

A GEOCHEMICAL BASELINE SURVEY OF SELECTED
TOXIC ELEMENTS IN SURFICIAL MATERIALS
IN THE VICINITY OF THE PARAHO DEMONSTRATION
OIL SHALE PROCESSING PLANT,
ANVIL POINTS, GARFIELD COUNTY, COLORADO

By

David W. Rutherford

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A Thesis submitted to the Faculty and the Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Master of Science in Geochemistry.

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ABSTRACT

A geochemical baseline survey was conducted on a four by nine mile area surrounding the Paraho Oil Shale Demonstration plant at Anvil Points, Garfield County, Colorado. This study determined the baseline concentrations and variability for selected trace elements that are of primary environmental concern during the proposed development of oil shale resources. The elements studied were Hg, Mo, B, and F. The pH and organic carbon of soils and sediments were also measured. The sample media consisted of surface soils, stream sediments, and the plant species: Big sage (*Artemisia tridentata*), Indian ricegrass (*Oryzopsis hymenoides*), and Western wheatgrass (*Agropyron smithii*).

Soil and plant samples were collected using a hierarchical first stage design and a systematic grid second stage design. Stream sediment samples were collected from all clearly defined stream channels within and surrounding the study area on an interval of 1/2 mile.

The elemental concentrations in soils, plant, and sediment samples were shown to vary significantly, reflecting the underlying geologic unit. Stream sediment concentrations also varied significantly between individual streams and gullies. Baseline values were determined for media derived from each geologic unit as well as the study area as a whole.

Monitoring of operations and potential contamination should consider the geologic unit being sampled. If stream sediments are to be used, individual baselines must be developed for each stream as well as the geologic unit underlying each stream channel.

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INTRODUCTION

The oil shales of the Green River Formation in Colorado, Wyoming, and Utah, contain approximately 1,781 billion barrels of oil (National Petroleum Council, 1974). This oil is held as an insoluble organic material called kerogen in a matrix of fine grained dolomitic marlstones. Oil shale is a term applied to any shale or marlstone from which more than 10 gallons of oil can be extracted from a short ton of rock by destructive distillation (U.S.G.S. 1965). The term oil shale is determined by the economic feasibility of extracting the oil, and not by the mode of origin or specific composition.

Several processes have been developed to extract shale oil, but all the presently commercially feasible processes involve heating the oil shale to 900°F or higher. This causes the kerogen to pyrolyze into oil vapors which can be condensed into shale oil (Prien, 1974).

At the Paraho Demonstration Plant, Anvil Points, Colorado, the oil shale is removed by conventional mining methods and retorted in a surface kiln. Other areas currently under development in the Piceance Basin will use modified in situ retorting. This involves creating underground chambers filled with rubblized oil shale and retorting the shale underground.

Any attempt to develop this oil resource will require the processing of large quantities of raw material and disposal of the residues. This presents the possibility of significant environmental impacts. In order to predict the magnitude of these effects and monitor these changes, it is necessary to gather information concerning the natural environmental baseline levels for this region. Studies are currently being conducted by a number of organizations and institutions. This data collection is being done prior to large scale industrial development and has been funded by the Department of Energy to obtain geochemical baseline data on surficial materials.

A geochemical baseline study is an attempt to determine the distribution of elements in biological and geologic materials. The sample media includes plants, as well as soils, sediments, and rocks. A geochemical baseline attempts to estimate the concentration of an element from various populations, and it must also estimate the degree of variability associated with the element within each population. Depending on the concentration and variability, a geochemical baseline can describe the spatial distribution, such as anomalies or trends, for elements within a particular population.

Objective and Scope

The objective of this study is to obtain baseline data for trace elements that are toxic to plants or animals, and are likely to be mobilized during the mining or processing of oil shale. The elements Mo, B, F, and Hg were chosen for this study because of their environmental importance and because of their volatility during retorting or their mobility in the alkaline surface conditions of the region.

The objectives of this study are:

- 1) To estimate the concentrations of these elements in surface soil, stream sediment, and selected plant materials
- 2) To estimate the variability of these elements within the sample populations
- 3) To determine if local anomalies or regional trends exist within the study area

The plant species selected for sampling are:

- 1) Big Sage (Artemisia tridentata)
- 2) Indian Ricegrass (Oryzopsis hymenoides)
- 3) Western Wheatgrass (Agropyron smithii)

These species were selected because of their availability within the study area, their value as forage, and their possible use for revegetation of the spent oil shale.

Description of the Study Area

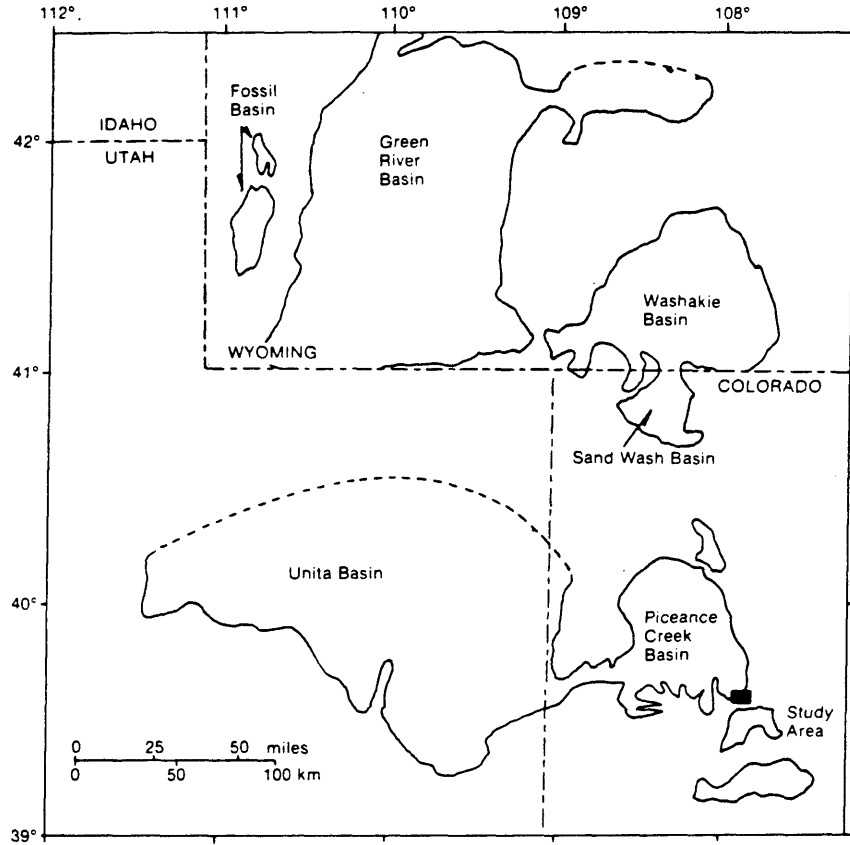
General Geography

The oil shale region of the western United States is located in the three corners region of Colorado, Utah, and Wyoming (Figure 1). The region contains seven basins covering 25,000 square miles. At the present time, economic deposits of oil shale underlie 17,000 square miles.

This study was conducted on a portion of the Piceance Creek Basin. This basin covers about 1600 square miles in northwestern Colorado and contains the largest deposits of economic oil shale in the region.

The Piceance Creek Basin is an asymmetrical structural and sedimentary basin with a northwest trending axis. The basin is bounded to the north by the White River uplift, to the south by the West Elk Mountains and the Uncompahgre Plateau, to the east by the Grand Hogback, and to the west by the Douglas Creek Arch. The northern portion of the basin is drained by tributaries of the White River, while the southern portion drains into the Colorado River.

The study area is a four by nine mile rectangular area surrounding the Paraho Demonstration Oil Shale Processing Plant and extending downwind from the plant. The plant is located near the southeastern border of the Piceance Basin. The plant is approximately seven miles west of Rifle, Colorado, and is accessible from highways I-70 and U.S. 6 (Figure 2).



**DISTRIBUTION OF OIL SHALE
IN COLORADO, UTAH, AND WYOMING**

Figure 1

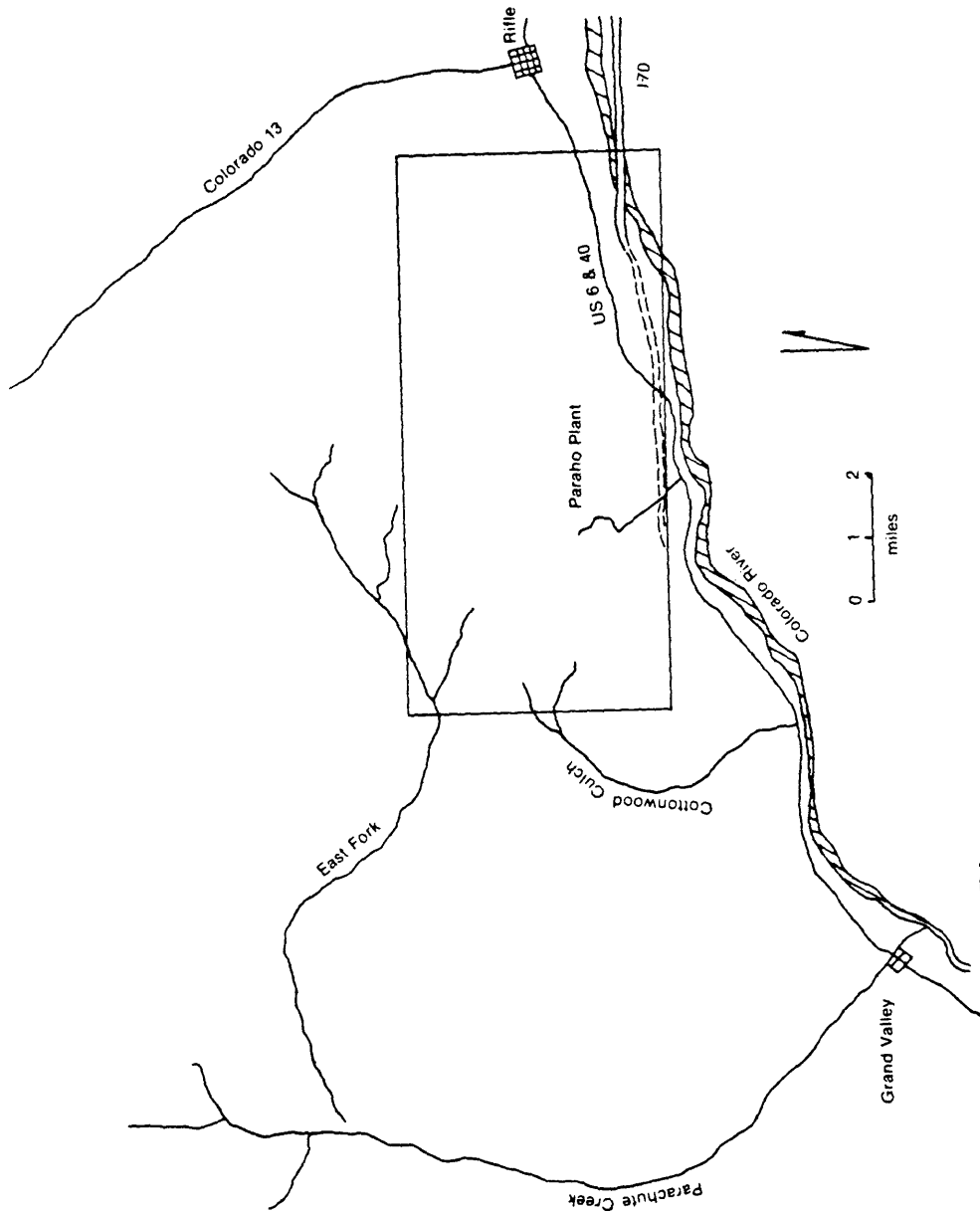


Figure 2: Location of Study Area

Topography

The Piceance Creek Basin is a dissected plateau which rises 1000 to 4000 ft above the surrounding valleys. Erosion has produced a ridge-valley network with a general north-northeast trend and local relief of 200 to 600 feet. To the south and northwest, the basin is rimmed by prominent cliffs formed by the resistant oil shale.

Being located on the southeastern edge of the basin, the study area contains the complete range of topography found within the basin. Elevations within the study area range from 5200 feet above sea level in the Colorado River Valley to 9000 feet on the rim of the Roan Cliffs.

The landforms within the study area consist of:

- 1) The broad alluvial valley floor of the Colorado River
- 2) Small tabular mesas south of the Colorado River which are part of the Battlement Mesa system
- 3) Numerous alluvial fans formed by streams draining south from the Roan Cliffs
- 4) Large steep talus slopes and ridges at the base of the Roan Cliffs
- 5) The Roan Cliffs
- 6) Rolling terrain formed on top of the intricately dissected plateau area

Climate

The Piceance Basin is semi-arid with 12 to 24 inches of precipitation yearly. About half of this precipitation is received as snow during the winter. The southwestern portion receives the most precipitation while the northwestern portion receives the least (Department of the Interior, 1973).

Temperatures can vary from 100°F in the summer to -40°F in the winter. The daily mean temperature for the coldest month (January) is 7.7°F, while the daily mean temperature for the warmest month (July) is 89.4°F (EPA 1977).

Rainfall and temperature vary with topography. Conditions are relatively drier and warmer at lower altitudes. The lower elevations have approximately 124 frost free days while upper elevations have about 50. Winds are generally from the west with local variations due to topography (DOI 1973).

Soils

Soils in the Piceance Basin vary from thin or absent on the steep talus slopes to thick alluvial soils formed on the valley floors. Rock outcrops, rough gullies, and shale badlands are common.

Within the study area no soils have been able to develop more than an A-C profile. In the Colorado River Valley, the

soils are generally deep silty clay loams. On the alluvial fans, the soils are variable in texture and depth. Most have been in place long enough to develop plant cover but exhibit little profile development other than a darkened A₁ layer. The talus slopes are barren or near barren with soils being highly lithic. These soils are composed of a mixture of shale, sandstone, and marlstone. The alluvial soils at the base of the talus slopes are moderately deep and loamy with up to 60% small shale fragments. Soils on top of the plateau are darker and loamy in texture. The depth and texture will depend on the slope, exposure, and vegetation cover. Soils on the ridge tops are shallow and loamy with abundant shale fragments. Soils on north facing slopes are clay loams which are deep and dark colored. These slopes are well vegetated. Soils on south facing slopes are thin, fine, sandy loams with shale fragments. Soils on the narrow valley floors are deep, dark colored, and loamy in texture.

Vegetation

The factors controlling the type of plant communities within the study area are primarily slope, elevation, and topographic aspect. The characteristic plants in the plant communities found within the study area are shown in Table I.

Table I: Selected Characteristic Species of Main Communities, Rifle Scenario (EPA 1977)

Community Type	Characteristic Plants
Riparian (bottomlands)	Crops Cottonwood Box elder Willow species Green ash
Salt desert shrub	Cropland (some irrigated) Shadscale Greasewood Fourwing saltbush Nuttall saltbush
Sagebrush	Big sage Silver sage Rabbitbrush Bitterbrush
Pinyon-juniper	Pinyon pine Utah juniper Bitterbrush Mountain mahogany Rabbitbrush
Mountain brush	Serviceberry Mountain mahogany Chokecherry Snowberry Gambel oak
Mid-elevation	Ponderosa pine Douglas fir Snowberry Mountain maple Serviceberry
Sub-alpine forest	Engelmann spruce Lodgepole pine Aspen Fescut species Needle grass

In the Colorado River Valley, the main community types are riparian and agricultural, with desert salt shrubs occurring where farming has not taken place. The alluvial fans are predominately open sage community. The vegetated portions of the talus slopes are generally Mountain Brush Community, while the ridge tops are covered by the Pinyon-Juniper Community. The vegetation on the Roan Plateau corresponds directly to the exposure. Southern exposures are covered by sage and grass species while northern exposures are covered with dense aspen forests.

Population and Industry

The study area is sparsely populated. Land ownership is predominately Federal with private ownership only in the Colorado River Valley bottom. The population density for Rio Blanco and Garfield Counties is 4.1 per square mile. (DOE 1973) Within the study area, the population is limited to individual farms situated in the Colorado River Valley and the small mesas to the south, and a small housing area associated with the Paraho Demonstration Plant. The town of Rifle with a population of about 2500, is located two miles east of the study area.

Besides the Paraho Plant, the only other major industry in the study area is a Union Carbide uranium mill on the eastern edge of the area. Grazing occurs on the useable

land north of the Colorado River, with sheep herding predominately on the lower elevations, and cattle on the plateau.

Geology

For the purpose of this study, the surface geology within the study area has been divided into five units. These units consist of the Wasatch Formation, the Anvil Points Member of the Green River Formation, the Parachute Creek Member of the Green River Formation, the Uinta Formation, and the unconsolidated alluvium in the Colorado River Valley (Figure 3). The stratigraphic units in the study are unfaulted with a northerly dip of 1 to 2 degrees.

The Wasatch Formation is the oldest exposed rock unit in the study area, outcropping below 6400 feet. This formation is present throughout the basin with a thickness that varies from 200 to 6000 feet. This is a late Paleocene-early Eocene deposit, representing a mixed fluvial, and piedmont environment. The formation is composed of sequences of brightly colored sandstones, claystones, and siltstones. The formation has been divided into three members (Donnell 1969), (the Atwell Gulch Member, the Molina Member, and the Shire Member) but no attempt has been made to separate these members in this study.

Overlying the Wasatch Formation is the Green River Formation which has been described as an Eocene lacustrine deposit.

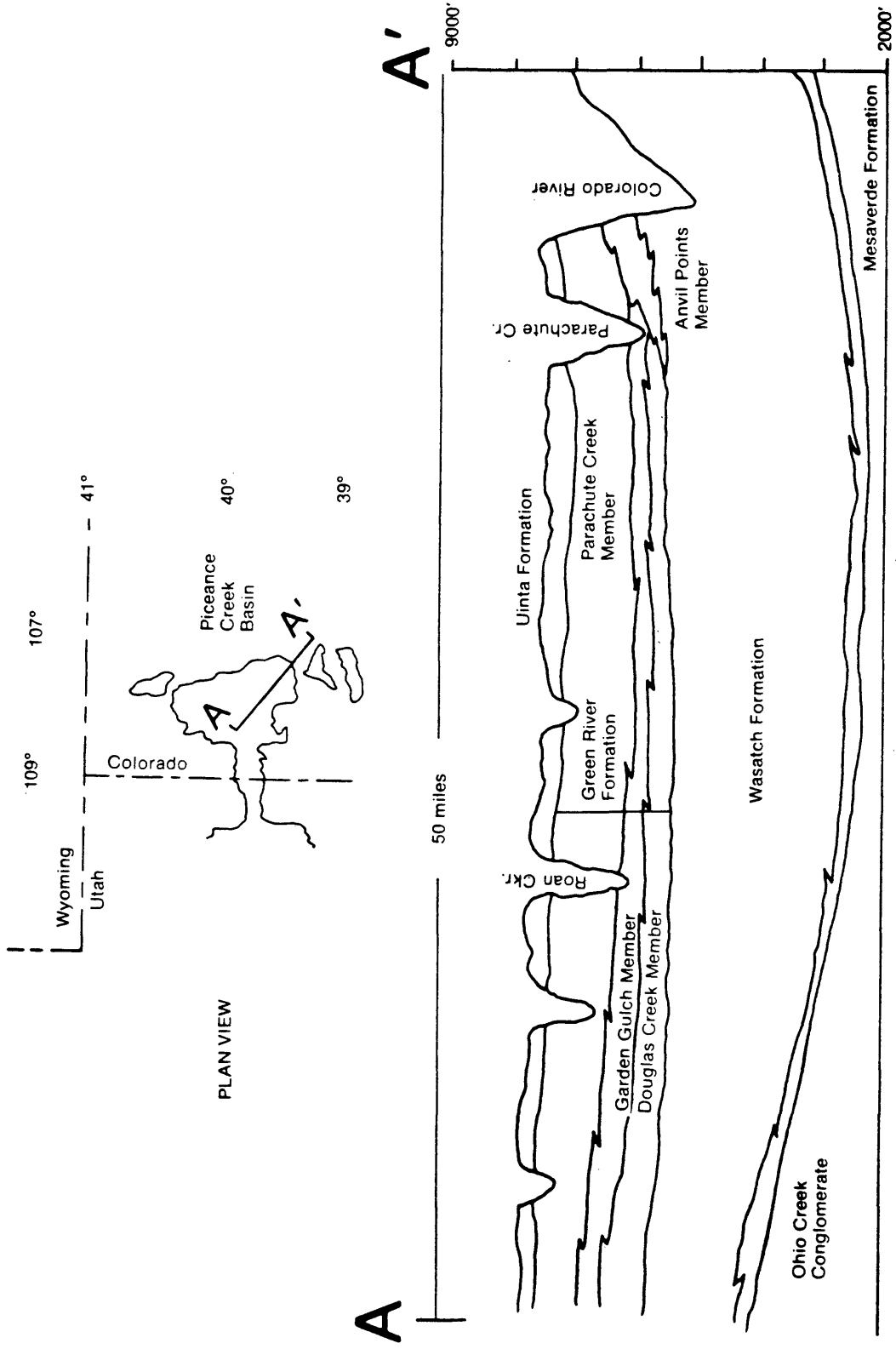


Figure 3: Geologic Cross Section of the Piceance Creek Basin (McDonald, 1972)

This formation has been divided into four members, two of which are present within the study area. The lower three units are not continuous throughout the Piceance Basin. In the western portion of the basin, the lowest member of the Green River Formation is the Douglas Creek Member. This member is composed of fine grained, cross-bedded and ripple marked sandstone. Overlying this member is the Garden Gulch Member which is composed of gray fissile shale interfingered with marlstone. The lateral extension of these two members in the eastern portion of the basin is the Anvil Points Member. This member is a shoreline facies representing a lacustrine and fluvial environment. It is composed of dull gray siltstones, sandstones, and marlstone. This member is found in the northeastern, eastern, and southeastern portion of the basin, and within the study area outcrops between 6640 and 8000 feet elevation. There are no economic oil shale deposits within this unit.

The uppermost member of the Green River Formation is the Parachute Creek Member. This is a deep water, low energy lacustrine deposit and contains rich deposits of oil shale. This member is present throughout the basin and is composed of massive to platy dolomitic marlstones. Within the study area, this unit outcrops between 8000 and 8400 feet elevation.

Above the Green River Formation is the Uinta Formation. This represents the waning of the ancient lakes and a return

to a fluvial type environment. In the Piceance Basin this unit was formerly called the Evacuation Creek Member of the Green River Formation (Cashion and Donnell 1974). Within the study area this formation outcrops above 8400 feet elevation and is composed of gray to orange sandstones with layers of siltstones and marlstones.

The surface geology of the study area is shown in Figure 4.

Geologic History

The geologic history of the Piceance Creek Basin begins in the Late Cretaceous with the Laramide Orogeny. This mountain building episode also resulted in large inter-mountain basins. The uplifted mountains disrupted the normal drainage to the east and provided a source of sediments from the south and east. The Ohio Creek Conglomerate rests unconformably on the Late Cretaceous Mesaverde Formation and thickens toward the center of the basin indicating that the basin was already in existence at this time. The streams probably flowed north into the Sand Wash Basin of Wyoming. During the Paleocene and early Eocene, the Wasatch Formation was laid down by low energy streams carrying sediments from the south and east. The Douglas Creek Arch was probably already in existence at this time. During Eocene time subsidence within the basin and uplift of the Uinta Arch to

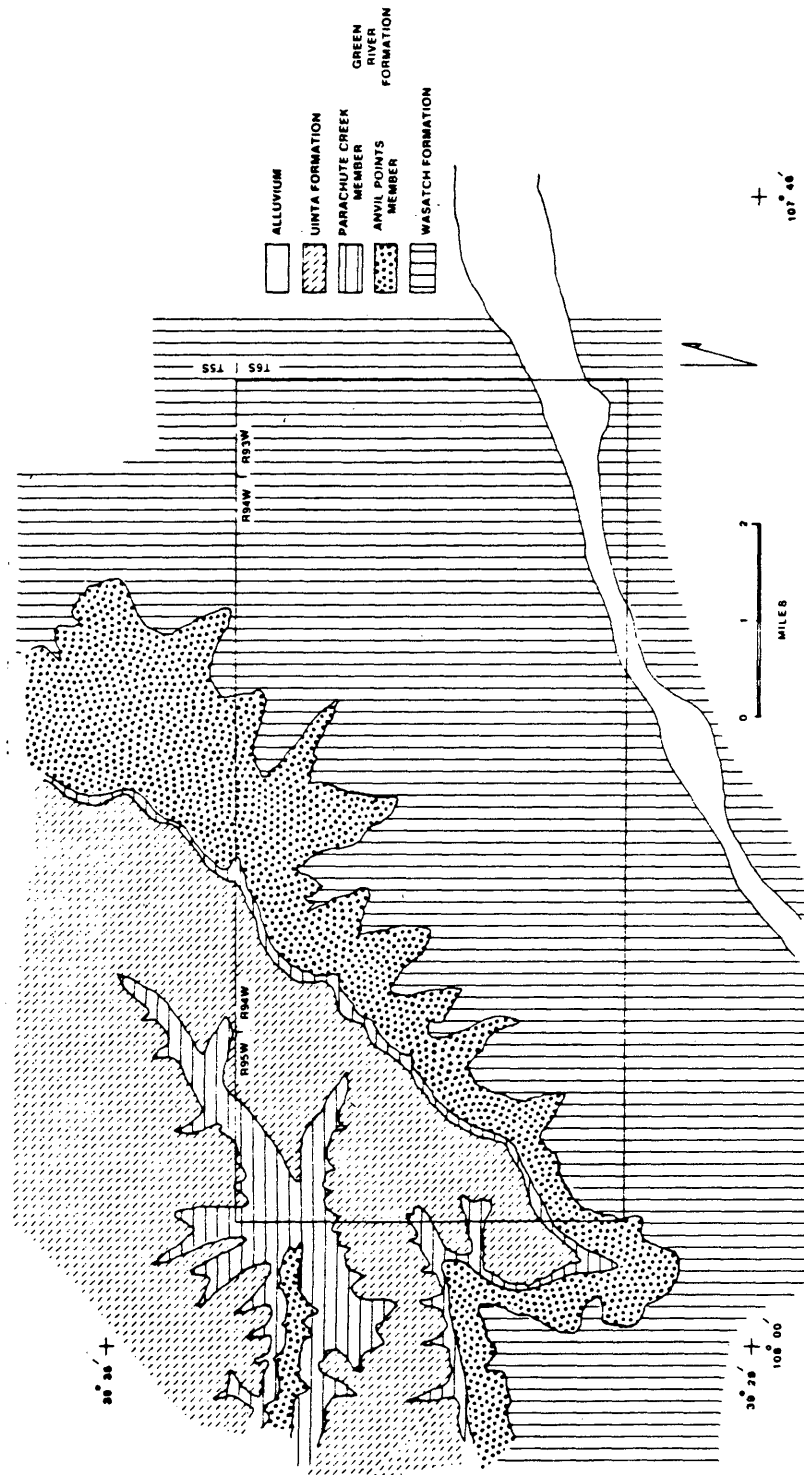


Figure 4: Surface Geology of the Anvil Points Region

the north closed off the basin leading to the formation of large lakes (McDonald 1972).

During the 6 million years of existence of Lake Uinta over 2000 feet of Green River Formation were deposited. Two models have been proposed for the depositional environment of these Eocene Lakes. A model supported by Bradley and Eugster (1969), Smith (1974), and Desborough (1978) call for a chemically stratified meromitic lake. Evidence for a broad shallow playa-lake environment for the Piceance Creek Basin has been presented by Lundell and Surdam (1975). It is unimportant for this study which model is correct.

Geochemical Setting

To predict the possible impacts of oil shale retorting on the Anvil Points area, it is useful to examine the geochemical nature of the oil shale of the Parachute Creek member.

Study of the mineralogy of the Green River formation indicates that these deposits were formed under conditions of high salinity and pH. A generalized mineralogy for oil shale from the Mahogany Zone of the Parachute Creek member is shown on the following page: (U.S. Bureau of Mines, 1960)

	Weight Percent
Mineral Constituents	86.2
Dolomite	35
Calcite	15
Feldspar	25
Quartz	15
Clay	5
Pyrite	1
Analcite & others	4
Kerogen	13.8

Over 50 authigenic minerals have been identified in the Green River oil shale and several of the saline minerals are also of economic importance. In the Piceance Basin the saline minerals of interest consist of nahcolite and dawsonite which are concentrated in saline facies toward the center of the basin.

Of interest to this study are the concentrations of the elements Mo, B, F, and Hg in oil shale. Because of the high pH during deposition, elements that form anions and are mobile at high pH would be expected to be concentrated in the oil shale. The following table compares the concentration of these elements with crustal average and standard shales.

<u>Element</u>	<u>Crustal Ave.¹</u>	<u>Ave. Shale¹</u>	<u>Green River Oil Shale²</u>
Mo	1.5 ppm	2 ppm	10 ppm
B	10	100	75
F	625	500	1000
Hg	.08	.4	.5

1) Krauskopf (1967)

2) Dean (1976)

Geochemical data on either the Wasatch formation or the Uinta formation within the Piceance Creek Basin are very limited. It is believed that these formations are lower in concentration for the elements of interest than the Green River formation. The only supporting evidence for this indicates that the Uinta is lower in Mo than the Green River (Ringrose 1976) while the Wasatch is lower in boron than the Green River (Vine 1973).

PREVIOUS WORK IN THE AREA

The first record of the geology of the Green River Formation was by Peale (1876). The economic importance of this formation was noted later on by Eldridge (1901). Since that time numerous studies and surveys have been done on this formation. A bibliography of the geology of the Green River Formation has been prepared and published by the U.S. Geological Survey (1977). The geology of the Piceance Creek Basin is summarized by Donnell (1961) and later revised by Cashion and Donnell (1974).

Within the Piceance Creek Basin, trace element baseline studies began in 1975 under the direction of R.W. Klusman. Ringrose, et al. (1976) studied the regional variation of 37 elements in soils over the entire basin (Figure 5). This study employed a five level analysis of variance design; analytical, sample (0-100m), section (.1-3km), township (3-19km), and supertownship (> 19 km). Information from this study was used to plan future smaller baseline studies of individual areas to be developed within the basin. Candito (1977) conducted a baseline study around oil shale lease Tract C-a, and Zuccaro (1978) conducted a baseline study around Tract C-b. (These areas along with the present study are shown in Figure 6.)

McNeal, et al (1976) studied trace element variation in stream sediment samples. Their data showed that sampling should be conducted on 1 km interval with a sample consisting of a composite of 10 m of stream bed.

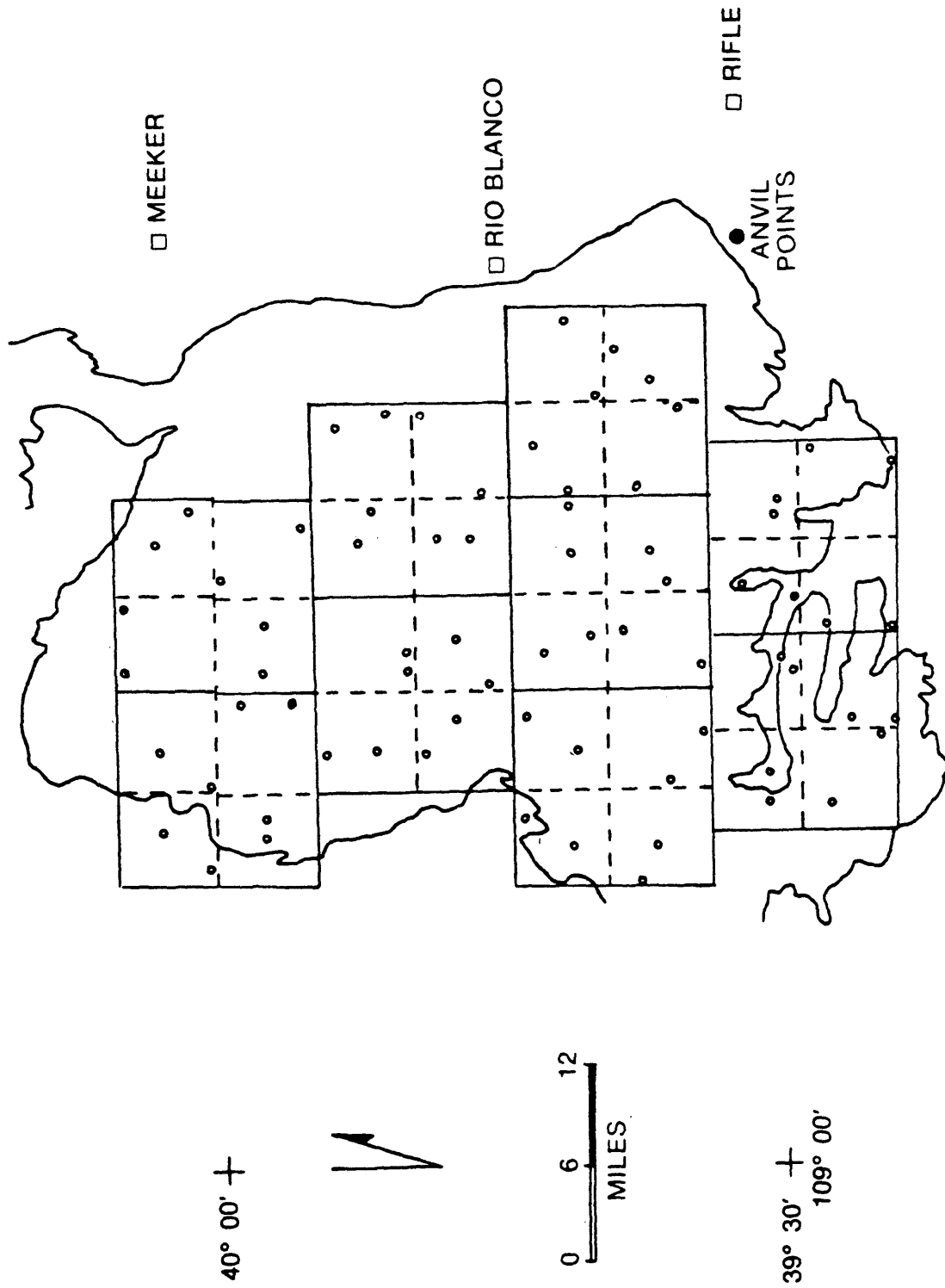


Figure 5: Regional Soil Survey of the Piceance Creek Basin (C.D. Ringrose, R.W. Klusman, W.E. Dean, 1976)

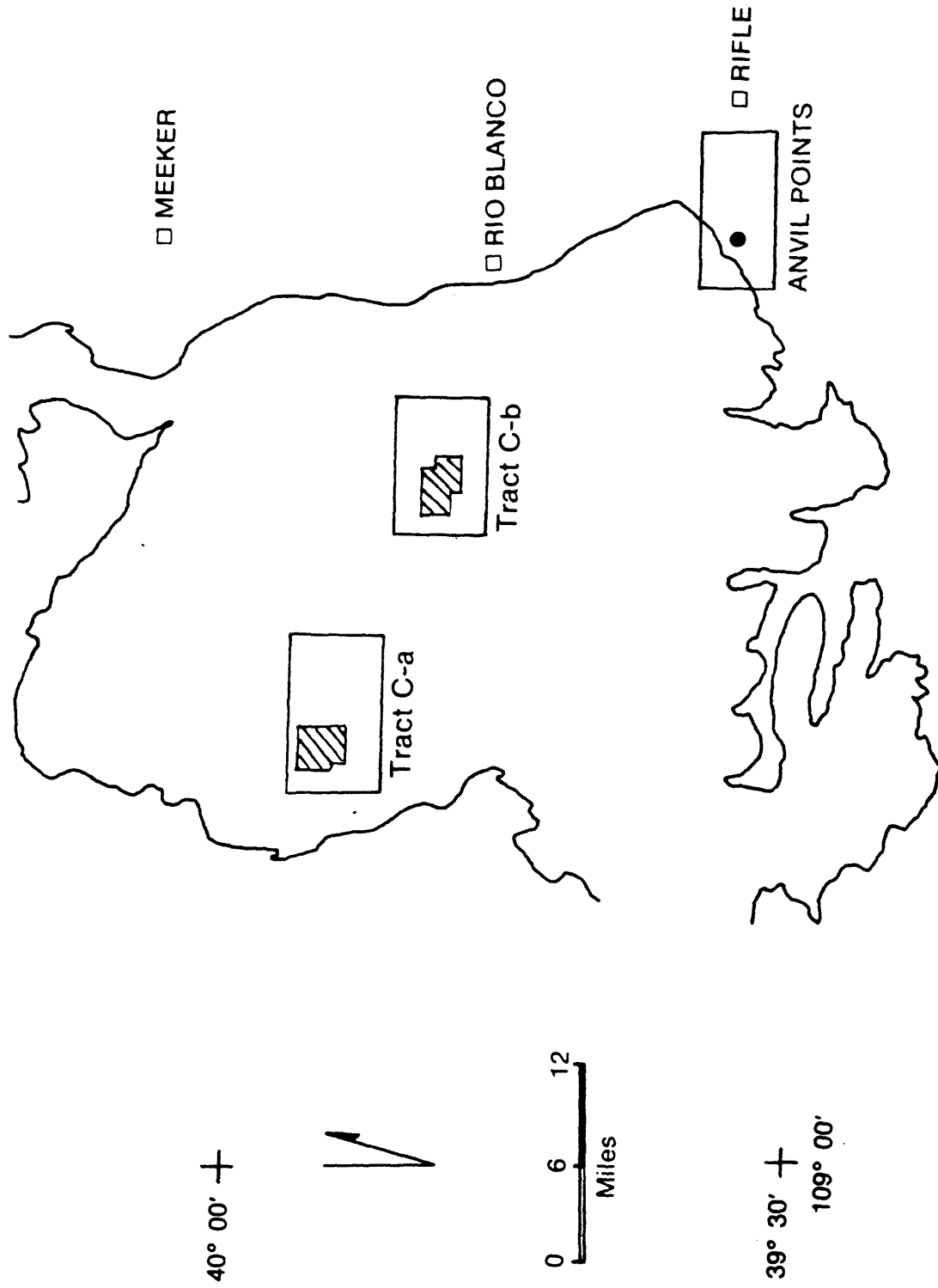


Figure 6: Geochemical Baseline Studies in the Piceance Creek Basin

SAMPLE DESIGN

Three sample designs were used for this study. A hierarchical analysis of variance design was used as a first stage design to assess the geochemical variability within the study area. This design has been previously used and described by Miesch (1976b). The purpose of this sample design is to determine the effect of sample spacing on geochemical variability and determine the sample density necessary to produce a reproducible map.

The second stage design consisted of collecting soil and plant samples on a grid system and collecting stream sediment samples on 1/2 mile intervals along stream channels. The purpose of the second stage sample design is to collect samples to calculate baseline levels and if possible outline areas of anomalous concentrations. The design of the second stage sampling system is usually determined after analysis of the results of the first stage sampling program, but for this study the second stage design was determined using data from Ringrose, et al (1976). This design was also used by Candito (1977) and Zuccaro (1978). The first stage sampling design completed as part of this study will be used to verify previous results and determine map stabilities for this study.

The selection of sample sites for soils and plant samples involved gridding the study on 1/2 mile intervals and locating

the sample site at the grid line intersections. Figure 7 shows the resulting sample pattern and sample location numbers. This sampling system would have resulted in 171 sample sites, but one site was omitted because it would have fallen in the Union Carbide uranium mill area.

This type of sample design was used since an objective of the study is to obtain baseline data for the area as a whole. This type of design results in the number of samples per geologic unit being proportional to the amount of surface area exposed. This is illustrated by Table II which lists the number of samples broken down by geologic unit. This is in effect an automatic weighting factor applied to each geologic unit as a result of exposure.

TABLE II

<u>Geologic Unit</u>	<u>Number of Samples</u>
Alluvium	10
Wasatch	103
Anvil Points	25
Parachute Creek	4
Uinta	28

Plant samples were collected when the species of interest was present at the sample site. Big sage was fairly evenly distributed over the study area with 125 out of the 170 possible sample sites having sage present. The main

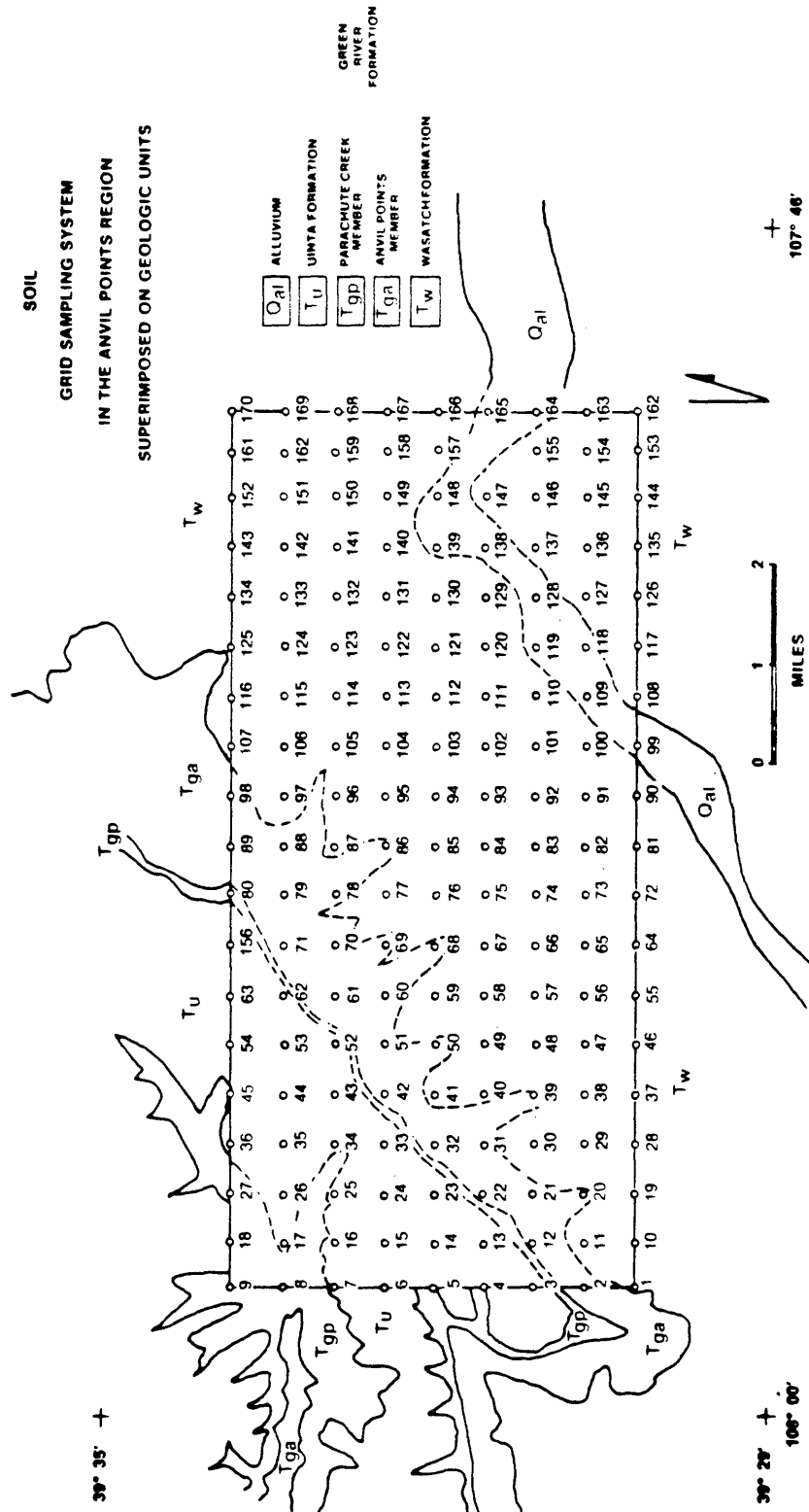


Figure 7: Sample Location Key

gaps for sage occurred on the steeper parts of the ridges and talus slopes and in the Colorado River Valley. The distribution of Indian ricegrass and Western wheatgrass was more dependent on local slope, exposure, and climate. Indian ricegrass was common on the ridges and slopes of the Wasatch and Anvil Points units but was not able to compete with other grass that grew on the less severe environment of the plateau area. Most of the gaps in the Indian ricegrass distribution occurred on the Uinta formation and in the valley of the Colorado River. Western wheatgrass grew well on the plateau area but was not well distributed on the drier slopes of the Anvil Points and Wasatch units. Gaps also occurred in the Alluvium unit. Table III shows the breakdown of samples by geologic unit and Figures 8, 9, and 10 illustrate these spatial relationships.

TABLE III

<u>Geologic Unit</u>	<u>Big sage</u>	<u>Indian ricegrass</u>	<u>Western wheatgrass</u>
Alluvium	3	2	0
Wasatch	93	75	24
Anvil Points	8	14	1
Parachute Creek	3	3	3
Uinta	18	8	19
	<hr/>	<hr/>	<hr/>
Total	125	102	47

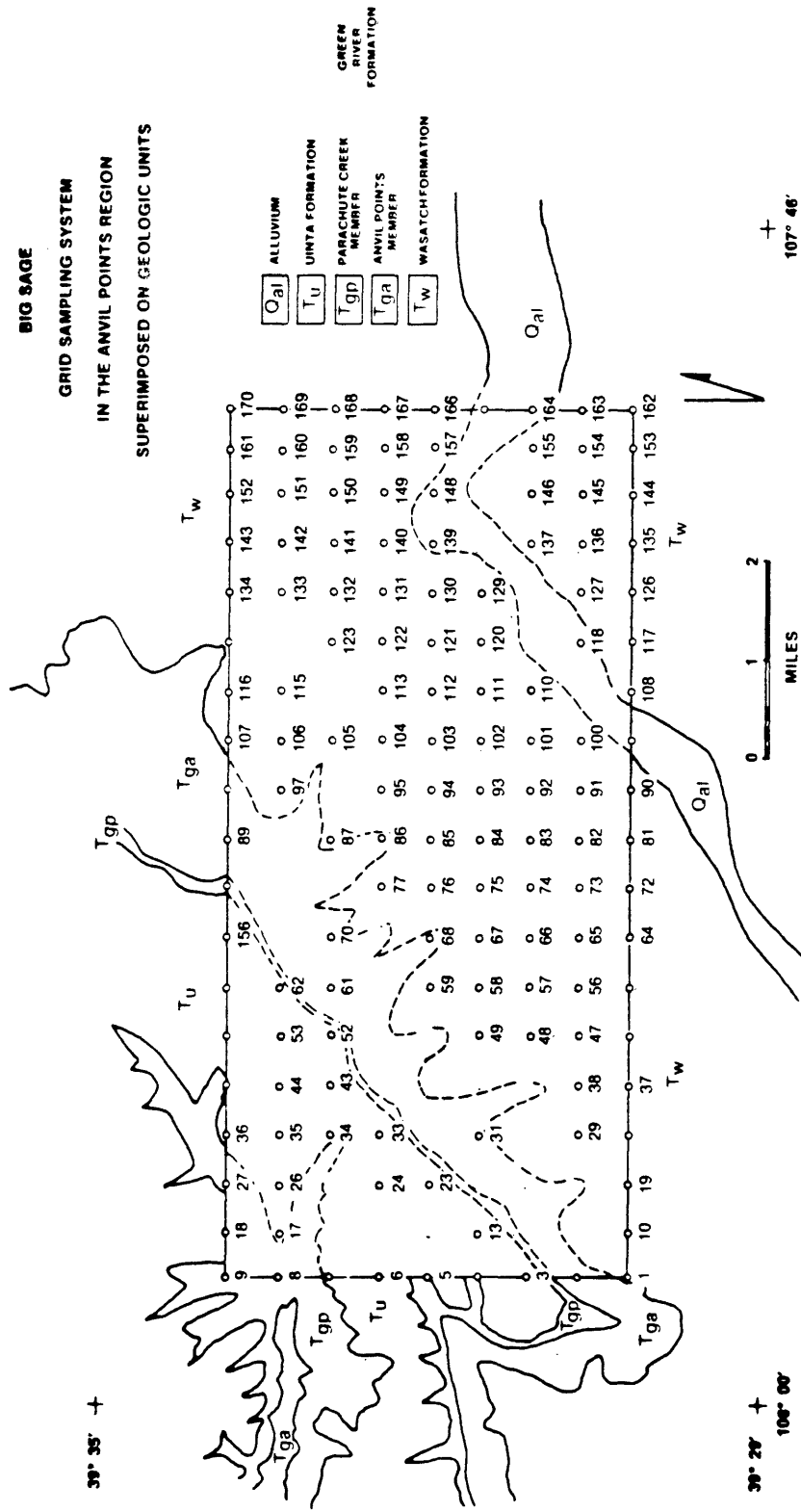


Figure 8: Sample Location Key

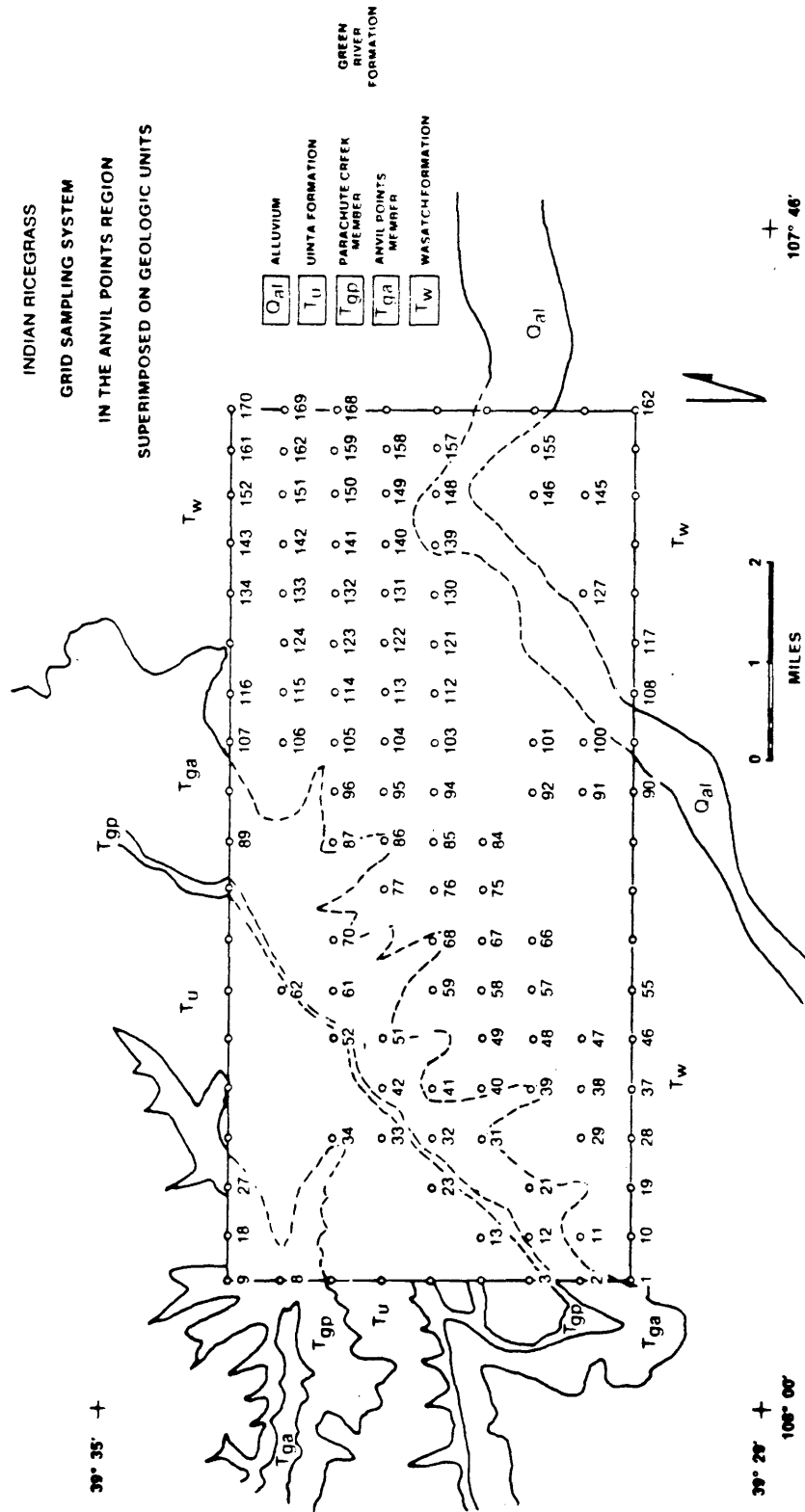


Figure 9: Sample Location Key

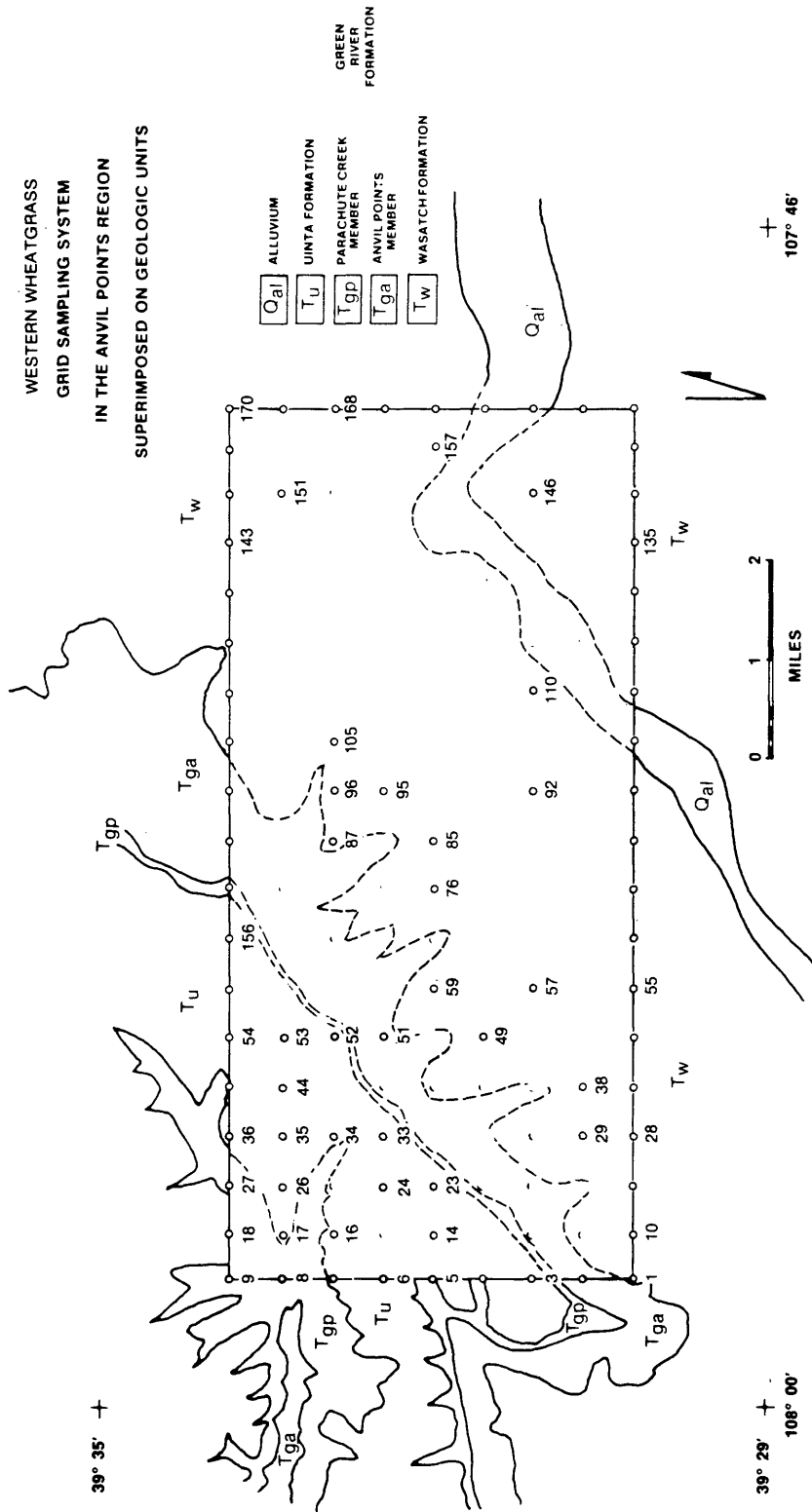


Figure 10: Sample Location Key

A sample site consists of an area 10 to 20 meters in diameter. Soil and plant samples are composites from about four to six locations within the sample site.

Soils were taken from the surface horizon using a chrome plated trowel and sieved in a stainless steel sieve. One sample of 200 to 400 grams was sieved to -1/4 inch and kept in a paper soil envelope. A -80 mesh sample was also sieved on site and stored in a vial to prevent loss of Hg.

Plant samples were kept in stapled paper bags to prevent dust contamination. Where possible, the plant sample consisted of first year growth.

Stream sediment samples were collected on 1/2 mile intervals on all clearly defined stream channels within and immediately adjacent to the study area (Figure 11). This included both flowing and dry channels. A sample site consisted of a 10 meter stretch of stream bed near the center of the channel and free of bank slumping. A minus 4 mesh and a minus 80 mesh sample were taken at each site as described for soil samples. There were a total of 161 sample sites broken down by geologic units in Table IV.

TABLE IV

<u>Geologic Unit</u>	<u>Sample Sites</u>
Alluvium	3
Wasatch	111

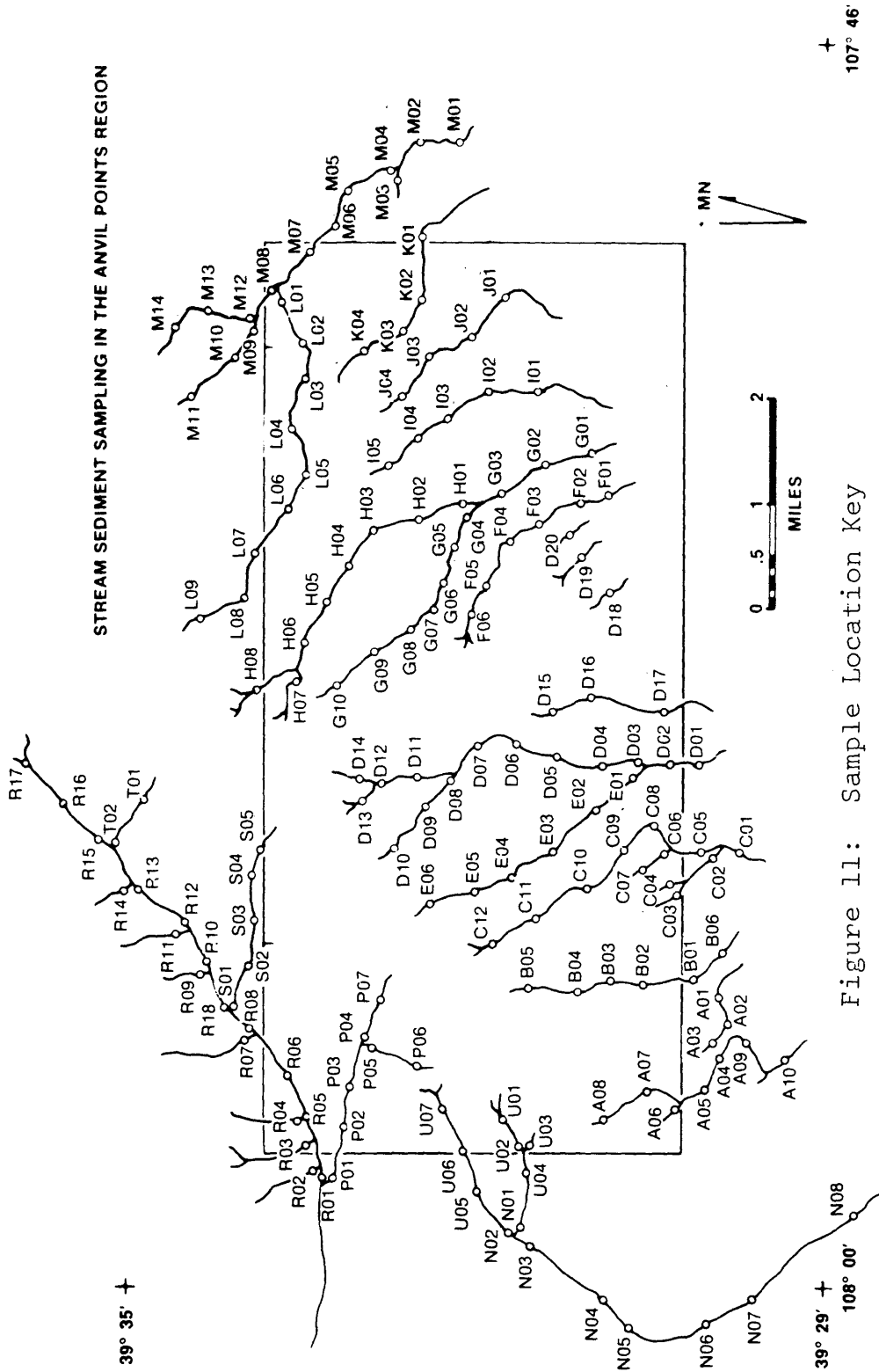


Figure 11: Sample Location Key

Table IV cont.

<u>Geologic Unit</u>	<u>Sample Sites</u>
Anvil Points	13
Parachute Creek	23
Uinta	11

The first stage sample design is based on a five level hierarchical analysis of variance model. This was accomplished by randomly selecting four sections out of the 36 possible sections in the study area (Figure 12). Each section was quartered with two quarters being randomly selected. These quarter sections were again quartered with two of these quarters being randomly selected. Within each of these 1/16 of a section two sample sites were located 50 meters apart. This system is illustrated in Figure 13. This design results in 32 samples evenly divided over four sections. The random selection process resulted in three of the sections being chosen over the Wasatch Formation and one section on the Uinta Formation. In one of the sections chosen from the Wasatch, Western wheatgrass could not be found. This resulted in only 24 sites in three sections for the analysis of variance for Western wheatgrass.

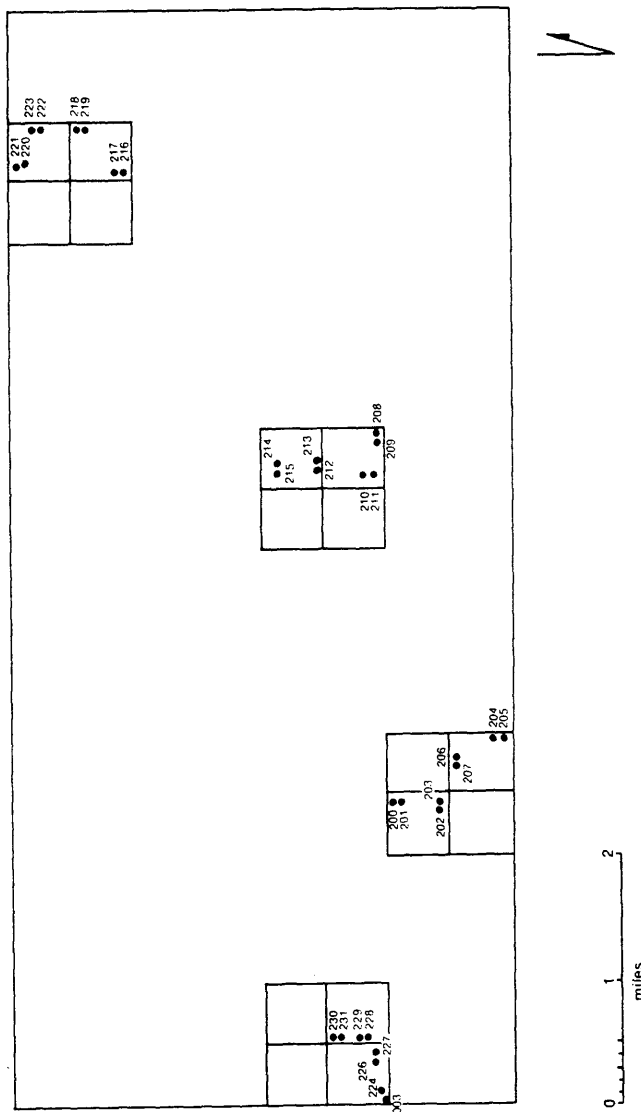


Figure 12: Analysis of Variance Sampling System for the Anvil Points Study Area

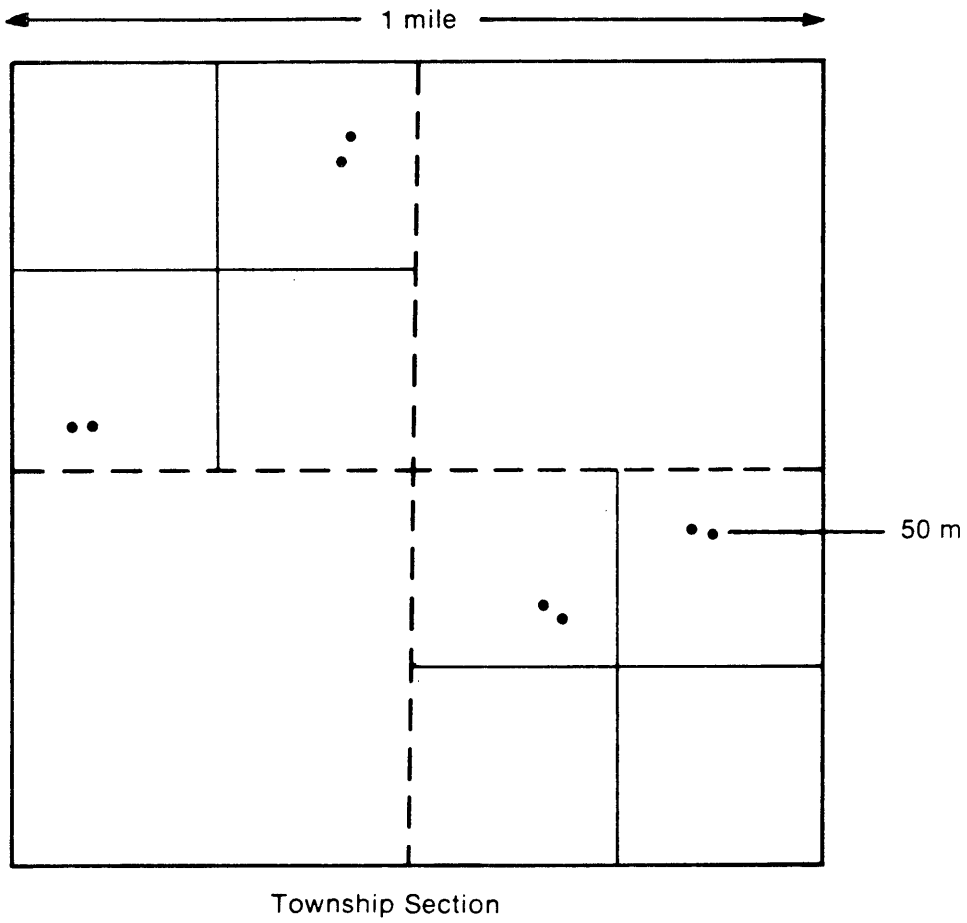


Figure 13: Analysis of Variance Sample Design

ANALYTICAL

Sample Preparation

Sample preparation was performed at the Colorado School of Mines. Preparation of soil and sediment samples was performed as follows:

- 1) Split the bulk sample down to a 15 to 20 gram sample using a Jones type splitter
- 2) Grind for 7 to 10 minutes in a Spex Mixer/Mill using tungsten carbide balls and mill
- 3) Store and label ground sample in two plastic vials
- 4) Return unground sample to original sample envelope

The procedure for grass sample preparation was:

- 1) Wash the grass in distilled water for 5 minutes using an ultrasonic cleaner
- 2) Rinse with distilled water
- 3) Dry thoroughly on paper towels
- 4) Grind the sample using a blender
- 5) Fill a 4 ounce sample jar and return excess to the original sample bag
- 6) Dry sample and jar at 60° to 70°C for 24 hours
- 7) Ash a three gram portion of dried sample
 - a) Weigh out as accurately as possible 3.000 gms of plant sample into a porcelain crucible
 - b) Ash the 3 gram portion at 250°C for one hour, then 350°C for two hours, and finally at 450°C for 21 hours
 - c) Quantitatively transfer the ashed sample into a plastic vial and label

Sample preparation for sage samples was similar to that just described for grass samples except that the sage samples were not washed. Sage tended to fall apart easily when dry and would be difficult to wash. It was not considered necessary to wash the sage samples since they were collected near the plant tops and thus not easily contaminated by rain splashed dirt.

A random number program was used to generate random sequences for analysis for all samples.

Analyses for Mo, B, and F were performed at Project Central Laboratory in Boulder, Colorado. Analysis for Hg, organic carbon, and pH in soils and sediments were performed at the Colorado School of Mines.

At Project Central Laboratory the ashed plant samples were transferred to plastic vials and dissolved in 20 ml of 1.0 molar HCl. From this solution, 5 mls were taken for F analysis, 5 mls were used in the B analysis, and the remaining 10 mls used for Mo analysis. The data reported by the Project Central Laboratory were as ppm dry plant weight.

The following fusion method was used to prepare soil and sediment samples for fluoride and boron analysis (Meglen 1978).

A 0.1 g sample and 1.0 g $\text{Na}_2\text{CO}_3:\text{K}_2\text{CO}_3$ flux (1:1 by weight) are mixed and fused in a 25 ml platinum crucible at 1000°C for 0.5 hours. After cooling the crucibles, 10 ml of 1.0 M HCl is added to the fusion mixture to initiate dissolution of the fusion mixture. The

contents are then transferred to a 100 ml plastic specimen cup. A second 10 ml portion of 1.0 M HCl is added to the crucible, stirred, and transferred to the plastic cup. The third rinse consists of 1.0 ml concentrated HCl and 4.5 ml deionized water. The sides of the crucible are scraped with a rubber spatula and the contents transferred to the specimen cup. The final rinse is carried out with 4.5 ml of deionized water. (If fused material remains in the crucible an additional rinse of 10 ml 1.0 M HCl may be necessary.) The final volume of 50.0 ml is obtained by addition of 1.0 M HCl.

For Mo determinations on soils and sediments, the following acid digestion was used (Meglen 1978):

Geological samples submitted to this laboratory which are suspected to have less than 2 ppm sample of Mo are prepared for analysis by acid digestion. This process allows for a greater amount of the sample to be used and is rigorous enough to break up the silicate matrix of the samples.

One gram of the sample is weighed into a 100 ml Teflon beaker. This is followed by the addition of 2.5 ml HNO_3 , 2.5 ml H_2SO_4 and 5.0 ml HF. The beakers are placed on a hot plate at 240°C and the acids are allowed to evaporate to dryness. This acid treatment is generally carried out three times on the sample but the number of times may vary with the grain size of the sample. The sample is considered "digested" when the dry residue consists of a white or yellow crust.

After allowing the sample to cool, 1.0 ml of concentrated HCl and 4.0 ml of deionized water are added. The beakers are covered with a watch glass and placed on low heat for five minutes to help dissolve the sample. The sample is then filtered and washed with deionized water. The volume is brought up to 15.0 ml in a test tube..

Analysis for Mo (Meglen 1978)

To analyze a digested sample for Mo, 10 ml aliquots are withdrawn and pipetted into test tubes. The following steps are modified for Mo-thiocyanate colorimetric analysis scheme:

- 1) Add 0.5 g sodium tartrate and stir.
- 2) Add 0.1 ml 1% ferrous ammonium sulfate solution.
- 3) Add 0.5 ml 10% potassium thiocyanate solution; stir; wait 15 minutes.
- 4) Add 2.0 ml 10% stannous chloride solution; stir; wait 15 minutes.
- 5) Add 2.0 ml of *i*-amyl alcohol to the samples and 4.0 ml to the standards; shake; allow 15 minutes for layers to separate; centrifuge for about 5 minutes.
- 6) Analyze the organic extract for Mo using flame atomic absorption.

AA parameters - Perkin-Elmer Model 5000

Lamp wavelength - 313.3 nm
Lamp current - 25 ma
Flame N₂O Acetylene - fuel rich
Burner height - 2 cm below the light beam
Aspiration rate - the nebulizer system is slightly adjusted for the alcohol to aspirate moderately slowly

The standards are 100, 200, 300, and 500 ug/ml. An isoamyl alcohol blank is used. The common practice in this lab is to include two or three of each standard, depending on the size of the run, to insure that there is surplus to monitor the calibration of the instrument.

The samples are analyzed using 5-second integration times. After analysis the peak heights are measured and the concentrations are calculated.

NOTE: Atomic Absorption is used to detect the Mo instead of colorimetry. Soil samples after digestion leave a yellow coloration (as yet of unknown origin) which interferes with the amber 460 nm complex band used in the colorimetric method.

Analysis for Boron (Meglen 1978)

One ml of sample or standard is pipetted into a plastic test tube followed by 2.0 ml of buffer. The contents are stirred on a Vari-Whirl. Two ml azomethine-H solution are then added and stirred. The tubes are allowed to sit for 0.5 hours before reading the absorbance values at 420 nm. The range of standards used is from 0-5 ppm B although the standard curve is linear up to 10 ppm B. Often the samples are too concentrated, as is the case with plants where 0.5 ml of sample is pipetted into the

test tube and then brought up to 1.0 ml with 0.5 ml deionized H₂O.

In some cases the samples may exhibit color before or after the addition of buffer. This is a potential interference in the absorbance measurements and therefore sample blanks are also prepared. The preparation involves the addition of 2.0 ml of a 1.0% ascorbic acid solution instead of the 2.0 ml of the azomethine-H solution. The absorbances are read at 420 nm and subtracted from the absorbances of samples with the azomethine-H solution.

When a yellow coloration is present in the samples (in the absence of the azomethine reagent) it is possible to prepare a "correction" calibration curve. This correction curve may be obtained by randomly selecting a number of samples to be analyzed as sample blanks; i.e., without the addition of azomethine reagent. The absorbance values of all azomethine-containing samples are read. The concentrations are calculated from the Beer's law plot. These are designated as uncorrected since they include absorbance of the interfering species. The absorbance values of the selected sample blanks are then read and subtracted from the corresponding absorbance values of the azomethine-containing samples. These corrected absorbance values are then used to calculate "corrected" concentrations from the Beer's law plot. A plot of uncorrected values (y-axis) against "corrected" (x-axis) may then be used to correct samples which have a similar matrix but for which no blanks have been prepared. This procedure has been used with excellent reproducibility for a given sample type. Occasional blank checks have shown that this procedure is accurate to within 3%.

Reagents:

Buffer:

500 gm ammonium acetate
30 gm disodium EDTA
800 ml deionized H₂O
250 ml glacial acetic acid

The ammonium acetate does not dissolve completely, however, this does not seem to affect the analysis.

Azomethine-H solution:

1.0 gm ascorbic acid is dissolved in 100 ml deionized H₂O. 0.45 azomethine-H (available from Pierce Chemical Co.) is added to the solution. The azomethine-H should dissolve completely. Due to the to the instability of the azomethine-H, the solution must not be allowed to sit at room temperature overnight. It can be stored in the refrigerator for one week or in the freezer for approximately one month. Upon thawing the solution for reuse, make certain that the azomethine has completely dissolved since it can precipitate out while freezing. NOTE: Prepare and store all reagents in plastic containers.

Analysis for Fluoride (Meglen 1978)

When this study began, a solvent extraction was used. This was later changed to a gas diffusion method with a different but equivalent method of analysis. Both methods will be described.

Extraction of F into the organic phase (Solvent Extraction):

Five ml of sample or standard is pipetted into a 20 ml plastic vial. Generally the range of standards used is from 0 to 3.0 ppm F. The samples and standards are acidified with 0.5 ml concentrated HCl followed by the addition of 5.0 ml diphenylsilanediol (DPSD) solution. The vials are capped tightly and then shaken for 1 hour on a wrist action shaker. The extracts may be stored for at most a week in the refrigerator. The efficiency of the extraction is 90-100%.

Reagents:

- 1) 5 M diphenylsilanediol in xylene
- 2) Aluminum reactant
0.01 M Al(NO₃)₃
0.005 M Ni(NO₃)₂
0.005 M Sr(NO₃)₂

Diffusion Separation

Ten ml of standard or acidified sample are pipetted into a plastic specimen cup. A plastic microbeaker containing 1.0 ml of 0.1 M Na₂CO₃ is floated on the

sample solution. A 0.5 ml of 6 M HCl saturated with hexamethyldisiloxane is carefully added to the sample avoiding contact with the carbonate solution in the microbeaker. The specimen cup is immediately capped tightly and the diffusion process is allowed to proceed for approximately 20 hours. After that period of time the microbeaker, into which the F has diffused, is removed and the contents are diluted to 10 ml.

The initial volume of sample and the final volume obtained do not necessarily have to be 10 ml. One must make certain that the final Na_2CO_3 solution is 0.005 - 0.01 M. Concentrations greater than 0.01 M result in a depressed absorption signal. The initial Na_2CO_3 concentration is adjusted accordingly.

Reagents:

- 1) Diffusion Reactant: 6 M HCl saturated with hexamethyl disiloxane

The detection of fluoride differed depending on which extraction was used. For the solvent extractions, the following method was used.

Combine equal volumes of sample and Al reactant solution for introduction into the graphite furnace. (It may be necessary to acidify the mixture to prevent precipitation of hydrous aluminum.) Twenty ml of the sample-reactant mixture is injected into a heated graphite furnace. The sample is dried at 100°C for 40 sec. Atomization occurs at 2250°C for 7 seconds. The absorbances are read at 227.5 nm using a hydrogen continuum lamp as the light source. A slit width of 0.2 nm is used for all measurements. A continuous purge with argon gas is used.

Standardization

The range of standards used is from 0-3 ppm F. The standard curve is not linear and therefore, samples greater than 3 ppm F are subject to greater error.

ANALYZER CONDITIONS

	Dry	Char	Atomize
Temp (°C)	100	500	2250
Time (sec)	50	30	7

A.A: Conditions

Hydrogen or Deuterium continuum lamp
Slit: 0.2 nm
Wavelength: 227.5 nm
Scale x 1.0

Reagents:

Aluminum Reactant: 0.01 M $\text{Al}(\text{NO}_3)_2$
0.005 M $\text{Ni}(\text{NO}_3)_2$
0.005 M $\text{Sr}(\text{NO}_3)_2$

When gas diffusion separation was used, the detection of fluoride was accomplished using Alizarin-complexone. Two mls of the diffused sample were mixed with 1 ml of H_2O and 1 ml of Alizarin-complexone. The mixture was stirred and allowed to sit for 30 minutes. The sample was then run at 622 nm.

Reagents: Alizarin-complexone

Alizarin
Sodium Acetate
Acetic acid
Acetone
HCl
Lanthanum oxide

Analysis for Mercury (Jerome Instrument Corporation 1978)

Mercury concentrations in soil and sediment samples were determined using an Instrument Model 301-Jerome Gold Film Detector. The method is based on the resistivity change in a thin gold film upon the adsorption of elemental mercury.

When a sample is heated in the combustion assembly, gaseous combustion products, including mercury from the sample, enter the air stream and pass over a gold-plated collector coil contained within the plug-in module on the panel face. The mercury is adsorbed on the gold collector and the remaining combustion products pass into the atmosphere. A timed cycle is then activated during which the gold collector coil is heated for 9-10 seconds to volatilize the mercury back into the air stream. The sample mercury and any H_2S that may be present pass into malleosorb where H_2S is selectively adsorbed. The air

stream is then split and mercury is removed from the reference stream by palladium black on pyrex wool before passing over the reference gold film. The other stream passes over an equal quantity of clean pyrex wool and over the sensor gold film; the mercury in the air stream causes the resistance of the sensor film to increase. The reference and sensor films are two legs of a wheatstone bridge. The resistance bias between them is measured and displayed on a digital galvanometer. Any mercury not adsorbed by the film or mercury released by the films when they are heated and cleaned is exhausted through a filter which contains activated charcoal to adsorb the mercury and prevent contamination of the work area.

An auto-zero circuit continually compensates for any drift in the resistance of the films. When mercury adsorbs on the sensor film the rate of change in resistance of the sensor film overrides the auto-zero and a readout is obtained on the digital meter. The peak reading will be displayed for a few seconds, then the auto-zero circuit will begin automatically re-zeroing the bridge.

Measurement of Soil pH (Black 1965)

Pour enough soil in a small beaker to allow sufficient immersion of electrodes for satisfactory reading. Add water in small increments, stirring with glass rod between additions. Water should be added until it forms a "saturation paste". A "saturation paste" is obtained when a smoothed soil surface just begins to glisten or when a groove created when the stirring rod is dragged through the paste just barely closes behind the rod.

Use a conventional pH meter with a rugged electrode pair that can be easily wiped clean with wet kimwipes. Do not use electrodes that will be difficult to wipe clean. Check the meter using standard buffer solutions differing by 2-3 pH units and preferably bracketing most of the soils being measured. Measure the pH after the electrodes have been "immersed" in the saturation paste. Check meter with buffer after about every 10th sample.

The following points should be considered while performing the pH measurements

- 1) If paste is not wet enough errors may result because poor soil-electrode contact and high electrical resistance of the soil.

- 2) If excess water is added pH reading will normally be too high.
- 3) Increasing concentration of neutral salts decreases pH reading.
- 4) Soils should be equilibrated with atmospheric CO₂.
- 5) If soils are calcareous, a thin CaCO₃ film may form on the electrode after several measurements. This can be removed with dilute HCl.

Measurement of Organic Carbon - Walkley-Black Method (Black 1965)

Weigh 0.4 - 0.5 g (four digits) of air dry soil sieved or ground to desired fraction into a 500 ml wide mouth Erlenmeyer flask. Use 0.9 - 1.0 g if the soil is obviously low in organic matter (light or red in color).

Add 10 ml of 1.000 N K₂Cr₂O₇ and swirl the flask gently to disperse the soil in suspension. Then rapidly add 20 ml of concentrated H₂SO₄, directing the stream into the suspension. Swirl the flask for one minute and allow to stand on a sheet of asbestos for about 30 minutes. Add 200 ml of water to the flask. Add 3 to 4 drops of o-phenanthroline indicator and titrate the solution with 0.500 N FeSO₄. As the end point is approached, the solution takes on a greenish cast and then turns dark green. At this point add the FeSO₄ drop by drop until the color changes sharply from blue to red (maroon). The endpoint may be difficult to discern in a soil suspension. A small Buchner funnel and a fast filtering paper may be used to remove the suspended material prior to back titration with FeSO₄.

Make a blank determination in the same manner, but without soil. Repeat the determination with less soil if more than 75% of the dichromate is reduced.

Calculation

$$\text{Organic C\%} = \frac{(\text{Meq K}_2\text{Cr}_2\text{O}_7 - \text{Meg FeSO}_4) \times 0.003 \times 100}{\text{Grams of air dry soil}} \times 1.33$$

The 1.33 factor is a correction for efficiency of oxidation by the method. This factor may vary slightly and for highly accurate work the combustion method is better or can be used to determine the correction factor.

Reagents

- 1) Potassium dichromate - 1.000 N. Dissolve 49.04 g of reagent grade $K_2Cr_2O_7$ (dried at $105^\circ C$) in water and dilute to 1000 ml.
- 2) Sulfuric acid - concentrated
- 3) o-phenanthroline-ferrous complex - 0.025 M. Dissolve 1.485 g of o-phenanthroline monohydrate and 0.695 g of $FeSO_4 \cdot 7H_2O$ in water and dilute to 100 ml.
- 4) Ferrous sulfate - 0.500 N. Dissolve 140.0 g of reagent grade $FeSO_4 \cdot 7H_2O$ in water, add 15 ml of concentrated H_2SO_4 , cool and dilute to 1000 ml. Standardize daily by titrating against 10 ml of 1.000 N $K_2Cr_2O_7$. If stored under hydrogen the titer is stable.

Detection Limits

The detection limits for the analysis performed at Project Central Laboratory were reported as:

Mo determinations	-	.05 ppm
B determinations	-	10 ppm
F determinations	-	2 ppm

The detection limits for work done at the Colorado School of Mines were:

Organic Carbon determinations	-	.05%
Hg determinations	-	.1 ppb

The only censored data sets were organic carbon and B in stream sediments. There were 10 samples out of 161 that were below the detection limit for B and 7 out of 161 that were below the limit for organic carbon. These values were recorded as .7 times the detection limit for the purposes of calculating

means and deviations. Because of the limited amount of censored data, more rigorous methods of treating censored data were not considered necessary (Miesch 1976a).

Analytical Precision

It is appropriate at this point to examine analytical error associated with the chemical analyses involved in this study. A general definition of analytical error is a departure from the true or expected value caused by the chemical tests. Errors caused by sampling will be examined later in the section on analysis of variance.

Analytical error is usually of two types. One type deals with the accuracy of the analytical method and the other type deals with the precision of a method. Errors in accuracy are difficult to deal with in geochemical studies since the true concentrations of samples are not known. This type of error is usually detected by analysis of standards and must be carefully considered when an analytical method is developed. A discussion of the accuracy of the methods used for this study is beyond the scope of this survey.

The problem of precision is always present in chemical analysis, and is of great importance to this study since variability induced by the analysis must be considered with the overall sampling variability in understanding geochemical variability within the study area.

In order to deal with error statistically, it is necessary to make several assumptions. These assumptions are:

- 1) The errors are independent of each other
- 2) The errors have a common variance
- 3) The errors are normally distributed

Table V shows the analytical deviations and percent deviations for each chemical test and each sample media. A comparison of the analytical precision with sampling variability will be discussed later.

These calculations were done using the computer program PRECIS.FOR (Klusman, 1977) which is listed in the appendix. The formula for deviations used in this program is:

$$\sqrt{\frac{1}{(n-1)} \left(\sum_{i=1}^n \chi_i^2 - \frac{(\sum_{i=1}^n x_i)^2}{n} \right)}$$

The percent deviation was calculated by the following equation:

$$\% \text{ Deviation} = \frac{\sum_{i=1}^n \frac{|x_i - \bar{x}|}{\bar{x}}}{n} \cdot 100$$

χ_i = individual sample

n = number of sample

\bar{x} = average of all samples

Table V

<u>Media Test</u>	<u>Arithmetic Standard Deviation</u>	<u>Percent Deviation</u>	<u>Geometric Deviation</u>	<u>Number of Replicates</u>
Soil				
pH	.033	.306	1.004	22
OC	.016	.959	1.014	4
Hg	4.43	7.45	1.21	39
Mo	.160	4.97	1.075	19
B	25.7	11.4	1.179	23
F	23.0	3.41	1.051	14
Big sage				
Mo	.071	4.54	1.071	5
B	1.16	3.67	1.054	7
F	2.65	11.2	1.184	21
Indian ricegrass				
Mo	.071	5.78	1.086	6
B	.438	7.54	1.257	20
Western wheatgrass				
Mo	.124	4.25	1.062	4
B	.427	4.63	1.068	21
Sediments				
pH	.153	1.49	1.023	12
OC	.120	16.6	1.413	7
Hg	35.5	21.9	1.599	17
Mo	.249	4.56	1.070	10
B	19.7	14.9	1.286	27
F	47.3	6.19	1.101	16

STATISTICAL REDUCTION OF DATA

Kolmogorov-Smirnov Test

Before any further statistical manipulations are performed, it is necessary to test the distribution of the sampled populations. The statistical tests that will be performed require a normal distribution. However, it is commonly found that geochemical data are lognormally distributed. A lognormal population is one that will fit a normal distribution when the sample values are logarithmic transformed.

The Kolmogorov-Smirnov test was used to test the hypothesis that the sample distributions were either normal or lognormal. A .05 significance level was used to reject either hypothesis.

This test is based on a comparison of the observed cumulative distribution with a theoretical distribution for the observed mean and deviation. This test is distribution free, but the data must be continuous (Johnson and Leone, 1977).

Calculations were performed using STATPAC (Houchard, 1977). The results are summarized in Table VI. If both normal and lognormal distributions could not be rejected, the table lists the best fit first with the other distribution shown in parenthesis. The pH distributions were not tested for a lognormal fit since they were already a logarithmic

Table VI: Results* of the Kolmogorov-Smirnov Goodness of Fit Test (Normal and Lognormal)

	Total Study Area	Geologic Units				
		Uinta	Parachute Creek	Anvil Points	Wasatch	Alluvium
Soil						
pH		L(N)	N(L)	N(L)		L(N)
OC	L	L(N)	N(L)	L(N)	L	L(N)
Hg	L	L(N)	L,N	L(N)	L	L(N)
Mo	L	L	N(L)	L(N)	L	L(N)
F	L	L(N)	L(N)	L(N)	N(L)	N(L)
B	N	N(L)	N(L)	L(N)	L(N)	L(N)
Sage						
Mo	L	N(L)	L,N	L(N)	L	N(L)
B	N(L)	L(N)	L,N	L(N)	N(L)	L(N)
F	L	L(N)	L(N)	L,N	L	L(N)
Ricegrass						
Mo	L	L(N)	N(L)	L(N)	L(N)	no sample
B	L	L(N)	L,N	L(N)	L	no sample
Wheatgrass						
Mo	N(L)	L(N)	N(L)	no sample	L(N)	no sample
B	L	N(L)	N(L)	no sample	L	no sample
Sediments						
pH		L,N	L(N)	L(N)	L	L(N)
OC	L	L(N)	N(L)	N(L)		L,N
Hg		N(L)	L	L(N)	L	L(N)
Mo		N(L)	L	N(L)	L(N)	L,N
F	L	N(L)	N(L)	N(L)	L(N)	N,L
B	L	N(L)	N(L)	N,L	N	N(L)

*Distributions that cannot be rejected at .05 significance

L = Lognormal

N = Normal

transformed function.

The results of these tests indicate that the lognormal distribution is more uniformly acceptable. Because of these results future analysis of variance calculations, hypothesis testing, and correlation determinations will use the log transformed data. This may also be desirable since it has been reported that calculations with small sample numbers show a relation between variance and mean (Krumbein and Miller, 1954). The log transformation has been shown to eliminate the dependence of standard deviation on means when groups of means and standard deviations are proportional (Snedecor 1946).

Analysis of Variance

A nested or hierarchial model for analysis of variance (ANOVA) has been used to estimate the nature of the geochemical variability within the study area. This model can be expressed mathematically as:

$$X_{ijklm} = \mu + A_i + B_{ij} + C_{ijk} + D_{ijkl} + E_{ijklm}$$

The terms i, j, k, l, and m correspond to the five levels in the analysis design. The X term represents a particular sample site and μ is the mean of all sites. The terms A, B, C, and D are differences for the sample at a particular site from the grand mean that are introduced as a result of different sample spacings. The five levels of this design

are illustrated by Figure 14. The differences introduced by the A term would appear at level one while differences due to the E term are seen at level five or the analytical level.

This type of statistical model has been widely used in geochemical studies and discussions of its applications (Miesch 1976a) as well as examples (Miesch 1976b) are readily available.

The theory behind this model is based on the additive property of variance. This allows the variability of a particular population to be divided up into the portions that are added at separate levels within the study. The variance for the five level design used in this study can be expressed as:

$$S_x^2 = S_a^2 + S_b^2 + S_c^2 + S_d^2 + S_e^2$$

The model used is unbalanced at the analytical level since every sample was not replicated an equal number of times. This adds considerably to the number of computations required. These calculations are straight forward but quite tedious. Examples of these calculations are contained in most statistical texts and in particular, Snedecor and Cochran (1976). A computer program, ANOVA.FOR, was used for these calculations and is listed in the appendix.

The F statistic is used to determine the significance

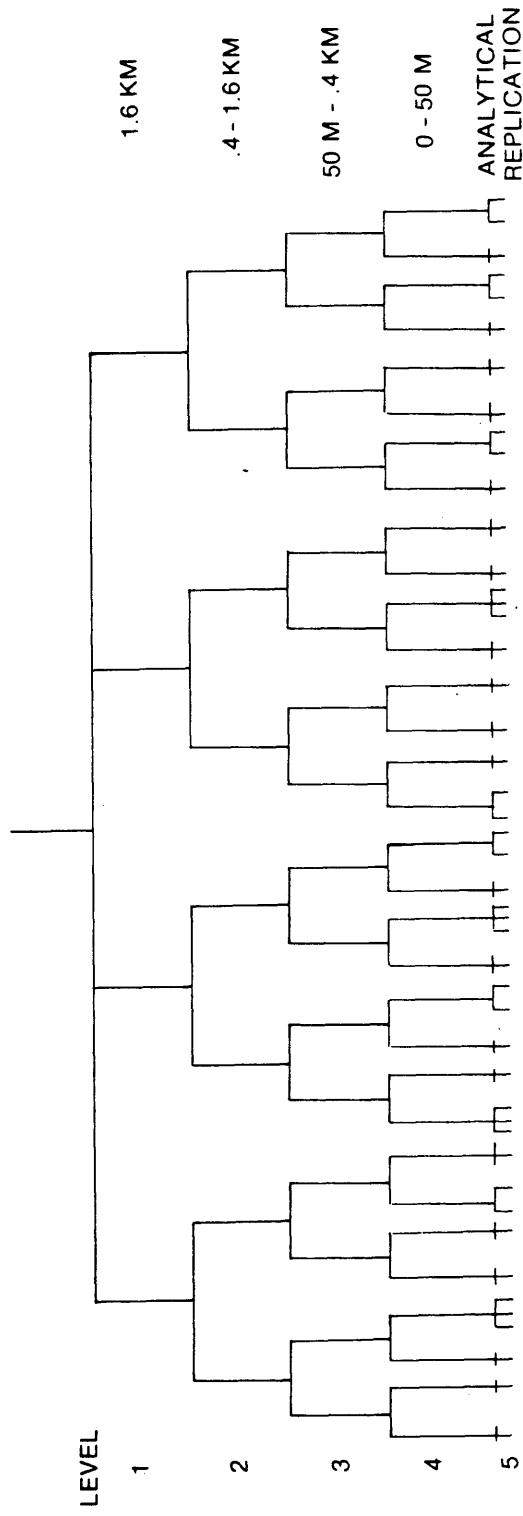


Figure 14: Hierarchical Model Analysis of Variance

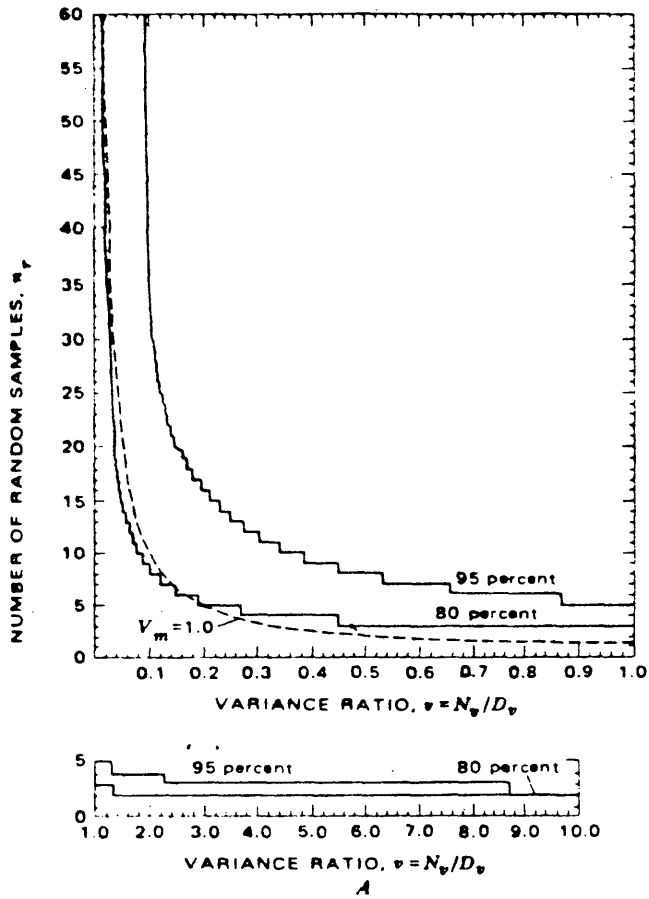
of variance at any given level. This test is dependent on the number of degrees of freedom at each level. The sensitivity of this test is therefore tied to the size of the experiment and should be carefully considered when looking at the results shown in the accompanying tables. The estimated variances for each level can also be used when comparing variances at different levels.

A useful calculation when considering map stabilities is the variance ratio (V_r). This ratio is a measure of the variance at a level compared to the variance components within that level. For this study it is desirable to know whether a distribution can be reproducibly mapped using the sample density obtained from the grid sample design. The variance ratio was calculated by:

$$V_r = S_a^2 / (S_b^2 + S_c^2 + S_d^2 + S_e^2)$$

This ratio has an F distribution and can be used to calculate the number of random samples (N_r) needed per square mile in order to map differences with a desired stability. A graph has been prepared by Miesch (1976b) for this purpose and is shown in Figure 15. The grid sample design used involved collection of four samples per square mile. If N_r is less than four, then that element should be mappable at the section level with 80% stability.

Table VII lists the ANOVA results for the first stage



(Miesch 1976b)

Figure 15

Table VII: Analysis of Variance Results for the Complete First Stage Hierarchical Design

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	% of Total Variance	Estimated Variance		Nr
						Component	Ratio	
<u>Soil</u>								
pH	1.6 km	3	1.1424	3.8945	41.28	.08085	.658	3
	.4-1.6 km	4	.2933	4.7389*	23.66	.04635		
	.05-.4km	8	.0619	.7792	0.00	0.00		
	0-50 m	16	.0794	19.5532***	32.99	.06461		
	Analytical	9	.0041	-	2.07	.00406		
OC	1.6 km	3	.6016	5.0243	55.08	.05349	1.226	3
	.4-1.6 km	4	.1197	3.7104	19.80	.01923		
	.05-.4 km	8	.0323	1.4851	4.46	.00434		
	0-50 m	16	.0217	467.336***	20.61	.02001		
	Analytical	4	.000046	-	.05	.0005		
Mo	1.6 km	3	.0560	2.8513	6.96	.00339	.0748	11
	.4-1.6 km	4	.0196	.2047	0.0	0.000		
	.05-.4km	8	.0959	5.0478***	66.49	0.02945		
	0-50 m	16	.0190	8.9895	28.21	.01373		
	Analytical	10	.0021	-	4.34	.00211		
Hg	1.6 km	3	.091195	3.7762	13.52	.00609	.1565	6
	.4-1.6 km	4	.024150	.4110	0.00	0.00		
	.05-.4 km	8	.058760	1.2699	5.65	.00254		
	0-50 m	16	.046271	38.4391***	78.15	.03517		
	Analytical	12	.001204	-	2.67	.00120		
F	1.6 km	3	.01613	.9742	0.00	0.00		
	.4-1.6 km	4	.01656	.4533	0.00	0.00		
	.05-.4 km	8	.03652	4.9378***	64.80	.01206		
	0-50	16	.007397	26.1658***	33.67	.00627		
	Analytical	7	.0002827	-	1.52	.00028		

Table VII: Continued

	<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>% of Total Variance</u>	<u>Estimated Variance Component</u>	<u>Variance Ratio</u>	<u>Nr</u>
<u>Soil</u>									
B	1.6 km	.1342	3	.04474	3.8516	32.94	.00309	.4905	3
	.4-1.6 km	.0465	4	.011617	1.6790	9.12	.00086		
	.05-.4 km	.0554	8	.006919	1.4323	8.34	.00078		
	0-50 m	.0773	16	.004831	1.3489	11.48	.00108		
	Analytical	.0358	10	.003581	-	38.12	.00358		
<u>Sage</u>									
Mo	1.6 km	1.0807	3	.3602	16.4872**	70.66	.03667	2.409	2
	.4-1.6 km	.0874	4	.0218	4.3492*	6.90	.00358		
	.05-.4 km	.0402	8	.0050	.3975	0.00	0.000		
	0-50 m	.2022	16	.1264	6.0407*	18.41	.00955		
	Analytical	.0105	5	.2092	-	4.03	.00209		
B	1.6 km	.3254	3	.1085	9.4733*	52.14	.01051	1.089	2
	.4-1.6 km	.0458	4	.0115	.7009	0.00	0.000		
	.05-.4 km	.1307	8	.0163	3.1497**	24.07	.00485		
	0-50 m	.0830	16	.0052	4.9506*	18.60	.00375		
	Analytical	.0052	5	.0010	-	5.20	.00105		
F	1.6 km	4.3872	3	1.4624	17.2685***	78.29	.14208	3.606	2
	.4-1.6 km	.3387	4	.0847	1.7933	4.08	.00741		
	.05-.4 km	.3778	8	.0472	2.6246*	6.85	.01243		
	0-50 m	.2879	16	.0180	.9201	0.00	0.000		
	Analytical	.1369	7	.0196	-	10.78	.01956		

Table VII: Continued

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	% of Total Variance	Estimated Variance		
						Component	Ratio	Nr
<u>Ricegrass</u>								
M0 1.6 km	1.7654	3	.58846	45.8763***	73.70	.06123	2.802	2
.4-1.6 km	.0513	4	.01283	.3100	0.00	0.000		
.05-.4 km	.3311	8	.04138	4.7302***	16.87	.01401		
0-50 m	.1400	16	.00875	5.4103**	7.49	.00622		
Analytical	.0097	6	.00162		1.95	.00162		
B 1.6 km	.2743	3	.09142	1.4209	9.5771	.00262	.1059	8
.4-1.6 km	.2574	4	.06434	8.2110***	40.2604	.01101		
.05-.4 km	.0627	8	.00784	.4804	0.00	0.000		
0-50 m	.2608	16	.01630	6.5716	41.0962	.01124		
Analytical	.0223	9	.00248		9.0664	.00248		
<u>Wheatgrass</u>								
M0 1.6 km	1.4582	2	.72910	52.3553***	69.97	.07730	2.330	2
.4-1.6 km	.0418	3	.01393	.3085	0.00	0.000		
.05-.4 km	.2708	6	.04514	1.4461	4.52	.00500		
0-50 m	.3746	12	.03121	38.5837***	24.77	.02737		
Replication	.0032	4	.000809		.73	.00081		
B 1.6 km	.0838	2	.04119	.4577	0.00	0.00		
.4-1.6 km	.2700	3	.09000	1.1635	3.09	.00185		
.05-.4 km	.4641	6	.07735	1.2807	8.08	.00483		
0-50 m	.7248	12	.06040	66.9147***	87.32	.05224		
Replication	.0045	5	.00090		1.51	.00090		

* Significant at .05

** Significant at .025

*** Significant at .01

sample design used in this study, as well as the variance ratio and the number of random samples necessary to produce a map with 80% stability.

Another approach to determining the most efficient second stage design can be taken using the first stage design just completed. The maximum acceptable error (E_r) that can be tolerated within a map unit can be calculated by:

$$E_r = S_b^2 + S_c^2 + S_d^2 + S_e^2 / N_r \quad (\text{Miesch 1976b})$$

The error within a map unit for a particular sample design can be calculated by:

$$E_s = (f_b \cdot S_{B/n_b}^2) + (f_c \cdot S_{C/n_b \cdot n_c}^2) + (S_{D/n_b \cdot n_c \cdot n_d}^2) \\ + S_{e/n_b \cdot n_c \cdot n_d \cdot n_e}^2$$

where N_b , N_c , N_d , and N_e are the number of samples taken or analyses done at each level within the next larger unit. As long as E_s is smaller than E_r then a map of the desired stability can be produced. The terms f_b and f_c are correction terms needed because there are a finite number of units within each of these levels which can be sampled. If all the units within a level are sampled, then all the variance at that level is accounted for and will not contribute to the total error of the map unit. The correction factor is calculated by:

$$f = (1 - N_s/N_t)$$

where N_t is the number of units within the level, and N_s is

the number of units actually sampled.

An example will help explain these calculations. The estimated components of variance at the five levels for Mo in soil are shown below:

$$\text{Level 1 } S_a^2 = .00339$$

$$\text{Level 2 } S_b^2 = .0000$$

$$\text{Level 3 } S_c^2 = .2945$$

$$\text{Level 4 } S_d^2 = .01373$$

$$\text{Level 5 } S_e^2 = .00211$$

If we wish to produce a map at level 1 with 80% stability, the variance ratio would be:

$$\begin{aligned} V_r &= .00339 / (.0000 + .02945 + .01373 + .00211) \\ &= .0748 \end{aligned}$$

From Figure 15 the N_r can be determined as 11 samples for each square mile area. The maximum acceptable variance within a square mile unit is:

$$E_r = (.0000 + .02945 + .01373 + .00211) / 11 = .00412$$

The error for the sample design can now be manipulated by selecting the number of samples in level 2 thru 5. The correction factor for level 2 is $(1 - N_b/4)$ since there are four possible units at level 2 within each square mile. The correction factor for level 3 is $(1 - (N_b/4) \cdot (N_c/4))$ since there are four units at level 3 for each unit at level 2, or a total of 16 level 3 units in each square mile. There are a very large number of possible sample locations at level 4 and an

infinite number of possible analytical replications that could be chosen so there is no need for a finite correction term for these levels. The end result is:

$$E_r \geq E_s = ((f_b \cdot S_b^2)/N_b) + ((f_{b \cdot c} \cdot S_{b \cdot c}^2)/N_{b \cdot c}) + (S_{b \cdot c \cdot d}^2/N_{b \cdot c \cdot d}) + (S_{b \cdot c \cdot d \cdot e}^2/N_{b \cdot c \cdot d \cdot e})$$

$$.00412 \geq \frac{(1-N/4)(.0000)}{N_b} + \frac{(1-N/16)(.02945)}{N_b \cdot N_c} + \frac{.01373}{N_b \cdot N_c \cdot N_d} + \frac{.00211}{N_b \cdot N_c \cdot N_d \cdot N_e}$$

Since practically no component of variance is added at level 2, it would not help to have more than one sample at this level. It would be easiest, as far as collection is concerned, to reduce the analytical component as low as possible. In this case, the analytical component is already lower than E_r so increasing the number of analyses will not solve the problem. It will be necessary to increase the number of samples at level 3 and 4 in order to reduce the E_s below .00412. The advantage of this type of design analysis is that since it is easiest to collect many samples at one location and to keep the travel between locations to a minimum, the designer can plan accordingly. One possible solution to the example problem is to randomly select 6 units at level 3 and to collect three samples at least 50 meters apart from within each unit. Another possible solution would be to select 7 units at level 3 with 2 samples taken in each unit.

Another aspect of geochemical variability that should be considered for this study is the variation caused by the dif-

ferent geologic units. The analysis of variance study just completed only looks at variations caused by sample spacing. This can be very misleading in the Anvil Points region since it is possible to encounter up to three different geologic units in the distance of 1/2 mile. If the rock unit varies significantly, then the results of the first stage sampling could be invalidated.

The model for examining the variance between underlying geologic units is:

$$X_{ijk} = \mu + A_i + B_{ij} + C_{ijk}$$

where μ is the grand mean for the study area, A is the difference caused by differences between geologic units, B is the difference within a geologic unit, and C is the analytical variation. The calculations for this model are similar to the model just described, except that there are only three levels. The complete set of gridded and first stage samples were used. The results are listed in Table VIII.

It can be seen from these results that the underlying geologic unit has a significant effect on the variability of every population except Western wheatgrass. This casts doubt on the results of the first stage design. The results of the original ANOVA design indicate that the grid sampling system would produce stable maps for pH, organic carbon, and boron in soils; Mo, B, and F in Sage; and Mo in ricegrass and wheatgrass. To check on these results, the analysis of variance

Table VIII: Analysis of Variance Results Gridded and First Stage Samples Broken Down by Geologic Unit.

<u>Rock Unit</u>	<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>% of Total Variance</u>	<u>Estimated Variance Component</u>
pH	Between						
	Rock Unit	29.22	4	7.305	54.99***	65.96	.2317
	Within						
OC	Rock Unit	26.17	197	.1328	51.59***	33.31	.1170
	Analytical	.05922	23	.002575		.73	.002575
	Between						
Hg	Rock Units	11.44	4	2.860	41.98***	59.52	.09822
	Within						
	Rock Units	13.42	197	.06814	146.6***	40.46	.06677
Mo	Analytical	.000186	4	.0004649			.0004649
	Between						
	Rock Units	.9346	4	.2336	5.285***	11.42	.00518
B	Within						
	Rock Units	8.709	197	.04421	1.238	14.69	.007097
	Analytical	1.464	41	.03571		73.90	.03571
B	Between						
	Rock Units	.5185	4	.1296	2.711*	5.62	.002613
	Within						
B	Rock Units	9.420	197	.04782	30.90***	91.06	.04236
	Analytical	.02941	19	.001548		3.33	.001548
	Between						
B	Rock Units	.3145	4	.07862	6.634***	15.61	.002062
	Within						
	Rock Unit	2.335	197	.01185	2.077**	41.19	.005441
B	Analytical	.1540	27	.005705		43.20	.005705

Table VIII: Continued

<u>Rock Unit</u>	<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>% of Total Variance</u>	<u>Estimated Variance Component</u>
<u>Soil</u>							
F	Between Rock Units	.4337	4	.1084	6.415***	16.50	.003121
	Within Rock Units	3.329	197	.01690	19.73***	78.97	.01493
	Analytical	.01285	15	.0008567		4.53	.0008567
<u>Sage</u>							
Mo	Between Rock Unit	2.988	4	.7470	18.82***	.04177	52.02
	Within Rock Unit	6.034	152	.03973	18.97***	.03644	45.38
	Analytical	.01046	5	.002092		2.61	.002092
B	Between Rock Unit	.2237	4	.05592	5.917***	22.89	.002695
	Within Rock Unit	1.436	152	.009451	12.44***	70.66	.008320
	Analytical	.005319	7	.0007598		6.45	.007598
F	Between Rock Units	10.49	4	2.621	26.08***	61.70	.1374
	Within Rock Units	15.28	152	.1005	16.31***	35.53	.07914
	Analytical	.1848	30	.006162		2.77	.006162

Table VIII: Continued

<u>Rock Unit</u>	<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>% of Total Variance</u>	<u>Estimated Variance Component</u>
<u>Ricegrass</u>							
Mo	Between						
	Rock Units	.4633	3	.1544	9.082***	1.23	.01006
	Within						
B	Rock Units	2.211	130	.01701	.02106	0.00	0.000
	Analytical	4.037	5	.8073		98.77	.8073
B	Between						
	Rock Units	.05043	3	.01681	.7066	0.00	0.00
	Within						
B	Rock Units	3.093	130	.02379	19.97***	94.33	.01983
	Analytical	.02383	20	.001191		5.67	.001191
<u>Wheatgrass</u>							
Mo	Between						
	Rock Units	.3837	3	.1279	2.243	9.13	.005530
	Within						
B	Rock Units	3.820	67	.05702	6.165	75.61	.04582
	Analytical	.02775	3	.009250		15.26	.009250
B	Between						
	Rock Units	.02036	3	.006787	.1589	0.00	0.000
	Within						
B	Rock Units	1.2862	67	.04271	36.88***	96.58	.03271
	Analytical	.02316	20	.001158		3.42	.001158

* Significant at .05

** Significant at .025

*** Significant at .01

was calculated using only the three sections that lie on the Wasatch unit. The model is the same as for the first analysis except that the degrees of freedom are reduced by the loss of one section.

The results of this statistical analysis are shown in Table IX. These results show that none of the soil parameters should be mapped within the Wasatch unit, but that the plant populations could still be mapped. With such a limited sample design, the F test is weak and the V_r and N_r are of more value when interpreting the results.

Analysis of variance was also calculated for stream sediment data. The first stage sampling design had been performed previously for another study (McNeal et al, 1976). This study demonstrated that there were significant differences between sediments from different streams, as well as within streams. Within each stream the variability was largely at the 0 to 10 meter scale. This information was used to formulate the second stage design for the present study.

The analysis of variance for this study was performed using the data from the second stage sample design (Figure 11). These calculations support the conclusions of the study by McNeal et al (1976). Table X shows the results of just considering between stream variability. Of the six parameters considered, all six show significant variation at the between stream level.

Table IX: Analysis of Variance Results for Hierarchical Sample Design Within Wasatch Unit

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	% of Total Variance	Estimated Variance Component	Variance Ratio	Nr
<u>Soil</u>								
pH 1.6 km	.001250	2	.0006251	1.752	11.91	.00002340	.135	7
.4-1.6 km	.001071	3	.0003569	1.636	15.40	.00003025		
.05-.4 km	.001309	6	.0002181	1.669	14.28	.00002805		
0-50 m	.001568	12	.0001307	12.34***	53.03	.0001042		
Analytical	.00006356	6	.0001059		5.39	.00001059		
OC 1.6 km	.04892	2	.02446	.1536	0.00	0.000	-	-
.4-1.6 km	.4777	3	.1592	5.604*	53.73	.02886		
.05-.4 km	.1705	6	.02841	1.066	.45	.0002404		
0-50 m	.3199	12	.02666	460.9***	45.71	.02455		
Analytical	.1735	3	.00005983		.11	.00005783		
Hg 1.6 km	.2671	2	.1335	10.50*	17.79	.01005	2.16	5
.4-1.6 km	.03816	3	.01272	.1645	0.00	0.000		
.05-.4 km	.4639	6	.07731	1.309	5.59	.003160		
0-50 m	.7089	12	.05908	49.01***	74.48	.04209		
Analytical	.01447	12	.001205		2.13	.001205		
Mo 1.6 km	.1679	2	.08394	14.03*	16.31	.007287	.0002	-
.4-1.6 km	.01795	3	.0005984	.0793	0.00	0.00		
.05-.4 km	.4527	6	.07545	3.578*	45.01	.02012		
0-50 m	.2531	12	.02109	10.11***	34.02	.01520		
Analytical	.01669	8	.002086		4.67	.002086		
B 1.6 km	.03396	2	.01698	.9902	0.00	0.00	-	-
.4-1.6 km	.05144	3	.01715	2.001	20.20	.001761		
.05-.4 km	.05140	6	.008567	1.430	12.04	.001050		
0-50 m	.07187	12	.005989	1.130	7.00	.000610		
Analytical	.03179	6	.005298		60.76	.005298		

Table IX: Continued

	<u>Source of Variation</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>% of Total Variance</u>	<u>Estimated Variance Component</u>	<u>Variance Ratio</u>	<u>Nr</u>
<u>Soil</u>									
F	1.6 km	.03329	2	.01665	.7809	0.00	0.00	-	-
	.4-1.6 km	.06395	3	.02132	2.121	24.25	.002181		
	.05-.4 km	.06032	6	.01005	1.577	13.81	.001242		
	0-50 m	.07648	12	.006373	19.72	58.35	.005248		
	Analytical	.001939	6	.0003231		3.59	.0003231		
<u>Sage</u>									
Mo	1.6 km	.3311	2	.1656	9.900*	51.45	.01604	1.06	3
	.4-1.6 km	.05017	3	.01672	2.918	7.29	.002273		
	.05-.4 km	.03439	6	.005732	.4095	0.00	0.00		
	0-50 m	.1680	12	.01400	5.353	32.87	.01025		
	Analytical	.01046	4	.002615		8.39	.002615		
B	1.6 km	.1326	2	.06629	4.450	32.24	.005545	.476	3
	.4-1.6 km	.04468	3	.01489	.6999	0.00	0.00		
	.05-.4 km	.1277	6	.02128	4.245**	41.08	.007065		
	0-50 m	.06016	12	.005013	6.486*	22.19	.003816		
	Analytical	.003092	4	.0005529		4.49	.0007729		
F	1.6 km	.9834	2	.4917	4.302	46.51	.03810	.869	3
	.4-1.6 km	.3429	3	.1143	2.172	14.52	.01182		
	.05-.4 km	.3157	6	.05262	2.511	15.74	.10289		
	0-50 m	.2515	12	.02096	2.179	11.59	.009493		
	Analytical	.05771	6	.009619		11.74	.009619		

Table IX: Continued

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	% of Total Variance	Estimated Variance Component	Variance Ratio	Nr
<u>Ricegrass</u>								
Mo 1.6 km	.9656	2	.4828	34.59***	77.87	.05443	3.52	2
.4-1.6 km	.04187	3	.01396	.5385	0.00	0.000		
.05-.4 km	.1555	6	.02592	3.813**	12.73	.008900		
0-50 m	.08158	12	.006798	2.807	5.93	.004146		
Analytical	.004844	2	.002422		3.47	.002422		
B 1.6 km	.2267	2	.1133	1.363	8.79	.003101	.096	9
.4-1.6 km	.2494	3	.08313	8.174**	44.30	.01562		
.05-.4 km	.06102	6	.01017	.5600	0.00	0.000		
0-50 m	.2179	12	.01816	9.034	41.21	.01453		
Analytical	.008040	4	.002010		5.70	.002010		
<u>Wheatgrass</u>								
Mo 1.6 km	.8833	1	.8833	66.01**	69.93	.08785	2.33	2
.4-1.6 km	.02676	2	.01338	.2097	0.00	0.00		
.05-.4 km	.2552	4	.06381	2.217	10.34	.01299		
0-50 m	.2303	8	.02879	35.58***	19.09	.02398		
Analytical	.003236	4	.0008090		.64	.0008090		
B 1.6 km	.05069	1	.05069	.3757	0.00	0.00		
.4-1.6 km	.2698	2	.1349	1.189	3.42	.002674		
.05-.4 km	.4540	4	.1135	1.415	11.47	.008972		
0-50 m	.4618	8	.08023	88.88***	83.95	.06565		
Analytical	.004513	5	.0009026		1.15	.0009026		

* Significant at .05

** Significant at .025

*** Significant at .01

Table X: Stream Sediments
 Analysis of Variance by Stream

	<u>Source</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>Probability</u>
pH	Between	4.6361	12	.3861	6.16	0.0000
	Within	9.2825	148	.06212		
	Total	13.9186	160			
OC	Between	230.8355	12	19.24	23.07	0.0000
	Within	123.4243	148	.8339		
	Total	354.2598	160			
Hg	Between	18.8763	12	7.573	7.683	0.0000
	Within	30.3005	148	.2047		
	Total	49.1768	160			
Mo	Between	5.5516	12	.4626	4.468	0.0000
	Within	15.3240	148	.1035		
	Total	20.8756	160			
F	Between	12.9586	12	1.080	14.38	0.0000
	Within	11.1122	148	.07508		
	Total	24.0709	160			
B	Between	82.9916	12	6.916	17.40	0.0000
	Within	58.8283	148	.3975		
	Total	141.8198	160			

Also of interest for the present study is the effect of the underlying geology on stream sediment geochemistry. Table XI shows the results of considering just the variability between geologic units. In every case the parameters show significant variations between geologic units.

Because of the sample distribution for this study it is possible that the variability between stream and the between geologic unit variability is confounded. Most of the drainages were completely within the Wasatch Formation. Two drainages were sampled only within the Parachute Creek Member and Uinta Formation. Only one drainage was sampled across the entire range of geologic units. To separate these two possible effects, a two way analysis of variance was performed using STATPAC. The results are shown in Table XII. This approach shows that except for Hg, both between stream variance and between geologic unit variance are significant. Hg was significant between streams but not between geologic units.

Mean and Deviations

The other part of a geochemical baseline study is the calculation of average concentrations for the elements of interest and the expected ranges that could be encountered in a sampling program. Once data have been generated, useful statistics such as mean, standard deviation, and expected

Table XI: Stream Sediments
 Analysis of Variance by Geologic Unit

	<u>Source</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>Probability</u>
pH	Between	3.9042	4	.9760	15.21	0.0000
	Within	10.0137	156	.06419		
	Total	13.9179	160			
OC	Between	181.037	4	45.26	40.76	0.0000
	Within	173.223	156	1.110		
	Total	345.260	160			
Hg	Between	18.8409	4	4.710	24.22	0.0000
	Within	30.3360	156	.1945		
	Total	49.1769	160			
Mo	Between	2.6238	4	.6560	5.607	0.0000
	Within	18.2518	156	.1170		
	Total	20.8756	160			
F	Between	9.5173	4	2.379	25.50	0.0000
	Within	14.5534	156	.09329		
	Total	24.0707	160			
B	Between	59.4179	4	14.85	28.12	0.0000
	Within	82.4020	156	.5282		
	Total	141.8199	160			

Table XII: Stream Sediments

Two-way Analysis of Variance - Geologic Unit and Stream

	<u>Source</u>	<u>Sum of Squares</u>	<u>Degrees of Freedom</u>	<u>Mean Square</u>	<u>F Value</u>	<u>Probability</u>
pH	G.U. elim. St.	1.04	4	.26	4.31	.0026
	St. elim. G.U.	1.77	12	.15	2.45	.0063
	Interactions	.14	9	.02	.27	.9822
	Within Cells	8.10	135	.06		
OC	G.U. elim. St.	11.73	4	2.93	3.66	.0073
	St. elim. G.U.	61.53	12	5.13	6.39	0.0000
	Interactions	3.40	9	.38	.47	.8921
	Within Cells	108.29	135	.40		
Hg	G.U. elim. St.	3.39	4	.85	4.67	.0015
	St. elim. G.U.	3.43	12	.29	1.56	.1068
	Interactions	2.38	9	.26	1.45	.1721
	Within Cells	24.53	135	.18		
Mo	G.U. elim. St.	.96	4	.24	2.68	.0392
	St. elim. G.U.	3.89	12	.32	3.62	.0001
	Interactions	2.30	9	.26	2.85	.0041
	Within Cells	12.07	135	.09		
F	G.U. elim. St.	.75	4	.19	2.79	.0287
	St. elim. G.U.	4.19	12	.35	5.20	.0000
	Interactions	1.29	9	.14	2.13	.0307
	Within Cells	9.07	135	.07		
B	G.U. elim. St.	8.01	4	2.00	5.52	.0004
	St. elim. G.U.	31.59	12	2.63	7.25	.0000
	Interactions	1.81	9	.20	.55	.8322
	Within Cells	49.00	135	.36		

St. = Between Stream effects

G.U. = Between Geologic Unit effects

ranges can be estimated. Other statistics such as median and range can be determined directly from the experimental data without calculation. The method of calculation for some of these statistics will differ depending on the distribution that is assumed for the target population. The most commonly encountered distributions for geochemical data are the normal and lognormal distributions, and these will be the only distributions considered for this study.

The average or mean value is an estimate of geochemical abundance, and is sometimes referred to as the expected value. This can differ from the median value which is the value that divides the observations of a variable into two equal halves. The mean is an estimate of the average for a population while the median can be considered as a typical value within that population. For normally distributed variables the median, mean, and mode are the same and can be calculated by:

$$\bar{X} = \sum_{i=1}^n X_i/n$$

where X_i are the individual measurements and n is the number of measurements.

A lognormal distribution is one that fits a normal distribution when the observations are log transformed. This distribution is asymmetrical so the median, mean, and mode are not equal. The antilog of the mean of the log transformed data is called the geometric mean and is the median of the

lognormal distribution. The mean of the lognormal distribution is calculated by:

$$\bar{X} = \exp(GM - GD^2/2)$$

where GM is the geometric mean and GD is the geometric deviation. The geometric deviation is obtained by determining the standard deviation of the log transformed data.

The standard deviation of a distribution is a measure of the degree of variability among the individual observations of a parameter. For a normal distribution, it is calculated by:

$$S = \sqrt{\frac{\sum_{i=1}^n (X_i - \bar{x})^2}{N}}$$

For a lognormal distribution the standard deviation is:

$$\sqrt{\bar{X}^2 \cdot (\exp(GD^2) - 1)}$$

where \bar{X} is the mean of the lognormal distribution. The range of observed values is also a measure of variability for the distribution but this is of limited usefulness since it can differ for each sampling. The standard deviation or its square, the variance, is a more accepted measure of a distribution.

Once the mean and deviation for a population are known, the expected range of observations can be calculated. This is important for baseline studies since the expected range describes the expected limits within which a certain percentage of observations should fall. Values occurring above this

range are usually considered anomalous. The expected range for this study was calculated to contain 95% of the population. For a normal distribution this range is from $(\bar{X} - 1.96 \cdot S)$ to $(\bar{X} + 1.96 \cdot S)$. For a lognormal distribution this range is from $(GM/GD^{1.96})$ to $(GM \cdot GD^{1.96})$.

Tables XIII - XVIII show the statistics just described, calculated for both a normal and lognormal distribution. Table 12 is for the study area as a whole and Table 13 through 17 are for each geologic unit individually.

Hypothesis Testing

The hypothesis to be tested in this section are hypotheses of equality among means for each geologic unit contained within the populations sampled for the baseline survey. The analysis of variance already completed indicates that plants, soils, and sediments collected from different geologic units have statistically significant differences. It would be valuable to determine which geologic units are different for each population considered.

The means for two groups can be tested for equality using the standard student's t-test. A significance level is selected for rejecting the hypothesis of equality. A problem arises when the t-test is used for comparing more than two means, as in the case of this study. The significance level that is selected fixes the probability for incorrectly

Table XIII: Population Mean, Deviation and 95% Expected Ranges for the Total Study Area

Soils (202)	EXPERIMENTAL		NORMAL POPULATION		LOGNORMAL POPULATION					
	Median	Range	Mean	Standard Deviation	Expected Range	Mean	Standard Deviation	Geometric Mean	Geometric Deviation	Expected Range
pH	7.89	7.68-8.52	7.61	.499	6.63-8.59	-	-	-	-	-
OC (%)	1.45	.7-9.60	2.04	.1780	0.00-5.53	2.05	1.951	1.48	2.23	.31-7.15
Hg (ppb)	24.3	10.0-109.	27.3	13.66	0.5-54.1	27.1	12.17	24.7	1.53	10.7-56.8
Mo (ppm)	2.1	.4-8.1	2.4	1.23	0.00-4.8	2.4	1.21	2.1	1.622	.81-5.42
B (ppm)	160.	60-285	158.	37.2	85-231	158.	39.9	153.	1.28	94-218
F (ppm)	485.	190-1300	503.	165.9	178-828	503	159.5	481.	1.36	263-879
Sage (157)										
Mo (ppm)	.8	.1-2.7	.9	.46	0.00-1.8	.9	.54	.8	1.73	.2-2.6
B (ppm)	24.5	12.5-39.0	24.9	5.45	14.2-25.6	24.9	5.74	24.3	1.26	15.4-38.2
F (ppm)	9.7	1.3-6.1	13.5	11.63	0.00-36.3	13.7	13.52	9.8	2.28	1.9-49.3
Ricegrass (134)										
Mo (ppm)	1.95	.5-7.1	2.1	1.09	0.00-4.2	2.2	1.13	1.9	1.63	.7-5.0
B (ppm)	4.8	2.2-16.2	5.2	1.91	1.5-8.9	5.2	1.71	5.0	1.38	2.7-9.4
Wheatgrass (71)										
Mo (ppm)	1.5	.4-4.6	1.7	.85	0.0-3.4	1.7	.99	1.5	1.72	.5-4.3
B (ppm)	6.1	3.2-48.2	7.2	6.19	0.0-19.3	6.9	3.25	6.2	1.57	2.6-15.0
Sediments (161)										
pH	8.15	7.62-9.36	8.20	.295	7.62-8.78	8.20	.295	7.62-8.78		
OC (%)	.57	.01-6.18	1.19	1.414	0.0-3.96	1.53	4.382	.51	4.43	.03-9.43
Hg (ppb)	38.	12-464	51.	49.2	0.0-147	49.	29.6	42.3	1.74	14.3-125
Mo (ppm)	3.2	1.1-22.0	3.5	2.25	0.0-7.91	3.4	1.28	3.2	1.44	1.6-6.5
B (ppm)	75.	7-310	98.	72.6	0.0-240	109.	132.6	70.	2.59	11-452
F (ppm)	460.	180-980	503.	196.9	117-889	504	203.2	468	1.47	220-996

Table XIV: Population Mean, Deviation and 95% Expected Ranges for the Alluvium Unit

	EXPERIMENTAL		NORMAL POPULATION			LOGNORMAL POPULATION				
	Median	Range	Mean	Standard Deviation	Expected Range	Mean	Standard Deviation	Geometric Mean	Geometric Deviation	Expected Range
Soils (10)										
pH	7.89	7.68-8.52	7.97	.249	7.48-8.46	-	-	-	-	-
OC (%)	.80	.3-3.0	1.17	.896	0.00-2.93	1.21	1.133	.89	2.203	.19-4.2
Hg (ppb)	30.	12-109	40.5	28.41	0.00-96.2	41.0	28.25	33.7	1.87	9.2-123.5
Mo (ppm)	2.6	1.5-5.0	2.9	1.08	.8-5.0	2.9	1.06	2.8	1.42	1.0-7.8
B (ppm)	145.	10-160	136.	26.7	84-188	137.	29.5	134.	1.24	55-326
P (ppm)	405.	275-530	414.	94.8	228-600	416.	100.9	404.	1.27	199-820
Sage (3)										
Mo (ppm)	1.3	.8-1.6	1.2	.40	.4-2.0	1.3	.46	1.2	1.43	.6-2.4
B (ppm)	28.7	26.0-38.0	30.9	6.30	18.6-43.2	31.1	6.18	30.5	1.22	20.7-45.0
P (ppm)	3.2	3.1-4.8	3.7	.95	1.8-5.6	3.7	.92	3.6	1.28	2.2-5.8
Ricegrass (0)										
Mo (ppm)	-	-	-	-	-	-	-	-	-	-
B (ppm)	-	-	-	-	-	-	-	-	-	-
Wheatgrass (0)										
Mo (ppm)	-	-	-	-	-	-	-	-	-	-
B (ppm)	-	-	-	-	-	-	-	-	-	-
Sediments (3)										
pH	8.32	8.23-8.64	8.40	.215	7.98-8.82	-	-	-	-	-
OC (%)	.08	.08-.53	.23	.260	0.00-.74	.27	.413	.15	2.989	.02-1.28
Hg (ppb)	38.	30-55	41.	12.8	15.9-66.1	42.	13.0	39.7	1.36	21.7-72.5
Mo (ppm)	3.9	3.2-3.9	3.7	.48	2.9-4.5	3.7	.42	3.7	1.12	3.0-4.6
B (ppm)	75.	7-310	98.	72.6	0.00-240	109.	132.6	39.	1.60	12-123
P (ppm)	300.	220-370	297.	75.1	150-444	300.	79.9	290.	1.30	173-484

Table XV: Population Mean, Deviation and 95% Expected Ranges for the Wasatch Unit

Soils (127)	EXPERIMENTAL			NORMAL POPULATION			LOGNORMAL POPULATION				
	Median	Range	Expected Range	Mean	Standard Deviation	Expected Range	Mean	Standard Deviation	Geometric Mean	Geometric Deviation	Expected Range
Soils (127)											
pH	7.85	6.69-8.48	7.17-8.37	7.77	.308		-	-	-	-	-
OC (%)	1.10	.2-3.6	0.00-2.62	1.24	.703		1.25	.815	1.05	1.811	.33-3.36
Hg (ppb)	22.6	10-59.6	2.0-49.8	25.9	12.19		25.8	11.58	23.5	1.53	10.2-54.1
Mo (ppm)	2.0	.4-8.1	.3-4.3	2.3	1.02		2.3	.96	2.1	1.50	.9-4.6
B (ppm)	150.	60-285	77-225	151.	38.0		152.	39.9	147.	1.30	88-246
P (ppm)	480.	190-780	253-697	475.	113.3		476.	123.2	461.	1.29	182-1166
Sage (116)											
Mo (ppm)	.9	.3-2.7	.1-1.9	1.0	.45		1.0	.47	.9	1.55	.4-2.1
B (ppm)	24.1	12.5-39.0	13.5-34.7	24.1	5.41		24.1	5.61	23.4	1.26	14.9-36.8
P (ppm)	12.2	2.8-61.0	0.00-19.5	16.1	11.94		16.0	12.03	12.8	1.95	3.4-47.4
Ricegrass (101)											
Mo (ppm)	2.0	.5-7.1	.0-4.4	2.2	1.10		2.2	1.10	2.0	1.61	.8-5.1
B (ppm)	4.8	2.5-16.2	1.1-9.3	5.2	2.09		5.2	1.81	4.9	1.40	2.5-9.5
Wheatgrass (40)											
Mo (ppm)	1.75	.40-4.6	.1-3.7	1.9	.9		1.9	1.1	1.65	1.71	.6-4.7
B (ppm)	5.85	3.3-48.2	0.0-23.8	7.9	8.11		7.5	4.56	6.4	1.76	2.1-19.4
Sediments (111)											
pH	8.24	7.7-9.16	7.72-8.86	8.29	.290		-	-	-	-	-
OC (%)	.36	.01-3.32	0.00-1.40	.46	.478		.54	.955	.26	3.30	.02-2.70
Hg (ppb)	35.	12-192	0.00-83.1	39.	22.5		38.	16.2	35.0	1.50	15.8-77.5
Mo (ppm)	3.1	1.8-7.6	1.5-4.7	3.1	.82		3.1	.79	3.1	1.28	1.9-5.0
B (ppm)	60.	7-190	0.00-141	63.	40.0		69.	70.4	48.	2.33	9-252
P (ppm)	400.	180-900	153-609	426.	139.3		426.	138.8	405.	1.37	219-750

Table XVI: Population Mean, Deviation and 95% Expected Ranges for the Anvil Points Unit

	EXPERIMENTAL			NORMAL POPULATION			LOGNORMAL POPULATION					
	Median	Range		Mean	Standard Deviation	Expected Range	Mean	Standard Deviation	Geometric Mean	Geometric Deviation	Expected Range	
Soils (25)												
pH	7.80	7.00-7.98		7.75	.199	7.36-8.14	-	-	-	-	-	
OC (%)	2.50	.4-6.7		2.77	1.692	0.00-6.1	2.86	2.274	2.26	2.008	.58-8.86	
Hg (ppb)	29.0	14-86		33.2	15.86	2.1-64.3	33.2	14.73	30.3	1.53	13.2-69.7	
Ko (ppm)	1.6	.9-6.5		2.4	1.66	0.00-5.7	2.4	1.53	2.0	1.82	.6-6.5	
B (ppm)	160.	100-270		161.	36.8	89-233	161.	39.4	157.	1.26	100-247	
F (ppm)	520.	340-1200		582.	218.3	154-1010	582.	206.2	549.	1.41	280-1077	
Sage (8)												
Mo (ppm)	.65	.3-.7		.6	.16	.3-.9	.6	.19	.6	1.38	.3-1.1	
B (ppm)	20.3	14.7-26.9		21.1	4.09	13.1-29.1	21.2	4.20	20.8	1.22	14.1-30.7	
F (ppm)	16.7	6.8-31.8		17.3	8.74	.2-34.4	17.8	10.58	15.3	1.73	5.2-44.8	
Ricegrass (14)												
Mo (ppm)	2.1	1.1-4.2		2.4	.98	.5-4.3	2.4	1.01	2.2	1.50	1.0-4.9	
B (ppm)	4.65	2.2-8.0		4.9	1.50	2.0-7.8	5.0	1.59	4.7	1.37	2.5-8.7	
Wheatgrass (1)												
Mo (ppm)	1.4	-		1.4	-	-	1.4	-	-	-	-	
B (ppm)	4.5	-		4.5	-	-	4.5	-	-	-	-	
Sediments (13)												
pH	8.08	7.93-8.25		8.08	.095	7.89-8.27	-	-	-	-	-	
OC (%)	1.97	.27-3.66		2.06	1.140	0.00-4.29	2.26	2.12	1.65	2.21	.35-7.81	
Hg (ppb)	35.	20-84		42.	18.9	5.0-79.0	42.	18.6	38.5	1.53	16.6-88.1	
Ko (ppm)	3.2	1.8-4.2		3.1	.84	1.5-4.7	3.1	.93	2.95	1.34	1.7-5.2	
B (ppm)	145.	90-220		146.	40.9	66-226	146.	41.9	141.	1.32	82-243	
F (ppm)	760.	380-980		698	206.4	285-1093	703.	285.0	666.	1.38	354-1252	

Table XVII: Population Mean, Deviation and 95% Expected Ranges for the Parachute Creek Unit

	EXPERIMENTAL		NORMAL POPULATION			LOGNORMAL POPULATION				
	Median	Range	Mean	Standard Deviation	Expected Range	Mean	Standard Deviation	Geometric Mean	Geometric Deviation	Expected Range
Soils (4)										
PB	7.76	7.43-7.80	7.69	.173	7.35-8.03	-	-	-	-	-
OC (%)	3.95	1.7-4.1	3.43	1.153	1.2-5.7	3.54	1.588	3.23	1.534	1.40-7.47
Hg (ppb)	25.5	22.0-30.0	25.8	3.50	18.9-32.7	25.8	3.51	25.6	1.145	19.6-33.4
Mo (ppm)	4.4	1.2-5.9	4.0	2.06	0.0-8.0	4.41	3.64	3.40	2.057	.83-13.98
B (ppm)	175.	170-200	180.	14.1	152-208	180.	13.8	180.	1.080	143-226
F (ppm)	830.	760-930	837.	74.1	692-982	838.	73.8	835.	1.092	703-214
Sage (3)										
Mo (ppm)	.60	.6-.7	.6	.06	.5-.7	.6	.06	.6	1.09	.5-.7
B (ppm)	29.0	26.7-29.1	28.3	1.36	25.6-31.0	28.3	1.38	28.2	1.05	25.6-31.0
F (ppm)	3.8	3.6-4.3	3.9	.36	3.2-4.6	3.9	.36	3.9	1.10	3.2-4.7
Ricegrass (3)										
Mo (ppm)	3.0	2.6-3.1	2.9	.26	2.4-3.4	2.9	.27	2.9	1.10	2.4-3.5
B (ppm)	6.0	4.5-6.0	5.5	.87	3.8-7.2	5.5	.92	5.4	1.18	3.9-7.5
Wheatgrass										
Mo (ppm)	2.3	2.2-2.8	2.4	.32	1.8-3.0	2.4	.31	2.4	1.14	1.9-3.1
B (ppm)	6.5	5.7-6.8	6.3	.56	5.2-7.4	6.3	.58	6.3	1.10	5.2-7.6
Sediments (23)										
PB	7.96	6.66-8.24	7.96	.130	7.71-8.21					
OC (%)	3.4	1.55-5.09	3.28	1.010	1.30-5.26	3.31	1.160	3.12	1.41	1.59-6.12
Hg (ppb)	77.	40-468	108.	100.7	0.0-305	103.	69.5	85.4	1.84	26-282
Mo (ppm)	3.6	2.3-22.0	5.5	5.23	0.0-15.8	5.28	3.57	4.4	1.85	1.3-14.7
B (ppm)	190.	12-310	202.	66.7	71-333	222.	158.8	180.	1.90	51-633
F (ppm)	770.	440-940	702.	180.6	348-1056	704.	194.9	679.	1.31	400-1153

Table XVIII: Population Mean, Deviation and 95% Expected Ranges for the Uinta Unit

Soils (36)	EXPERIMENTAL			NORMAL POPULATION			LOGNORMAL POPULATION				
	Median	Range	Expected Range	Mean	Standard Deviation	Expected Range	Mean	Standard Deviation	Geometric Mean	Geometric Deviation	Expected Range
Soils (36)											
pH	6.78	5.90-7.94	5.60-	6.87	.547	5.60-	-	-	-	-	-
OC (%)	3.5	1.4-9.6	.04-8.84	4.44	2.244	.04-8.84	4.46	2.345	3.35	1.639	1.50-10.40
Hg (ppb)	21.0	14-46	8.7-40.5	24.6	8.03	8.7-40.5	24.6	7.94	23.4	1.37	12.6-43.3
Ko (ppm)	1.6	.6-5.3	0.00-7.7	2.3	1.39	0.00-7.7	2.4	1.57	1.97	1.83	.6-6.4
B (ppm)	185.	120-240	128-234	181.	26.8	128-234	181.	27.9	178.	1.165	131-240
P (ppm)	465.	210-1300	86-986	536.	229.7	86-986	536.	220.9	502.	1.456	240-372
Sage (27)											
Mo (ppm)	.4	.1-1.2	0.0-1.0	.5	.24	0.0-1.0	.5	.30	.4	1.75	.1-1.2
B (ppm)	27.7	20.2-35.2	20.8-36.0	28.4	3.86	20.8-36.0	28.4	3.95	28.2	1.15	21.4-37.1
P (ppm)	3.3	1.3-7.8	.6-6.6	3.6	1.51	.6-6.6	3.6	1.63	3.3	1.53	1.4-7.6
Ricegrass (16)											
Mo (ppm)	1.25	.6-4.8	0.0-3.8	1.7	1.06	0.0-3.8	1.7	1.02	1.4	1.76	.5-4.2
B (ppm)	5.35	4.3-7.3	3.5-7.5	5.5	1.03	3.5-7.5	5.5	1.07	5.4	1.20	3.8-7.7
Wheatgrass (27)											
Mo (ppm)	1.1	.4-2.8	0.0-2.6	1.3	.65	0.0-2.6	1.3	.70	1.1	1.65	.4-2.9
B (ppm)	6.3	3.2-9.5	3.4-9.0	6.2	1.45	3.4-9.0	6.2	1.58	6.0	1.28	3.7-9.7
Sediments (11)											
pH	7.82	7.62-8.07	7.60-8.12	7.86	.131	7.60-8.12					
OC (%)	3.5	1.72-6.18	.14-6.72	3.43	1.680	.14-6.72	3.59	2.398	2.99	1.84	.90-9.88
Hg (ppb)	83.	25-94	39-117	78.	19.8	39-117	79.	31.0	73.8	1.46	35.0-15.5
Ko (ppm)	3.8	1.1-4.8	1.1-5.7	3.4	1.19	1.1-5.7	3.47	1.73	3.1	1.60	1.2-7.8
B (ppm)	210.	110-250	125-273	199.	37.8	125-273	200.	44.8	195.	1.23	82-185
P (ppm)	740.	450-900	411-96.0	705.	134.6	411-96.0	707.	145.6	693.	1.23	462-1040

rejecting the hypothesis of equality for only one comparison of means. If more than one comparison is attempted, the significance level no longer holds. For example, when five means are tested for equality, there are actually ten comparisons to be tested. If all five means were actually equal, and a .05 significance level was used to reject a comparison, there would be a .29 probability that one of the ten comparisons would be incorrectly rejected (Snedecor and Cochran, 1976). The t statistic and associated probability for the ten comparisons within each population are shown in Table XIX. Careful consideration should be given to the use of these results.

Several other approaches have been used for this study, and will be described here. These methods are designed so that the probability of falsely rejecting equal means is fixed at a desired level. Consequently, the ability to detect real differences among means has been reduced.

The first method (LSD/SR), is a modification of the least significant difference method that is based on the t-test, but employs a studentized range instead of the t statistic (Snedecor and Cochran, 1976). This results in a larger difference before two means can actually be considered different. The method based on the t-test suffers from the same problem just discussed for the actual t-test.

Table XIX: Student's T-Test and Associated Probabilities for Pairs of Means for Geologic Units.

	<u>Alluvium</u>	<u>Wasatch</u>	<u>Anvil Points</u>	<u>Parachute Creek</u>
<u>pH of Soils</u>				
Wasatch	-1.884 .062P			
Anvil Points	-2.698 .011P	-.4287 .669P		
Parachute Creek	-2.017 .067P	-.5752 .566P	-.5844 .564P	
Uinta	-6.105 .000P	-12.84 .000P	-7.657 .000P	-2.934 .006P
<u>Organic Carbon in Soils</u>				
Wasatch	.8256 .410P			
Anvil Points	3.430 .002P	5.707 .000P		
Parachute Creek	3.036 .010P	3.743 .000P	.9908 .331P	
Uinta	7.343 .000P	12.22 .000P	3.677 .001P	.7809 .440P
<u>Hg in Soils</u>				
Wasatch	-2.470 .015P			
Anvil Points	-.5868 .561P	2.708 .008P		
Parachute Creek	-.8600 .407P	.3876 .699P	-.7843 .440P	
Uinta	-2.560 .014P	-.4743E-01 .962P	-2.719 .009P	-.5432 .590P

Table XIX: Continued

	<u>Alluvium</u>	<u>Wasatch</u>	<u>Anvil Points</u>	<u>Parachute Creek</u>
<u>Mo in Soils</u>				
Wasatch	-2.143 .034P			
Anvil Points	-1.684 .102P	-.6055 .546P		
Parachute Creek	.7359 .476	2.309 .023P	1.653 .110P	
Uinta	-1.699 .096P	-.6680 .505P	.6842E-02 .955P	-1.685 .100P
<u>B in Soils</u>				
Wasatch	1.071 .286P			
Anvil Points	1.832 .076P	1.199 .233P		
Parachute Creek	2.633 .022P	1.564 .120P	1.137 .265P	
Uinta	4.862 .000P	4.414 .000P	2.683 .009P	-.4433E-01 .965P
<u>F in Soils</u>				
Wasatch	1.570 .119P			
Anvil Points	2.561 .015P	2.944 .004P		
Parachute Creek	5.791 .000P	4.644 .000P	2.396 .024P	
Uinta	1.545 .130P	1.329 .186P	-1.038 .304P	-2.598 .013P

Table XIX: Continued

	<u>Alluvium</u>	<u>Wasatch</u>	<u>Anvil Points</u>	<u>Parachute Creek</u>
<u>Mo in Sage</u>				
Wasatch	-.9711 .333P			
Anvil Points	-3.434 .007P	-3.232 .002P		
Parachute Creek	-2.972 .041P	-1.484 .141P	.6954 .504P	
Uinta	-3.079 .005P	-7.822 .000P	-1.263 .215P	-1.211 .236P
<u>B in Sage</u>				
Wasatch	-1.958 .053P			
Anvil Points	-2.889 .018P	-1.456 .148P		
Parachute Creek	-.6544 .549P	1.396 .165P	2.601 .029P	
Uinta	-.9103 .370P	3.976 .000P	4.974 .000P	-.3261E-01 .974P
<u>F in Sage</u>				
Wasatch	3.259 .001P			
Anvil Points	4.275 .002P	.7331 .465P		
Parachute Creek	.4690 .664P	-3.080 .003P	-4.163 .002P	
Uinta	-.3609 .721P	-10.06 .000P	-8.337 .000P	-.6446 .524P

Table XIX: Continued

	<u>Alluvium</u>	<u>Wasatch</u>	<u>Anvil Points</u>	<u>Parachute Creek</u>
<u>Mo in Ricegrass</u>				
Anvil Points		.8749 .384P		
Parachute Creek		1.418 .159P	1.141 .272P	
Uinta		-2.455 .016P	-2.419 .022P	-2.140 .047P
<u>B in Ricegrass</u>				
Anvil Points		-.3674 .714P		
Parachute Creek		.5375 .592P	.7475 .466P	
Uinta		1.178 .241P	1.497 .146P	-.3132E-01 .975P
<u>Mo in Wheatgrass</u>				
Parachute Creek		1.220 .229P		
Uinta		-2.814 .006P		-2.522 .018P
<u>B in Wheatgrass</u>				
Parachute Creek		-.3134E-01 .975P		
Uinta		-.4904 .625P		-.3145 .756P

Table XIX: Continued

	<u>Alluvium</u>	<u>Wasatch</u>	<u>Anvil Points</u>	<u>Parachute Creek</u>
<u>pH of Sediments</u>				
Wasatch	-.5949 .553P			
Anvil Points	-4.114 .001P	-2.649 .009P		
Parachute Creek	-5.069 .000P	-5.364 .000P	-2.835 .008P	
Uinta	-5.579 .000P	-4.959 .000P	-4.849 .000P	-2.251 .031P
<u>Organic Carbon in Sediments</u>				
Wasatch	-.2110E+38 .000P			
Anvil Points	4.477 .001P	.2166E+38 .000P		
Parachute Creek	11.10 .000P	.4743E+38 .000P	3.357 .002P	
Uinta	6.483 .000P	.2734E+38 .000P	2.014 .056P	-.2623 .795P
<u>Hg in Sediments</u>				
Wasatch	-.5277 .599P			
Anvil Points	-.1215 .905P	.7799 .437P		
Parachute Creek	2.105 .046P	8.673 .000P	4.156 .000P	
Uinta	2.594 .023P	5.809 .000P	3.939 .001P	-.7267 .473P

Table XIX: Continued

	<u>Alluvium</u>	<u>Wasatch</u>	<u>Anvil Points</u>	<u>Parachute Creek</u>
<u>Mo in Sediments</u>				
Wasatch	-1.244 .216P			
Anvil Points	-1.217 .244P	-.4861 .628P		
Parachute Creek	.4996 .622P	4.647 .000P	2.171 .037P	
Uinta	-.5743 .576P	.1850 .854P	.3284 .746P	-1.630 .113P
<u>B in Sediments</u>				
Wasatch	.4251 .672P			
Anvil Points	5.828 .000P	4.518 .000P		
Parachute Creek	3.893 .001P	7.059 .000P	1.319 .196P	
Uinta	6.845 .000P	5.446 .000P	3.131 .005P	.3939 .696P
<u>F in Sediments</u>				
Wasatch	1.797 .075P			
Anvil Points	4.092 .001P	5.339 .000P		
Parachute Creek	5.111 .000P	7.264 .000P	.1804 .858P	
Uinta	6.233 .000P	5.488 .000P	.3432 .735P	.2234 .825P

The second method to be used is the Duncan's Multiple Range Test (Duncan, 1955). This method will break the means down into groups of means that can be considered equal. This may result in more than one combination of means with overlapping members.

Both these methods require the calculation of the variance between means. This could not be done exactly since the groups were of unequal sample sizes. The variance that was calculated is the largest possible variance, which was obtained using the group with the fewest number of observations to determine the mean. This makes these tests more conservative. The results of these tests are shown in Table XX.

Correlation Matrix

The correlation coefficient is a measure of the mutual relationship between two variables. It is calculated by:

$$r = \frac{\sum X_1 \cdot X_2}{(\sum X_1^2)(\sum X_2^2)}$$

The correlation coefficient (r) is a measure of the degree of closeness to a linear relationship.

Tables XXI and XXII show the correlation coefficients for the soil and plant populations, and the sediment populations. All values except pH have been log transformed. The population being correlated must be common to the same site in order to calculate a correlation. This results in the number of

Table XX: Results of the Modified Least Significant Difference Test and Duncan's Multiple Range Test.

LSD/SR is the least significant difference between any two means in a population that can be considered significant at the .05 level.

The means for a population are listed from largest to smallest.

The results of the Duncan's Multiple Range Test are shown below the group means. Any two means not underscored by the same line are significantly different at the .05 level. Any two means underscored by the same line are not significantly different.

pH of Soils

LSD/SR = .667

Alluvium	Wasatch	Anvil Points	Parachute Creek	Uinta
<u>7.97</u>	<u>7.78</u>	<u>7.75</u>	<u>7.69</u>	6.87

Organic Carbon in Soils (log transformed)

LSD/SR = .498

Uinta	Parachute Creek	Anvil Points	Wasatch	Alluvium
.577	.509	<u>.354</u>	<u>.0212</u>	<u>-.506</u>

Hg in Soils (log transformed)

LSD/SR = .399

Alluvium	Anvil	Parachute	Wasatch	Uinta
<u>1.53</u>	<u>1.48</u>	<u>1.41</u>	<u>1.37</u>	<u>1.37</u>

Table XX: Continued

B in Soils (log transformed)

LSD/SR = .204

Parachute Creek	Uinta	Anvil Points	Wasatch	Alluvium
<u>2.26</u>	<u>2.25</u>	<u>2.20</u>	<u>2.16</u>	<u>2.13</u>

Mo in Soils (log transformed)

LSD/SR = .404

Parachute Creek	Alluvium	Wasatch	Uinta	Anvil Points
<u>.532</u>	<u>.443</u>	<u>.319</u>	<u>.294</u>	<u>.293</u>

F in Soils (log transformed)

LSD/SR = .242

Parachute Creek	Anvil Points	Uinta	Wasatch	Alluvium
<u>2.92</u>	<u>2.74</u>	<u>2.70</u>	<u>2.66</u>	<u>2.62</u>

Mo in Sage (log transformed)

LSD/SR = .436

Alluvium	Wasatch	Parachute Creek	Anvil Points	Uinta
<u>.074</u>	<u>-.035</u>	<u>-.200</u>	<u>-.258</u>	<u>-.372</u>

Table XX: Continued

B in Sage (log transformed)

LSD/SR = .212

Alluvium	Parachute Creek	Uinta	Wasatch	Anvil Points
1.48	1.45	1.45	1.37	1.32

F in Sage (log transformed)

LSD/SR = .651

Anvil Points	Wasatch	Parachute Creek	Alluvium	Uinta
1.18	1.11	.590	.559	.519

Mo in Ricegrass (log transformed)

LSD/SR = .577

Parachute Creek	Anvil Points	Wasatch	Uinta
.461	.342	.291	.151

B in Ricegrass (log transformed)

LSD/SR = .304

Parachute Creek	Uinta	Wasatch	Anvil Points
.737	.735	.690	.675

Mo in Wheatgrass (log transformed)

LSD/SR = .459

Parachute Creek	Wasatch	Uinta
.384	.218	.0595

Table XX: Continued

B in Wheatgrass (log transformed)

LSD/SR = .361

Wasatch	Parachute Creek	Uinta
<u>.805</u>	<u>.800</u>	<u>.780</u>

pH of Sediments

LSD/SR = .565

Alluvium	Wasatch	Anvil Points	Parachute Creek	Uinta
<u>8.40</u>	<u>8.30</u>	<u>8.08</u>	<u>7.96</u>	<u>7.86</u>

Organic Carbon in Sediments (log transformed)

LSD/SR = 1.428

Parachute Creek	Uinta	Anvil Points	Wasatch	Alluvium
<u>.493</u>	<u>.475</u>	<u>.218</u>	<u>-.580</u>	<u>-.823</u>

Hg in Sediments (log transformed)

LSD/SR - 0.983

Parachute Creek	Uinta	Alluvium	Anvil Points	Wasatch
<u>1.93</u>	<u>1.88</u>	<u>1.60</u>	<u>1.59</u>	<u>1.55</u>

Mo in Sediments (log transformed)

LSD/SR - 0.762

Parachute Creek	Alluvium	Uinta	Wasatch	Anvil Points
<u>.641</u>	<u>.562</u>	<u>.492</u>	<u>.485</u>	<u>.469</u>

Table XX: Continued

B in Sediments (log transformed)

LSD/SR = 1.62

Parachute Creek	Uinta	Anvil Points	Wasatch	Alluvium
2.30	2.29	2.15	1.68	1.59

F in Sediments (log transformed)

LSD/SR = .681

Uinta	Parachute Creek	Anvil Points	Wasatch	Alluvium
2.84	2.83	2.82	2.61	2.46

samples used in each correlation being different.

The number of samples used in determining the correlation will also determine the critical value for testing the null hypothesis that $r = 0$. A rejection of the null hypothesis indicates that there is some sort of relationship between the populations being correlated, although this relationship may not be linear. The critical r value was calculated by:

$$t_{.05, v} = r\sqrt{n-2} / \sqrt{1-r^2} \qquad v = n-2$$

Table XXI: Correlation Matrix for Soil and Plant Populations

	a	b	c	d	e	f	g	NUMBER OF SAMPLES	CRITICAL r (0.05)
Elev	.9631							202	.1155
pH/So	-.6875	-.6474						157	.1310
OC/So	.6574	.6665	-.5715					134	.1417
Hg/So	-.0343	.0337	.1308	.1069				71	.1972
Mo/So	-.0637	-.0637	.2535	.0337	.3444			118	.1521
F/So	.1991	.1913	.2032	.1888	.1628	.3360		64	.2076
B/So	.3347	.3113	-.1213	.2886	-.0642	.0579	.3443	56	.2217
Mo/BS	-.5561	-.6043	.5412	-.3143	.0181	.2089	.1352		
B/BS	.2680	.2182	-.2165	.3675	-.2953	.0679	.0209	.2601	.0529
F/BS	-.5797	-.5478	.5584	-.5432	.1103	.1576	-.0939	-.1901	.3377
Mo/IR	-.1569	-.1618	.2485	.0025	.0177	.1236	.0663	0.0179	.3506
B/IR	.1008	.0683	.0731	.1035	.0177	.1391	.1470	.0263	.1002
Mo/WW	-.2988	-.3212	.2715	-.2246	.1694	.3720	.2644	-.1298	.5655
B/WW	-.0577	-.0445	.0319	.0341	-.0991	-.0563	-.1727	-.0113	.0487

So = Soil
 BS = Big sage
 IR = Indian ricegrass
 WW = Western wheatgrass

Rock Elev pH/So OC/So Hg/So Mo/So F/So B/So Mo/BS B/BS F/BS Mo/IR B/IR Mo/WW

Table XXII: Correlation Matrix for Sediment Populations

<u>Var.</u>	<u>Ru</u>	<u>Elev</u>	<u>pH</u>	<u>OC</u>	<u>Hg</u>	<u>Mo</u>	<u>F</u>
Elev	0.9401						
pH	-0.5252	-0.9401					
OC	0.6813	0.7338	-0.6994				
Hg	0.5640	0.5768	-0.2929	0.4739			
Mo	0.1973	0.1785	-0.0152	0.1802	0.1792		
F	0.5860	0.6068	-0.5543	0.7529	0.3749	0.3463	
B	0.5869	0.6000	-0.5056	0.5071	0.3109	0.1706	0.6845

161 Samples

Critical $r = .1294$ at .05 significance

Discussion

The purpose of a baseline study is primarily to determine natural background levels and variability, not to determine geochemical principles or to test hypotheses. The detailed results of this baseline study have been set out in the preceding section; however, there are several points that are worth emphasizing.

The results of the Kolmogorov-Smirnov test listed in Table VI, generally support the hypothesis that trace element distributions in the regions under study are best described as a lognormal function. Assuming the lognormal distribution to be true for the elements of interest for this study, subsequent statistical calculations were performed using logarithmically transformed data.

Analysis of variance has revealed several significant points. The original hierarchical analysis of variance sample design only attempted to determine the variance caused by sample spacing and ignored any variations caused by geologic units. The results of this analysis, listed in Table VII can not distinguish between variance caused by sample spacings and that caused by changing geologic units. A second analysis of variance was performed to determine if there was significant variation between geologic units. The results of these calculations, listed in Table VIII, demonstrate that all populations studied did demonstrate signi-

ficant variation between rock units. Because of the differences between rock units, the original hierarchical sample design should only have been attempted within a geologic unit.

The original hierarchical analysis of variance was altered so as to include only those samples that were taken within the Wasatch Unit. The results of this approach are listed in Table IX. The Wasatch Unit is the only unit with sufficient exposure within the study area to consider mapping for trace elements. The majority of any potential contamination could be expected to occur in the surficial materials of this unit. The results shown in Table IX indicate that Mo, B, and F in Big Sage, and Mo in Indian ricegrass and Western wheatgrass could be mapped within the Wasatch Unit using the sample density obtained from the grid sampling design. All the soil parameters measured had too much local variation to be mapped with the desired 80% reproducibility. The results of the F-tests in Table IX should be used with reservation. The sample design was very limited and a larger study might have been able to detect significant variations.

Because of the importance of geologic unit on trace element concentrations, background levels and expected ranges should also be calculated for each geologic unit. These calculations are listed in Tables XIV through XVIII. The baseline levels for the study area as a whole (Table XIII) are of limited usefulness. Caution should be exercised when

using these tables since several populations consisted of only 3 or 4 samples.

The analysis of variance conducted on stream sediment samples clearly show that both between-stream and between-geologic unit variations are significant. This is an important limitation if sediments are to be used to monitor possible contamination. Individual baseline levels would have to be developed for each stream and each geologic unit within that stream. The hypothesis testing that was attempted in Table XX was weak due to the uneven sample distribution. The tests were conducted using the fewest number of samples for any geologic unit. This will give conservative results.

In spite of the lack of statistical proof, several geochemical trends can be suggested within the study area. Both soil and sediment samples show decreasing pH with increasing elevation. Organic carbon shows the inverse relationship. Mercury concentrations do not appear to have any definite trends, but Mo, B, and F appear to be higher in concentrations in samples taken from the Parachute Creek Member. In order to statistically prove or disprove these hypothetical trends it would be necessary to sample the study area in such a manner as to ensure a minimum number of samples from each of the geologic units.

The concentrations of Mo, B, and F in plant samples do not show the same trends as soils from the same sites. The weak correlations shown in Table XXI suggest that other factors affecting the uptake of trace elements by plants are having important effects.

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Appendix I
PRECIS. FOR

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DIMENSION DATA(10)
C COMPUTES MEANS, DEVIATIONS FOR ANALYTICAL REPLICATES OF AN
C INDIVIDUAL SAMPLE AND AVERAGE DEVIATIONS FOR A SET OF SAMPLES.
C R W KLUSMAN 1977
C READ IN ELEMENT BEING PROCESSED
  6 WRITE(4,109)
 109 FORMAT(48H ELEMENT BEING PROCESSED? IF DONE, TYPE IN 9999)
  READ (4,100) LABEL
 100 FORMAT(A4)
  IF(LABEL.EQ.4H9999) GO TO 1
C SET SUMS TO ZERO
  GSUM1=0.
  GSUM2=0.
  GSUM3=0.
  K=0
C PRINT HEADINGS
  WRITE(6,101) LABEL
 101 FORMAT(1H1,30X,A4)
  WRITE(6,102)
 102 FORMAT(1H0,4HDATA/53H ARITHMETIC STANDARD PERCENT GEOMETRIC G
 1EOMETRIC/54H MEAN DEVIATION DEVIATION MEAN DEVIATION
 2)
  WRITE(4,110)
 110 FORMAT(66H ENTER REPLICATE DATA IN F FORMAT, UP TO 10 REPLICATES P
 1ER SAMPLE,/36H SEPERATED BY COMMAS, ENDING WITH 0.)
  WRITE(4,111)
 111 FORMAT(64H IF END OF DATA SET OR END OF ELEMENT FOR ALL SAMPLES, E
 1NTER 99.)
  7 READ(4,103)(DATA(I),I=1,10)
 103 FORMAT(10F)
C SET SUMS TO ZERO
  N=1
  SUM=0.
  SUM2=0.
  SUML=0.
  SUML2=0.
C CHECK FOR END OF REPLICATIONS ON ONE SAMPLE
  4 IF(DATA(N).EQ.0.) GO TO 2
C CHECK FOR END OF DATA SET
  IF(DATA(N).EQ.99.) GO TO 3
C SUM DATA
  SUM=SUM+DATA(N)
  SUML=SUML+ALOG10(DATA(N))
  SUM2=SUM2+(DATA(N))**2
  SUML2=SUML2+(ALOG10(DATA(N))**2)
  N=N+1
  GO TO 4
C DETERMINE NUMBER OF REPLICATIONS
  2 N=N-1
C WRITE INDIVIDUAL DATA
  WRITE(6,104)(DATA(I),I=1,N)
 104 FORMAT(1H ,10F8.2)
  XN=FLOAT(N)
C CALCULATE MEAN AND DEVIATIONS
  XMEAN=SUM/XN
  XDEV=SQRT((1./((XN**2)-XN))*(((XN*SUM2)-(SUM**2))))
  GMEAN=EXP(2.303*(SUML/XN))
  GDEV=EXP(2.303*(SQRT((1./((XN**2)-XN))*(((XN*SUML2)-(SUML**2))))))
  SPERD=0.
C DETERMINE PERCENT DEVIATION ON EACH REPLICATE

```

```
DO 5 I=1,N
  5 SPERD=SPERD+ABS(((DATA(I)-XMEAN)/XMEAN)*100.)
  PERD=SPERD/XN
  WRITE(6,105) XMEAN,XDEV,PERD,GMEAN,GDEV
105 FORMAT(1H ,5F10.3)
C ADD TO GRAND SUMS
  GSUM1=GSUM1+XDEV
  GSUM2=GSUM2+PERD
  GSUM3=GSUM3+GDEV
  K=K+1
C RETURN TO NEW SAMPLE INPUT
  GO TO 7
  3 XK=FLOAT(K)
C COMPUTE AND WRITE GRAND MEANS AND DEVIATIONS
  AVDEV=GSUM1/XK
  WRITE(6,106) LABEL,AVDEV
106 FORMAT(1H0,31HAVERAGE STANDARD DEVIATION FOR ,A4,3H = ,F10.3)
  AVPER=GSUM2/XK
  WRITE(6,107) LABEL,AVPER
107 FORMAT(1H ,30HAVERAGE PERCENT DEVIATION FOR ,A4,3H = ,F10.3)
  AGDEV=GSUM3/XK
  WRITE(6,108) LABEL,AGDEV
108 FORMAT(1H ,32HAVERAGE GEOMETRIC DEVIATION FOR ,A4,3H = ,F10.3)
  GO TO 6
1 END
```

ANOVA. FOR

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C      PROGRAM TO PERFORM ANALYSIS OF VARIANCE ON NESTED SAMPLING MODELS
C      TO EXECUTE PROGRAM TYPE IN : "exe anova.for,LBY:IMSL/SEARCH " AFTER
C      FILE HAS BEEN OBTAINED IN YOUR AREA.
      DIMENSION NL(999),Y(999),S(999), NDF(999),EMS(999),IWK(9
1  99)
      DIMENSION NSC(999),YY(999),YS(999)
      DIMENSION AREA(999),SIG(999),PCSIG(999)
      DIMENSION WMSQ(999),FVAL(999)
      DOUBLE PRECISION A,B,C
4     WRITE(4,5)
5     FORMAT(1X,"ENTER INPUT FILE NAME FOR NLS: _____.DAT")
      READ(4,6) A
6     FORMAT(1A10)
      WRITE(4,7)
7     FORMAT(1X,"ENTER INPUT FILE NAME FOR DATA VALUES: _____.DAT")
      READ(4,6) B
      WRITE(4,8)
8     FORMAT(1X,"ENTER OUTPUT FILE NAME : _____.DAT")
      READ(4,6) C
      OPEN(UNIT=8,FILE=C)
      OPEN(UNIT=10,FILE=A)
      OPEN(UNIT=12,FILE=B)
      ICHECK=0
      IFLAG=0
      NCT=1
      NYCT=0
      IF (IFLAG.EQ.0)GO TO 53
10    IF(IFLAG.EQ.0) GO TO 4
      NCT=1
C     READ IN INPUT VECTOR (NL)CONTAINING THE NUMBER OF LEVELS OF
C     EACH FACTOR AT ALL THE NESTED LEVELS OF EACH FACTOR SEE DOC-
C     UMENTATION FOR EXAMPLE, USE A FLAG OF 99 AT THE END OF EACH
C     NL SET, A FLAG OF 90 AT THE END OF THE LAST NL SET. IF NO
C     MERGING OF THE NL SUBSETS IS DESIRED A FLAG OF 90 IS SUFFICIENT.
C     NL'S ARE ENTERED 20 PER LINE SEPARATED BY " , " BEGIN A NEW
C     LINE AFTER A 90 OR 99 FLAG HAS BEEN ENTERED.
20    READ(10,30)(NL(I),I=1,20)
30    FORMAT(20I)
      DO 40 I=1,20
      IF (NL(I).EQ.90) GO TO 460
      NS(NCT)=NL(I)
      NCT=NCT+1
40    CONTINUE
      GO TO 20
C     TYPE IN THE VALUE OF NF: NUMBER OF FACTORS IN THE MODEL.
50    WRITE(4,60)
60    FORMAT(1H0,"ENTER THE VALUE FOR NF"/)
      READ(4,70) NF
70    FORMAT(I1)
      NF1=NF+1
      NF2=NF*(NF+1)/2
      NCT=1
C     READ IN THE FIRST SET OF NL'S
80    READ(10,90)(NL(I),I=1,20)
90    FORMAT(20I)
      DO 120 I=1,20
      IF(NL(I).NE.90) GO TO 100
      IFLAG=1
      GO TO 125
100   IF(NL(I).NE.99) GO TO 110

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```

      GO TO 125
110   NS(NCT)= NL(I)
      NCT=NCT+1
120   CONTINUE
      GO TO 80
C     READ IN THE DATA(Y), (ONE PIECE PER LINE)
C     USE A FLAG OF 99 AT THE END OF THE SET
C     CONVERSION OF DATA TO LOG(10) VALUES IF DESIRED
125   WRITE(4,126)
126   FORMAT(1X,"IF LOG CONVERSION OF DATA IS DESIRED TYPE 2, IF NOT,
1     TYPE 1"/)
      READ(4,70) ILOG
130   J=1
140   READ(12,150) YY(J)
      IF(YY(J).EQ.99.) GO TO 180
      IF(ILOG.EQ.1) GO TO 145
      Y(J) = ALOG10 (YY(J))
      GO TO 160
145   Y(J)=(YY(J))
150   FORMAT(F10.3)
160   NYCT=NYCT+1
      YS(NYCT)= Y(J)
      J=J+1
      GO TO 140
C     WRITE OUT DATA VALUES TO TTY AND FILE
180   WRITE (8,185)
185   FORMAT(1X,/,10X,"DATA AND NL VALUES",/)
      WRITE(8,480)(Y(J),J=1,NYCT)
      WRITE(8,200)(NS(I),I=1,NCT)
      WRITE(4,190)(NS(I),I=1,NCT)
190   FORMAT(/20I2/)
200   FORMAT(/40I2/)
C     CALL ANESTU SUBROUTINE TO ANALYSE NESTED DATA
      CALL ANESTU (NF,NS,Y,GM,S,NDF,EMS,IWK,IER)
C     CALCULATE MEAN SQUARE VALUES
      DO210 I=1,NF
      WMSQ(I)= S(I) / FLOAT(NDF(I))
210   CONTINUE
C     CALCULATE F STAT. VALUES
      DO 220 I=1,NF-1
      FVAL(I) = WMSQ(I) / WMSQ(I+1)
220   CONTINUE
      WRITE(4,230)
      WRITE(8,230)
230   FORMAT(1X,/"EXPECTED MEAN SQUARE COEFFICIENTS"/)
240   FORMAT(F10.5,I10)
      IS=1
      IF=NF
C     WRITE OUT EXPECTED MEAN SQUARE COEFFICIENTS
      DO 250 N=1,NF
      WRITE(4,260)(EMS(I),I=IS,IF)
      WRITE(8,260)(EMS(I),I=IS,IF)
      IS=IF+1
      IF=IS+(NF-N)-1
250   CONTINUE
260   FORMAT(12F10.4)
      WRITE(4,270)
C     CONFIRM VALIDITY OF DATA, IF BAD PRGM. STARTS OVER.
270   FORMAT(1X,"IF DATA IS GOOD,ENTER 1, IF BAD,ENTER 0")
      READ (4,280) IPRINT

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280     FORMAT(I1)
      IF(IPRINT.EQ.1) GO TO 290
      GO TO 10
290     WRITE(4,300)
C     TYPE IN AND WRITE OUT AREA TITLE
300     FORMAT(1X,"ENTER AREA TITLE,UP TO 24 SPACES"/)
      READ(4,310)(AREA(L),L=1,4)
310     FORMAT(4A5)
      WRITE (8,320)(AREA(L),L=1,4)
320     FORMAT(1H0,(4A5)/)
330     FORMAT(1X,/,3X,"TOTAL SUM OF SQUARES",5X,"DEG. OF FREEDOM"/)
C     CALCULATE ESTIMATED COMPONENTS OF VARIANCE
340     SIG(NF)=S(NF)/NDF(NF)
      SIG(NF-1)=(S(NF-1)/NDF(NF-1) - SIG(NF))/EMS(NF2-1)
      IF ((NF-2).EQ.0) GO TO 360
      SIG(NF-2)=(S(NF-2)/NDF(NF-2)-SIG(NF)-EMS(NF2-4)*SIG(NF-1
1  ))/EMS(NF2-3)
      IF((NF-3).EQ.0)GO TO 360
      SIG(NF-3)=(S(NF-3)/ NDF(NF-3)-SIG(NF)-EMS(NF2-8)* SIG(NF
1  -1)-EMS(NF2-7)*SIG(NF-2))/ EMS(NF2-6)
      IF((NF-4).EQ.0) GO TO 360
      SIG(NF-4)=(S(NF-4)/NDF(NF-4)-SIG(NF)-EMS(NF2-13)*SIG(NF-
1  1)-EMS(NF2-12)*SIG(NF-2)-EMS(NF2-11)*SIG(NF-3))/EMS(NF2-
1  10)
      IF((NF-5).EQ.0) GO TO 360
      SIG(NF-5)=(S(NF-5)/NDF(NF-5)-SIG(NF)-EMS(NF2-19)*SIG(NF-
1  -1)-EMS(NF2-18)*SIG(NF-2)-EMS(NF2-17)*SIG(NF-3
1  )-EMS(NF2-16)*SIG(NF-4))/ EMS(NF2-15)
350     FORMAT(1X,F15.6,2X,I10,F10.6 ,5X,F10.6 //)
C     WRITE OUT COLUMN HEADINGS FOR ANOVA TABLE

360     WRITE(8,370)
      WRITE(4,370)
370     FORMAT(1X,"LEVEL",10X,"SUM OF SQUARES",10X,"DEG. OF FR.",
17X,"MEAN SQUARE",10X,"F VALUE",8X,"EST. COMP. OF VAR.",
1  6X,"PCT.OF TOT.VAR."////)
C     CALCULATE TOTAL ESTIMATED COMP. OF VARIANCE(TOTSIG) OMMITING
C     VALUES LESS THAN OR EQUAL TO ZERO
      IF (ICHECK .EQ. 1) GO TO 375
      TOTSIG=0
375     DO380 I=1,NF
      IF((SIG(I)).LE. 0.) GO TO 380
      TOTSIG= TOTSIG+SIG(I)
380     CONTINUE
C     CALCULATE PERCENT OF TOTAL VARIANCE (PCSIG)
      DO390 I=1,NF
      PCSIG(I)= (SIG(I) / TOTSIG ) *(100)
      IF((SIG(I)) .LE. 0.) PCSIG(I)=0.
390     CONTINUE
400     FORMAT(F10.5)
C     WRITE OUT ANOVA TABLE
      DO420 I=1,NF
      WRITE(8,410)I,S(I),NDF(I),WMSQ(I),FVAL(I),SIG(I),PCSIG
1(I)
      WRITE(4,410)I,S(I),NDF(I),WMSQ(I),FVAL(I),SIG(I),PCSIG
1(I)
410     FORMAT(1X,3X,I3,11X,1E10.4,13X,I3,13X,1E10.4,8X,E10.4,12X
1  ,1E10.4,10X,1F8.4,////)
420     CONTINUE
      WRITE(4,330)

```

```

        WRITE(8,330)
        WRITE(4,440)S(NF1),NDF(NF1)
C      WRITE TOTAL SUM OF SQUARES AND DEGREES OF FREEDOM
        WRITE(8,440)S(NF1),NDF(NF1)
C      WRITE GRAND MEAN AND ERROR PARAMETER
        WRITE(4,430)
        WRITE(8,430)
430     FORMAT(1X,/,2X,"GRAND MEAN",10X,"ERROR PARAMETER"/)
        WRITE(8,440) GM,IER
        WRITE(4,440)GM,IER
440     FORMAT(1G,13X,I10)
C      ENTER 0 IF MORE DATA, 1 TO MERGE DATA SETS, 2 TO STOP
        WRITE(4,450)
450     FORMAT(1X,"IF MORE DATA,ENTER 0,IF MERGE ENTER 1, IF STO
        IP , ENTER 2")
        READ(4,280) IFLAG
        IF(IFLAG.EQ.2) CALL EXIT
        GO TO 10
C      ANALYSE MERGED DATA SETS
C      NOTE A NEW SET OF NL'S MUST BE ENTERED CONSTRUCTED FROM
C      THE NEWLY COMBINED OR MERGED VALUES
460     WRITE(4,60)
        READ(4,70) NF
470     FORMAT((10I))
        WRITE(8,470) (NS(I),I=1,NCT)
        WRITE(8,480) (YS(I),I=1,NYCT)
480     FORMAT(8F10.4)
        NF1=NF+1
        NF2=NF*(NF+1)/2
        CALL ANESTU(NF,NS,YS,GM,S,NDF,EMS,IWK,IER)
C      ENTER ELEMENT NAME
        WRITE(4,490)
490     FORMAT(1X,"ENTER ELEMENT"/)
        READ(4,500) ELEM
500     FORMAT(A6)
        WRITE(8,510)ELEM
510     FORMAT(1X,A6)
        WRITE(4,240)(S(I),NDF(I),I=1,NF1)
        WRITE(4,260)(EMS(I),I=1,NF2)
        WRITE(8,240)(S(I),NDF(I),I=1,NF1)
        WRITE(8,260)(EMS(I),I=1,NF2)
        WRITE(8,440) GM,IER
        IFLAG=2
        ICHECK=1
        GO TO 340
        STOP
        END

```

Lognormal Mean and Deviations

```

C   THIS PROGRAM WILL CALCULATE THE MEAN AND STANDARD DEVIATION
C   FOR A LOGNORMAL DISTRIBUTION. TO USE THIS PROGRAM, EDIT THE
C   PROGRAM AND REPLACE THE VARIABLE NAME IN THE READ STATEMENT
C   WITH "VAR(I)".
      DIMENSION LOC(202),IRU(202),ELEV(202),PH(202),OC(202),HG(202),
      &ARMO(202),ARF(202),ARB(202),ABMO(202),ABB(202),ABF(202),AOMO(202)
      &,AOB(202),AAMO(202),AAB(202),VAR(202)
      WRITE(4,5)
5   FORMAT (' NUMBER OF OBSERVATIONS = ')
      READ(4,10) M
10  FORMAT(I3)
      READ(15,30)(LOC(I),IRU(I),ELEV(I),PH(I),OC(I),HG(I),ARMO(I),
      &ARF(I),ARB(I),ABMO(I),ABB(I),ABF(I),AOMO(I),AOB(I),AAMO(I),AAB(I)
      &,I=1,M)
30  FORMAT(I4,23X,I1,2X,I4,2X,F4.2,2X,F4.2,2X,F5.1,2X,F4.1,2X,F5.0
      &,2X,F4.0,2X,F4.1,2X,F4.1,2X,F4.1,2X,F4.1,2X,F4.1,2X,F4.1,2X,F4.1)
      SVAR=0.
      SSVAR=0.
      DO 40 I=1,M
      SVAR=SVAR+ALOG(VAR(I))
      SSVAR=SSVAR+(ALOG(VAR(I)) **2.0)
40  CONTINUE
      D=FLOAT(M)
      VVAR=(SSVAR-(SVAR**2./D))/(D-1.)
      EVAR=SVAR/D
      GMVAR=EXP(EVAR)*EXP(VVAR/2.)
      GOVAR=SQRT((GMVAR**2.)*(EXP(VVAR)-1.))
      WRITE(4,50) GMVAR,GOVAR
50  FORMAT('      MEAN =',1G,'      STANDARD DEVIATION =', 1G)
      STOP
      END

```

Appendix 2

GRID AND ADV DATA - SOILS AND PLANTS

LOC	LATITUDE D M S	LONGITUDE D M S	ROCK UNIT	ELEV	SOIL PH	SOIL OC	SOIL HG	SOIL MO	SOIL F	SOIL B	SAGE MO	SAGE B	SAGE F	RICEGRASS MO	RICEGRASS B	WHEATGRASS MO	WHEATGRASS B
-1	39 30 11	107 58 15	1	6160	7.90	1.80	47.0	3.4	660.	140.	0.9	24.4	9.8	2.3	6.2	1.5	4.2
-2	39 30 39	107 58 29	2	6800	7.76	3.60	28.0	4.8	840.	170.	-1.0	-1.0	-1.0	2.1	4.7	-1.0	-1.0
-3	39 31 10	107 58 31	4	8720	6.94	1.40	17.0	0.8	320.	170.	0.5	24.5	3.2	0.9	4.3	0.8	6.3
-4	39 31 27	107 58 30	4	8520	6.49	9.60	28.0	1.6	420.	140.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-5	39 31 55	107 58 30	4	8670	6.29	5.20	19.0	1.6	480.	180.	0.2	20.2	1.9	-1.0	-1.0	1.0	4.3
-6	39 32 22	107 58 30	4	8640	6.30	3.50	15.0	0.6	340.	160.	0.1	32.1	1.5	-1.0	-1.0	1.0	7.0
-7	39 32 46	107 58 26	4	8520	5.90	9.30	32.0	1.1	360.	140.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-8	39 33 16	107 58 30	3	8040	7.43	4.00	22.0	3.7	930.	170.	0.7	29.1	4.3	3.0	6.0	2.8	6.8
-9	39 33 44	107 58 27	3	8240	7.76	3.90	24.0	5.9	760.	170.	0.6	26.7	3.6	2.6	4.5	2.3	6.5
-10	39 30 11	107 57 53	1	5560	7.97	.90	34.0	2.1	540.	170.	1.3	24.3	5.8	4.6	8.0	3.7	5.8
-11	39 30 39	107 58 1	1	6360	7.74	.40	39.0	2.1	540.	140.	-1.0	-1.0	-1.0	2.2	5.6	-1.0	-1.0
-12	39 31 5	107 57 56	2	7760	7.86	6.00	25.0	3.6	410.	140.	-1.0	-1.0	-1.0	1.9	4.5	-1.0	-1.0
-13	39 31 29	107 57 57	4	8680	7.03	2.40	14.0	4.4	700.	150.	0.2	24.4	3.2	1.2	4.9	-1.0	-1.0
-14	39 31 55	107 57 56	4	8560	6.49	3.30	17.0	1.3	550.	160.	-1.0	-1.0	-1.0	-1.0	-1.0	1.5	5.0
-15	39 32 22	107 57 56	4	8640	6.78	8.30	46.0	1.3	430.	190.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-16	39 32 47	107 57 54	4	8680	6.58	8.60	32.0	1.2	650.	140.	-1.0	-1.0	-1.0	-1.0	-1.0	1.5	5.0
-17	39 33 17	107 57 57	4	8540	6.55	2.80	21.0	2.8	690.	180.	0.6	24.5	1.9	-1.0	-1.0	1.4	7.1
-18	39 33 45	107 57 58	4	8400	6.28	4.60	20.0	4.0	400.	120.	0.5	32.9	2.1	2.5	5.2	1.7	6.3
-19	39 30 10	107 57 23	1	5680	8.48	.50	33.0	2.3	740.	180.	0.6	21.2	11.0	1.9	7.3	-1.0	-1.0
-20	39 30 39	107 57 22	2	7000	7.46	1.50	37.0	2.7	470.	120.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-21	39 31 3	107 57 23	2	6800	7.51	4.50	32.0	1.3	940.	200.	-1.0	-1.0	-1.0	1.8	7.8	-1.0	-1.0

GRID AND ADV DATA - SOILS AND PLANTS

LOC	LATITUDE D M S	LONGITUDE D M S	ROCK UNIT	ELEV ELEV	SOIL PH	SOIL UC	SOIL HG	SOIL MO	SOIL F	SOIL H	SAGE MO	SAGE H	SAGE F	RICEGRASS MU	RICEGRASS H	WHEATGRASS MO	WHEATGRASS H
-22	39 31 29	107 57 23	2	7600	7.75	5.40	47.0	5.5	460.	210.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-23	39 31 59	107 57 28	4	8840	7.18	2.40	20.0	1.4	340.	210.	0.2	29.1	4.6	1.9	6.0	0.5	6.3
-24	39 32 22	107 57 22	4	8680	6.46	3.10	19.0	2.6	440.	190.	0.4	31.6	3.4	-1.0	-1.0	2.7	8.4
-25	39 32 47	107 57 22	4	8600	6.56	7.70	31.0	1.6	400.	190.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-26	39 33 17	107 57 27	4	8720	6.60	4.10	22.0	1.5	440.	200.	0.4	22.9	1.3	-1.0	-1.0	1.1	6.6
-27	39 33 48	107 57 23	3	8360	7.76	4.10	27.0	5.1	800.	200.	0.6	29.0	3.8	3.1	6.0	2.2	5.7
-28	39 30 11	107 56 43	1	5400	7.89	.20	25.0	2.9	590.	150.	-1.0	-1.0	-1.0	3.1	4.8	1.6	3.4
-29	39 30 35	107 56 42	1	5600	7.92	.60	63.0	3.8	480.	150.	0.9	16.7	16.0	1.7	5.0	1.5	6.2
-30	39 31 3	107 56 50	1	6400	7.89	2.30	22.0	1.6	575.	180.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-31	39 31 30	107 56 48	2	6680	7.72	2.80	27.0	2.8	640.	180.	0.7	20.7	6.8	2.2	4.6	-1.0	-1.0
-32	39 31 59	107 56 48	2	7540	7.81	3.00	42.0	1.4	780.	160.	-1.0	-1.0	-1.0	1.7	5.4	-1.0	-1.0
-33	39 32 25	107 56 49	4	8720	7.94	3.50	36.0	5.3	550.	190.	0.8	32.1	7.8	2.4	7.2	2.8	7.0
-34	39 32 47	107 56 48	4	8400	7.60	4.70	32.0	4.2	1300.	240.	0.6	29.2	3.6	2.3	5.6	2.3	7.5
-35	39 33 14	107 56 46	4	8880	6.36	3.10	19.0	1.1	340.	220.	0.2	29.9	2.4	-1.0	-1.0	1.0	7.0
-36	39 33 47	107 56 46	4	8880	6.38	5.40	14.0	1.0	300.	210.	0.8	26.4	2.6	-1.0	-1.0	1.8	6.8
-37	39 30 11	107 56 15	1	5280	7.74	1.40	23.0	3.6	420.	160.	2.0	25.2	9.6	0.8	3.9	-1.0	-1.0
-38	39 30 40	107 56 14	1	5880	8.00	.30	16.0	1.4	320.	100.	0.7	24.4	14.9	1.8	3.9	2.0	6.1
-39	39 31 5	107 56 17	2	6680	7.93	.90	21.0	1.5	400.	120.	-1.0	-1.0	-1.0	4.0	3.8	-1.0	-1.0
-40	39 31 27	107 56 12	1	6440	7.81	1.60	33.0	0.7	480.	150.	-1.0	-1.0	-1.0	2.8	3.3	-1.0	-1.0
-41	39 31 54	107 56 14	1	6600	7.82	2.40	26.0	1.8	460.	155.	-1.0	-1.0	-1.0	2.5	5.2	-1.0	-1.0
-42	39 32 17	107 56 16	2	7000	7.66	6.70	50.0	6.5	930.	270.	-1.0	-1.0	-1.0	2.6	4.6	-1.0	-1.0

GRID AND ADV DATA - SOILS AND PLANTS

LOC	LATITUDE D M S	LONGITUDE D M S	ROCK UNIT	ELEV	SOIL PH	SOIL OC	SOIL HG	SOIL MO	SOIL F	SOIL B	SAGE MO	SAGE R	SAGE F	RICEGRASS MO	RICEGRASS R	WHEATGRASS MO	WHEATGRASS B
-64	39 30 38	107 54 39	1	5300	7.75	2.60	38.0	2.5	600.	190.	2.7	26.8	6.9	-1.0	-1.0	-1.0	-1.0
-65	39 31 9	107 54 40	1	5390	7.94	1.30	32.0	3.4	580.	150.	1.9	24.0	8.8	-1.0	-1.0	-1.0	-1.0
-66	39 31 34	107 54 38	1	5720	7.96	.40	10.0	1.9	350.	190.	0.8	31.6	20.6	1.5	2.7	-1.0	-1.0
-67	39 31 57	107 54 48	1	6440	7.90	1.10	21.0	1.0	300.	160.	0.5	19.2	18.8	1.1	5.6	-1.0	-1.0
-68	39 32 27	107 54 39	2	7080	7.92	.70	18.0	0.9	600.	160.	0.5	19.9	31.8	1.1	3.8	-1.0	-1.0
-69	39 32 49	107 54 40	2	6800	7.91	2.10	29.0	1.6	520.	210.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-70	39 33 17	107 54 48	2	6840	7.63	4.50	36.0	2.3	620.	210.	0.4	21.7	24.6	1.6	4.8	-1.0	-1.0
-71	39 33 47	107 54 41	2	7320	7.86	2.90	41.0	6.1	1200.	210.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-72	39 30 16	107 54 8	1	5260	8.00	1.20	24.0	3.2	500.	200.	1.5	24.4	14.2	-1.0	-1.0	-1.0	-1.0
-73	39 30 38	107 54 7	1	5340	7.90	1.10	15.0	2.6	490.	220.	1.0	22.8	7.3	-1.0	-1.0	-1.0	-1.0
-74	39 31 4	107 54 7	1	5470	7.97	.60	16.0	2.6	620.	210.	1.1	26.9	7.4	-1.0	-1.0	-1.0	-1.0
-75	39 31 29	107 54 8	1	5760	8.08	.90	60.0	3.0	540.	180.	0.5	18.5	33.5	2.7	6.6	-1.0	-1.0
-76	39 31 57	107 54 9	1	6170	7.99	.50	26.0	2.2	550.	190.	0.8	25.5	42.3	1.7	4.8	3.1	8.5
-77	39 32 23	107 54 8	1	6000	7.76	1.70	47.0	1.7	460.	110.	0.6	21.3	9.4	3.6	3.7	-1.0	-1.0
-78	39 32 51	107 54 6	2	6800	7.78	2.90	34.0	1.6	380.	160.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-79	39 33 17	107 54 5	2	7280	7.98	1.60	29.0	1.6	620.	130.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-80	39 33 44	107 54 6	3	8200	7.80	1.70	30.0	1.2	860.	180.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-81	39 30 12	107 53 39	1	5240	7.74	1.90	29.0	2.4	510.	200.	1.8	39.0	14.1	-1.0	-1.0	-1.0	-1.0
-82	39 30 39	107 53 32	1	5340	7.93	1.70	18.0	2.8	600.	160.	2.0	30.3	5.6	-1.0	-1.0	-1.0	-1.0
-83	39 31 5	107 53 29	1	6460	7.94	1.50	24.0	3.4	580.	190.	1.6	36.1	4.6	-1.0	-1.0	-1.0	-1.0
-84	39 31 30	107 53 32	1	5600	7.88	1.40	21.0	2.2	420.	180.	1.2	28.6	6.2	1.5	3.7	-1.0	-1.0

GRID AND ADV DATA - SOILS AND PLANTS

LOC	LATITUDE		LONGITUDE		ROCK UNIT	ELEV	SOIL PH		SOIL OC	SOIL HG	SOIL MO	SOIL F	SOIL B	SAGE MO	SAGE B	SAGE F	RICEGRASS MO	RICEGRASS B	WHEATGRASS MO	WHEATGRASS B	
	D	M	S	0			M	S													
-85	39	31	57	107	53	32	1	6040	7.82	1.70	40.0	2.4	520.	110.	0.7	28.9	16.3	0.8	2.8	1.1	7.3
-86	39	32	27	107	53	31	2	7160	7.81	.40	86.0	2.3	500.	170.	0.3	14.7	11.0	1.3	2.2	-1.0	-1.0
-87	39	32	52	107	53	29	1	6560	7.75	1.50	25.0	1.6	380.	95.	0.5	22.3	8.3	1.8	4.1	0.9	5.1
-88	39	33	18	107	53	32	2	7240	7.89	1.10	63.0	1.7	390.	200.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-89	39	33	47	107	53	29	2	7080	7.72	2.50	20.0	2.7	700.	100.	0.7	26.8	8.7	3.0	5.4	-1.0	-1.0
-90	39	30	12	107	53	0	1	5510	8.00	1.10	22.0	2.7	340.	120.	1.2	25.8	18.2	2.5	9.8	-1.0	-1.0
-91	39	30	38	107	53	0	1	5440	7.95	.40	16.0	2.1	330.	120.	1.0	35.9	18.3	2.7	3.7	-1.0	-1.0
-92	39	31	5	107	53	1	1	5500	7.90	1.80	16.0	2.0	410.	120.	1.1	26.5	18.1	4.2	4.5	1.9	4.6
-93	39	31	30	107	53	0	1	5850	6.80	1.80	23.0	2.1	320.	160.	0.5	23.1	12.3	-1.0	-1.0	-1.0	-1.0
-94	39	31	56	107	53	1	1	5770	7.27	.80	15.0	1.9	260.	120.	0.8	29.8	18.0	2.8	4.0	-1.0	-1.0
-95	39	32	25	107	52	59	1	6200	7.90	1.10	25.0	2.9	450.	140.	1.1	22.4	31.0	1.7	4.8	1.5	5.8
-96	39	32	51	107	52	59	1	6300	7.79	.80	34.0	1.7	450.	140.	-1.0	-1.0	-1.0	1.2	4.2	2.5	9.1
-97	39	33	17	107	52	59	2	7000	7.76	2.30	18.0	2.0	380.	130.	0.7	26.9	22.9	-1.0	-1.0	-1.0	-1.0
-98	39	33	48	107	53	0	2	6840	7.85	1.40	28.0	1.3	580.	160.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-99	39	30	7	107	52	24	0	5220	7.82	2.10	44.0	5.0	500.	160.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-100	39	30	41	107	52	25	1	5300	7.91	.40	27.0	3.6	370.	160.	1.2	33.3	40.0	2.0	8.8	-1.0	-1.0
-101	39	31	4	107	52	24	1	5660	7.80	1.10	29.0	1.6	460.	140.	0.4	23.8	11.0	2.6	8.8	-1.0	-1.0
-102	39	31	30	107	52	20	1	5660	6.90	1.60	13.0	2.1	430.	200.	0.9	38.1	10.0	-1.0	-1.0	-1.0	-1.0
-103	39	31	56	107	52	20	1	5620	7.80	1.90	26.0	2.0	500.	160.	0.8	25.3	23.0	1.9	3.9	-1.0	-1.0
-104	39	32	23	107	52	26	1	5820	7.50	1.90	16.0	2.8	260.	120.	0.6	24.7	17.0	2.8	4.0	-1.0	-1.0
-105	39	32	50	107	52	26	1	6440	7.96	.60	18.0	3.1	410.	130.	1.0	33.0	52.0	1.3	3.3	1.8	5.9

GRID AND ADV DATA - SOILS AND PLANTS

LOC	LATITUDE D M S	LONGITUDE D M S	ROCK UNIT	ELEV	SOIL PH	SOIL OC	SOIL HG	SOIL MO	SOIL F	SOIL R	SAGE MO	SAGE B	SAGE F	RICEGRASS MO	RICEGRASS R	WHEATGRASS MO	WHEATGRASS R
-106	39 33 17	107 52 26	1	6500	7.80	1.50	26.0	2.0	380.	160.	0.9	23.1	7.3	1.4	5.8	-1.0	-1.0
-107	39 33 47	107 52 25	2	7100	7.00	3.60	16.0	1.0	340.	140.	0.6	19.5	15.0	2.1	4.3	-1.0	-1.0
-108	39 30 12	107 51 53	1	5300	7.82	1.20	16.0	1.3	460.	180.	0.9	20.8	9.5	1.7	3.8	-1.0	-1.0
-109	39 30 39	107 51 52	0	5220	7.89	1.60	28.0	2.2	530.	160.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-110	39 31 4	107 51 53	1	5540	7.58	.70	20.0	1.4	360.	140.	0.8	26.9	22.0	-1.0	-1.0	2.6	4.0
-111	39 31 30	107 51 53	1	5560	6.82	1.00	18.0	1.9	360.	140.	1.8	29.5	14.4	-1.0	-1.0	-1.0	-1.0
-112	39 31 57	107 51 52	1	5860	7.90	1.20	44.0	2.3	320.	140.	0.6	24.1	22.0	2.6	4.5	-1.0	-1.0
-113	39 32 26	107 51 52	1	5760	7.84	1.40	40.0	6.3	230.	130.	0.8	21.6	17.0	1.3	4.7	-1.0	-1.0
-114	39 32 50	107 51 53	1	5920	7.98	1.10	30.0	2.2	500.	130.	-1.0	-1.0	-1.0	1.4	4.6	-1.0	-1.0
-115	39 33 16	107 51 53	1	6160	8.03	.50	42.0	2.0	500.	160.	0.3	18.4	61.0	1.8	3.2	-1.0	-1.0
-116	39 33 47	107 51 52	1	6440	7.87	2.60	36.0	2.6	520.	190.	0.6	13.2	9.3	3.7	5.0	-1.0	-1.0
-117	39 30 13	107 51 18	1	5500	7.72	1.80	29.0	1.5	490.	140.	0.7	33.5	11.3	1.2	3.2	-1.0	-1.0
-118	39 30 34	107 51 20	0	5240	7.85	3.00	31.0	2.6	490.	160.	1.3	38.0	3.1	-1.0	-1.0	-1.0	-1.0
-119	39 31 3	107 51 18	0	5270	8.52	.40	12.0	2.3	275.	160.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-120	39 31 30	107 51 17	1	5480	7.11	1.10	14.0	1.9	310.	190.	0.8	20.2	14.5	-1.0	-1.0	-1.0	-1.0
-121	39 31 55	107 51 18	1	5560	7.81	.70	26.0	1.2	290.	100.	0.9	20.0	14.0	1.8	3.5	-1.0	-1.0
-122	39 32 26	107 51 20	1	5640	8.06	.70	34.0	2.6	460.	170.	1.2	25.6	22.3	1.9	5.0	-1.0	-1.0
-123	39 32 49	107 51 18	1	5880	7.90	2.00	17.0	2.2	450.	180.	1.2	26.0	48.7	2.7	5.0	-1.0	-1.0
-124	39 33 16	107 51 17	1	6040	7.86	1.40	68.0	4.0	630.	240.	-1.0	-1.0	-1.0	0.9	4.0	-1.0	-1.0
-125	39 33 47	107 51 20	1	6480	7.87	.40	38.0	1.9	320.	170.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
-126	39 30 13	107 50 44	1	5640	7.46	1.70	16.0	1.4	400.	250.	1.1	27.3	6.7	-1.0	-1.0	-1.0	-1.0

GRID AND AOV DATA - SOILS AND PLANTS

LOC	LATITUDE		LONGITUDE		ROCK UNIT	ELEV	SOIL PH		SOIL OC		SOIL HG		SOIL MO		SOIL F		SOIL B		SAGE MO		SAGE F		RICEGRASS MO		RICEGRASS B		WHEATGRASS MO		WHEATGRASS B		
	D	M	S	D			M	S	PH	OC	MO	HG	MO	F	B	MO	F	MO	B	MO	F	MO	B	MO	B	MO	B	MO	B		
-148	39	31	57	107	49	38	1	5400	8.00	.50	21.0	1.1	420.	175.	1.4	21.7	14.0	3.1	6.3	-1.0	-1.0	3.1	6.3	-1.0	-1.0	3.1	6.3	-1.0	-1.0		
-149	39	32	23	107	49	38	1	5640	7.64	.60	11.0	1.4	440.	130.	1.2	23.6	14.0	4.4	4.7	-1.0	-1.0	4.4	4.7	-1.0	-1.0	4.4	4.7	-1.0	-1.0		
-150	39	32	49	107	49	38	1	5720	7.95	1.60	10.0	1.9	550.	120.	0.7	21.2	13.0	1.6	5.3	-1.0	-1.0	1.6	5.3	-1.0	-1.0	1.6	5.3	-1.0	-1.0		
-151	39	33	17	107	49	38	1	5740	6.99	1.00	15.0	1.5	380.	100.	0.6	21.0	7.7	1.1	4.8	2.1	11.8	1.1	4.8	2.1	11.8	1.1	4.8	2.1	11.8		
-152	39	33	47	107	49	37	1	5880	7.89	1.90	52.0	5.1	410.	120.	0.7	17.5	16.0	4.0	9.4	-1.0	-1.0	4.0	9.4	-1.0	-1.0	4.0	9.4	-1.0	-1.0		
-153	39	30	17	107	49	4	1	5880	7.79	3.00	25.0	1.1	410.	180.	1.3	30.4	3.2	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0		
-154	39	30	38	107	49	4	1	5720	7.73	2.10	22.0	1.5	490.	285.	0.8	33.9	11.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0		
-155	39	31	5	107	49	3	1	5400	7.88	2.10	32.0	1.6	610.	110.	1.6	29.6	3.9	2.3	10.3	-1.0	-1.0	2.3	10.3	-1.0	-1.0	2.3	10.3	-1.0	-1.0		
-156	39	33	47	107	54	41	4	9040	6.84	5.60	23.0	5.0	790.	155.	0.4	34.1	3.1	-1.0	-1.0	1.5	6.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0		
-157	39	31	57	107	49	6	1	5400	7.98	.50	15.0	1.7	510.	110.	1.2	20.6	6.5	3.5	6.7	2.5	20.3	6.5	3.5	6.7	2.5	20.3	6.5	3.5	6.7	2.5	20.3
-158	39	32	23	107	49	6	1	5620	6.69	1.20	36.0	1.8	190.	60.	0.7	24.0	6.4	1.7	4.8	-1.0	-1.0	1.7	4.8	-1.0	-1.0	1.7	4.8	-1.0	-1.0		
-159	39	32	49	107	49	8	1	5880	7.82	1.30	42.0	1.3	530.	115.	0.6	24.4	5.3	2.0	10.5	-1.0	-1.0	5.3	2.0	10.5	-1.0	-1.0	5.3	2.0	10.5	-1.0	-1.0
-160	39	33	17	107	49	4	1	5840	7.78	1.20	40.0	2.0	380.	60.	0.7	19.2	7.9	1.0	6.5	-1.0	-1.0	7.9	1.0	6.5	-1.0	-1.0	7.9	1.0	6.5	-1.0	-1.0
-161	39	33	45	107	49	6	1	5720	7.80	1.00	28.0	2.4	780.	140.	0.5	23.0	10.0	1.3	5.8	-1.0	-1.0	1.3	5.8	-1.0	-1.0	1.3	5.8	-1.0	-1.0		
-162	39	30	17	107	48	29	1	5720	7.92	1.20	16.0	2.6	560.	170.	1.1	36.4	4.5	1.0	3.8	-1.0	-1.0	4.5	1.0	3.8	-1.0	-1.0	4.5	1.0	3.8	-1.0	-1.0
-163	39	30	47	107	48	29	1	5620	7.91	.90	19.0	1.4	500.	210.	1.7	30.7	9.2	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	
-164	39	31	5	107	48	30	0	5260	8.02	.80	28.0	1.5	410.	140.	1.6	28.7	4.8	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	
-165	39	31	36	107	48	30	0	5280	7.72	1.70	109.0	4.6	530.	115.	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	
-166	39	31	59	107	48	31	1	5360	7.57	2.30	16.0	2.3	580.	220.	0.9	28.8	6.8	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	
-167	39	32	25	107	48	31	1	5460	7.66	1.70	23.0	2.3	450.	80.	1.0	35.0	6.7	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	
-168	39	32	50	107	48	31	1	5820	7.77	3.30	34.0	2.9	280.	90.	0.4	19.3	9.3	1.2	4.3	1.0	48.2	9.3	1.2	4.3	1.0	48.2	9.3	1.2	4.3	1.0	48.2

GRID AND ADV DATA - SOILS AND PLANTS

LOC	LATITUDE D M S	LONGITUDE D M S	ROCK UNIT	ELEV	SOIL PH	SOIL OC	SOIL HG	SOIL MO	SOIL F	SOIL B	SAGE MO	SAGE B	SAGE F	RICEGRASS MO	RICEGRASS B	WHEATGRASS MO	WHEATGRASS B
-169	39 33 15	107 48 31	1	5580	7.91	.80	18.0	2.0	380.	100.	0.5	25.1	10.0	1.3	4.8	-1.0	-1.0
-170	39 33 44	107 48 32	1	6040	7.96	.50	15.0	0.4	445.	170.	0.8	21.6	7.8	1.8	3.9	0.4	5.9
-200	39 31 2	107 55 54	1	5880	8.00	.80	25.0	2.0	540.	120.	1.1	15.6	42.5	1.7	4.7	2.1	7.3
-201	39 31 0	107 55 55	1	5880	8.08	.60	29.1	2.3	660.	110.	1.5	15.6	29.0	1.9	3.1	2.8	7.3
-202	39 30 45	107 55 52	1	5780	7.83	.80	52.1	3.3	630.	130.	1.1	14.9	33.0	2.7	4.1	3.0	4.5
-203	39 30 45	107 55 49	1	5740	7.79	1.20	21.7	2.8	500.	120.	1.1	16.5	31.0	2.7	4.9	1.6	4.0
-204	39 30 22	107 55 17	1	5380	8.16	.40	45.4	2.3	610.	140.	1.5	12.5	28.0	3.0	5.9	4.6	4.8
-205	39 30 19	107 55 18	1	5440	7.97	.50	25.0	1.8	580.	130.	1.0	13.9	15.0	2.0	3.7	2.7	3.5
-206	39 30 36	107 55 29	1	5540	8.01	.90	20.3	2.0	615.	160.	1.4	24.1	17.5	2.1	3.3	1.8	8.9
-207	39 30 36	107 55 31	1	5560	7.85	1.00	69.6	5.1	520.	120.	1.1	24.4	15.3	2.2	3.3	1.7	3.3
-208	39 31 5	107 52 32	1	5680	7.82	1.30	23.1	2.1	560.	110.	0.8	21.3	11.6	2.7	5.6	-1.0	-1.0
-209	39 31 5	107 52 35	1	5680	7.74	1.20	14.0	1.5	520.	130.	1.4	28.3	8.8	3.2	4.5	-1.0	-1.0
-210	39 31 9	107 52 53	1	5720	7.83	1.20	12.2	3.1	520.	140.	0.8	27.1	18.2	2.7	5.1	-1.0	-1.0
-211	39 31 6	107 52 53	1	5720	7.81	1.20	22.6	2.7	590.	160.	1.4	27.6	11.9	2.4	5.2	-1.0	-1.0
-212	39 31 31	107 52 51	1	5780	7.78	.80	13.8	1.3	680.	180.	1.3	26.3	19.6	4.8	9.6	-1.0	-1.0
-213	39 31 31	107 52 48	1	5780	7.89	.70	12.9	1.1	580.	180.	1.5	22.4	17.2	2.7	4.7	-1.0	-1.0
-214	39 31 47	107 52 52	1	5800	7.91	.70	21.1	2.9	560.	160.	1.3	18.4	15.3	3.1	6.9	-1.0	-1.0
-215	39 31 47	107 52 54	1	5800	7.88	.70	38.1	3.2	363.	115.	1.2	14.3	9.7	3.2	7.6	-1.0	-1.0
-216	39 32 50	107 50 13	1	5920	7.10	1.00	38.0	1.3	420.	115.	0.8	18.1	9.0	1.3	2.7	1.4	5.7
-217	39 32 52	107 50 13	1	5920	7.85	1.50	12.0	1.9	530.	190.	0.6	24.1	17.9	0.9	3.2	1.0	3.8
-218	39 33 15	107 49 38	1	5880	7.79	1.00	18.2	1.3	360.	100.	0.4	18.5	5.2	0.8	4.7	0.6	6.2

GRID AND ADV DATA - SOILS AND PLANTS

LOC	LATITUDE D M S	LONGITUDE D M S	ROCK UNIT	ELEV	SOIL PH	SOIL OC	SOIL HC	SOIL MO	SOIL F	SOIL B	SAGE MO	SAGE R	SAGE F	RICEGRASS MO	RICEGRASS B	WHEATGRASS MO	WHEATGRASS B
-219	39 33 13	107 49 38	1	5920	7.81	2.10	44.6	2.5	400.	140.	0.7	24.3	8.5	1.0	2.5	0.6	3.7
-220	39 33 45	107 50 7	1	6020	7.90	.30	17.8	1.6	675.	180.	1.0	13.1	17.7	0.8	3.7	1.6	4.7
-221	39 33 47	107 50 8	1	5980	7.88	1.10	21.5	1.7	500.	160.	0.6	20.8	20.0	1.0	5.8	0.6	4.5
-222	39 33 40	107 49 42	1	5900	7.81	.60	24.6	1.5	490.	150.	0.8	22.4	8.7	2.1	9.3	1.6	30.0
-223	39 33 42	107 49 42	1	5900	8.12	.30	12.3	2.9	720.	180.	0.8	21.9	11.9	1.6	5.2	0.9	4.4
-224	39 31 10	107 58 28	4	8680	6.58	2.30	16.1	1.4	340.	160.	0.4	32.5	4.4	0.7	6.5	0.7	4.7
-225	39 31 10	107 58 31	4	8720	6.94	1.40	17.2	0.8	320.	170.	0.5	24.5	3.3	0.9	4.3	0.8	6.3
-226	39 31 14	107 58 10	4	8560	7.60	3.00	20.6	3.0	970.	190.	0.4	26.4	4.7	0.9	4.3	0.9	3.5
-227	39 31 14	107 58 8	4	8520	6.79	3.50	18.9	2.4	630.	200.	0.4	35.2	3.8	1.2	6.8	1.1	6.0
-228	39 31 13	107 57 52	4	8520	7.69	3.00	34.3	4.0	550.	170.	0.6	25.1	5.4	2.1	6.1	0.4	3.2
-229	39 31 15	107 57 50	4	8520	7.13	2.60	19.9	4.2	460.	200.	0.6	34.5	4.4	1.3	4.7	1.3	6.4
-230	39 31 25	107 57 49	4	8620	7.65	2.50	25.5	1.6	940.	150.	0.7	26.4	2.5	0.6	4.8	0.8	5.7
-231	39 31 27	107 57 49	4	8560	7.24	2.80	29.9	2.5	630.	195.	0.4	27.3	3.3	0.9	5.5	0.6	4.9

SEDIMENT DATA

LOC	LATITUDE			LONGITUDE			ROCK		PH	OC	HG	MO	F	B
	D	M	S	D	M	S	UNIT	ELEV						
A01	39	29	47	107	56	41	1	5180	8.54	.04	192.0	4.3	420.	95.
A02	39	29	47	107	57	2	1	5240	8.51	.07	42.0	4.4	530.	130.
A03	39	29	55	107	57	16	1	5320	8.40	.06	41.0	3.4	500.	120.
A04	39	29	51	107	57	27	1	5340	8.11	.49	42.0	4.4	570.	110.
A05	39	30	1	107	57	45	1	5500	8.16	.85	112.0	4.2	760.	160.
A06	39	30	13	107	57	59	1	5600	8.10	.62	26.0	3.2	660.	130.
A07	39	30	26	107	57	48	1	5720	7.87	.99	47.0	3.7	730.	160.
A08	39	30	50	107	58	2	2	6680	8.08	1.95	27.0	3.4	860.	140.
A09	39	29	40	107	57	13	1	5240	8.23	.57	43.0	3.4	530.	100.
A10	39	29	22	107	57	23	1	5140	8.27	.44	29.0	3.7	440.	50.
B01	39	30	5	107	56	31	1	5260	8.30	.21	27.0	3.2	420.	80.
B02	39	30	27	107	56	37	1	5350	7.86	.23	38.0	3.4	550.	70.
B03	39	30	47	107	56	36	1	5720	7.93	.51	39.0	3.1	580.	80.
B04	39	31	6	107	56	40	1	5920	8.15	.65	24.0	2.8	580.	80.
B05	39	31	32	107	56	42	1	6400	8.04	.71	32.0	2.7	520.	40.
B06	39	29	49	107	56	13	1	5150	8.28	.12	40.0	2.6	360.	40.
C01	39	29	48	107	55	12	1	5160	8.18	.36	24.0	3.1	330.	50.
C02	39	29	59	107	55	7	1	5220	8.59	.13	26.0	3.2	420.	70.
C03	39	30	15	107	55	32	1	5400	8.05	.80	20.0	3.4	720.	70.
C04	39	30	18	107	55	28	1	5400	8.61	.13	25.0	3.8	430.	80.
C05	39	30	3	107	55	4	1	5240	8.25	.90	45.0	3.8	460.	40.
C06	39	30	18	107	55	4	1	5300	8.63	.10	30.0	2.8	400.	50.
C07	39	30	34	107	55	20	1	5480	8.17	.09	36.0	2.6	320.	40.
C08	39	30	24	107	54	49	1	5360	8.35	.70	28.0	2.6	460.	60.
C09	39	30	41	107	55	4	1	5500	8.12	1.07	48.0	4.0	560.	75.
C10	39	31	2	107	55	32	1	5700	7.98	1.38	51.0	4.2	580.	50.
C11	39	31	31	107	55	50	1	5880	8.18	1.56	38.0	3.8	360.	70.

SEDIMENT DATA

LOC	LATITUDE			LONGITUDE			ROCK		PH	OC	HG	MO	F	B
	D	M	S	D	M	S	UNIT	ELEV						
C12	39	31	52	107	56	4	1	6220	8.30	.87	46.0	2.5	480.	50.
D01	39	30	6	107	54	2	1	5200	8.15	.09	25.0	2.0	320.	30.
D02	39	30	18	107	54	2	1	5260	8.00	.34	29.0	1.9	320.	40.
D03	39	30	34	107	54	3	1	5320	8.01	.58	38.0	3.4	390.	120.
D04	39	30	58	107	54	8	1	5420	8.01	.44	52.0	2.9	260.	60.
D05	39	31	23	107	54	0	1	5560	8.05	.65	39.0	2.5	380.	50.
D06	39	31	44	107	53	48	1	5680	8.00	.49	35.0	2.9	380.	60.
D07	39	32	0	107	53	52	1	5780	8.00	.16	30.0	2.3	230.	10.
D08	39	32	10	107	54	13	1	5880	8.05	.36	24.0	2.7	390.	20.
D09	39	32	17	107	54	40	1	6100	8.52	.12	30.0	3.3	400.	70.
D10	39	32	33	107	55	2	2	6800	7.93	1.16	20.0	2.2	570.	160.
D11	39	32	20	107	54	10	1	5920	7.87	.67	48.0	2.9	640.	70.
D12	39	32	40	107	54	16	1	6100	8.10	.45	42.0	3.2	320.	80.
D13	39	32	56	107	54	29	1	6280	8.04	1.27	54.0	2.3	680.	120.
D14	39	32	57	107	54	17	1	6320	8.23	.55	64.0	2.8	420.	40.
D15	39	31	20	107	53	27	1	5480	8.43	.13	36.0	3.5	440.	60.
D16	39	31	0	107	53	18	1	5420	8.79	.09	23.0	2.7	310.	35.
D17	39	30	26	107	53	28	1	5300	8.57	.23	23.0	2.8	340.	30.
D18	39	30	50	107	52	12	1	5300	8.23	.12	24.0	4.3	460.	170.
D19	39	31	7	107	51	47	1	5340	8.42	.49	16.0	4.9	640.	90.
D20	39	31	13	107	51	37	1	5320	8.03	.24	29.0	2.7	420.	140.
E01	39	30	39	107	54	17	1	5360	8.01	.45	46.0	3.0	310.	80.
E02	39	31	0	107	54	41	1	5520	7.93	.40	54.0	2.9	280.	60.
E03	39	31	16	107	55	4	1	5680	8.62	.82	56.0	4.1	900.	100.
E04	39	31	37	107	55	18	1	5880	8.38	.55	28.0	3.2	460.	70.
E05	39	32	1	107	55	20	1	6080	8.13	.66	38.0	3.2	460.	90.
E06	39	32	22	107	55	29	1	6480	8.07	.63	32.0	2.5	500.	120.

SEDIMENT DATA

LOC	LATITUDE			LONGITUDE			ROCK	ELEV	PH	OC	HG	MO	F	B
	D	M	S	D	M	S	UNIT							
F01	39	30	55	107	51	2	0	5240	8.32	.08	38.0	3.2	300.	60.
F02	39	31	9	107	51	9	0	5270	8.64	.08	30.0	3.9	220.	50.
F03	39	31	28	107	51	24	1	5340	8.57	.05	28.0	2.2	280.	60.
F04	39	31	45	107	51	42	1	5380	8.50	.08	34.0	3.8	300.	90.
F05	39	31	55	107	52	6	1	5460	8.28	.06	39.0	4.1	310.	40.
F06	39	32	1	107	52	25	1	5520	8.56	.01	40.0	2.6	340.	65.
G01	39	31	3	107	50	36	0	5260	8.23	.53	55.0	3.9	370.	20.
G02	39	31	31	107	50	42	1	5350	8.15	.78	36.0	3.5	480.	70.
G03	39	31	51	107	51	1	1	5420	8.13	.71	52.0	3.8	480.	40.
G04	39	32	7	107	51	22	1	5500	8.53	.06	38.0	4.7	320.	70.
G05	39	32	15	107	51	47	1	5580	9.02	.03	30.0	4.1	270.	20.
G06	39	32	17	107	52	9	1	5640	8.38	.05	40.0	3.8	290.	50.
G07	39	32	22	107	52	28	1	5740	8.51	.04	31.0	2.7	300.	120.
G08	39	32	42	107	52	45	1	6080	8.10	.07	29.0	2.9	320.	40.
G09	39	32	53	107	53	20	1	6280	8.05	.10	20.0	3.4	300.	40.
G10	39	33	15	107	53	41	2	6800	8.01	.27	35.0	2.3	460.	100.
H01	39	32	8	107	51	16	1	5500	8.28	.61	47.0	2.8	390.	60.
H02	39	32	33	107	51	26	1	5640	8.18	.31	51.0	2.3	380.	100.
H03	39	32	57	107	51	32	1	5760	8.24	.47	35.0	3.1	400.	40.
H04	39	33	8	107	51	50	1	5860	8.25	.33	54.0	2.4	480.	10.
H05	39	33	24	107	52	17	1	6070	8.22	.40	41.0	2.9	630.	190.
H06	39	33	34	107	52	48	1	6320	8.11	.53	27.0	2.6	500.	70.
H07	39	33	39	107	53	10	2	6640	8.09	2.29	35.0	4.2	980.	135.
H08	39	33	50	107	53	18	2	6760	7.97	1.27	25.0	3.2	740.	150.
I01	39	31	32	107	49	42	1	5270	8.66	.08	30.0	3.7	320.	30.
I02	39	31	57	107	49	44	1	5320	8.93	.02	25.0	7.6	320.	50.
I03	39	32	15	107	50	14	1	5390	8.39	.06	25.0	3.2	370.	110.

SEDIMENT DATA

LOC	LATITUDE			LONGITUDE			ROCK UNIT	ELEV	PH	OC	HG	MO	F	B
	D	M	S	D	M	S								
I04	39	32	33	107	50	27	1	5460	8.40	.02	25.0	3.1	570.	75.
I05	39	32	45	107	50	43	1	5520	8.44	.08	27.0	3.4	400.	120.
J01	39	31	50	107	48	52	1	5340	8.16	.16	28.0	3.4	400.	60.
J02	39	32	6	107	49	13	1	5440	8.24	.16	31.0	3.1	470.	90.
J03	39	32	23	107	49	32	1	5580	8.25	.08	18.0	3.1	340.	20.
J04	39	32	37	107	49	56	1	5700	8.18	.14	12.0	4.1	440.	110.
K01	39	32	29	107	48	26	1	5460	8.62	.09	113.0	4.1	300.	7.
K02	39	32	28	107	48	53	1	5540	8.11	.21	22.0	3.1	360.	40.
K03	39	32	37	107	49	22	1	5620	8.25	.15	18.0	2.3	280.	10.
K04	39	31	59	107	49	49	1	5760	7.98	.24	37.0	2.1	500.	60.
L01	39	33	42	107	48	58	1	5660	8.10	.94	22.0	2.7	460.	40.
L02	39	33	32	107	49	27	1	5760	8.06	.60	26.0	2.2	360.	80.
L03	39	33	31	107	49	45	1	5820	8.10	.30	30.0	2.3	320.	65.
L04	39	33	38	107	50	25	1	5980	8.08	.56	38.0	2.0	410.	50.
L05	39	33	32	107	50	55	1	6140	8.35	.35	28.0	1.8	320.	40.
L06	39	33	37	107	51	21	1	6240	8.13	.68	26.0	2.2	410.	10.
L07	39	33	50	107	51	53	1	6420	8.43	.45	39.0	2.0	400.	90.
L08	39	33	59	107	52	20	1	6600	8.24	.59	36.0	2.3	520.	50.
L09	39	34	18	107	52	43	2	6840	8.15	.49	25.0	1.8	480.	100.
M01	39	32	18	107	47	10	1	5340	8.48	.41	51.0	2.2	240.	7.
M02	39	32	31	107	47	8	1	5380	8.20	.64	59.0	3.1	410.	7.
M03	39	32	40	107	47	34	1	5420	7.74	1.63	114.0	2.3	430.	20.
M04	39	32	43	107	47	31	1	5420	8.48	.72	35.0	4.1	380.	7.
M05	39	33	5	107	47	50	1	5480	8.36	.50	38.0	4.1	320.	7.
M06	39	33	10	107	48	11	1	5520	8.22	.80	39.0	3.7	280.	7.
M07	39	33	24	107	48	38	1	5580	8.94	.29	25.0	4.0	280.	7.
M08	39	33	45	107	48	53	1	5640	9.36	.05	27.0	2.6	200.	7.

SEDIMENT DATA

LOC	LATITUDE			LONGITUDE			ROCK		PH	OC	HG	MO	F	B
	D	M	S	D	M	S	UNIT	ELEV						
M09	39	33	57	107	49	19	1	5680	9.01	.01	40.0	4.1	180.	7.
M10	39	34	10	107	49	36	1	5720	9.10	.08	68.0	3.1	230.	30.
M11	39	34	24	107	49	54	1	5780	9.12	.06	79.0	2.0	200.	7.
M12	39	33	59	107	49	12	1	5680	8.29	.07	30.0	2.5	340.	30.
M13	39	34	17	107	49	1	1	5720	8.57	.08	32.0	1.9	250.	50.
M14	39	34	31	107	49	8	1	5790	8.56	.09	37.0	2.5	380.	30.
N01	39	31	38	107	59	18	2	6880	8.07	2.93	43.0	4.1	760.	110.
N02	39	31	41	107	59	20	2	6880	8.25	2.87	35.0	4.0	810.	90.
N03	39	31	29	107	59	31	1	6600	8.25	3.32	34.0	4.1	820.	160.
N04	39	30	53	108	0	6	1	5980	8.47	1.51	29.0	3.5	680.	70.
N05	39	30	40	108	0	18	1	5840	8.22	1.69	32.0	2.8	700.	60.
N06	39	30	1	108	0	22	1	5600	8.17	1.21	26.0	2.6	540.	60.
N07	39	29	42	108	0	8	1	5180	8.37	1.24	42.0	3.3	630.	50.
N08	39	28	43	107	59	13	1	5500	7.99	.49	19.0	2.6	400.	40.
P01	39	33	19	107	58	42	2	7920	8.22	3.55	84.0	3.8	930.	145.
P02	39	33	10	107	58	13	3	8000	7.88	4.43	93.0	20.0	800.	150.
P03	39	33	4	107	57	42	3	8120	7.86	4.63	102.0	3.4	770.	187.
P04	39	32	52	107	57	8	3	8260	7.90	4.06	40.0	22.0	850.	190.
P05	39	32	50	107	57	13	3	8280	7.99	1.60	41.0	3.2	440.	280.
P06	39	32	25	107	57	22	4	8620	7.62	6.18	94.0	3.8	830.	180.
P07	39	32	45	107	56	45	3	8360	8.24	3.56	91.0	5.8	720.	150.
R01	39	33	22	107	58	43	2	7920	8.12	3.22	41.0	3.2	800.	160.
R02	39	33	24	107	58	42	2	7920	8.00	1.97	45.0	2.6	380.	170.
R03	39	33	31	107	58	25	2	7960	8.14	1.12	61.0	1.9	430.	215.
R04	39	33	34	107	58	10	3	8000	7.88	2.50	55.0	2.6	480.	140.
R05	39	33	33	107	58	2	2	7980	8.02	3.66	69.0	3.1	870.	220.
R06	39	33	41	107	57	36	3	8050	7.94	3.35	145.0	3.1	780.	310.

SEDIMENT DATA

LOC	LATITUDE			LONGITUDE			ROCK UNIT	ELEV	PH	OC	HG	MO	F	B
	D	M	S	D	M	S								
R07	39	33	57	107	57	9	3	8200	8.00	1.79	48.0	4.3	580.	260.
R08	39	33	57	107	57	4	3	8160	8.04	3.86	72.0	4.2	890.	230.
R09	39	34	29	107	56	29	3	8280	8.18	1.55	77.0	2.6	530.	260.
R10	39	34	29	107	56	24	3	8280	7.92	3.17	347.0	3.1	800.	250.
R11	39	34	43	107	55	55	3	8340	8.12	3.40	468.0	2.6	720.	200.
R12	39	34	44	107	55	49	3	8340	7.96	3.46	84.0	3.6	920.	240.
R13	39	34	56	107	55	22	3	8380	7.96	3.71	48.0	2.5	680.	240.
R14	39	34	59	107	55	17	4	8420	7.99	3.65	69.0	2.6	640.	240.
R15	39	34	10	107	54	54	4	8500	8.07	2.69	25.0	3.3	740.	250.
R16	39	34	32	107	54	33	4	8640	8.03	1.96	79.0	4.3	810.	110.
R17	39	34	43	107	54	4	4	8840	7.79	2.15	91.0	4.8	680.	220.
R18	39	34	9	107	56	50	3	8200	7.99	2.84	92.0	4.7	900.	190.
S01	39	34	4	107	56	50	3	8200	8.04	3.57	58.0	4.5	940.	180.
S02	39	33	57	107	56	21	3	8360	8.02	3.28	125.0	11.2	920.	300.
S03	39	33	54	107	55	50	3	8520	7.96	5.01	63.0	4.7	940.	165.
S04	39	33	54	107	55	24	4	8680	7.78	5.66	90.0	3.9	760.	210.
S05	39	33	49	107	55	4	4	8840	7.82	2.50	72.0	4.5	610.	200.
T01	39	34	50	107	54	29	4	8500	7.80	5.15	83.0	3.4	800.	170.
T02	39	35	6	107	54	55	4	8640	7.88	3.48	88.0	3.9	900.	210.
U01	39	31	45	107	58	2	4	8440	7.77	3.62	93.0	1.5	470.	190.
U02	39	31	36	107	58	26	3	8280	8.03	1.95	138.0	3.4	460.	190.
U03	39	31	34	107	58	25	3	8280	7.66	5.09	50.0	2.3	470.	160.
U04	39	31	34	107	58	38	3	8220	8.04	3.54	74.0	2.7	460.	120.
U05	39	31	58	107	58	52	3	8200	7.83	2.61	63.0	5.1	580.	240.
U06	39	32	7	107	58	26	3	8360	7.73	2.59	101.0	6.0	520.	12.
U07	39	32	16	107	57	58	4	8500	7.87	.72	69.0	1.1	520.	210.

Appendix 3

Analytical Replications - Soils

pH

Sample #	Sample #	Sample #
15 - 6.78/6.79	90- 7.99/8.01	204- 8.20/8.12
43 - 7.06/7.07	103- 7.80/7.81	206- 7.96/7.99/8.09
44 - 6.28/6.24	113- 7.88/7.80	209- 7.81/7.68
56 - 7.80/7.86	122- 8.05/8.07	216- 7.10/7.11
60 - 7.77/7.86	127- 7.84/7.82	219- 7.80/7.82
68 - 7.93/7.92	140- 7.90/7.98	227- 6.78/6.80
75 - 8.04/7.92	162- 7.92/7.92	230- 7.71/7.69/7.55
82 - 7.96/7.90	164- 8.01/8.02	

Organic Carbon

Sample #
200- .77/.80
206- .93/.94
222- .61/.62
227- 3.45/3.49

Hg

Sample #	Sample #	Sample #
1- 50.1/43.1	84- 22.0/19.9	201- 28.6/29.6
8- 23.6/21.4	86- 78.8/93.1	202- 44.6/59.6
15- 35.9/56.6	94- 15.1/15.9	203- 20.6/22.8
21- 46.3/25.8/23.8	104- 15.4/17.2	206- 19.8/20.7
24- 19.9/18.1	109- 26.2/30.5	208- 25.0/21.1
29- 63.6/62.2	128- 38.9/38.3	212- 13.1/14.6
32- 36.3/48.6	131- 29.9/29.3	215- 39.2/36.9
29- 23.7/19.2	135- 19.1/18.2	216- 11.7/12.2
42- 41.2/59.6	137- 37.1/96.8	217- 21.4/21.6
53- 22.0/20.7	141- 17.5/18.1	219- 44.5/43.6/45.6
59- 46.6/59.1	143- 22.1/19.7	221- 22.4/20.5
63- 41.9/41.6	144- 18.4/20.8	
69- 29.7/27.9	154- 21.6/22.7	
75- 51.3/69.3	165- 110.5/108.0	

Mo

Sample #	Sample #	Sample #
15- 1.3/1.3	148- 1.0/1.1	212- 1.6/1.3
27- 4.7/5.5	154- 1.5/1.6	214- 3.1/2.9
30- 1.6/1.6	170- .4/.5	215- 3.5/3.2
57- 2.6/2.6	200- 2.0/2.0	218- 1.6/1.3
98- 1.3/1.3	205- 2.1/1.8	222- 1.8/1.5
129- 1.6/1.6	207- 5.9/5.1	226- 2.5/3.0

B

Sample #	Sample #	Sample #
2- 160/180	141- 180/110	170- 140/200
6- 160/160	148- 200/150	204- 120/160
27- 230/170	152- 140/100	212- 200/160
28- 170/130	154- 270/300	215- 120/110
41- 160/150	156- 180/130	220- 150/220/
62- 200.150	159- 130/100	200/160
71- 230/190	165- 130/100	226- 200/200/
129- 220/170	178- 100/80	190/170
		231- 180/210

F

Sample #	Sample #	Sample #
15- 420/440	148- 420/420	206- 610/620
30- 540/610	154- 460/520	215- 390/360/340
57- 440/480	170- 450/440	220- 670/680
98- 540/620	201- 660/660	226- 960/980
129- 300/380	204- 620/600	

Analytical Replications - Sage

Mo

Sample #
202- 1.1/.8
204- 1.5/1.4
209- 1.4/1.4
213- 1.5/1.4
226- .4/.4

B

Sample #	Sample #	Sample #
1- 24.8/24.1	204- 12.5/14.3	213- 22.4/23.2
5- 20.2/20.3	209- 28.3/31.2	226- 26.4/30.7
202- 14.8/13.9		

F

Sample #	Sample #	Sample #
13- 2.0/2.3	117- 9.7/13.	200- 45./40.
19- 10./11./11.	120- 12./17.	202- 33. 58.
43- 7.1/5.5/5.3	122- 19./26./22.	204- 28./39.
58- 47./50./49.	123- 49./53./44.	209- 8.8/6.0
83- 5.1/4.4/4.3	127- 3.3/2.4	212- 19./20.
95- 31./30./32.	135- 3.9/3.2	213- 17./18.
106- 7.0/7.7/7.3	141- 9.1/7.6/6.4	226- 4.7/2.2

Mo

Sample #
219- 1.0/.9
221- .9/1.1
224- .7/.7
226- .9/.8
230- .6/.7
231- .9/.8

B

Sample #	Sample #	Sample #
1- 6.5/5.8	13- 4.9/5.0	221- 5.7/5.8
2- 4.7/4.7	18- 5.3/5.1	224- 6.9/6.0
8- 6.0/6.0	19- 7.4/7.3	226- 5.7/4.8
9- 4.5/4.5	57- 16.4/16.0	227- 6.9/6.7
10- 8.0/8.0	206- 3.1/3.4	230- 4.5/5.1
11- 5.6/5.7	212- 9.6/9.7	231- 6.3/4.7
12- 4.5/4.5	2190 2.9/2.2	

Analytical Replications - Wheatgrass

Mo

Sample #
 202- 2.8/3.1
 204- 4.6/4.5
 206- 1.9/1.7
 212- 1.0/.9

B

Sample #	Sample #	Sample #
1- 3.8/4.6	16- 4.7/5.3	28- 3.1/3.7
5- 4.1/4.6	17- 6.8/7.5	29- 6.0/6.5
6- 6.8/7.2	18- 6.2/6.4	202- 4.8/4.1
8- 6.3/7.4	23- 6.2/6.4	204- 5.0/4.5
9- 6.3/6.8	24- 8.2/8.6	206- 9.1/8.6
10- 5.7/5.9	26- 6.9/6.4	212- 3.9/3.7
14- 5.5/5.2/6.4	27- 5.6/5.9	222- 28.7/31.0

Analytical Replications - Sediments

pH

Sample #	Sample #	Sample #
A05- 8.13/8.19	G06- 8.39/8.36	L08- 8.22/8.27
C10- 7.98/7.99	K02- 8.12/8.10	M11- 9.14/9.11
D05- 7.99/8.10	L03- 8.08/8.11	N01- 8.08/8.06
E04- 8.42/8.34	L06- 8.15/8.12	N02- 8.29/8.22

OC

Sample #	Sample #
C07- .10/.08	M09- .01/.002
D04- .43/.46	R05- 4.18/3.24
G04- .07/.05	R10- 3.25/3.10
M07- .28/.30	

Hg

Sample #	Sample #	Sample #
A01- 190.0/194.2	I04- 24./25./396.	R11- 370.0/566.0
C09- 44.7/51.5	K01- 112./114.	R12- 66.8/100.5
D15- 44.0/27.0	M03- 125./104.	S02- 126.8/122.4
D20- 29.0/30.0	P03- 74.1/130.1	U02- 120.3/155.0
E02- 53.2/55.3	R06- 145.3/144.6	U06- 92.5/108.8
G05- 32.0/29.0/123.	R10- 322.2/372.6	

Mo

Sample #	Sample #	Sample #
A01- 4.2/4.5	P01- 3.8/3.19	R16- 4.3/4.3
C09- 3.4/4.7	P03- 3.3/3.6	S03- 4.7/4.7
G06- 4.0/3.7	P06- 3.5/4.1	S05- 4.4/4.6
I09- 2.8/3.4/3.1		

B

Sample #	Sample #	Sample #
A01- 90/100	H07- 110/160	P06- 200/230/140/150
A10- 40.60	H08- 160/140	R01- 140/180
C07- 30-50	I04- 100/50	R03- 200/203
C09- 70/8	K01- 7/7	R13- 230/250
D16- 7/30	L03- 70/60	R16- 90/130
D20- 140/140	L04- 60/40	S03- 170/160
F06- 70/60	N04- 70/70	S04- 210/210
G06- 70/30	P01- 180/110	S05- 280/120
G10- 110/90	P03- 210/180/170	T02- 210/210

F

Sample #	Sample #	Sample #
A01- 440/400	I04- 770/370	P03- 740/800
B06- 380/340	K04- 500/500	P06- 780/880
C09- 520/600	L01- 470/450	R16- 780/840
D08- 360/420	L02- 370/340	S03- 960/920
G05- 280/260	P01- 940/920	S05- 640/580
G06- 310/270		

