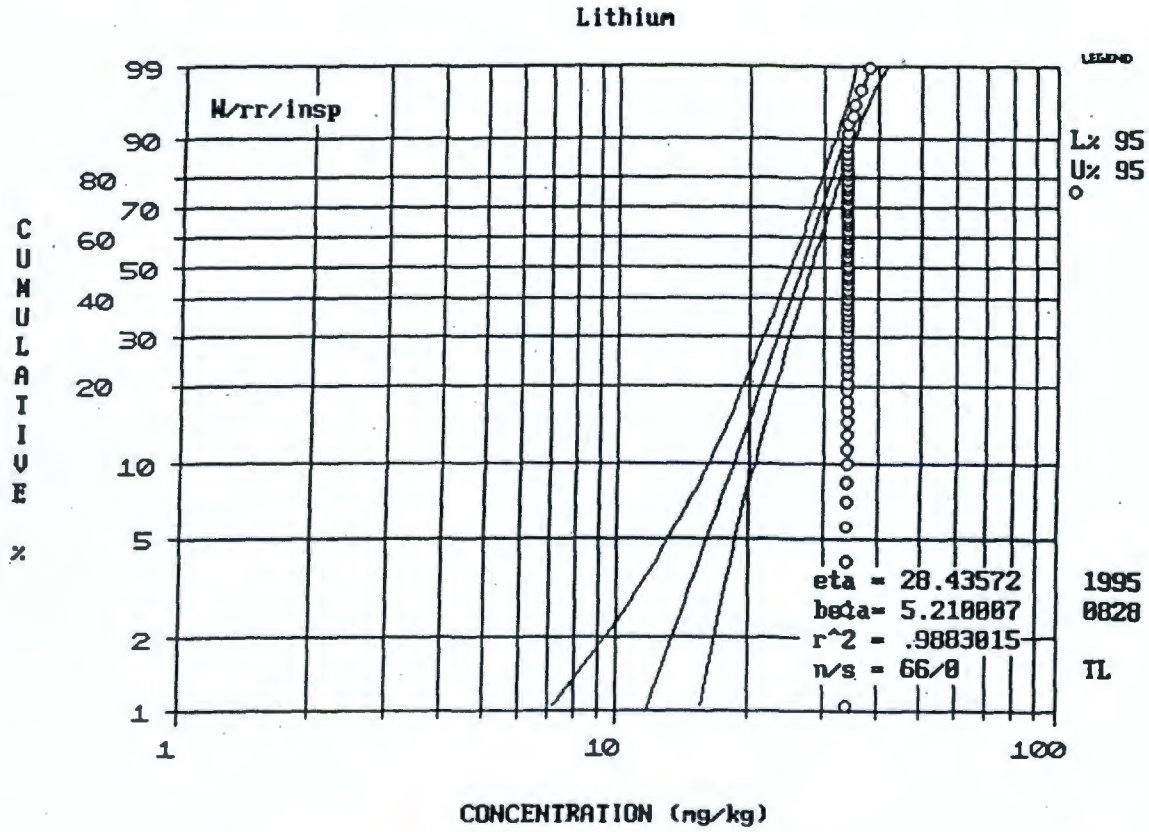


Figure D7-21. Weibull and Lognormal Probability Plots for Zirconium.



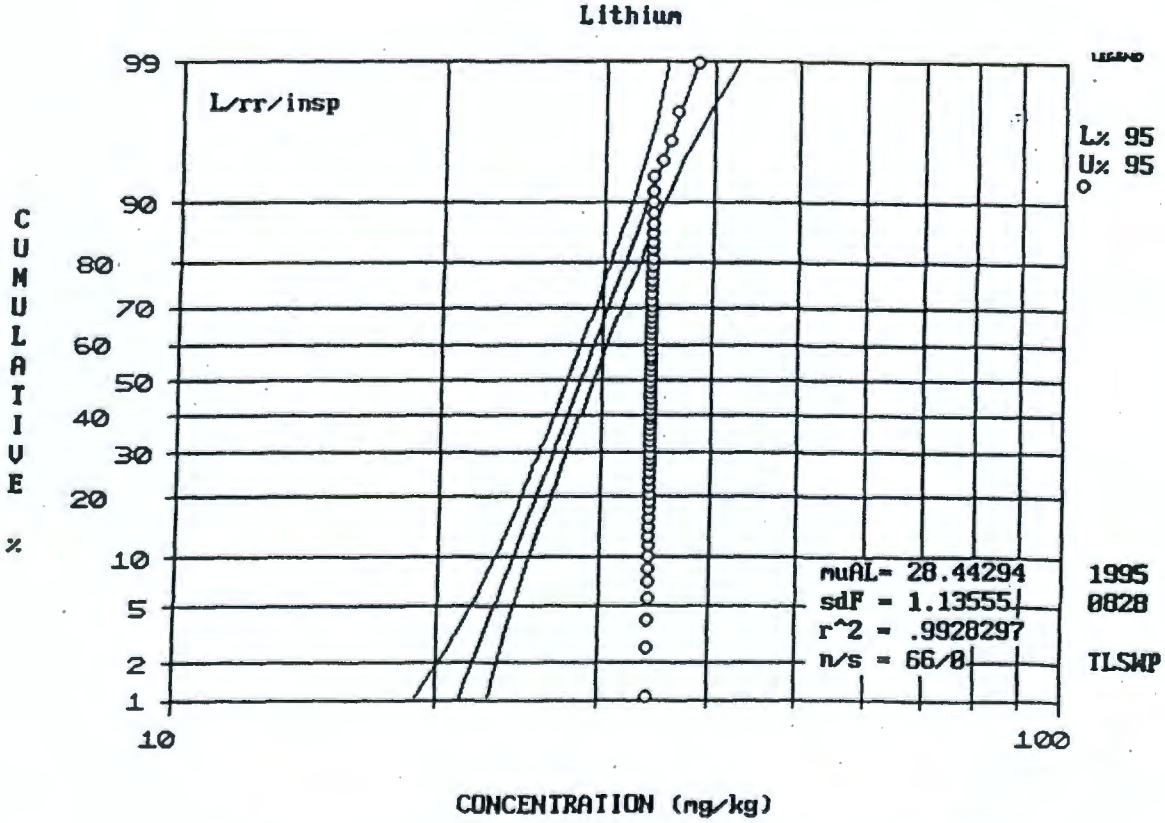
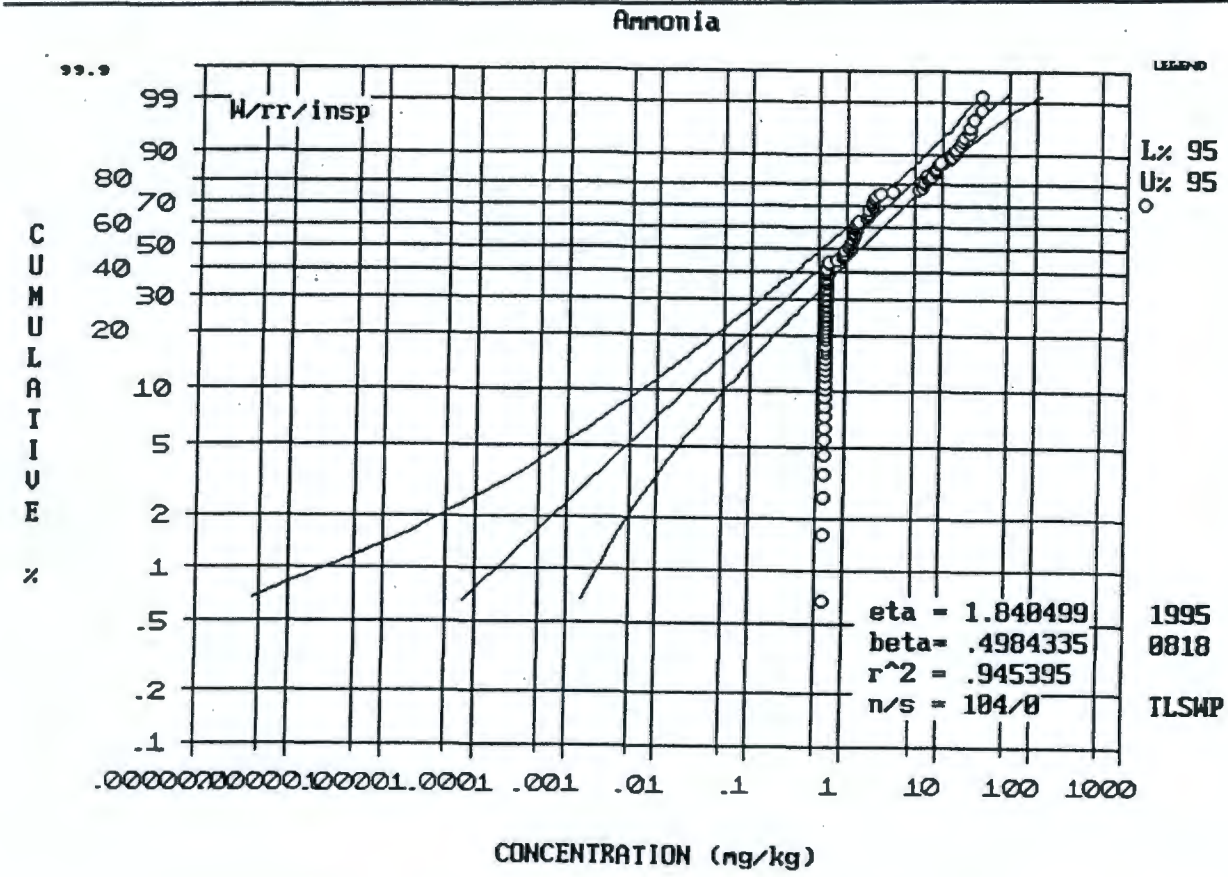


Figure D7-22. Weibull and Lognormal Probability Plots for Lithium.



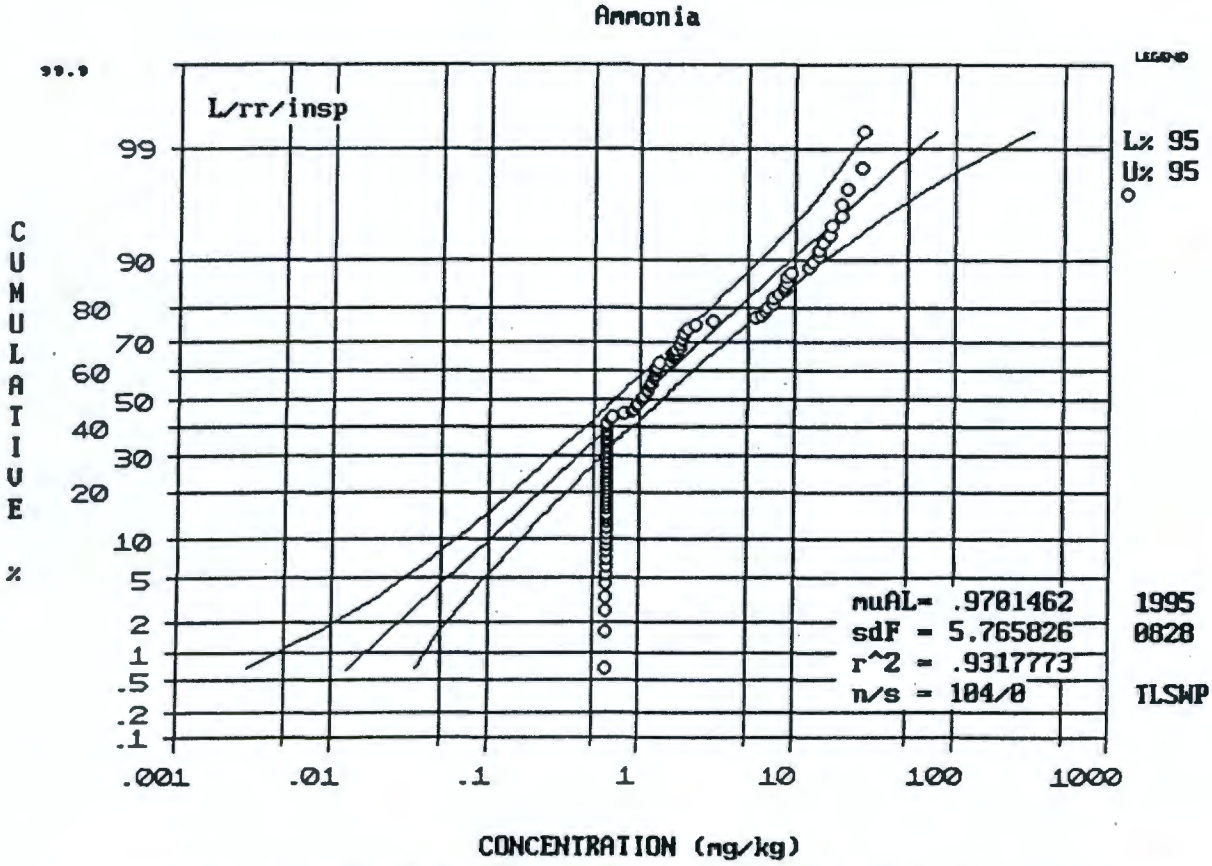
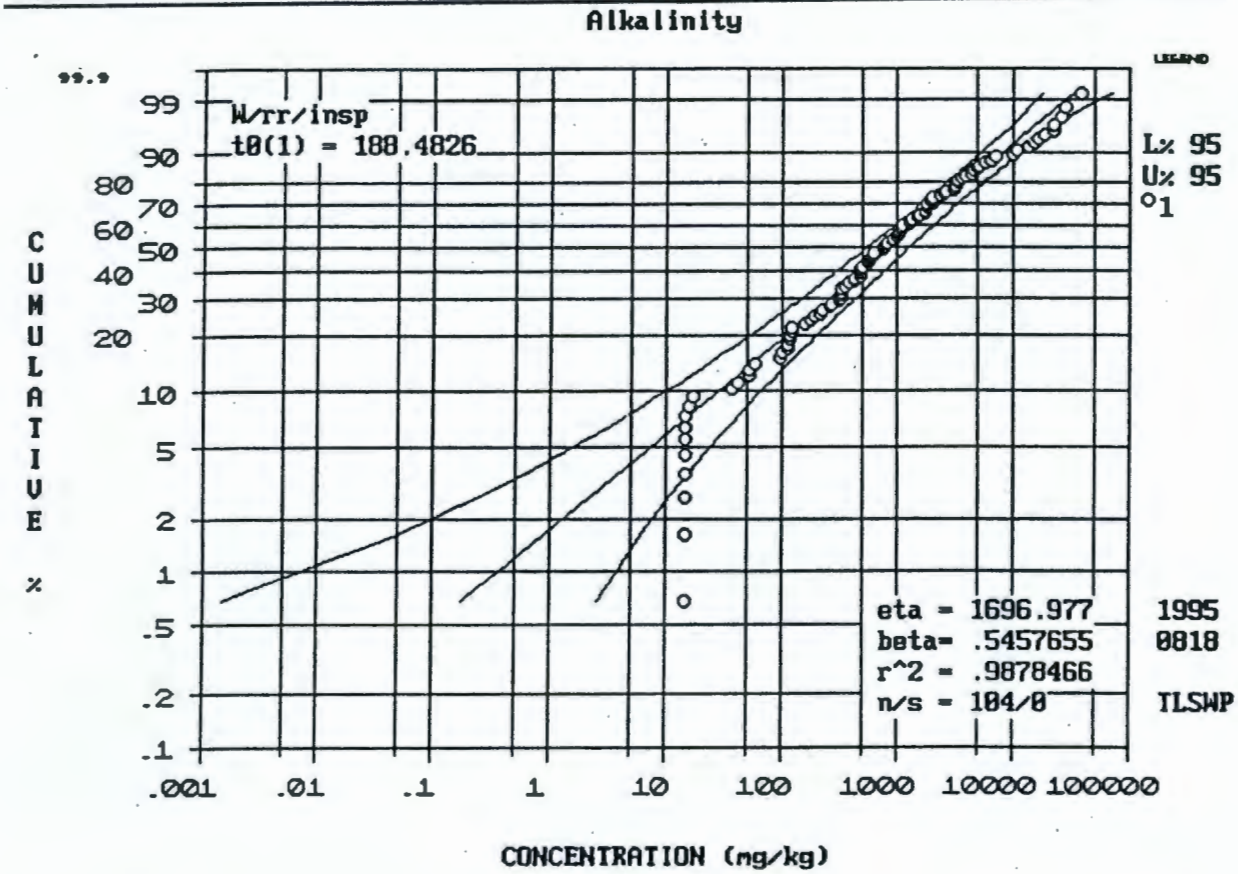


Figure D7-23. Weibull and Lognormal Probability Plots for Ammonia.



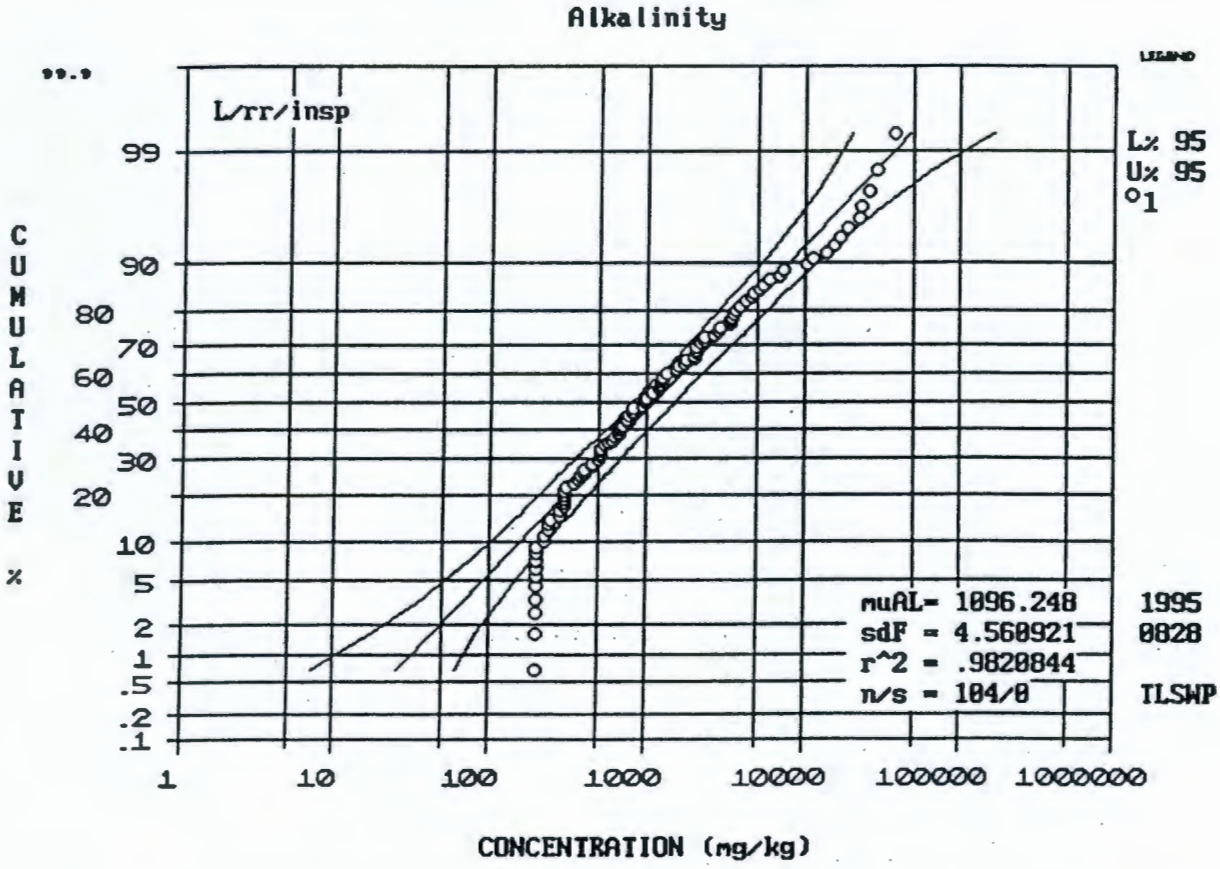
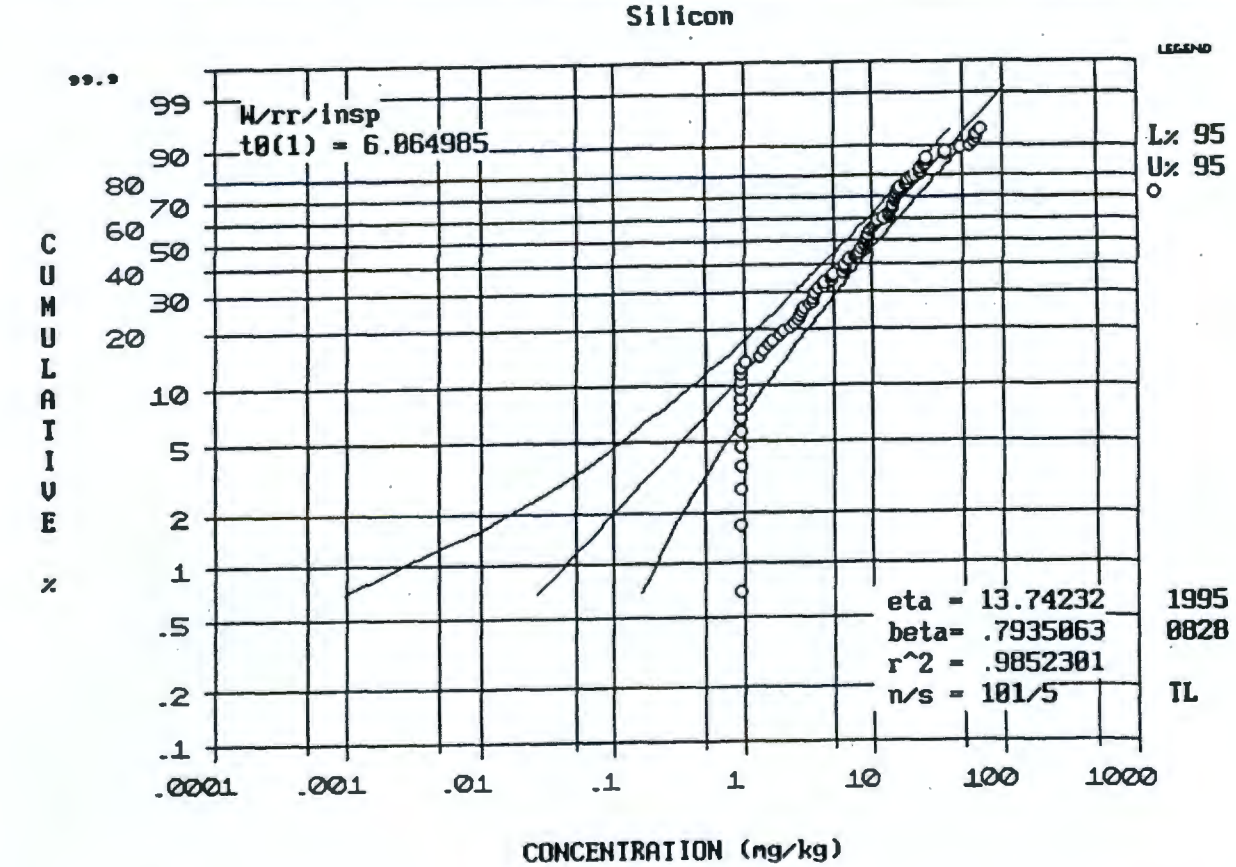


Figure D7-24. Weibull and Lognormal Probability Plots for Alkalinity.



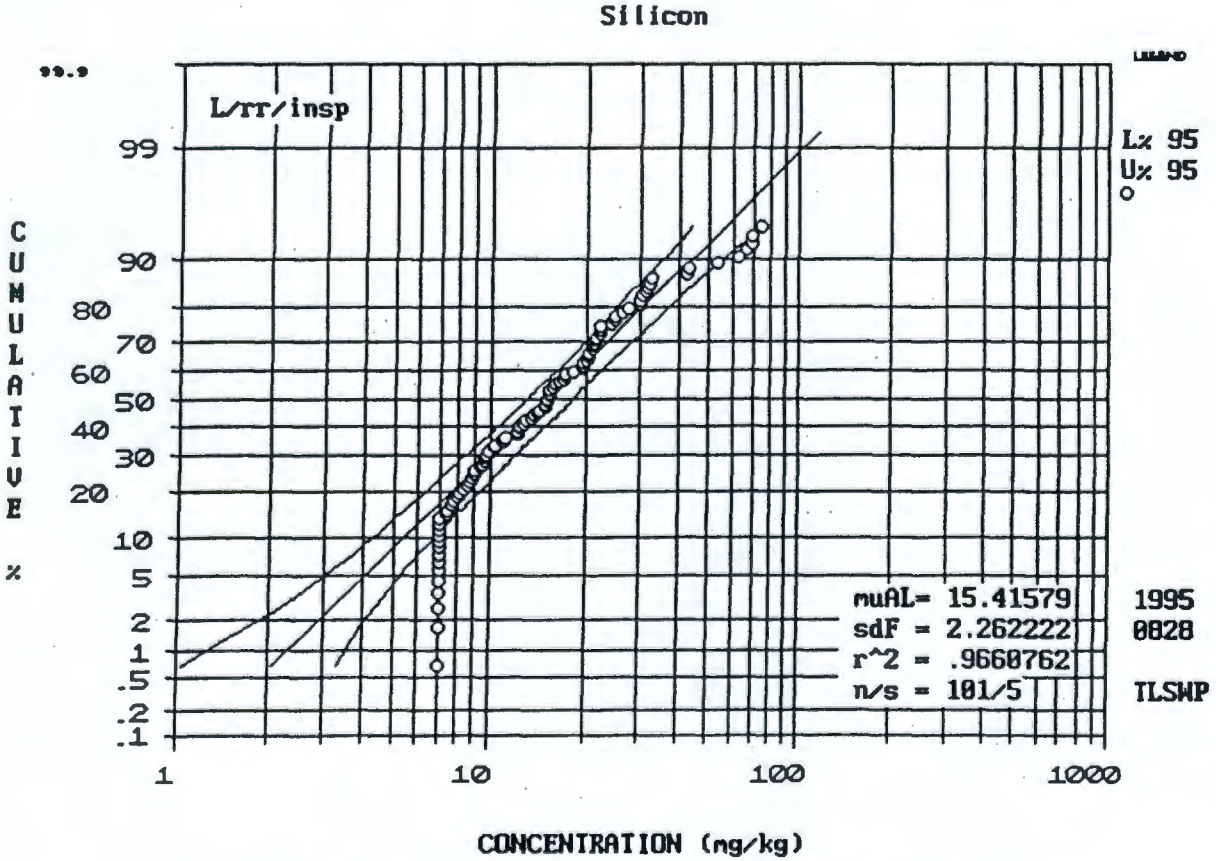
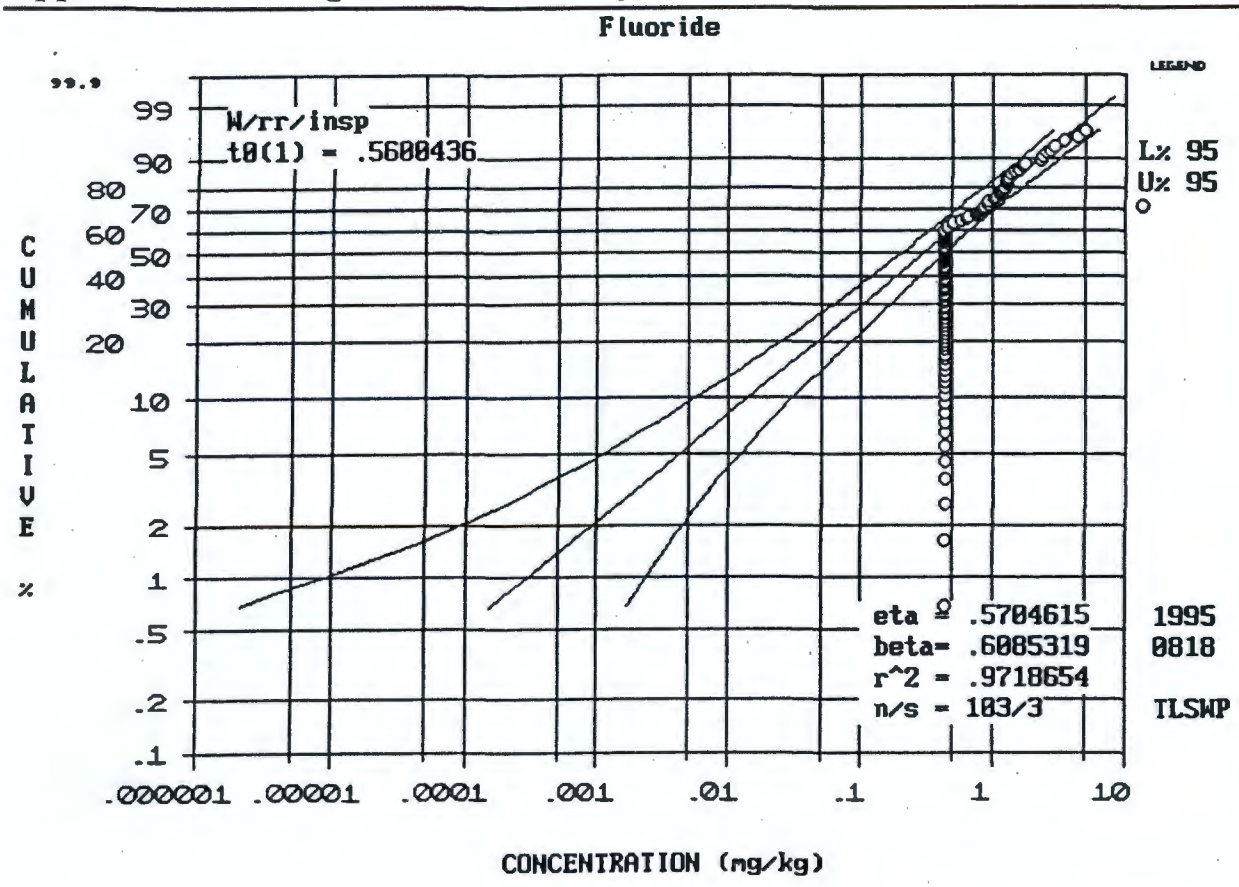


Figure D7-25. Weibull and Lognormal Probability Plots for Silicon.



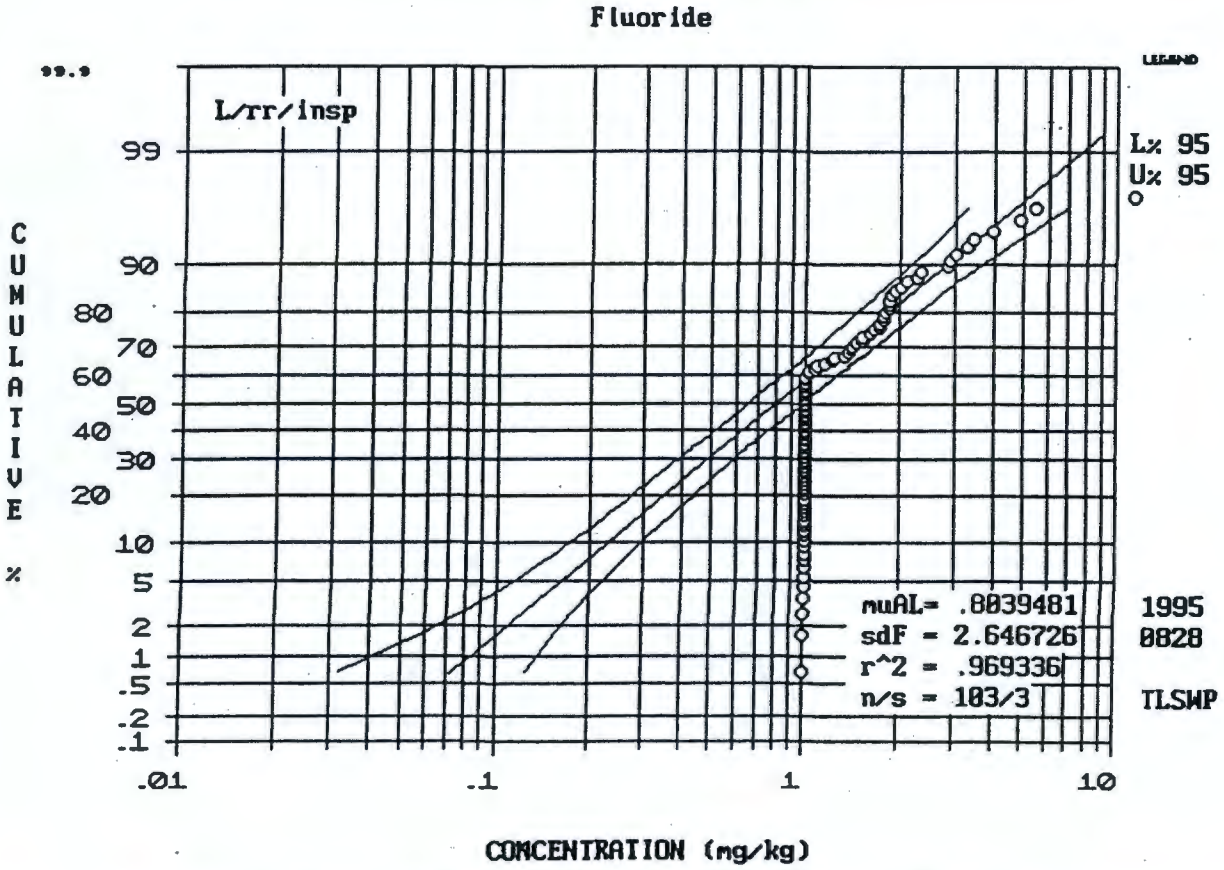
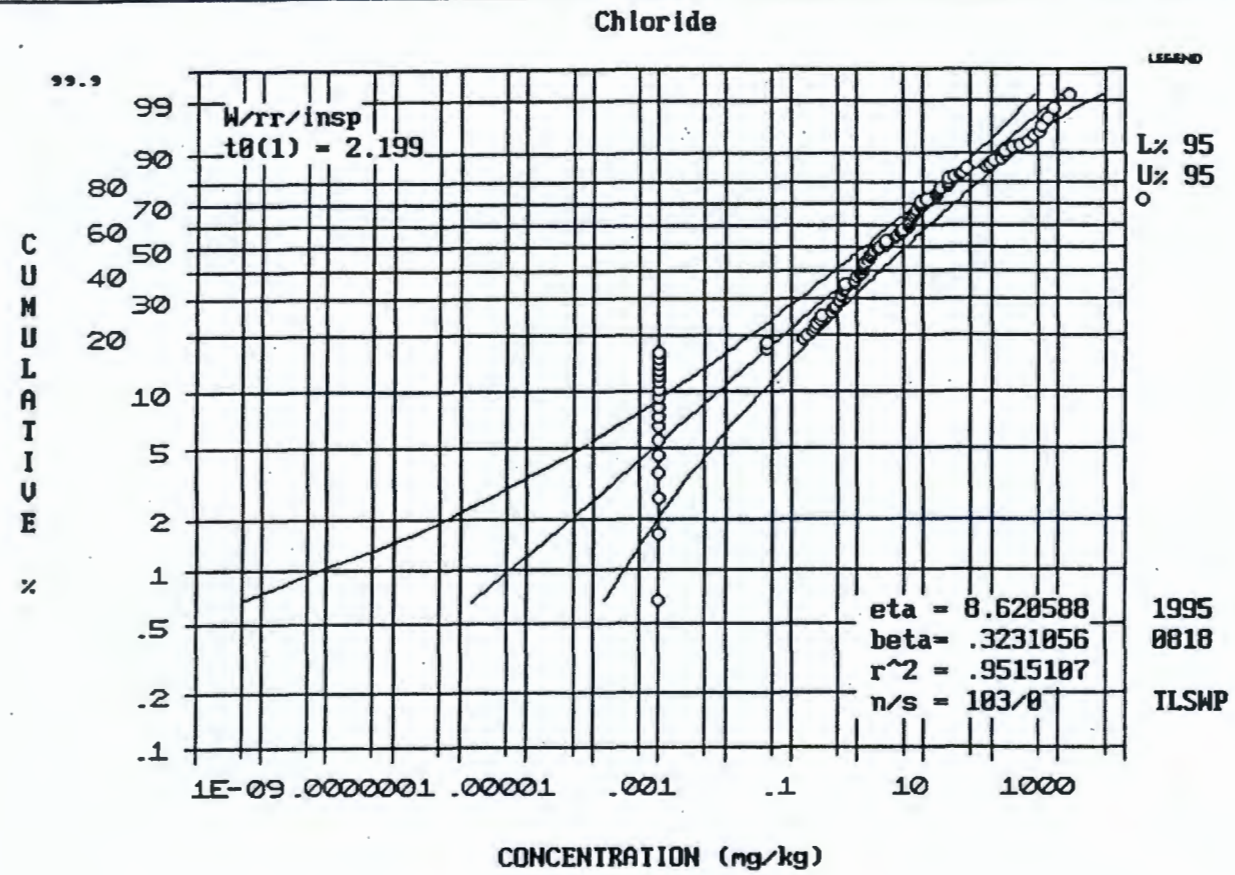


Figure D7-26. Weibull and Lognormal Probability Plots for Fluoride.



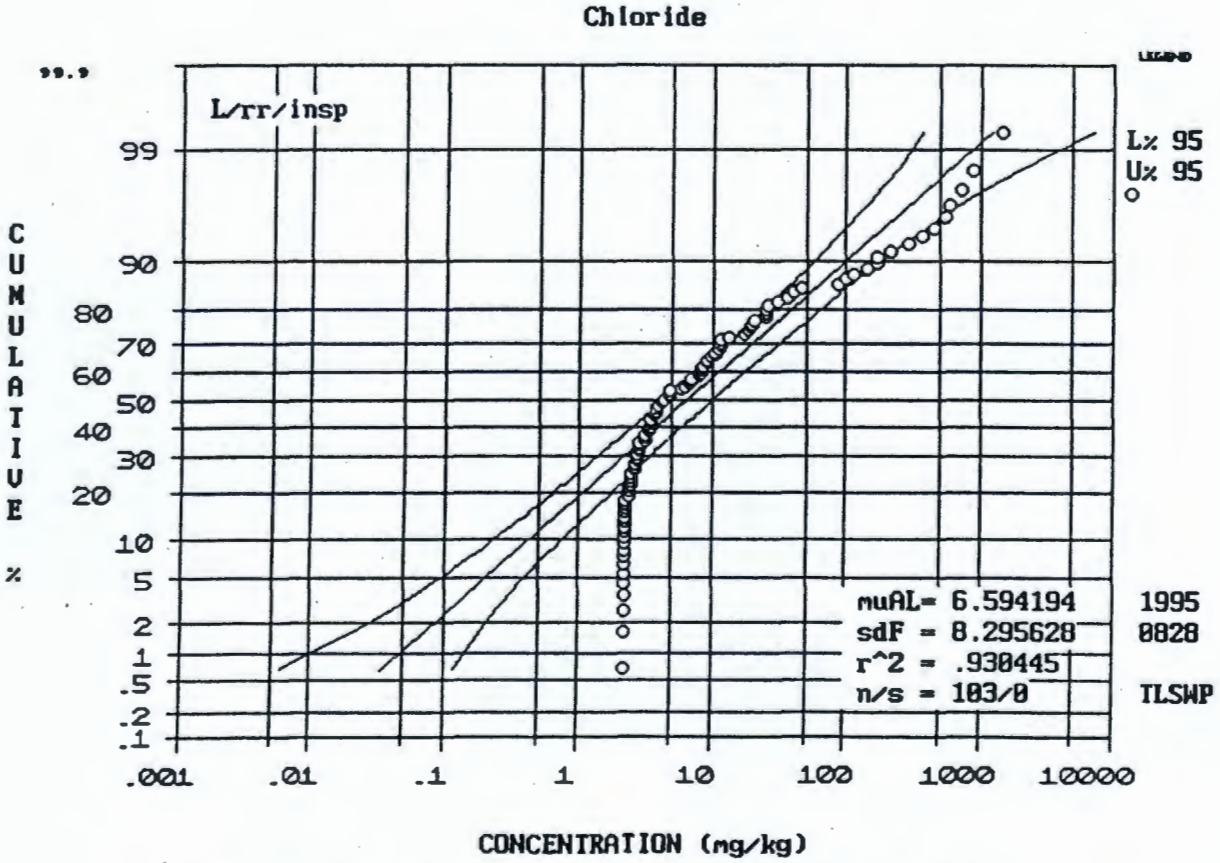
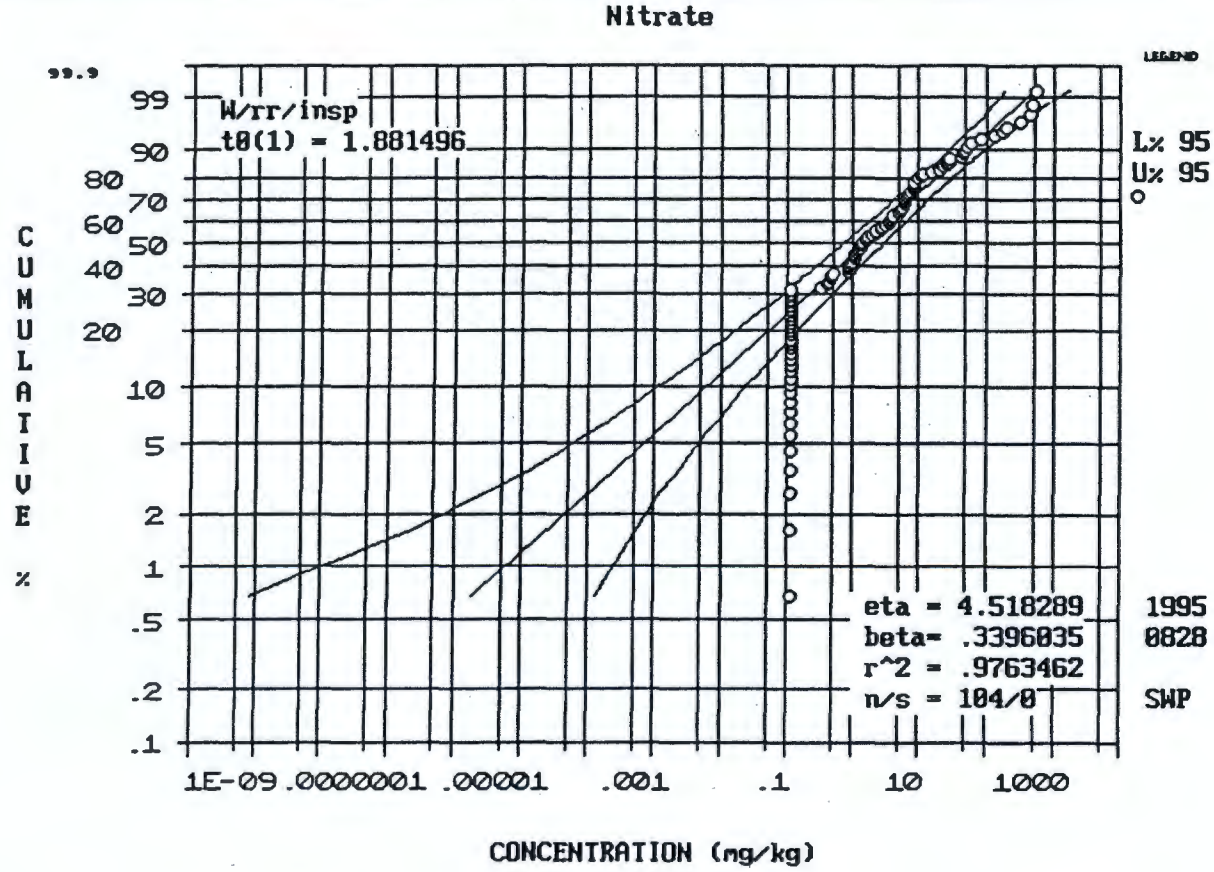


Figure D7-27. Weibull and Lognormal Probability Plots for Chloride.



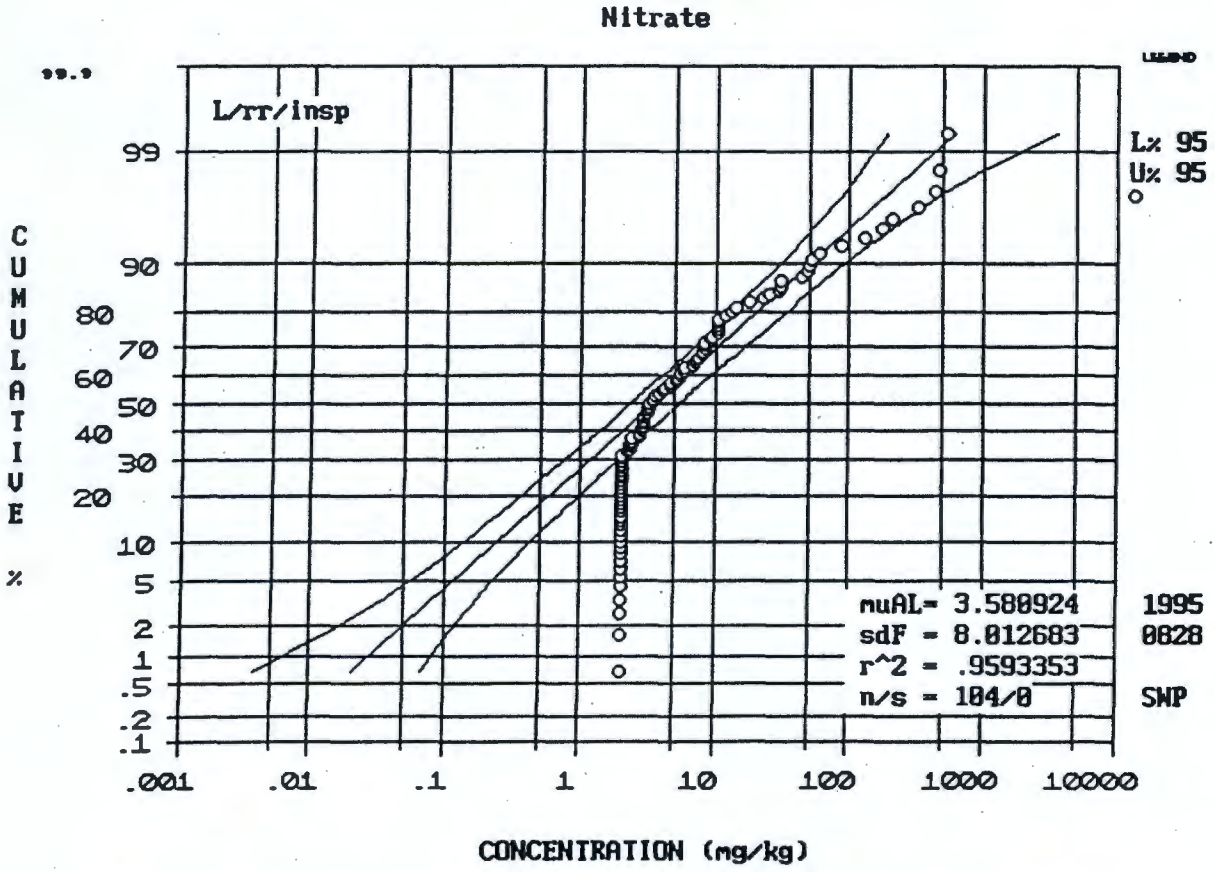
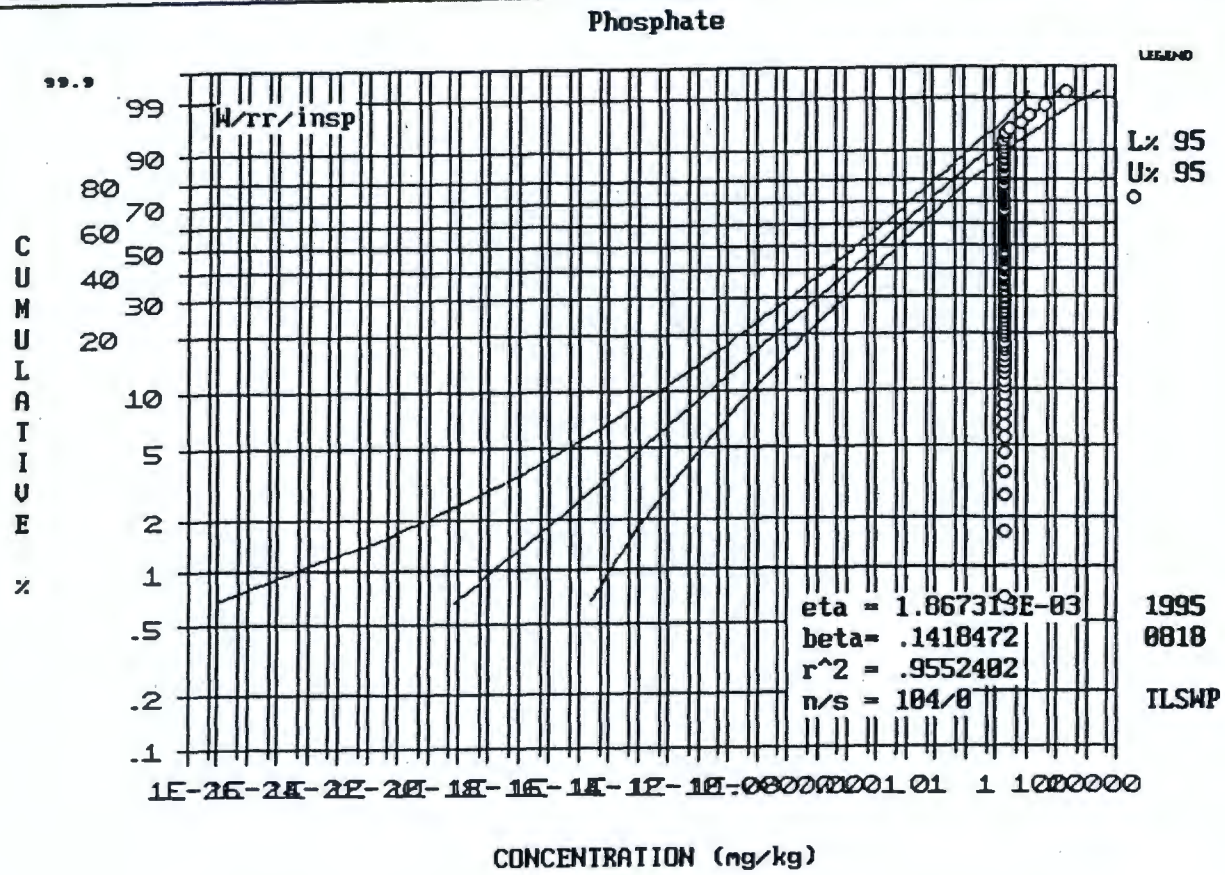


Figure D7-28. Weibull and Lognormal Probability Plots for Nitrate.



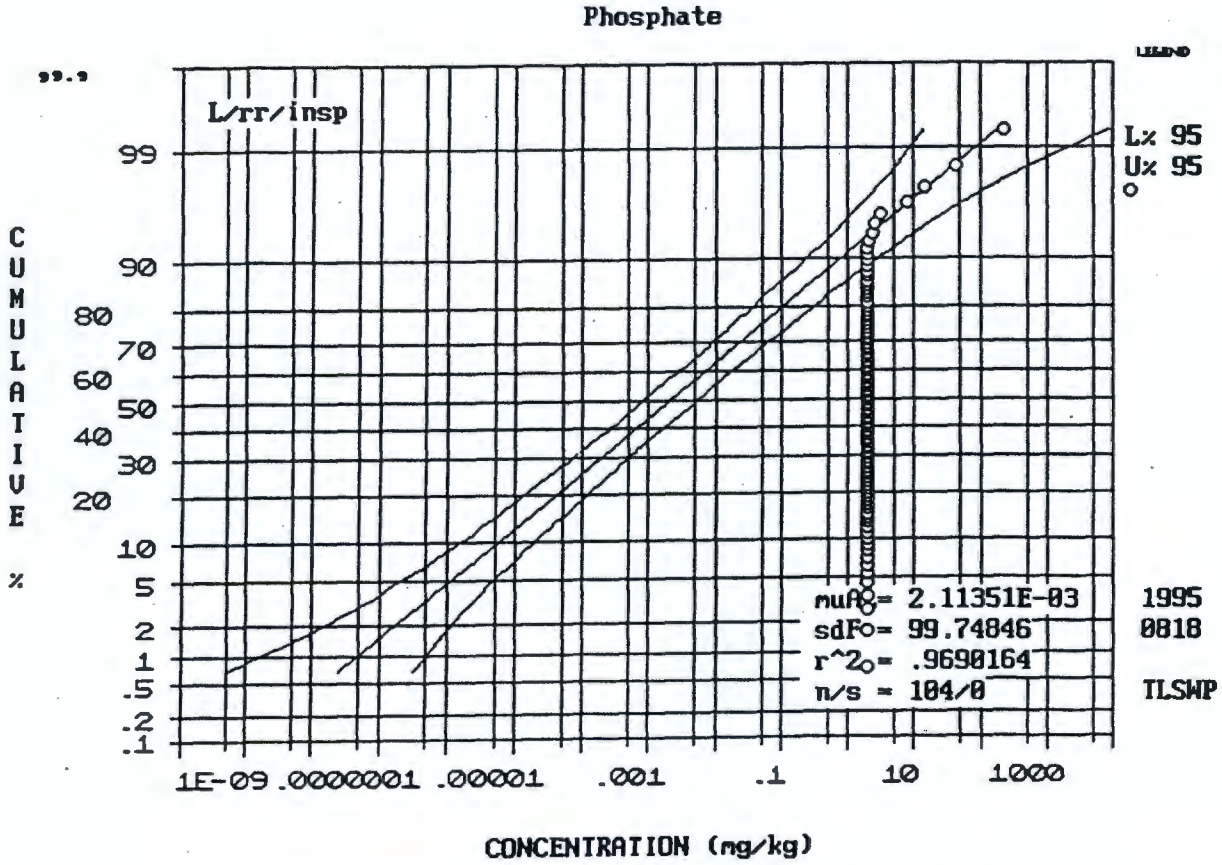
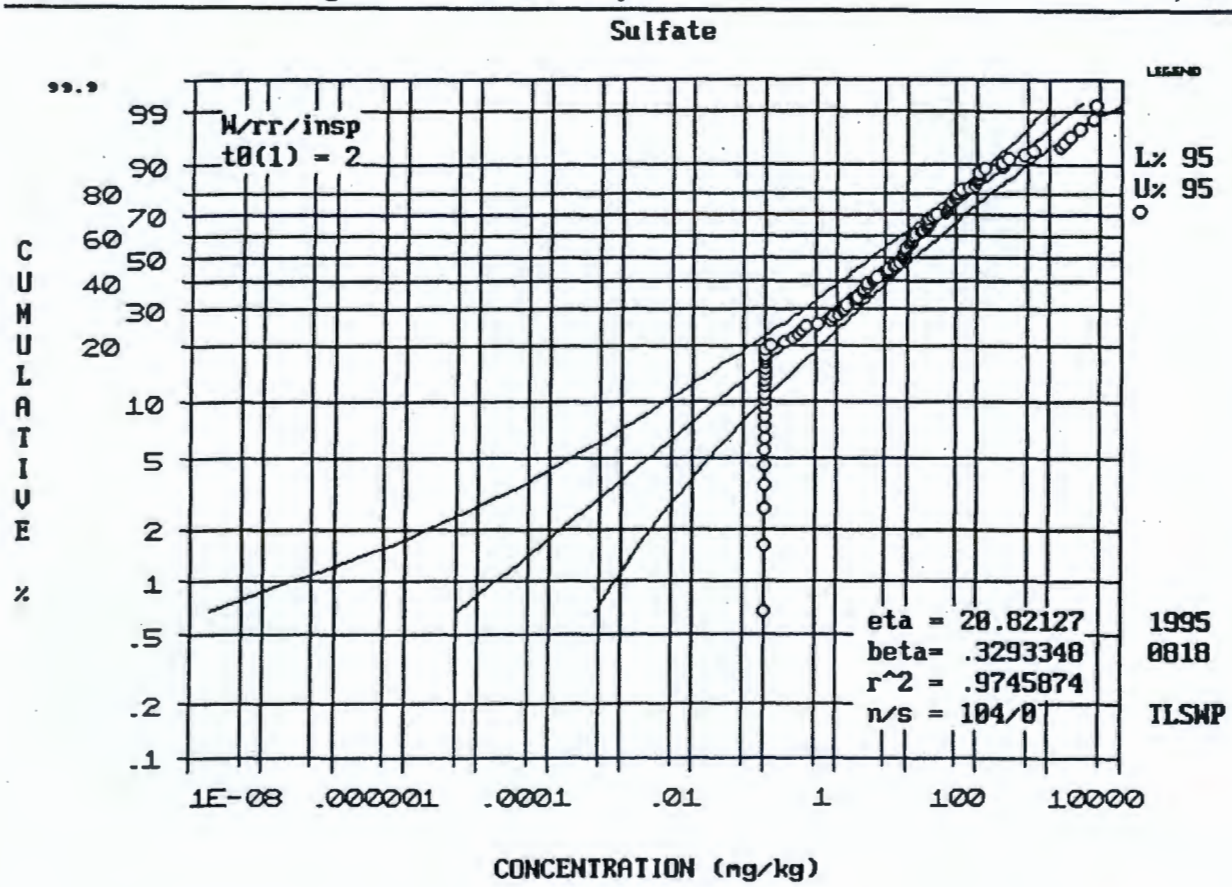


Figure D7-29. Weibull and Lognormal Probability Plots for O-Phosphate.



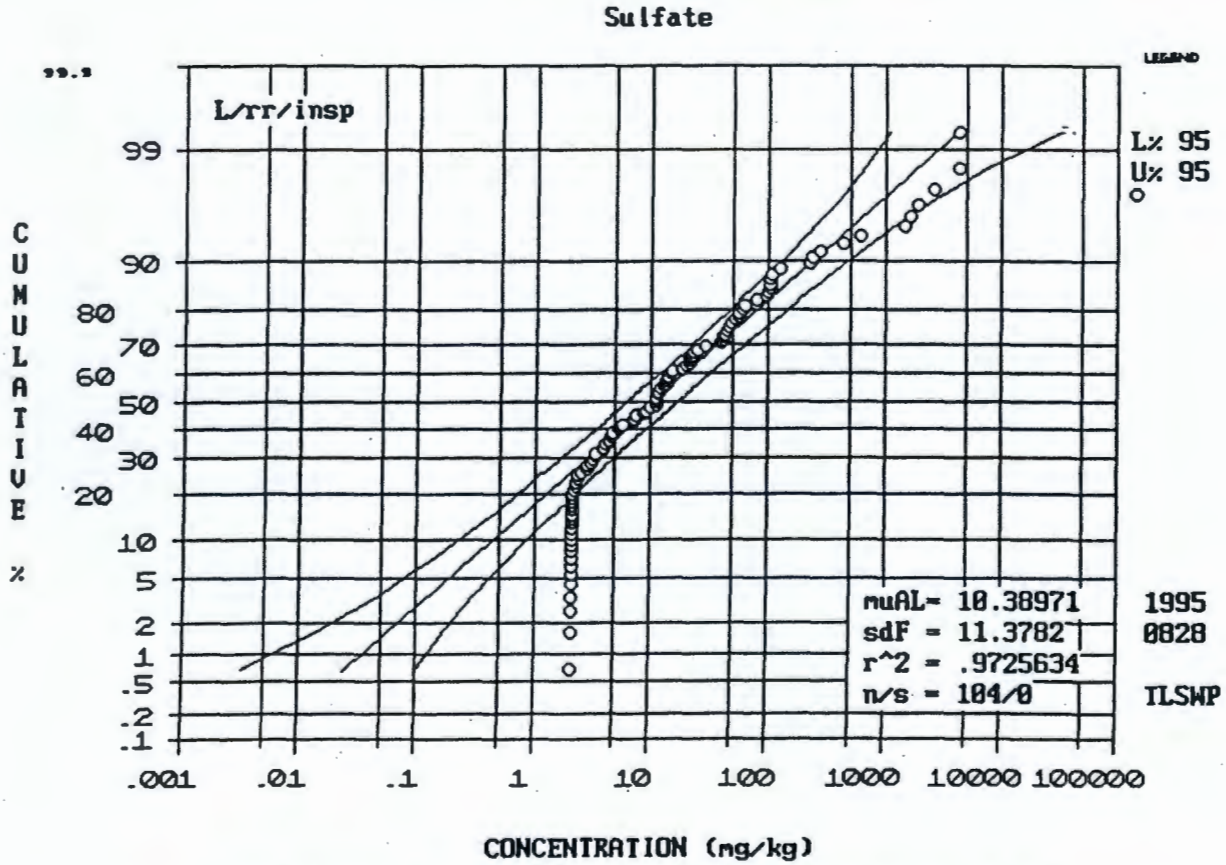


Figure D7-30. Weibull and Lognormal Probability Plots for Sulfate.

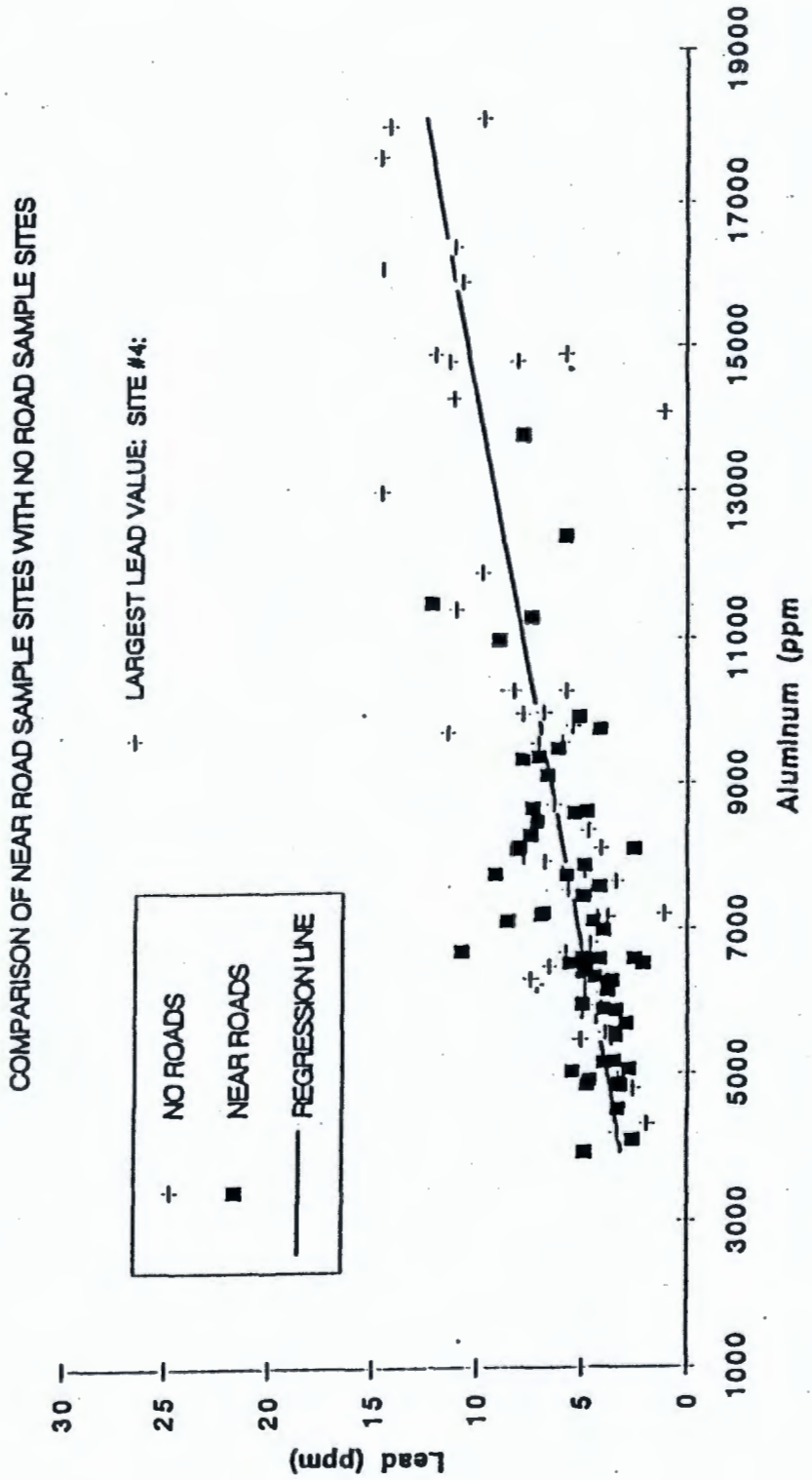


Figure D8. Variation Diagram: Lead Versus Aluminum.

Table D1. Sample Data Reporting Statistics.

	HANFORD FORM. RANDOM		HANFORD FORM. JUDGEMENT		TOPSOIL SAMPLES		RINGOLD SAMPLES		TOTAL	TOTAL	PERCENT	NUMBER
	RECEIVED	VALIDATED	RECEIVED	VALIDATED	RECEIVED	VALIDATED	RECEIVED	VALIDATED	RECEIVED	VALIDATED	VALIDATED	REJECTED
Aluminum	119	119	31	31	13	13	17	17	180	180	100.0%	0
Antimony	119	65	31	9	13	13	8	6	171	93	54.4%	78
Arsenic	119	117	31	30	13	13	17	17	180	177	98.3%	3
Barium	119	119	31	31	13	13	17	17	180	180	100.0%	0
Beryllium	119	117	31	30	13	13	17	15	180	175	97.2%	5
Cadmiun	119	117	31	30	13	13	17	15	180	175	97.2%	5
Calcium	119	119	31	31	13	13	17	17	180	180	100.0%	0
Chromium	119	119	31	31	13	13	17	17	180	180	100.0%	0
Cobalt	119	118	31	30	13	13	17	17	180	178	98.9%	2
Copper	119	119	31	31	13	13	17	17	180	180	100.0%	0
Iron	119	119	31	31	13	13	17	17	180	180	100.0%	0
Lead	119	119	31	31	13	13	17	17	180	180	100.0%	0
Magnesium	119	119	31	31	13	13	17	17	180	180	100.0%	0
Manganese	119	118	31	30	13	13	8	6	171	167	97.7%	4
Mercury	119	119	31	31	13	13	17	17	180	180	100.0%	0
Nickel	119	117	31	30	13	13	17	17	180	177	98.3%	3
Potassium	119	98	31	24	13	13	8	6	171	141	82.5%	30
Selenium	119	117	31	30	13	13	8	6	171	166	97.1%	5
Silver	119	117	31	30	13	13	17	17	180	177	98.3%	3
Sodium	119	118	31	30	13	13	8	6	171	167	97.7%	4
Thallium	119	119	31	31	13	13	17	17	180	180	100.0%	0
Vanadium	119	119	31	31	13	13	17	17	180	180	100.0%	0
Zinc	70	68	26	25	13	13	17	7	126	113	89.7%	13
Molybdenum	116	93	31	19	13	13	9	9	169	134	79.3%	35
Titanium	68	68	7	7	13	13	0	0	88	88	100.0%	0
Lithium	116	94	31	19	0	0	8	1	155	114	73.5%	41
Zirconium	119	119	31	31	12	12	0	0	162	162	100.0%	0
NH3	105	105	29	29	12	12	8	3	154	149	96.8%	5
Alkalinity	101	101	29	29	12	12	17	10	159	152	95.6%	7
Silicon	118	118	31	31	12	12	17	7	178	168	94.4%	10
Fluorine	118	118	31	31	12	12	17	7	178	168	94.4%	10
Chlorine	119	119	31	31	12	12	8	3	170	165	97.1%	5
NO2	119	119	31	31	12	12	17	5	179	167	93.3%	12
NO3	119	119	31	31	12	12	8	3	170	165	97.1%	5
O-PO4	119	119	31	31	12	12	17	9	179	171	95.5%	8
SO4	0	0	0	0	0	0	17	10	17	10	58.8%	7
Phosphorus	0	0	0	0	12	12	0	0	12	12	100.0%	0
TOC												

Appendix D – Background Data Analysis

Table D2. Inductively Coupled Plasma Analyses of Preparation Blank Standards. (sheet 1 of 5)

Sample	Date	Time	Sample Type	Lab #	Day	Run	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
PBS0920	09/23/91	12:58:52	P0920	2597	1	1	0.002	0.083	-0.014	0.001	0.000	0.105	0.001	0.003	0.000	0.001	0.051	0.018
PBS0920	09/23/91	12:58:52	P0920	2597	1	2	-0.007	0.010	-0.013	0.000	0.000	0.078	0.001	-0.002	-0.002	-0.001	0.042	-0.777
PBS0920	09/23/91	12:58:52	P0920	2597	1	3	-0.003	0.040	-0.062	0.001	0.000	0.082	0.000	0.001	0.002	0.000	0.046	-0.064
PBS1010	10/20/91	18:26:43	P1010	2618	28	1	-0.002	-0.002	-0.005	0.000	0.000	0.036	0.001	-0.005	0.003	0.002	0.015	-0.453
PBS1010	10/20/91	18:26:43	P1010	2618	28	2	-0.001	-0.026	0.001	0.000	0.000	0.027	0.000	0.000	-0.001	0.004	0.017	-0.379
PBS1010	10/20/91	18:26:43	P1010	2618	28	3	0.004	0.049	-0.072	-0.001	0.000	0.027	0.000	0.002	0.002	0.003	0.021	-0.659
PBS1017-1	10/20/91	18:31:20	P10171	2618	28	1	-0.003	0.017	0.018	0.001	0.000	0.402	0.000	-0.002	-0.001	0.004	0.028	-0.612
PBS1017-1	10/20/91	18:31:20	P10171	2618	28	2	-0.006	0.039	-0.002	0.000	0.000	0.403	0.001	-0.002	-0.001	0.001	0.024	-1.100
PBS1017-1	10/20/91	18:31:20	P10171	2618	28	3	-0.004	0.029	0.030	0.000	0.000	0.396	0.000	-0.004	0.002	0.003	0.026	-0.536
PBS1018	10/20/91	18:35:57	P1018	2618	28	1	0.010	-0.005	-0.025	0.000	0.000	0.497	0.000	-0.003	0.001	0.007	0.020	-0.883
PBS1018	10/20/91	18:35:57	P1018	2618	28	2	0.011	0.016	-0.015	0.000	0.000	0.483	0.000	-0.002	0.005	-0.002	0.018	0.383
PBS1018	10/20/91	18:35:57	P1018	2618	28	3	0.005	0.012	0.014	0.000	0.000	0.508	0.001	0.003	0.002	0.001	0.013	-0.648
PBS1017-2	10/20/91	18:40:34	P10172	2630	28	1	-0.003	0.042	-0.028	0.001	0.000	0.416	-0.001	0.004	0.002	0.001	0.019	0.200
PBS1017-2	10/20/91	18:40:34	P10172	2630	28	2	-0.006	0.037	0.047	0.000	0.000	0.425	0.001	-0.001	-0.001	0.000	0.019	-0.534
PBS1017-2	10/20/91	18:40:34	P10172	2630	28	3	0.002	0.052	-0.015	0.001	0.000	0.418	-0.001	-0.001	-0.002	0.000	0.018	0.059
PBS1014-1	10/25/91	15:07:21	P10141	2630	33	1	-0.007	0.049	0.040	0.001	0.000	0.217	0.000	0.004	0.000	0.003	0.027	0.365
PBS1014-1	10/25/91	15:07:21	P10141	2630	33	2	-0.005	0.044	0.020	0.001	0.000	0.211	0.001	0.002	0.001	0.007	0.021	-0.646
PBS1014-1	10/25/91	15:07:21	P10141	2630	33	3	-0.004	0.057	-0.028	0.001	0.000	0.196	-0.001	-0.002	0.001	0.002	0.020	-0.451
PBS1014-2	10/25/91	15:10:37	P10142	2630	33	1	-0.008	0.037	-0.044	0.001	0.000	0.520	0.000	-0.001	0.001	-0.001	0.027	0.295
PBS1014-2	10/25/91	15:10:37	P10142	2630	33	2	-0.003	-0.010	0.040	0.001	0.000	0.502	-0.001	-0.004	0.001	0.002	0.025	-0.310
PBS1014-2	10/25/91	15:10:37	P10142	2630	33	3	-0.008	-0.016	-0.036	0.002	0.000	0.497	-0.001	-0.004	-0.001	0.002	0.024	0.190
PBS1022-1	10/29/91	18:38:17	P10221	2633	37	1	-0.001	0.044	0.020	0.001	0.000	0.367	0.000	-0.001	0.007	0.018	0.035	0.338
PBS1022-1	10/29/91	18:38:17	P10221	2633	37	2	0.004	0.030	0.033	0.000	0.000	0.356	0.002	0.001	0.001	0.018	0.030	-0.357
PBS1022-1	10/29/91	18:38:17	P10221	2633	37	3	-0.001	0.002	-0.054	0.001	0.000	0.361	0.000	0.003	0.003	0.015	0.025	-0.598
PBS1022-2	10/29/91	18:41:33	P10222	2633	37	1	0.002	0.016	0.016	0.001	0.000	0.832	0.001	0.007	0.004	0.015	0.017	-0.019
PBS1022-2	10/29/91	18:41:33	P10222	2633	37	2	-0.005	-0.001	0.011	0.000	0.000	0.855	0.001	-0.004	0.000	0.013	0.020	0.339
PBS1022-2	10/29/91	18:41:33	P10222	2633	37	3	-0.004	-0.020	-0.014	0.000	0.000	0.839	0.000	0.002	0.006	0.012	0.016	-0.125
PBS1031-2	11/01/91	12:35:35	P10312	2652	40	1	0.003	0.056	-0.008	0.001	0.000	0.630	0.000	0.001	0.005	0.004	0.024	-0.410
PBS1031-2	11/01/91	12:35:35	P10312	2652	40	2	0.002	0.038	0.011	0.001	0.000	0.639	0.000	0.001	0.005	0.003	0.024	0.055
PBS1031-2	11/01/91	12:35:35	P10312	2652	40	3	0.002	0.500	0.003	0.001	0.000	0.634	0.000	-0.003	0.002	0.001	0.018	-0.604
PBS1028-1	11/01/91	12:38:49	P101281	2652	40	1	0.000	0.043	0.020	0.001	0.000	1.460	-0.001	0.000	0.003	0.004	0.050	0.071
PBS1028-1	11/01/91	12:38:49	P101281	2652	40	2	0.001	0.053	0.001	0.002	0.000	1.450	0.000	0.002	0.003	0.004	0.042	-0.489
PBS1028-1	11/01/91	12:38:49	P101281	2652	40	3	0.001	0.041	0.035	0.001	0.000	1.450	0.000	0.003	0.001	0.002	0.042	-0.495

Table D2. Inductively Coupled Plasma Analyses of Preparation Blank Standards. (sheet 2 of 5)

Sample	Date	Time	Sample Type	Lab #	Day	Run	Ma	Mn	Mo	Na	Ni	Pb	Sb	Se	Tl	V	Zn
PBS0920	09/23/91	12:58:52	P0920	2597	1	1	0.094	0.001	-0.003	0.238	0.003	0.024	-0.003	0.055	0.006	0.002	0.013
PBS0920	09/23/91	12:58:52	P0920	2597	1	2	0.037	0.000	-0.001	0.045	-0.006	-0.028	-0.035	-0.038	-0.003	0.001	0.017
PBS0920	09/23/91	12:58:52	P0920	2597	1	3	0.072	0.001	-0.002	0.187	-0.005	-0.011	-0.034	0.052	0.085	0.003	0.016
PBS1010	10/20/91	18:26:43	P1010	2618	28	1	0.030	0.000	0.004	0.034	-0.005	-0.003	-0.021	-0.029	0.053	0.001	0.018
PBS1010	10/20/91	18:26:43	P1010	2618	28	2	0.044	0.001	0.001	0.110	0.003	0.016	0.100	-0.020	-0.123	0.002	0.017
PBS1010	10/20/91	18:26:43	P1010	2618	28	3	0.022	0.000	-0.012	0.128	0.001	-0.021	-0.105	0.036	-0.163	0.002	0.018
PBS1017-1	10/20/91	18:31:20	P10171	2618	28	1	0.052	0.006	0.015	0.012	-0.007	-0.013	0.013	0.030	0.032	0.002	0.015
PBS1017-1	10/20/91	18:31:20	P10171	2618	28	2	0.034	0.006	0.002	0.226	-0.008	-0.007	-0.095	-0.067	0.087	0.001	0.017
PBS1017-1	10/20/91	18:31:20	P10171	2618	28	3	0.026	0.006	-0.004	0.010	-0.005	-0.030	0.036	0.022	0.021	0.005	0.016
PBS1018	10/20/91	18:35:57	P1018	2618	28	1	0.021	0.001	-0.004	0.209	-0.005	0.005	-0.028	0.002	-0.209	-0.004	0.028
PBS1018	10/20/91	18:35:57	P1018	2618	28	2	0.012	0.000	0.003	0.257	-0.004	0.002	-0.006	-0.018	-0.113	-0.005	0.024
PBS1018	10/20/91	18:35:57	P1018	2618	28	3	0.042	0.000	0.007	0.229	-0.005	0.027	-0.035	-0.063	0.106	0.000	0.025
PBS1017-2	10/20/91	18:40:34	P10172	2630	28	1	0.020	0.005	0.004	0.250	-0.003	-0.001	-0.071	0.020	-0.055	0.000	0.016
PBS1017-2	10/20/91	18:40:34	P10172	2630	28	2	0.015	0.006	0.007	0.137	-0.007	-0.003	-0.067	-0.003	-0.105	-0.003	0.018
PBS1017-2	10/20/91	18:40:34	P10172	2630	28	3	0.015	0.006	-0.001	0.045	0.001	-0.026	-0.041	-0.038	0.059	0.001	0.017
PBS1014-1	10/25/91	15:07:21	P10141	2630	33	1	0.049	-0.001	-0.001	0.040	0.004	0.005	-0.025	-0.014	0.108	0.003	0.028
PBS1014-1	10/25/91	15:07:21	P10141	2630	33	2	0.066	0.000	-0.013	0.073	-0.001	-0.025	-0.055	-0.002	-0.148	-0.001	0.028
PBS1014-1	10/25/91	15:07:21	P10141	2630	33	3	0.066	-0.001	-0.002	0.082	0.003	0.005	0.027	0.035	-0.140	-0.001	0.032
PBS1014-2	10/25/91	15:10:37	P10142	2630	33	1	0.084	0.001	-0.005	0.155	0.003	-0.010	0.036	0.013	0.052	0.000	0.046
PBS1014-2	10/25/91	15:10:37	P10142	2630	33	2	0.049	0.000	-0.005	0.027	0.004	-0.046	0.027	0.013	0.016	0.003	0.042
PBS1014-2	10/25/91	15:10:37	P10142	2630	33	3	0.037	0.001	0.001	0.110	0.003	-0.033	-0.050	-0.018	0.061	0.003	0.047
PBS1022-1	10/29/91	18:38:17	P10221	2633	37	1	0.061	0.001	0.006	-0.069	0.024	0.027	0.011	-0.015	0.072	0.003	0.014
PBS1022-1	10/29/91	18:38:17	P10221	2633	37	2	0.049	0.000	-0.003	0.302	0.021	0.017	-0.051	0.046	0.113	0.003	0.014
PBS1022-1	10/29/91	18:38:17	P10221	2633	37	3	0.007	0.001	0.003	0.081	0.023	0.002	0.099	0.021	0.021	-0.003	0.013
PBS1022-2	10/29/91	18:41:33	P10222	2633	37	1	0.020	0.000	0.005	0.074	0.017	0.009	-0.035	-0.010	0.184	-0.002	0.021
PBS1022-2	10/29/91	18:41:33	P10222	2633	37	2	0.005	0.000	0.001	0.030	0.016	0.014	0.076	0.117	0.125	-0.002	0.020
PBS1022-2	10/29/91	18:41:33	P10222	2633	37	3	0.018	0.000	0.002	0.085	0.015	-0.008	-0.049	0.048	0.014	0.000	0.022
PBS1031-2	11/01/91	12:35:35	P10312	2652	40	1	0.050	0.001	-0.003	0.154	-0.010	0.004	-0.062	-0.060	0.016	0.003	0.023
PBS1031-2	11/01/91	12:35:35	P10312	2652	40	2	0.045	0.000	0.007	0.159	-0.012	0.013	-0.090	0.620	-0.005	0.002	0.020
PBS1031-2	11/01/91	12:35:35	P10312	2652	40	3	0.032	0.000	-0.004	0.027	-0.011	-0.005	-0.013	-0.022	-0.091	-0.001	0.024
PBS1028-1	11/01/91	12:38:49	P101281	2652	40	1	0.028	0.001	-0.004	0.005	-0.012	0.018	-0.075	0.027	-0.034	0.002	0.046
PBS1028-1	11/01/91	12:38:49	P101281	2652	40	2	0.026	0.000	-0.002	-0.049	0.002	0.022	0.026	0.031	0.095	0.003	0.045
PBS1028-1	11/01/91	12:38:49	P101281	2652	40	3	0.021	0.000	-0.002	-0.026	-0.012	0.000	-0.008	-0.018	0.072	0.001	0.044

Table D2. Inductively Coupled Plasma Analyses of Preparation Blanks. (sheet 3 of 5)

Sample	Date	Time	Sample Type	Lab #	Day	Run	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
PBS1025-2	11/05/91	16:28:15	P10252	2663	44	1	-0.002	0.026	-0.011	0.000	0.000	0.932	-0.001	0.003	0.001	0.002	0.032	0.552
PBS1025-2	11/05/91	16:28:15	P10252	2663	44	2	-0.006	-0.010	0.036	-0.001	0.000	0.936	-0.001	0.002	0.004	0.004	0.031	-0.675
PBS1025-2	11/05/91	16:28:15	P10252	2663	44	3	-0.003	0.032	-0.018	0.000	0.000	0.939	0.002	0.003	0.001	0.002	0.030	0.265
PBS1101-1	11/05/91	16:32:51	P11011	2663	44	1	0.000	0.002	0.035	0.000	0.000	0.791	-0.001	0.004	0.000	0.001	0.032	-0.194
PBS1101-1	11/05/91	16:32:51	P11011	2663	44	2	-0.004	0.022	0.014	0.000	0.000	0.801	-0.001	-0.003	0.000	-0.002	0.034	0.630
PBS1101-1	11/05/91	16:32:51	P11011	2663	44	3	-0.007	0.024	-0.019	0.000	0.000	0.803	-0.001	0.000	0.002	-0.001	0.031	-0.022
PBS1101-2	11/05/91	16:37:27	P11012	2663	44	1	-0.002	0.021	0.036	0.013	0.000	1.500	0.001	0.003	0.002	0.001	0.022	-0.614
PBS1101-2	11/05/91	16:37:27	P11012	2663	44	2	0.000	0.048	-0.033	0.013	0.000	1.540	0.000	0.001	0.002	0.002	0.026	-0.227
PBS1101-2	11/05/91	16:37:27	P11012	2663	44	3	0.003	0.036	-0.027	0.013	0.000	1.530	0.001	0.001	-0.003	0.003	0.021	0.191
PBS1030-1	11/27/91	16:56:23	P10301	2646	66	1	-0.012	0.069	-0.018	0.000	0.000	0.665	0.000	0.000	0.000	0.024	0.044	0.055
PBS1030-1	11/27/91	16:56:23	P10301	2646	66	2	-0.005	0.083	0.007	0.000	0.000	0.646	0.001	-0.003	0.003	0.022	0.047	0.095
PBS1030-1	11/27/91	16:56:23	P10301	2646	66	3	0.004	0.104	0.058	0.000	0.000	0.677	-0.001	0.000	0.002	0.024	0.047	0.317
PBS1030-2	11/27/91	17:00:33	P10302	2646	66	1	-0.004	-0.068	0.047	0.000	0.000	1.050	0.001	0.005	0.002	0.006	0.037	0.161
PBS1030-2	11/27/91	17:00:33	P10302	2646	66	2	-0.010	0.070	-0.062	-0.001	0.000	1.020	0.000	-0.001	0.001	0.002	0.039	0.227
PBS1030-2	11/27/91	17:00:33	P10302	2646	66	3	-0.013	0.075	0.001	-0.001	0.000	1.010	0.000	0.000	0.003	0.003	0.031	0.066
PBS1025	11/27/91	17:04:43	P1025	2646	66	1	-0.001	0.052	-0.061	0.002	0.000	0.718	0.001	-0.003	0.007	-0.002	0.022	0.364
PBS1025	11/27/91	17:04:43	P1025	2646	66	2	-0.007	0.021	-0.036	0.001	0.000	0.741	-0.001	0.001	0.005	0.000	0.018	-0.350
PBS1025	11/27/91	17:04:43	P1025	2646	66	3	-0.006	0.022	0.024	0.003	0.000	0.747	0.000	0.003	0.007	0.000	0.016	0.331
PBS1114-2	11/27/91	21:55:38	P11142	2646	66	1	0.002	0.063	0.004	0.000	0.000	0.077	0.001	-0.002	0.001	0.007	0.023	-0.898
PBS1114-2	11/27/91	21:55:38	P11142	2646	66	2	0.004	0.060	-0.079	0.001	0.000	0.068	0.000	-0.004	0.001	0.007	0.022	0.000
PBS1114-2	11/27/91	21:55:38	P11142	2646	66	3	0.003	0.049	0.033	0.001	0.000	0.071	0.000	0.003	0.006	0.004	0.022	0.918
PBS1213-1	12/17/91	17:50:51	P12131	2730	86	1	0.006	0.004	0.032	-0.001	0.000	0.001	0.000	-0.003	0.005	0.004	1.200	-0.822
PBS1213-1	12/17/91	17:50:51	P12131	2730	86	2	0.001	0.003	0.029	-0.001	0.000	-0.002	0.000	-0.003	0.002	0.003	1.220	-0.013
PBS1213-1	12/17/91	17:50:51	P12131	2730	86	3	0.001	0.005	0.022	-0.002	0.000	0.002	0.000	-0.004	0.004	0.002	1.220	0.064
PBS1210-2	12/17/91	17:55:42	P12102	2730	86	1	0.002	-0.022	-0.047	-0.001	0.000	-0.043	0.001	-0.002	0.002	-0.001	0.014	-0.796
PBS1210-2	12/17/91	17:55:42	P12102	2730	86	2	0.001	-0.018	-0.006	-0.001	0.000	-0.044	0.001	0.002	0.005	0.000	0.010	0.047
PBS1210-2	12/17/91	17:55:42	P12102	2730	86	3	0.000	-0.015	0.032	-0.001	0.000	-0.047	0.001	-0.003	0.004	0.002	0.007	-0.234
PBS1216-2	12/17/91	18:00:33	P12162	2730	86	1	0.001	-0.025	-0.012	-0.002	0.000	-0.069	-0.001	0.000	0.006	0.002	0.012	-0.475
PBS1216-2	12/17/91	18:00:33	P12162	2730	86	2	0.001	-0.020	0.000	-0.001	0.000	-0.075	0.000	-0.006	0.009	-0.002	0.009	-0.726
PBS1216-2	12/17/91	18:00:33	P12162	2730	86	3	0.000	-0.025	-0.018	-0.001	0.000	-0.075	0.000	-0.002	0.007	0.000	0.008	-0.591
PBS1209-3	12/17/91	18:05:24	P12093	2730	86	1	-0.001	0.022	0.019	-0.002	0.000	0.423	0.000	-0.003	0.010	-0.003	0.030	-1.440
PBS1209-3	12/17/91	18:05:24	P12093	2730	86	2	-0.003	0.001	0.000	-0.001	0.000	0.430	-0.001	-0.006	0.010	0.001	0.034	-0.816
PBS1209-3	12/17/91	18:05:24	P12093	2730	86	3	-0.002	0.008	0.043	-0.002	0.000	0.424	0.000	-0.004	0.008	-0.001	0.033	-0.762

Table D2. Inductively Coupled Plasma Analyses of Preparation Blanks. (sheet 4 of 5)

Sample	Date	Time	Sample Type	Lab #	Day	Run	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Tl	V	Zn
PBS1025-2	11/05/91	16:28:15	P10252	2663	44	1	0.021	0.000	0.002	0.132	0.009	0.006	0.023	-0.105	-0.135	-0.011	0.051
PBS1025-2	11/05/91	16:28:15	P10252	2663	44	2	0.029	0.001	0.000	0.184	0.000	-0.015	0.015	0.026	-0.033	-0.014	0.053
PBS1025-2	11/05/91	16:28:15	P10252	2663	44	3	0.019	0.001	0.000	0.188	0.002	-0.025	-0.097	0.006	-0.033	-0.013	0.052
PBS1101-1	11/05/91	16:32:51	P11011	2663	44	1	0.011	0.001	-0.006	0.253	-0.001	-0.036	0.000	-0.075	0.007	-0.015	0.001
PBS1101-1	11/05/91	16:32:51	P11011	2663	44	2	0.014	0.002	0.005	0.309	0.003	-0.036	0.076	-0.045	-0.067	-0.011	0.003
PBS1101-1	11/05/91	16:32:51	P11011	2663	44	3	0.000	0.001	-0.004	0.267	0.001	0.000	-0.034	0.060	0.115	-0.014	0.003
PBS1101-2	11/05/91	16:37:27	P11012	2663	44	1	0.045	0.001	-0.002	0.380	-0.003	-0.015	0.053	0.010	-0.031	-0.014	0.025
PBS1101-2	11/05/91	16:37:27	P11012	2663	44	2	0.032	0.002	0.005	0.403	0.007	0.003	-0.016	-0.077	0.000	-0.011	0.029
PBS1101-2	11/05/91	16:37:27	P11012	2663	44	3	0.042	0.001	0.007	0.301	0.001	0.002	-0.002	-0.008	0.071	-0.016	0.029
PBS1030-1	11/27/91	16:56:23	P10301	2646	66	1	0.093	0.001	-0.002	0.102	0.002	-0.030	-0.013	0.029	0.027	-0.011	0.023
PBS1030-1	11/27/91	16:56:23	P10301	2646	66	2	0.088	0.001	-0.002	0.196	-0.005	-0.002	0.019	0.068	0.108	-0.009	0.024
PBS1030-1	11/27/91	16:56:23	P10301	2646	66	3	0.053	0.001	0.000	0.227	0.003	-0.001	0.071	0.017	-0.056	-0.009	0.027
PBS1030-2	11/27/91	17:00:33	P10302	2646	66	1	0.084	-0.001	-0.004	0.425	0.000	-0.040	-0.046	0.020	-0.157	-0.011	0.032
PBS1030-2	11/27/91	17:00:33	P10302	2646	66	2	0.043	0.001	-0.009	0.118	-0.004	-0.032	0.053	0.016	-0.023	-0.011	0.029
PBS1030-2	11/27/91	17:00:33	P10302	2646	66	3	0.057	0.002	0.009	0.336	0.003	0.008	0.021	0.025	-0.075	-0.010	0.029
PBS1025	11/27/91	17:04:43	P1025	2646	66	1	0.035	0.001	0.000	0.290	-0.012	0.012	0.005	0.055	-0.231	-0.009	0.015
PBS1025	11/27/91	17:04:43	P1025	2646	66	2	0.034	0.001	0.003	0.299	-0.007	-0.025	-0.096	-0.091	-0.107	-0.009	0.022
PBS1025	11/27/91	17:04:43	P1025	2646	66	3	0.056	0.001	0.003	0.244	-0.007	-0.006	-0.073	0.060	-0.072	-0.010	0.024
PBS1114-2	11/27/91	21:56:38	P11142	2646	66	1	0.015	0.001	0.003	0.213	-0.010	-0.010	0.030	0.087	-0.007	-0.013	0.032
PBS1114-2	11/27/91	21:56:38	P11142	2646	66	2	0.037	0.001	0.001	0.035	-0.006	0.005	-0.020	0.013	0.086	-0.012	0.034
PBS1114-2	11/27/91	21:56:38	P11142	2646	66	3	0.027	0.000	0.001	0.168	-0.006	-0.009	0.036	0.060	-0.047	-0.014	0.032
PBS1213-1	12/17/91	17:50:51	P12131	2730	86	1	-0.080	0.004	-0.002	0.135	0.008	0.012	0.047	-0.030	0.017	-0.008	0.022
PBS1213-1	12/17/91	17:50:51	P12131	2730	86	2	-0.088	0.005	0.004	0.019	0.002	-0.006	-0.119	-0.019	0.031	-0.006	0.021
PBS1213-1	12/17/91	17:50:51	P12131	2730	86	3	-0.106	0.005	0.003	-0.078	0.008	-0.003	-0.061	0.016	0.055	-0.009	0.021
PBS1210-2	12/17/91	17:55:42	P12102	2730	86	1	-0.118	0.000	-0.002	0.090	0.006	0.009	0.042	-0.061	-0.106	-0.007	0.023
PBS1210-2	12/17/91	17:55:42	P12102	2730	86	2	-0.102	0.001	-0.003	0.020	0.009	0.011	-0.046	0.023	-0.012	-0.009	0.022
PBS1210-2	12/17/91	17:55:42	P12102	2730	86	3	-0.110	0.000	0.000	-0.035	0.004	0.020	-0.057	-0.111	-0.050	-0.010	0.021
PBS1216-2	12/17/91	18:00:33	P12162	2730	86	1	-0.118	0.000	-0.003	-0.091	0.003	-0.005	-0.068	-0.056	-0.042	-0.008	0.013
PBS1216-2	12/17/91	18:00:33	P12162	2730	86	2	-0.104	-0.001	0.001	-0.185	0.004	-0.008	-0.016	0.055	0.070	-0.009	0.012
PBS1216-2	12/17/91	18:00:33	P12162	2730	86	3	-0.123	0.000	-0.001	-0.039	-0.003	0.002	-0.072	-0.010	-0.070	-0.007	0.014
PBS1209-3	12/17/91	18:05:24	P12093	2730	86	1	-0.104	0.000	0.000	-0.088	0.007	0.009	0.015	-0.014	-0.013	-0.007	0.044
PBS1209-3	12/17/91	18:05:24	P12093	2730	86	2	-0.091	0.001	-0.001	-0.073	0.006	0.004	-0.009	-0.037	0.072	-0.008	0.046
PBS1209-3	12/17/91	18:05:24	P12093	2730	86	3	-0.116	0.001	0.004	-0.005	0.004	-0.009	-0.002	-0.041	0.072	-0.010	0.045

Table D2. Inductively Coupled Plasma Analyses of Preparation Blanks. (sheet 5 of 5)

Sample	Date	Time	Sample Type	Lab #	Dev	Run	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Tl	V	Zn
PBS0107-1	01/31/92	15:08:34	P01071	2751	131	1	0.003	0.001	-0.006	0.066	0.000	-0.026	-0.078	-0.030	-0.003	-0.004	0.004
PBS0107-1	01/31/92	15:08:34	P01071	2751	131	2	-0.013	0.001	-0.008	0.130	-0.006	-0.047	0.018	-0.125	-0.058	-0.006	0.004
PBS0107-1	01/31/92	15:08:34	P01071	2751	131	3	0.014	0.002	-0.007	-0.072	0.002	-0.046	-0.020	-0.032	-0.031	0.002	0.003
PBS0107-2	01/31/92	15:09:12	P01072	2751	131	1	-0.002	0.001	0.002	0.217	0.007	0.020	0.004	0.014	0.061	-0.005	0.007
PBS0107-2	01/31/92	15:09:12	P01072	2751	131	2	-0.002	0.000	-0.006	0.329	-0.001	-0.027	-0.163	-0.082	0.000	-0.006	0.005
PBS0107-2	01/31/92	15:09:12	P01072	2751	131	3	-0.010	0.001	-0.002	0.162	0.004	0.001	-0.047	-0.057	-0.088	-0.004	0.006

Sample	Date	Time	Sample Type	Lab #	Dev	Run	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
PBS0107-1	01/31/92	15:08:34	P01071	2751	131	1	-0.004	-0.058	-0.013	0.000	0.000	0.126	0.000	-0.005	0.000	0.003	0.010	-0.109
PBS0107-1	01/31/92	15:08:34	P01071	2751	131	2	-0.007	-0.023	0.026	0.000	0.000	0.125	0.000	-0.005	0.003	-0.003	0.010	-0.217
PBS0107-1	01/31/92	15:08:34	P01071	2751	131	3	-0.004	-0.014	-0.016	0.000	0.000	0.131	0.001	-0.003	0.003	0.000	0.010	-0.077
PBS0107-2	01/31/92	15:09:12	P01072	2751	131	1	0.000	0.002	-0.064	0.001	0.000	0.204	0.000	-0.003	0.003	0.003	0.018	0.321
PBS0107-2	01/31/92	15:09:12	P01072	2751	131	2	0.002	-0.011	0.002	0.000	0.000	0.198	0.001	-0.001	-0.001	0.004	0.014	-0.361
PBS0107-2	01/31/92	15:09:12	P01072	2751	131	3	-0.005	0.000	0.051	-0.001	0.000	0.195	-0.001	-0.003	0.003	0.001	0.013	-0.198

Table D3. Limit of Detection and Limit of Quantitation Summary.

ANALYTE	number blanks	x-bar	IF XBAR < 0, = 0	s.d.	LOD (3 x s.d	LOQ (10 x s.	CRDL	IDL
Ag	78	-0.185	0.000	0.452	1.355	4.515	1.00	1.00
Al	78	2.758	2.758	6.334	21.760	66.100	20.00	8.10
As	78	-0.018	0.000	3.252	9.757	32.524	1.00	
Ba	78	0.072	0.072	0.265	0.867	2.722	20.00	3.50
Be	78	0.000	0.000	0.000	0.000	0.000	0.50	0.20
Ca	78	48.254	48.254	42.148	174.698	469.733	500.00	106.70
Cd	78	0.008	0.008	0.078	0.242	0.788	0.50	0.30
Co	78	-0.062	0.000	0.292	0.877	2.923	5.00	1.00
Cr	78	0.240	0.240	0.277	1.069	3.006	1.00	0.70
Cu	78	0.368	0.368	0.579	2.105	6.158	2.50	1.80
Fe	78	7.059	7.059	22.879	75.696	235.848	10.00	6.20
K	78	-19.851	0.000	45.078	135.234	450.779	500.00	129.80
Mg	78	1.486	1.486	5.643	18.414	57.912	500.00	249.10
Mn	78	0.109	0.109	0.173	0.629	1.842	1.50	0.60
Mo	78	-0.058	0.000	0.481	1.442	4.808	1.40	1.40
Na	78	12.160	12.160	12.835	50.664	140.507	5.00	0.99
Ni	78	0.095	0.095	0.763	2.385	7.729	4.00	3.20
Pb	78	-0.645	0.000	1.879	5.636	18.787	0.50	2.50
Sb	78	-1.662	0.000	5.223	15.670	52.232	6.00	7.40
Se	78	0.336	0.336	7.531	22.929	75.646	0.50	
Tl	78	-0.769	0.000	8.647	25.940	86.465	1.00	
V	78	-0.431	0.000	0.590	1.770	5.899	5.00	2.00
Zn	78	2.471	2.471	1.313	6.411	15.605	2.00	5.00

Table D4-1. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Aluminum.

Aluminum

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
8670	8630	40	1	1
10300	14900	-4600	0	1
8360	9580	-1220	0	1
7230	11300	-4070	0	1
4930	6340	-1410	0	1
14900	15900	-1000	0	1
14300	14800	-500	0	1
5170	6580	-1410	0	1
9950	9760	190	1	1
8110	11100	-2990	0	1
7770	8110	-340	0	1
17600	16100	1500	1	1
7600	6520	1080	1	1
8710	10300	-1590	0	1
7780	4800	2980	1	1
6330	5620	710	1	1
4190	4310	-120	0	1

SUM	6
N PAIRS	17
UCL	13
LCL	5

MANN-WHITNEY U-TEST RESULTS

Aluminum

U =	124	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	1340.831
Std Err of Y Est	1973.052
R Squared	0.758565
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.933877
Std Err of Coef.	0.136034

Table D4-2. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Arsenic.

Arsenic

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
3	3	0		0
5	4.2	1	1	1
3.6	3	1	1	1
4.7	4.5	0	1	1
3	3	0		0
5	4.1	1	1	1
5	3.3	2	1	1
3	3	0		0
3.3	4.4	-1	0	1
5.4	4.6	1	1	1
3	3	0		0
11.4	8.3	3	1	1
4.3		4		
3	3	0		0
4.6		5		
4.7		5		
3	3	0		0
			7	
			8	
			8	
			1	

Arsenic

U =	129	DC	14
COUNT =	238	S-3	17
E(U) =	119		
VAR U =	25.2		
LCL =	68.6		
UCL =	169.4		

Regression Output:

Constant	1.332573
Std Err of Y Est	0.669236
R Squared	0.853794
No. of Observations	8
Degrees of Freedom	6
X Coefficient(s)	0.593074
Std Err of Coef.	0.100193

Table D4-3. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Barium.

Barium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
83.4	77.6	6	1	1
116	115	1	1	1
97	96.8	0	1	1
116	134	-18	0	1
52.5	81.7	-29	0	1
143	146	-3	0	1
132	105	27	1	1
79.6	156	-76	0	1
193	187	6	1	1
79.7	94.1	-14	0	1
85.1	61.2	24	1	1
170	163	7	1	1
65.2	64.6	1	1	1
64.7	67	-2	0	1
72.8	73.6	-1	0	1
68.7	51	18	1	1
63.1	65	-2	0	1
			9	
			17	
			13	
			5	

Barium

U =	142	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	17.90205
Std Err of Y Est	23.40807
R Squared	0.69739
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.852816
Std Err of Coef.	0.145048

Table D4-4. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Calcium.

Calcium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
3970	4060	-90	0	1
10400	10600	-200	0	1
3980	5060	-1080	0	1
13500	17400	-3900	0	1
5870	6410	-540	0	1
5830	6480	-650	0	1
18600	13100	5500	1	1
11800	11100	700	1	1
11700	10700	1000	1	1
7250	7110	140	1	1
6820	8450	-1630	0	1
16400	15400	1000	1	1
19300	18100	1200	1	1
11100	10800	300	1	1
8900	7060	1840	1	1
5740	5280	460	1	1
6710	4780	1930	1	1
			10	
			17	
			13	
			5	

Calcium

U =	151	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	1267.39
Std Err of Y Est	1811.076
R Squared	0.842238
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.83603
Std Err of Coef.	0.093424

Table D4-5. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Chromium.

Chromium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
12.3	10.7	2	1	1
10.6	17.2	-7	0	1
10.4	14.3	-4	0	1
7.6	12	-4	0	1
5.2	7.3	-2	0	1
30.6	33.2	-3	0	1
22.5	20.8	2	1	1
4.1	5	-1	0	1
12.4	12.7	-0	0	1
13.1	14.4	-1	0	1
12.8	14.2	-1	0	1
23.8	24.3	-1	0	1
14.6	13.3	1	1	1
13.2	16	-3	0	1
12.4	7.8	5	1	1
11.6	9.9	2	1	1
6.5	3.9	3	1	1
			6	
			17	
			13	
			5	

Chromium

U =	127	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	1.133757
Std Err of Y Est	2.932038
R Squared	0.845688
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.973295
Std Err of Coef.	0.107348

Table D4-6. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Cobalt.

Cobalt

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
11.1	13.1	-2	0	1
12.8	15.9	-3	0	1
11.6	15.7	-4	0	1
9.9	15.1	-5	0	1
10.4	14.9	-5	0	1
11.2	12.5	-1	0	1
14.5	17.3	-3	0	1
14.8	17.4	-3	0	1
9	9.7	-1	0	1
7.6	9.3	-2	0	1
9.2	10.9	-2	0	1
12.8	12.6	0	1	1
7.4		7		
7.8	8.5	-1	0	1
16	17	-1	0	1
7.6		8		
11.2	11.6	-0	0	1
			1	
			15	
			12	
			4	
			S-3 < DC	

Cobalt

U =	66	DC	15
COUNT =	255	S-3	17
E(U) =	127.5		
VAR U =	26.5	S-3 < DC	
LCL =	74.5		
UCL =	180.5		

Regression Output:

Constant	1.88986
Std Err of Y Est	1.649178
R Squared	0.720216
No. of Observations	15
Degrees of Freedom	13
X Coefficient(s)	1.019141
Std Err of Coef.	0.176174

Table D4-7. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Copper.

Copper

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
12	28.3	-16	0	1
16.5	19.9	-3	0	1
12.1	12.2	-0	0	1
13.9	16.5	-3	0	1
16.2	14.3	2	1	1
22.8	22.6	0	1	1
29.6	26.5	3	1	1
12.1	13.6	-2	0	1
13.6	11.4	2	1	1
10.6	11.9	-1	0	1
22.8	15	8	1	1
23.5	21.9	2	1	1
13.6	14	-0	0	1
14.5	17.1	-3	0	1
14.9	17	-2	0	1
9	8.5	1	1	1
14.2	15	-1	0	1
			7	
			17	
			13	
			5	

Copper

U =	124	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	7.157329
Std Err of Y Est	4.432725
R Squared	0.372702
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.603256
Std Err of Coef.	0.202075

Table D4-8. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Iron.

Iron

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
25500	22700	2800	1	1
23800	31600	-7800	0	1
24800	28400	-3600	0	1
22400	33000	-10600	0	1
22800	29700	-6900	0	1
24400	26300	-1900	0	1
28400	34500	-6100	0	1
29900	34200	-4300	0	1
20800	20000	800	1	1
19500	21400	-1900	0	1
23500	23200	300	1	1
27000	24900	2100	1	1
16300	13600	2700	1	1
15900	18400	-2500	0	1
30800	21100	9700	1	1
15200	13000	2200	1	1
22700	20300	2400	1	1
			8	
			17	
			13	
			5	

Iron

U =	130	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	2095.322
Std Err of Y Est	5147.713
R Squared	0.443812
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.966928
Std Err of Coef.	0.279486

Table D4-9. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Lead.

Lead

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
7.4	4.8	3	1	1
8.3	5.8	3	1	1
4.7	6	-1	0	1
6.9	7.5	-1	0	1
4.7	4.4	0	1	1
12.1	10.8	1	1	1
11.2	8.1	3	1	1
3.5	2.5	1	1	1
5.2	4.2	1	1	1
9.5	7.6	2	1	1
9.2	2.5	7	1	1
14.8	14.7	0	1	1
4.2	2.1	2	1	1
6.4	5.8	1	1	1
6	2.6	3	1	1
4.2	3.1	1	1	1
3.3	1.9	1	1	1
			15	
			17	
			13	
			5	
			S-3 > DC	

Lead

U =	190	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant		-0.80958
Std Err of Y Est		1.840602
R Squared		0.730215
No. of Observations		17
Degrees of Freedom		15
X Coefficient(s)	0.889498	
Std Err of Coef.	0.139599	

Table D4-10. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Magnesium.

Magnesium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
4870	4610	260	1	1
9150	10500	-1350	0	1
4570	5660	-1090	0	1
3950	4800	-850	0	1
3620	4820	-1200	0	1
6820	7610	-790	0	1
7950	8370	-420	0	1
3670	4110	-440	0	1
5160	5580	-420	0	1
4830	6090	-1260	0	1
4670	4900	-230	0	1
8460	8500	-40	0	1
4410	4600	-190	0	1
4960	5250	-290	0	1
6060	3870	2190	1	1
4210	3590	620	1	1
4030	3130	900	1	1
			4	
			17	
			13	
			5	
			S-3 < DC	

Magnesium

U =	132	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	62.94581
Std Err of Y Est	925.5339
R Squared	0.797763
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	1.038625
Std Err of Coef.	0.135023

Table D4-11. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Manganese.

Manganese

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
369	323	46	1	1
506	534	-28	0	1
380	427	-47	0	1
355	344	11	1	1
253	378	-125	0	1
407	426	-19	0	1
473	518	-45	0	1
411	491	-80	0	1
356	359	-3	0	1
364	394	-30	0	1
377	300	77	1	1
528	478	50	1	1
279	253	26	1	1
316	310	6	1	1
455	445	10	1	1
262	227	35	1	1
285	221	64	1	1
			9	
			17	
			13	
			5	

Manganese

U =	140	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	0.918623
Std Err of Y Est	54.74146
R Squared	0.709027
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	1.005706
Std Err of Coef.	0.166349

Table D4-12. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Nickel.

Nickel

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
12.7	10.9	2	1	1
14.1	17.3	-3	0	1
11.8	19.9	-8	0	1
9.9	12.1	-2	0	1
7.7	10.3	-3	0	1
28.2	28.4	-0	0	1
25.1	24.4	1	1	1
7.8	7.2	1	1	1
10.7	12.2	-2	0	1
9.3	12.6	-3	0	1
13.1	14.9	-2	0	1
20.4	21.9	-2	0	1
11.5	9.6	2	1	1
13.4	13.1	0	1	1
16.6	11.3	5	1	1
13	8.9	4	1	1
9.6	7.2	2	1	1
			8	
			17	
			13	
			5	

Nickel

U =	143	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	1.647829
Std Err of Y Est	3.23812
R Squared	0.738502
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.911822
Std Err of Coef.	0.140095

Table D4-13. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Potassium.

Potassium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
1700	1640	60	1	1
3280	3780	-500	0	1
2190	2220	-30	0	1
1160	1370	-210	0	1
939	1170	-231	0	1
1370	1410	-40	0	1
2140	2370	-230	0	1
851	851	0		0
1840	1880	-40	0	1
1720	2380	-660	0	1
1370	1130	240	1	1
2950	2860	90	1	1
1010		1010		
1660	1860	-200	0	1
1330		1330		
1140		1140		
851	851	0		0
			3	
			12	
			10	
			3	

Potassium

U =	94	DC	14
COUNT =	238	S-3	17
E(U) =	119		
VAR U =	25.2		
LCL =	68.6		
UCL =	169.4		

Regression Output:

Constant	40.20627
Std Err of Y Est	260.1449
R Squared	0.897332
No. of Observations	12
Degrees of Freedom	10
X Coefficient(s)	1.056836
Std Err of Coef.	0.113044

Table D4-14. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Sodium.

Sodium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
361	405	-44	0	1
5620	6060	-440	0	1
190	294	-104	0	1
336	424	-88	0	1
341	277	64	1	1
316	297	19	1	1
717	664	53	1	1
251	237	14	1	1
511	561	-50	0	1
317	399	-82	0	1
228	448	-220	0	1
331	287	44	1	1
256		256		
235	304	-69	0	1
304		304		
149		149		
202	278	-76	0	1
			5	
			14	
			12	
			3	

Sodium

U =	87	DC	14
COUNT =	238	S-3	17
E(U) =	119		
VAR U =	25.2		
LCL =	68.6		
UCL =	169.4		

Regression Output:

Constant	18.58903
Std Err of Y Est	84.98328
R Squared	0.99713
No. of Observations	14
Degrees of Freedom	12
X Coefficient(s)	1.072193
Std Err of Coef.	0.016604

Table D4-15. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Vanadium.

Vanadium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
60.6	55.6	5	1	1
80.7	104	-23	0	1
59.7	75	-15	0	1
48.8	86.3	-38	0	1
48.1	76.2	-28	0	1
49.7	54.3	-5	0	1
60.2	77	-17	0	1
90.1	105	-15	0	1
39.1	38.6	1	1	1
35.4	38.9	-4	0	1
53.1	58.8	-6	0	1
45.8	42.3	4	1	1
37.3	27.4	10	1	1
31.6	36.7	-5	0	1
82.3	51.8	31	1	1
31.4	28.6	3	1	1
48.7	53.4	-5	0	1
			6	
			17	
			13	
			5	

Vanadium

U =	127	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	3.876132
Std Err of Y Est	16.28294
R Squared	0.576701
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	1.045874
Std Err of Coef.	0.231356

Table D4-16. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Zinc.

Zinc

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
49.9	41.6	8	1	1
46.9	54.4	-8	0	1
62.3	55.8	7	1	1
49.5	66.2	-17	0	1
47.6	53.7	-6	0	1
70.5	69.1	1	1	1
77.2	62.4	15	1	1
50.1	51.4	-1	0	1
45.6	41.1	5	1	1
43.4	46.8	-3	0	1
43.4	40.6	3	1	1
68.2	59.9	8	1	1
35.5	30.7	5	1	1
39.8	41.8	-2	0	1
60.8	39	22	1	1
34.7	26.7	8	1	1
48.6	37.2	11	1	1
			11	
			17	
			13	
			5	

Zinc

U =	164	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	10.90389
Std Err of Y Est	8.743942
R Squared	0.523093
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.724295
Std Err of Coef.	0.178565

Table D4-17. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Titanium.

Titanium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
	1800	-1800		
1120		1120		
1930		1930		
1300		1300		
1570		1570		
1110	1330	-220	0	1
1730	1850	-120	0	1
2600	3180	-580	0	1
	1130	-1130		
	1130	-1130		
	1590	-1590		
	1130	-1130		
743	606	137	1	1
681		681		
2780	1650	1130	1	1
864	781	83	1	1
1530	1930	-400	0	1
			3	
			7	
			7	
			1	

Titanium

U =	65	DC	12
COUNT =	144	S-3	12
E(U) =	72		
VAR U =	17.3		
LCL =	37.4		
UCL =	106.6		

Regression Output:

Constant	282.6216
Std Err of Y Est	589.7165
R Squared	0.604784
No. of Observations	7
Degrees of Freedom	5
X Coefficient(s)	0.823162
Std Err of Coef.	0.297589

Table D4-18. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Zirconium.

Zirconium

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
	19.9	-20		
26.4		26		
22.4		22		
20.2		20		
17.9	30.3	-12	0	1
15.1	15.3	-0	0	1
48.8	53.7	-5	0	1
34.4	39.3	-5	0	1
	12.5	-13		
	12.5	-13		
	15.5	-16		
	14.6	-15		
11	11	0		0
11		11		
27.2	20.6	7	1	1
11	11	0		0
19.9	23.9	-4	0	1
			1	
			6	
			6	
			1	

Zirconium

U =	79	DC	13
COUNT =	156	S-3	12
E(U) =	78		
VAR U =	18.4		
LCL =	41.2		
UCL =	114.8		

Regression Output:

Constant	3.508035
Std Err of Y Est	6.999875
R Squared	0.801692
No. of Observations	6
Degrees of Freedom	4
X Coefficient(s)	0.992356
Std Err of Coef.	0.246776

Table D4-19. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Chlorine.

Chlorine

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
1	2	-1	0	1
889	830	59	1	1
1	1	0		0
25.1	18	7	1	1
2.44	2	0	1	1
3.65	2	2	1	1
101	30	71	1	1
2.75	1	2	1	1
30.7	40	-9	0	1
365	720	-355	0	1
3.77	2	2	1	1
560	3	557	1	1
13.4	13	0	1	1
1	1	0		0
3.34	1	2	1	1
1.9	1	1	1	1
4.86	2	3	1	1
			12	
			15	
			12	
			4	

Chlorine

U =	170	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	4.070983
Std Err of Y Est	174.9543
R Squared	0.611813
No. of Observations	15
Degrees of Freedom	13
X Coefficient(s)	0.799804
Std Err of Coef.	0.176695

Table D4-20. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Nitrate.

NO3

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
7.47	1.8	6	1	1
10.3	2.4	8	1	1
5.51	0.7	5	1	1
14	1.9	12	1	1
4.14	0.6	4	1	1
3.46	0.6	3	1	1
132	13	119	1	1
1.16	0.6	1	1	1
2.29	0.6	2	1	1
18	6.3	12	1	1
1.23	0.6	1	1	1
29.2	5.6	24	1	1
6.76	1.8	5	1	1
1.62	0.6	1	1	1
2.23	0.6	2	1	1
2.97	0.6	2	1	1
10.5	1.3	9	1	1
			17	
			17	
			13	
			5	
			S-3 > DC	

NO3

U =	242	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4	S-3 > DC	
UCL =	202.6		

Regression Output:

Constant	0.874822
Std Err of Y Est	1.184627
R Squared	0.875233
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	0.097801
Std Err of Coef.	0.009534

Table D4-21. Field Duplicate Analysis: Results of Mann Whitman U-Test Results for Sulfate.

SO4

S-3	DC	DELTA S-3 - DC	SIGN S3>DC=1	Pair =1
3.32	3	0	1	1
1480	1400	80	1	1
2.87	3	-0	0	1
22.6	32	-9	0	1
20.8	12	9	1	1
11.2	7	4	1	1
1650	550	1100	1	1
2.54	4	-1	0	1
28.5	62	-34	0	1
91.1	120	-29	0	1
4.82	6	-1	0	1
21	23	-2	0	1
125	140	-15	0	1
1.18	2	-1	0	1
1	1	0		0
1.09	1	0	1	1
1.95	1	1	1	1
			7	
			16	
			13	
			4	

SO4

U =	141	DC	17
COUNT =	289	S-3	17
E(U) =	144.5		
VAR U =	29.0		
LCL =	86.4		
UCL =	202.6		

Regression Output:

Constant	18.55311
Std Err of Y Est	181.5787
R Squared	0.763564
No. of Observations	16
Degrees of Freedom	14
X Coefficient(s)	0.596646
Std Err of Coef.	0.088733

Table D5. Standard Deviation of Laboratory Duplicates.

ANALYTE	STANDARD DEVIATION (1)	3*SD
ALUMINUM	1259	3776
ANTIMONY	1.2	3.7
ARSENIC	0.5	1.4
BARIUM	29	86
BERYLLIUM	0.1	0.4
CADMIUM	0.1	0.4
CALCIUM	1876	5628
CHROMIUM	2.2	6.7
COBALT	3.0	9.1
COPPER	2.9	8.8
IRON	2142	6426
LEAD	1.2	3.6
MAGNESIUM	491	1474
MANGANESE	113	340
MERCURY	0.3	0.8
NICKEL	3.3	10.0
POTASSIUM	245	736
SELENIUM		0.0
SILVER	0.2	0.6
SODIUM	136	407
THALLIUM	1.1	3.3
VANADIUM	8	24
ZINC	5.0	14.9
MOLYBDENUM	0.3	0.8
TITANIUM	232	696
ZIRCONIUM	2.5	7.5
LITHIUM	5	16
ANIONS		
FLUORIDE	0.6	1.7
CHLORIDE	1.4	4.3
NITRATE	1.7	5.2
SULFATE	40	120

(1) ALL PAIRS > LAB CLAIMED DETECTION LIMIT

Table D6-1. Factor Analysis Tables Results from Random Data, Using Principal Component Analysis. Number of factors is 6.

(a) Measures of Variable Sampling Adequacy

Total matrix sampling adequacy: .811			
Analyte	Variable sampling index	Analyte	Variable sampling index
Aluminum	0.833	Manganese	0.877
Arsenic	0.775	Nickel	0.792
Barium	0.878	Potassium	0.813
Beryllium	0.886	Sodium	0.514
Calcium	0.463	Vanadium	0.781
Chromium	0.765	Zinc	0.919
Cobalt	0.793	Alkalinity	0.575
Copper	0.929	Silicon	0.149
Iron	0.821	Fluoride	0.747
Lead	0.881	Chloride	0.715
Magnesium	0.93	Sulfate	0.823

(b) Communality Summary

Analyte	SMC	Final estimate	Analyte	SMC	Final estimate
Aluminum	0.957	0.924	Manganese	0.737	0.706
Arsenic	0.754	0.776	Nickel	0.901	0.788
Barium	0.661	0.563	Potassium	0.864	0.787
Beryllium	0.927	0.911	Sodium	0.729	0.827
Calcium	0.612	0.881	Vanadium	0.928	0.895
Chromium	0.934	0.859	Zinc	0.636	0.659
Cobalt	0.968	0.951	Alkalinity	0.588	0.832
Copper	0.737	0.783	Silicon	0.211	0.869
Iron	0.972	0.967	Fluoride	0.569	0.553
Lead	0.621	0.685	Chloride	0.692	0.735
Magnesium	0.82	0.802	Sulfate	0.64	0.82

Table D6-2. Factor Analysis Tables Results from Random Data, Using Principal Component Analysis. Number of factors is 6.

(c) Proportionate Variance Contributions

	Orthogonal direct	Oblique		
		Direct	Joint	Total
Factor 1	0.341	0.321	-1.52 e-03	0.319
Factor 2	0.28	0.31	-2.71 e-03	0.307
Factor 3	0.097	0.101	-6.15 e-05	0.101
Factor 4	0.111	0.109	-6.88 e-03	0.102
Factor 5	0.111	0.106	1.94 e-03	0.108
Factor 6	0.06	0.062	6.39 e-05	0.062

(d) Primary Intercorrelations, Orthotran/Varimax

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Factor 1	1					
Factor 2	0.355	1				
Factor 3	0.021	0.03	1			
Factor 4	0.204	0.182	0.147	1		
Factor 5	0.372	0.274	0.037	0.163	1	
Factor 6	-0.039	-0.038	-0.057	-0.081	-0.024	1

Table D6-3. Factor Analysis Tables Results from Random Data, Using Principal Component Analysis. Number of factors is 6.

(e) Variable Complexity, Orthotran/Varimax

Analyte	Variable		Analyte	Variable	
	Orthogonal	Oblique		Orthogonal	Oblique
Aluminum	1.396	1.248	Nickel	1.433	1.492
Arsenic	1.403	1.486	Potassium	1.784	1.757
Barium	3.181	3.11	Sodium	1.157	1.13
Beryllium	1.651	1.181	Vanadium	1.196	1.508
Calcium	1.073	1.112	Zinc	1.395	1.182
Chromium	1.476	1.6	Alkalinity	1.22	1.188
Cobalt	1.041	1.099	Silicon	1.024	1.011
Copper	2.442	2.595	Fluoride	1.794	1.239
Iron	1.05	1.109	Chloride	1.673	1.507
Lead	1.198	1.219	Sulfate	1.801	1.339
Magnesium	1.618	1.369			
Manganese	2.004	1.625	Average	1.546	1.459

Table D7. Coordinates for Variogram Analysis.

X-Y LOCATIONS FOR VARIOGRAM ANALYSIS

SITE	LONG	LAT	X KM	Y KM
1	119.2902	46.3484	3.40	0.00
2	119.3199	46.4693	5.70	26.79
3	119.3808	46.4964	10.40	32.80
4	119.3264	46.5596	6.20	46.80
5	119.5233	46.6841	21.40	74.39
6	119.5026	46.5505	19.80	44.79
7	119.5104	46.5668	20.40	48.40
8	119.5492	46.5632	23.40	47.60
9	119.5674	46.5596	24.80	46.80
10	119.7228	46.6065	36.80	57.19
11	119.7358	46.5505	37.80	44.79
12	119.7073	46.5036	35.60	34.39
13	119.2539	46.3700	0.60	4.79
14	119.2461	46.4639	0.00	25.59
15	119.715	46.5719	36.20	49.53

SITE NUMBER 14 IS ARBITRARY REFERENCE POINT FOR X DISTANCES
SITE NUMBER 1 IS ARBITRARY REFERENCE POINT FOR Y DISTANCES

Table D8. Anisotropy Ratios Estimated From Variogram Plots.

	HORIZONTAL	VERTICAL	ANISOTROPY RATIO
ALUMINUM	5.0E+06	1.2E+06	4.2
IRON	3.0E+07	1.5E+07	2.0
CALCIUM	1.3E+07	6.0E+06	2.2
SODIUM	3.0E+04	2.6E+04	1.2
COPPER	16	6	2.7
LEAD	7	3.5	2.0

Table D9-1. Weibull Distribution Parameters, Quantiles, and Confidence Limits.

ANALYTE	CENSOR LEVEL	to	ETA	BETA	R	50%	80%	80% UCL	90%	90% UCL	95% LCL	95%	95% UCL
Aluminum	4800	4473	3880	1.276	0.994	7383	10113	11053	11933	13263	12133	13643	15573
Antimony	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	3	2.37	1.74	0.977	0.994	3.56	5.2	5.83	6.44	7.42	6.59	7.71	9.18
Barium	62.2	54.3	43	1.382	0.997	87.3	114.9	124.2	132.8	145.7	134.8	149.3	166.3
Beryllium	1.1	1.036	0.145	0.797	0.996	1.1275	1.296	1.376	1.446	1.576	1.466	1.606	1.806
Cadmium	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	5600	5009	5809	1.069	0.996	9131	14079	15909	17709	20409	18109	21209	25309
Chromium	4	3.72	7.66	1.185	0.997	9.34	15.12	17.32	19.22	22.22	19.62	23.02	27.32
Cobalt	0	4.8	7.72	2.342	0.992	11.4	14.25	15.1	15.8	16.8	16	17.1	18.4
Copper	11.9	11.39	3.99	0.885	0.991	14.03	18.22	19.92	21.59	24.39	21.99	25.19	29.39
Iron	0	11650	14440	2.119	0.99	23750	29750	31450	33050	35250	33450	35850	38750
Lead	3.3	2.87	3.54	1.121	0.997	5.42	8.28	9.31	10.31	11.84	10.54	12.28	14.47
Lithium	0	0	28.4	5.21	0.994	26.5	31.2	32.7	33.4	35.1	33.2	35.1	37.2
Magnesium	3820	3630	1653	1.143	0.992	4830	6140	6610	7060	7750	7160	7950	8950
Manganese	0	153	260	2.708	0.998	380	463	486	506	535	511	542	578
Mercury	0	0.08	0.01346	0.287	0.982	0.08375	0.1507	0.22	0.35	0.59	0.36	0.7	1.49
Molybdenum	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	0	6.35	7.35	1.53	0.991	12.15	16.35	17.75	19.05	20.85	19.35	21.45	23.95
Potassium	851	587	815	1.261	0.997	1197	1777	1977	2167	2447	2207	2537	2937
Selenium	-	-	-	-	-	-	-	-	-	-	-	-	-
Silicon	7.01	6.06	13.7	0.794	0.993	14.12	31.76	40.46	56.06	63.46	-	66.36	-
Silver	0	1.36	0.000033	0.129	0.976	1.360002	1.3613	1.36594	1.3807	1.46	1.3868	1.52	2.36
Sodium	408	349	25.4	0.324	0.967	357.2	459	551	682	984	718	1099	1909
Thallium	-	-	-	-	-	-	-	-	-	-	-	-	-
Titanium	0	441	1305	1.711	0.997	1491	2161	2401	2561	2881	2571	2921	3341
Vanadium	0	21.9	40.3	1.863	0.995	55	74	79.8	85	92.5	86.1	94.6	104.5
Zinc	0	26.7	29	2.497	0.994	51.7	61.7	64.6	67.1	70.7	67.7	71.6	76.1
Zirconium	0	0	24.9	2.313	0.995	21.3	30.6	33.7	35.8	39.6	-	40.1	-
Alkalinity	203	188	1700	0.546	0.994	1055	4248	6008	8008	11688	8508	12888	19788
Ammonia	0	0	1.84	0.498	0.972	0.88	4.8	7.1	9.8	14.9	10.5	16.6	26.8
Chloride	2.2	2.199	8.62	0.323	0.975	4.999	39.799	71.499	116.199	220.199	128.199	259.199	541.199
Fluoride	0	0.56	0.57	0.609	0.986	0.87	1.81	2.28	2.81	3.73	2.93	4.02	5.69
Nitrate	2	1.88	4.38	0.336	0.986	3.35	19.88	34.28	54.18	99.38	59.68	115.88	234.88
Nitrite	-	-	-	-	-	-	-	-	-	-	-	-	-
O-Phosphate	0	0	0.00187	0.142	0.977	0.000141	0.0535	0.21	0.668	2.9	0.85	4.27	22.9
Sulfate	2.1	2	20.8	0.329	0.987	8.8	90.3	162	264	497	292	585	1202

Table D9-2. Lognormal Distribution Parameters, Quantiles, and Confidence Limits.

ANALYTE	CENSOR LEVEL	MEAN LOG(X)	STDEV LOG(X)	R	50%	80%	80% UCL	90%	90% UCL	95% LCL	95%	95% UCL
Aluminum	4800	8.94	0.342	0.983	7600	10100	11000	11800	13000	12000	13300	15100
Antimony	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	3	1.27	0.47	0.99	3.55	5.28	5.89	6.47	7.38	6.61	7.65	9.06
Barium	62.2	4.48	0.312	0.993	88.4	115	124	132	144	134	148	165
Beryllium	1.1	0.0866	0.251	0.974	1.09	1.35	1.44	1.51	1.62	1.52	1.65	1.8
Cadmium	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	5600	9.15	0.467	0.987	9450	14000	15700	17200	19700	17600	20400	24100
Chromium	4	2.26	0.513	0.995	9.57	14.8	16.7	18.5	21.4	18.9	22.3	26.8
Cobalt	0	2.42	0.263	0.977	11.2	14	14.9	15.7	16.9	15.9	17.3	19.2
Copper	11.9	2.66	0.331	0.96	14.4	19	20.6	22	24.1	22.3	24.7	27.9
Iron	0	10.1	0.249	0.98	23600	29200	31000	32600	35000	33000	35600	39000
Lead	3.3	1.72	0.472	0.994	5.45	8.24	9.36	10.2	11.7	10.4	12.2	14.5
Lithium	0	3.35	0.127	0.996	28.4	31.7	32.9	33.5	35	33.4	35.1	37.2
Magnesium	3820	8.51	0.272	0.971	4980	6260	6680	7060	7620	7140	7780	8580
Manganese	0	5.92	0.25	0.996	372	460	488	512	550	518	561	613
Mercury	0	-3.75	2.07	0.982	0.023	0.13	0.22	0.33	0.6	0.36	0.7	1.47
Molybdenum	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	0	2.5	0.346	0.99	12.2	16.4	17.8	19.1	21	19.4	21.6	24.5
Potassium	851	7.09	0.449	0.995	1210	1760	1960	2150	2440	2190	2520	2960
Selenium	-	-	-	-	-	-	-	-	-	-	-	-
Silicon	7.01	2.74	0.816	0.983	15.4	36.8	37.5	44	55.6	-	59	-
Silver	0	-2.92	2.03	0.879	0.054	0.3	0.49	0.73	1.33	0.81	1.52	3.16
Sodium	408	5.44	0.853	0.968	231	475	581	690	878	716	937	1274
Thallium	-	-	-	-	-	-	-	-	-	-	-	-
Titanium	0	7.28	0.441	0.988	1460	2110	2380	2570	2950	2580	3000	3600
Vanadium	0	4	0.348	0.988	54.4	73	79.3	85.1	93.9	86.4	96.4	110
Zinc	0	3.94	0.217	0.996	51.1	61.7	64.9	67.8	72.1	68.5	73.3	79.3
Zirconium	0	3.03	0.511	0.986	20.6	31.8	36.4	39.8	46.8	40	47.8	58.8
Alkalinity	203	7	1.52	0.991	1100	3960	5680	7710	11800	8240	13300	23000
Ammonia	0	-0.103	1.75	0.965	0.97	4.28	6.48	9.23	15.1	9.95	17.3	32.5
Chloride	2.2	1.89	2.12	0.965	6.59	39.6	65.5	100	182	109	214	460
Fluoride	0	-0.18	0.973	0.985	0.8	1.83	2.31	2.81	3.7	2.93	3.98	5.67
Nitrate	2	1.28	2.08	0.979	3.58	20.9	34.2	52	93.4	56.9	110	232
Nitrite	-	-	-	-	-	-	-	-	-	-	-	-
O-Phosphate	0	-6.16	4.6	0.984	0.00211	0.104	0.31	0.785	2.87	0.958	4.08	21.5
Sulfate	2.1	2.34	2.43	0.986	10.4	81.4	145	237	469	263	566	1360

Table D10-1. Comparison of Weibull versus Lognormal Distributions: Correlation Coefficients (R).

ANALYTE	WEIBULL R	LOGNORMAL R	Best Correlation
Aluminum	0.994	0.983	WEIBULL
Antimony	-	-	
Arsenic	0.994	0.99	WEIBULL
Barium	0.997	0.993	WEIBULL
Beryllium	0.996	0.974	WEIBULL
Cadmium	-	-	
Calcium	0.996	0.987	WEIBULL
Chromium	0.997	0.995	WEIBULL
Cobalt	0.992	0.977	WEIBULL
Copper	0.991	0.96	WEIBULL
Iron	0.99	0.98	WEIBULL
Lead	0.997	0.994	WEIBULL
Lithium	0.994	0.996	LOGNORMAL
Magnesium	0.992	0.971	WEIBULL
Manganese	0.998	0.996	WEIBULL
Mercury	0.982	0.982	Same
Molybdenum	-	-	
Nickel	0.991	0.99	WEIBULL
Potassium	0.997	0.995	WEIBULL
Selenium	-	-	
Silicon	0.993	0.983	WEIBULL
Silver	0.976	0.879	WEIBULL
Sodium	0.967	0.968	LOGNORMAL
Thallium	-	-	
Titanium	0.997	0.988	WEIBULL
Vanadium	0.995	0.988	WEIBULL
Zinc	0.994	0.996	LOGNORMAL
Zirconium	0.995	0.986	WEIBULL
Alkalinity	0.994	0.991	WEIBULL
Ammonia	0.972	0.965	WEIBULL
Chloride	0.975	0.965	WEIBULL
Fluoride	0.986	0.985	WEIBULL
Nitrate	0.986	0.979	WEIBULL
Nitrite	-	-	
O-Phosphate	0.977	0.984	LOGNORMAL
Sulfate	0.987	0.986	WEIBULL

Table D10-2. Comparison of Weibull versus Lognormal Distributions: 50th Percentile.

	WEIBULL 50%	LOGNORMAL 50%	W>L?
Aluminum	7383	7600	No
Antimony	-	-	
Arsenic	3.56	3.55	Yes
Barium	87.3	88.4	No
Beryllium	1.1275	1.09	Yes
Cadmium	-	-	
Calcium	9131	9450	No
Chromium	9.34	9.57	No
Cobalt	11.4	11.2	Yes
Copper	14.03	14.4	No
Iron	23750	23600	Yes
Lead	5.42	5.45	No
Lithium	26.5	28.4	No
Magnesium	4830	4980	No
Manganese	380	372	Yes
Mercury	0.08375	0.023	Yes
Molybdenum	-	-	
Nickel	12.15	12.2	No
Potassium	1197	1210	No
Selenium	-	-	
Silicon	14.12	15.4	No
Silver	1.360002	0.054	Yes
Sodium	357.2	231	Yes
Thallium	-	-	
Titanium	1491	1460	Yes
Vanadium	55	54.4	Yes
Zinc	51.7	51.1	Yes
Zirconium	21.3	20.6	Yes
Alkalinity	1055	1100	No
Ammonia	0.88	0.97	No
Chloride	4.999	6.59	No
Fluoride	0.87	0.8	Yes
Nitrate	3.35	3.58	No
Nitrite	-	-	
O-Phosphate	0.000141	0.00211	No
Sulfate	8.8	10.4	No

Table D10-3. Comparison of Weibull versus Lognormal Distributions: 80th Percentile.

	WEIBULL 80%	LOGNORMAL 80%	W>L?
Aluminum	10113	10100	Yes
Antimony	-	-	
Arsenic	5.2	5.28	No
Barium	114.9	115	No
Beryllium	1.296	1.35	No
Cadmium	-	-	
Calcium	14079	14000	Yes
Chromium	15.12	14.8	Yes
Cobalt	14.25	14	Yes
Copper	18.22	19	No
Iron	29750	29200	Yes
Lead	8.28	8.24	Yes
Lithium	31.2	31.7	No
Magnesium	6140	6260	No
Manganese	463	460	Yes
Mercury	0.1507	0.13	Yes
Molybdenum	-	-	
Nickel	16.35	16.4	No
Potassium	1777	1760	Yes
Selenium	-	-	
Silicon	31.76	36.8	No
Silver	1.3613	0.3	Yes
Sodium	459	475	No
Thallium	-	-	
Titanium	2161	2110	Yes
Vanadium	74	73	Yes
Zinc	61.7	61.7	Same
Zirconium	30.6	31.8	No
Alkalinity	4248	3960	Yes
Ammonia	4.8	4.28	Yes
Chloride	39.799	39.6	Yes
Fluoride	1.81	1.83	No
Nitrate	19.88	20.9	No
Nitrite	-	-	
O-Phosphate	0.0535	0.104	No
Sulfate	90.3	81.4	Yes

Table D10-4. Comparison of Weibull versus Lognormal Distributions: 80 Percent Upper Confidence Limit.

	WEIBULL 80% UCL	LOGNORMAL 80% UCL	W>L?
Aluminum	11053	11000	Yes
Antimony	-	-	
Arsenic	5.83	5.89	No
Barium	124.2	124	Yes
Beryllium	1.376	1.44	No
Cadmium	-	-	
Calcium	15909	15700	Yes
Chromium	17.32	16.7	Yes
Cobalt	15.1	14.9	Yes
Copper	19.92	20.6	No
Iron	31450	31000	Yes
Lead	9.31	9.36	No
Lithium	32.7	32.9	No
Magnesium	6610	6680	No
Manganese	486	488	No
Mercury	0.22	0.22	Same
Molybdenum	-	-	
Nickel	17.75	17.8	No
Potassium	1977	1960	Yes
Selenium	-	-	
Silicon	40.46	37.5	Yes
Silver	1.3659	0.49	Yes
Sodium	551	581	No
Thallium	-	-	
Titanium	2401	2380	Yes
Vanadium	79.8	79.3	Yes
Zinc	64.6	64.9	No
Zirconium	33.7	36.4	No
Alkalinity	6008	5680	Yes
Ammonia	7.1	6.48	Yes
Chloride	71.499	65.5	Yes
Fluoride	2.28	2.31	No
Nitrate	34.28	34.2	Yes
Nitrite	-	-	
O-Phosphate	0.21	0.31	No
Sulfate	162	145	Yes

Table D10-5. Comparison of Weibull versus Lognormal Distributions: 90th Percentile.

	WEIBULL 90%	LOGNORMAL 90%	W>L?
Aluminum	11933	11800	Yes
Antimony	-	-	
Arsenic	6.44	6.47	No
Barium	132.8	132	Yes
Beryllium	1.446	1.51	No
Cadmium	-	-	
Calcium	17709	17200	Yes
Chromium	19.22	18.5	Yes
Cobalt	15.8	15.7	Yes
Copper	21.59	22	No
Iron	33050	32600	Yes
Lead	10.31	10.2	Yes
Lithium	33.4	33.5	No
Magnesium	7060	7060	Same
Manganese	506	512	No
Mercury	0.35	0.33	Yes
Molybdenum	-	-	
Nickel	19.05	19.1	No
Potassium	2167	2150	Yes
Selenium	-	-	
Silicon	56.06	44	Yes
Silver	1.3807	0.73	Yes
Sodium	682	690	No
Thallium	-	-	
Titanium	2561	2570	No
Vanadium	85	85.1	No
Zinc	67.1	67.8	No
Zirconium	35.8	39.8	No
Alkalinity	8008	7710	Yes
Ammonia	9.8	9.23	Yes
Chloride	116.2	100	Yes
Fluoride	2.81	2.81	Same
Nitrate	54.18	52	Yes
Nitrite	-	-	
O-Phosphate	0.668	0.785	No
Sulfate	264	237	Yes

Table D10-6. Comparison of Weibull versus Lognormal Distributions: 90 Percent Upper Confidence Limit.

	WEIBULL 90% UCL	LOGNORMAL 90% UCL	W>L?
Aluminum	13263	13000	Yes
Antimony	-	-	
Arsenic	7.42	7.38	Yes
Barium	145.7	144	Yes
Beryllium	1.576	1.62	No
Cadmium	-	-	
Calcium	20409	19700	Yes
Chromium	22.22	21.4	Yes
Cobalt	16.8	16.9	No
Copper	24.39	24.1	Yes
Iron	35250	35000	Yes
Lead	11.84	11.7	Yes
Lithium	35.1	35	Yes
Magnesium	7750	7620	Yes
Manganese	535	550	No
Mercury	0.59	0.6	No
Molybdenum	-	-	
Nickel	20.85	21	No
Potassium	2447	2440	Yes
Selenium	-	-	
Silicon	63.46	55.6	Yes
Silver	1.46	1.33	Yes
Sodium	984	878	Yes
Thallium	-	-	
Titanium	2881	2950	No
Vanadium	92.5	93.9	No
Zinc	70.7	72.1	No
Zirconium	39.6	46.8	No
Alkalinity	11688	11800	No
Ammonia	14.9	15.1	No
Chloride	220.2	182	Yes
Fluoride	3.73	3.7	Yes
Nitrate	99.38	93.4	Yes
Nitrite	-	-	
O-Phosphate	2.9	2.87	Yes
Sulfate	497	469	Yes

Table D10-7a. Comparison of Weibull versus Lognormal Distributions: 95 Percent Lower Confidence Limit.

	WEIBULL 95% LCL	LOGNORMAL 95% LCL	W>L?
Aluminum	12133	12000	Yes
Antimony	-	-	
Arsenic	6.59	6.61	No
Barium	134.8	134	Yes
Beryllium	1.466	1.52	No
Cadmium	-	-	
Calcium	18109	17600	Yes
Chromium	19.62	18.9	Yes
Cobalt	16	15.9	Yes
Copper	21.99	22.3	No
Iron	33450	33000	Yes
Lead	10.54	10.4	Yes
Lithium	33.2	33.4	No
Magnesium	7160	7140	Yes
Manganese	511	518	No
Mercury	0.36	0.36	Same
Molybdenum	-	-	
Nickel	19.35	19.4	No
Potassium	2207	2190	Yes
Selenium	-	-	
Silicon	-	-	
Silver	1.3868	0.81	Yes
Sodium	718	716	Yes
Thallium	-	-	
Titanium	2571	2580	No
Vanadium	86.1	86.4	No
Zinc	67.7	68.5	No
Zirconium	-	40	
Alkalinity	8508	8240	Yes
Ammonia	10.5	9.95	Yes
Chloride	128.2	109	Yes
Fluoride	2.93	2.93	Same
Nitrate	59.68	56.9	Yes
Nitrite	-	-	
O-Phosphate	0.85	0.958	No
Sulfate	292	263	Yes

Table D10-7b. Comparison of Weibull versus Lognormal Distributions: 95th Percentile.

	WEIBULL 95%	LOGNORMAL 95%	W>L?
Aluminum	13643	13300	Yes
Antimony	-	-	
Arsenic	7.71	7.65	Yes
Barium	149.3	148	Yes
Beryllium	1.606	1.65	No
Cadmium	-	-	
Calcium	21209	20400	Yes
Chromium	23.02	22.3	Yes
Cobalt	17.1	17.3	No
Copper	25.19	24.7	Yes
Iron	35850	35600	Yes
Lead	12.28	12.2	Yes
Lithium	35.1	35.1	Same
Magnesium	7950	7780	Yes
Manganese	542	561	No
Mercury	0.7	0.7	Same
Molybdenum	-	-	
Nickel	21.45	21.6	No
Potassium	2537	2520	Yes
Selenium	-	-	
Silicon	66.36	59	Yes
Silver	1.52	1.52	Same
Sodium	1099	937	Yes
Thallium	-	-	
Titanium	2921	3000	No
Vanadium	94.6	96.4	No
Zinc	71.6	73.3	No
Zirconium	40.1	47.8	No
Alkalinity	12888	13300	No
Ammonia	16.6	17.3	No
Chloride	259.2	214	Yes
Fluoride	4.02	3.98	Yes
Nitrate	115.88	110	Yes
Nitrite	-	-	
O-Phosphate	4.27	4.08	Yes
Sulfate	585	566	Yes

Table D10-8. Comparison of Weibull versus Lognormal Distributions: 95 Percent Upper Confidence Limit.

	WEIBULL 95% UCL	LOGNORMAL 95% UCL	W>L?
Aluminum	15573	15100	Yes
Antimony	-	-	
Arsenic	9.18	9.06	Yes
Barium	166.3	165	Yes
Beryllium	1.806	1.8	Yes
Cadmium	-	-	
Calcium	25309	24100	Yes
Chromium	27.32	26.8	Yes
Cobalt	18.4	19.2	No
Copper	29.39	27.9	Yes
Iron	38750	39000	No
Lead	14.47	14.5	No
Lithium	37.2	37.2	Same
Magnesium	8950	8580	Yes
Manganese	578	613	No
Mercury	1.49	1.47	Yes
Molybdenum	-	-	
Nickel	23.95	24.5	No
Potassium	2937	2960	No
Selenium	-	-	
Silicon	-	-	
Silver	2.36	3.16	No
Sodium	1909	1274	Yes
Thallium	-	-	
Titanium	3341	3600	No
Vanadium	104.5	110	No
Zinc	76.1	79.3	No
Zirconium	-	58.8	
Alkalinity	19788	23000	No
Ammonia	26.8	32.5	No
Chloride	541.2	460	Yes
Fluoride	5.69	5.67	Yes
Nitrate	234.88	232	Yes
Nitrite	-	-	
O-Phosphate	22.9	21.5	Yes
Sulfate	1202	1360	No

Table D10-9. Comparison of Weibull versus Lognormal Distributions: 80 Percent Confidence Interval.

	WEIBULL 80% CI	LOGNORMAL 80% CI	W>L?
Aluminum	940	900	Yes
Antimony	-	-	
Arsenic	0.63	0.61	Yes
Barium	9.3	9	Yes
Beryllium	0.08	0.09	No
Cadmium	-	-	
Calcium	1830	1700	Yes
Chromium	2.2	1.9	Yes
Cobalt	0.85	0.9	No
Copper	1.7	1.6	Yes
Iron	1700	1800	No
Lead	1.03	1.12	No
Lithium	1.5	1.2	Yes
Magnesium	470	420	Yes
Manganese	23	28	No
Mercury	0.0693	0.09	No
Molybdenum	-	-	
Nickel	1.4	1.4	Same
Potassium	200	200	Same
Selenium	-	-	
Silicon	8.7	0.7	Yes
Silver	0.0046	0.19	No
Sodium	92	106	No
Thallium	-	-	
Titanium	240	270	No
Vanadium	5.8	6.3	No
Zinc	2.9	3.2	No
Zirconium	3.1	4.6	No
Alkalinity	1760	1720	Yes
Ammonia	2.3	2.2	Yes
Chloride	31.7	25.9	Yes
Fluoride	0.47	0.48	No
Nitrate	14.4	13.3	Yes
Nitrite	-	-	
O-Phosphate	0.1565	0.206	No
Sulfate	71.7	63.6	Yes

Table D10-10. Comparison of Weibull versus Lognormal Distributions: 90 Percent Confidence Interval.

	WEIBULL 90% CI	LOGNORMAL 90% CI	W>L?
Aluminum	1330	1200	Yes
Antimony	-	-	
Arsenic	0.98	0.91	Yes
Barium	12.9	12	Yes
Beryllium	0.13	0.11	Yes
Cadmium	-	-	
Calcium	2700	2500	Yes
Chromium	3	2.9	Yes
Cobalt	1	1.2	No
Copper	2.8	2.1	Yes
Iron	2200	2400	No
Lead	1.53	1.5	Yes
Lithium	1.7	1.5	Yes
Magnesium	690	560	Yes
Manganese	29	38	No
Mercury	0.24	0.27	No
Molybdenum	-	-	
Nickel	1.8	1.9	No
Potassium	280	290	No
Selenium	-	-	
Silicon	7.4	11.6	No
Silver	0.0793	0.6	No
Sodium	302	188	Yes
Thallium	-	-	
Titanium	320	380	No
Vanadium	7.5	8.8	No
Zinc	3.6	4.3	No
Zirconium	3.8	7	No
Alkalinity	3680	4090	No
Ammonia	5.1	5.87	No
Chloride	104	82	Yes
Fluoride	0.92	0.89	Yes
Nitrate	45.2	41.4	Yes
Nitrite	-	-	
O-Phosphate	2.232	2.085	Yes
Sulfate	233	232	Yes

Table D10-11. Comparison of Weibull versus Lognormal Distributions: 95 Percent Confidence Interval.

	WEIBULL 95% CI	LOGNORMAL 95% CI	W>L?
Aluminum	1930	1800	Yes
Antimony	-	-	
Arsenic	1.47	1.41	Yes
Barium	17	17	Same
Beryllium	0.2	0.15	Yes
Cadmium	-	-	
Calcium	4100	3700	Yes
Chromium	4.3	4.5	No
Cobalt	1.3	1.9	No
Copper	4.2	3.2	Yes
Iron	2900	3400	No
Lead	2.19	2.3	No
Lithium	2.1	2.1	Same
Magnesium	1000	800	Yes
Manganese	36	52	No
Mercury	0.79	0.77	Yes
Molybdenum	-	-	
Nickel	2.5	2.9	No
Potassium	400	440	No
Selenium	-	-	
Silicon	-	-	
Silver	0.84	1.64	No
Sodium	810	337	Yes
Thallium	-	-	
Titanium	420	600	No
Vanadium	9.9	13.6	No
Zinc	4.5	6	No
Zirconium	-	11	
Alkalinity	6900	9700	No
Ammonia	10.2	15.2	No
Chloride	282	246	Yes
Fluoride	1.67	1.69	No
Nitrate	119	122	No
Nitrite	-	-	
O-Phosphate	18.63	17.42	Yes
Sulfate	617	794	No

APPENDIX E

SITEWIDE BACKGROUND SOIL SAMPLING PLAN

Appendix E – Soil Sampling Plan

JUN 20 1991 Sta. 21 | (20) **ENGINEERING DATA TRANSMITTAL** | Page 1 of 1

1. EDT 133003

2. To: (Receiving Organization) Distribution

3. From: (Originating Organization) Environmental Engineering Technical Baseline Section

4. Related EDT No: N/A

5. Proj/Prog/Dept/Div: 81223

6. Cog/Proj Engr: C. D. Kramer

7. Purchase Order No: N/A

8. Originator Remarks: Please sign indicating approval of WHC-SD-EN-AP-052, Rev. 0

9. Equip/Component No: N/A

10. System/Bldg/Facility: N/A

11. Receiver Remarks:

12. Major Assm Dwg No: N/A

13. Permit/Permit Application No. N/A

14. Required Response Date: N/A

15. **DATA TRANSMITTED**

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-EN-AP-052		0	Site-wide Background Soil Sampling Plan	3	1	1	

16. **KEY**

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 see MRP 5.43 and EP-1.7	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. **SIGNATURE/DISTRIBUTION** (See Impact Level for required signatures)

(G) Reason	(H) Disp	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp
1	1	Cog./Proj. Eng C.D. Kramer	C.D. Kramer	6/26/91	H4-55						
1	1	Cog./Proj. Eng. Mgr. R.P. Henckel		6/26/91	H4-55	H4-55					
1	1	QA D.G. Farwick	D.G. Farwick	6/26/91	H4-16	H4-16					
		Safety									
1	1	A.L. Prignano		6/26/91	H4-57						
1	1	F.A. Ruck	for FAR	6/26/91	H4-57						

Signature of EDT Originator	Date	Authorized Representative for Receiving Organization	Date	Cognizant/Project Engineer's Manager	Date	21. DOE APPROVAL (if required) Ltr No.
C.D. Kramer	6/26/91			RPH	6/26/91	☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

BD-7400-172 (2/89)

INSTRUCTIONS FOR COMPLETION OF THE ENGINEERING DATA TRANSMITTAL

(USE BLACK INK OR TYPE)

BLOCK	TITLE	
(1)*	EDT	• Enter the assigned EDT number.
(2)	To: (Receiving Organization)	• Enter the individual's name, title of the organization, or entity (e.g., Distribution) that the EDT is being transmitted to.
(3)	From: (Originating Organization)	• Enter the title of the organization originating and transmitting the EDT.
(4)	Related EDT	• Enter EDT numbers which relate to the data being transmitted.
(5)*	Project/Program/ Dept/Div	• Enter the Project/Program/Department/Division title or Project/Program acronym or Project Number. Work Order Number or Organization Code.
(6)	Cognizant /Project Engineer	• Enter the name of the individual identified as being responsible for coordinating disposition of the EDT.
(7)	Purchase Order No.	• Enter related Purchase Order (P.O.) Number, if available.
(8)*	Originator Remarks	• Enter special or additional comments concerning transmittal, or "Key" retrieval words may be entered.
(9)	Equipment/Component No.	• Enter equipment/component number of affected item, if appropriate.
(10)	System/Bldg./Facility	• Enter appropriate system, building or facility number, if appropriate.
(11)	Receiver Remarks	• Enter special or additional comments concerning transmittal.
(12)	Major Assm. Dwg. No.	• Enter applicable drawing number of major assembly, if appropriate.
(13)	Permit/Permit Application No.	• Enter applicable permit or permit application number, if appropriate.
(14)	Required Response Date	• Enter the date a response is required from individuals identified in Block 17. (Signature/Distribution)
(15)*	Data Transmitted	
	(A)* Item Number	• Enter sequential number, beginning with 1, of the information listed on EDT.
	(B)* Document/ Drawing No.	• Enter the unique identification number assigned to the document or drawing being transmitted.
	(C)* Sheet No.	• Enter the sheet number of the information being transmitted. If no sheet number, leave blank
	(D)* Rev. No.	• Enter the revision number of the information being transmitted. If no revision number, leave blank.
	(E) Title or Description of Data Transmitted	• Enter the title of the document or drawing or a brief description of the subject if no title is identified.
	(F) Impact Level	• Enter the appropriate Impact Level (Block 15). Use NA for non-engineering documents.
	(G) Reason for submittal	• Enter the appropriate code to identify the purpose of the data transmittal (see Block 16).
	(H) Originator Disposition	• Enter the appropriate disposition code (see Block 16).
	(I) Receiver Disposition	• Enter the appropriate disposition code (see Block 16).
(16)	Key	• Number codes used in completion of Blocks 15 (G), (H), and (I), and 17 (G), (H) (Signature/Distribution).
(17)	Signature/Distribution	
	(G) Reason	• Enter the code of the reason for transmittal (Block 16).
	(H) Disposition	• Enter the code for the disposition (Block 16).
	(J) Name	• Enter the signature of the individual completing the Disposition 17(H) and the Transmittal.
	(L) Date	• Enter date signature is obtained.
	(M) MSIN	• Enter MSIN. Note: If Distribution Sheet is used, show entire distribution (including that indicated on Page 1 of the EDT) on the Distribution Sheet.
(18)	Signature of EDT Originator	• Enter the signature and date of the individual originating the EDT (entered prior to transmittal to Receiving Organization). If the EDT originator is the Cognizant/Project Engineer, sign both Blocks 17 and 18.
(19)	Authorized Representative for Receiving Organization	• Enter the signature and date of the individual identified by the Receiving Organization as authorized to approve disposition of the EDT and acceptance of the data transmitted, as applicable.
(20)*	Cognizant/Project Manager	• Enter the signature and date of the Cognizant/Project Engineer's manager. (This signature is authorization for release.)
(21)	DOE Approval	• Enter DOE approval (if required) by letter number and indicate DOE action.

*Asterisk denote the required minimum items checked by Engineering Document Control prior to release; these are the minimum release requirements.

BD-7400-172R (2/89)

Appendix E – Soil Sampling Plan

SUPPORTING DOCUMENT

1 Total Pages ~~60~~ 59

2. Title	3 Number	4. Rev. No.
Site-Wide Background Soil Sampling Plan	WHC-SD- EN-AP-052	0

5. Key Words
Background, Composition, Soil, Natural, Hazardous Substance, Waste, Sampling Plan

6. Author
C. D. Kramer
Name (Type or Print)
C. D. Kramer
Signature
81223 / EK16B
Organization/Charge Code 6C276

7. Abstract

This document describes a proposed sampling effort of background sites representative of Hanford Site soils and subsoils. A variety of sites are to be selected primarily based upon accessibility, professional judgement, variety of material, and lack of significant known or suspect local contamination. This effort has developed from the approach described in *Characterization and Use of Soil and Groundwater Background for the Hanford Site*, WHC-MR-0246. It is meant to provide baseline information for use in Hanford Site cleanup activities.

APPROVED FOR PUBLIC RELEASE
V. Birkland 6/26/91

8. PURPOSE AND USE OF DOCUMENT – This document was prepared for use within the U.S. Department of Energy and its contractors. It is to be used only to perform, direct, or integrate work under U.S. Department of Energy contracts. This document is not approved for public release until reviewed.

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9 Impact Level 3

10. R. P. Henckel
Authorized Manager's Name (Type or Print)
R P Henckel
Authorized Manager's Signature
Specify Distribution Limit EXTERNAL

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ENGINEERING CHANGE NOTICE

Page 1 of 16

1. ECN 164706

Proj. ECN

2. ECN Category (mark one)	Supplemental	[X]	Change ECN	[]	Supersedure []
Cancel/Void []	Direct Revision	~~[x]~~ 3/7/92	Temporary	[]	Discovery []

3. Originator's Name, Organization, MSIN, and Telephone No. 68276 C.D. Kramer, 81223, 6-4186 H4-55		4. Date February 26, 1992
5. Project Title/No./Work Order No. EK16B Site-wide Background Soil Sampling	6. Bldg./Sys./Fac. No. NA	7. Impact Level 3
8. Document Number Affected (include rev. and sheet no.) WHC-SD-EN-AP-052, REV 0	9. Related ECN No(s). NA	10. Related PO No. NA

11a. Modification Work	11b. Work Package Doc. No.	11c. Complete Installation Work	11d. Complete Restoration (Temp. ECN only)
[] Yes (fill out Blk. 11b) [X] No (NA Blks. 11b, 11c, 11d)	NA	NA Cog. Engineer Signature & Date	NA Cog. Engineer Signature & Date

12. Description of Change

Page changes describe additional sampling work that will be performed as part of the Site-wide Soil Background study. This additional sampling will focus on determination of organic constituents in the soil. Both sampling and field screening methods are described.

13a. Justification (mark one)	Criteria Change	[X]	Environmental	[]	Facilitate Const.	[]
Design Error/Omission []	Design Improvement	[]	As-Found	[]	Const. Error/Omission	[]

13b. Justification Details

The additional sampling is required to ensure completeness of the effort. The additional sample sites were chosen to specifically focus on naturally occurring organic compounds. The field screening is required at the original (inorganic) sampling sites to determine if any of the sites show evidence of contamination that may affect interpretation of the analytical results.

14. Distribution (include name, MSIN, and no. of copies)

C.D. Kramer, H4-55, 1 copy
R.P. Henckel, H4-55, 1 copy
D.G. Farwick, H4-16, 1 copy
A.L. Prignano, H4-57, 1 copy
F.A. Ruck, H4-57, 1 copy

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DATE MAR 05 1992
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A-7900-013-2 (11/88) (EF) GEF095
Engineering Change Notice

A-7900-013-1 (11/88

ENGINEERING CHANGE NOTICE	Page 2 of 16	1. ECN (use no. from pg. 1) 164706

15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[NA] $	Additional	[NA] $	Improvement	[NA]
[X] No	Savings	[NA] $	Savings	[NA] $	Delay	[NA]

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]		[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
NA		

20. Approvals

	Signature	Date		Signature	Date
OPERATIONS AND ENGINEERING			ARCHITECT-ENGINEER		
Cog./Project Engineer	E. P. Kramer	3/3/92	PE		
Cog./Project Engr. Mgr.	RP [illegible]	3/3/92	QA		
QA	R.W. Vance	3/3/92	Safety		
Safety			Design		
Security			Other		
Proj. Prog./Dept. Mgr.					
Def. React. Div.					
Chem. Proc. Div.					
Def. Wst. Mgmt. Div.			DEPARTMENT OF ENERGY		
Adv. React. Dev. Div.					
Proj. Dept.					
Environ. Div.			ADDITIONAL		
IRM Dept.					
Facility Rep. (Ops.)					
Other: Project Coordinator	[illegible]	3/3/92			
Project Coord. Mgr	J.G. [illegible] III	3/3/92			

A-7900-013-3 (11/88) (EF) GEF096
Engineering Change Notice (Page 2)

Appendix E – Soil Sampling Plan

INFORMATION

INFORMATION RELEASE REQUEST

References: WHC-CM-3-4

COMPLETE FOR ALL TYPES OF RELEASE

Purpose

- [ ] Speech or Presentation
  - [ ] Full Paper
  - [ ] Summary
  - [ ] Abstract
  - [ ] Visual Aid
  - (Check only one suffix)
- [ ] Speakers Bureau
- [ ] Poster Session
- [ ] Videotape
- [x] Reference
  - [ ] Technical Report
  - [ ] Thesis or Dissertation
  - [ ] Manual
  - [ ] Brochure/Flier
  - [ ] Software/Database
  - [ ] Controlled Database
  - [ ] Other

New ID Number ECN 164706 ~~WHC-SD-EN-AP-052 Rev. 0-A~~ to 3/

Existing ID Number (include revision, volume, etc.) WHC-SD-EN-AP-052 Rev. 0

If previously cleared, list ID number WHC-SD-EN-AP-052 Rev. 0

Date Release Required March 31, 1992

Title: Site-wide Background Soil Sampling Plan

Unclassified Category: UC-

Impact Level: 3

COMPLETE FOR SPEECH OR PRESENTATION

Title of Journal: NA

Group or Society Sponsoring: NA

Date(s) of Conference or Meeting: NA

City/State: NA

Will proceedings be published? [ ] Yes [X] No

Will material be handed out? [ ] Yes [X] No

Title of Conference or Meeting: NA

CHECKLIST FOR SIGNATORIES

Review Required per WHC-CM-3-4	Yes	No	Reviewer Name (printed)	Signature	Date
Classification/Unclassified Controlled Nuclear Information	[ ]	[x]			
Patent - General Counsel	[ ]	[x]			
Legal - General Counsel	[ ]	[x]			
Applied Technology/Export Controlled Information or International Program	[ ]	[x]			
WHC Program	[ ]	[x]			
Communications	[ ]	[x]			
DOE-RL Program	[ ]	[x]			
Publication Services	[x]	[ ]	DE Smith	DE Smith	3/4/92
Other Program	[ ]	[x]			
References Available to Intended Audience	[x]	[ ]	CD Kramer	C. D. Kramer	3/3/92
Transmit to DOE-HQ/Office of Scientific and Technical Information	[ ]	[x]			

Information conforms to all applicable requirements. The above information is certified to be correct.

Author/Requestor (Printed/Signature) Date

C. D. Kramer

C. D. Kramer 3/3/92

Responsible Manager (Printed/Signature) Date

R. P. Henckel

RPH 3/3/92

Intended Audience

[ ] Internal [ ] Sponsor [x] External

INFORMATION RELEASE ADMINISTRATION APPROVAL STAMP

Stamp is required before release. Release is contingent upon resolution of mandatory comments.

APPROVED FOR RELEASE — SPECIAL DOCUMENT — NS — Date 3/4/92

Date Received 3/4/92 DS

80-7600-062 (4/90) (EF) WEF074
Information Release Request

Part 1

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1.0 OBJECTIVE

This plan outlines the sample collection and analysis effort for a Hanford site-wide soil background study. Baseline data will be generated to support Hanford cleanup activities. The word "soil" is meant to be understood as that called "soil" in the context of environmental cleanup regulations--not another field of study. The collection and analysis effort will employ procedures used for characterization activities. Both the concentration and variability of selected naturally occurring soil constituents are of interest.

The domain of the study will be a variety of judgement-selected locations within the boundaries of the U.S. Department of Energy's Hanford Site. Selected locations will include the Hanford formation and younger geologic units.

Samples will represent a compositional range typical of uncontaminated Hanford Site soil. Study results will provide regional Hanford Site background data, rather than specific localized background data for any particular Hanford hazardous waste site, or waste management unit. Data will support the development of contamination identification and cleanup standards for the Hanford Site by (1) allowing for testing and refinement of a site conceptual model, and (2) providing a database for future comparisons.

This plan is intended to be a general soil sampling plan to support and integrate with the activities evolving from the Environmental Division background task teams. The draft Westinghouse Hanford Company (Westinghouse Hanford) document, *Characterization and Use of Soil and Groundwater Background for the Hanford Site* (WHC 1991), has served as a basis for this plan. The sampling covered by this plan is currently proposed for fiscal year 1991.

2.0 PROJECT/FIELD TEAM ORGANIZATION

Overall project organization is the responsibility of the Westinghouse Hanford Environmental Division RCRA Closure Activities Section as sponsor of the background task teams (see Appendix A and Figure A-1). A project coordinator (Project Lead) has been assigned by management. Various tasks have been delegated among the participants of the background strategy task team. Development and performance of this sampling plan combined with other task team work will help achieve the overall project objectives. The Project Lead will be a focal point for project-related decisions, and will facilitate work on all aspects of this project.

The Westinghouse Hanford Geosciences Group will be responsible for choosing general sampling locations in conjunction with the Project Lead or designee, and for determining specific authoritative sample locations, geologic logging, and geological interpretation. The field team geologist shall be a member of the Geosciences Group.

Field team leadership shall be provided by the Westinghouse Hanford Environmental Engineering Group. The Environmental Engineering Group will interface with Environmental Field Services, Office of Sample Management (OSM), Traffic and Shipping, Operations Support Services, and other organizations as necessary to perform sampling as directed by the Project Lead. The OSM shall be responsible for arranging laboratory support and validating related chemical analyses. All field activities are to be consistent with this sampling plan and applicable sections of WHC-CM-7-7 (WHC 1988a).

Members of the field team shall include the team leader, geologist(s), samplers, and the following, as necessary: health and safety personnel, quality assurance and/or operations support personnel. All field personnel shall be familiar with this plan, the Quality Assurance Project Plan (Appendix A), and the appropriate job safety analysis (JSA) (or Health and Safety Plan, if applicable) before sample collection. It is the responsibility of the Field Team Leader to have a copy of this plan and the JSA (or Health and Safety Plan, if applicable) for field reference.

Because this project involves multiple separate areas to be sampled, the Project Lead will assign an individual(s) to determine and confirm that current requirements, if any, are met with respect to an excavation permit, cultural resource review, and *National Environmental Policy Act of 1969* documentation. Sampling will not be undertaken at any location for which applicable requirements of the aforementioned are not satisfied. If the assigned individual(s) is <u>not</u> the Field Team Leader, documentation will be furnished to the Field Team Leader to confirm compliance.

3.0 SCHEDULE

Sampling will begin upon approval of this plan. Sampling is scheduled to be completed by August 1991, subject to laboratory availability. Laboratory availability for all mandatory analytes will be confirmed before samples are collected. Sampling after August 1991 shall be authorized by the Westinghouse Environmental Division RCRA Closure Activities Section manager. Samples collected after August 1991 may require fast laboratory turnaround to complete current project reporting schedules. The OSM shall provide a complete and validated data package by October 1 for all samples received by the laboratory before August 1991. Project reporting is currently scheduled for completion by the end of January 1992. Deviations to this schedule may be arranged by the Plan Lead or delegate. Schedule changes will be documented in project files by an Internal Memo. Schedule changes alone will not be sufficient cause to issue plan revisions.

4.0 SAMPLING EQUIPMENT

Samples will be collected using stainless steel tools. Collection equipment may include trowels, spoons, scoopulas, bowls, screens, and funnels. All tools contacting the sample material will be laboratory decontaminated in accordance with EII 5.5, "1706 KE Laboratory Decontamination of RCRA/CERCLA Sampling Equipment" (WHC 1988a), or other approved method. Sampling site overburden may be removed with non-stainless steel tools. The Field Team Leader will be responsible for providing or arranging for enough decontaminated equipment and sample jars to complete each day's sampling activities.

Sample jars will either be cleaned by Westinghouse Hanford personnel, per EII 5.5 (WHC 1988a) or equivalent, or will be purchased precleaned from a sample jar supplier. In the latter case, evidence of cleanliness may include a quality control certificate of analysis from a reputable supplier, and tamper-indicating seals on unopened factory cartons. Archived samples shall be kept in jars cleaned to similar standards as those containing samples for chemical analyses. All sample jars shall be kept closed while in storage.

As a matter of policy, Westinghouse Hanford requires a radiological survey of all sample material prior to transport off the Site (see Section 9.0). This total activity determination is for release from administrative radiologic controls. Containers for material to be surveyed may be new, stores-stocked containers. The latter may be rinsed with deionized water prior to use (at the Field Team Leader's option), but need not necessarily be chemically decontaminated by EII 5.5 (WHC 1988a).

Other common supplies used by the sampling team may include, but are not limited to, the following.

Shovels	Paper towels
Latex or vinyl gloves	Clean rags
Ice chests with wet or "blue" ice	Plastic or paper sheeting
Absorbent (vermiculite) for shipping	Field work table
Permanent black marking pens	Black pens
Evidence tape	Wooden stakes
Measuring tapes	Bright flagging material
Compass	Hammer
Maps	Ropes
Plastic bags (variety of sizes)	Ladders
Squirt bottles	Camera with film
Water (potable and deionized)	Coveralls (Blues)
Cups	Personal safety equipment
Sample Labels	Dilute HCl
Tape (masking, plastic, and duct)	Hand lens
Scissors	Logbook
Forms • Chain-of-custody • Sample Analysis Request • Offsite Property Control • Geotechnical Sample Transfer Record	

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5.0 SELECTION OF GENERAL SAMPLE SITES

General background sampling areas were determined by soil exposure and accessibility, professional judgement, and opportunity. The stratigraphic units of the study population are (1) the early to late Pleistocene Hanford formation, (2) late Pleistocene-Holocene Columbia River and side stream deposits, and (3) Pleistocene to Holocene eolian deposits. Sites at which a variety of soil types could be sampled were favored over those exhibiting only a single type. Another strategy, presented below, was used for selecting sites for organic constituent measurement.

Fourteen general sites have been identified within the project area as suitable candidates for sampling. Inorganic samples and field screening measurements for organic constituents will take place at these sites. Twelve of these sites are within the boundaries of the Hanford Site. Two sites are located outside Hanford boundaries, east of the Columbia River. Most samples will be taken from the vertical exposures of borrow pits or outcrops. Appendix B contains maps showing aggregate and individual site locations. Additional sites may be included at the discretion of the Project Lead with management approval. The Project Lead will document the inclusion of any additional sites by a letter of instruction to the Environmental Engineering Technical Baseline manager and the assigned Field Team Leader. A copy of this letter will be retained in the associated project file records by the Project Lead.

Sampling for organic compounds will be divided into two phases. One phase will consist of qualitative field measurements as described in Appendix C. The other phase will consist of laboratory measurements on select scoping samples. The objective of the latter is to explore a range of typical natural conditions for general comparative purposes.

Sampling for laboratory measurement of naturally occurring organic compounds will be conducted at a minimum of 30 feet from pits, excavations, or vertical outcropping to minimize the effects of aeration induced dilution of volatile/semivolatile soil constituent concentrations. A botanist/soil scientist will identify candidate sample locations within each main ecosystems where waste operations exist on the Hanford Site. Each of the following ecosystems has different vegetation assemblages that can be associated with naturally occurring organic compounds:

- Columbia River Plain: extending inland from the Columbia River westward to the Cold Creek Valley
- Old Field: pre-Hanford Site abandoned agricultural fields within the upper Columbia River Plain (representative of 100-F, 100-H, and 100-D Areas)
- 200 Area Plateau: broad elevated area topographically higher than the Columbia River Plain.
- Riparian: A narrow zone alone the wetted shoreline of the Columbia River and spring streams in the Rattlesnake Hills.

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Supporting analyses on these samples will include field screening and inorganic analyses similar to the fourteen general sites referenced in Appendix B.

A prime requirement of all sample locations was and is no known or suspected significant, localized soil contamination. The Field Team Leader is authorized to disqualify any sample collection locations that, in his or her judgement, do not reflect sufficiently native conditions in part of the Hanford Site vadose zone.

6.0 SELECTION OF SAMPLE MATERIAL

6.1 DEFINITIONS

- *Sample*: A sample shall consist of an adequate volume of soil mixed in the field and submitted for the analysis and/or archiving. Samples will be processed to achieve a degree of homogeneity throughout the media thereby minimizing subsample variability.

- *Field Split Samples*: Two or more sample volumes collected in such a manner that they are equally representative of the variables of interest at a given location. For this study, split samples shall be mixed either in a large stainless steel container or in-place at the site of collection.

- *Collocated Samples*: Uncomingled samples attributed to a common location in the time and space. Whereas field split samples have been mixed and reallocated by sample collection, collocated samples have preserved natural diversity between samples ascribed to the location.

- *Subsample*: A portion of a sample less than the entire sample. Subsamples will be submitted for analysis. For example, from one sample point, two 120-mL portions may be submitted for various analyses, and another 120-mL jar archived. They may be generically referred to as samples.

- *Representative*: Exhibiting a typical or common characteristic of a class. A sample is representative of an entire population only to the extent that it reflects the average of that population.

- *End member*: One of the two extremes of a geologic compositional series.

Additional definitions can be found in the glossary of Appendix A.

6.2 CHOOSING THE SAMPLE

The following four basic categories of samples will be selected from the field:

- Systematic samples
- Judgement (authoritative) samples
- Grain size effect samples
- Organic analyses samples.

Each sample shall be composed of material collected from a single contiguous area (i.e., not a composite). Aliquots from the sampled locations may be reserved for radiologic shipping surveys (Section 9.0). Aliquots collected for this purpose can be composited at the Field Team Leader's discretion.

Consistent with the requirements of EII 5.1 (WHC 1988a), a representative portion of each sample is to be sent to the analytical laboratory. The remainder of the sample is to be archived in the Hanford Geotechnical Library should further analyses be desired. Unused samples may be disposed of after 24 months with written permission from the Project Lead.

6.2.1 Systematic Samples

These samples will be selected by systematic allocation along a single line perpendicular to the major strata at a site; the number of samples at each site will be proportional to the vertical height of the exposure to be sampled. The Project Lead will assign an individual to provide the Field Team Leader with a suggested target number and spacing of systematic population samples to be chosen at each general location. The distance between sample points shall remain relatively constant throughout all locations. The geologist will determine, consistent with the above constraints, which general section of the exposure is most representative for sampling. The Field Team Leader will randomly select an initial sample location from the eligible

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surface. Sample points will be centered at regular intervals from this point to the upper- and lowermost eligible areas. Field splits (3) shall be collected at the randomly determined initial sample location. Two will be submitted for inorganic chemical analysis. See Section 6.2.3 for a discussion of the third split sample.

6.2.2 Judgement Samples

Specific locations of judgement samples will be based solely upon professional judgement of the geologist field team member. The objective of this sampling is to allow the geologist to have the latitude to collect the following:

- Selected end member samples
- Potential outlier samples
- Samples that represent typical local lithology.

As a matter of allocation of project resources, it is recommended that the total judgement samples collected throughout the project not exceed the total systematic samples.

Compositional end members are discussed further in *Characterization and Use of Soil and Groundwater Background for the Hanford Site*, WHC-MR-0246 (WHC 1991). End members are defined to be either quartz-feldspar or basaltic silts and sands. Potential outlier samples are those materials that are compositionally discontinuous with the above series. They are not mixtures of quartz-feldspar and basaltic silts and sands. Such samples may be ash layers, caliche, etc. The geologist also may select samples representative of the major lithologies at the sites.

6.2.3 Grain Size Effect Samples

An evaluation of the effect of grain size on leachate concentrations for inorganic species will be conducted in conjunction with soil sampling and analysis for the Site-wide background survey (see Appendix A1.2). Material for grain size effect samples shall be collected from the same location where field split samples are collected. These samples will be collected as one of three field splits from the selected locations. Sample jars of the same dimensions as those submitted for chemical analysis will be used with this exception: a third 250-mL archived portion need not be retained from the location of the field split samples. After collection, a random-number table or equivalent will be used to assign subsamples for grain size analysis, and chemical analyses of routine samples and splits.

6.2.4 Samples for Organic Analysis

Field measurements will be performed on samples collected along the systematic lines chosen in conjunction with Section 6.2.1. Field measurements shall also be made in conjunction with samples collected for laboratory organic analysis.

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At the time of this plan modification, inorganic sampling per Section 6.2.1 has already been completed at the fourteen sites listed in Appendix B. These sites will be revisited for the purpose of making organic field measurements.

One sample from above the uppermost, and one below the lowermost systematic sampling points shall be collected for field measurements. Several locations are in active borrow pits. Field samples shall not be collected where, in the field team leader's judgement, site excavation has obliterated previously sampled areas. This will be noted in the field logbook. At site #6, the Grout Facility pit, an additional sample is to be collected at the approximate midpoint of the sampled exposure. An additional sample shall also be collected from the west extension of site #7, the submarine reactor core pit, in a moist silt/clay lens. This sample is to be as close as possible to the collection point of B014D5 (10/11/91).

Field measurements will be made using the methodology of Appendix C.

Samples for laboratory analysis will be chosen on a judgement basis per Section 5.0. These are described in the remainder of this section. Project personnel will use professional judgement to select specific sampling locations from among the locations identified by the botanist/soil scientist.

Selected samples will be collected to evaluate the types and levels of organic compounds that occur naturally in the Hanford Site soil and corresponding inorganic soil compositions. Field measurements, as above, shall also be made on collocated samples from the selected sites.

At least one sample will be collected within each of the four ecological categories listed in Section 5.0.

The vegetation type, proportions, density, etc. in the sampling vicinity will be photographed at the time of sampling. The vegetation type associated with or immediately above specific soil samples will be noted in the field logbook.

All samples will be analyzed for total organic carbon (TOC), routine Contract Laboratory Program (CLP) volatiles and semivolatiles to characterize naturally occurring levels. Routine CLP organochlorine pesticides and polychlorinated biphenyls (PCBs) will also be analyzed as screening criteria regarding the integrity of the samples as background for completeness. Tentatively identified compounds also may be reported in accordance with CLP protocols. Splits of these samples will also be analyzed for the inorganic analytes listed in Tables A-1 and A-2. Individual analytes may be excluded at the direction of the Project Lead. Changes will be documented by the Project Lead and included in project files. Changes prior to shipment will be noted by the Field Team Leader in the controlled field logbook. Grain size analysis is not planned for samples collected for either field or offsite laboratory organic analysis.

6.3 WHAT MATERIAL IS EXCLUDED

Sample collection may exclude stones, organic debris, etc., that are larger than 2 mm. The *Model Toxics Control Act Cleanup Regulations*

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(Ecology 1991) specify soil compliance monitoring on the <2-mm-size fraction unless larger particles can be expected to contain higher concentrations of hazardous substances. Because most situations at the Hanford Site involve soil contaminated by various liquid sources, the 2-mm-size fraction cutoff point will be applicable. In lieu of onsite sieving to 2-mm, the analytical chemistry facilities must be instructed when to use only the <2-mm portion of submitted material.

Where field and/or laboratory sieving would be reasonably expected to compromise the analysis, it shall not be performed. All samples collected for the purposes of measuring organic constituents, and their split or collocated samples submitted for corresponding inorganic analyses shall not be sieved.

Recent river, stream, lake, or pond sediments are not within the scope of this study. (This is not intended to be confused with a geologic definition of a sediment.) For the purposes of this study, any soil covered by an open body of water at the time of sample collection shall be considered a sediment.

7.0 BOTTLE AND FIELD PACKAGING REQUIREMENTS

Samples are to be collected in compliance with EII 5.2, "Soil and Sediment Sampling" (WHC 1988a). Sample numbers are to be obtained from OSM. Unused sample numbers will be returned to OSM after sampling concludes.

Sample labels should include at least the following:

- Company name (or initials, WHC)
- Company contact and phone number
- Hanford Environmental Information System (HEIS) sample number
- Name of collector
- Date and time of collection
- General place of collection.

Tamper-indicating seals must be attached in such a way as to require breaking to open the sample container. The seals must be applied before samples leave the custody of sampling personnel. Sampling personnel must date and initial the seals.

Samples submitted for total activity may be composite samples. The Field Team Leader may exercise discretion when determining how many samples to represent with each composite. There shall be at least one total activity sample for each ice chest of samples to be sent offsite.

Sample analytes, volumes, and type of jar are as follows:

- Inorganics--Three 120-mL or one 250-ml glass or plastic jars.

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- Archived Subsample--One 250-mL (or two 120-mL) glass or plastic jars for all samples submitted for inorganics, and one 120-mL jar for grain size samples (see below).
- Grain Size--Two 120-mL glass or plastic jars for analysis and one 120-mL jar reserved as archived material.
- Total Activity--One glass or plastic jar with ≥10 g of soil.
- Volatiles--One or two 120-mL glass jars, as required by the laboratory.
- Semivolatiles, Pesticides/PCBs, and TOC--One 250-mL or two 120-mL glass jars.

Glass jars are required to have teflon-lined caps. All sample containers shall meet the requirements of Section 4.0. Additional 120-mL containers may be submitted for chemical analyses, if necessary.

8.0 CHEMICAL ANALYSES

Analytical methodology to be used is listed in Appendix A. Section 9.0 of this plan deals with radiation surveys. Additional analyses may be performed on any archived portion with written permission from the Plan Lead. The analysis methodology, provision for quality control, and return of any material shall be specified in the request.

Onsite analytical work shall be arranged by the Project Lead or designee. Offsite analytical work for the inorganic and organic analyses that follow shall be requested by an Environmental Engineering task order to OSM.

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The task order title will be "Site-Wide Soil Background." Task agreements developed by OSM will be consistent with Appendix A.

INORGANICS

All systematic and judgement-selected samples are to be analyzed for the following list of inorganic analytes.

Inductively Coupled Plasma Method Metals

Aluminum	Iron	Silicon
Barium	Magnesium	Silver
Beryllium	Manganese	Sodium
Calcium	Molybdenum	Titanium
Chromium	Nickel	Vanadium
Cobalt	Potassium	Zinc
Copper		Zirconium

Atomic Absorption Method Metals

Antimony	Cadmium	Selenium
Arsenic	Lead	Thallium
	Mercury	

Anions and other analytes

Chloride	Nitrite	Carbonate
Nitrate	Phosphate	Ammonium
Fluoride	Sulfate	

GRAIN SIZE

Westinghouse Hanford personnel will perform separate sieve analyses on each submitted subsample in accordance with Section 11.2 and Appendix A.

ORGANICS

Samples collected for organic analysis will be analyzed for the most recent CLP Statement of Work volatile organic, semivolatile, and pesticide/PCB target compound list. Subsamples shall also be analyzed for TOC.

9.0 RADIOLOGICAL SURVEYS

Movement of samples originating on the Hanford Site will be subject to radiologic controls. Offsite shipment will require a total activity analysis at the 222-S Laboratory or a comparable facility for this determination. Samples received by the Geotechnical Library for archiving will require a radiological survey. The Health Physics organization shall be responsible for

designating the radiologic status of the samples. Any sample or subsample that does not qualify for unconditional offsite release will be excluded from the study. The Project Lead is to be notified promptly by the Field Team Leader if this occurs.

10.0 SHIPPING

Shipping will be performed in compliance with EII 5.11 (WHC 1988a). The Field Team Leader may designate a member of the field team to be responsible for outgoing shipments. This person(s) should coordinate shipping with Westinghouse Hanford Shipping personnel at least 1 week before sample collection. Generally, samples should be at Shipping by 1300 hours.

Samples leaving the city of Richland will be shipped in ice chests with "blue" ice. Vermiculite or similar absorbent should be placed over and around samples for padding and insulation. Ice chests should not be sealed until final shipping documentation is placed inside. This will include the chain-of-custody form, sample analysis requests, and an offsite property control form (OPSC). (Retain photocopies of at least the chain-of-custody and analysis request forms.) Copies shall be forwarded to OSM.

A bill of lading number is obtained from Westinghouse Hanford Shipping and placed on the OSPC form. A unique OSPC "serial" number and approval need to be obtained from Westinghouse Hanford Property Management (1163 Building, room 396L). Record the bill of lading and OSPC serial numbers on the chain-of-custody form.

11.0 QUALITY CONTROL

11.1 FIELD DOCUMENTATION

Documents to be originated and maintained by field personnel include a controlled field logbook, chain-of-custody documentation, and sample analysis requests.

A field logbook will be kept by the Field Team Leader or his designee consistent with the instructions for RCRA and CERCLA/SARA field activities, EII 1.5, "Field Logbooks." Sufficiently detailed information should be entered to allow unfamiliar personnel to reconstruct sampling activities. The minimal information necessary to support project objectives will include the following:

- Names of individuals involved in field activity
- Signature of person making the entry
- Locations of all sampling points

- Site description
- Sample identification
- Date and time of collection
- Method of choosing exact location
- Method of collection
- Type and origin of sample containers
- Problems and corrective action, if necessary.

Conditions and the exact location of each sampling site should be documented with photographs (prints or slides) before, during, or immediately after sampling. Attempt to obtain a photographic record of both the specific and general location to the extent feasible. An object to show scale also may be helpful. A detailed description of each photograph should be maintained for future reference. At a minimum, this should include a record of the time, date, and location of the photograph.

The geologist is required to maintain a controlled logbook. At a minimum, the geologist will record a geologic description of the sampled area and material collected. This will include the thickness of the sampled unit and approximate depth from the surface. Many sample locations in this study will be specified by the geologist in the field. The justification for field decisions regarding sampled location will be outlined in this logbook.

The Field Team Leader will maintain a file of project-related documentation and will be responsible for final disposition of its contents in accordance with EII 1.6, "Records Management." Individuals will be responsible for the final disposition of assigned logbooks. The Project Lead will be responsible for other project data in accordance with Chapter 1.0 of WHC-CM-7-7 (WHC 1988a).

11.2 QUALITY CONTROL SAMPLING

Unused portions of all samples will be stored at the Geotechnical Library in accordance with Section 5.2.2.

For split samples, it is recommended that sample containers be filled concurrently rather than sequentially to further minimize the affect of any stratification of analytes in the media. The purpose is to minimize variability, and provide substantially identical samples.

Field quality control sampling will be as follows for systematic and judgement sampling:

- One set of split samples per general site for systematic sampling
- One set of split samples per general site for judgement sampling.

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An aliquot of one sample will be sent to the primary laboratory; the other sample sent to an alternate laboratory. In the event that an alternate laboratory is not available for a particular analysis, the Project Lead may direct the Field Team Leader to temporally separate the submission of split samples to a single laboratory. This will be bounded by the ability of laboratory to analyze the sample within the respective allowed holding time. These samples will be used to estimate precision of the entire measurement system.

Field quality control for volatile organic sampling shall include the following:

- One pair of collocated samples for each 10 samples--Collect it at the first or second sample point and every tenth point thereafter. One of the pair should be sent to the primary laboratory, and the other should be sent to an alternate laboratory. Samples will be considered as collocated when removed concurrently from a common sampling point. Collect at least one collocated pair per sampling day.

- One sand equipment/field blank for each 10 samples--Expose trip blank material to ambient field conditions and collection equipment. The blanks may be increased to one per general site at the Field Team Leader's discretion. Collect at least one volatile organic analysis (VOA) field blank per sampling day.

- One sand trip blank for each 20 samples--Use collection equipment similar to that used in the field to process this sample. Do not open this container in the field unless preparing a field blank. Submit at least one per ice chest of VOA samples (see Appendix A, Section A9.0).

At the Project Lead's option, material submitted for VOA blanks may be heat treated or microwaved before use to reduce the possibility of the presence of any detectable volatile compounds. If such operations are performed, they will be documented in project records. Attempt to separate in both time and location those blanks collected in a single day.

Field quality control for semivolatile, pesticide/PCB, and TOC sampling shall include the following:

- One pair of collocated samples for each 20 samples--Collect it at the first or second sample point and every 20th point thereafter. One of the pair should be sent to the primary laboratory, and the other should be sent to an alternate laboratory. Samples will be considered as collocated when removed concurrently from a common sampling point. Collect at least one collocated pair per sampling day for each analysis.

- One sand equipment/field blank for each 20 samples--Expose sand blank material to ambient field conditions and collection equipment. The blanks may be increased to one per general site at the Field Team Leader's discretion. Collect at least one field blank per sampling day for semivolatiles and pesticides/PCBs. Field blanks are not required for TOC measurements.

Grain size sampling shall include the following:

- Duplicate subsamples for each sample--Two identical containers for separate analysis. Remaining sample material should be reserved for optional, Project Lead-specified analyses and/or submitted to the Geotechnical Library.

11.3 SAMPLING PLAN DEVIATIONS

Every reasonable effort will be made to comply with the intent of this sampling plan as written. Significant revisions to this plan may be made in accordance with WHC-CM-6-1, *Standard Engineering Practices* (WHC 1988b). Deviations from the EII because of unforeseen situations may be made by following EII 1.4. Should field conditions require minor modification of this plan, the problem and its solution will be documented in the appropriate logbook as soon as possible. Minor modifications are those not affecting the schedule or cost of this project by more than 10%. The Field Team Leader may exercise his or her discretion or consult with management regarding field problems. Field deviations shall not compromise data quality. Field deviations are justified when they improve the efficiency of achieving project objectives without jeopardizing safety or environmental protection.

12.0 JOB SAFETY REQUIREMENTS

A health and safety evaluation and project safety review (as necessary) shall be performed before sample collection. All field personnel shall read the appropriate JSA (or Health and Safety Plan, if applicable) before sampling. Personnel are subject to the requirements of the applicable document. Pre-job planning and safety meetings will be held at least daily at the work sites. The Field Team Leader shall ensure that adequate communication equipment is available during field activities.

13.0 WASTE MANAGEMENT

No hazardous waste will be generated by field operations. Routine nonhazardous waste disposal methods will be used for waste.

14.0 REFERENCES

Ecology, 1991, *The Model Toxics Control Act Regulation*, Chapter 173-340 WAC, Washington State Department of Ecology, Olympia, Washington.

National Environmental Policy Act of 1969, Public Law 91-190, 83 Stat. 852, 42 USC 4321 et seq.

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WHC, 1988a, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC 1988b, *Standard Engineering Practices*, WHC-CM-6-1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991, *Characterization and Use of Soil and Groundwater Background for the Hanford Site*, WHC-MR-0246, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A

QUALITY ASSURANCE PROJECT PLAN
FOR HANFORD SITE-WIDE BACKGROUND SOIL SAMPLING

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GLOSSARY

Accuracy: Accuracy is the closeness of a measured value to the true value. It is estimated using reference samples and percent recoveries.

Blind Sample: A blind sample refers to any type of sample routed to the primary laboratory for purposes of auditing performance relative to a particular sample matrix and analytical method. Blind samples are not specifically identified as such to the laboratory; they may be made from traceable standards, or may consist of sample material spiked with a known concentration of a known compound.

Case: The entire number of samples from this study that are submitted for analytical analysis at a particular laboratory.

Contamination: Excess concentration of a material in a detrimental context.

Comparability: Comparability is an expression of the relative confidence with which one data set may be compared with another.

Completeness: Completeness may be interpreted as a qualitative parameter expressing the percentage of measurements judged to be valid.

Hazardous Substance: Defined by section 101(14) of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as any substance designated pursuant to section 311(b)(2)(A) of the *Clean Water Act*; any element, compound, mixture, solution, or substance designated pursuant to section 102 of CERCLA; any hazardous waste having the characteristics identified under or listed pursuant to section 3001 of the *Solid Waste Disposal Act* (but not including any waste the regulation of which under the *Solid Waste Disposal Act* has been suspended by Congress); any toxic pollutant listed under section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture with respect to which the Administrator has taken action pursuant to section 7 of the *Toxic Substances Control Act*. The term does not include petroleum, including crude oil or any fraction thereof, which is not otherwise specifically listed or designated as a hazardous substance in the first sentence of this paragraph, and the term does not include natural gas, natural gas liquids, liquified natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas). [This definition is different from that used in the current state *Dangerous Waste Regulations*, WAC 173-303, but is identical to its use in the *Hanford Federal Facility and Consent Order* (1989).]

Instrument Detection Limit (IDL): As defined per Contract Laboratory Program (CLP) protocol, it will be equivalent to three times the average of standard deviations obtained on three nonconsecutive days from the analysis of a standard solution (each analyte in reagent water) at a concentration of three to five times the manufacturer's suggested IDL, with seven consecutive measurements per day.

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Method Detection Limit (MDL): As defined per SW-846 Third Edition (EPA 1986a), Chapter ONE, Section 1.3. It is defined as seven times the standard deviation of three replicates of a spiked sample matrix containing the analyte of interest at three to five times the estimated MDL.

Nonconformance: A nonconformance is a deficiency in character, documentation, or procedure that renders the quality of material, equipment, services, or activities unacceptable or indeterminate. When the deficiency is of a minor nature, does not affect a permanent or significant change in quality if it is not corrected, and can be brought into conformance with immediate corrective action, it shall not be categorized as a nonconformance. However, if the nature of the condition is such that it cannot be immediately and satisfactorily corrected, it shall be documented in compliance with approved procedures and brought to the attention of management for disposition and appropriate corrective action.

Precision: A measure of the repeatability or reproductibility of specific measurements under a given set of conditions. Precision may be expressed as standard deviation, coefficient of variation (i.e., relative standard deviation), range, or relative range. Precision is assessed by multiple analyses.

Probability sampling: Sampling that employs a method of random selection.

Quality Assurance: Quality assurance refers to the total integrated quality planning, quality control, quality assessment, and corrective action activities that collectively ensure that the data from monitoring and analysis meets all end user requirements and/or the intended end use of the data.

Quality Control: Quality control refers to the routine application of procedures and defined methods to the performance of sampling, measurement, and analytical processes.

Reference Samples: Reference samples are a type of laboratory quality control sample prepared from an independent, traceable standard at a concentration other than that used for analytical equipment calibration, but within the calibration range. Such reference samples are required for every analytical batch or every 20 samples, whichever is greater.

Release: Defined by section 101 of CERCLA as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant), but excludes (A) any release which results in exposure to persons solely within a workplace, with respect to a claim which such persons may assert against the employer of such persons, (B) emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel or pipeline pumping station engine, (C) release of source, byproduct, or special nuclear material from a nuclear incident, as those terms are defined in the *Atomic Energy Act of 1954*, if such release is subject to requirements with respect to financial protection established by the U.S. Nuclear Regulatory Commission under section 170 of such Act, or, for the purposes of section 104 of CERCLA or any other response action, any release of source byproduct, or special nuclear material from any processing site

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designated under section 102(a)(1) or 302(a) of the *Uranium Mill Tailings Radiation Control Act of 1978*, and (D) the normal application of fertilizer.

Sample delivery groups (SDG): Assigned by the laboratory as the most frequent of the following:

- Each case of field samples received
- Each 20 field samples within a case
- Each 14 calendar day period during which field samples in a case are received.

Validation: Validation refers to a systematic process of reviewing a body of data against a set of criteria to provide assurance that the data are acceptable for their intended use. Validation methods may include review of verification activities, editing, screening, cross-checking, or technical review.

Verification: Verification refers to the process of determining whether procedures, processes, data, or documentation conform to specified requirements. Verification activities may include inspections, audits, surveillances, or technical review.

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A1.0 PROJECT DESCRIPTION

A1.1 CONTEXT OF THE STUDY

Historically, detrimental effects have been associated with contamination (i.e., an excess of some hazardous substance, pollutant, or contaminant). The study will be most concerned with defining upper natural ranges of elements or compounds.

At this time, background soil data collected and analyzed using the current U.S. Environmental Protection Agency (EPA) protocols and methods have been generated on a project-by-project basis. These projects have focused primarily on the constituents of interest at potentially hazardous waste sites--not background. Background sampling was generally performed for local conditions and units. Common elemental concentration ranges and averages are available in literature sources for comparison, but analytical methods are not always stated or comparable. This project will provide information about a variety of locations on or considered similar to the Hanford Site.

Although substantially all environmental cleanup efforts at the Hanford Site are governed by the Tri-Party Agreement (Ecology et al. 1989), and the Site is considered a single facility for RCRA permitting purposes, no common site-wide standard or strategy exists for consolidated use of chemical background data. Individual project background data sets have been used thus far to define contamination. Consequently, "contamination" in one project could easily be consistent with background defined at another project or on another scale. Intuitively, there seems to be little value in defining areas as candidates for remediation solely because they are different.

Both contamination and cleanup standards must have a traceable and justifiable legal basis. The newly promulgated *Model Toxics Control Act* (MTCA) regulations provide some basis for cleanup standards, but do not define when contamination is significant. Under the MTCA regulations, natural background can be used to establish cleanup levels when natural background exceeds cleanup levels established by other methods.

A conceptual model for the chemical compositions of the Hanford Site soils has been developed. Collection and evaluation of new data will help corroborate, refute, or refine the model. This work will enable a more consistent use of contaminant and cleanup definitions predicated upon soil background concentrations.

The background conceptual model views soil background concentrations at the Hanford Site as a unified set of natural compositions ("single population" concept). Although two background areas may differ significantly in variability and/or average concentration, they may still be viewed as subsets of the overall Hanford Site background population. If this larger set can be described sufficiently by a single function, the two subsets are for practical purposes accepted as belonging to a common background population.

The *Characterization and Use of Soil and Groundwater Background for the Hanford Site* (WHC 1991) serves as a basis for this quality assurance (QA) plan

and the associated sampling plan. Soil will be selected from a wide variety of pits, outcrops, and surface sites consistent with the aforementioned.

A1.2 STUDY OBJECTIVES

This project is to provide data to characterize soil background chemical composition on a site-wide scale and allow evaluation of a site-wide conceptual model. Data from this project will be used as a basis for comparison. Background soil concentrations will be measured and documented for selected inorganic elements using a set of defined sample collection procedures and EPA analytical methods. These elements are among those comprising compounds on the groundwater monitoring list (40 CFR Part 264 Appendix IX), the federal hazardous constituents list (40 CFR Part 261 Appendix VIII), and the dangerous waste constituents list of the Washington Administrative Code (WAC) 173-303-9905. (Table A-1 elements can be found on at least one of the three aforementioned regulatory lists.) Background soil concentrations of specified common soil elements, selected anions, and total organic carbon will be also be measured. Organic analytes that have been targeted include routine CLP volatile organics, semivolatiles, and pesticides/polychlorinated biphenyls (PCB). Nontarget compounds may also be reported in accordance with CLP protocols. Tables A-1, A-2, and A-3 list analytes and analytical methodology to be employed. Equivalent methods must be pre-approved by the Project Lead, and documented in project reporting.

Another objective of sampling is to gather data on grain size of those samples submitted for inorganic analysis. The variability of analytical results is a function of physical as well as chemical heterogeneity. The determination of the extent to which grain size (i.e., effective surface area) influences soil leachate compositions is the main objective of this part of the evaluation. Though fractions of the sample larger than 2-mm may be excluded from analysis, smaller fractions can still vary widely in relative particle size and hence, surface area per unit mass. This preliminary assessment will examine correlations between resulting chemical determinations and particle size.

Collection of extra sample material is also a sampling objective. Sufficient sample will be collected to allow future analyses (e.g., X-ray fluorescence, X-ray diffraction, petrographic examinations), at the discretion of the Plan Lead. Such measurements, as well as field observations, may be used with the above chemical data to generate a better understanding of background across the Hanford Site.

A2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

A2.1 SCOPE OF THIS PLAN

This Quality Assurance Project Plan (QAPP) applies specifically to the collection and analysis of background samples per the attached plan, and under the authorization of the RCRA Closure Activities Section's Background Task Teams. It is designed to be implemented in conjunction with the overall QA

program requirements defined by the *Westinghouse Hanford Company Quality Assurance Manual* (WHC-CM-4-2) (WHC 1989). Quality assurance requirements shall also be implemented by the analytical laboratory Statement of Work (SOW) issued through the Westinghouse Hanford Company (Westinghouse Hanford) Office of Sample Management (OSM) and/or other governing procurement documents, as applicable.

A2.2 PROJECT MANAGEMENT RESPONSIBILITIES

Overall Westinghouse Hanford management and organizational structure may be found in WHC-CM-1-2, *Organizational Charts and Charters* (WHC 1987), and WHC-CM-1-3, *Management Requirements and Procedures* (WHC 1988). A project organizational chart is included as Figure A-1. Responsibilities of key personnel and organizations are described as follows:

- Plan Lead (RCRA Closure Activities Section). Westinghouse Hanford Environmental Division's RCRA Closure Activities Section manager is the Plan Lead responsible for overall project organization, performance, and any interface with the regulatory agencies and the U.S. Department of Energy.

- Project Lead. The Project Lead will be appointed by the manager of the RCRA Closure Activities Section. This person shall be responsible for overall direction of sampling and testing activities; responsibilities include the planning and authorization of all work and management of any subcontracted activities, as well as overall technical schedule.

- Geologist (Geosciences). Personnel assigned by the Geosciences Group manager will be responsible for choosing general sampling locations in conjunction with the Project Lead, determining specific judgement-selected sample locations, geologic logging, and geological interpretation. This interpretation may, at the discretion of the Project Lead, be supplemented with optional analyses. Geosciences will be responsible for arranging and verifying supplemental testing to support geological interpretations.

- Field Team Leader (Environmental Engineering). The Field Team Leader is assigned by the Environmental Engineering Technical Baseline manager. The Field Team Leader is responsible for onsite direction of the sampling team in compliance with the requirements of this QAPP, the respective sampling plan, and all implementing Environmental Investigation Instructions (EII).

- Quality Assurance Officer (Environmental Quality Assurance). The QA Officer is responsible for performing formal audits/surveillances to ensure compliance with requirements contained within the QA Project Plan. The QA Officer retains the necessary organizational independence and authority to identify conditions adverse to quality and to inform the Project Lead of needed corrective action. The QA Officer will review all proposals for additional analyses having an impact level 3 or higher.

- Office of Sample Management. The Westinghouse Hanford OSM is responsible for coordinating qualified and approved laboratory support for all analytes listed in Tables A-1, A-2, and A-3; assisting in the tracking of sample shipments; resolution of any chain-of-custody issues; and validating all related data.

A2.3 ANALYTICAL LABORATORIES

Soil samples shall be submitted to an approved Westinghouse Hanford, participant contractor, or subcontractor laboratory, which shall be responsible for performing the analyses identified in this plan in compliance with work order or contractual requirements and Westinghouse Hanford-approved procedures (see Section A4.2). All analytical laboratory work shall be subject to the surveillance controls invoked by QI 7.3, "Source Surveillance and Inspection" (WHC 1989). Each laboratory shall be responsible for the implementation of a written laboratory QA plan. This plan will meet appropriate requirements of the U.S. Department of Energy and the Tri-Party Agreement (Ecology et al. 1989). The Westinghouse Hanford OSM will retain the prime responsibility for ensuring the adequacy of offsite chemical laboratory QA activities.

A2.4 OTHER SUPPORT CONTRACTORS

Procurement of other support contractors may be assigned project responsibilities at the direction of the Project Lead. Such services shall be in compliance with standard Westinghouse Hanford procurement procedure requirements as discussed in Section A4.2. All work shall be performed in compliance with Westinghouse Hanford-approved QA plans and/or procedures, subject to controls of QI 7.3, "Source Surveillance and Inspection" (WHC 1989).

A3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENTS

The EPA has defined five analytical support levels for environmental investigations (EPA 1987a). Analytical support for this project shall correspond to levels IV and V for all EPA methods.

Chemical analyses and documentation needs will be accommodated by adherence to the latest applicable CLP SOW. Laboratory QA/quality control (QC) protocols shall be consistent with all EPA requirements therein. Requirements for laboratory instrument detection limits, precision, accuracy, and reporting are addressed by the protocol.

Some requested analytes and methods are not part of the CLP program. Analytical documentation should be comparable in detail to CLP Routine Analytical Services (RAS). Quality control deliverables shall include source and preparation date of calibration standards, initial and continuing calibration blanks, calibration verification data, matrix spike and duplicate data, sufficient information to confirm calculations, time and date of the

analysis, analyst comments, and other pertinent information. Achieved analytical accuracy will be estimated by the laboratory from predigestion matrix spikes. Matrix spikes should be at appropriate concentrations and volumes to assess method accuracy at the mid-to-upper range of submitted samples. Laboratory duplicates shall be used by the laboratory to evaluate and report intralab-analytical precision. Laboratory accuracy and precision should be no less than recommended method and media specific guidelines contained in the applied procedure. Analyst comments are appropriate when guidelines are exceeded and/or unachievable. Detection limits shall be estimated and reported as either method detection limits per Chapter One of the Third Edition of SW-846 (EPA 1986a) or a comparable method based on standard deviation of multiple analyses of matrix blanks [e.g., limit of detection (LOD) defined by the American Chemical Society]. The definition used shall be clearly indicated in project documentation. Requested detection limits in Table A-2 are examples of approximate anticipated limits--not required parameters.

Goals for data comparability are addressed qualitatively by the adherence to written protocols for sample collection, shipment, and analysis. Sample data shall be reported on a dry-weight basis. Soil chemical data shall be reported consistently for each type of analysis as either mg/kg or µg/kg. Approved analytical procedures shall be consistent with the requested standard reference methods to facilitate the comparability of data sets. All significant deviations must be pre-approved in compliance with Section A4.1. The Westinghouse Hanford OSM will be responsible for notifying the Project Lead of all deviations.

Goals for data representativeness are addressed qualitatively by professional judgement regarding adequacy of geological coverage and by randomization of specific sample collection locations over delineated target units. The Project Lead or designee will justify sampling sites as being accurately representative of Hanford Site soils.

A4.0 SAMPLING PROCEDURES

A4.1 WESTINGHOUSE HANFORD COMPANY SAMPLING AND INVESTIGATIVE PROCEDURES

All sampling activities are to be consistent with the applicable current procedures of WHC-CM-7-7 (WHC 1988) and the Site-Wide Background Soil Sampling Plan. Matters adversely affecting quality shall be reported to management. The QA Officer shall assist in resolving any conflicts arising between this plan, the sampling plan, and company procedures.

Field work shall be reasonably distant from any known or suspected hazardous waste site or localized pollutant source. All sampling equipment shall be clean before use in accordance with the sampling plan. Decontamination may be performed by EII 5.5, "1706 KE Laboratory Decontamination of RCRA/CERCLA Sampling Equipment" (WHC 1988). Soil sampling activities shall be performed in compliance with the applicable sampling plan and EII 5.2, "Soil and Sediment Sampling" (WHC 1988). The eligible material

and basis of selection for each sampled location shall be documented. Soil samples shall routinely be routed to offsite analytical laboratories for chemical analyses. The procedure EII 5.11, "Sample Packaging and Shipping," will guide this effort. Other applicable investigation procedures to be used by sampling personnel include the following:

- "Field Logbooks" . . . . . EII 1.5
- "Chain of Custody" . . . . . EII 5.1
- "Hanford Geotechnical Sample Library Control" . . . . . EII 5.7A
- "Geologic Logging" . . . . . EII 9.1

A4.2 PARTICIPANT CONTRACTOR/SUBCONTRACTOR PROCEDURES

As noted in Section A2.3, participant contractor and/or subcontractor services may be procured at the direction of the Project Lead. All such procurement shall be subject to the applicable requirements of QR 4.0, "Procurement Document Control;" QI 4.1, "Procurement Document Control;" QI 4.2, "External Services Control;" QR 7.0, "Control of Purchased Items and Services;" QI 7.1, "Procurement Planning and Control;" and/or QI 7.2, "Supplier Evaluation" (WHC 1989). Whenever such services require procedural controls, requirements for use of Westinghouse Hanford procedures, or for submittal of contractor procedures for Westinghouse Hanford review and approval before use, shall be included in the procurement document or work order, as applicable. In addition to the submittal of analytical procedures, analytical laboratories shall be required to submit the current version of their internal QA/QC program plans. All analytical laboratory QA/QC plans and procedures shall be reviewed and approved before use by qualified Westinghouse Hanford personnel. All participant contractor or subcontractor procedures, plans, and/or manuals shall be retained as project quality records in compliance with EII 1.6, "Records Management" (WHC 1988); QR 17.0, "Quality Assurance Records;" and QI 17.1, "Quality Assurance Records Control" (WHC 1989).

A4.3 PROCEDURE ADDITIONS AND CHANGES

Should deviations from established EIIs be required to accommodate unforseen field situations, they may be authorized by the Field Team Leader in accordance with the requirements of EII 1.4, "Deviation from Environmental Investigation Instructions" (WHC 1988). Documentation, review, and disposition of instruction change authorization forms are defined within EII 1.4. Other types of document change requests shall be completed as required by the Westinghouse Hanford procedures governing their preparation and revision.

A5.0 SAMPLE CUSTODY

All samples obtained during the implementation of the sampling and analysis plan shall be controlled as required by EII 5.1, "Chain of Custody" (WHC 1989), from the point of origin to the analytical laboratory. Laboratory

chain-of-custody procedures shall be reviewed and approved as required by Westinghouse Hanford procurement control procedures as noted in Section A4.2, and shall ensure the maintenance of sample integrity and identification throughout the analytical process. Offsite sample tracking will be performed by the Westinghouse Hanford OSM procedure "Sample Tracking" (WHC 1990).

Results of analyses shall be traceable to original samples through a unique code or identifier. Westinghouse Hanford will assign the samples Hanford Environmental Information System (HEIS) sample numbers. All results of analyses shall be controlled as permanent project quality records as required by QR 17.0, "Quality Assurance Records" (WHC 1989), and EII 1.6, "Records Management" (WHC 1988).

A6.0 CALIBRATION PROCEDURES

Calibration of all critical Westinghouse Hanford measuring and test equipment, whether in existing inventory or newly purchased, shall be controlled as required by QR 12.0, "Control of Measuring and Test Equipment;" QI 12.1, "Acquisition and Calibration of Portable Measuring and Test Equipment" (WHC 1989); QI 12.2, "Measuring and Test Equipment Calibration by User" (WHC 1989); and/or EII 3.1, "User Calibration of Health and Safety Measuring and Test Equipment" (WHC 1988). Routine operational checks for Westinghouse Hanford field equipment shall be as defined within applicable EIIs or procedures; similar information shall be provided in Westinghouse Hanford-approved participant contractor or subcontractor procedures.

Calibration of Westinghouse Hanford, participant contractor, or subcontractor laboratory analytical equipment shall be as defined by applicable standard analytical methods, subject to Westinghouse Hanford review and approval.

A7.0 ANALYTICAL PROCEDURES

Analytical chemical methods are identified in Tables A-1, A-2, and A-3. Physical analysis of particle size shall be performed by ASTM D 422 - 63. Other analyses may be performed on reserved portions of the samples in accordance with Section A1.2. Procedures based on the referenced methods shall be selected or developed, and approved before use in compliance with appropriate Westinghouse Hanford procedure and/or procurement control requirements as noted in Section A4.2.

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A8.0 DATA REDUCTION, VALIDATION, AND REPORTING

A8.1 DATA REDUCTION AND DATA PACKAGE PREPARATION

All analytical laboratories shall be responsible for preparing a report summarizing the results of analysis and for preparing a detailed data package that includes all information necessary to perform data validation to the extent indicated by the minimum requirements of Section A8.2. Data shall be reported on a dry-weight basis. Data summary report format and data package content shall be defined in procurement documentation subject to Westinghouse Hanford review and approval as noted in Section A4.2. At a minimum, laboratory data packages shall include the following:

- Sample receipt and tracking documentation, including identification of the organization and individuals performing the analysis, the names and signatures of the responsible analysts, sample holding time requirements, references to applicable chain of custody procedures, and the dates of sample receipt, extraction, and analysis

- Instrument calibration documentation, including equipment type and model, initial and continuing calibration data, and method detection limits including reference to the procedure used for their determination

- Additional quality control data, as appropriate for the methods used, including matrix spikes, duplicates, recovery percentages, precision data, laboratory blank data, and identification of any nonconformances that may have affected the laboratory's measurement system during the time period in which the analysis was performed

- The analytical results or data deliverables, including reduced data, reduction formulas or algorithms, unique laboratory identifiers, and description of deficiencies.

Other supporting information, such as reconstructed ion chromatographs, spectrograms, traffic reports, and raw data, will be included in the submittal of individual data packages as necessary to meet the requirements of Section A8.2. All sample data shall be retained by the analytical laboratory and made available for systems or program audit purposes upon request by Westinghouse Hanford, DOE-RL, or regulatory agency representatives (see Section A10.0). Such data shall be retained by the analytical laboratory through the duration of their contractual statement of work, at which point it shall be turned over to Westinghouse Hanford for archiving.

The completed data package shall be reviewed and approved by the analytical laboratory's QA Manager before submittal to Westinghouse Hanford OSM for validation as discussed in Section A8.2. The requirements of this section shall be included in procurement documentation or work orders, as appropriate, in compliance with the standard Westinghouse Hanford procurement control procedures referenced in Section A4.2.

A8.2 VALIDATION

Validation of the completed data package shall be performed by qualified Westinghouse Hanford OSM personnel. Validation requirements will be defined within approved Westinghouse Hanford OSM data validation procedures (WHC 1990) or if lacking, within the referenced guideline document. At a minimum validation will include the requirements as defined within this section.

For CLP inorganic RAS analyses, validation reports shall be prepared documenting checks of the following areas, as recommended in *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA 1988a):

- Sample holding times
- Initial and continuing calibration
- Method blank samples
- Interference check samples
- Laboratory control samples
- Duplicate sample analysis
- Matrix spike samples
- Atomic absorption quality control requirements
- Inductively coupled plasma serial dilutions
- Sample result verification
- Overall data assessments.

For volatile and semivolatile analyses, validation reports shall be prepared documenting checks of the following areas, as recommended in *Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses* (EPA 1988b):

- Holding times
- Gas chromatography/mass spectroscopy tuning and instrument performance
- Initial and continuing calibration
- Blanks
- Surrogate recoveries
- Matrix spike/matrix spike duplicate performance
- Internal standards performance
- Compound identification
- Compound quantitation and reported detection limits
- Tentatively identified compounds
- System performance
- Overall data assessments.

For pesticides/PCB analyses, validation reports shall be prepared documenting checks of the following areas in accordance with the previous guidance (EPA 1988b):

- Holding times
- Pesticides instrument performance
- Initial, analytical sequence and continuing calibration
- Blanks
- Surrogate recoveries
- Matrix spike/matrix spike duplicate performance

- Compound identification
- Compound quantitation and reported detection limits
- Overall data assessments.

For other analyses performed by offsite laboratories, validation reports shall be also be prepared. The results of these analyses will be substantiated with checks similar to the above two lists as applicable per the analytical procedure, EPA guidance, and OSM policy.

A8.3 FINAL REVIEW AND RECORDS MANAGEMENT CONSIDERATIONS

All validation reports and supporting analytical data packages shall be subjected to a final technical review by qualified reviewers at the direction of the Westinghouse Hanford Project Lead, before submittal to regulatory agencies or inclusion in reports or technical memoranda. All validation reports, data packages, and review comments shall be retained as permanent project quality records in compliance with EII 1.6, "Records Management" (WHC 1988), and QA 17.0, "Quality Assurance Records" (WHC 1989). The Project Lead will bear the primary responsibility for dispositioning project related records and data.

A9.0 INTERNAL QUALITY CONTROL

All analytical samples shall be subject to in-process quality control measures in both the field and laboratory. The quality of data generated in this project will be operationally defined by the following internal quality control sampling.

- Split or collocated samples shall be collected and submitted to separate laboratories for a measurement precision assessment.
- Sample splits will be submitted to the Hanford Geotechnical Library for later reference at the option of the Plan Lead. Storage need not exceed 24 months.
- Blind reference samples may be introduced into any sampling round at the Project Lead's direction as a performance and audit of the primary laboratory.
- Sand trip and equipment/field blanks are to be submitted with samples designated for volatile organic analysis (VOA). The latter will also be submitted in conjunction with semivolatile and pesticide/PCB analyses.
- Trip (VOA) blanks shall be prepared before going in the field. These blanks should not be opened in the field, but should accompany samples from the field to the analytical laboratory. Trip blanks may help to assess a source if samples are found to contain unexpected compounds. Trip blanks shall be submitted at a frequency of one per shipping chest of VOA samples.

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- Laboratory internal quality control checks performed per applicable protocol for the analysis. For chemical analysis, this must include data demonstrating achieved accuracy, precision, method calibration, and performance. Reportables will include:

  - Preparation and calibration blanks
  - Calibration verification standards
  - Matrix spikes
  - Duplicates
  - Control samples
  - Other supporting documentation.

The minimum requirements of this section shall be invoked in procurement documents or work orders, compliant with standard Westinghouse Hanford procedures as noted in Section A4.2.

A10.0 PERFORMANCE AND SYSTEM AUDITS

No performance, system, or program audits are currently scheduled, but all program activities are subject to oversight by Westinghouse Hanford QA personnel. Audits may address quality-affecting activities that include, but are not limited to, measurement system accuracy; intramural and extramural analytical laboratory services; field activities; and data collection, processing, validation, reporting, and management. Any Westinghouse Hanford QA audits will be performed under the Standard Operating Procedure requirements of WHC-CM-4-2 (WHC 1989).

System audit requirements are implemented in accordance with Standard Operating Procedure QI 10.4, "Surveillance" (WHC 1989). All quality-affecting activities are subject to surveillance. The Project Lead will interface with both the Environmental Field Services Quality Coordinator and the QA Officer. The former is responsible for performing surveillance oversight of Environmental Engineering, Geotechnology, and Permitting function activities. The QA Officer is responsible for providing independent formal audits/surveillances to ensure compliance with planned activities, and identify conditions adverse to or enhancing overall performance quality.

A11.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field and laboratory that directly affects the quality of the analytical data shall be subject to preventive maintenance measures that ensure minimization of measurement system downtime. Field equipment maintenance instructions shall be as defined by the approved procedures governing their use. Laboratories shall be responsible for performing or managing the maintenance of their analytical equipment; maintenance requirements, spare parts lists, and instructions shall be included in individual methods or in laboratory QA plans, subject to Westinghouse Hanford review and approval. When samples are analyzed using EPA

reference methods, the requirements for preventive maintenance of laboratory analytical equipment as defined by the reference method shall apply.

A12.0 DATA ASSESSMENT PROCEDURES FOR PRECISION, ACCURACY, AND COMPLETENESS

A12.1 DATA ASSESSMENTS BY ANALYTICAL FACILITY

Precision, accuracy, and completeness procedures for reporting laboratory measurements are specified by CLP protocol. Adherence to this protocol and approved procedures will be sufficient for the majority of measurements. Several analytical measurements will not be made by standard CLP methods. To the extent possible, performance-based standards will be the preferred method of assessment for precision and accuracy measurements. A familiar example is the use of control charts. Values exceeding a 3-sigma limit on well-established and appropriate control chart should be flagged when reported. Samples in the analytical batch should be rerun if possible, and those results also reported.

When appropriate performance-based standards are not available and referenced procedures do not specify, the following two rules may be used.

1. Precision--The difference between laboratory duplicates will be subject to a control limit of 150% of the requested limit whenever both sample values exceed the estimated method detection limit (MDL). If the estimated MDL exceeds the requested limit, the higher value may be used to calculate the control limit. When either or both duplicates are below the estimated method detection limit, laboratory precision may be assessed by comparing identically spiked samples. Samples exceeding five times the control limit can be subject to a 20% relative percent difference limit, where:

   $$\text{Relative Percent Difference} = \frac{(S - D) \times 100}{((S+D)/2)}$$

   S = Higher of two duplicate sample values
   D = Lower of two duplicate sample values

   Failure to meet a precision limit will require evaluation and corrective action as appropriate.

2. Accuracy--Accuracy will be defined by percent recovery data where

   $$\%\ \text{Recovery} = \frac{(\text{Spiked Sample Result} - \text{Sample Result})}{\text{Spike Added}} \times 100$$

When the sample result (SR) is less than the MDL, use SR=0 for the purpose of calculating the percent recovery. Spiked samples having concentrations two to five times greater of the requested detection limit or MDL will have recovery control limits of 50% to 150%. Spiked samples exceeding five times the estimated MDL will have recovery control limits

of 75% to 125%. Failure to meet the control limit will require evaluation and corrective action as appropriate. Applicable samples not meeting the limit should be rerun using a postdigestion spike if possible. Postdigestion spikes should be made at two times the indigenous level or lower reporting limit, whichever is greater.

A12.2 PROJECT LEVEL ASSESSMENTS

All data requested through OSM will be subject to Westinghouse Hanford OSM validation procedures as previously described (Section A8.2). Completeness of requested analyses will be assessed and reported to the Project Lead by Westinghouse Hanford OSM. The EPA guidance suggests 80% to 85% is a reasonable expectation (EPA 1987b).

Summary statistics for measurement precision and accuracy shall be prepared in conjunction with the data analysis.

Precision evaluation at the project level will address interlaboratory precision. Precision of environmental measurement systems is often a function of concentration. This relationship should be considered before selecting the most appropriate form of summary statistic. Simplistically, this relationship can usually be classified as falling into one of the following three categories.

1. Standard deviation (or range) is constant.

2. Coefficient of variation (or relative range) is constant.

3. Both standard deviation (or range) <u>and</u> coefficient of variation (or relative range) vary with concentration.

The pooled standard deviation or pooled coefficient of variation can be used to summarize data in cases 1 and 2, respectively. Case 3 will require either graphical summary of the data or specialized regression techniques.

Data quality assessments are generally made at concentrations typical of the observed range in routine analyses. In some situations the typical value measurement will be below an estimated practical method, or instrument detection limit (i.e., an engineering zero). If a standard exists (or is to be set) at some positive finite value, quality assessment summaries may be desired at that level rather than the most representative concentration.

A13.0 CORRECTIVE ACTION

Corrective action requests required as a result of surveillance reports, nonconformance reports, or audit activity shall be documented and dispositioned as required by QR 16.0, "Corrective Action;" QI 16.1, "Trending/Trend Analysis;" and QI 16.2, Corrective Action Reporting" (WHC 1989). Primary responsibilities for corrective action resolution are assigned to the Project Lead and the QA Officer. Other measurement systems,

procedures, or plan corrections that may be required as a result of routine review processes shall be resolved as required by governing procedures or shall be referred to the Project Lead for resolution. Copies of all surveillance, nonconformance, audit, and corrective action documentation shall be routed to the project QA records upon completion or closure.

A14.0 QUALITY ASSURANCE REPORTS

Special QA reports are not planned for this project. Project records will be maintained in conformance with standard operating procedure requirements of WHC-CM-7-7 (WHC 1988). Project records will maintained according to EII 1.6, "Records Management," and technical data will be dispositioned according to EII 1.11, "Technical Data Management." Surveillance, nonconformance, audit, and corrective action documentation shall be routed to the project quality records upon completion or closure of the activity. The final report shall include an assessment of the overall adequacy of the total measurement system with regard to the data quality objectives of the investigation.

A15.0 REFERENCES

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WHC, 1990, *Westinghouse Hanford Company Sample Management and Administration Manual*, WHC-CM-5-3, Westinghouse Hanford Company, Richland, Washington.

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Figure A-1. Project Organization.

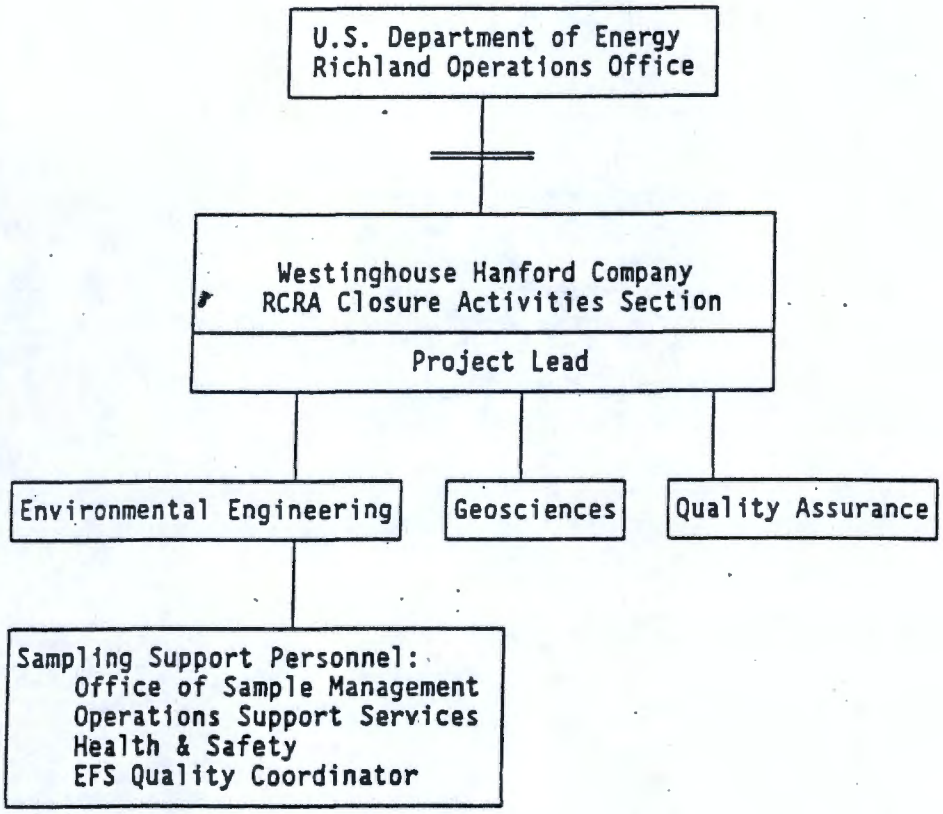

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Table A-1. Primary Inorganic Analytes.

Element	Typical expected (mg/kg)	Requested soil detection (mg/kg)	Requested method
Antimony	0 - 3	12	204.2 CLP-M
Arsenic	0 - 8	2	206.2 CLP-M
Barium	44 - 229	40	200.7 CLP-M
Beryllium	0 - 0.8	1	200.7 CLP-M
Cadmium	0 - 8	1	213.2 CLP-M
Chromium	2 - 48	2	200.7 CLP-M
Cobalt	0 - 15	10	200.7 CLP-M
Copper	0 - 20	5	200.7 CLP-M
Lead	1 - 13	0.6	239.2 CLP-M
Mercury	< 0.2	0.1	245.5 CLP-M
Nickel	6 - 25	8	200.7 CLP-M
Selenium	0 - 0.1	1	270.2 CLP-M
Silver	0 - 1.5	2	272.2 CLP-M
Thallium	0 - 0.2	2	279.2 CLP-M
Vanadium	24 - 96	10	200.7 CLP-M
Zinc	27 - 112	4	200.7 CLP-M

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Table A-2. Secondary Inorganic Analytes.

Element	Typical expected (mg/kg)	Requested soil detection (mg/kg)	Requested method
Aluminum	3600 - 13300	40	200.7 CLP-M
Calcium	2000 - 14000	1000	200.7 CLP-M
Iron	19000 - 29000	20	200.7 CLP-M
Magnesium	2780 - 6910	1000	200.7 CLP-M
Manganese	164 - 2870	3	200.7 CLP-M
Molybdenum	< 4	0.5	7481
Potassium	455 - 2600	1000	200.7 CLP-M
Sodium	125 - 1710	1000	200.7 CLP-M
Silicon	200 - 2900	20	200.7 CLP-M
Titanium	500 - 3500	50	Any method capable of meeting the requested DL
Zirconium	15 - 65	5	Any method capable of meeting the requested DL
Chloride	0 - 20	1	300.0
Nitrate and nitrite	0 - 15	1	300.0
Phosphate	0 - 3	2	300.0
Sulfate	0 - 35	2	300.0
Fluoride	0 - 8	1	Extraction by 300.0, Analysis by ASTM D 3868 - 79
Ammonium	0 - 4	1	Any method capable of meeting the requested DL
Carbonate	Highly Variable	1.0%	ASTM D 4373 - 84

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Table A-3. Contract Laboratory Program Organic Analyses and Total Organic Carbon.

Contract Laboratory Program target compounds	Typical expected (ug/kg)	Requested quantitation limits	Requested method
Volatiles (currently 33 compounds)	0	Low Soil	Most recent CLP-SOW[1]
Semivolatiles (currently 64 compounds)	0	Low Soil	Most recent CLP-SOW[2]
Pesticides/PCBs (currently 28 compounds)	0	Low Soil	Most recent CLP-SOW[3]
Total organic carbon	Variable (usually< 1%)	0.1% detection limit (DL)	Any method capable of meeting the requested DL

[1]A CLP modification of EPA Method 624 (Purgeables).
[2]A CLP modification of EPA Method 625 (Bases/Neutrals and Acids).
[3]A CLP modification of EPA Method 608.

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APPENDIX B

SOIL BACKGROUND SITE MAPS

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APPENDIX B

SOIL BACKGROUND SITE MAPS

This appendix contains a map showing the 12 proposed general sites within the Hanford Site boundaries. Each site is also shown on a more detailed topographic map. Additionally, the two sites located outside the Hanford Site boundaries are shown on detailed maps.

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Figure B-1. Hanford Site Map Showing Locations of Soil Background Sampling Sites.

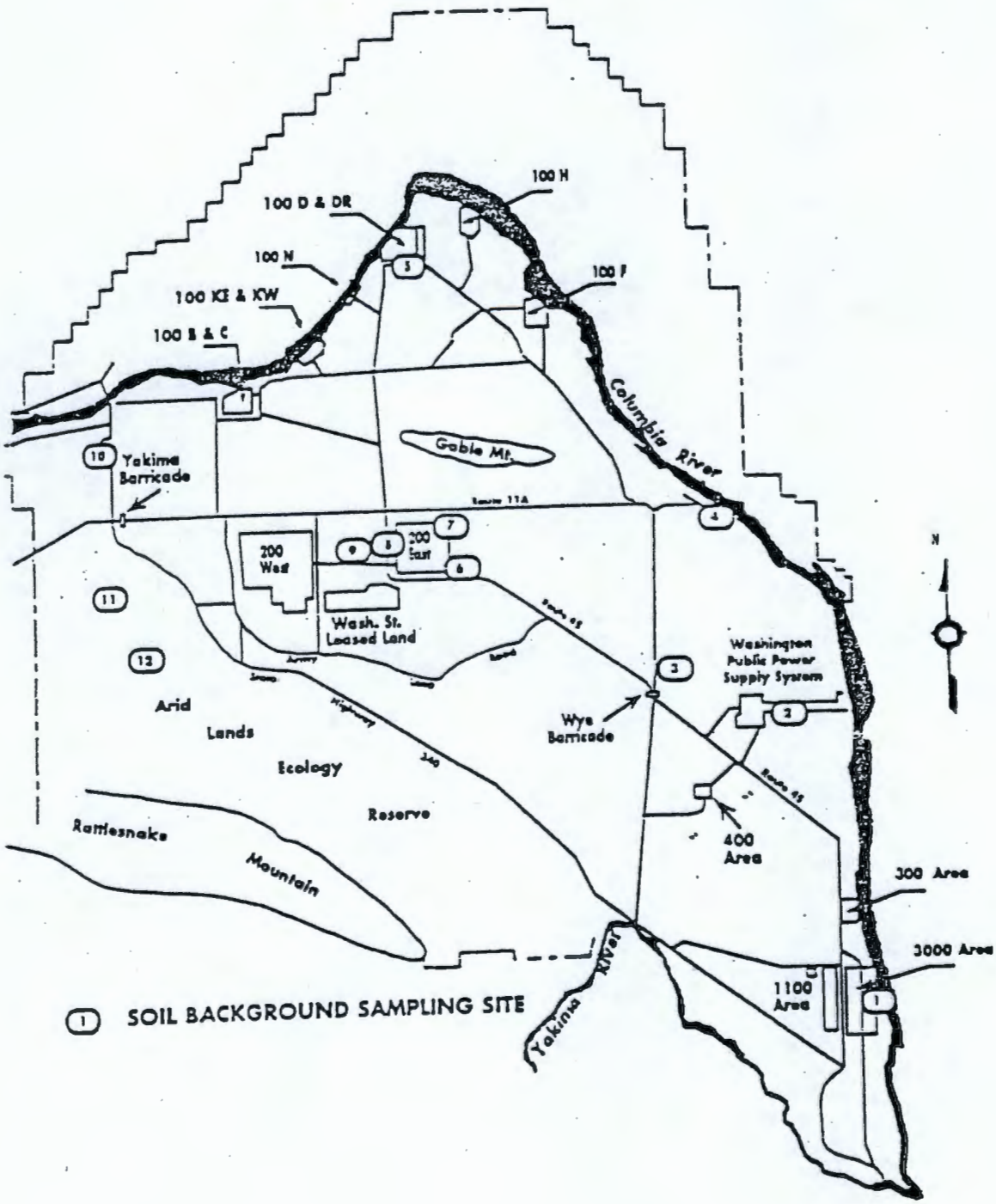

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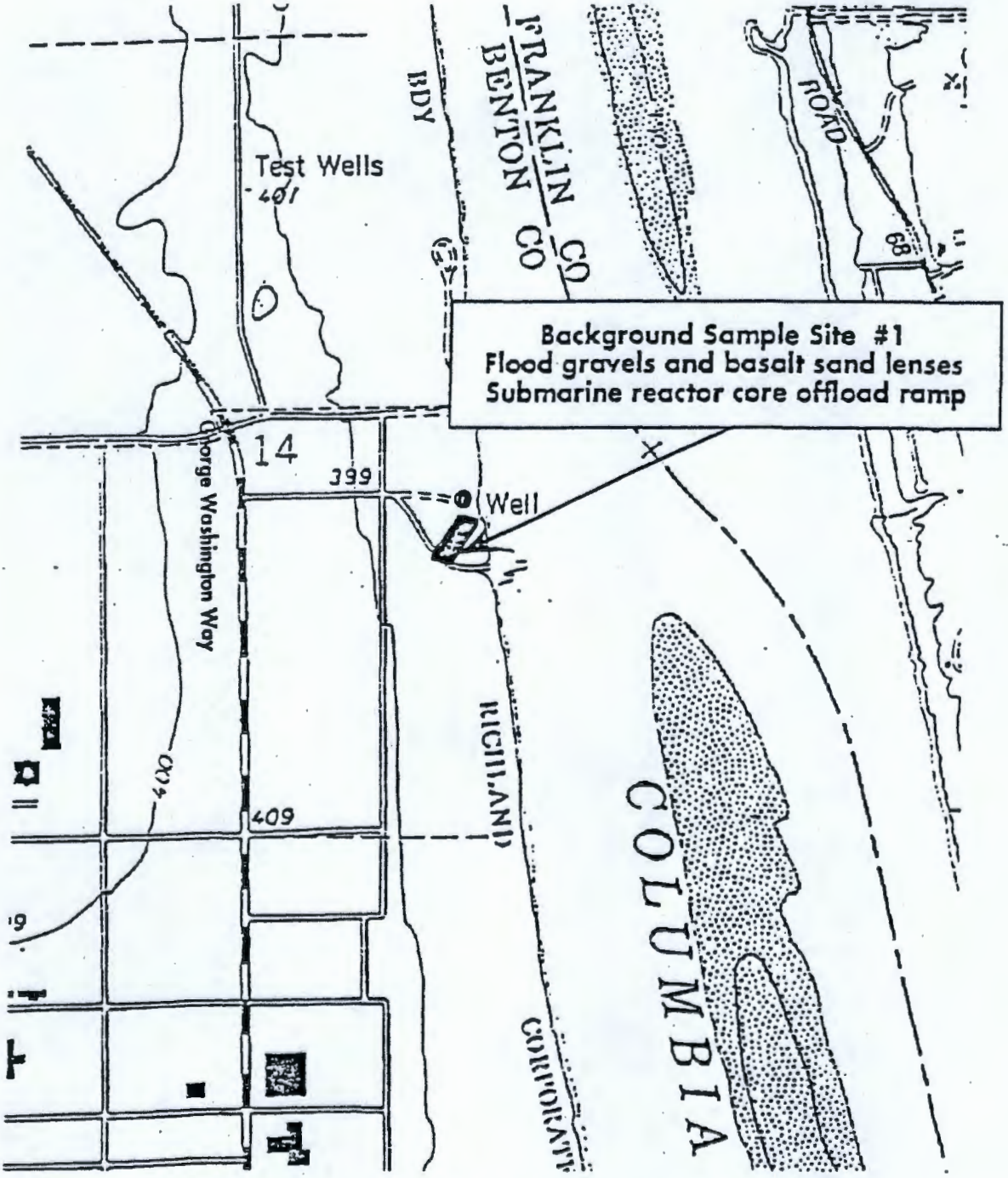
Figure B-2. Background Sample Site #1.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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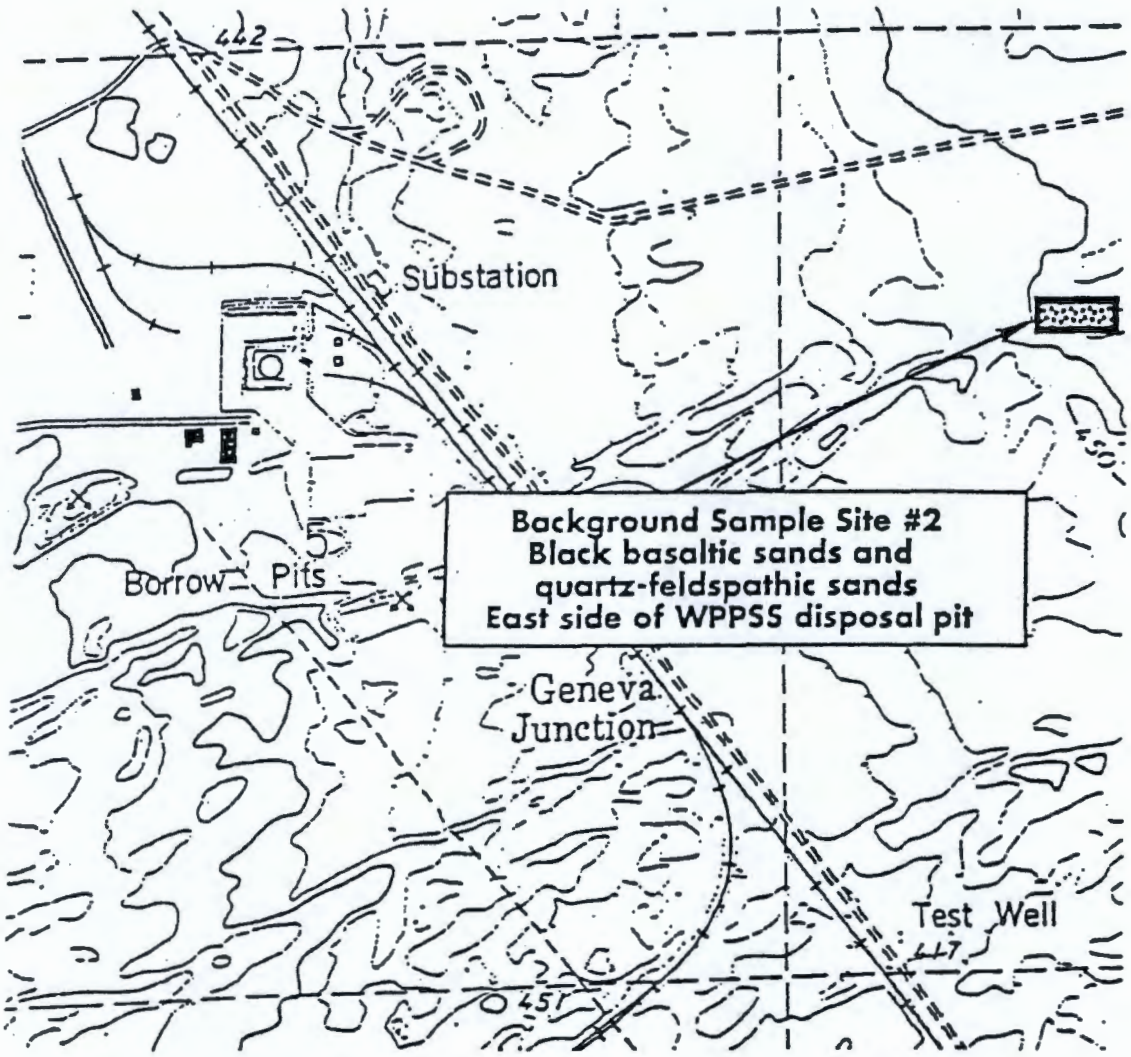
Figure B-3. Background Sample Site #2.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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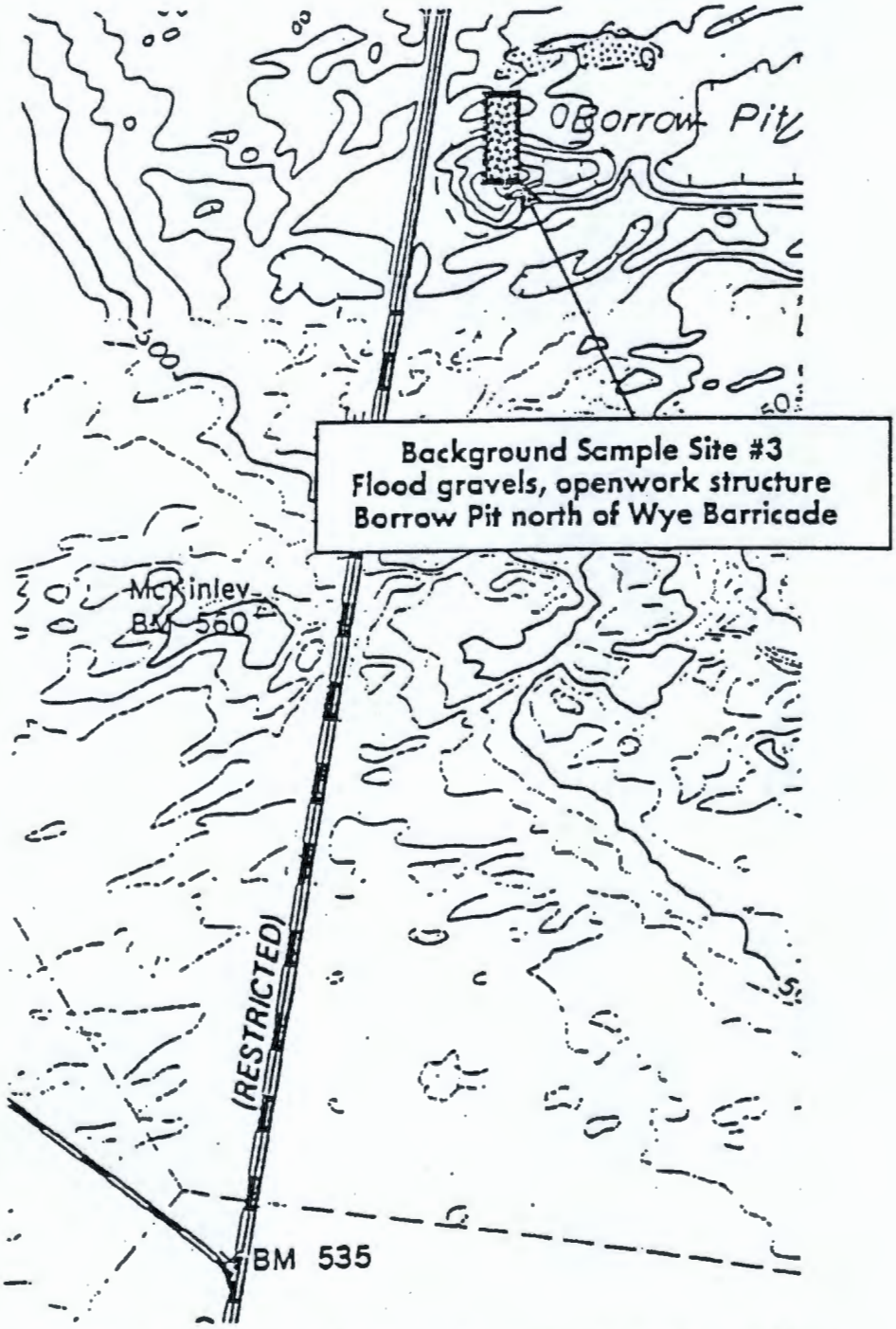
Figure B-4. Background Sample Site #3.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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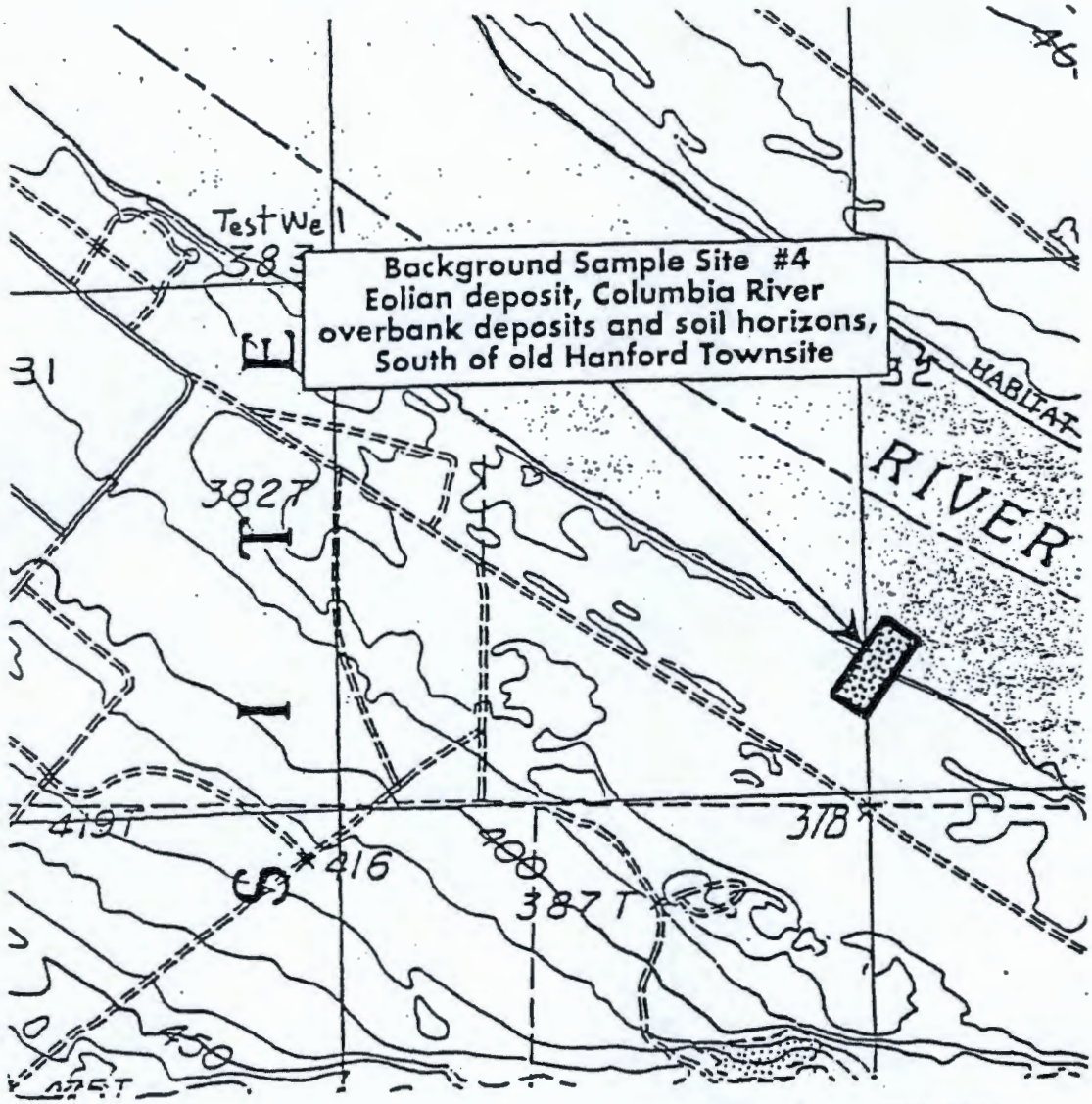
Figure B-5. Background Sample Site #4.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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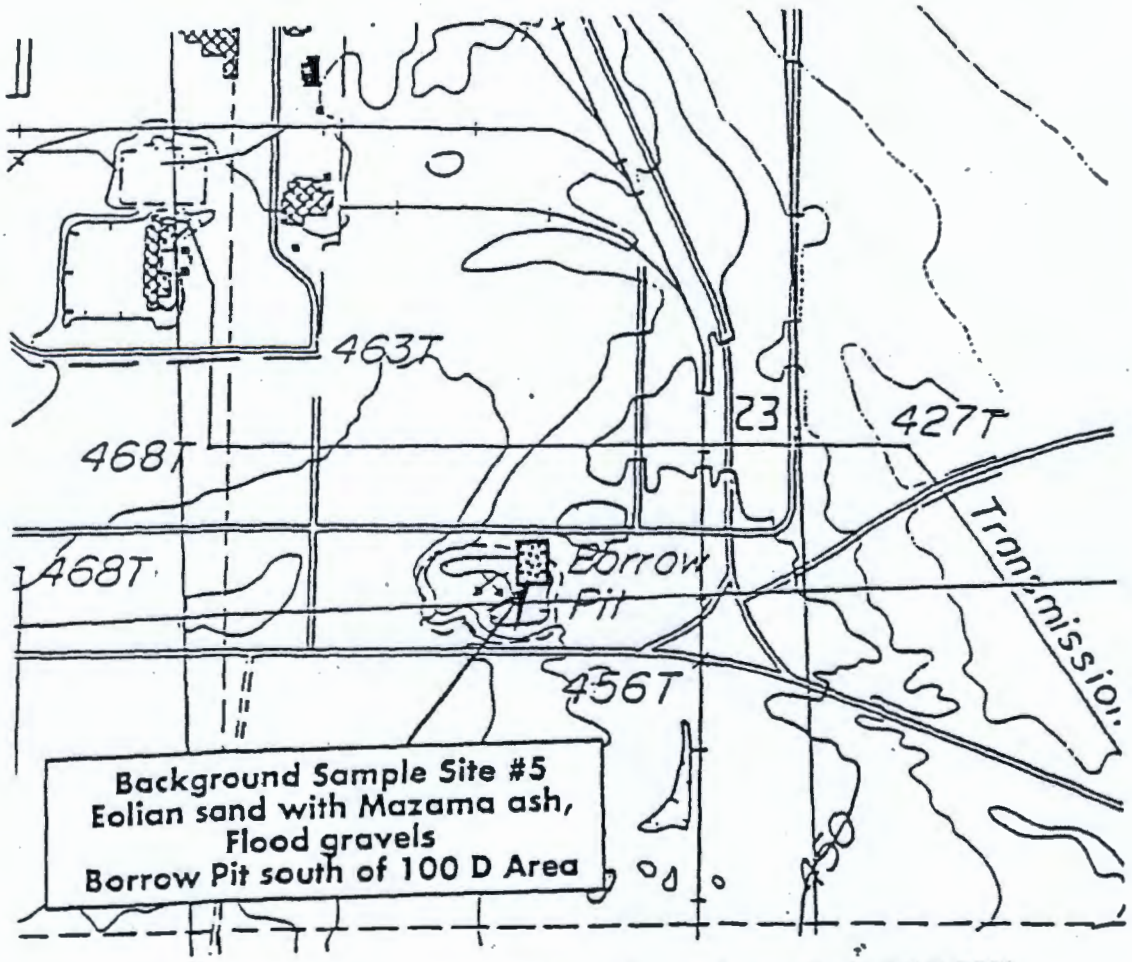
Figure B-6. Background Sample Site #5.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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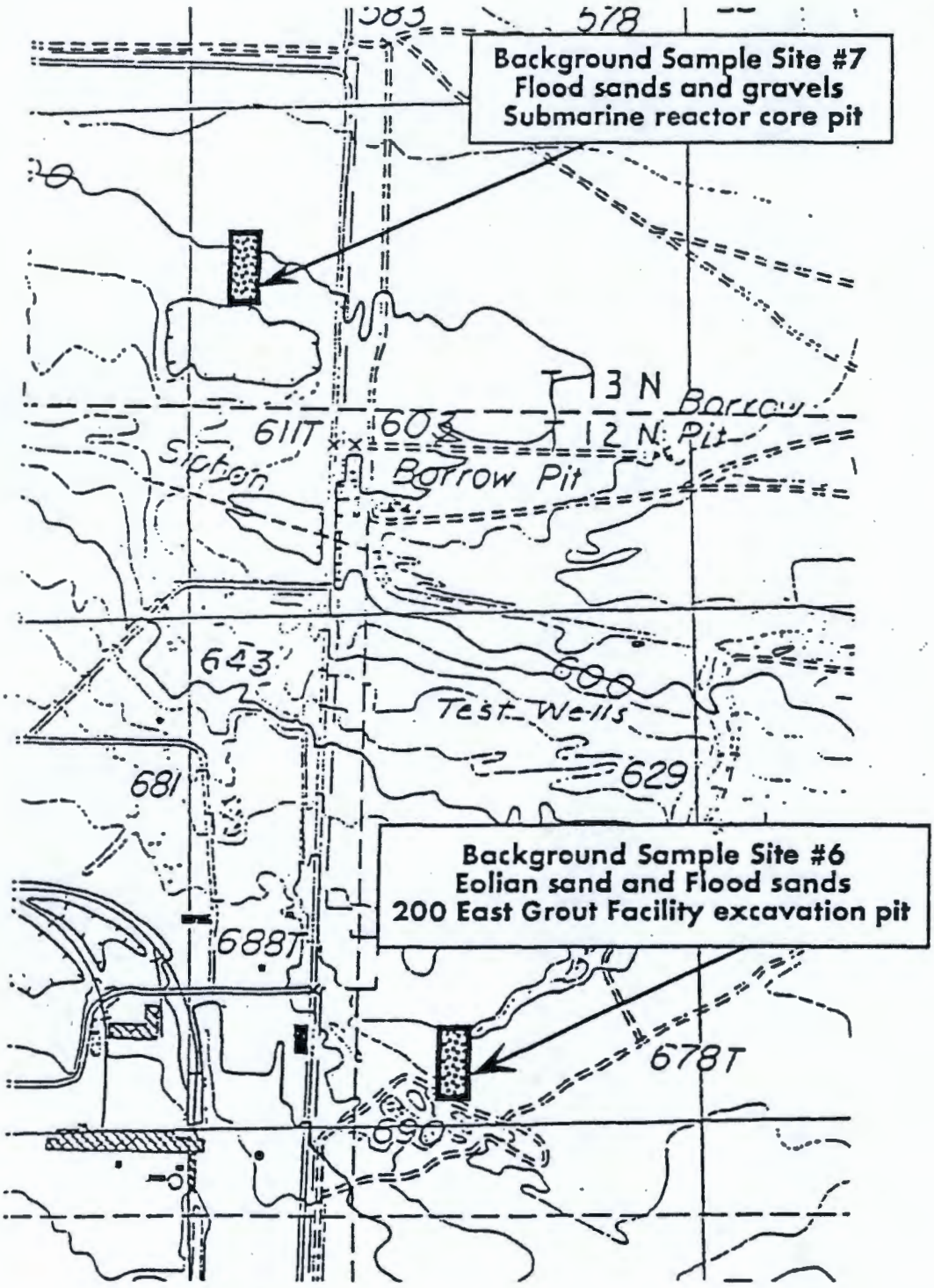
Figure B-7. Background Sample Sites #6 and #7.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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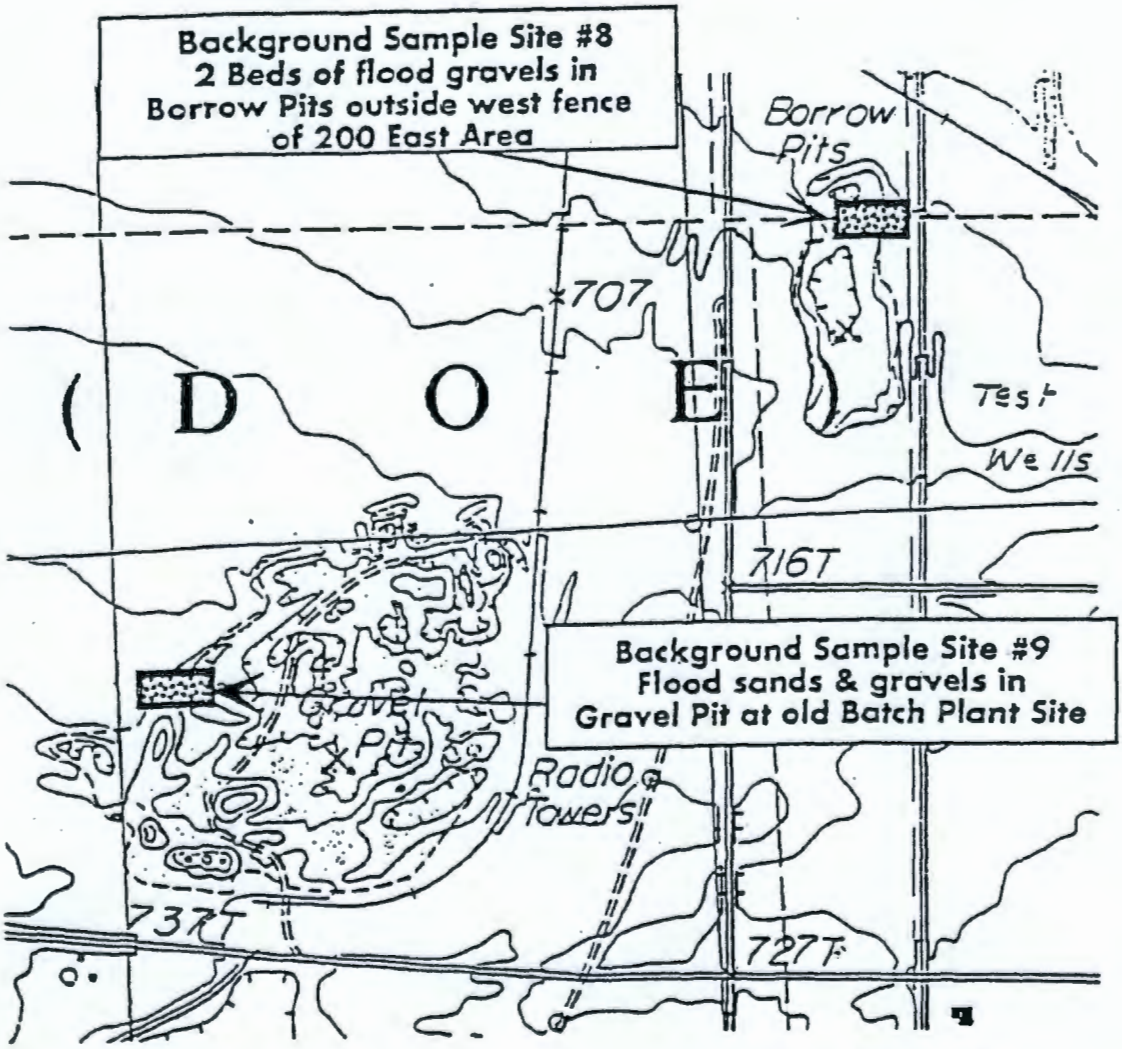
Figure B-8. Background Sample Sites #8 and #9.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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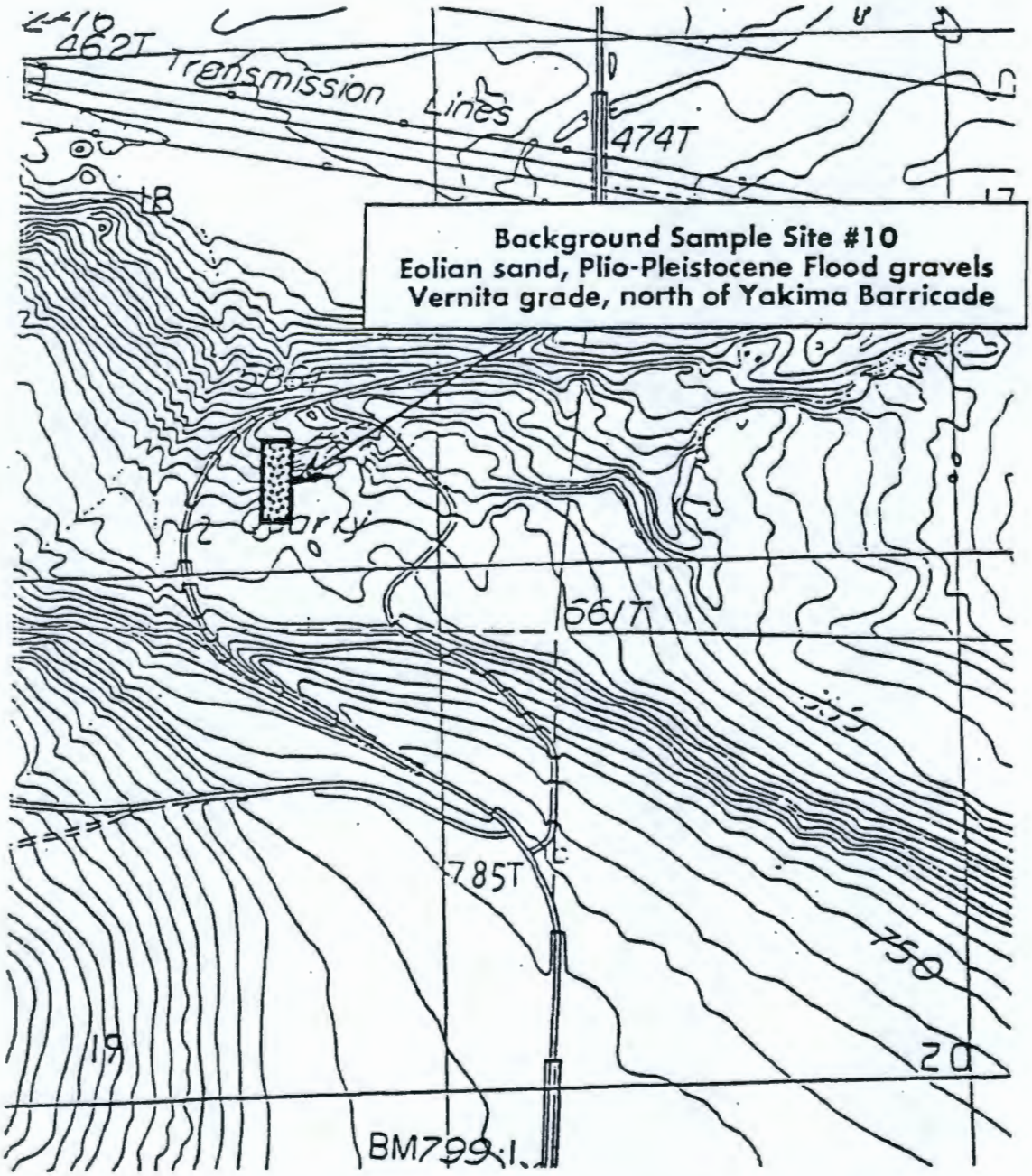
Figure B-9. Background Sample Site #10.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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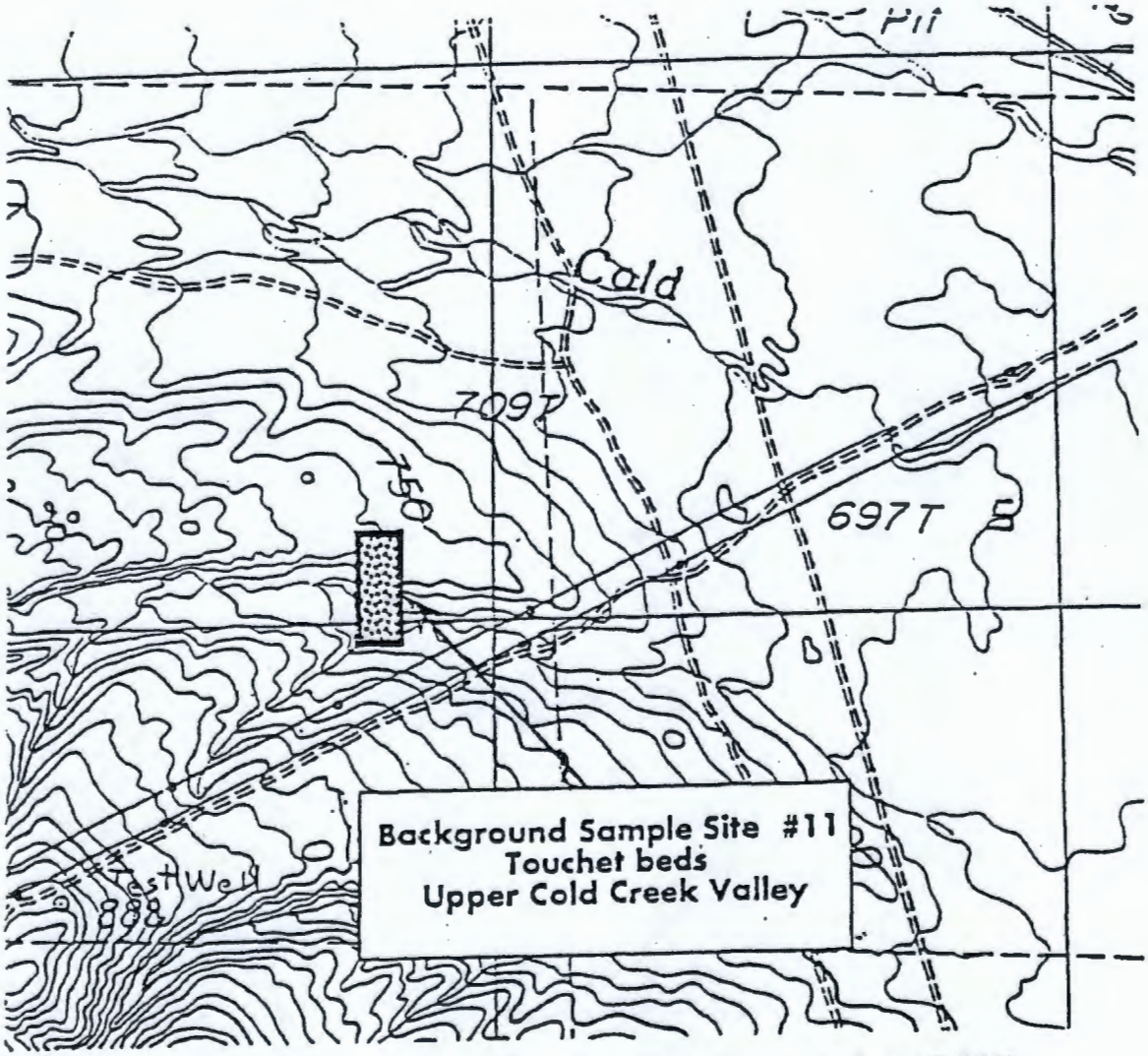
Figure B-10. Background Sample Site #11.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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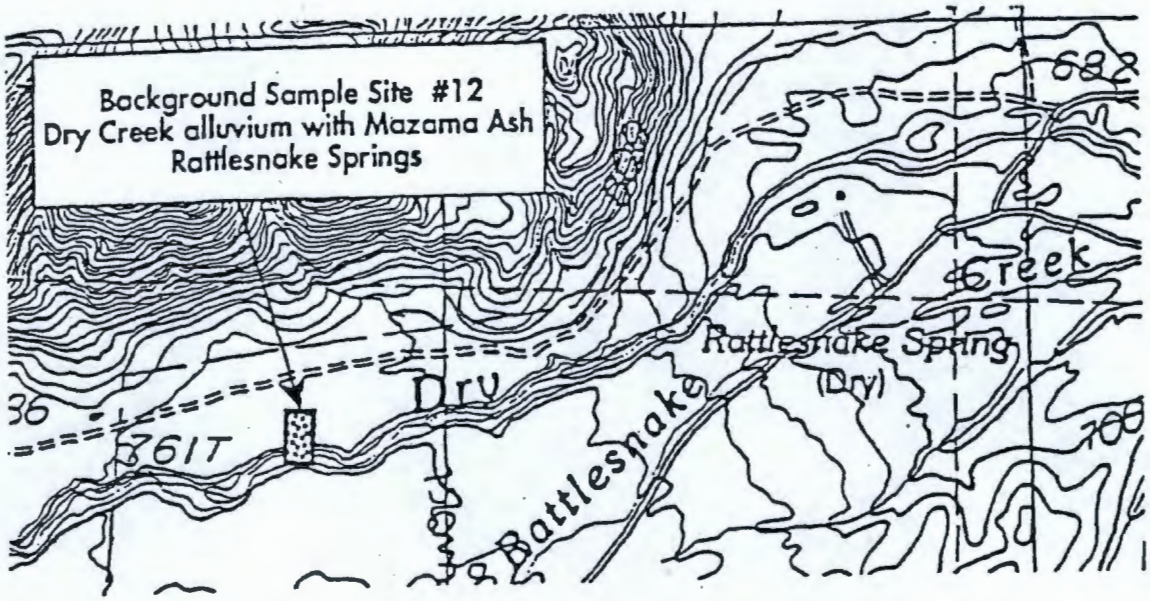
Figure B-11. Background Sample Site #12.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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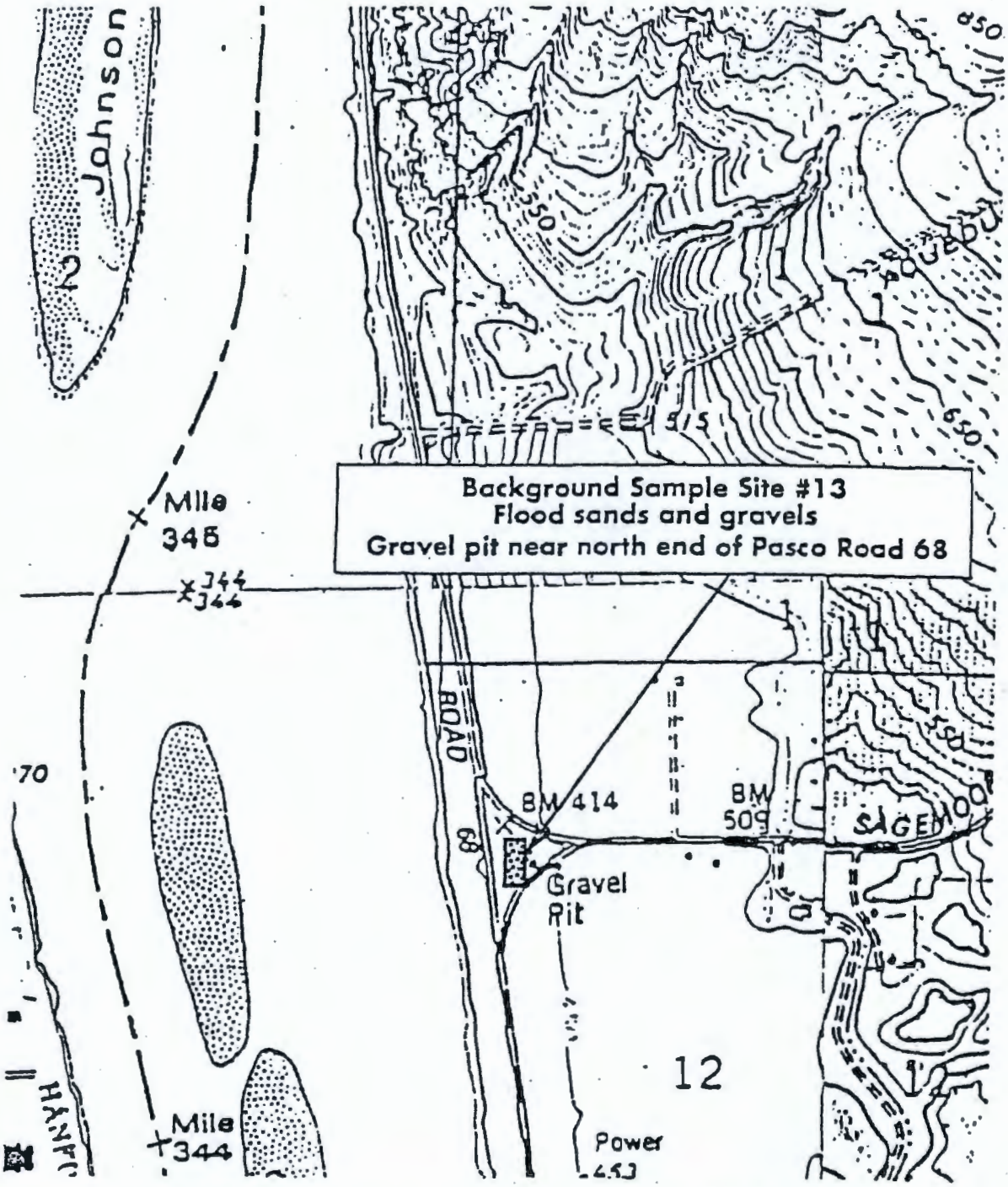
Figure B-12. Background Sample Site #13.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000

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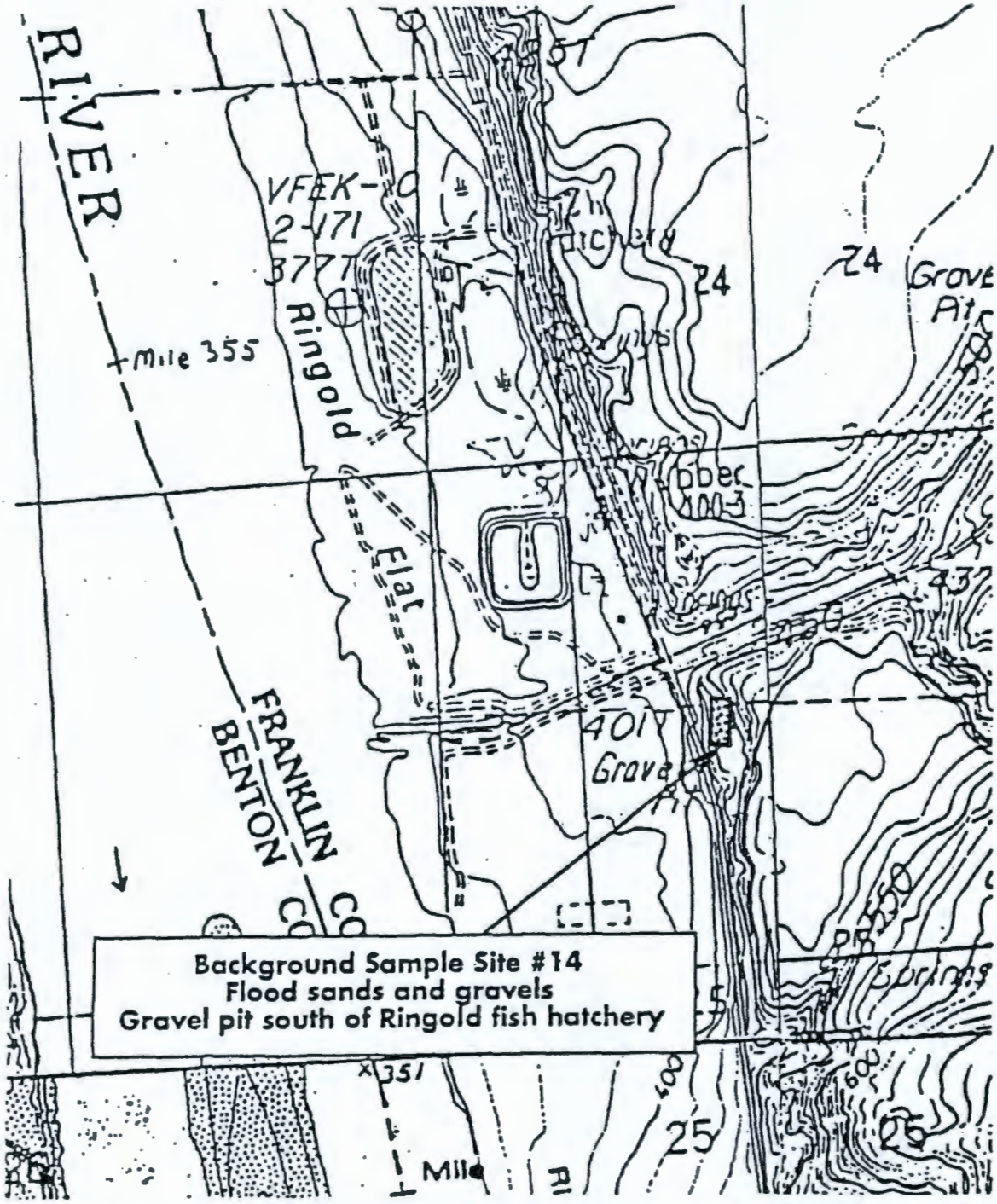
Figure B-13. Background Sample Site #14.



(From 1982 USGS Topographic Map, Approximate Scale 1:12,000)

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APPENDIX C

DETECTION OF VOLATILE ORGANIC COMPOUNDS IN SOILS

EQUILIBRIUM HEADSPACE METHOD

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C1. INTRODUCTION

The purpose of the equilibrium headspace method is to rapidly and reliably detect volatile organic compounds (VOC's) in soil samples in the low ppm range. This method is designed to provide rapid, broad spectrum, cost effective field screening. The presence of volatile organic compounds should be interpreted with a knowledge about the site, and objectives of the investigation. This particular procedure does not by itself *determine* (i.e. define) contamination or individually *identify* measured compounds.

A basic assumption of all headspace methods is that detectable concentrations of VOCs in a soil or water sample will be present in the air volume (headspace) immediately above the sample. A sample from this gas phase can be introduced into a gas chromatograph (GC) or total organic vapor detector (TOVD) for analysis. The vapor concentration in the gas phase is then an indication of the sample VOC content.

Many headspace methods used in field screening do not exhibit a high degree of sensitivity or reproducibility. This at least partially due to a lack of control over the headspace volume, with the result that thermodynamic equilibrium is not achieved, and the headspace sample may be diluted by outside air as it is drawn into the instrument.

In the equilibrium headspace method, a quantity of soil is placed inside a closed container and allowed to equilibrate. The headspace gas is then circulated through a "non-destructive" analytical instrument, with the exhaust from the instrument routed back to the sample container. In effect, this creates a closed system, and the concentration read by the instrument should reach a temperature dependent equilibrium value established between VOCs in the sample and corresponding vapors in the headspace. Since the technique is intended to be implemented in the field as a screening method, temperature is not strictly controlled. The samples are given time to equilibrate to the ambient temperature in the mobile screening laboratory and VOC headspace concentrations are measured at this temperature. Comparison of data between samples must take into account the ambient temperature at which each measurement was made. This field screening procedure controls headspace volume and sample size to achieve superior low cost field screening results. It is possible that "plate-out" of some dilute compounds on the walls of the sample container and associated tubing may occur. However, even the plate-out will eventually establish an equilibrium.

This technique is considered to be only semi-quantitative for unknown VOCs in soil samples. Because of variations in vapor pressure, volatilization from the soil matrix, and detector response for various compounds, this method may not be appropriate for all foreseeable combinations of compounds and concentrations. The measurements can be useful for comparative purposes.

C2. EQUIPMENT

Equipment required to conduct an equilibrium headspace analysis for VOC's in soil samples includes clean glass jars, a TOVD, thermometer(s), scale and associated fittings and tubing.

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A TOVD utilizing a photo-ionization detector (PID) such as the Thermo Environmental (trademark of Thermo Environmental, Inc., Franklin, Massachusetts) model 580-B Organic Vapor Monitor (OVM) will be used for analysis of the headspace vapor in the field. This instrument measures the total organic vapor in the headspace gas within a concentration range of 0.1 to 2000 ppm. The OVM can be equipped with either a 9.6, 10.0, 10.6 or 11.8 eV lamp. Compounds with ionization potentials less than that of the lamp can be detected. Because the 11.8 eV lamps are inherently less stable, vapor measurements will be made with the 10.0 or 10.6 eV lamp, unless a compound with a higher ionization potential is suspected.

One quart, wide-mouth glass canning jars will be used for sample analysis. These jars are readily available, and have sufficient volume for soil samples. Quart jars shall be marked with a unique alphanumeric sample number prior to use in the field. During analysis, the jars will be fitted with a specially fabricated Teflon cap with gas-tight fittings and Teflon tubing to connect to the OVM.

C3. METHOD

Table 1 provides a step-by-step listing of the field screening procedure.

Samples will be collected directly into tared quart jars. Jars will be filled half full and immediately sealed with a matching conventional lid. Samplers will record the time of sample collection, jar number and a brief soil description. An example field data form is shown in Figure 1. An electronic form may be used. Samples will be brought to the mobile lab, and allowed to reach room temperature (± 2° C).

Samples will be processed at the mobile laboratory in batches. Each batch will consist of a maximum of 20 field samples. For each batch, at least two samples will be field duplicates collected from a single field location to assess collection and measurement variability.

Each soil sample will be weighed and a net sample weight calculated.

The OVM will be calibrated for each batch according to the manufacturer's instructions. Multiple measurement control checks will be made at the beginning, middle, and end of each batch. Measurement checks are made using a standard of known concentration. Ambient air will be circulated through the instrument between each check. Individual measurement control checks, in addition to multiple checks, may be made between each soil sample at the option of the analyst.

Immediately before a sample analysis, the conventional lid will be replaced with a headspace cap and the headspace VOC concentration will be monitored for a minimum of five minutes. The analyst will record the ambient VOC concentration the sample headspace VOC concentration, and the ambient and headspace temperatures (± ½° C).

C4. QUALITY CONTROL

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The repeatability and reliability of the equilibrium headspace method will be demonstrated by analysis of several types of quality control samples. These are described in Table 2. Results of quality control samples will be reported on the field data sheets. The analyst will flag data if parameters exceed the indicated criteria or goals. The project coordinator may authorize documented exemptions to unachievable control criteria.

C5. DATA REPORTING

A completed field data sheet constitutes the primary data deliverable for this test method.

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Table I. EQUILIBRIUM HEADSPACE SCREENING PROCEDURE

I. Prepare sample jars. Equip each loosely with a standard cap assembly. All units should be clean, numbered and dry. Weigh each empty unit. Record the tare weight (± 0.5 g) and sample number.

II. Collect soil samples. Each jar should be approximately half full of soil. Wipe any soil from the lip of the jar and immediately re-seal. Record the time of sample collection and a brief soil description, (ex. color, soil type, physical characteristics, grain size distribution and moisture content). Deliver samples to the mobile lab.

III. Equilibrate samples to room temperature. Allow the sample jars to sit inside the mobile laboratory for a minimum of ½ hour before analysis.

IV. Calibrate the OVM. Set the averaging interval to 5 seconds. Make a measurement of the calibration gas. The reading should be within 2% of the known value. If not, recalibrate the instrument.

V. Check the OVM. Make five separate measurements of a low-level known gas standard. Let ambient air circulate through the system between measurements. Record the measurements. Repeat this step at the middle and end of each sample batch. Additional checks may be performed between each soil sample at the analyst's option.

VI. Monitor ambient air. Before each sample headspace measurement, allow the OVM to sample ambient air through the headspace tubing. Be alert for trends that may indicate a change in ambient air levels, instrument drift, or residual contamination.

VII. Connect the OVM to the sample. Quickly remove the lid and replace it with the headspace lid.

VIII. Monitor Headspace Concentration. Turn on the OVM and monitor the headspace VOC concentration for a minimum of five minutes. Record the OVM reading when a change of less than 10% is observed over three successive readings (5 second averages). Record the time of the measurement and the headspace temperature and ambient temperatures. The autologging function of the OVM may be used to collect data. Data collected by autologging can later be downloaded to produce a plot of headspace concentration as a function of time.

IX. Weigh the sample. Disconnect the apparatus, weigh sample and jar, and the record gross weight.

X. Confirm process control. Check QC parameters, and flag data as necessary. Repeat process, steps V or VI through X, until all samples and checks are complete.

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Table 2. QUALITY CONTROL SAMPLES

Purpose	Type	Method	Minimum Frequency	Acceptance Criteria/ Goal
Demonstrate proper functioning of the OVM.	Calibration Check	Calibrate per manufacturer's instruction. Measure calibration standard and compare to nominal value.	Beginning of each sample batch	± 2%
	Instrument Check	Make five measurements of a low level (≈10 ppm) isobutylene control standard. Let ambient air circulate between multiple check measurements.	Beginning, middle, and end of each sample batch	Average ± 2 ppm of nominal low level standard
Control/ Detect residual contamination in instrument and headspace tubing.	Ambient measurement	Circulate ambient air through the headspace tubing and record reading. Watch for variation in the ambient reading.	Before each headspace sample	< 1 ppm
	Blank	Measure headspace concentration in an empty jar.	After every fourth site sample	< 1 ppm
Assess analytical variability	Replicate measurements	Make a second independent measurement of a selected sample.	Minimum of two replicate measurements for each sample batch.	Measurements should agree to within 10%
Assess measurement system variability	Field Duplicate Measurements	Collect duplicate samples in the field and treat as separate samples in the measurement process.	Minimum of two duplicate measurements for each sample batch.	Measurements should agree to within 25%

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EQUILIBRIUM HEADSPACE METHOD - FIELD DATA SHEET

Date: _____ Project: _____ Instrument: _____

Sample Data						Headspace Data					
		Weight, g					VOC conc, ppm		Temp, °C		
Sample	Time	tare	tot	Soil Description	Time	amb	hdspc	amb	hdspc	Comments

Sampler: _____ Date: _____

Analyst: _____ Date: _____

Reviewed by: _____ Date: _____

APP E-5