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GEOLOGY

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HYDROGEOCHEMICAL AND STREAM SEDIMENT DETAILED GEOCHEMICAL SURVEY FOR THOMAS RANGE-WASATCH, UTAH

COTTONWOOD PROJECT AREA

T. R. Butz, C. S. Bard, D. A. Witt,
R. N. Helgerson, J. G. Grimes, and P. M. Pritz
Uranium Resource Evaluation Project

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Uranium Resource Evaluation Project

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Oak Ridge, Tennessee

Prepared for the U. S. Department of Energy
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ABSTRACT

Results of the Cottonwood project area of the Thomas Range-Wasatch detailed geochemical survey are reported. Field and laboratory data are presented for 15 groundwater samples, 79 stream sediment samples, and 85 radiometric readings. Statistical and areal distributions of uranium and possible uranium-related variables are given. A generalized geologic map of the project area is provided, and pertinent geologic factors which may be of significance in evaluating the potential for uranium mineralization are briefly discussed.

Uranium concentrations in groundwater range from 0.25 to 3.89 ppb. The highest concentrations are from groundwaters from the Little Cottonwood and Ferguson Stocks. Variables that appear to be associated with uranium in groundwater include cobalt, iron, potassium, manganese, nickel, sulfate, and to a lesser extent, molybdenum and strontium. This association is attributed to the Monzonitic Little Cottonwood Stock, granodioritic to granitic and lamprophyric dikes, and known sulfide deposits.

Soluble uranium concentrations (U-FL) in stream sediments range from 0.31 to 72.64 ppm. Total uranium concentrations (U-NT) range from 1.80 to 75.20 ppm. Thorium concentrations range from <2 to 48 ppm. Anomalous values for uranium and thorium are concentrated within the area of outcrop of the Little Cottonwood and Ferguson Stocks. Variables which are areally associated with high values of uranium, thorium, and the U-FL:U-NT ratio within the Little Cottonwood Stock are barium, copper, molybdenum, and zinc. High concentrations of these variables are located near sulfide deposits within the Little Cottonwood Stock.

HYDROGEOCHEMICAL AND STREAM SEDIMENT DETAILED GEOCHEMICAL SURVEY FOR THE COTTONWOOD PROJECT AREA OF THOMAS RANGE-WASATCH, UTAH

INTRODUCTION

The National Uranium Resource Evaluation (NURE) Program was established by the U. S. Atomic Energy Commission, now the U. S. Department of Energy (DOE), in the spring of 1973 to assess uranium resources and to identify favorable areas for detailed uranium exploration throughout the United States. The principal objectives of the NURE Program are: (1) to provide a comprehensive in-depth assessment of the nation's uranium resources for national energy planning, and (2) to identify areas favorable for uranium resources. A NURE Program report covering uranium resource assessment in 116 National Topographic Map Series (NTMS) 1° x 2° quadrangles, which contain 100% of the currently estimated uranium resources, is targeted for 1980. The complete resource assessment of the 272 highest-priority quadrangles is scheduled for completion in 1985, and the first comprehensive assessment report of the entire United States is scheduled for completion in 1988. This program, which is being administered by DOE, is expected to increase the activity of commercial exploration for uranium in the United States.

The NURE Program consists of five parts:

1. Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program,
2. Aerial Radiometric and Magnetic Survey,
3. Surface Geologic Investigations,
4. Drilling for Geologic Information, and
5. Geophysical Technology Development.

The objective of the HSSR Program is to provide information to be used in accomplishing the overall NURE Program objectives. This is accomplished by a reconnaissance of surface water, groundwater, stream sediment, and lake sediment. The survey is being conducted by three Government-owned laboratories. Union Carbide Corporation, Nuclear Division (UCC-ND), under contract with DOE, is conducting its survey in 154 NTMS 1° x 2° quadrangles which cover approximately 2,500,000 km^2 (1,000,000 mi^2) of the Central United States. This area includes most of the states of Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Minnesota, Wisconsin, Michigan, Indiana, Illinois, and Iowa, as well as parts of Arkansas, Missouri, New Mexico, and Ohio.

As a part of the HSSR Program, detailed geochemical surveys were initiated in the fall of 1978 to supply comprehensive detailed geochemical data from specific areas. These surveys are designed to characterize the hydrogeochemistry, stream sediment geochemistry, and/or radiometric patterns of known or potential uranium occurrences. The information can be used to interpret data from the 1° x 2° NTMS quadrangle basic data surveys. This report on the Cottonwood project area represents the third volume of geochemical data which describe three select areas in the Thomas Range-Wasatch region, Utah (Figure 1).

LOCATION AND PHYSIOGRAPHY

The Cottonwood project area covers approximately 260 km^2 (100 mi^2) of surface area between lat. 40°30'30" to 40°41'00" N. and long. 111°38'00" to 111°50'00" W. The area sampled includes parts of Sugar House, Mount Aire, Draper, and Dromedary Peak 7-1/2-minute Quadrangles in southeastern Salt Lake and northern Utah Counties, Utah (Figure 2).

The Cottonwood project area includes Big and Little Cottonwood Canyons which extend eastward from Salt Lake Valley, on the western boundary at an elevation of approximately 1,400 m (4,500 ft) to approximately 2,300 m (7,600 ft) and 2,600 m (8,600 ft) in Big and Little Cottonwood Canyons, respectively, on the eastern boundary of the project area. The southern boundary of the project area is a ridge, which forms the county line between Utah and Salt Lake Counties and averages over 3,350 m (11,000 ft) in elevation. The ridge dividing Big and Little Cottonwood Canyons also averages an elevation of over 3,350 m (11,000 ft) while the elevation of the divide between Big Cottonwood and Neffs Canyons at the northern boundary of the project area averages between 2,950 m (9,700 ft) and 3,050 m (10,000 ft).

A geomorphic difference exists between Big and Little Cottonwood Canyons. Little Cottonwood Canyon is a broad, straight, U-shaped valley which has been glaciated with many of the tributary streams flowing from hanging valleys along its entire length. In contrast, Big Cottonwood Canyon is narrow with a v-shaped valley in its lower reaches. Only the head of the canyon was occupied by glaciers.

The Cottonwood project area lies at the junction of four major physiographic provinces. To the west of the Wasatch Front is the Basin and Range Province. To the east are the Uinta Mountains which separate the Wyoming Basin to the north from the Colorado Plateau to the south.

CLIMATE

The Thomas Range-Wasatch detailed geochemical survey area is located in two climatological regions. The Thomas Range-Sheeprock Mountain project area is located in the north central region of Utah, a region which includes the Great Salt Lake and is typified by Basin and Range topography. The mean annual temperature of this region is 10°C (50°F) and varies from -3°C (26.6°F) in January to 22.8°C (73.0°F) in August. The annual precipitation is 38.71 cm (15.24 in.) which occurs predominantly as snowfall during the winter and early spring months. The Cottonwood

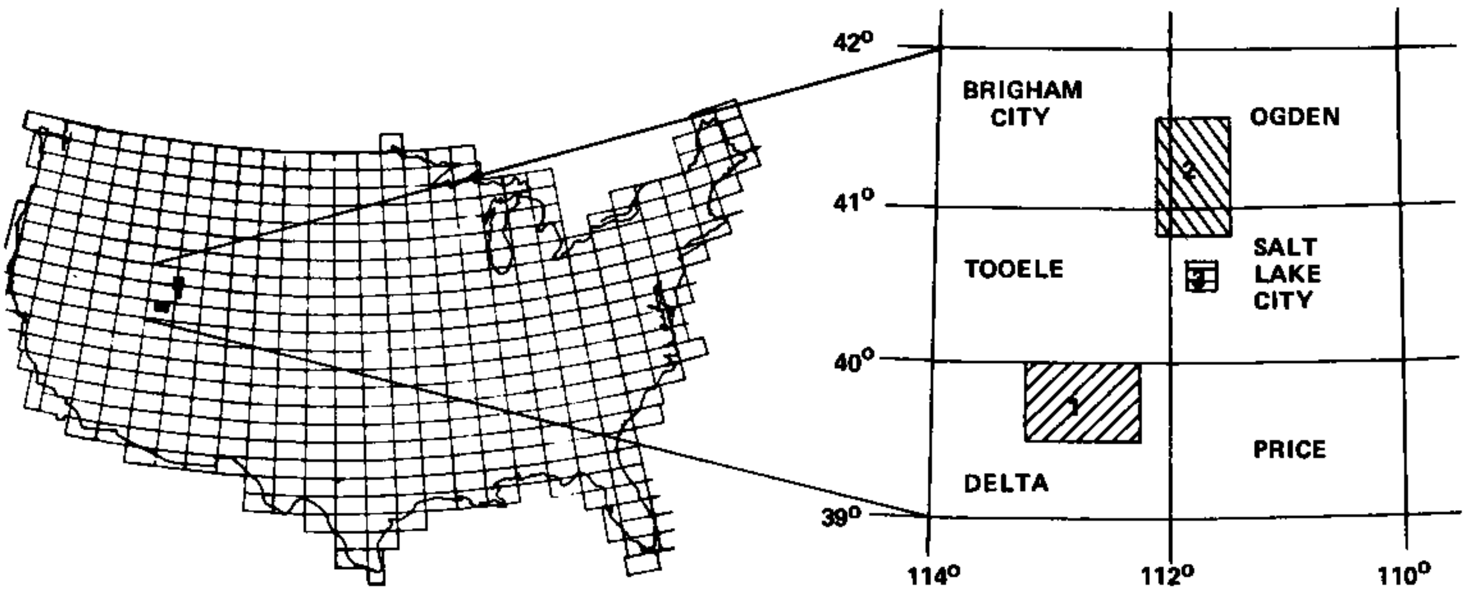

Figure 1

INDEX MAP SHOWING THE MAP BOUNDARIES OF THE COTTONWOOD PROJECT AREA,(3)
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

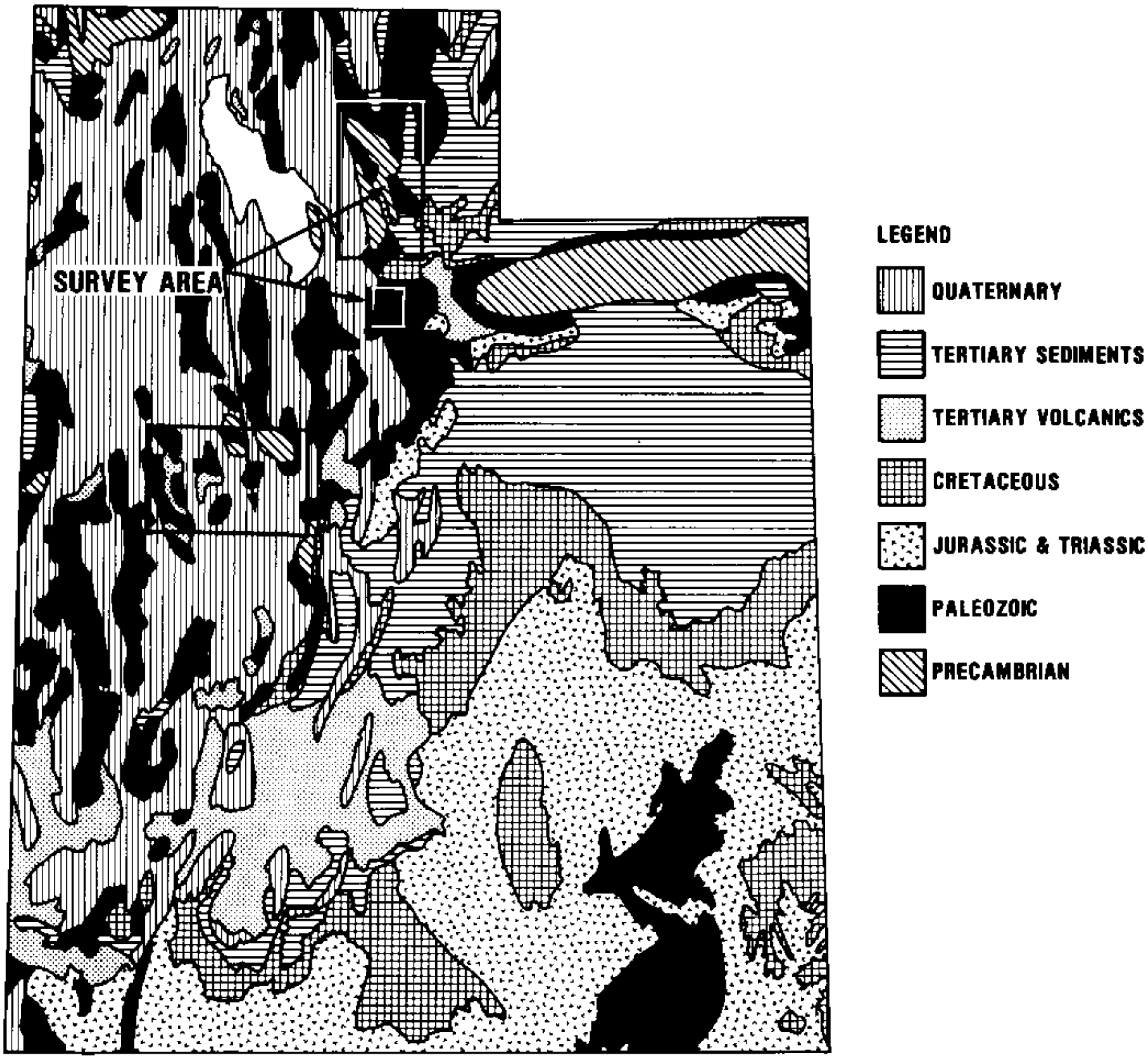

Figure 2

GENERALIZED GEOLOGIC MAP OF UTAH WITH LOCATION
OF THE THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH
(AFTER KING, ET AL, 1974)

and Farmington project areas lie within the northern mountains climatological region which includes the Wasatch and Uinta Mountain Ranges. The mean annual temperature of this region is 5.7°C (42.3°F) and varies from -6.5°C (20.3°F) in January to 18.3°C (65.0°F) in July. The annual precipitation is 49.07 cm (19.32 in.) which also predominantly occurs as snowfall during the winter and early spring months (National Oceanic and Atmospheric Administration, 1974).

GEOLOGY

STRATIGRAPHY

The oldest stratigraphic unit found in the Cottonwood project area is the Little Willow Formation (XLW) located just north of the mouth of Little Cottonwood Canyon. The formation was originally named the Little Willow series and was described as a sequence of strongly folded gneissic quartzites, quartz-mica schists, and stretched-pebble schists, intruded by basic igneous rocks now altered to amphibolites and chlorite-amphibole schists, (Crittenden, et al, 1952). Recent work has added more detail to the basic description and it has been suggested that, although most of the Little Willow Formation is of sedimentary origin, sericite schist units present may have formed from volcanic ash beds (James, 1979). The age of the Little Willow Formation is uncertain because attempts to date it radiometrically have only produced erroneous 27 to 29 million year ages from the nearby Tertiary intrusives (King, 1976).

The Little Willow Formation has been compared to the Farmington Canyon Complex located approximately 24 km (15 mi) north of the Cottonwood project area. Recent dating of the Farmington Canyon Complex migmatites by rubidium/strontium methods have given Precambrian W ages (Bryant, 1980). The Little Willow Formation is less deformed, is lower in metamorphic grade, contains more abundant rocks of basic igneous origin, and contains no injected granite or pegmatite in contrast to the Farmington Canyon Complex (James, 1979). The U.S. Geological Survey (USGS) has assigned the Little Willow Formation to Precambrian X (Crittenden, et al, 1972).

Unconformably overlying the Little Willow Formation is the Big Cottonwood Formation (YBC) consisting of approximately 4,900 m (16,000 ft) of supracrustal interbedded quartzites and shales. Only slight dynamothermal metamorphism has altered the Big Cottonwood Formation shales to slate and phyllite (James, 1979). The general strike of the Big Cottonwood Formation and all younger strata in the project area is northwesterly in contrast to the northeasterly strike of the underlying Little Willow Formation (Crittenden, 1965a, b, c, and d; James, 1978). Ripple marks, cross bedding and mudflake conglomerates indicating deposition in shallow water are common (King, 1976).

During Precambrian Y (Middle Proterozoic) time, the area now occupied by the Uinta Mountains of northeastern Utah was an east trending embayment branching off of the north-south trending Beltian Geosyncline (Erickson, 1974; Burke and Dewey, 1973). The Cottonwood project area lies at the junction between these two zones. Sediments of the Big Cottonwood Formation represent a deltaic environment at the continental margin and transport was from the east. Equivalent sediments of the Uinta Group east of the project area are lithologically different, the environment of deposition being more fluvial in the Uinta Embayment. Sources of the fluvial sediments were from the north and northeast (Crittenden and Wallace, 1973).

Overlying the irregularly eroded surface of the Big Cottonwood Formation is the Upper Precambrian Y (Upper Proterozoic) Mineral Fork Tillite (YMFT) consisting of a diamictite or massive graywacke with embedded clasts of all sizes up to boulders. It also contains interbedded layers of quartzite and laminated argillite. The clasts are composed of Precambrian crystalline basement rocks. The Mineral Fork Tillite thins and thickens over the eroded Big Cottonwood surface and reaches more than 900 m (3,000 ft) in the Mineral Fork drainage which is a tributary of Big Cottonwood Creek. Sediment of the Mineral Fork Tillite are thin or absent due to erosion along its strike (King, 1976). Several geologists have proposed a glacial origin for this unit (Crittenden, et al, in Marsell, 1952; King, 1976; Condie, 1967; Ojakangas and Matsch, 1976). Subaqueous mudflows and turbidites were suggested as the origin of the Mineral Fork Tillite by Condie. Mudflows and turbidites can be manifestations of a glacial episode. Regional occurrences of Mineral Fork Tillite and correlative diamictites in the eastern Great Basin are known, and a glacial origin for the unit seems likely (Crittenden, et al, 1972).

Unconformably overlying the Mineral Fork Tillite are the red-purple quartzites and red to green shales of the Mutual Formation (ZMI). This unit represents a return of a depositional environment equivalent to that of the Big Cottonwood Formation. Except for the color difference and the intervening tillite, it would be difficult to distinguish between the two formations (Crittenden, et al, 1952).

The basal Lower Cambrian is represented by the Tintic Quartzite (CTQ) which rests with a slight angular unconformity on the underlying Mutual Formation or Mineral Fork Tillite. Basal beds of Tintic Quartzite are composed of up to about 1 m of pebble to small-cobble conglomerate. Above the basal conglomeratic beds, the Tintic Quartzite is composed of white or pinkish, rusty-weathering quartzite. As much as 240 m (800 ft) of Tintic Quartzite is present in the Cottonwood project area (Crittenden, et al, 1952).

The lower olive-green micaceous shale member of the Ophir Formation (COS) interfingers with the uppermost Tintic Quartzite beds. This lower shale of the Ophir Formation is the first unit with identifiable Cambrian fossil fragments. The lower shale is approximately 76 m (250 ft) thick. The middle member is a blue-gray to white limestone showing prominent wavy or crinkly brown laminae and reaches a thickness of about 24 m (80 ft). The upper member of the Ophir Formation is composed of approximately 21 m (70 ft) of yellow-brown weathering limy shale with a characteristic blockly fracture (Crittenden, et al, 1952). For the purposes of this project, the Tintic Quartzite (CTQ) and the Ophir Formation (COS) are shown on the geologic map as one unit (CTQ) (Plate 7 and Figure 3).

The Maxfield Limestone (CML) of Middle Cambrian age is a three-member dolomite to dolomitic limestone which conformably overlies the Ophir Formation. Maximum thickness of the Maxfield Limestone is about 305 m (1,000 ft) although the formation is entirely absent due to erosion in much of the Cottonwood project area (Crittenden, et al, 1952).

Unconformably overlying the Maxfield Limestone or Ophir Formation is a thick carbonate sequence of Mississipian to Pennsylvanian in age. This sequence (PLSU) which incorporates the Cambrian Maxfield Limestone, includes the Mississippian Fitchville Formation, Gardison Limestone, Deseret Limestone, Humbug Formation, and Doughnut Formation, and the Pennsylvanian Round Valley Limestone. This sequence has a combined thickness of approximately 700 m (2,300 ft) and is composed of dolomites and limestones with minor amounts of sandstone, shale, and cherty carbonate. Many of the units are highly fossiliferous (Crittenden, et al, 1952; Crittenden, 1965a, b, c, and d; and James, 1979).

Conformably overlying the Round Valley Limestone is 370 m (1,200 ft) to approximately 460 m (1,500 ft) of Pennsylvanian Weber Quartzite (PWQ) consisting of quartzite and calcareous sandstone which weathers to a pale gray to tan, with some interbedded gray to white limestone and dolomite (James, 1979). The resistant quartzite forms abundant talus which masks the interbedded calcareous zones in the Webster Quartzite making them appear subordinate (Crittenden, et al, 1952).

The Park City Formation (PPC) is an approximate 180 m (600 ft) thick, three-member formation which is conformable with the underlying Weber Quartzite. The lower member which has been assigned a Pennsylvanian age is a breccia of quartzitic sandstone fragments. The middle and upper members are Permian in age. The middle member consists of a limy shale, in part phosphatic, and the upper member consists of gray-weathering fossiliferous and cherty limestone.

Overlying the Park City Formation in the extreme northeastern portion of the project area are minor amounts of Triassic and Jurassic formations. For the purposes of this report, the Triassic formations are undivided and mapped as MTFU because of their very limited exposure in the project area. Triassic units include the Woodside Shale, Thaynes Formation, and Ankareh Formation which are basically "red bed" shales, siltstones, sandstones, and include minor calcareous units. The Woodside Shale and

STRATIGRAPHIC COLUMN FOR THE COTTONWOOD PROJECT AREA

ERA	SYSTEM	SERIES	NURE CODE MAP	NURE CODE FIELD	GEOLOGIC UNIT
CENOZOIC	QUATERNARY		QUD	QAL	ALLUVIUM
				QTL	TALUS, COLLUVIUM, AND LANDSLIDE DEPOSITS
				QPLB	LAKE BONNEVILLE DEPOSITS
				QPGM	GLACIAL MORAINE
	TERTIARY OR CRETACEOUS		TGD	TGD	GRANODIORITIC TO GRANITIC INTRUSIVE DIKES
			TAD	TAD	DIORITES OF ARGENTA INTRUSIVE COMPLEX AND INTERMEDIATE DIKES
			TLD	TLD	LAMPROPHYE INTRUSIVE DIKES
			TQM	TQM	QUARTZ MONZONITE OF LITTLE COTTONWOOD AND FERGUSON CANYON
MESOZOIC	JURASSIC		MJFU	MJFU	JURASSIC UNITS, UNDIVIDED INCLUDES: MORRISON FORMATION PREUSS FORMATION TWIN CREEK LIMESTONE NUGGET SANDSTONE
	TRIASSIC		MTFU	MTFU	TRIASSIC UNITS, UNDIVIDED INCLUDES: ANKAREH FORMATION THAYNES FORMATION WOODSIDE SHALE
PALEOZOIC	PERMIAN		PPC	PPC	PARK CITY FORMATION
	PENNSYLVANIAN	UPPER PENNSYLVANIAN	PWQ	PWQ	WEBER QUARTZITE
		LOWER PENNSYLVANIAN	PLSU	PRV	ROUND VALLEY LIMESTONE
	MISSISSIPPIAN	UPPER MISSISSIPPIAN		MDS	DOUGHNUT FORMATION
				MHF	HUMBUG FORMATION
				MDL	DESERET LIMESTONE
		LOWER MISSISSIPPIAN		MGL	GARDISON LIMESTONE
				MFD	FITCHVILLE FORMATION
	CAMBRIAN	MIDDLE CAMBRIAN		CML	MAXFIELD LIMESTONE
			CTQ	COS	OPHIR FORMATION
		LOWER CAMBRIAN		CTQ	TINTIC QUARTZITE
PRECAMBRIAN	Z		ZMI	ZMI	MUTUAL FORMATION
	Z OR Y		YMFT	YMFT	MINERAL FORK TILLITE
	Y		YBC	YBC	BIG COTTONWOOD FORMATION
	X		XLW	XLW	LITTLE WILLOW FORMATION

SOURCES:

1. CRITTENDEN, MAX D., JR.; GEOLOGY OF DRAPER QUADRANGLE, U.S.G.S. MAP GQ-377 (1965a).
2. ________________; GEOLOGY OF DROMEDARY PEAK QUADRANGLE, U.S.G.S. MAP GQ-378 (1965b).
3. ________________; GEOLOGY OF MOUNT AIRE QUADRANGLE, U.S.G.S. MAP GQ-379 (1965c).
4. ________________; GEOLOGY OF SUGAR HOUSE QUADRANGLE, U.S.G.S. MAP GQ-380 (1965d).
5. JAMES, L. P.; GEOLOGY, ORE DEPOSITS, AND HISTORY OF THE BIG COTTONWOOD MINING DISTRICT (1979).

LEGEND FOR FIGURE 3

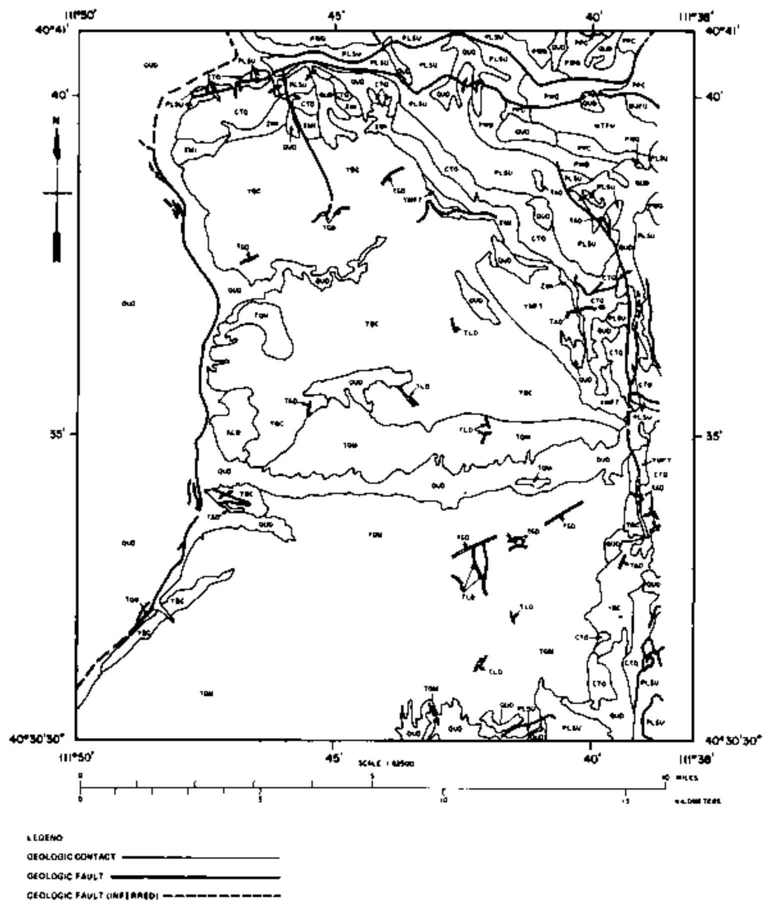

Figure 3

GENERALIZED GEOLOGIC MAP OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH the lower part of the Ankareh Formation are equivalent to the Moenkopi Formation and the middle and upper member of the Ankareh Formation are equivalent to the Shinarump and Chinle Formation of southeastern Utah (Crittenden, et al, 1952).

The overlying Jurassic units (MJFU) include the Nugget Sandstone, Twin Creek Limestone, Preuss Formation, and Morrison Formation, and consist of resistant crossbedded sandstones, silty limestones, red shale and sandstone, and white algal limestone, respectively (James, 1979). In southeastern Utah, the Nugget Sandstone is the equivalent of the Navajo Sandstone (Crittenden, et al, 1952).

During Late Cretaceous and Tertiary time, the Central Wasatch Range was intruded by several igneous stocks. In the Cottonwood project area, these intrusives are represented by the diorites of the Argenta Intrusive Complex (TAD), the Little Cottonwood and Ferguson Canyon Stocks (TQM), and dikes of lamprophyric (TLD), intermediate (TAD), and granitic (TGD) composition.

The Argenta Intrusive Complex includes as many as 40 individual intrusions with somewhat differing textures occurring as dikes and sills and some larger intrusive bodies. In general, they are hornblende-biotite quartz diorite in composition (Crittenden, 1965a, b, c, and d; James, 1979). Radiometric dating of the Argenta diorites have given them an age of 72.4 ± 4 million years (James, 1979).

The Little Cottonwood Stock (TQM) occupies approximately 40% of the Cottonwood project area. It occurs generally in the area from just south of the divide between Big and Little Cottonwood Canyons to the southern boundary of the project area, and from the Wasatch Front on the west to about long. 111°40' on the east. Rocks of the Little Cottonwood Stock and related Ferguson Stock, located just south of the mouth of Big Cottonwood Canyon, are mainly granodiorite to quartz monzonite in composition. Age of the Little Cottonwood Stock is 24 to 31 million years (James, 1979).

Xenoliths of dioritic rocks possibly from the older Argenta Complex have been found in the Little Cottonwood Stock (James, 1979). There is also a zone of intense alteration and pyritization east of the White Pine Fork. The Little Cottonwood Stock in this area contains anomalous concentrations of molybdenite (James, 1979; Crittenden, 1965a, b, c, and d).

Associated with the larger intrusive rocks are intrusive dike rocks of lamprophyric (TLD), intermediate (TAD), and granitic (TGD) composition. These dikes are of limited aerial extent and are scattered throughout the project area (Crittenden, 1965a, b, c, and d).

Surficial deposits (QUD) found in the Cottonwood project area include abundant glacial moraine deposits in Little Cottonwood and Bells Canyons and also in the upper portion of Big Cottonwood Canyon and several of its major tributaries. Other glacial moraines are found in cirques surrounding the high mountain peaks of the project area. Along the base of the Wasatch Front, terrace deposits from the highest stage of Glacial Lake Bonneville extend from the Salt Lake Valley floor approximately 1,270 m (4,200 ft) to an elevation of approximately 1,500 m (5,200 ft) (Crittenden, 1965a, b, c, and d).

Nonglacial surficial deposits, also mapped as QUD, include talus, colluvium, and landslide deposits found in steep valleys and on the flanks of the mountain peaks. Recent alluvium is present in many of the streams of the project area (Crittenden, 1965a, b, c, and d).

Structure

The dominant structural features of the Cottonwood project area include intensely folded and faulted sediments which dip predominantly away from a central core of Tertiary quartz monzonite (the Little Cottonwood Stock), major east-west and north-south trending thrust faults (the Upper Strand Mt. Raymond, Strand Mt. Raymond, and Alta Thrust Faults), and major north-south trending normal faults (the Superior and Silver Fork normal faults and the Wasatch Fault zone). In addition to these features the project area lies on the economically important lineament known as the Uinta-Gold Hill Trend or simply the Uinta Trend (Erickson, 1974).

The Cottonwood project area lies within the Central Wasatch Mountains. It is located at the junction of three regional tectonic environments: the Basin and Range Province to the west, the Colorado Plateau to the southeast and the Green River Basin to the northeast. The Uinta-Gold Hill Trend (Uinta Trend) (Erickson, 1974), now represented by the Unita Mountains, seperates the Colorado Plateau from the Green River Basin and may represent a failed-arm of a Precambrian triple junction which lay at the continental margin approximately 1,200 million years ago (Burke and Dewey, 1973). [The Uinta Arch, which is the western extension of the anticline which forms the Uinta Mountains proper, is represented in the project area by an east-west trending anticline whose axis is located north of Little Cottonwood Canyon, at approximately lat. 40°39' N. (Crittenden, 1964).] This lineament together with the east northeast-west southwest trending Towanta Lineament (Ritzma, 1974) may be related to the Mullen Creek-Nash Fork shear of southeastern Wyoming. Basement rocks in northern Utah located north of this projected trend are important in terms of uranium exploration. Units of the Wyoming Precambrian Province located north of the Mullen Creek-Nash Fork shear, include Archean rocks (>2.5 billion years) which are similar to those in the Slave Province in Canada. In the region north of the Mullen Creek-Nash Fork Shear, lower and middle Proterozoic sequences unconformably overlie the older Archean rocks. These Proterozoic sequences are similar to the Huronian Supergroup of Canada which contains the Elliot Lake-Blind River deposits. Basement rocks of this type are represented in the Cottonwood project area by the Little Willow Formation [Precambrian X in age (King, 1976)].

Between 1.6 and 1.8 billion years ago, the Hudsonian Orogeny resulted in metamorphism of the flanks of the Wyoming Precambrian Province and of the Little Willow Formation to amphibolite grade. Two major geosynclinal episodes followed the Hudsonian Orogeny and are represented by Precambrian Y sedimentary rocks [the Big Cottonwood Formation (YBC) and the Mineral Fork Tillite (YMFT)] of the Beltian Geosyncline and by Late Precambrian Z to Jurassic sedimentary rocks of the Cordilleran Geosyncline (Crittenden and Wallace, 1973).

Starting approximately 100 million years ago and lasting until about 40 million years ago, the Laramide Orogeny resulted in thin layers of sediments being moved slowly eastward in series of thin, wrinkled sheets (Crittenden, 1964). This orogeny began with simple folding and developed into a period of extensive thrust faulting represented in the project area by the Upper Strand Mt. Raymond, Strand Mt. Raymond, and Alta Thrust Faults. The Strand Mt. Raymond Thrust Faults are located at approximately lat. 40°40'30" N., parallel each other, and extend east-west almost the width of the project area. The Alta Thrust Fault, which is slightly older than the Strand Mt. Raymond Thrust Faults is located approximately from lat. 40°35'00" to about 39°00'00" N. and long. 111°37'30" to about 43°00'00" W.

These major thrust faults were cut and offset by numerous normal faults in Tertiary time. Normal faulting began approximately 20 million years ago and is best represented in the project area by the major Superior and Silver Fork Faults. The Superior Fault is a north-south trending normal fault located approximately at lat. 40°35' to 40°39' N. and long. 111°39' to 111°40' W. The Silver Fork Fault is also a north-south trending normal fault and parallels the Superior Fault. It is located at the eastern margin of the project area. The Wasatch Fault Zone is located at the western edge of the project area and represents the youngest major structural element in the area. Displacement along the zone averages 910 m (3,000 ft) (James, 1979), but may reach a maximum of 4,570 m (15,000 ft) (Crittenden, 1964). Fault scarps along the Wasatch Front cut Quaternary gravel and several earthquakes have been recorded along the zone in recent history indicating the zone is still tectonically active.

HYDROLOGY

Water resources of the Cottonwood project area are limited to direct runoff and numerous springs which generally occur between elevations of 1,700 to 2,600 m (5,600 to 8,600 ft), although some over 3,050 m (10,000 ft) also exist. The springs achieve peak flow rates in the spring when recharge by snow melt and rain is at a maximum. The major producing units include fractured Precambrian-Cambrian metamorphosed clastics (quartzite, tillite), Paleozoic carbonates, jointed Tertiary intrusives (quartz monzonite), unconsolidated alluvium, colluvium, and glacial moraine deposits. Considerable water infiltrates into the consolidated bedrock of the Wasatch Mountains along fractures, faults, bedding planes, solution channels, or lithologically porous zones and may eventually reappear in springs at lower elevations or discharge into the adjoining Jordan Valley water table aquifer without surfacing (Jensen, 1969). High water yields are obtained along or in close proximity to, major structural features such as overthrusts in the consolidated units and along the boundary between consolidated bedrock and overlying unconsolidated Quaternary sediments. The chemical composition of selected springs in the area as determined by Mundorff (1971) is generally of the calcium bicarbonate type with the dissolved solids content ranging from 200 to 430 ppm. In some areas (especially in the higher elevations) the distance between the recharge and discharge zones is small, and hence, the water chemistry may not accurately reflect the geochemistry of the host rock through which it passes.

URANIUM OCCURRENCES

No uranium mines, prospects, or occurrences of uranium are known in the Cottonwood project area.

Geochemical analysis of five rocks samples from the Big Cottonwood mining district gave values for U_3O_8 from <1.0 to 2.0 ppm. James (1979) states that uranium was measured only in a few samples, and was found to occur at very low levels when compared to uranium-bearing rocks of other regions. Examination of many samples with a scintillation counter failed to show anomalous radioactivity.

An areal gamma ray and magnetic survey conducted by EG&G Geometrics (1980) detected a 6.0 ppm eU anomaly associated with the Tertiary Little Cottonwood Stock (quartz monzonite) approximately located at lat. 40°35' N. and long. 111°45' W.

SAMPLE COLLECTION

CHRONOLOGY OF THE SURVEY

The Cottonwood detailed geochemical survey area was sampled by UCC-ND personnel from late October to late November 1979. Laboratory analysis, as well as compilation and verification of all field and laboratory data, was completed in April 1980. The final field and laboratory data base used to prepare the statistical and areal distribution of uranium and other related variables for this report was completed in April 1980.

FIELD PROCEDURES

A total of 15 groundwater and 79 stream sediment samples were collected during the detailed sampling of the Cottonwood project area. Plates 1 and 4 show sample locations for groundwater and stream sediment sites, respectively. Radiometric sample locations are shown on Plate 8. A total of 85 radiometric readings were taken.

Detailed information regarding techniques in sample collection, recording site data, field equipment, and field measurements may be found in the following reports: "Hydrogeochemical and Stream Sediment Reconnaissance Procedures for the Uranium Resource Evaluation Project" (Arendt, et al, December 1979); "Procedures Manual for Groundwater Reconnaissance Sampling" (Uranium Resource Evaluation Project, March 1978); and "Procedures Manual for Stream Sediment Reconnaissance Sampling" (Uranium Resource Evaluation Project, May 1978). Field observations were recorded on the field form shown in Table C-2 and are included in the microfiche in Appendix D.

Scintrex BGS-1SL scintillometers were used in the area to determine general radioactive backgrounds and to locate areas of possible interest. The GR410 Exploranium Geometrics Gamma-Ray Spectrometer was used as follow-up in the areas of possible anomalous radioactivity to obtain more precise radiometric data. These readings were used in directing sampling towards geologic units of positive radioactive anomalies.

CONTAMINATION

Precautions were taken to avoid the possibility of collecting contaminated samples. Sediment samples were collected upstream from road crossings and railroad tracks, except where this was not feasible. Visible signs of possible contamination were noted on the field form. Special care was taken to avoid streams which were connected upstream to irrigation ditches in the agricultural areas.

CHEMICAL ANALYSIS

All samples collected in the Cottonwood project area were returned to the URE Project laboratory in Oak Ridge, Tennessee for preparation and analysis. The elements determined and the analytical techniques used along with the appropriate detection limits are given in Table 1. These detection limits are considered the best average during normal operation; however, some variables have values reported below these limits. All water samples were received in 250-ml polyethylene bottles and were filtered through 0.45-μm cellulose acetate paper. Stream sediment samples were dried overnight at 85°C and sieved to collect the <150-μm fraction. Part of the sediment sample was dissolved in 10 ml of 1:1 nitric-hydrofluoric acid. The analytical procedures which were used have been described by Cagle (1977) and Arendt, et al (December 1979). All observed data from all samples are included in the microfiche in Appendix D.

Table 1

DETECTION LIMITS OF VARIABLES DETERMINED IN WATER AND SEDIMENT SAMPLES

Variable	Method	Detection Limits Sediment (ppm)	Water (ppb)
U-FL	Fluorometry	0.25	0.2
U-MS	Mass Spectrometry-Isotope Dilution	--	0.02
U-NT	Neutron Activation-Delayed Neutron Count	0.02	--
As	Atomic Absorption	0.1	0.5
Se	Atomic Absorption	0.1	0.2
Ag	Plasma Source Emission Spectrometry	2	2
Al	Plasma Source Emission Spectrometry	0.05[a]	10
B	Plasma Source Emission Spectrometry	10	4
Ba	Plasma Source Emission Spectrometry	2	2
Be	Plasma Source Emission Spectrometry	1	1
Ca	Plasma Source Emission Spectrometry	0.05[a]	0.1[b]
Ce	Plasma Source Emission Spectrometry	10	30
Co	Plasma Source Emission Spectrometry	4	2
Cr	Plasma Source Emission Spectrometry	1	4
Cu	Plasma Source Emission Spectrometry	2	2
Fe	Plasma Source Emission Spectrometry	0.05[a]	10
Hf	Plasma Source Emission Spectrometry	15	--
K	Plasma Source Emission Spectrometry	0.05[a]	0.1[b]
La	Plasma Source Emission Spectrometry	2	--
Li	Plasma Source Emission Spectrometry	1	2
Mg	Plasma Source Emission Spectrometry	0.05[a]	0.1[b]
Mn	Plasma Source Emission Spectrometry	4	2
Mo	Plasma Source Emission Spectrometry	4	4
Na	Plasma Source Emission Spectrometry	0.05[a]	0.1[b]
Nb	Plasma Source Emission Spectrometry	4	--
Ni	Plasma Source Emission Spectrometry	2	4
P	Plasma Source Emission Spectrometry	5	40
Pb	Plasma Source Emission Spectrometry	10	--
Sc	Plasma Source Emission Spectrometry	1	1
Si	Plasma Source Emission Spectrometry	--	0.1[b]
Sr	Plasma Source Emission Spectrometry	1	2
Th	Plasma Source Emission Spectrometry	2	--
Ti	Plasma Source Emission Spectrometry	10	2
V	Plasma Source Emission Spectrometry	2	4
Y	Plasma Source Emission Spectrometry	1	1
Zn	Plasma Source Emission Spectrometry	2	4
Zr	Plasma Source Emission Spectrometry	2	2
SO_4	Spectrophotometry	--	5[b]
Cl	Spectrophotometry	--	10[b]

[a]Detection limits expressed in percent.
[b]Detection limits expressed in ppm.

QUALITY CONTROL

MEASUREMENTS CONTROL

The procedures used to analyze URE Project samples require that calibration standards, check samples, and blanks be analyzed along with normal samples to ensure the validity of the reported results. A measurements control program provides information concerning precision and reliability of these measurements. Control samples of two water batches and three sediment batches are submitted anonymously along with routine samples on a daily basis. A statistical summary of results reported on control samples, which were analyzed along with the samples included in this survey, is given in Tables 2 and 3. Results of uranium analysis of water and sediment control samples obtained from the Ames Laboratory as part of the Multilaboratory Analytical Quality Control for the HSSR Program are reported by D'Silva, et al (1980).

PRINCIPAL COMPONENT ERROR ANALYSIS

A principal component analysis of data from groundwater and stream sediment samples was used to produce an ordered list of samples using the eigenvalue statistics as described by Kane, et al (1977), where the the most extreme samples were listed first. Additional samples were identified if single-element measurements were outside a three standard deviation confidence interval around the mean. The laboratory and field data from the samples identified by this procedure were reviewed. Four stream sediment samples (908928, 909300, 909326, and 909335) were submitted for reanalysis. The original results were compared to the results from reanalysis. Of the more than 100 individual analyses that were compared, the only results which were considered to be in error in the original analysis and thus require corrections were arsenic and selenium values for Sample 909335 and multielement values for Sample 909300. This low error rate indicates a high level of reliability for the laboratory measurements.

GEOCHEMICAL RESULTS

Statistical summaries of geochemical variables determined and correlation matrices of select variables for groundwater and stream sediment samples collected in the Cottonwood project area of the Thomas Range-Wasatch detailed geochemical survey are presented in Appendixes A and B, respectively. Areal distribution maps (concentration maps for groundwater data, symbol maps for sediment data), log frequency, lognormal probability, percentile plots, and tabular data listings for select variables are also included. All field and laboratory data for all samples may be found on microfiche in Appendix D. Details of all sampling, analytical, and statistical procedures are discussed in Report K/UR-100 (Arendt, et al, December 1979).

Table 2

SUMMARY OF THE MEASUREMENTS CONTROL RESULTS OBTAINED WITH GROUNDWATER SAMPLES FROM THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

		Batch L-4				Batch H-4			
Element	Method	No. of Samples	Mean (ppb)	Standard Deviation (ppb)	Coefficient of Variation	No. of Samples	Mean (ppb)	Standard Deviation (ppb)	Coefficient of Variation
U	FL[(a)]	17	0.75	0.351	0.47	11	10.87	0.897	0.08
AS	AA[(b)]	20	3.3	1.11	0.33	17	0.6	0.31	0.55
SE	AA	20	1.2	0.31	0.26	17	0.8	0.24	0.29
AL	PS[(c)]	13	92.0	20.2	0.22	18	330.0	25.0	0.08
B	PS	13	1,570.0	62.2	0.04	19	69.0	4.6	0.07
BA	PS	12	140.0	3.3	0.02	19	31.0	1.4	0.05
CA	PS	14	10,000.0	850.0	0.08	18	91,400.0	6,190.0	0.07
CO	PS	14	20.0	4.1	0.20	17	90.0	2.9	0.03
CR	PS	14	93.0	5.6	0.06	18	18.0	1.8	0.10
CU	PS	8	45.0	1.8	0.04	18	202.0	23.3	0.11
FE	PS	13	103.0	7.2	0.07	18	960.0	50.7	0.05
K	PS	14	1,800.0	229.0	0.13	17	19,490.0	937.0	0.05
LI	PS	14	16.0	1.1	0.07	18	100.0	5.6	0.06
MG	PS	14	9,200.0	420.0	0.05	18	67,900.0	2,710.0	0.04
MN	PS	14	20.0	2.3	0.11	16	96.0	4.1	0.04
MO	PS	13	24.0	10.1	0.41	13	11.0	6.3	0.57
NA	PS	14	1,600.0	150.0	0.10	18	43,800.0	2,120.0	0.05
NI	PS	13	195.0	10.7	0.05	18	37.0	6.2	0.16
P	PS	13	90.0	23.8	0.26	17	4,498.0	134.3	0.03
SC	PS	13	63.0	2.8	0.04	17	11.0	0.5	0.05
SI	PS	14	870.0	164.0	0.19	18	7,940.0	371.0	0.05
SR	PS	14	56.29	2.644	0.05	18	5,012.55	170.85	0.03
TI	PS	13	118.0	8.2	0.07	18	38.0	4.4	0.11
V	PS	12	9.0	1.5	0.15	18	41.0	3.5	0.08
Y	PS	14	9.0	1.4	0.14	18	45.0	2.4	0.05
ZN	PS	14	498.0	42.7	0.09	18	45.0	24.3	0.54

(a)Fluorometric analysis.
(b)Atomic absorption.
(c)Plasma source emission spectroscopy.

Table 3

SUMMARY OF THE MEASUREMENTS CONTROL RESULTS OBTAINED WITH STREAM SEDIMENT SAMPLES FROM THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

		Batch Q-1				Batch R-3				Batch S-3			
Element	Method	No. of Samples	Mean (ppm)	Standard Deviation (ppm)	Coefficient of Variation	No. of Samples	Mean (ppm)	Standard Deviation (ppm)	Coefficient of Variation	No. of Samples	Mean (ppm)	Standard Deviation (ppm)	Coefficient of Variation
U	FL[a]	40	0.79	0.268	0.34	37	4.26	0.469	0.11	38	28.52	2.674	0.09
U	NT[b]	39	0.67	0.160	0.24	50	4.91	0.102	0.02	35	26.25	0.797	0.03
AS	AA[c]	17	1.8	0.25	0.14	27	3.6	0.64	0.18	19	26.4	3.11	0.12
SE	AA	12	0.5	0.31	0.57	28	0.2	0.43	2.02	20	1.4	0.62	0.45
AL	PS[d]	36	9,700.0	490.0	0.05	39	34,100.0	2,730.0	0.08	30	48,700.0	3,430.0	0.07
B	PS	38	7.0	3.5	0.46	34	20.0	7.1	0.34	30	61.0	10.3	0.17
BA	PS	38	130.0	14.6	0.11	39	454.0	51.0	0.11	32	314.0	31.1	0.10
BE	PS	37	<1.0			40	<1.0			32	2.0	4.0	1.74
CA	PS	38	1,200.0	100.0	0.08	40	3,100.0	300.0	0.10	31	16,900.0	80.0	0.06
CE	PS	37	19.08	3.677	0.19	39	68.82	7.196	0.10	29	55.59	4.968	0.09
CO	PS	38	4.0	2.7	0.59	40	10.0	2.2	0.20	31	33.0	3.1	0.09
CR	PS	38	14.0	2.1	0.14	39	28.0	3.2	0.11	32	65.0	6.6	0.10
CU	PS	35	3.0	0.8	0.22	38	20.0	1.5	0.07	30	69.0	2.9	0.04
FE	PS	37	9,700.0	390.0	0.04	40	18,000.0	1,070.0	0.06	30	40,800.0	2,070.0	0.05
K	PS	37	1,900.0	190.0	0.10	38	9,900.0	930.0	0.09	31	17,200.0	2,000.0	0.12
LI	PS	37	9.0	0.8	0.08	39	23.0	1.8	0.08	32	35.0	3.6	0.10
MG	PS	38	1,100.0	50.0	0.05	39	2,200.0	110.0	0.05	32	5,600.0	260.0	0.05
MN	PS	37	317.0	9.9	0.03	40	1,909.0	87.8	0.05	30	404.0	15.9	0.04
MO	PS	1	0.0	0.0	0.0	40	2.0	0.9	0.41	29	43.0	3.7	0.08
NA	PS	1	0.0	0.0	0.0	40	1,600.0	190.0	0.13	31	1,600.0	220.0	0.14
NB	PS	37	2.0	0.7	0.32	41	8.0	4.3	0.49	33	2.0	1.6	0.58
NI	PS	37	6.0	1.0	0.16	41	20.0	3.1	0.15	30	108.0	6.3	0.06
P	PS	36	70.0	6.0	0.09	35	2,149.0	217.3	0.10	28	1,441.0	83.8	0.06
PB	PS	28	5.0	3.0	0.50	27	38.0	5.6	0.14	28	21.0	3.6	0.16
SC	PS	38	1.0	0.5	0.31	41	5.0	0.8	0.15	32	10.0	0.8	0.08
SR	PS	36	19.17	1.320	0.07	39	55.33	4.054	0.07	32	85.56	6.133	0.07
TH	PS	38	2.0	1.7	0.74	41	8.0	2.8	0.34	33	8.0	2.5	0.30
TI	PS	38	572.0	54.8	0.10	39	3,321.0	369.9	0.11	32	2,123.0	174.9	0.08
V	PS	35	20.0	0.9	0.04	38	55.0	4.4	0.08	30	166.0	6.7	0.04
Y	PS	37	4.0	0.3	0.08	39	20.0	1.7	0.08	30	33.0	1.6	0.05
ZN	PS	36	13.0	2.1	0.16	35	93.0	7.5	0.08	29	185.0	12.0	0.06
ZR	PS	38	30.0	2.9	0.10	38	136.0	10.9	0.08	31	83.0	6.0	0.07
HF	PS	27	2.11	1.577	0.75	27	3.83	2.685	0.70	28	1.95	1.455	0.75
LA	PS	28	20.89	3.023	0.14	27	78.00	15.056	0.19	28	90.61	4.787	0.05

(a) Fluorometric analysis.
(b) Neutron activation delayed neutron count.
(c) Atomic absorption.
(d) Plasma source emission spectroscopy.

For discussion purposes, the 16th and 84th percentile concentrations are contoured on the areal distribution maps for all elements in Appendix B, to indicate areas of low and high concentrations. This represents values of approximately one standard deviation below and above the mean for a normally distributed population. For more careful evaluation of the data presented, concentration levels considered to be anomalous should be determined separately for each geologic unit within the project area.

GEOCHEMICAL DISTRIBUTIONS IN GROUNDWATER

Sample site locations for groundwater samples collected in the Cottonwood project area are shown on Plate 1. Concentrations of the variables uranium and specific conductance are presented in Plates 2 and 3, and Figures A-1b and A-2b, respectively. Figure 4 presents the geologic units from which the springs produce. The number of samples from each of the major geologic and lithologic units in the project area is presented in Table 4. A correlation matrix has been supplied (Table A-2), but due to the small number of samples (15), interpretation of the table is minimized. Observed data for uranium, specific conductance, cobalt, iron, potassium, manganese, nickel, sulfate, molybdenum, and strontium are given in Table A-3. Concentration maps, log frequency, lognormal probability, and percentile plots for these same variables are presented in Appendix A.

Uranium

Uranium concentrations in groundwater from the Cottonwood project area range from 0.25 to 3.89 ppb (Plate 1 and Figures A-1a, A-1b). Three samples which represent the upper 20th percentile of the data (908938, 908915, and 908930) have uranium concentrations of 3.89, 3.63, and 2.80 ppb, respectively. These samples produce from and represent groundwater within the quartz monzonite of Little Cottonwood and Ferguson Canyons, and the Little Water Stock (TQM). They are located at lat. 40°32'53" N., long. 111°41'31" W. (for Sample 908938); lat. 40°34'52" N., long. 111°39'54" W. (for Sample 908915), and lat. 40°33'25" N., long. 111°40'41" W. (for Sample 908930).

Specific Conductance

Specific conductance values (Plate 2 and Figure A-2b) for the samples with highest uranium concentrations are within the 40th to 65th percentile grouping for all specific conductance values observed. Sample 908938 has a specific conductance value of 448 µmhos/cm (64th percentile or 9th highest sample); Sample 908915 has a specific conductance value of 428 µmhos/cm (50th percentile or 8th highest sample), and Sample 908930 has a specific conductance value of 412 µmhos/cm (43rd percentile or 6th highest sample). The samples with the highest specific conductance values, which are the upper 20th percentile of the data, are 908906 (728 µmhos/cm, located at lat. 40°35'24" N., long. 111°39'14"

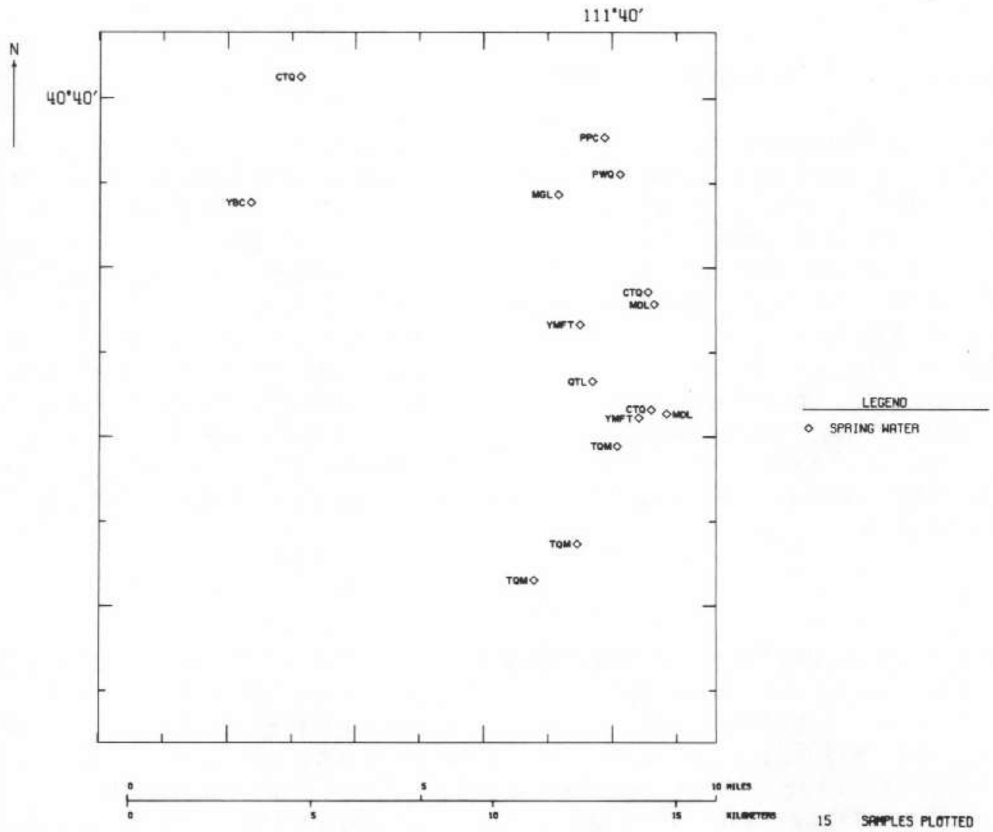

Figure 4

PRODUCING HORIZON MAP FOR GROUNDWATER OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

Table 4

DISTRIBUTION OF SAMPLES BY GEOLOGIC CODE FROM THE COTTONWOOD PROJECT AREA

Geologic Code (a)	No. of Groundwater Samples	No. of Sediment Samples	No. of Radiometric Readings
QUD	-	2	-
QAL	-	6	-
QTL	1	9	-
QPGM	-	6	-
TAD	-	-	3
TLD	-	-	2
TQM	3	20	22
MTFU	-	2	-
PPC	1	-	1
PWQ	1	2	-
PRV	-	-	2
PLSU	-	-	-
MDS	-	-	1
MDL	2	2	2
MGL	1	2	-
COS	-	2	3
CTQ	3	-	5
ZMI	-	1	5
YMFT	2	1	9
YBC	1	21	22
XLW	-	3	8
Total	15	79	85

(a) See Figure 3 for unit names.

W.), 908539 (542 μmhos/cm, located at lat. 40°37'58" N., long. 111°39'11" W.), and 909315 (486 μmhos/cm, located at lat. 40°40'19" N., long. 111°46'05" W.). Samples 908906 and 909315 produce from the Ophir Formation or Tintic Quartzite (CTQ). Sample 908539 produces from the Deseret Limestone (MDL).

Related Variables

Variables with concentrations positively associated with the high concentrations of uranium in the samples include cobalt (Figure A-3b), iron (Figure A-4b), potassium (Figure A-5b), manganese (Figure A-6b), nickel (Figure A-8b), and sulfate (Figure A-10b). Sample 908930 also has relatively high concentrations of molybdenum (Figure A-7b) and strontium (Figure A-9b). Strontium, iron, and rarely manganese are present in limited amounts in alkali feldspars (Deer, et al, 1971) which are abundant within the Little Cottonwood Stock (TQM). At approximately lat. 32°33'00" to 32°34'00" N. and long. 111°40'00" to 111°42"30" W., sulfide deposits occur within the Little Cottonwood Stock (TQM) near a dike complex (TGD and TLD) of granodioritic to granitic and lamprophyric composition. The anomalous concentrations of cobalt, iron, manganese, nickel, and molybdenum may be associated with these dikes and with the sulfide occurrences since these elements are often geochemically associated with each other and with sulfides.

This same association of variables; cobalt, iron, potassium, manganese, nickel, and sulfate also occurs in anomalous concentrations in Samples 908538 and 909333. These samples produce from the Ophir Formation or Tintic Quartzite (CTQ) and the Mineral Fork Tillite (YMFT), respectively. Sulfide deposits associated with the Superior Fault Zone (a normal fault located at approximately lat. 40°35' to 40°39' N. and long. 111°39' to 111°40' W.) are located near Sample 908538. No known sulfide deposits occur near Sample 909333, however, dikes of intermediate composition are found near the sample location. The uranium concentrations for these samples are 0.25 and 0.75 ppb, respectively, anomalously low values for the region.

Summary of Groundwater Data

In the Cottonwood project area, uranium concentrations are highest in groundwaters producing from the quartz monzonite of Little Cottonwood and Ferguson Canyons. Specific conductance values for these samples are relatively moderate for the area. Variables that appear associated with the uranium include cobalt, iron, potassium, manganese, nickel, sulfate, and to a lesser extent molybdenum and strontium. This association may be attributable to the presence of the Little Cottonwood Stock, granodioritic to granitic and lamprophyric dikes and sulfide deposits located near the sample locations.

GEOCHEMICAL DISTRIBUTIONS IN STREAM SEDIMENTS

Sample site locations and the outline of drainage basins from which stream sediment samples were collected in the Cottonwood project area are shown on Plate 4. Areal distribution maps for hot-acid-soluble uranium (U-FL) as determined by fluorometric analysis and thorium are presented on Plates 5 and 6 and Figures B-1b and B-4b, respectively. The number of stream sediment samples which were collected from each of the major geologic and lithologic units of the survey area is presented in Table 4. Stream sediment data used to generate the tables and figures in Appendix B include all sediment samples collected within the Cottonwood project area. Observed data for hot-acid-soluble uranium as determined by fluorometric analysis (U-FL), total uranium as determined by neutron activation (U-NT), the U-FL:U-NT ratio, thorium, barium, cerium, copper, molybdenum, phosphorus, strontium, and zinc are given in Table B-3. Areal distribution maps, log frequency, lognormal probability, and percentile plots for these same variables plus sodium, niobium, and titanium are presented in Appendix B.

Uranium

The areal distribution map of U-FL concentrations (Plate 5 and Figure B-1b) indicates that values ≧84th percentile (15.34 ppm), with the exception of three samples (908530, 909099, and 908540) occur within the Little Cottonwood drainage basin where the basin cuts into the Little Cottonwood Stock (TQM). The Little Cottonwood drainage basin is an east-west trending basin with the main stream, Little Cottonwood Creek, being located approximately between lat. 40°34'00" and 40°35'00" N. and extending east-west almost the entire width of the project area. Samples 908530, 909099, and 908540 also, in part, represent sediment derived from the Little Cottonwood or Ferguson Stocks (TQM).

The percentile plot, (Figure B-1a) confirms that the highest concentrations of U-FL are from sediments derived from the Little Cottonwood and Ferguson Stocks (TQM). The 84th percentile for these units is 31.19 ppm. The highest U-FL concentration determined was 72.64 ppm from Sample 908928 (located in the southeastern corner of the project area, lat. 40°33'18" N., and long. 111°40'48" W.).

The correlation matrix (Table B-2) indicates a significant positive Spearman and Pearson correlation (≧0.30) between the natural logs of U-FL and U-NT, thorium, sodium, strontium, barium, phosphorus, cerium, niobium, yttrium, aluminum, titanium, vanadium, iron, and the U-FL:U-NT (extractable to total uranium) ratio. A significant negative Spearman and Pearson correlation (≦-0.30) is indicated between the natural logs of U-FL and nickel and the thorium:U-NT ratio. A significant positive Spearman correlation (≧0.30) is indicated for U-FL with scandium.

The areal distribution map of uranium as determined by neutron activation (U-NT) delineates those sediment samples which contain ≧84th percentile concentrations (17.21 ppm) of total uranium. The area of anomalously high concentrations of U-NT is approximately the same as that described for U-FL. Two additional samples outside of the Little Cottonwood drainage basin are included with the ≧84th percentile grouping; they are 908537 (located in the southwestern corner of the project area, lat. 40°33'32" N. and long. 111°47'42" W.) and 908701 (also located in the southwestern corner of the project area, lat. 40°32'13" N. and long. 111°48'58" W.). These samples also represent sediment derived primarily from the Little Cottonwood Stock (TQM).

The percentile plot (Figure B-2a) confirms that the highest concentrations of U-NT are from sediments derived from the Little Cottonwood and Ferguson Stocks (TQM). The 84th percentile for these units is 30.54 ppm. The highest U-NT concentration determined was 75.20 ppm from Sample 908928 (previously described).

The correlation matrix (Table B-2) indicates a significant positive Spearman and Pearson correlation (≧0.30) between the natural logs of U-NT and U-FL, thorium, sodium, strontium, barium, phosphorus, cerium, niobium, yttrium, aluminum, titanium, vanadium, iron, potassium, and the U-FL:U-NT (extractable to total uranium) ratio. A significant negative Spearman and Pearson correlation (≦-0.30) is indicated between the natural logs of U-NT and nickel and the thorium:U-NT ratio. A significant positive Spearman correlation (≧0.30) is indicated between U-NT and scandium. A significant negative Pearson correlation (≦-0.30) is indicated between U-NT and arsenic.

The U-FL:U-NT ratio indicates the percentage of total uranium in sediments which is present in hot-acid-soluble form. A sample with a high U-FL:U-NT value and a high U-NT value indicates anomalous accumulations of uranium in a hot-acid-soluble form. Low U-FL:U-NT values in samples with high U-NT values indicates that the uranium present is probably within relatively insoluble (resistate) minerals [i.e. zircon, allanite, pyrochlore, monazite, and xenotime (Levinson, 1980)].

The areal distribution map (Figure B-3b) indicates that of the thirteen samples which contain ≧84th percentile concentrations of U-NT (≧30.54 ppm), six have U-FL:U-NT values ≧0.97. Almost all of the uranium present in these six samples is, therefore, in a hot-acid-soluble form. These samples are 908920, 908706, 908933, 908940, 908942, and 909099. Sample 908942 is located at the mouth of Little Cottonwood Canyon and incorporates sediments representing the entire Little Cottonwood Canyon basin. The location of Sample 909099 has been described previously. The remaining four samples are located within the Little Cottonwood Canyon basin, within the area of outcrop of the Little Cottonwood Stock, and where the granodioritic, granitic, and lamprophyric dike complexes (TGD, TLD) described in the groundwater section occur. Samples 908918 and 908705 are also located in the same general area as these four samples, and also have a U-FL:U-NT ratio value ≧0.97. The U-NT values for these samples are slightly less than the 84th percentile for U-NT but are relatively high for the project area, being 15.60 and 13.00 ppm, respectively. Samples 909300, 909321, and 908948 also have U-FL:U-NT values ≧0.97 but the U-FL and U-NT values for these samples are <84th percentile for those variables.

The correlation matrix (Table B-2) indicates a significant positive Spearman and Pearson correlation (≧0.30) between the natural logs of the U-FL:U-NT ratio (shown as LUTU on matrix) and U-FL, U-NT, sodium, strontium, phosphorus, yttrium, and calcium. A significant positive Spearman correlation is indicated between the U-FL:U-NT ratio and cerium and titanium.

Thorium

The areal distribution map of thorium (Plate 6 and Figure B-4b) indicates that values ≧84th percentile (19 ppm) occur predominantly north and south of, but adjacent to, the Little Cottonwood Canyon drainage basin. However, three samples within the Little Cottonwood Canyon basin also have concentrations ≧84th percentile. These three samples (908920, 908918, and 908706) are included in the six samples with anomalous U-NT, U-FL, and U-FL:U-NT ratios discussed previously.

The percentile plot (Figure B-4a) indicates that high concentrations of thorium are from sediments derived from the Little Cottonwood Stock (TQM) and from Quaternary sediments (QPGM, QTL, QAL, and QUD). The 84th percentile for these groups are 19.00 and 19.64 ppm, respectively. The highest thorium concentration determined for the area was 48 ppm from Sample 909099 (whose location has been described) which represents sediments derived from the Little Cottonwood Stock (TQM).

The correlation matrix (Table B-2) indicates a significant positive Spearman and Pearson correlation (≧0.30) between the natural logs of thorium and U-FL, U-NT, sodium, strontium, barium, phosphorus, cerium, niobium, yttrium, aluminum, scandium, titanium, vanadium, and iron. A significant positive Spearman correlation is indicated between thorium and potassium.

Related Variables

In addition to U-FL, U-NT, the U-FL:U-NT ratio and thorium, other variables which may be useful in understanding areas of potential uranium mineralization include barium, cerium, copper, molybdenum, sodium, niobium, phosphorus, strontium, titanium, and zinc.

Variables which are areally associated with U-FL, U-NT, and thorium include cerium, sodium, niobium, phosphorus, strontium, and titanium. The percentile plots and areal distribution maps for these variables (Figures B-6a, b; B-9a, b; B-10a, b; B-11a, b; B-12a, b; and B-13a, b; respectively) indicate that values ≧84th percentile (110.72 ppm, 1.40%, 16 ppm, 1,697 ppm, 297.16 ppm, and 4,256 ppm, respectively) occur predominantly within the area of outcrop of the Little Cottonwood and/or

Ferguson Stocks (TQM). All of these lithophile elements are common in granitic rocks. Sodium, and to a lesser extent strontium, is commonly present in alkali feldspars (Deer, et al, 1971), a main constituent of granites. Cerium and niobium, as well as uranium and thorium do not readily substitute for the major elements in the essential minerals of igneous rocks and thus remain in solution to be enriched in residual liquid of magmatic crystallization (Mason and Berry, 1968) and are therefore concentrated in aplitic or pegmatitic rocks. In Siegel (1974) average concentrations of cerium and niobium are given for granitic and syenitic rocks. The ratio of these elements (Ce:Nb) is approximately 4 to 5. Since cerium can substitute for calcium in CaF_2 (fluorite) in igneous rocks (Hurlbut, 1971) samples with high concentrations of cerium with a Ce:Nb ratio of greater than 5 may indicate favorable areas for uranium mineralization in igneous rocks. Phosphorus, related to silicate rocks, is most often concentrated in the minerals apatite and monazite, common trace minerals in granites which do not weather easily and may therefore be concentrated in sediments derived from granitic rocks. The anomalous concentrations of titanium are probably due to that element's presence in iron-titanium oxides and/or ferromagnesium minerals which are also commonly present in minor or trace amounts in granites.

The areal association of the above elements with uranium and thorium is probably due to the association of all of these elements to the Little Cottonwood and/or Ferguson Stocks (TQM). In addition to those related variables discussed, high values for uranium, thorium, and the U-FL:U-NT ratio are also areally associated with barium, copper, molybdenum, and zinc in the area within the Little Cottonwood Stock which is intruded by the dike complex (TLD, TGD) and has sulfide mineralization. These variables are shown in Figures B-5b, B-7b, B-8b, and B-14b. Uranium in this area may be related to this sulfide mineralization. Uranium is spatially associated with copper-zinc sulfides and fluorite in the Sheeprock Mountain area and the Marysvale district (Cohenour, 1959). A similar association may exist in the Cottonwood project area, although no fluorite has been observed.

<u>Summary of Stream Sediment Data</u>

Anomalous values for U-FL, U-NT, and thorium are areally concentrated within the area of outcrop of the Little Cottonwood and Ferguson Stocks (TQM). Of the samples with high U-FL and U-NT values, the U-FL:U-NT ratio indicates that those samples located near granitic to granodioritic, and lamprophyric dikes, and sulfide mineralization (approximately lat. 32°33'00" to 32°34'00" N. and long. 111°40'00" to 111°42'30" W.) have anomalous concentrations of uranium in a hot-acid-soluble form. Variables which are areally associated with uranium and thorium and the Little Cottonwood Stock include cerium, sodium, niobium, phosphorus, strontium, and titanium. Variables which are areally associated with high values of uranium, thorium, and the U-FL:U-NT ratio within the Little Cottonwood Stock include barium, copper, molybdenum, and zinc, suggesting an association of uranium with sulfide mineralization an association observed at both the Marysvale District and Sheeprock Mountain area, Utah.

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APPENDIX A

GROUNDWATER

*Where probability, frequency, and/or percentile plots are not present, they are unavailable because of the small number of samples.

APPENDIX A

GROUNDWATER

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Table A-1

STATISTICAL SUMMARY FOR GROUNDWATER OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

	NO. SAMPLES ANALYZED											LN TRANSFORMATION			
		BELOW								COEFFICIENT				ROBUST	
ELEMENT	MEASURABLE VALUES	DETECTION LIMIT	DETECTION LIMIT	MINIMUM VALUE	MAXIMUM VALUE	MEAN	MEDIAN	MODE	STANDARD DEVIATION	OF VARIATION	MEAN	S. D.	MEAN	S. D.
U	15			0.25	3.89	1.39	0.88	1.49	1.163	0.838	0.01	0.84		
SP	15			116	728	384	420	466	164.7	0.4	5.84	0.51		
U/SP	15			0.53	10.29	4.36	3.32	8.64	3.402	0.780	1.07	1.02		
U/B	15			13.18	486.25	146.08	38.03	89.31	144.385	0.988	4.46	1.15		
U/SO	15			7.35	279.23	85.91	51.77	49.54	78.097	0.909	4.02	1.03		
AG	10	5	<2	<2	17	9	5	<2	4.0	0.4	2.16	0.44		
AL	7	8	<10	<10	29	20	<10	<10	7.3	0.4	2.93	0.39		
AS	9	6	<0.5	<0.5	4.3	1.3	0.6	0.8	1.21	0.94	0.01	0.65		
B	15			5	34	13	10	10	7.8	0.6	2.46	0.51		
BA	15			2	97	32	21	24	28.0	0.9	2.99	1.16		
BE	0	15	<1	<1	<1		<1	<1						
CA	15			9.1	61.2	36.8	30.3	60.4	17.78	0.48	3.47	0.58		
CO	7	8	<2	<2	10	4	<2	<2	3.3	0.7	1.39	0.65		
CR	0	15	<4	<4	<4		<4	<4						
CU	1	14	<2	<2	4	4	<2	<2	0.0	0.0	1.39	0.0		
FE	15			10	22	12	11	11	3.5	0.3	2.53	0.23		
K	15			0.1	1.6	0.9	0.9	1.1	0.41	0.46	-0.26	0.69		
LI	12	3	<2	<2	7	2	<2	<2	1.5	0.5	0.96	0.39		
MG	15			0.9	26.2	11.3	8.1	4.6	8.09	0.71	2.12	0.91		
MN	5	10	<2	<2	738	267	<2	<2	286.1	1.1	4.77	1.85		
MO	3	12	<4	<4	18	12	<4	<4	4.7	0.4	2.50	0.36		
NA	15			1.3	16.0	4.7	2.5	3.9	4.98	1.07	1.14	0.86		
NI	6	9	<4	<4	14	10	<4	<4	4.4	0.4	2.25	0.53		
P	0	15	<40	<40	<40		<40	<40						
SC	0	15	<1	<1	<1		<1	<1						
SE	1	14	<0.2	<0.2	0.6	0.6	<0.2	<0.2	0.0	0.0	-0.51	0.0		
SI	15			0.3	8.7	3.6	3.1	3.1	2.13	0.59	1.07	0.80		
SR	15			20	1006	157	90	1004	239.5	1.5	4.60	0.86		
TI	0	15	<2	<2	<2		<2	<2						
V	0	15	<4	<4	<4		<4	<4						
Y	2	13	<1	<1	1	1	<1	<1	0.0	0.0	0.0	0.0		
ZN	13	2	<4	<4	380	81	15	9	107.3	1.3	3.58	1.38		
ZR	4	11	<2	<2	6	4	<2	<2	1.0	0.2	1.54	0.20		
T-AK	15			20	234	100	72	180	68.3	0.7	4.38	0.73		
M-AK	15			22	236	100	71	87	69.5	0.7	4.38	0.72		
P-AK	15			0	80	6	0	0	20.7	3.4				
CL	0	15	<10	<10	<10		<10	<10						
NA/C	15			0.26	3.20	0.93	0.51	0.77	0.997	1.071	-0.47	0.86		
PH	15			5.9	8.9	6.9	6.6	7.8	0.89	0.13				
SO4	15			6	90	24	13	12	24.0	1.0	2.90	0.75		

NOTE: Refer to Table 1, Page 25 and Table C-1, Page C-4 for concentration units and symbol definitions.

Table A-2

CORRELATION MATRIX FOR GROUNDWATER
OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

	L-U	LU/B	LUSP	LUSO	L-SP	L-ZN	LSO4	L-BA	PH
L-U	1.00 (15)								
LU/B	0.92*** 0.90*** (15)	1.00 (15)							
LUSP	0.86*** 0.83*** (15)	0.73*** 0.69*** (15)	1.00 (15)						
LUSO	0.70*** 0.66*** (15)	0.56** 0.54** (15)	0.80*** 0.80*** (15)	1.00 (15)					
L-SP	-0.08 -0.23 (15)	0.04 -0.11 (15)	-0.57** -0.63** (15)	-0.44* -0.45* (15)	1.00 (15)				
L-ZN	-0.04@ -0.01@ (13)	0.18@ 0.22@ (13)	-0.36@ -0.33@ (13)	-0.52@ -0.49@ (13)	0.61@ 0.52@ (13)	1.00 (13)			
LSO4	0.16 0.08 (15)	0.26 0.22 (15)	-0.13 -0.17 (15)	-0.60** -0.61** (15)	0.52** 0.39 (15)	0.59@ 0.61@ (13)	1.00 (15)		
L-BA	0.24 0.17 (15)	0.06 0.09 (15)	0.30 0.27 (15)	0.25 0.34 (15)	-0.20 -0.15 (15)	-0.04@ -0.05@ (13)	-0.07 -0.18 (15)	1.00 (15)	
PH	0.29 0.38 (15)	0.39 0.38 (15)	0.20 0.21 (15)	0.10 0.11 (15)	0.07 0.17 (15)	-0.28@ -0.22@ (13)	0.18 0.06 (15)	-0.49* -0.33 (15)	1.00 (15)
LTAK	0.08 0.19 (15)	0.02 0.05 (15)	0.15 0.23 (15)	0.02 0.09 (15)	-0.16 -0.06 (15)	-0.41@ -0.49@ (13)	0.07 -0.11 (15)	0.33 0.30 (15)	0.13 0.39 (15)
L-NA	-0.30 -0.14 (15)	-0.62** -0.47* (15)	-0.12 0.07 (15)	-0.00 0.10 (15)	-0.24 -0.36 (15)	-0.43@ -0.49@ (13)	-0.33 -0.28 (15)	0.12 0.20 (15)	-0.36 -0.29 (15)
LN/C	-0.30 -0.14 (15)	-0.62** -0.47* (15)	-0.12 0.07 (15)	-0.00 0.10 (15)	-0.24 -0.36 (15)	-0.43@ -0.49@ (13)	-0.33 -0.28 (15)	0.12 0.20 (15)	-0.36 -0.29 (15)
L-B	-0.42 -0.38 (15)	-0.75*** -0.72*** (15)	-0.23 -0.13 (15)	-0.10 -0.07 (15)	-0.23 -0.23 (15)	-0.49@ -0.52@ (13)	-0.33 -0.34 (15)	0.26 0.22 (15)	-0.41 -0.31 (15)
L-K	0.26 0.21 (15)	0.51* 0.46* (15)	0.12 -0.03 (15)	-0.02 -0.11 (15)	0.19 0.31 (15)	0.62@ 0.77@ (13)	0.32 0.51* (15)	-0.15 0.08 (15)	-0.08 -0.21 (15)
L-CA	-0.10 -0.04 (15)	-0.40 -0.40 (15)	0.01 -0.00 (15)	-0.11 -0.11 (15)	-0.19 -0.10 (15)	-0.43@ -0.32@ (13)	0.04 -0.10 (15)	0.40 0.17 (15)	-0.12 0.07 (15)
L-MG	-0.31 -0.32 (15)	-0.57** -0.60** (15)	-0.10 -0.09 (15)	-0.12 -0.13 (15)	-0.31 -0.07 (15)	-0.46@ -0.43@ (13)	-0.18 -0.22 (15)	0.40 0.16 (15)	-0.29 -0.07 (15)
L-SI	0.05 0.06 (15)	-0.21 -0.21 (15)	0.17 0.20 (15)	0.02 0.10 (15)	-0.25 -0.32 (15)	-0.37@ -0.27@ (13)	0.02 0.01 (15)	-0.00 0.17 (15)	-0.24 -0.36 (15)
L-SR	0.15 0.00 (15)	-0.10 -0.29 (15)	0.18 0.16 (15)	-0.13 -0.09 (15)	-0.11 -0.31 (15)	-0.36@ -0.31@ (13)	0.35 0.12 (15)	0.30 0.20 (15)	-0.14 -0.14 (15)

NOTE: (1) Pearson correlation/Spearman correlation/(sample size). If either element has a concentration below the laboratory detection limits, it is omitted from the pairwise computations.
(2) Significance levels: *-10%, **-5%, ***-1%.

	LTAK	L-NA	LN/C	L-B	L-K	L-CA	L-MG	L-SI	L-SR
LTAK	1.00 (15)								
L-NA	-0.16 -0.03 (15)	1.00 (15)							
LN/C	-0.16 -0.03 (15)	1.00*** 1.008 (15)	1.00 (15)						
L-B	0.09 0.18 (15)	0.92*** 0.89*** (15)	0.92*** 0.89*** (15)	1.00 (15)					
L-K	-0.03 -0.16 (15)	-0.64** -0.57** (15)	-0.64** -0.57** (15)	-0.73*** -0.63** (15)	1.00 (15)				
L-CA	0.50* 0.31 (15)	0.57** 0.64*** (15)	0.57** 0.64*** (15)	0.74*** 0.77*** (15)	-0.55** -0.65*** (15)	1.00 (15)			
L-MG	0.53** 0.33 (15)	0.51* 0.45* (15)	0.51* 0.45* (15)	0.77*** 0.74*** (15)	-0.57** -0.60** (15)	0.84*** 0.73*** (15)	1.00 (15)		
L-SI	-0.12 -0.19 (15)	0.72*** 0.90*** (15)	0.72*** 0.90*** (15)	0.55** 0.68*** (15)	-0.28 -0.30 (15)	0.30 0.49* (15)	0.18 0.21 (15)	1.00 (15)	
L-SR	0.23 0.20 (15)	0.48* 0.71*** (15)	0.48* 0.71*** (15)	0.48* 0.71*** (15)	-0.32 -0.41 (15)	0.66*** 0.77*** (15)	0.35 0.42 (15)	0.58** 0.71*** (15)	1.00 (15)

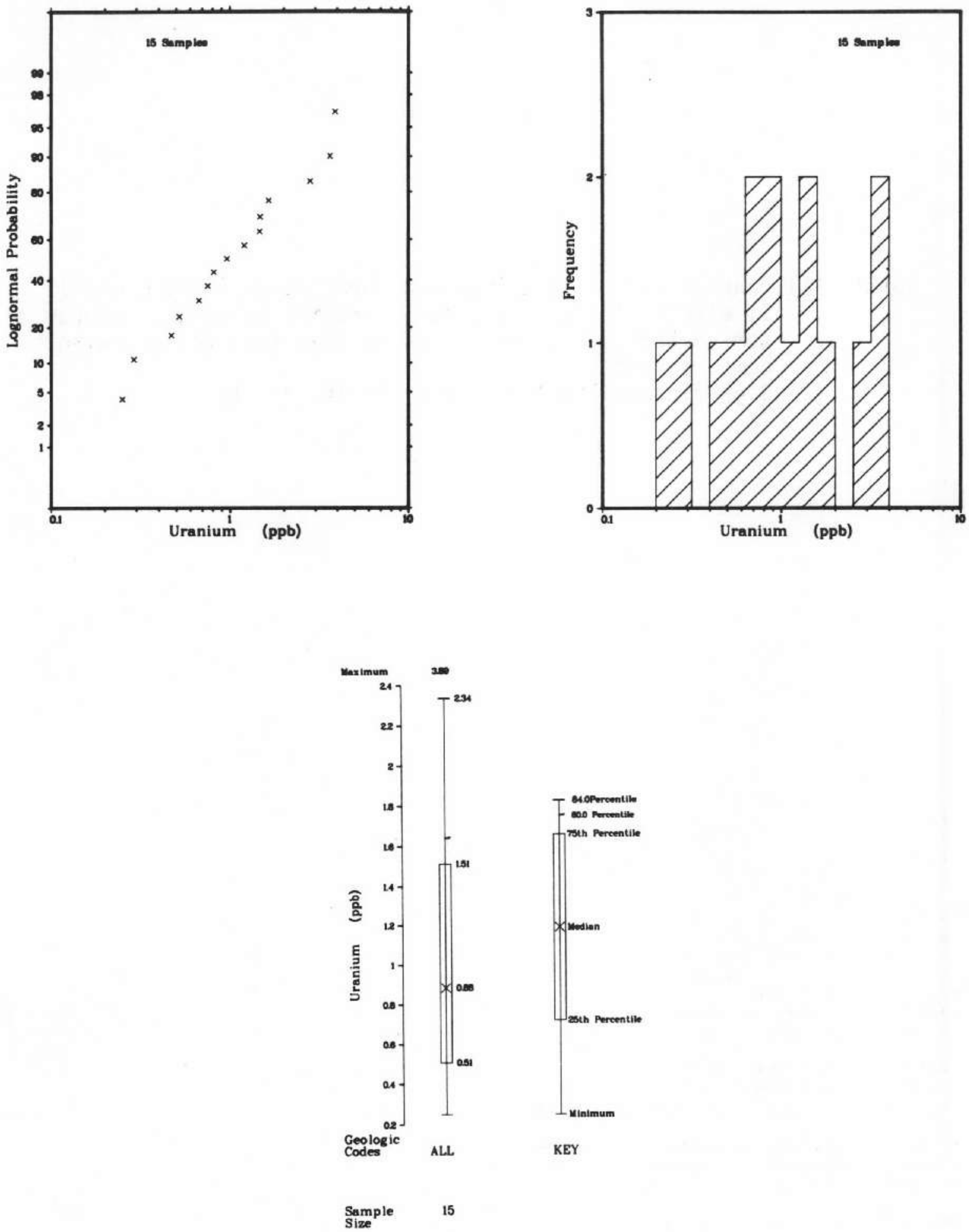


Figure A-1a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR URANIUM (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

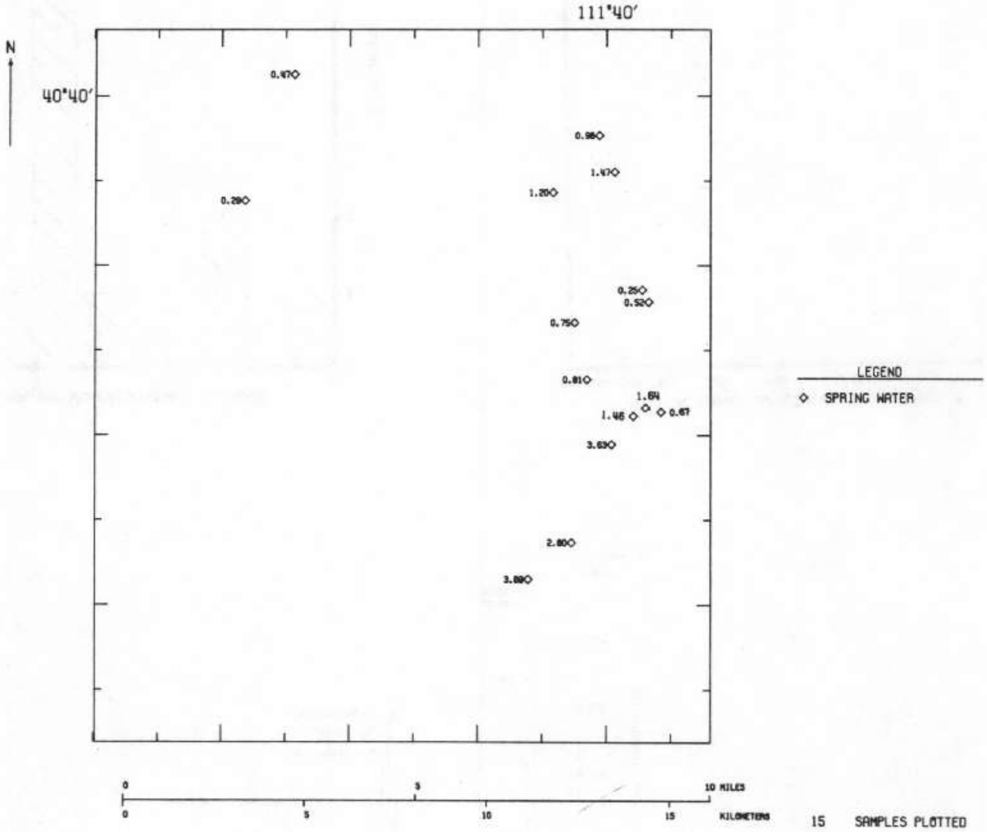


Figure A-1b

GEOCHEMICAL DISTRIBUTION OF URANIUM (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

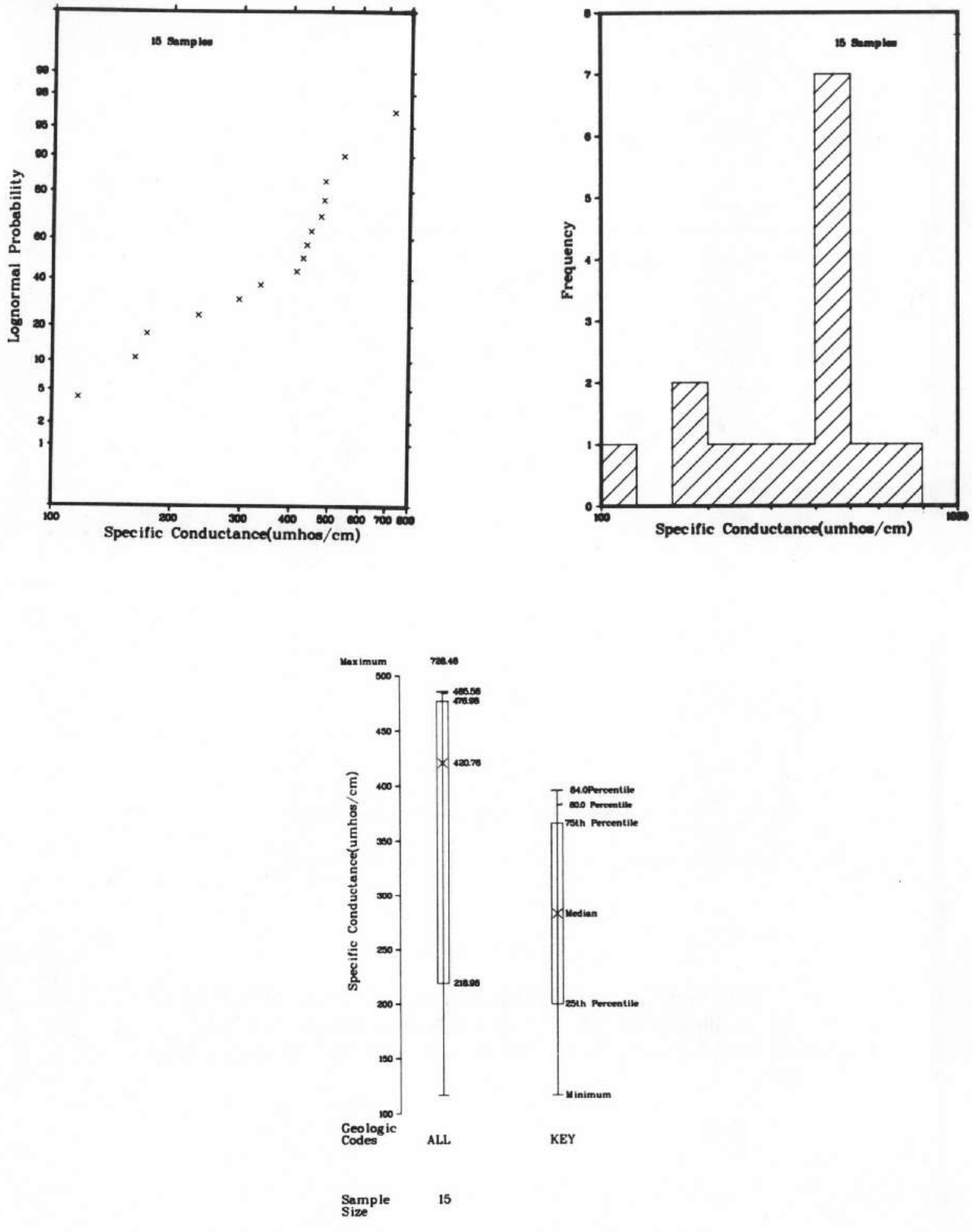


Figure A-2a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR SPECIFIC CONDUCTANCE (μMHOS/CM) IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

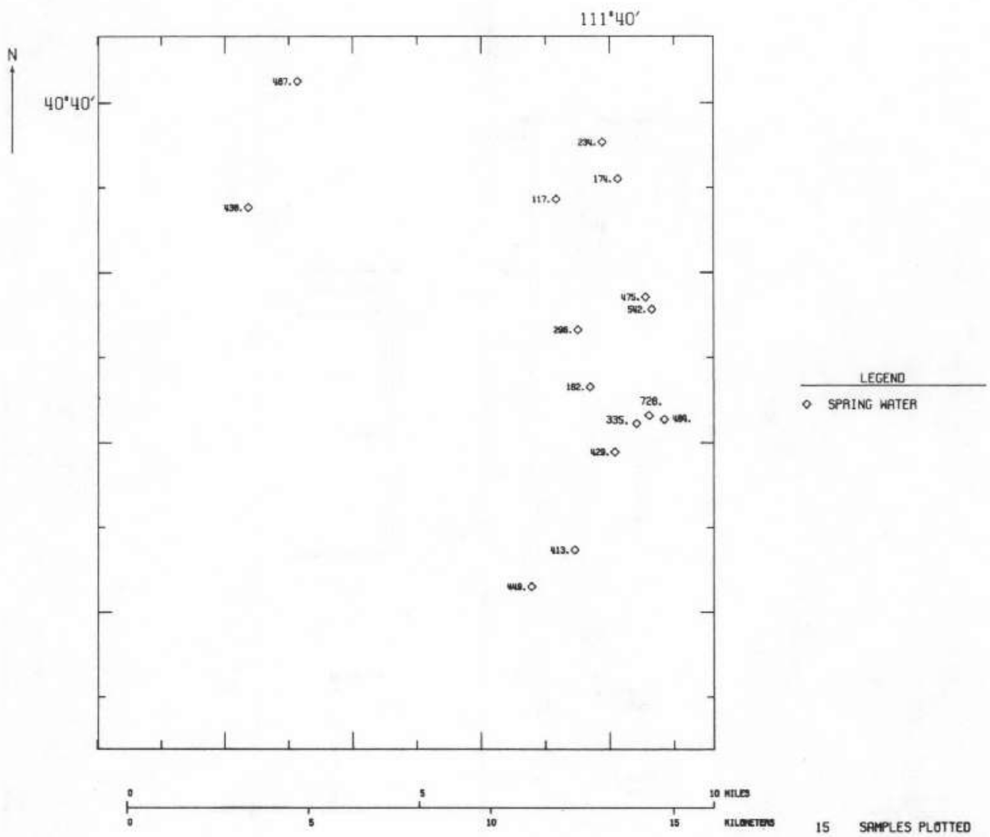


Figure A-2b

GEOCHEMICAL DISTRIBUTION OF SPECIFIC CONDUCTANCE (μMHOS/CM)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

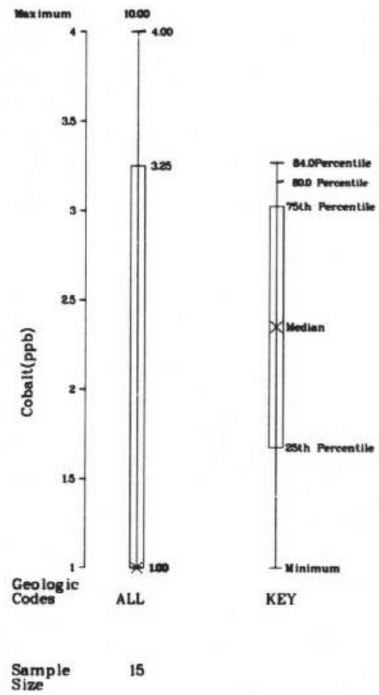


Figure A-3a

PERCENTILE PLOT FOR COBALT (PPB) IN GROUNDWATER
OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

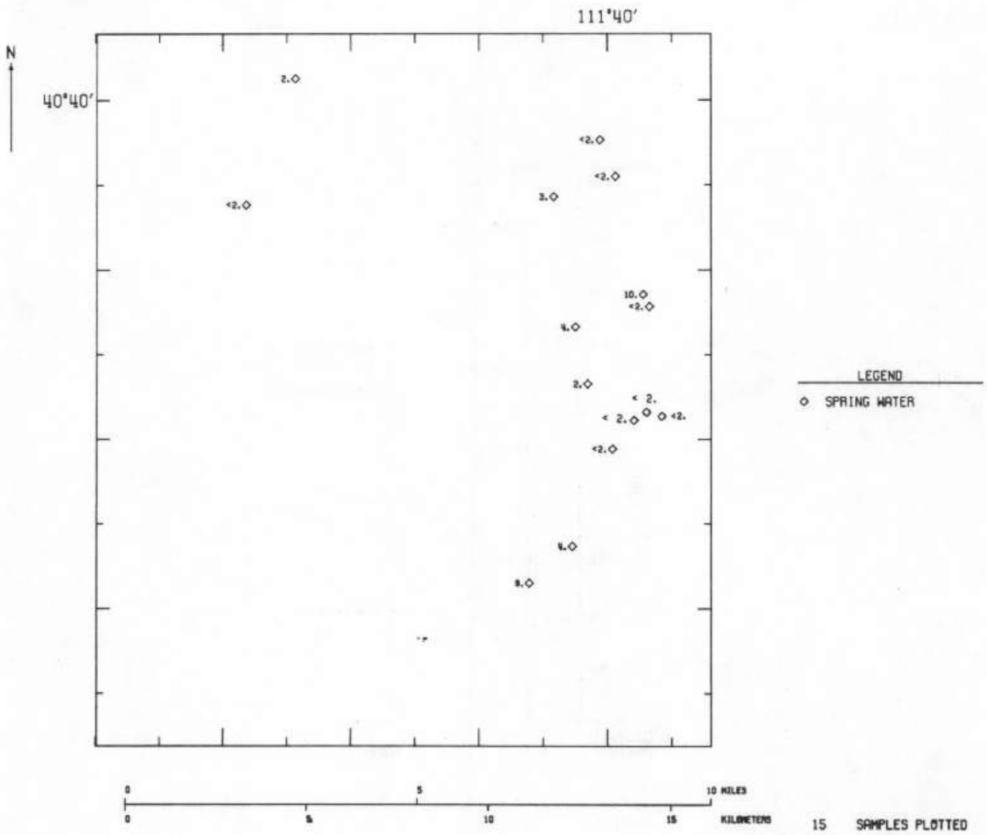


Figure A-3b

GEOCHEMICAL DISTRIBUTION OF COBALT (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

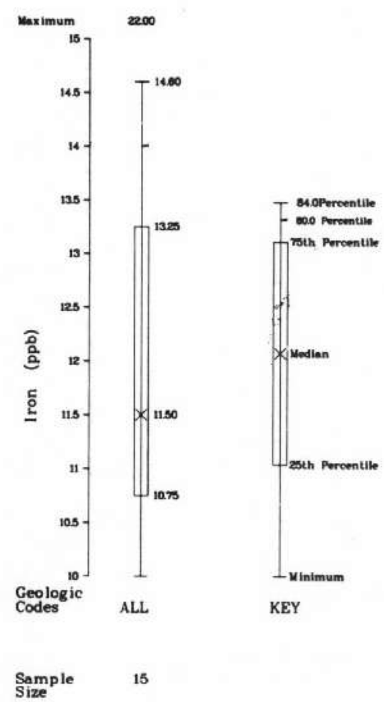


Figure B-4a

PERCENTILE PLOT FOR IRON (PPB) IN GROUNDWATER
OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

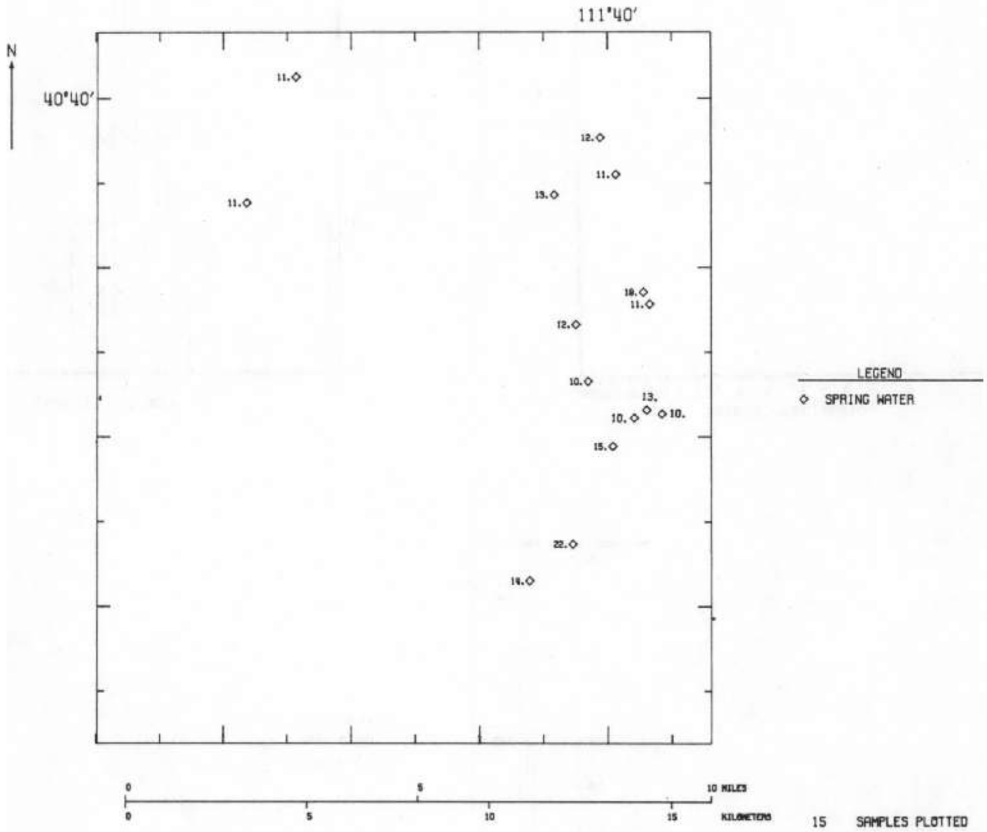


Figure A-4b

GEOCHEMICAL DISTRIBUTION OF IRON (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

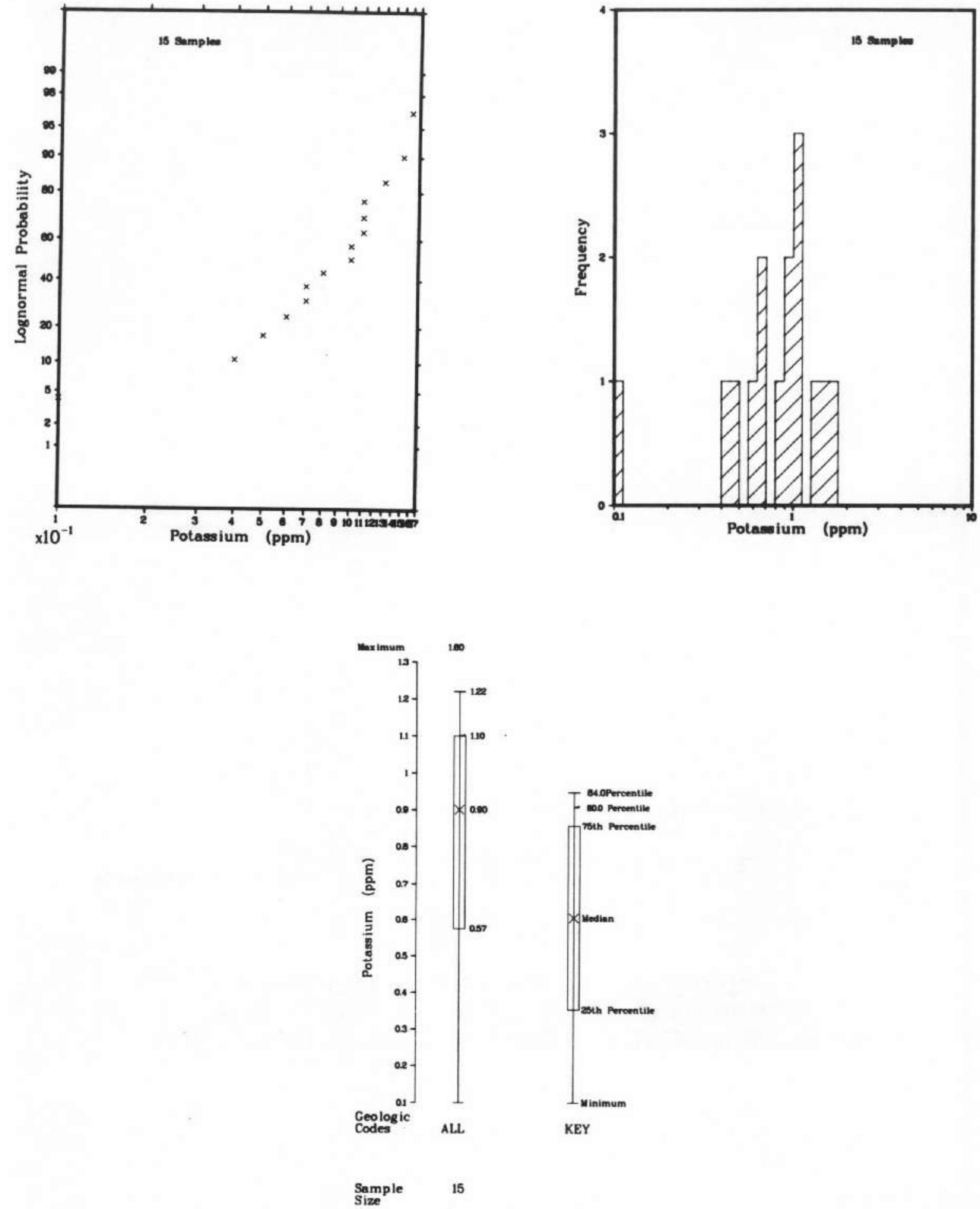


Figure A-5a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR POTASSIUM (PPM)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

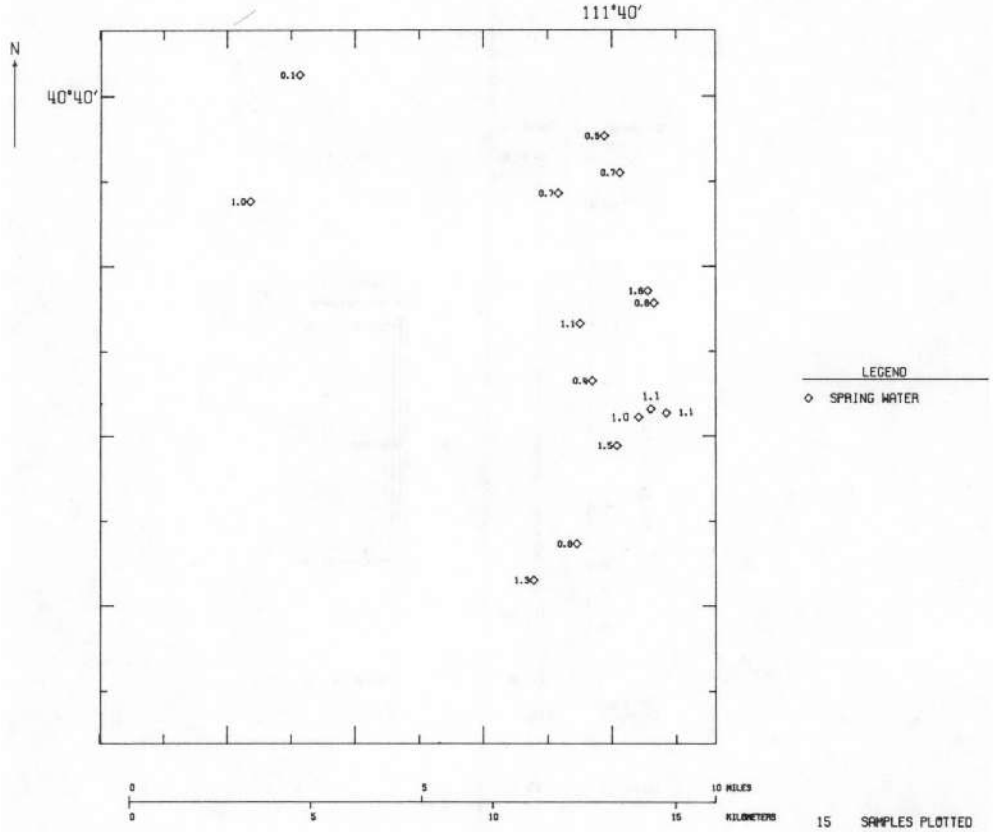


Figure A-5b

GEOCHEMICAL DISTRIBUTION OF POTASSIUM (PPM)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

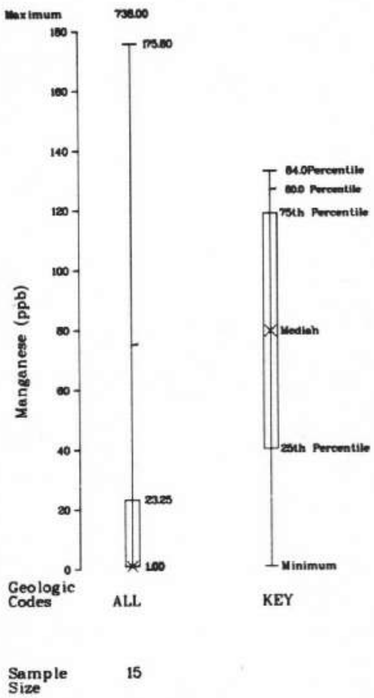


Figure A-6a

PERCENTILE PLOT FOR MANGANESE (PPB) IN GROUNDWATER
OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

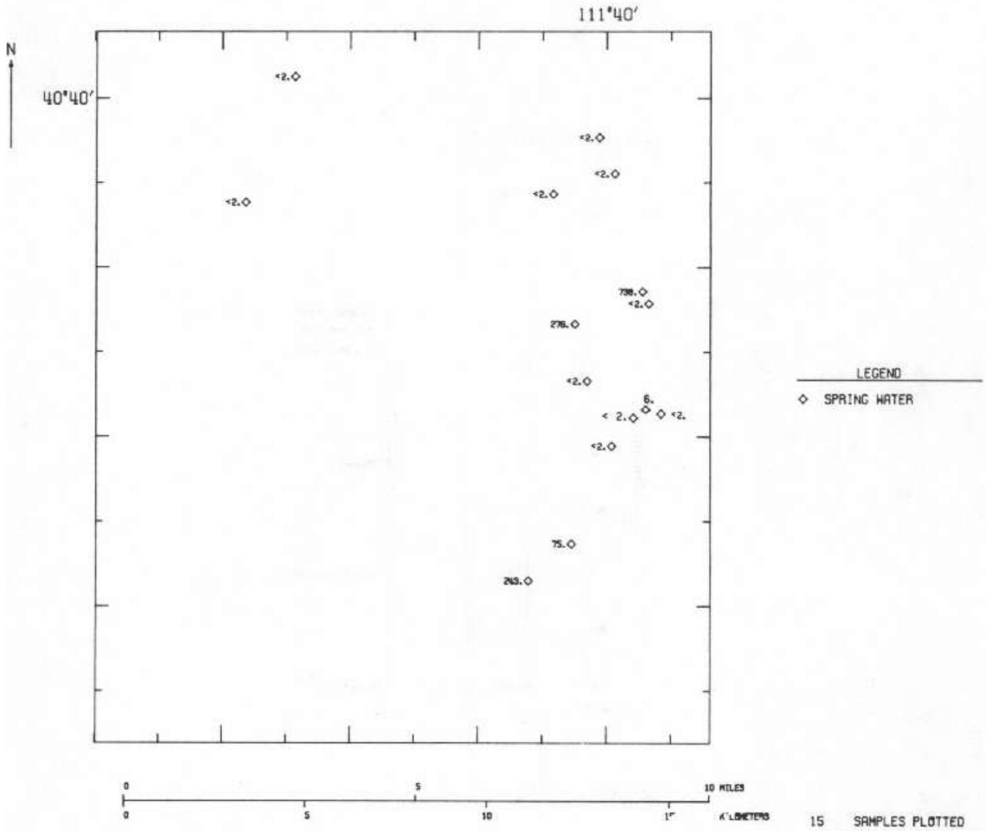


Figure A-6b

GEOCHEMICAL DISTRIBUTION OF MANGANESE (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

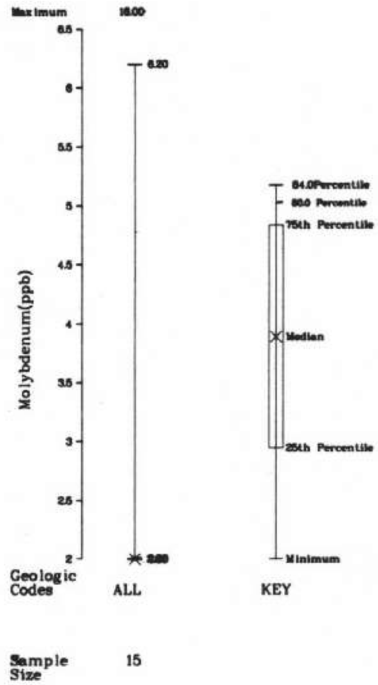


Figure A-7a

PERCENTILE PLOT FOR MOLYBDENUM (PPB) IN GROUNDWATER
OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

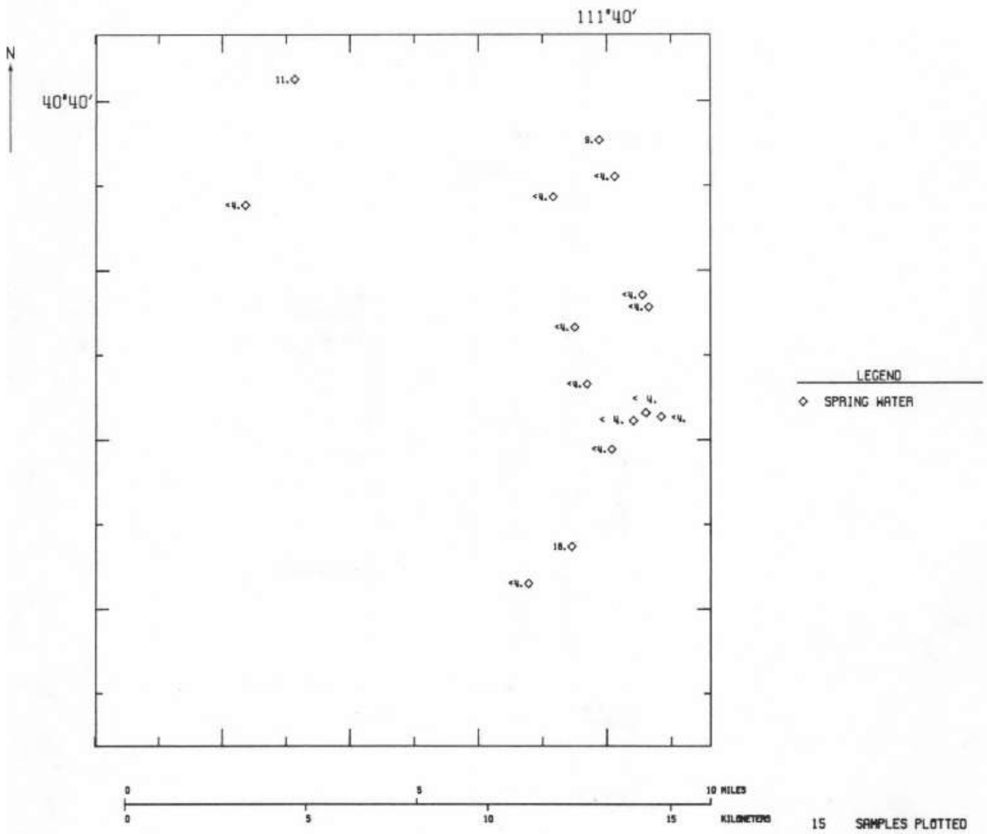


Figure A-7b

GEOCHEMICAL DISTRIBUTION OF MOLYBDENUM (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

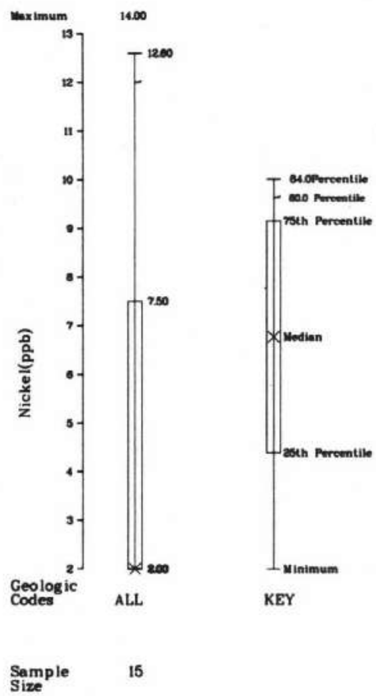


Figure A-8a

PERCENTILE PLOT FOR NICKEL (PPB) IN GROUNDWATER
OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

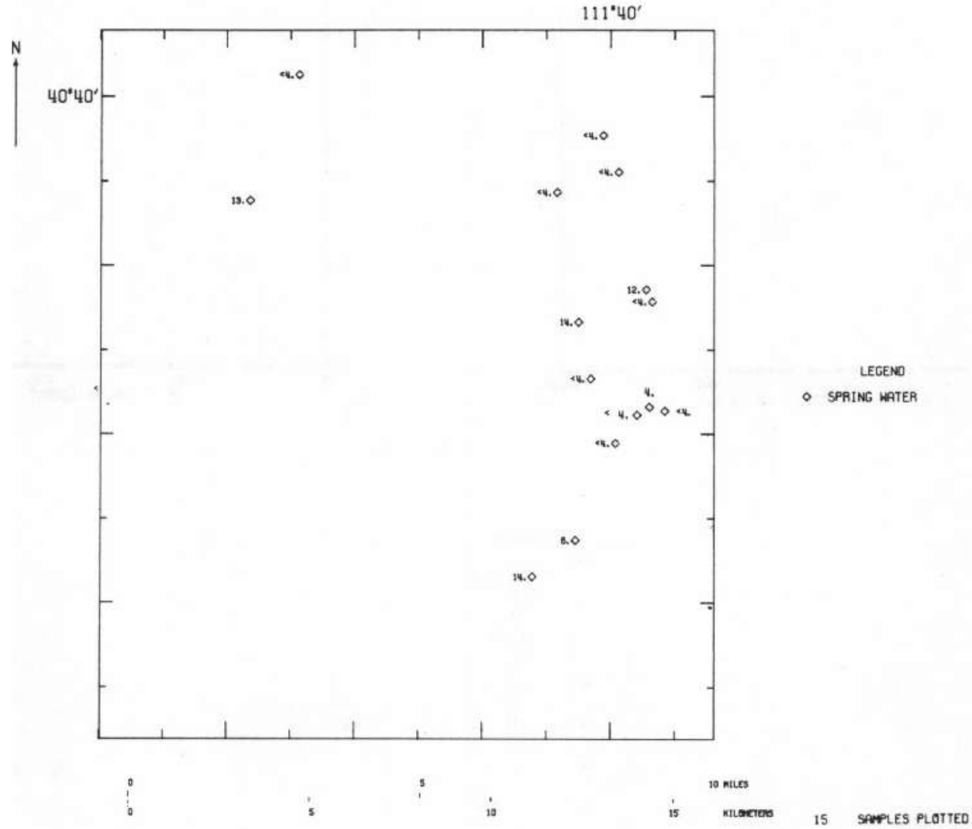


Figure A-8b

GEOCHEMICAL DISTRIBUTION OF NICKEL (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

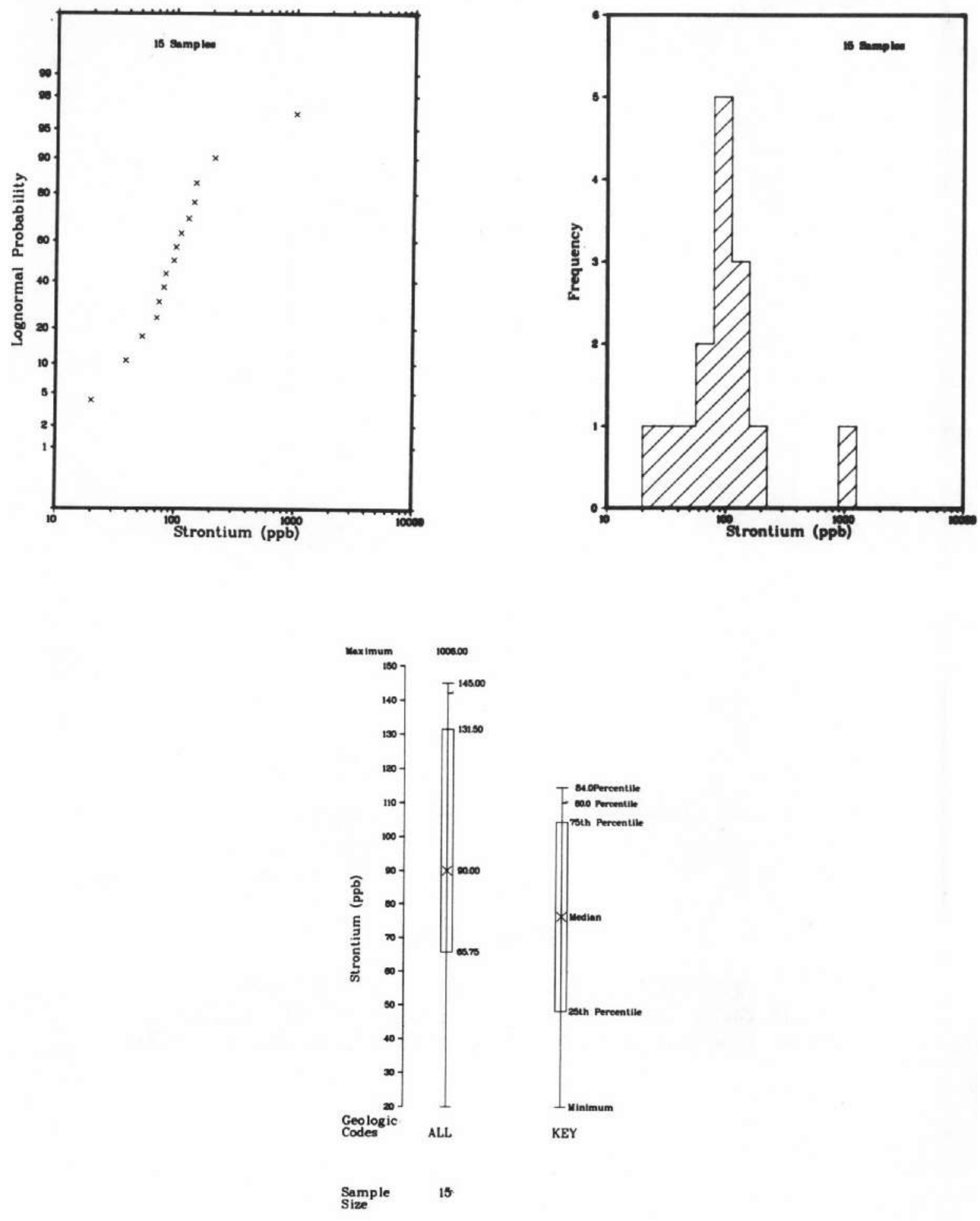


Figure A-9a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR STRONTIUM (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

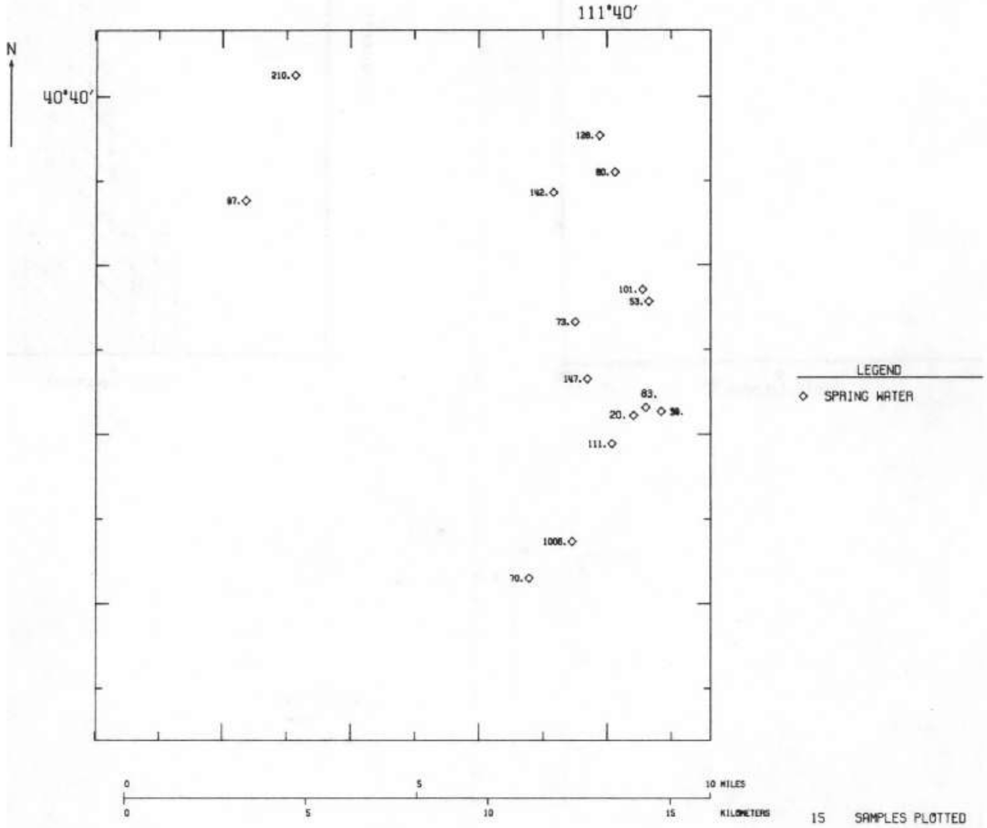
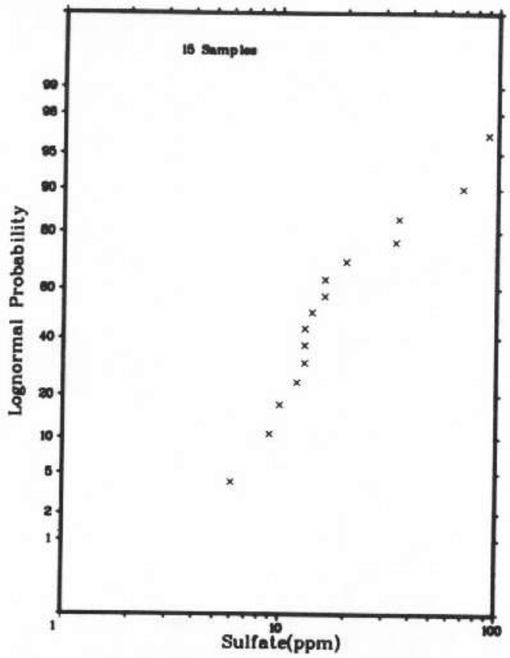
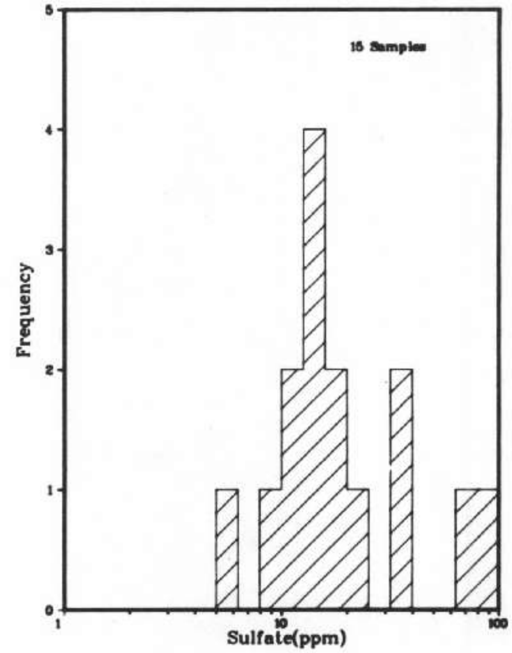


Figure A-9b

GEOCHEMICAL DISTRIBUTION OF STRONTIUM (PPB)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH





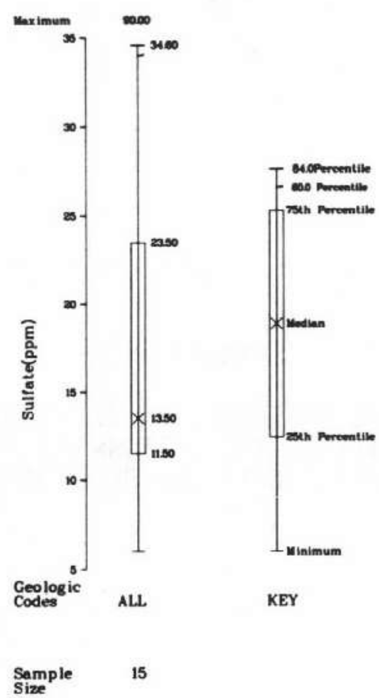


Figure A-10a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR SULFATE (PPM)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

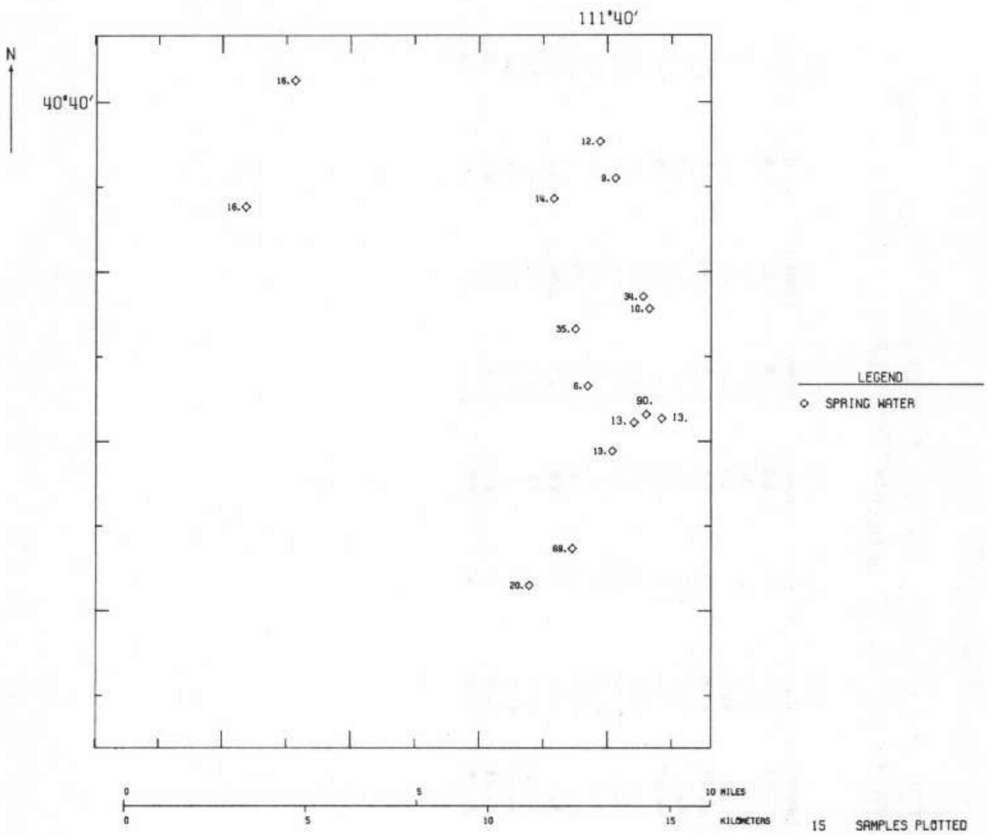


Figure A-10b

GEOCHEMICAL DISTRIBUTION OF SULFATE (PPM)
IN GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

Table A-3

PARTIAL DATA LISTING FOR GROUNDWATER OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

DR SAMPLE NJMBER	D. O. E. SAMPLE NUMBER ST LAT LONG L TY REP	U (PPB)	SP UMHOS/CM	CO (PPB)	FE (PPB)	K (PPM)	MN (PPB)	NI (PPB)	SO4 (PPM)	MO (PPB)	SR (PPB)
908526	18-40.657 -111.669 -3-01-	0.96	230	<2	12	0.5	<2	<4	12	9	130
908527	18-40.648 -111.664 -3-01-	1.5	170	<2	11	0.7	<2	<4	9	<4	80
908528	18-40.643 -111.684 -3-01-	1.2	120	3	13	0.7	<2	<4	14	<4	140
908538	18-40.619 -111.655 -3-01-	0.25	470	10	19	1.6	740	12	34	<4	100
908539	18-40.616 -111.653 -3-01-	0.52	540	<2	11	0.6	<2	<4	10	<4	53
908904	18-40.589 -111.649 -3-01-	0.67	480	<2	10	1.1	<2	<4	13	<4	39
908905	18-40.588 -111.658 -3-01-	1.5	340	<2	10	1.0	<2	<4	13	<4	20
908906	18-40.590 -111.654 -3-01-	1.6	730	<2	13	1.1	6	4	90	<4	83
908915	18-40.581 -111.665 -3-01-	3.6	430	<2	15	1.5	<2	<4	13	<4	110
908930	18-40.557 -111.678 -3-01-	2.8	410	4	22	0.8	75	6	69	18	1000
908938	18-40.548 -111.692 -3-01-	3.9	450	9	14	1.3	240	14	20	<4	70
909312	18-40.641 -111.784 -3-01-	0.29	440	<2	11	1.0	<2	13	16	<4	97
909315	18-40.672 -111.768 -3-01-	0.47	490	2	11	0.1	<2	<4	16	11	210
909331	18-40.597 -111.673 -3-01-	0.81	160	2	10	0.4	<2	<4	6	<4	150
909333	18-40.611 -111.677 -3-01-	0.75	300	4	12	1.1	280	14	35	<4	73

APPENDIX B

STREAM SEDIMENT

APPENDIX B

STREAM SEDIMENT

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES, Continued

LIST OF FIGURES, Continued

LIST OF FIGURES, Continued

Table B-1

STATISTICAL SUMMARY FOR STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

ELEMENT	NO. SAMPLES ANALYZED: MEASURABLE VALUES	NO. SAMPLES ANALYZED: BELOW DETECTION LIMIT	DETECTION LIMIT	MINIMUM VALUE	MAXIMUM VALUE	MEAN	MEDIAN	MODE	STANDARD DEVIATION	COEFFICIENT OF VARIATION	LN TRANSFORMATION: MEAN	LN TRANSFORMATION: S. D.	LN TRANSFORMATION: ROBUST MEAN	LN TRANSFORMATION: ROBUST S. D.
U-FL	77			0.31	72.64	8.73	3.69	2.44	12.247	1.404	1.57	1.03	1.55	1.01
U-NT	78			1.80	75.20	10.17	4.90	3.33	12.335	1.212	1.90	0.83	1.86	0.84
TH	74	3	<2	<2	48	12	11	7	9.0	0.7	2.33	0.69	2.29	0.80
U/TU	77			0.07	1.15	0.75	0.74	0.96	0.213	0.282	-0.34	0.39	-0.31	0.32
TH/U	77			0.23	6.00	1.80	1.53	2.10	1.252	0.696	0.33	0.77	0.35	0.86
AG	17	60	<2	<2	24	5	<2	<2	7.2	1.3	1.27	0.86		
AL	77			2.37	8.51	5.58	5.67	6.74	1.427	0.256	1.68	0.29	1.70	0.32
AS	77			1.0	295.4	23.4	11.5	8.2	42.59	1.82	2.53	1.00	2.51	1.04
B	55	22	<10	<10	228	31	22	<10	29.1	0.9	3.28	0.53	3.01	0.70
BA	77			270	1354	728	663	675	249.2	0.3	6.53	0.35	6.54	0.37
BE	77			1	5	2	2	2	0.8	0.4	0.69	0.40	0.69	0.40
CA	77			0.25	13.17	2.30	1.27	1.95	2.743	1.190	0.38	0.91	0.36	0.97
CE	77			12	247	74	62	45	44.6	0.6	4.16	0.57	4.16	0.57
CO	76	1	<4	<4	175	15	10	10	20.8	1.4	2.44	0.61	2.39	0.73
CR	77			17	114	45	40	38	17.9	0.4	3.74	0.35	3.74	0.37
CU	77			14	1767	116	49	23	232.4	2.0	4.08	0.99	4.02	0.99
FE	77			1.18	13.45	3.61	3.37	2.34	1.805	0.501	1.18	0.44	1.18	0.42
K	77			0.53	2.48	1.56	1.54	1.55	0.393	0.252	0.41	0.27	0.42	0.27
LI	77			17	81	36	34	45	13.5	0.4	3.54	0.36	3.53	0.37
MG	77			0.33	6.55	1.40	0.86	0.76	1.339	0.960	0.05	0.68	0.02	0.75
MN	77			210	5228	909	730	706	669.6	0.7	6.66	0.52	6.65	0.54
MO	22	55	<4	<4	147	23	<4	<4	35.8	1.5	2.42	1.12		
NA	77			0.13	2.78	0.81	0.63	0.41	0.595	0.735	-0.48	0.75	-0.47	0.79
NB	63	14	<4	<4	72	12	7	<4	10.9	0.8	2.32	0.65	2.07	0.86
NI	77			5	178	30	22	23	27.6	0.9	3.22	0.59	3.18	0.57
P	77			380	5407	1207	978	856	869.2	0.7	6.92	0.56	6.90	0.59
SC	77			3	18	7	7	7	3.0	0.4	1.98	0.39	1.98	0.43
SE	75	2	<0.1	<0.1	5.9	1.3	1.0	0.6	1.03	0.77	0.05	0.71	0.02	0.78
SR	77			40	589	184	142	111	111.6	0.6	5.05	0.57	5.05	0.54
TI	77			796	9729	2905	2565	2966	1562.7	0.5	7.86	0.48	7.85	0.49
V	77			27	160	74	70	70	26.7	0.4	4.25	0.35	4.25	0.40
Y	77			5	74	18	15	13	11.4	0.6	2.76	0.50	2.75	0.50
ZN	77			36	5214	406	131	98	755.2	1.9	5.23	1.07	5.18	1.11
ZR	77			14	81	35	31	22	16.6	0.5	3.47	0.44	3.47	0.44

NOTE: Refer to Table 1, Page 25 and Table C-1, Page C-4 for concentration units and symbol definitions.

Table B-2

CORRELATION MATRIX FOR STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

	L-U	LUNT	L-TH	L-NA	L-SR	L-BA	L-P	L-CE	L-NB	L-Y	L-AL	L-SC	L-TI	L-V
L-U	1.00 (77)													
LUNT	0.93*** 0.90*** (77)	1.00 (78)												
L-TH	0.52*** 0.58*** (74)	0.58*** 0.60*** (74)	1.00 (74)											
L-NA	0.69*** 0.75*** (77)	0.70*** 0.69*** (77)	0.49*** 0.54*** (74)	1.00 (77)										
L-SR	0.63*** 0.63*** (77)	0.63*** 0.60*** (77)	0.34*** 0.36*** (74)	0.79*** 0.80*** (77)	1.00 (77)									
L-BA	0.51*** 0.57*** (77)	0.60*** 0.62*** (77)	0.49*** 0.51*** (74)	0.73*** 0.67*** (77)	0.71*** 0.71*** (77)	1.00 (77)								
L-P	0.59*** 0.64*** (77)	0.55*** 0.49*** (77)	0.39*** 0.43*** (74)	0.68*** 0.67*** (77)	0.69*** 0.63*** (77)	0.62*** 0.60*** (77)	1.00 (77)							
L-CE	0.67*** 0.79*** (77)	0.69*** 0.76*** (77)	0.64*** 0.67*** (74)	0.78*** 0.81*** (77)	0.66*** 0.68*** (77)	0.72*** 0.69*** (77)	0.69*** 0.65*** (77)	1.00 (77)						
L-NB	0.55*** 0.61*** (63)	0.57*** 0.62*** (63)	0.53*** 0.49*** (62)	0.74*** 0.79*** (63)	0.62*** 0.62*** (63)	0.46*** 0.46*** (63)	0.53*** 0.45*** (63)	0.77*** 0.76*** (63)	1.00 (63)					
L-Y	0.52*** 0.64*** (77)	0.45*** 0.51*** (77)	0.33*** 0.31*** (74)	0.67*** 0.72*** (77)	0.47*** 0.57*** (77)	0.45*** 0.47*** (77)	0.63*** 0.69*** (77)	0.69*** 0.70*** (77)	0.68*** 0.65*** (63)	1.00 (77)				
L-AL	0.38*** 0.49*** (77)	0.47*** 0.57*** (77)	0.43*** 0.55*** (74)	0.68*** 0.65*** (77)	0.42*** 0.45*** (77)	0.75*** 0.70*** (77)	0.33*** 0.30*** (77)	0.60*** 0.62*** (77)	0.39*** 0.50*** (63)	0.39*** 0.41*** (77)	1.00 (77)			
L-SC	0.18 0.30*** (77)	0.20* 0.31*** (77)	0.31*** 0.36*** (74)	0.54*** 0.46*** (77)	0.22* 0.21* (77)	0.47*** 0.40*** (77)	0.33*** 0.25** (77)	0.48*** 0.47*** (77)	0.46*** 0.48*** (63)	0.54*** 0.46*** (77)	0.78*** 0.69*** (77)	1.00 (77)		
L-TI	0.57*** 0.67*** (77)	0.61*** 0.67*** (77)	0.58*** 0.60*** (74)	0.84*** 0.85*** (77)	0.58*** 0.61*** (77)	0.70*** 0.68*** (77)	0.63*** 0.56*** (77)	0.85*** 0.84*** (77)	0.78*** 0.77*** (63)	0.70*** 0.68*** (77)	0.75*** 0.77*** (77)	0.77*** 0.74*** (77)	1.00 (77)	
L-V	0.38*** 0.49*** (77)	0.44*** 0.54*** (77)	0.48*** 0.58*** (74)	0.74*** 0.70*** (77)	0.46*** 0.46*** (77)	0.67*** 0.66*** (77)	0.53*** 0.48*** (77)	0.67*** 0.69*** (77)	0.60*** 0.61*** (63)	0.53*** 0.46*** (77)	0.80*** 0.77*** (77)	0.84*** 0.75*** (77)	0.88*** 0.88*** (77)	1.00 (77)
L-FE	0.37*** 0.47*** (77)	0.41*** 0.51*** (77)	0.41*** 0.49*** (74)	0.55*** 0.55*** (77)	0.23** 0.28** (77)	0.54*** 0.55*** (77)	0.43*** 0.45*** (77)	0.51*** 0.58*** (77)	0.48*** 0.49*** (63)	0.41*** 0.36*** (77)	0.64*** 0.64*** (77)	0.67*** 0.64*** (77)	0.71*** 0.75*** (77)	0.84*** 0.87*** (77)
L-C	0.23** 0.29** (77)	0.35*** 0.40*** (77)	0.28** 0.32*** (74)	0.36*** 0.33*** (77)	0.14 0.16 (77)	0.56*** 0.46*** (77)	0.12 0.10 (77)	0.47*** 0.42*** (77)	0.09 0.14 (63)	0.22* 0.21* (77)	0.75*** 0.72*** (77)	0.43*** 0.36*** (77)	0.47*** 0.48*** (77)	0.44*** 0.43*** (77)
L-LI	0.11 0.17 (77)	0.05 0.08 (77)	0.04 0.06 (74)	0.28** 0.24** (77)	0.15 0.19 (77)	0.27** 0.23** (77)	0.14 0.22* (77)	0.09 0.09 (77)	-0.17 -0.12 (63)	0.20* 0.26** (77)	0.45*** 0.39*** (77)	0.38*** 0.35*** (77)	0.14 0.18 (77)	0.19* 0.14 (77)
L-ZR	-0.10 0.04 (77)	-0.16 -0.02 (77)	-0.15 -0.17 (74)	0.07 0.06 (77)	0.04 0.09 (77)	0.06 0.01 (77)	-0.10 -0.05 (77)	0.10 0.11 (77)	-0.15 -0.11 (63)	0.19* 0.23** (77)	0.25** 0.18 (77)	0.23** 0.23** (77)	0.06 0.09 (77)	-0.05 -0.10 (77)
L-SE	-0.07 -0.13 (75)	-0.07 -0.06 (75)	-0.11 -0.20* (73)	-0.29** -0.27** (75)	-0.10 -0.13 (75)	-0.25** -0.25** (75)	-0.17 -0.19 (75)	-0.26** -0.30*** (75)	-0.10 -0.05 (61)	-0.19 -0.11 (75)	-0.20* -0.23* (75)	-0.17 -0.07 (75)	-0.33*** -0.31*** (75)	-0.38*** -0.38*** (75)
L-CA	0.15 0.27** (77)	0.02 0.10 (77)	-0.06 -0.01 (74)	0.16 0.34*** (77)	0.32*** 0.39*** (77)	-0.11 0.03 (77)	0.34*** 0.44*** (77)	0.14 0.25** (77)	0.23* 0.32*** (63)	0.38*** 0.53*** (77)	-0.38*** -0.11 (77)	-0.20* -0.02 (77)	0.05 0.22* (77)	-0.09 0.09 (77)
L-MG	-0.11 0.05 (77)	-0.25** -0.14 (77)	-0.14 -0.10 (74)	-0.08 0.07 (77)	-0.06 0.00 (77)	-0.30*** -0.18 (77)	0.09 0.25** (77)	-0.07 0.05 (77)	-0.08 0.05 (63)	0.16 0.30*** (77)	-0.39*** -0.13 (77)	-0.12 0.15 (77)	-0.07 0.15 (77)	-0.09 0.14 (77)
LUTU	0.64*** 0.67*** (77)	0.32*** 0.34*** (77)	0.13 0.25** (74)	0.34*** 0.51*** (77)	0.30*** 0.43*** (77)	0.06 0.24** (77)	0.39*** 0.56*** (77)	0.27** 0.44*** (77)	0.18 0.29** (63)	0.40*** 0.50*** (77)	-0.01 0.18 (77)	0.05 0.13 (77)	0.21* 0.33*** (77)	0.07 0.17 (77)
L-MN	-0.01 0.03 (77)	-0.06 -0.04 (77)	0.01 0.03 (74)	0.02 0.08 (77)	-0.06 -0.02 (77)	0.13 0.21* (77)	0.16 0.22** (77)	-0.01 0.02 (77)	-0.17 -0.12 (63)	0.14 0.10 (77)	0.05 0.15 (77)	0.09 0.11 (77)	0.07 0.14 (77)	0.12 0.19* (77)
L-ZN	0.03 0.05 (77)	-0.05 -0.11 (77)	-0.04 -0.01 (74)	-0.13 -0.06 (77)	-0.13 -0.13 (77)	-0.10 -0.04 (77)	0.06 0.20* (77)	-0.01 0.02 (77)	-0.23* -0.19 (63)	-0.03 0.01 (77)	-0.19* -0.02 (77)	-0.25** -0.09 (77)	-0.12 0.01 (77)	-3.10 0.38 (77)
L-CU	0.04 -0.09 (77)	0.02 -0.09 (77)	-0.01 -0.01 (74)	-0.05 -0.10 (77)	-0.03 -0.10 (77)	0.07 0.09 (77)	0.02 0.15 (77)	-0.11 -0.13 (77)	-0.18 -0.17 (63)	-0.10 -0.13 (77)	0.02 0.02 (77)	-0.16 -0.15 (77)	-0.15 -0.11 (77)	0.03 0.09 (77)
L-AS	-0.29** -0.28** (77)	-0.31*** -0.28** (77)	-0.19 -0.15 (74)	-0.33*** -0.30*** (77)	-0.21* -0.13 (77)	-0.26** -0.21* (77)	-0.15 -0.10 (77)	-0.30*** -0.30*** (77)	-0.28** -0.25* (63)	-0.28** -0.26** (77)	-0.23** -0.19* (77)	-0.20* -0.19* (77)	-0.30*** -0.28** (77)	-0.24** -0.25** (77)
L-CO	-0.18 -0.14 (76)	-0.16 -0.08 (76)	0.11 0.08 (73)	-0.05 -0.06 (76)	-0.33*** -0.24** (76)	0.13 0.18 (76)	-0.11 -0.07 (76)	-0.05 -0.00 (76)	-0.18 -0.17 (62)	-0.11 -0.12 (76)	0.37*** 0.36*** (76)	0.43*** 0.43*** (76)	0.18 0.22* (76)	0.38*** 0.44*** (76)
L-NI	-0.37*** -0.35*** (77)	-0.37*** -0.32*** (77)	-0.05 -0.13 (74)	-0.28** -0.31*** (77)	-0.47*** -0.46*** (77)	-0.06 -0.06 (77)	-0.21* -0.22* (77)	-0.29** -0.28** (77)	-0.36*** -0.40*** (63)	-0.18 -0.19 (77)	0.19* 0.15 (77)	0.38*** 0.35*** (77)	-0.34 -0.04 (77)	0.20* 0.18 (77)
L-CR	-0.25** -0.19 (77)	-0.25** -0.18 (77)	0.00 -0.05 (74)	-0.03 -0.10 (77)	-0.30*** -0.24** (77)	0.04 0.01 (77)	0.01 -0.02 (77)	-0.01 -0.07 (77)	-0.14 -0.22* (63)	-0.01 -0.08 (77)	0.31*** 0.15 (77)	0.56*** 0.51*** (77)	0.22* 0.13 (77)	0.46*** 0.39*** (77)
LTUN	-0.45*** -0.37*** (77)	-0.48*** -0.40*** (77)	0.30** 0.27** (74)	-0.13 -0.19* (77)	-0.25** -0.26** (77)	-0.04 -0.08 (77)	-0.13 -0.12 (77)	0.00 -0.06 (77)	-0.15 -0.20 (63)	-0.03 -0.15 (77)	0.04 0.06 (77)	0.26** 0.28** (77)	0.04 -0.00 (77)	0.12 0.14 (77)

NOTE: (1) Pearson correlation/Spearman correlation/(sample size). If either element has a concentration below the laboratory detection limits, it is omitted from the pairwise computations.
(2) Significance levels: *-10%, **-5%, ***-1%.

	L-FE	L-K	L-LI	L-ZN	L-SE	L-CA	L-MG	LUTU	L-MN	L-ZN	L-CU	L-AS	L-CO	L-NI	L-CR	LTUN
L-FE	1.00 (77)															
L-K	0.42*** 0.39*** (77)	1.00 (77)														
L-LI	0.14 0.12 (77)	0.35*** 0.32*** (77)	1.00 (77)													
L-ZN	-0.19* -0.20* (77)	0.24** 0.23** (77)	0.64*** 0.67*** (77)	1.00 (77)												
L-SE	-0.37*** -0.35*** (75)	-0.11 -0.08 (75)	0.28** 0.34*** (75)	0.35*** 0.33*** (75)	1.00 (75)											
L-CA	-0.14 0.04 (77)	-0.34*** -0.23** (77)	-0.16 -0.11 (77)	-0.15 -0.17 (77)	-0.14 -0.19 (75)	1.00 (77)										
L-MG	-0.02 0.22* (77)	-0.29** -0.19 (77)	-0.08 0.03 (77)	-0.16 -0.11 (77)	-0.17 -0.14 (75)	0.84*** 0.75*** (77)	1.00 (77)									
LUTU	0.06 0.19 (77)	-0.13 -0.05 (77)	0.18 0.27** (77)	0.08 0.09 (77)	-0.02 -0.15 (75)	0.35*** 0.40*** (77)	0.24** 0.25** (77)	1.00 (77)								
L-MN	0.44*** 0.39*** (77)	0.13 0.11 (77)	0.30*** 0.30*** (77)	0.04 0.01 (77)	-0.17 -0.17 (75)	0.17 0.15 (77)	0.36*** 0.36*** (77)	0.10 0.16 (77)	1.00 (77)							
L-ZN	0.22* 0.34*** (77)	0.02 0.02 (77)	0.03 0.13 (77)	-0.15 -0.10 (77)	-0.22* -0.22* (75)	0.34*** 0.25** (77)	0.54*** 0.53*** (77)	0.19* 0.26** (77)	0.75*** 0.72*** (77)	1.00 (77)						
L-CU	0.35*** 0.30*** (77)	0.04 0.00 (77)	0.08 0.10 (77)	-0.22* -0.21* (77)	-0.27** -0.17 (75)	0.03 -0.04 (77)	0.14 0.05 (77)	0.07 0.03 (77)	0.57*** 0.54*** (77)	0.69*** 0.60*** (77)	1.00 (77)					
L-AS	0.02 -0.09 (77)	-0.08 -0.08 (77)	0.12 0.14 (77)	0.04 0.06 (77)	0.19* 0.22* (75)	0.11 0.02 (77)	0.32*** 0.22* (77)	-0.11 -0.13 (77)	0.52*** 0.45*** (77)	0.63*** 0.50*** (77)	0.43*** 0.42*** (77)	1.00 (77)				
L-CO	0.63*** 0.55*** (76)	0.30*** 0.34*** (76)	0.21* 0.22* (76)	-0.03 0.02 (76)	-0.15 -0.14 (74)	-0.42*** -0.29** (76)	-0.05 0.10 (76)	-0.15 -0.14 (76)	0.55*** 0.45*** (76)	0.33*** 0.41*** (76)	0.42*** 0.51*** (76)	0.26** 0.17 (76)	1..0 (76)			
L-NI	0.41*** 0.28** (77)	0.13 0.16 (77)	0.22* 0.26** (77)	-0.03 0.10 (77)	-0.04 0.00 (75)	-0.34*** -0.30*** (77)	0.03 0.11 (77)	-0.20* -0.25** (77)	0.45*** 0.37*** (77)	0.23** 0.29** (77)	0.32*** 0.38*** (77)	0.26** 0.18 (77)	0.84*** 0.83*** (76)	1.00 (77)		
L-CR	0.41*** 0.40*** (77)	0.19* 0.09 (77)	0.17 0.21* (77)	0.00 0.05 (77)	-0.04 0.00 (75)	-0.27** -0.22* (77)	0.02 0.16 (77)	-0.13 -0.22* (77)	0.04 0.05 (77)	-0.04 0.08 (77)	0.01 0.07 (77)	0.01 -0.03 (77)	0.56*** 0.52*** (76)	0.66*** 0.88*** (77)	1.00 (77)	
LTUN	0.07 0.08 (77)	0.03 -0.01 (77)	0.14 0.19 (77)	0.18 0.19 (77)	-0.09 -0.10 (75)	-0.05 -0.16 (77)	0.17 0.12 (77)	-0.17 -0.15 (77)	0.16 0.13 (77)	0.04 0.13 (77)	-0.06 0.01 (77)	0.14 0.19* (77)	0.34*** 0.40*** (76)	0.34*** 0.38*** (77)	0.37*** 0.39*** (77)	1.00 (77)

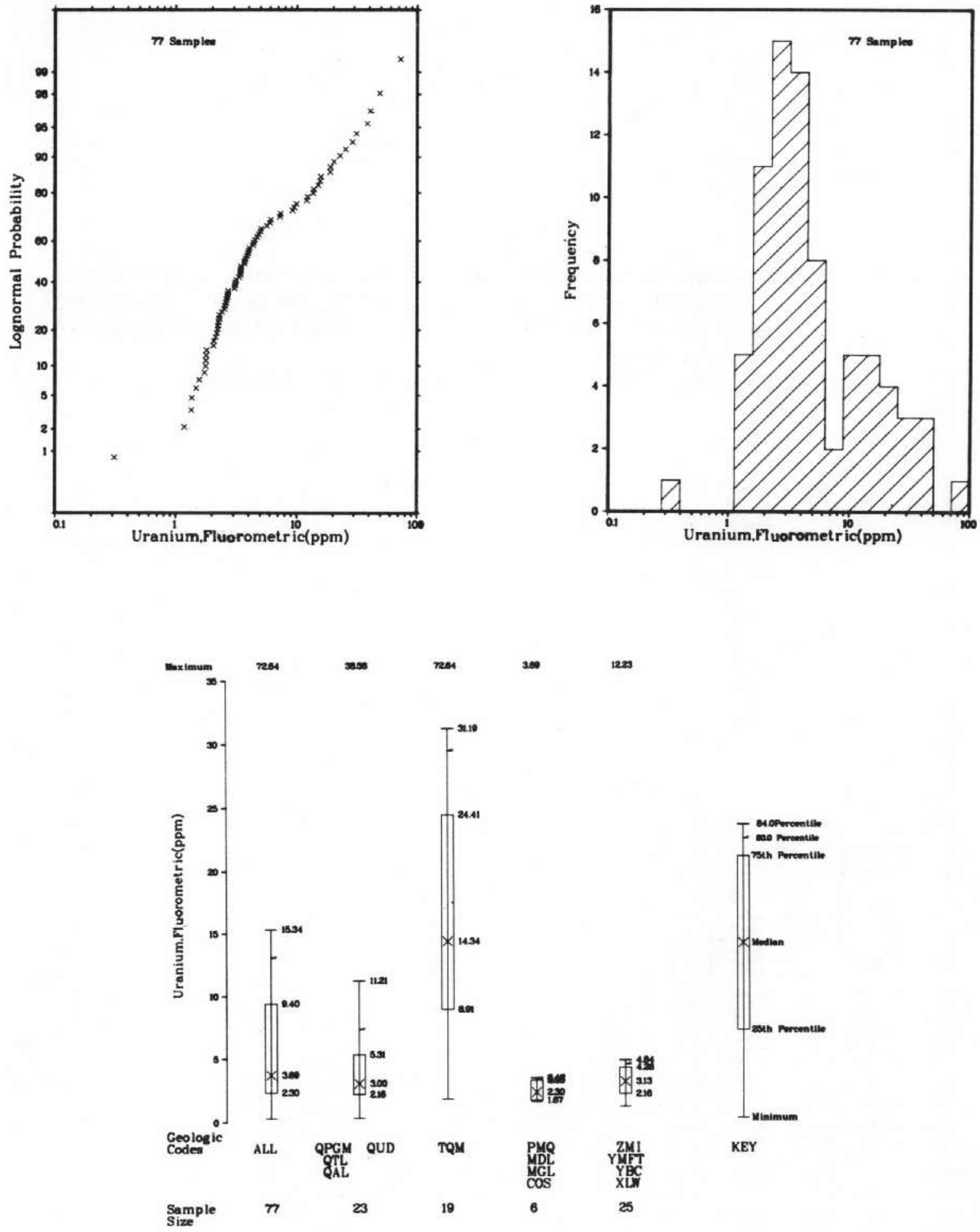


Figure B-1a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR SOLUBLE URANIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

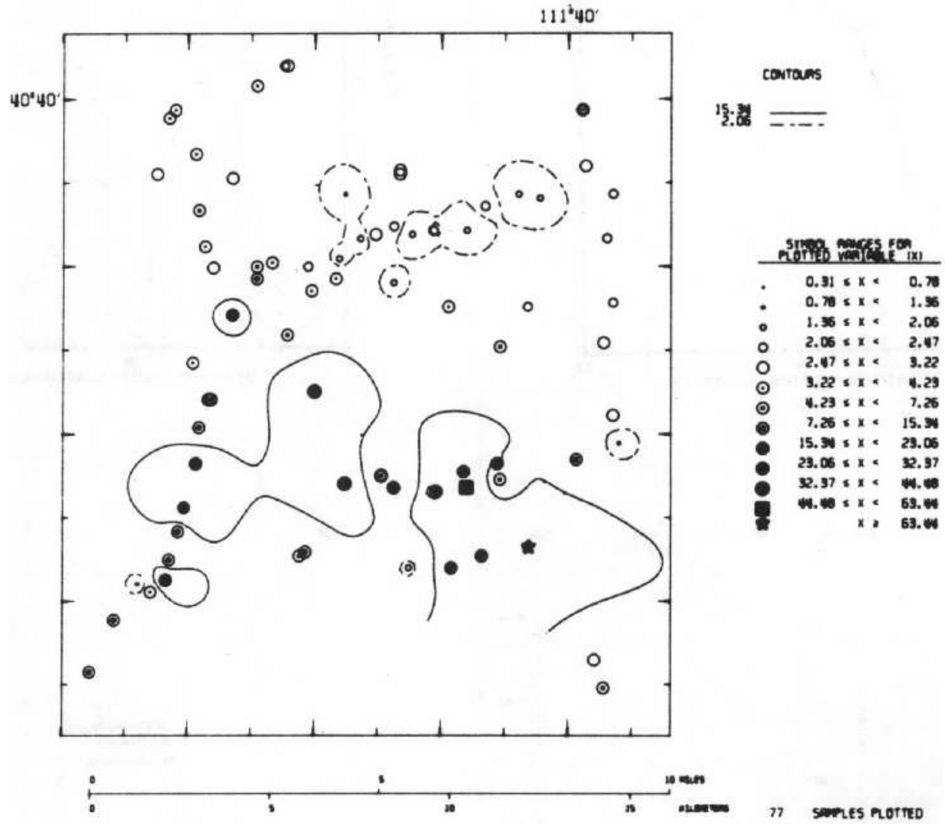


Figure B-1b

GEOCHEMICAL DISTRIBUTION OF SOLUBLE URANIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

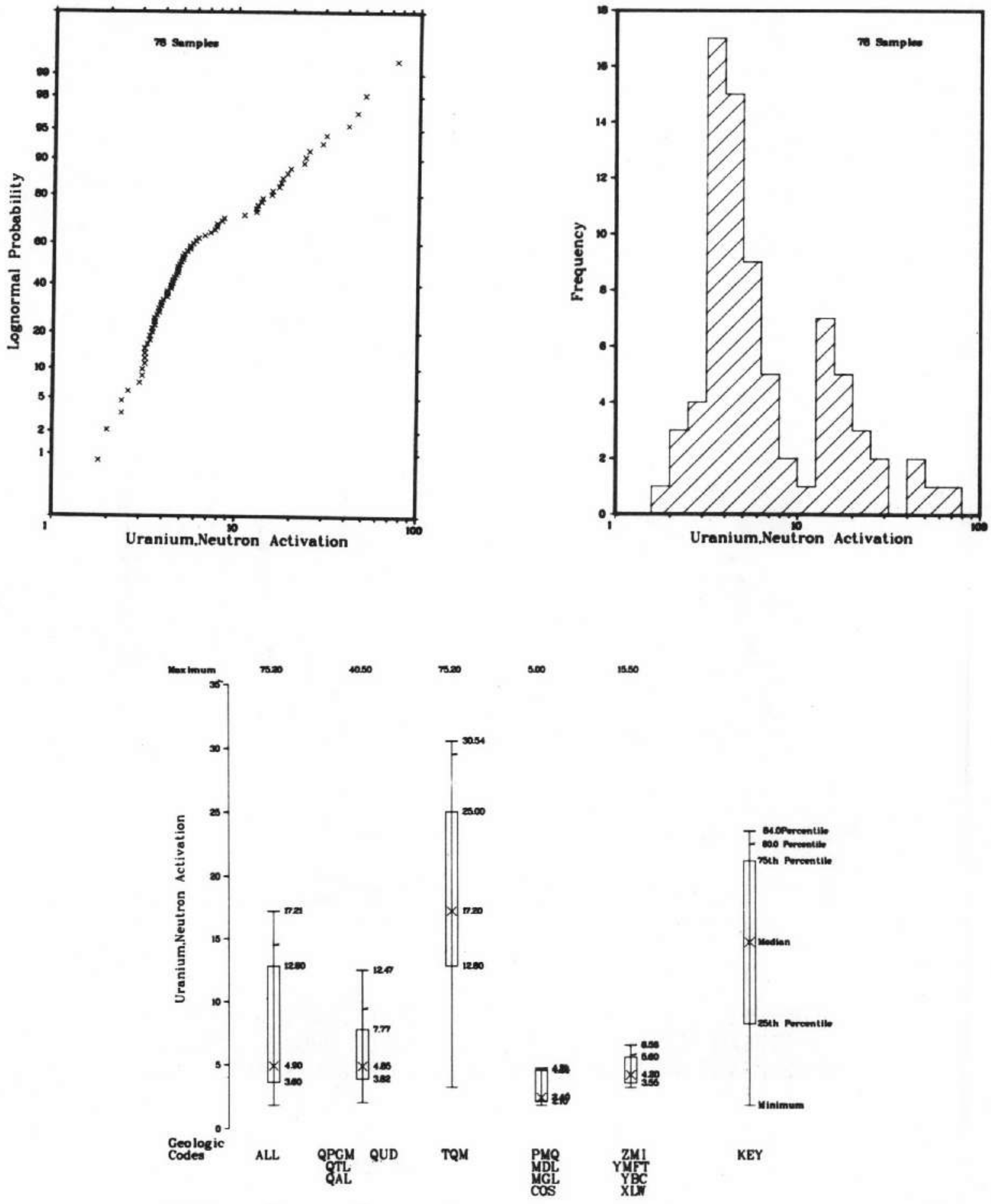


Figure B-2a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR URANIUM BY NEUTRON ACTIVATION IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

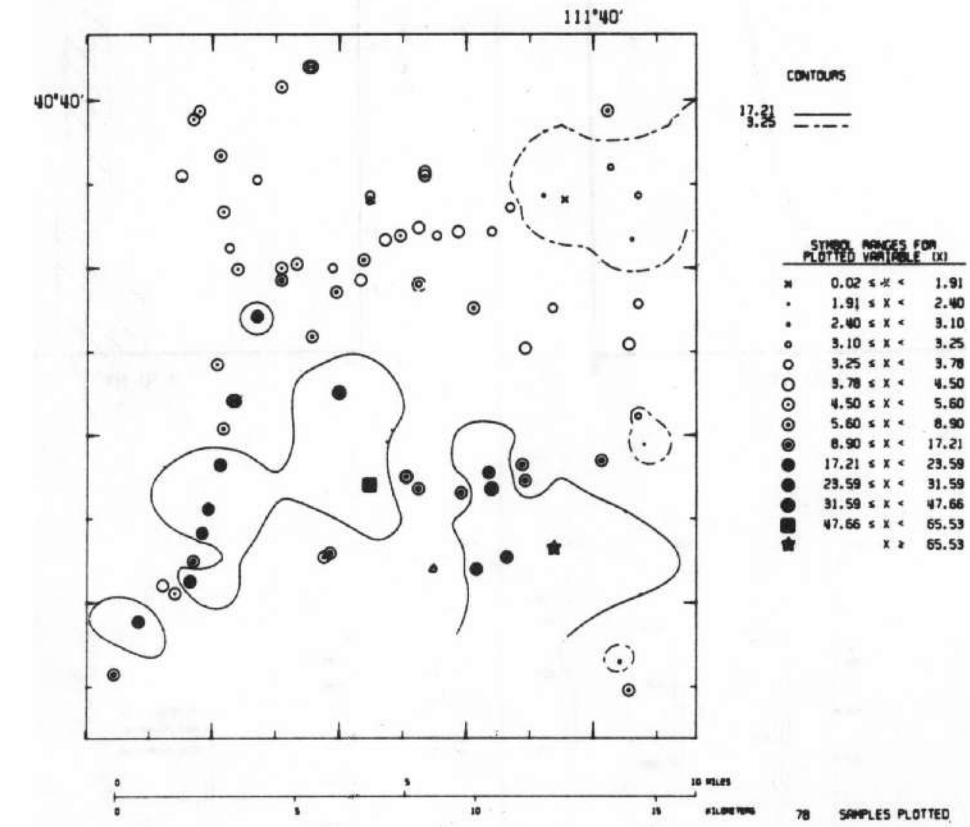


Figure B-2b

GEOCHEMICAL DISTRIBUTION OF URANIUM BY NEUTRON ACTIVATION IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

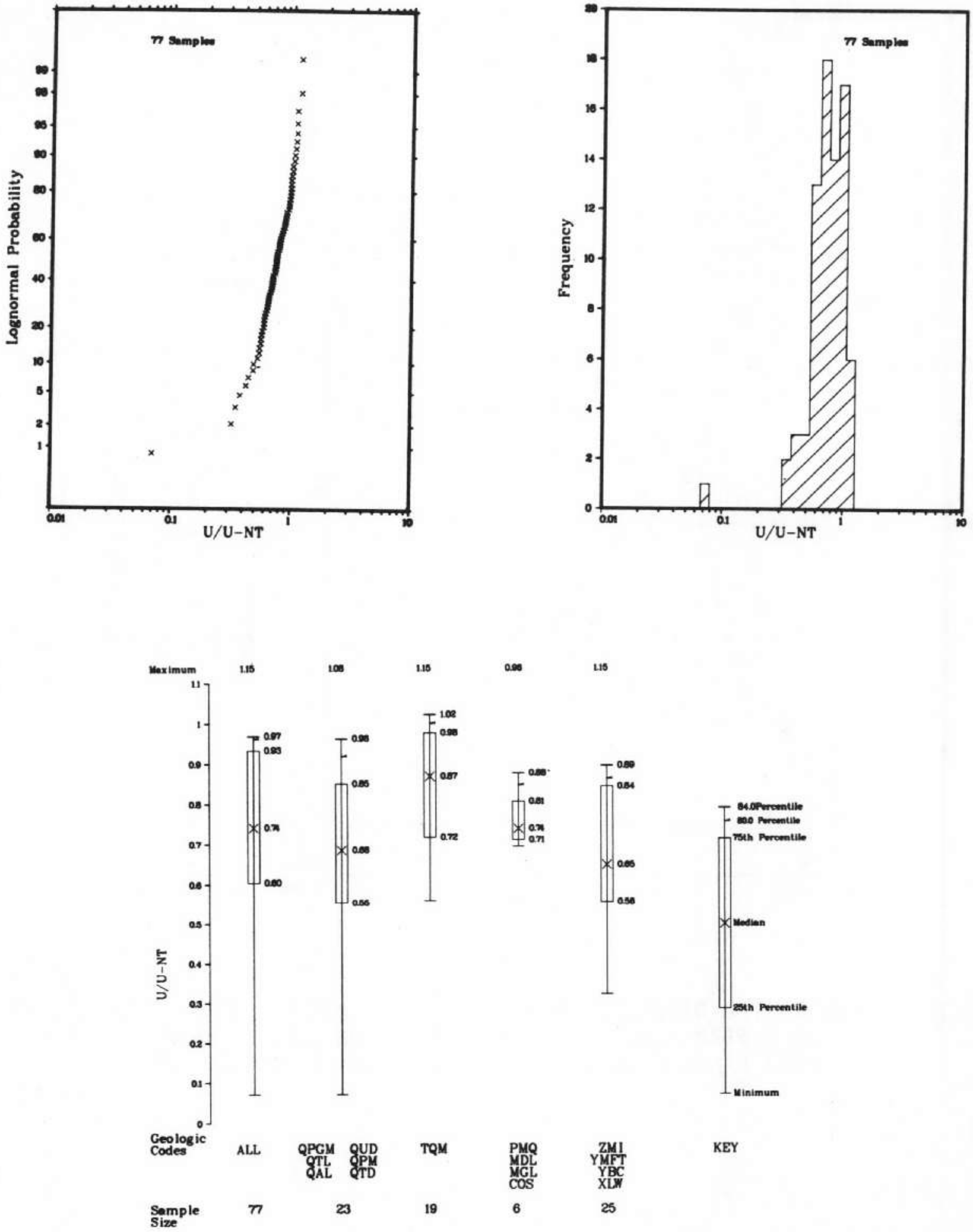


Figure B-3a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR URANIUM FLUOROMETRIC/
URANIUM NEUTRON ACTIVATION IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

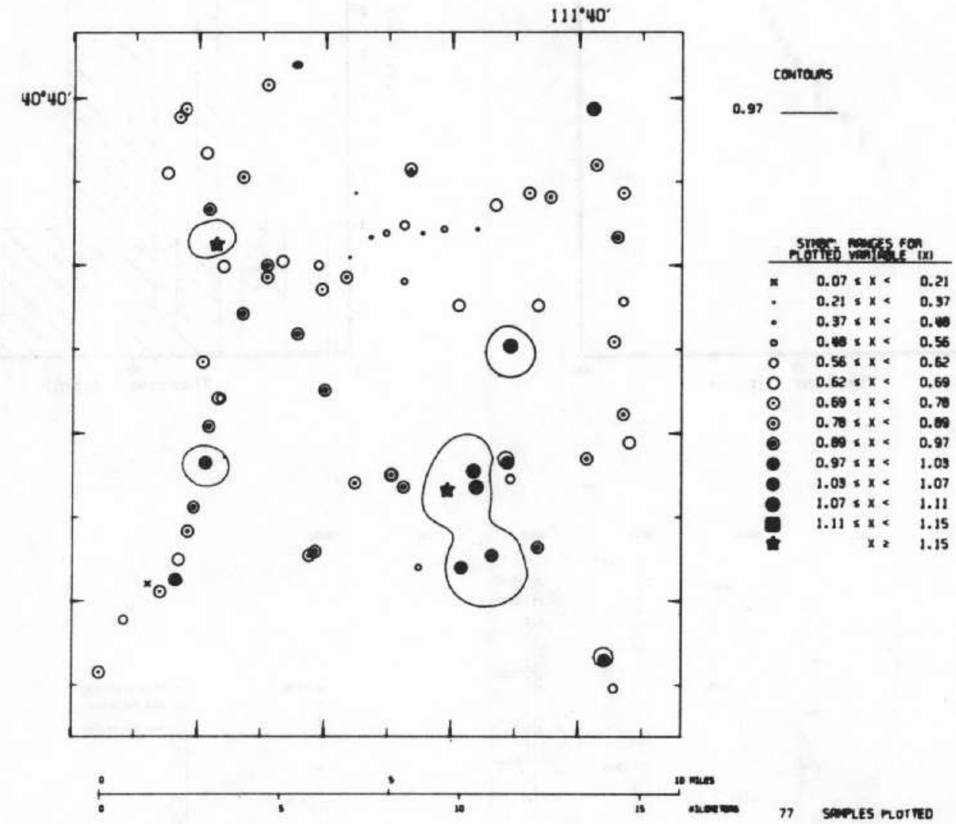


Figure B-3b

GEOCHEMICAL DISTRIBUTION OF URANIUM FLUOROMETRIC/URANIUM NEUTRON ACTIVATION IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

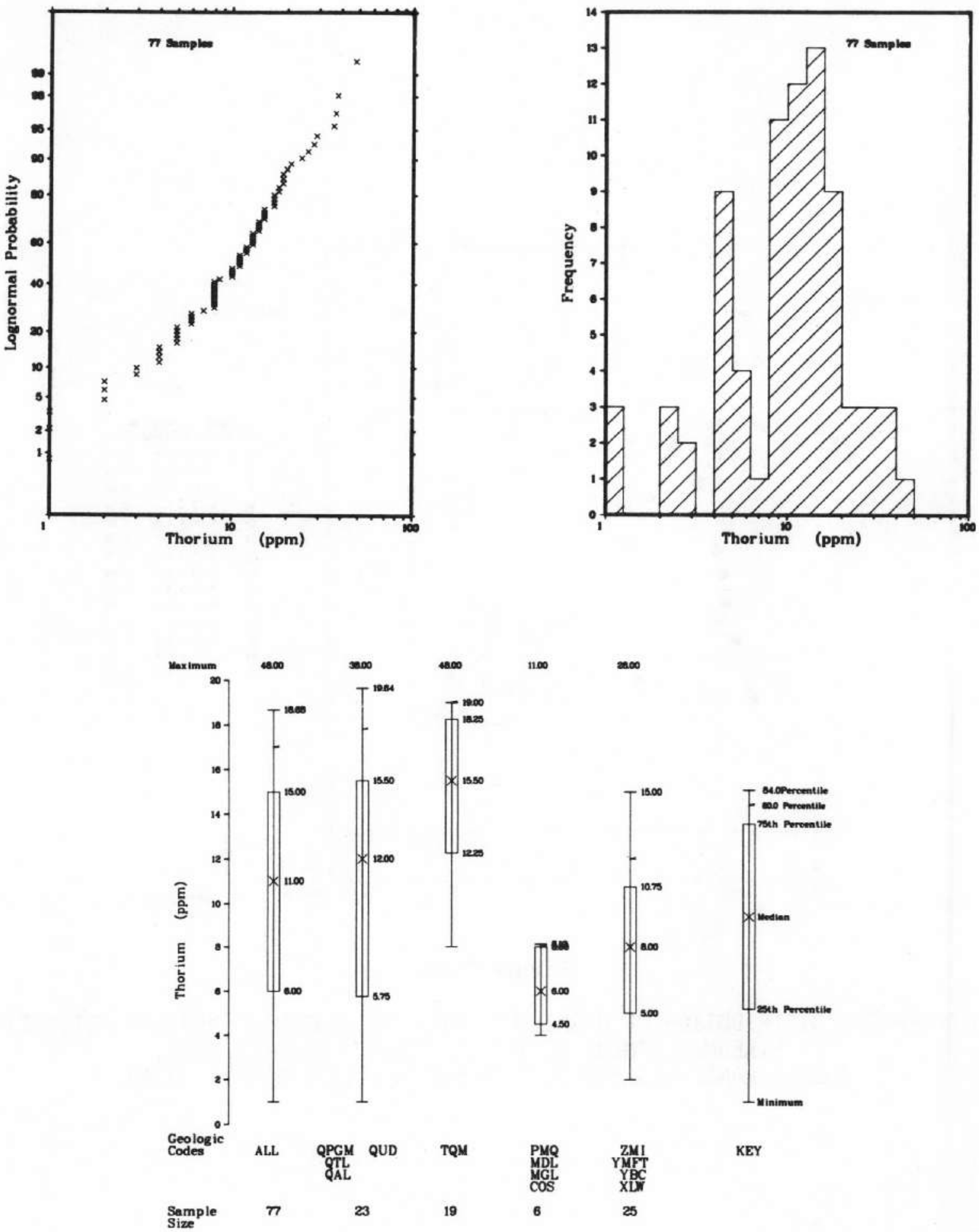


Figure B-4a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR THORIUM (PPM) IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

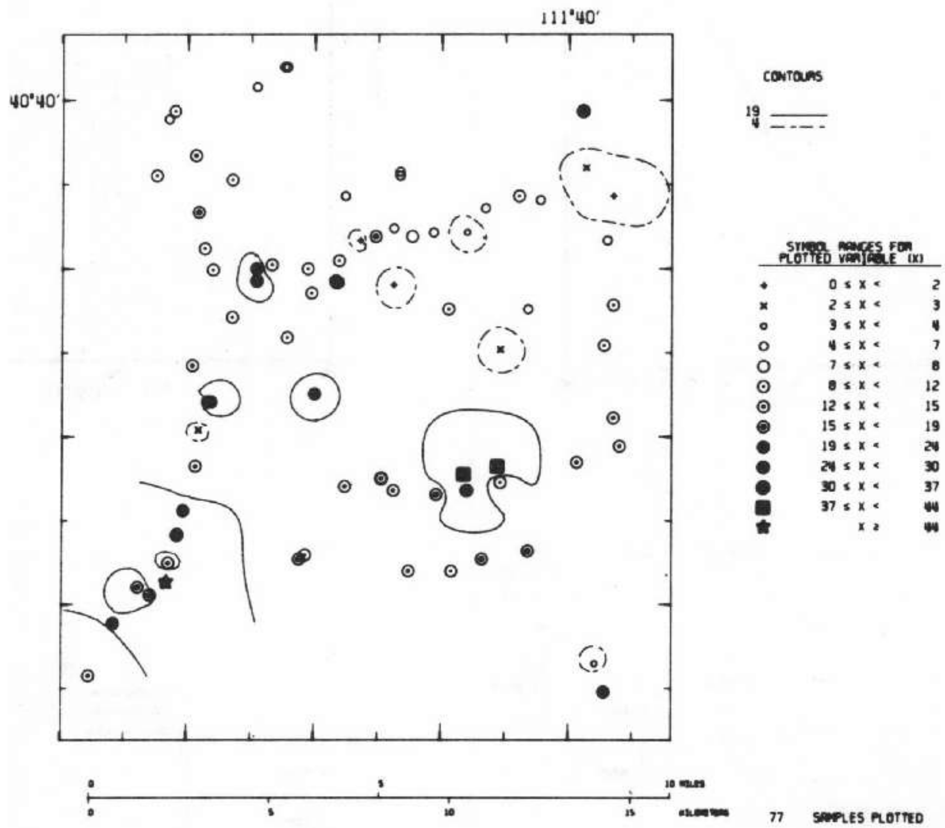


Figure B-4b

GEOCHEMICAL DISTRIBUTION OF THORIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

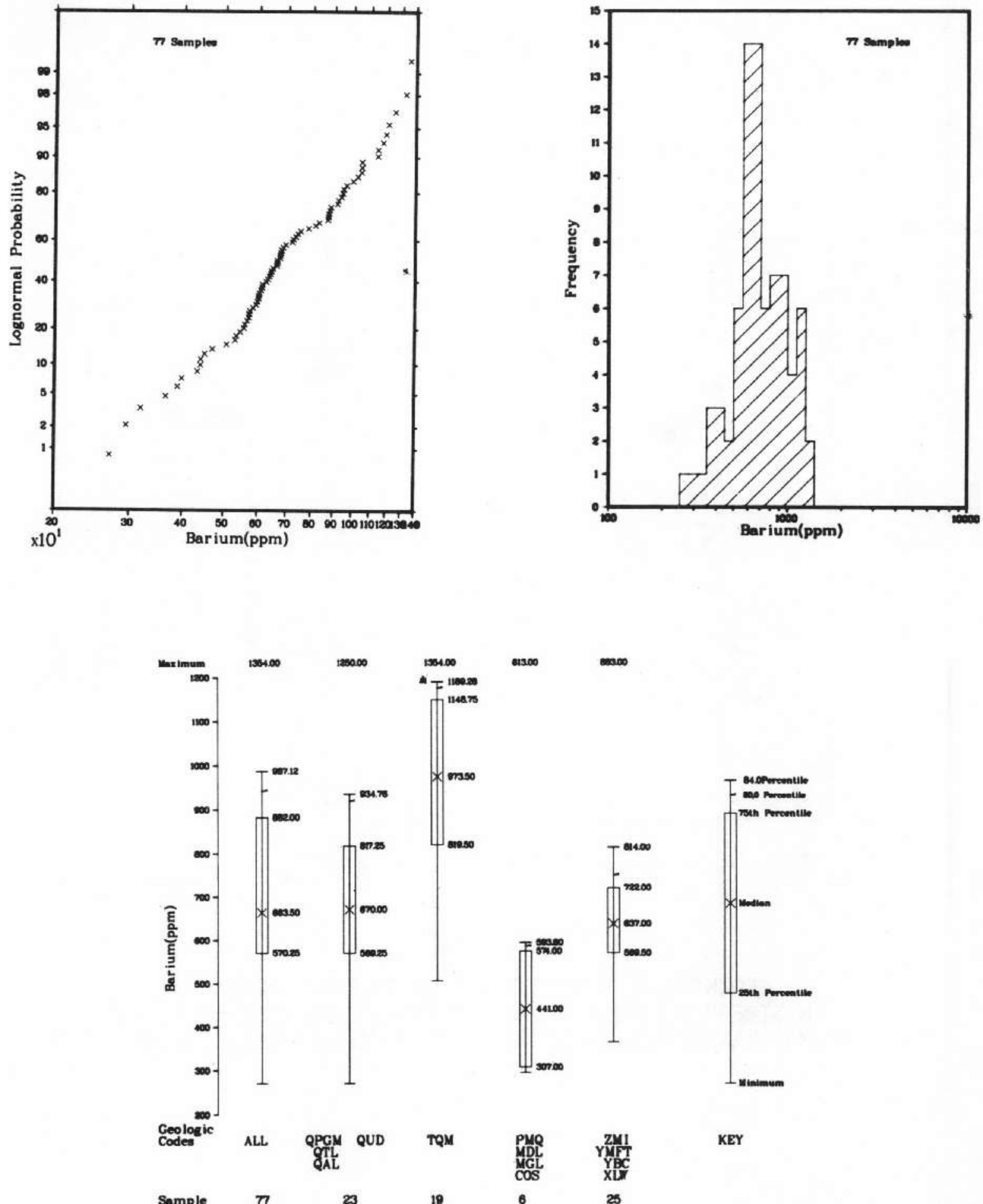


Figure B-5a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR BARIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

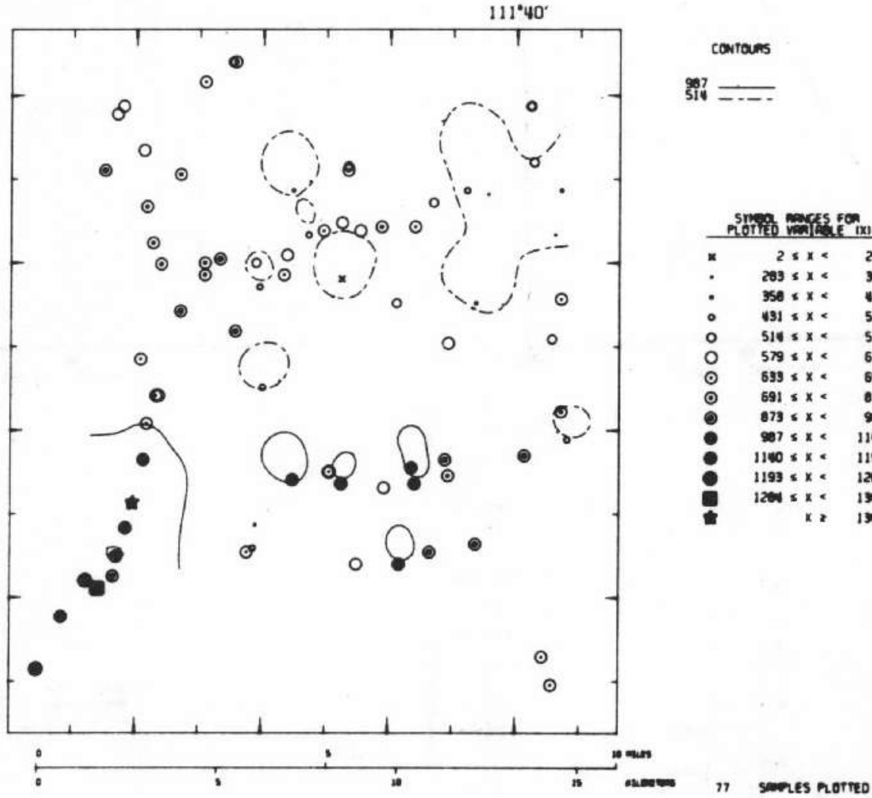


Figure B-5b

GEOCHEMICAL DISTRIBUTION OF BARIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

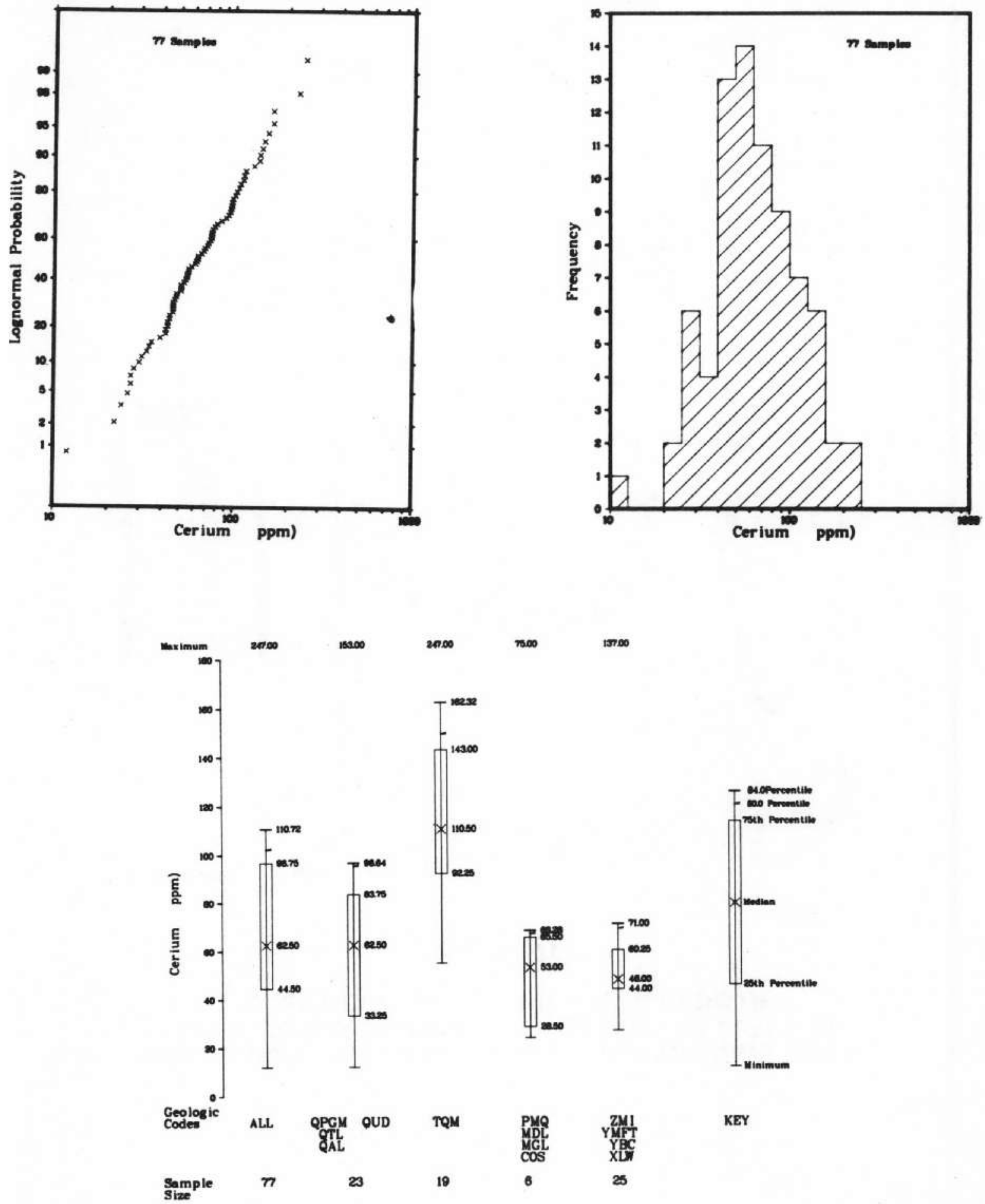


Figure B-6a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR CERIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

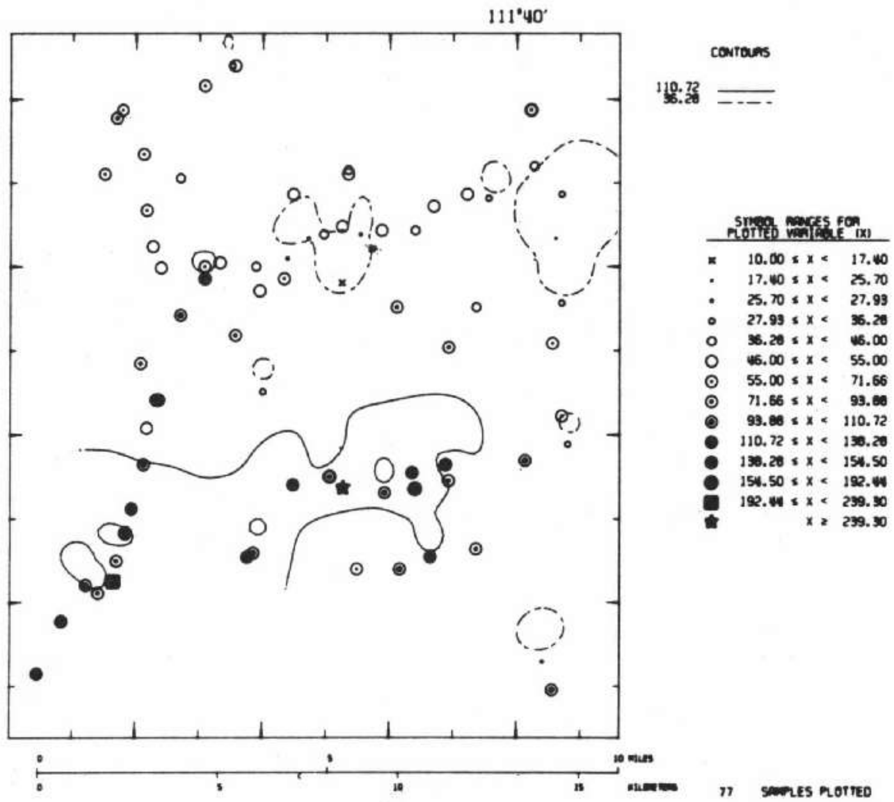


Figure B-6b

GEOCHEMICAL DISTRIBUTION OF CERIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

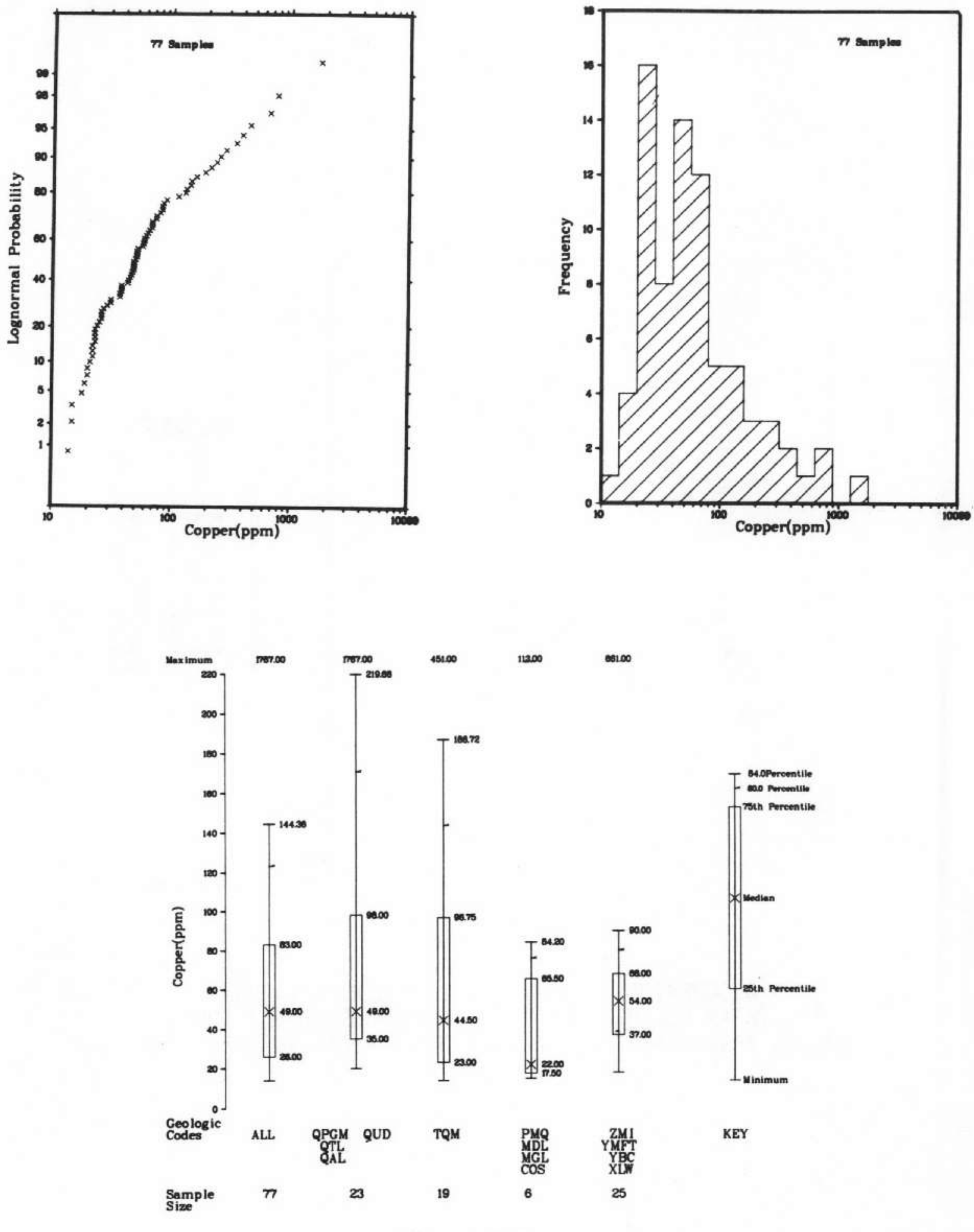


Figure B-7a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR COPPER (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

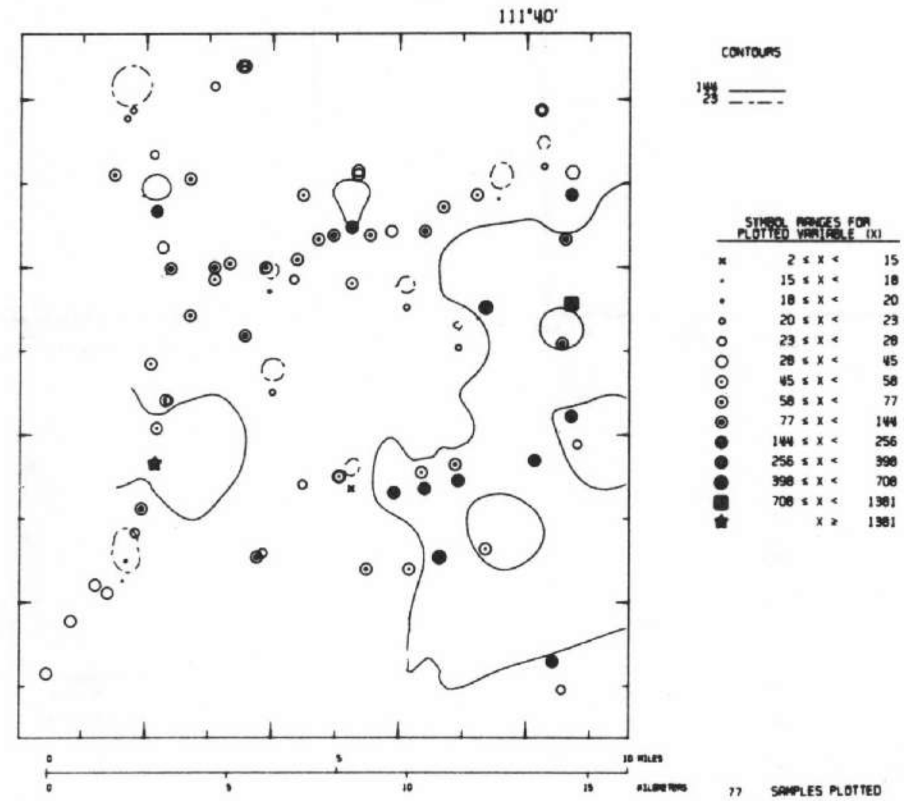


Figure B-7b

GEOCHEMICAL DISTRIBUTION OF COPPER (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

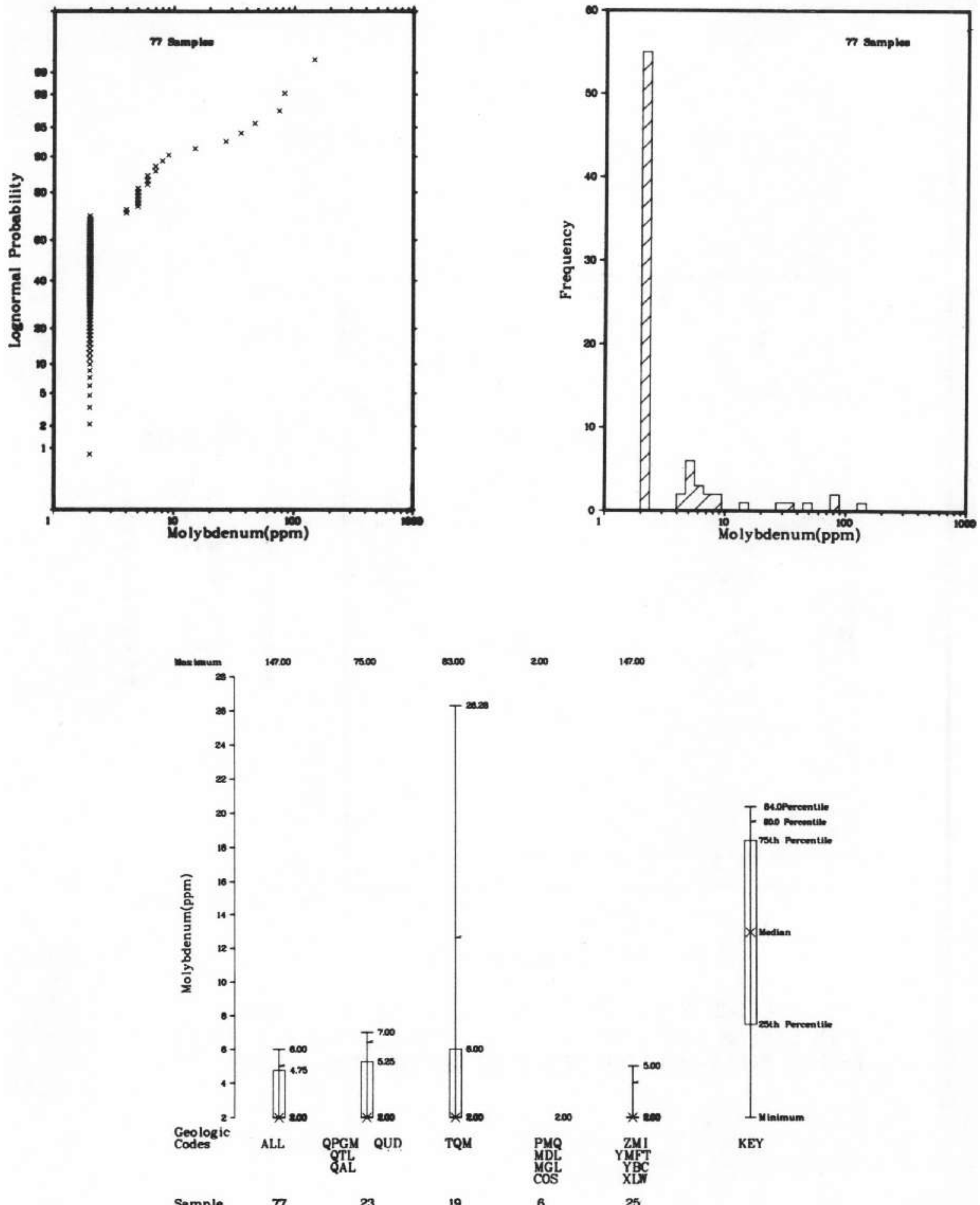


Figure B-8a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR MOLYBDENUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

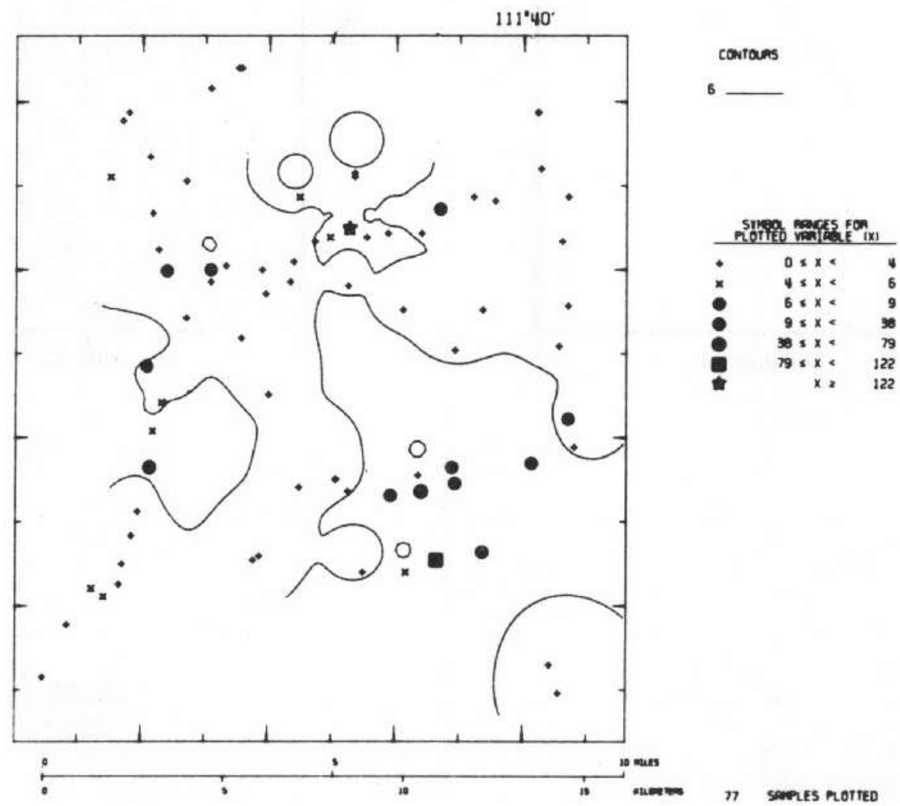


Figure B-8b

GEOCHEMICAL DISTRIBUTION OF MOLYBDENUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

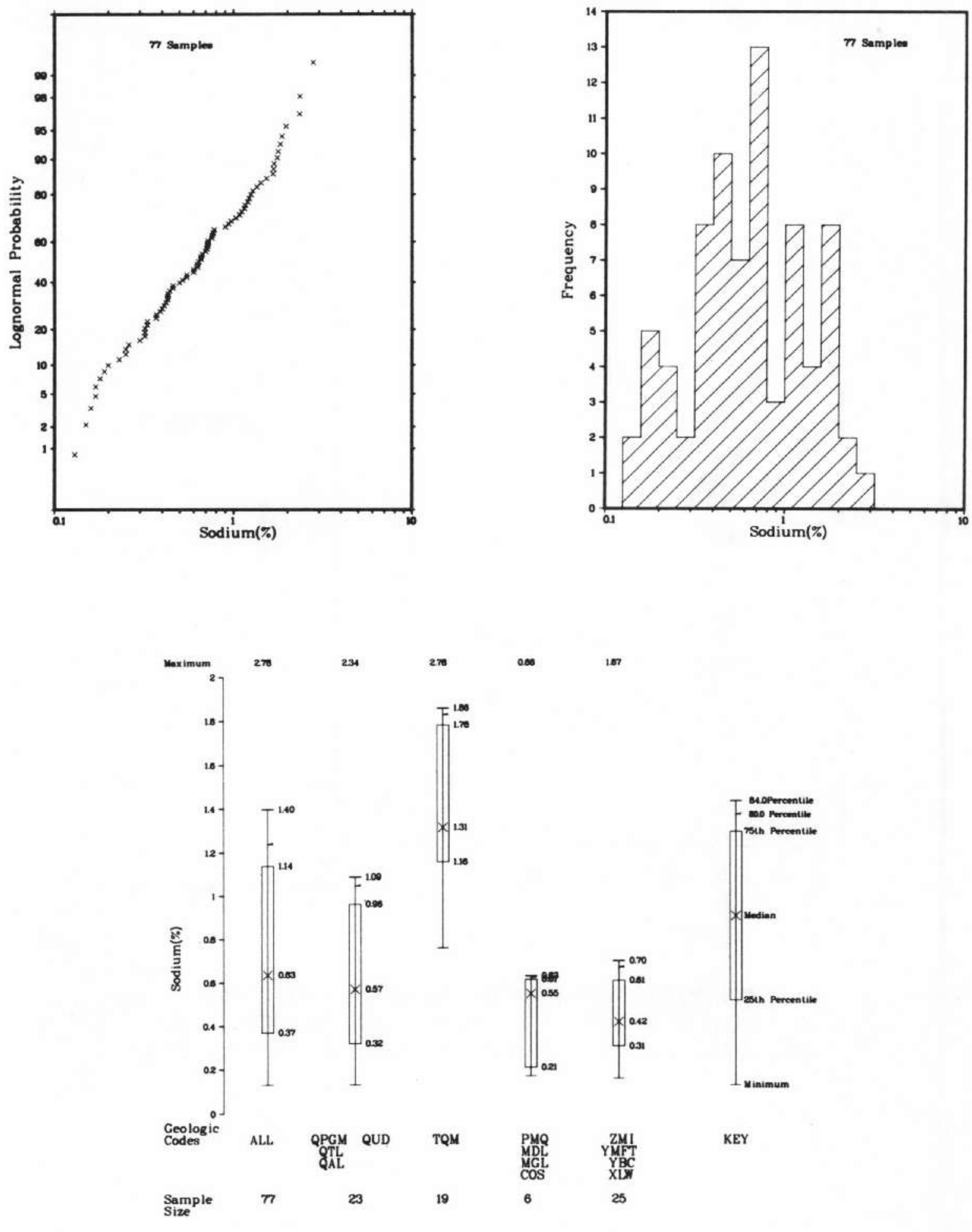


Figure B-9a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR SODIUM (%)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

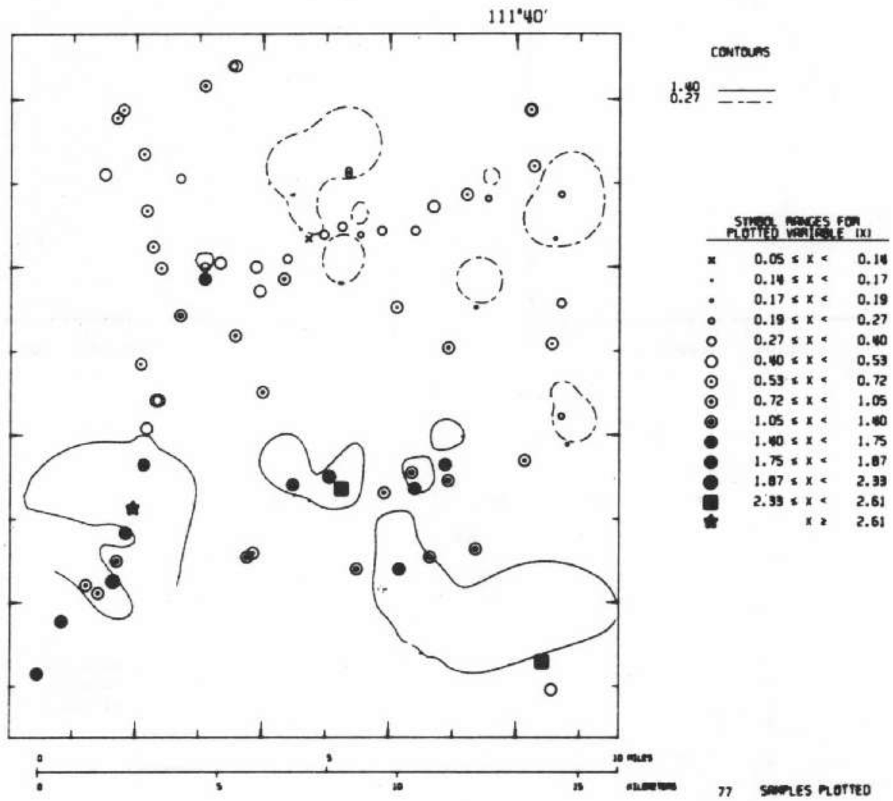


Figure B-9b

GEOCHEMICAL DISTRIBUTION OF SODIUM (%)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

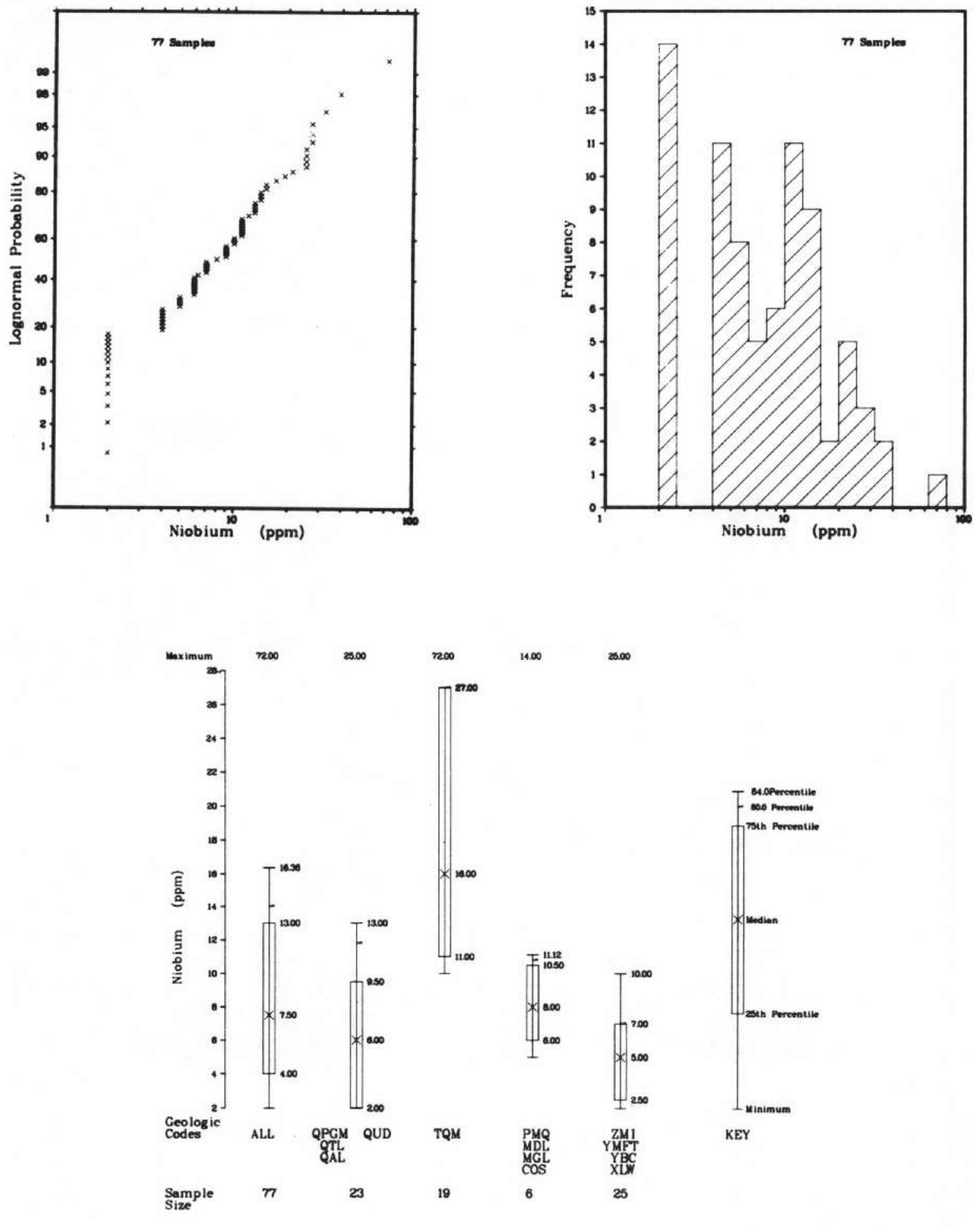


Figure B-10a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR NIOBIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

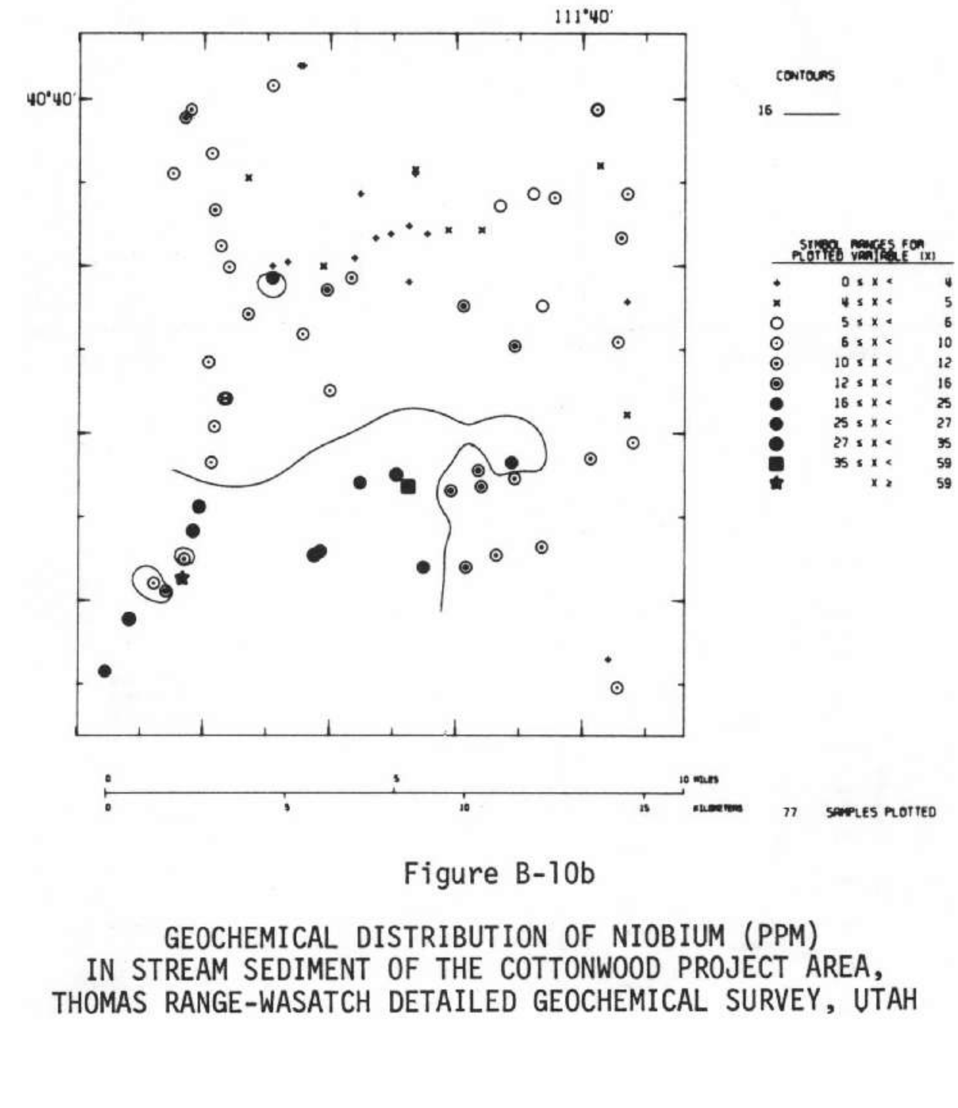
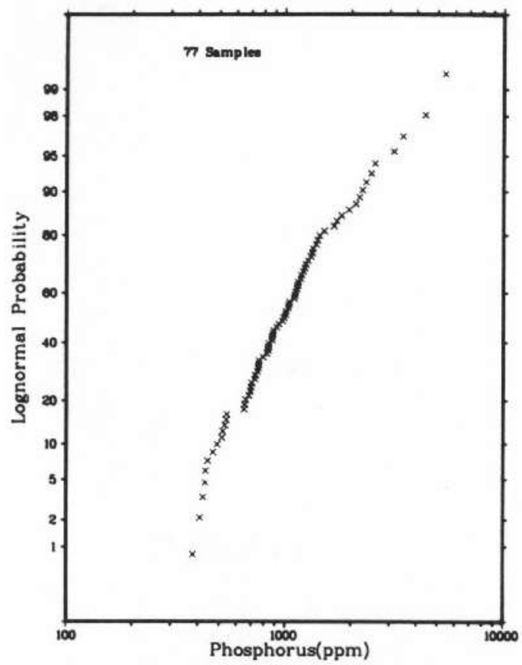
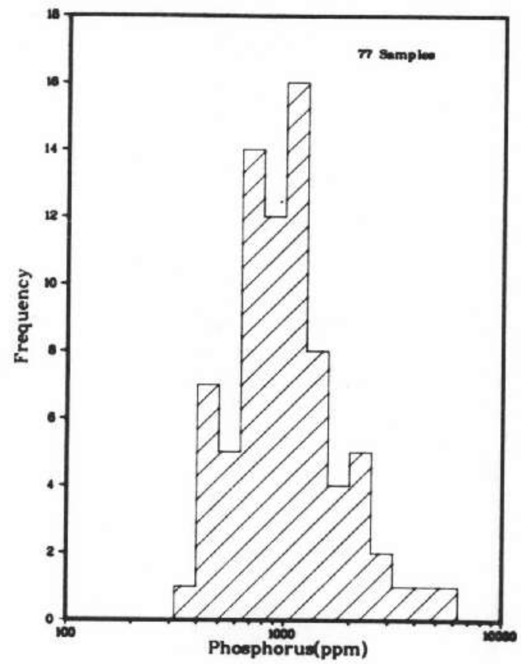


Figure B-10b

GEOCHEMICAL DISTRIBUTION OF NIOBIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH





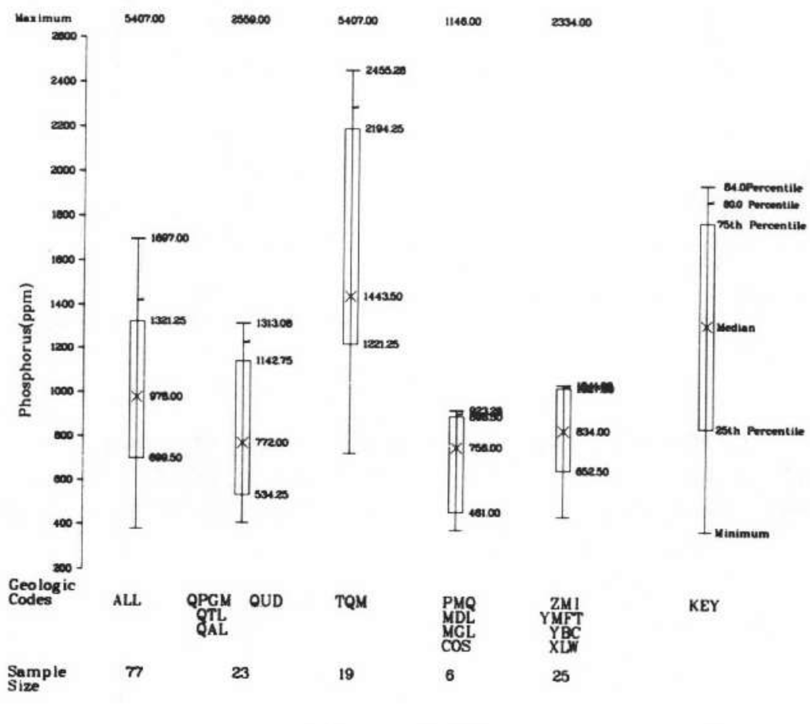


Figure B-11a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR PHOSPHORUS (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

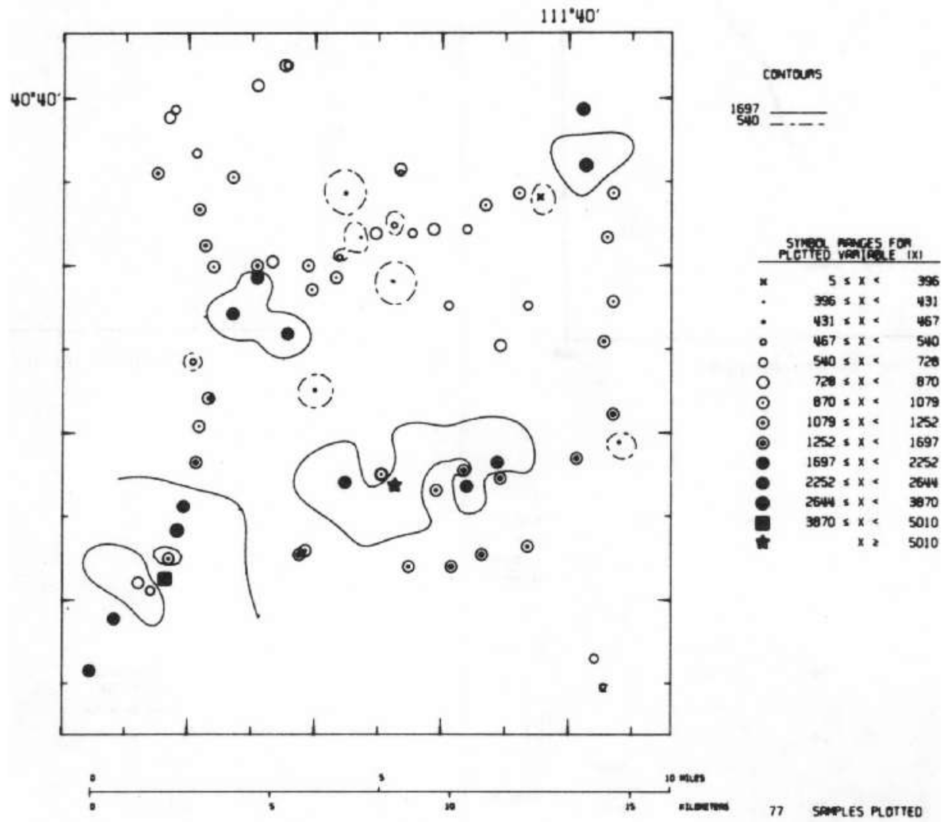


Figure B-11b

GEOCHEMICAL DISTRIBUTION OF PHOSPHORUS (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

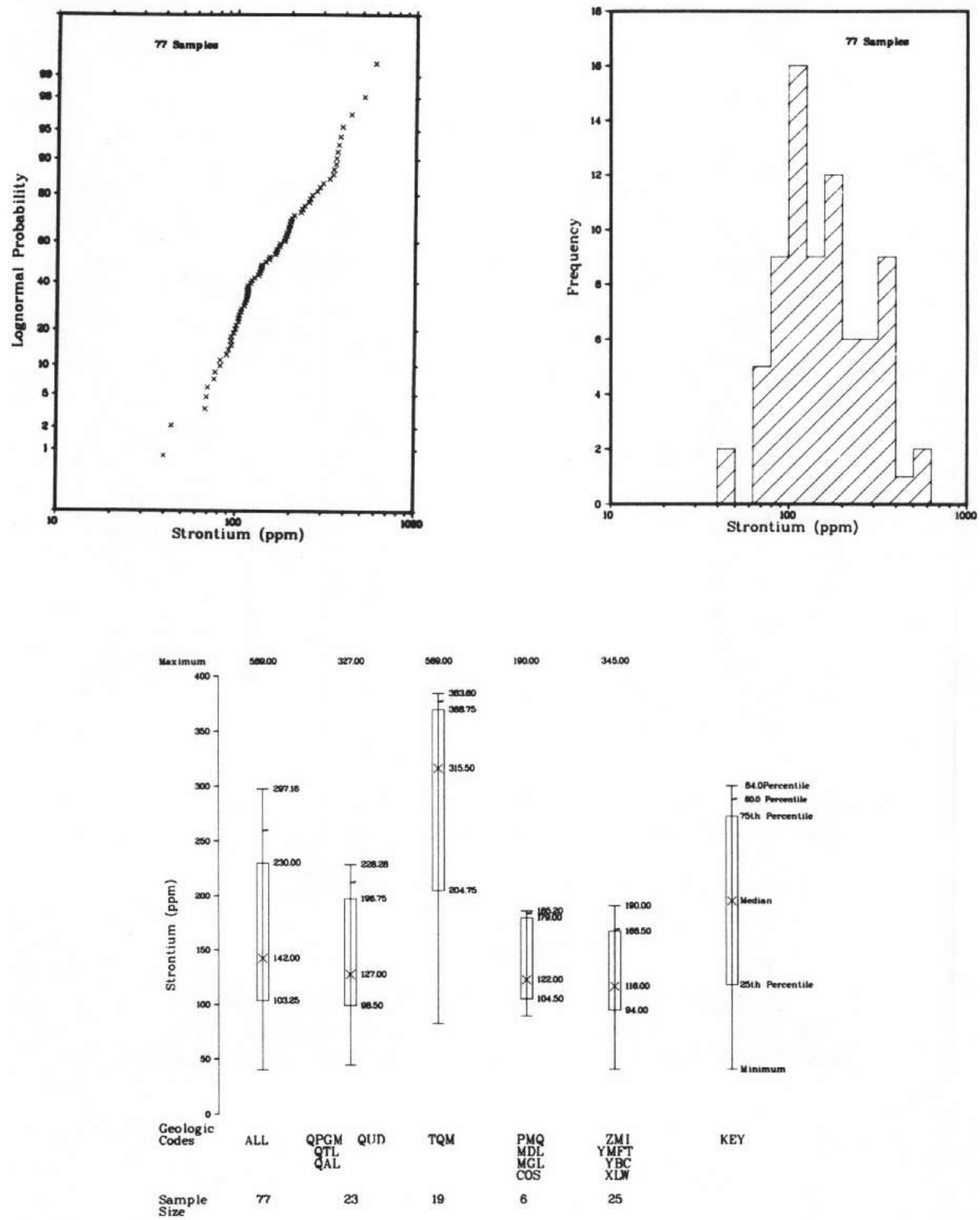


Figure B-12a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR STRONTIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

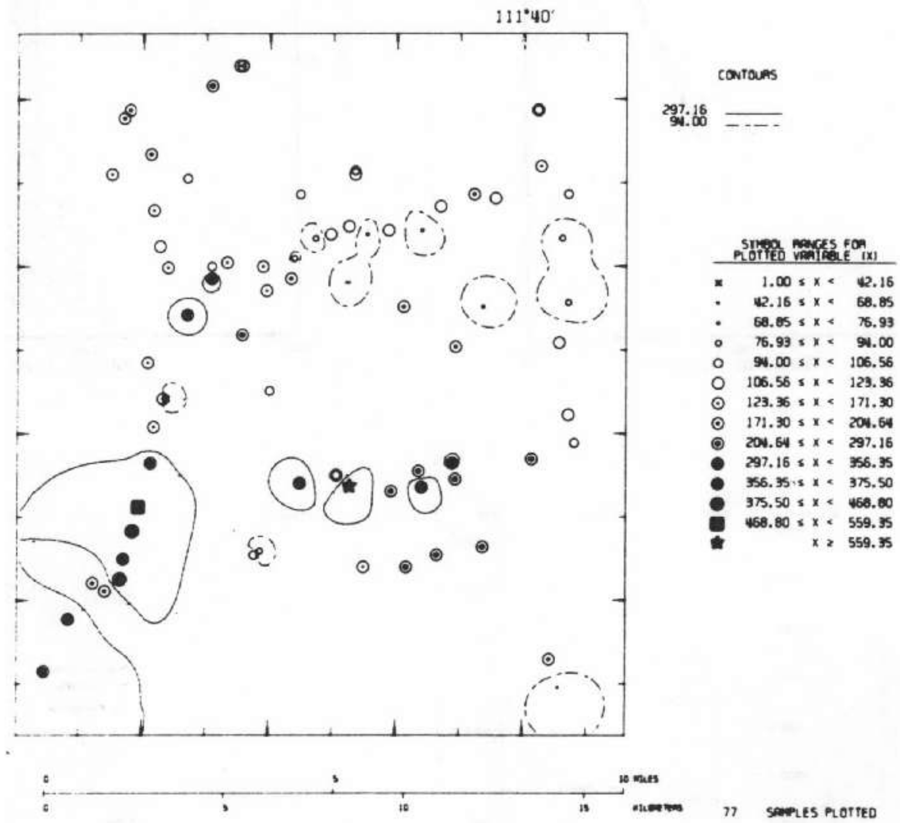


Figure B-12b

GEOCHEMICAL DISTRIBUTION OF STRONTIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

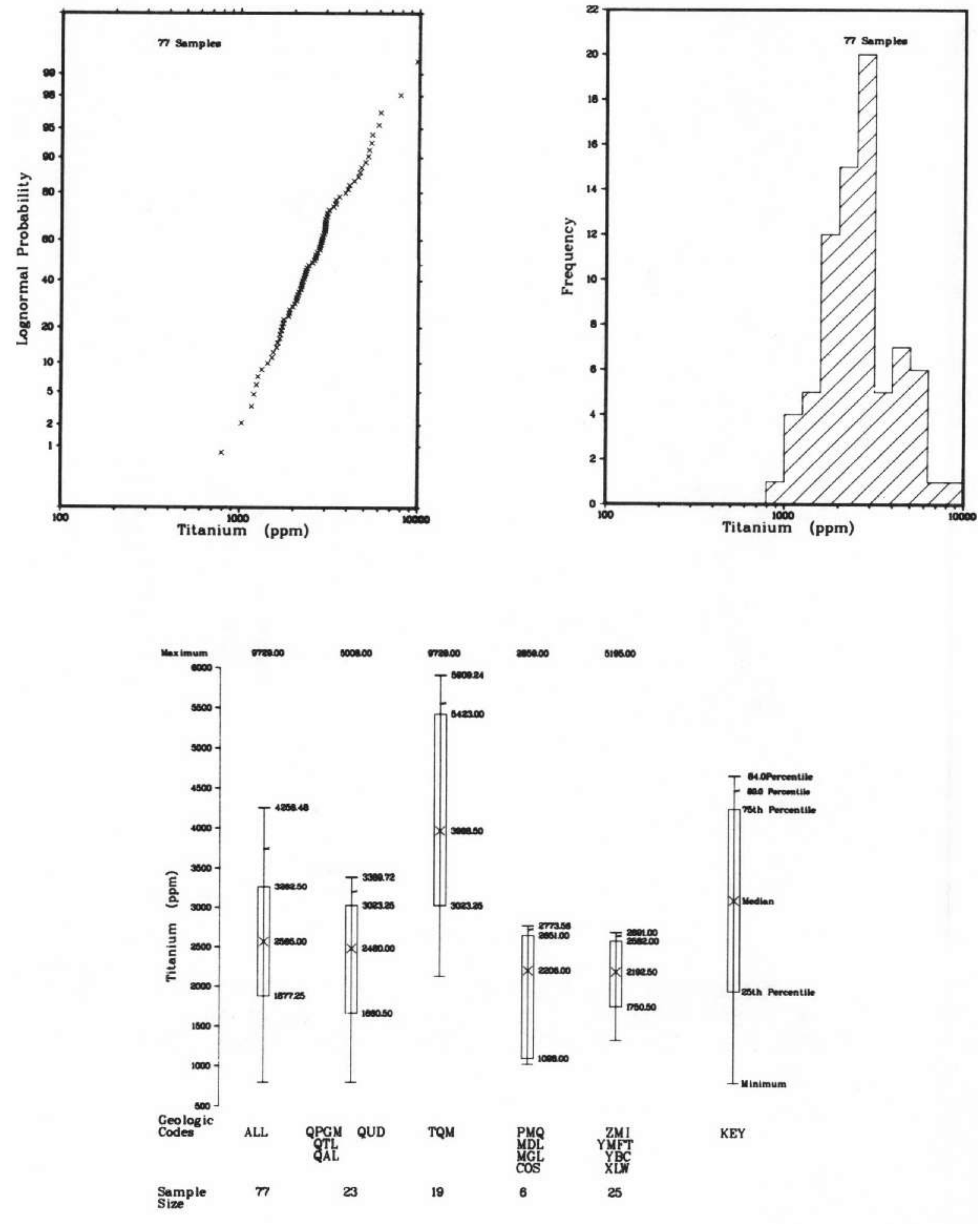


Figure B-13a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR TITANIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

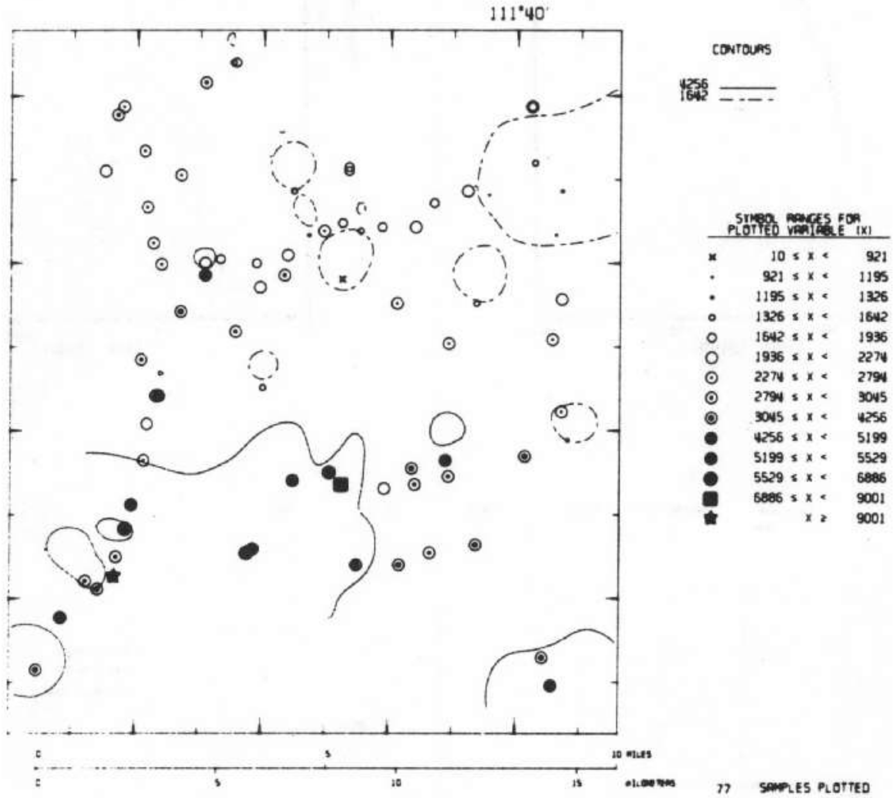


Figure B-13b

GEOCHEMICAL DISTRIBUTION OF TITANIUM (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

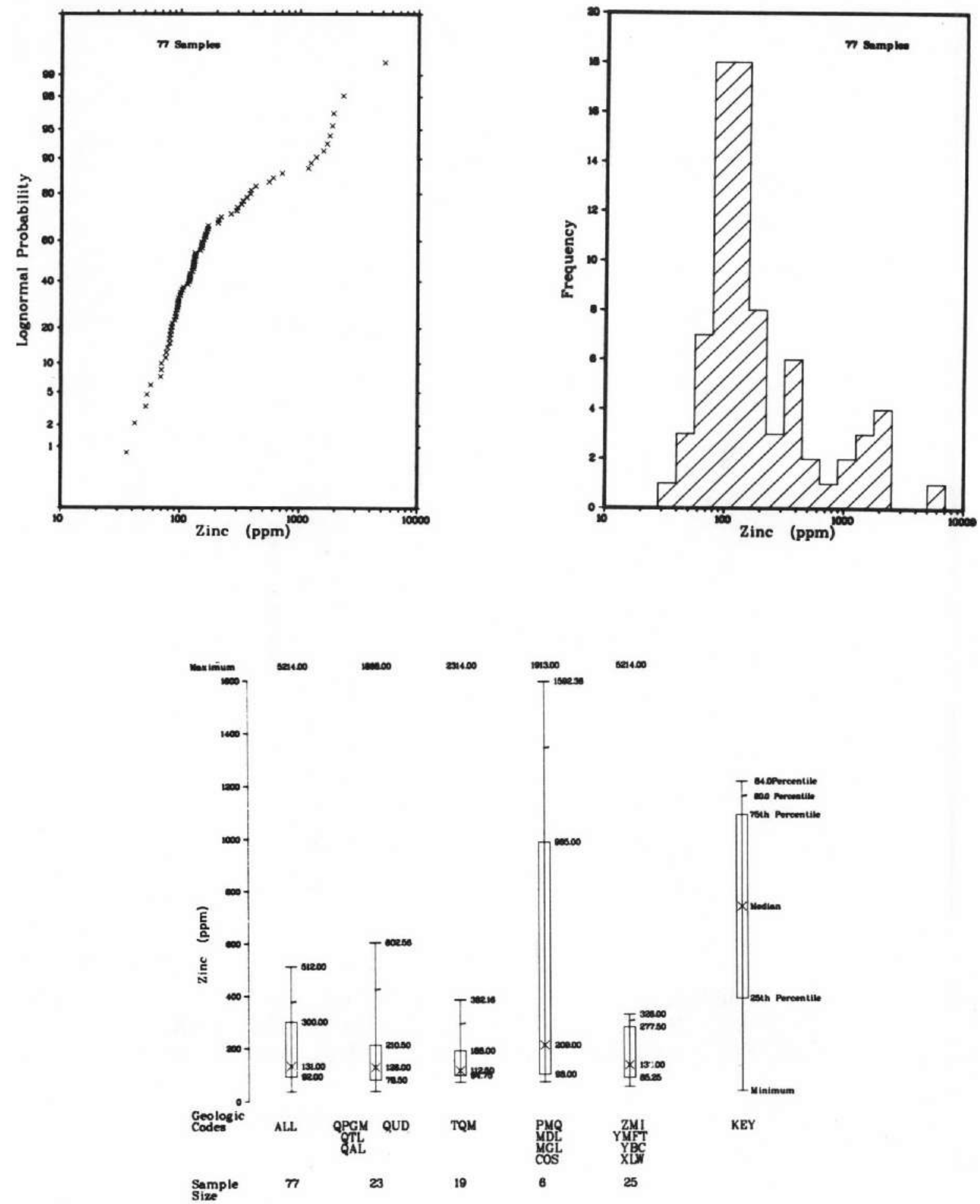


Figure B-14a

PROBABILITY, FREQUENCY, AND PERCENTILE PLOTS FOR ZINC (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

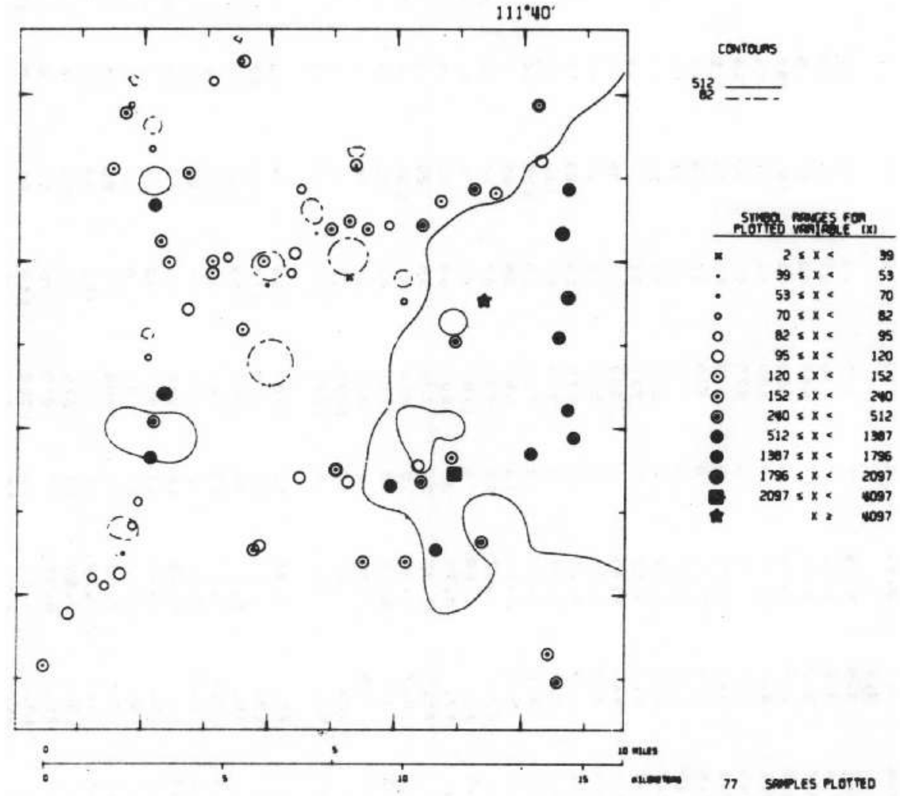


Figure B-14b

GEOCHEMICAL DISTRIBUTION OF ZINC (PPM)
IN STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

Table B-3

PARTIAL DATA LISTING FOR STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA,
THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

DR SAMPLE NUMBER	D. D. E. ST LAT	SAMPLE LONG	NUMBER L TY REP	U-FL (PPM)	U-NT (PPM)	U/TJ	TH (PPM)	BA (PPM)	CE (PPM)	CU (PPM)	MO (PPM)	P (PPM)	SR (PPM)	ZN (PPM)
908500	18-40.627	-111.742	-3-15-	1.8	5.6	0.32	11	630	27	68	<4	520	91	97
908502	18-40.643	-111.740	-3-15-	1.2	3.4	0.35	4	370	46	51	4	440	94	85
908503	18-40.642	-111.740	-3-15-		3.2									
908504	18-40.632	-111.735	-3-15-	1.7	3.9	0.44	<2	470	26	68	<4	420	82	52
908505	18-40.633	-111.718	-3-12-	1.4	3.6	0.38	7	600	27	63	<4	660	76	170
908506	18-40.633	-111.730	-3-12-	2.5	5.2	0.48	17	680	42	83	5	790	110	170
908507	18-40.635	-111.724	-3-12-	2.3	3.9	0.59	6	580	51	350	150	470	120	220
908508	18-40.634	-111.711	-3-12-	2.1	3.8	0.54	4	690	46	37	<4	760	110	82
908509	18-40.634	-111.700	-3-12-	1.5	3.5	0.42	3	670	42	80	<4	700	70	300
908510	18-40.640	-111.694	-3-15-	2.1	3.3	0.65	5	570	46	59	6	990	120	130
908511	18-40.643	-111.683	-3-15-	1.8	2.4	0.74	8	440	53	48	<4	910	170	390
908512	18-40.642	-111.676	-3-12-	1.6	1.8	0.87	4	300	33	15	<4	380	120	130
908513	18-40.650	-111.661	-3-12-	2.7	3.1	0.87	2	570	43	22	<4	3400	130	120
908514	18-40.648	-111.722	-3-12-	2.7	5.1	0.53	5	720	51	37	<4	530	120	53
908516	18-40.649	-111.722	-3-12-	3.2	4.2	0.75	5	530	43	38	<4	840	94	130
908517	18-40.664	-111.662	-3-15-	4.0	3.8	1.0	8	540	55	31	<4	1100	110	130
908518	18-40.664	-111.662	-3-12-	2.2	3.0	0.74	15	570	56	26	<4	1400	100	92
908519	18-40.632	-111.654	-3-12-	2.3	2.4	0.96	5	320	24	110	<4	880	89	1900
908520	18-40.643	-111.652	-3-12-	2.4	3.1	0.78	<2	400	28	150	<4	930	97	1800
908529	18-40.501	-111.790	-3-15-	3.3	4.8	0.69	13	680	78	45	7	520	140	79
908530	18-40.613	-111.777	-3-15-	19.	20.	0.97	10	950	97	65	<4	2200	340	120
908536	18-40.552	-111.798	-3-12-	9.5	14.	0.69	14	1100	75	19	<4	1200	360	69
908537	18-40.559	-111.795	-3-15-	14.	17.	0.78	36	1200	160	23	<4	3100	430	92
908540	18-40.594	-111.750	-3-12-	39.	41.	0.95	21	430	35	20	<4	440	100	42
908541	18-40.608	-111.759	-3-12-	6.0	6.7	0.89	8	880	85	130	<4	2100	250	130
908542	18-40.625	-111.752	-3-15-	2.2	3.7	0.60	8	530	44	68	<4	1000	140	120
908543	18-40.625	-111.783	-3-15-	3.1	4.8	0.65	8	810	51	90	6	1000	170	150
908701	18-40.537	-111.816	-3-15-	14.	23.	0.59	19	1000	140	29	<4	2200	360	95
908702	18-40.571	-111.740	-3-12-	41.	50.	0.81	14	1200	130	23	<4	2500	370	100
908703	18-40.570	-111.744	-3-15-											
908704	18-40.570	-111.724	-3-12-	16.	17.	0.93	13	1100	250	14	<4	5400	590	97
908705	18-40.569	-111.710	-3-12-	15.	13.	1.2	17	600	110	280	27	1200	210	1700
908706	18-40.570	-111.700	-3-12-	49.	46.	1.1	29	1000	160	190	47	1900	370	390
908907	18-40.588	-111.652	-3-15-	2.6	3.2	0.82	13	740	66	210	6	1300	120	1400
908914	18-40.581	-111.650	-3-12-	1.3	2.0	0.67	12	450	34	23	<4	430	94	550
908915	18-40.577	-111.664	-3-12-	9.2	11.	0.83	14	920	95	240	15	1400	240	710
908918	18-40.576	-111.690	-3-15-	16.	16.	0.99	37	920	150	61	8	2600	300	150
908920	18-40.574	-111.701	-3-15-	20.	19.	1.1	38	1000	110	51	<4	1700	230	100
908921	18-40.573	-111.728	-3-12-	6.1	7.6	0.80	11	600	74	50	<4	1000	110	130
908922	18-40.573	-111.728	-3-15-	4.7	6.2	0.76	12	640	80	43	<4	840	100	120
908924	18-40.572	-111.689	-3-12-	7.2	13.	0.55	10	870	90	390	36	1300	260	2300
908928	18-40.555	-111.680	-3-12-	73.	75.	0.97	17	870	76	52	9	1200	280	270
908933	18-40.550	-111.705	-3-12-	19.	18.	1.1	10	1000	110	51	5	1500	290	150
908940	18-40.553	-111.695	-3-12-	31.	31.	1.0	18	940	110	450	83	1400	260	1200
908942	18-40.576	-111.789	-3-12-	25.	25.	1.0	13	1000	98	1800	75	1300	330	1200
908943	18-40.585	-111.788	-3-15-	7.3	7.8	0.94	2	640	48	57	5	1000	130	360
908945	18-40.592	-111.785	-3-15-	4.8	7.8	0.62	15	670	58	48	5	880	140	300
908946	18-40.592	-111.784	-3-15-	5.0	8.5	0.59	28	630	97	24	<4	490	40	330
908947	18-40.520	-111.655	-3-15-	5.0	8.3	0.61	19	650	100	26	<4	540	44	340
908948	18-40.527	-111.658	-3-15-	2.5	2.6	0.98	3	660	22	250	<4	700	200	160
908949	18-40.554	-111.753	-3-12-	12.	13.	0.94	8	510	100	25	<4	1100	82	110
908950	18-40.553	-111.755	-3-12-	5.6	7.2	0.78	17	660	140	85	<4	1300	99	160
908951	18-40.565	-111.793	-3-12-	23.	24.	0.97	19	1400	150	130	<4	1800	510	94
909095	18-40.524	-111.824	-3-12-	9.9	14.	0.73	14	1200	120	38	<4	1700	350	120
909097	18-40.546	-111.808	-3-15-	0.31	4.4	0.07	15	1300	96	38	5	840	190	90

Table B-3, Continued

PARTIAL DATA LISTING FOR STREAM SEDIMENT OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH

OR SAMPLE NUMBER	D. O. E. SAMPLE ST	LAT	LONG	NJMBER L TY REP	U-FL (PPM)	U-NT (PPM)	U/TU	TH (PPM)	BA (PPM)	CE (PPM)	CU (PPM)	MO (PPM)	P (PPM)	SR (PPM)	ZN (PPM)
909098	18	-40.544	-111.804	-3-15-	3.4	4.6	0.74	18	1300	93	31	5	730	200	84
909099	18	-40.547	-111.799	-3-15-	29.	29.	0.99	48	950	230	15	<4	4400	380	100
909300	18	-40.630	-111.786	-3-15-	4.0	3.5	1.2	8	720	54	43	<4	1100	120	170
909302	18	-40.647	-111.777	-3-15-	3.1	3.6	0.86	10	750	44	59	<4	1000	110	210
909303	18	-40.639	-111.788	-3-12-	4.3	4.5	0.96	15	830	71	160	<4	1200	170	600
909306	18	-40.626	-111.764	-3-15-	3.5	5.4	0.64	8	880	48	58	<4	830	170	83
909307	18	-40.625	-111.769	-3-15-	4.4	4.9	0.89	24	730	63	140	7	1100	100	150
909308	18	-40.653	-111.789	-3-15-	4.0	5.8	0.68	12	610	69	26	<4	650	200	76
909309	18	-40.662	-111.798	-3-15-	3.7	5.0	0.74	6	610	75	22	<4	760	190	210
909310	18	-40.664	-111.796	-3-15-	3.4	4.7	0.73	8	590	68	20	<4	540	190	70
909311	18	-40.648	-111.802	-3-12-	2.7	4.2	0.64	11	960	56	74	4	1200	150	130
909313	18	-40.670	-111.769	-3-15-	3.7	5.1	0.73	5	690	62	23	<4	750	230	82
909316	18	-40.675	-111.759	-3-15-	2.6	4.8	0.54	5	780	47	48	<4	650	170	96
909317	18	-40.675	-111.760	-3-15-	2.2	4.5	0.49	4	560	30	47	<4	750	150	77
909319	18	-40.619	-111.751	-3-12-	3.9	5.6	0.59	8	440	46	18	<4	870	140	57
909320	18	-40.622	-111.743	-3-12-	3.4	4.0	0.86	20	660	61	27	<4	970	200	86
909321	18	-40.605	-111.689	-3-12-	4.5	4.2	1.1	2	600	75	22	<4	730	190	430
909323	18	-40.615	-111.706	-3-12-	3.8	6.0	0.63	11	570	72	21	<4	680	200	70
909324	18	-40.621	-111.724	-3-12-	1.8	3.2	0.56	<2	270	12	48	<4	410	68	36
909325	18	-40.622	-111.769	-3-12-	12.	16.	0.79	26	870	140	46	<4	2300	350	130
909326	18	-40.616	-111.652	-3-15-	2.1	3.6	0.57	8	640	31	760	<4	870	77	1900
909327	18	-40.606	-111.655	-3-12-	3.0	4.4	0.69	11	560	63	83	<4	1100	120	1600
909335	18	-40.615	-111.680	-3-12-	2.3	3.4	0.55	5	390	39	660	<4	700	69	5200
909336	18	-40.550	-111.719	-3-15-	1.8	3.2	0.55	13	610	55	74	<4	1100	150	160

APPENDIX C

FIELD FORM AND COMPUTER CODE LIST

APPENDIX C

FIELD FORM AND COMPUTER CODE LIST

LIST OF TABLES

Table C-1

COMPUTER CODE LIST OF GEOCHEMICAL VARIABLES

Variable[a]	Code	Variable[a]	Code
Uranium Measured by Fluorometry[b]	U-FL	Scandium	SC
		Silicon	SI
Uranium Measured by Mass Spectrometry[b]	U-MS	Strontium	SR
Uranium Measured by Neutron Activation	U-NT	Thorium	TH
		Titanium	TI
Arsenic	AS	Vanadium	V
Selenium	SE	Yttrium	Y
Silver	AG	Zinc	ZN
Aluminum	AL	Zirconium	ZR
Boron	B	Sulfate (ppm)	SO_4
Barium	BA	Chloride (ppm)	CL
Beryllium	BE	Conductivity from Lab (μmhos/cm)	CT-L
Calcium	CA	Conductivity from Field (μmhos/cm)	CT-F
Cerium	CE	Dissolved Oxygen (ppm)	DO
Cobalt	CO	Air Temperature (°C)	ATEM
Chromium	CR	Water Temperature (°C)	WTEM
Copper	CU	pH	PH
Iron	FE	pH Measured by Lo Ion Paper	PH-P
Hafnium	HF	Total Alkalinity (ppm)	T-AK
Potassium	K	M-Alkalinity (ppm)	M-AK
Lanthanum	LA	P-Alkalinity (ppm)	P-AK
Lithium	LI	Carbonate (ppm)[c]	CB
Mangesium	MG	Bicarbonate (ppm)[c]	BC
Manganese	MN	Undissociated Carbonic Acid (ppm)[c]	CAB
Molybdenum	MO	U-NT/U-FL	TU/U
Sodium	NA	U-FL/U-NT	U/TU
Niobium	NB	TH/U-NT	TH/U
Nickel	NI	1,000·U/SP	U/SP
Phosphorus	P	1,000·U/B	U/B
Lead	PB	1,000·U/SO	U/SO
Platinum	PT		

(a) If natural logarithm of variable is used, L or L- precedes the variable code.

(b) If method is not specified for waters, U-FL is used, except where value is below laboratory detection limit in which case U-MS is substituted if it is available.

(c) These variables were approximated using cubic spline functions to fit the curves in Hem (1970), p. 155.

Table C-2

OAK RIDGE GEOCHEMICAL SAMPLING FORM
SHOWING FIELD DATA RECORDED ON MICROFICHE

OAK RIDGE GEOCHEMICAL SAMPLING FORM

1 Card Number

GENERAL SITE DATA

Attach Identical Sample Number Here

2 3 4 5 6 7

8 9 10 11 Site Number

12 13 14 15 – 16 17 Map Code

Sample Type

18	
M	Stream Sediment
H	Lake Sediment
S	Stream Water
W	Well Water
P	Spring Water
L	Lake Water
A	Bog Water
B	Plant
F	Soil (Use Remarks)
G	Rock
Ø	Other

19 Replicate Letter (A–Z)

Hour		Day		Month		Year	
20	21	22	23	24	25	26	27

28 29 30 Collector's Initials

31 Phase (P, 1, 2, or G)

Field Sheet Status

32	
Ø	Original
C	Correction
V	Voiding

Control Sample

33	
A	Sediment, High U
B	Sediment, Low U
C	Water, High U
D	Water, Low U
Ø	Other

34 35 36 37 Air Temperature (°C)

Location

Latitude						Longitude						
Deg.		Min.		Sec.		Deg.			Min.		Sec.	
38	39	40	41	42	43	44	45	46	47	48	49	50

51 52 53 54 Surface Geologic Unit Code

Type of Vegetation

55	(Within 1 Km Upstream)
C	Conifer
&	Conifer & Deciduous
D	Deciduous
B	Brush
G	Grass
M	Moss
L	Lichen
Ø	Other

Density of Vegetation

56	(Within 1 Km Upstream)
B	Barren
S	Sparse
M	Moderate
D	Dense
V	Very Dense

Local Relief

57	(Within 1 Km Upstream)	
F	Flat	(<2m)
L	Low	(2–15m)
G	Gentle	(15–60m)
M	Moderate	(60–300m)
H	High	(>300m)
Ø	Other	

Weather

58		59	
C	Calm	C	Clear
P	Lt Wind	L	Pt Cldy
V	Windy	W	Overcst
R	V. Windy	V	Rainy
S	Gale	G	Snowy

Classes of Contaminants

60	(Use Remarks)
N	None
M	Mining
A	Agriculture
F	Oil Field
I	Industry
S	Sewage
P	Power Plant
U	Urban
Ø	Other

Average Stream Velocity (m/sec)

61 62 63

N = No Visible Movement
P = Stagnant Pool

64 65 66 Water Width (m)

67 68 69 Average Depth (m)

Water Level

70		70	
D	Dry	N	Normal
P	Pools	H	High
L	Low	F	Flood

Dominant Bed Material

71	
B	Boulder
C	Cobble
P	Pebble
S	Sand
T	Silt
Y	Clay
N	None (Use Remarks)

Sample Color (Except Plants)

Adj			Noun	
72	73	74	75	76

V	V Lt	PK	Pink
L	Light	RD	Red
M	Medium	GN	Green
D	Dark	BU	Blue
		BN	Brown
CL	Clear	GY	Gray
WH	White	BK	Black
YL	Yellow	OT	Other
OR	Orange		

Odor of Sampled Material

77	
N	None
S	H_2S
Ø	Other

78	
R	Results Request (Use Remarks)

2 Card Number

PLANT SAMPLE

18 19 Number of Plants Sampled (Number of grabs for moss)

20 21 22 Trunk Diameter (m) (1 m above ground)

23 24 25 Plant Height (m) (Average of Plants Sampled)

Name of Tree, Deciduous

26		26	
R	Alto Verde	U	Locust
A	Ash	P	Maple
B	Beech	M	Mesquite
I	Birch	K	Oak, Other
D	Box Elder	V	Olive
F	Cherry	Y	Poplar
N	Cottonwood	S	Sycamore
E	Elm	T	Salt Cedar
H	Hackberry	G	Walnut
C	Hickory	X	Willow
W	Huisache	Ø	Other
L	Live Oak		

Name of Tree, Conifer

27		27	
A	N. Wh. Cedar	L	Larch
C	Cedar, Other	P	Pine
F	Fir	S	Spruce
H	Hemlock	Ø	Other
J	Juniper		

Name of Bush

28		28	
A	Alder	W	Witch Hazel
B	Blueberry	Y	Yew
P	Pussy Willow	Ø	Other

Name of Moss

29	
P	Peat
S	Sphagnum (live)
Ø	Other

Algae

30	
G	Blue-Green
B	Brown
Ø	Other

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(1 6-77)

Table C-2, Continued

OAK RIDGE GEOCHEMICAL SAMPLING FORM
SHOWING FIELD DATA RECORDED ON MICROFICHE

STREAM OR LAKE SEDIMENT

Sample Condition (31)
- D Dry
- W wet

Sample Treatment (32)
- N None
- S Sieved
- Ø Other

(33, 34) Number of Grabs

(35, 36) % Organic Material (Field Estimate)

GENERAL WATER SAMPLES

Water Sample Treatment (37)
- N None
- F Filtered Only
- C Acidified Only
- A Acidified and Filtered
- Ø Other

Depth of Visibility (m) (38, 39, 40) C = Clear

(41, 42, 43, 44, 45) Conductivity (μmhos/cm)

(46, 47, 48) Dissolved O_2 (ppm)

(49, 50, 51) Temperature (°C)

(52, 53, 54) pH

(55) P pH by Le-Ion Paper

(56, 57, 58, 59) Total Alkalinity (ppm)

(60, 61, 62, 63) P Alkalinity (ppm)

(64, 65, 66, 67) M Alkalinity (ppm)

Appearance of Water (68)
- C Clear
- M Murky
- A Algal
- Ø Other

(69, 70, 71, 72, 73) Discharge (liters/min)

(74, 75, 76, 77) Identification of Producing Horizon (Geologic Unit Code)

Confidence of Producing Horizon Identification (78)
- H High Degree
- R Probable
- S Possible

Source of Producing Horizon Identification (79)
- P Publication
- W Owner
- U User
- G Geologic Inference
- Ø Other

(1) 3 Card Number

WELL WATER

Type of Well (18)
- D Drilled
- P Drive Point
- G Dug
- U Unknown
- Ø Other

Power Classification (19)
- A Artesian Flow
- E Electric
- G Gasoline
- W Wind
- H Hand
- Ø Other

Casing (20)
- N None (Below Water Table)
- S Steel
- G Galvanized
- P Plastic
- U Unknown
- Ø Other

Pipe Composition (21)
- F Steel
- Z Galvanized
- C Copper
- P Plastic
- U Unknown
- Ø Other

Sample Location (22, 23, 24) Meters from Well Head; H = Holding Tank (Use Remarks)

Where Sample Taken With Respect To Pressure Tank (25)
- B Before
- A After
- N No Pressure Tank
- F From Pressure Tank (Use Remarks)

Use of Well (26)
- M Municipal
- H Household
- S Stock
- I Irrigation
- A All of above
- X H and S
- Y H and I
- Z S and I
- N None
- Ø Other

Frequency of Pumping (27)
- C Constant (hourly)
- F Frequent (daily)
- I Infrequent (weekly)
- R Rare (no recent use)

Depth to top of Producing Horizon (28, 29, 30, 31) (Meters)

Confidence of Producing Depth (32)
- H High
- R Probable
- S Possible

Source of Producing Depth Information (33)
- P Publication
- W Owner
- U User
- G Geologic Inference
- Ø Other

Total Well Depth (34, 35, 36, 37) (Meters)

Confidence of Total Depth (38)
- H High
- R Probable
- S Possible

Source of Total Depth Information (39)
- P Publications
- W Owner
- U User
- G Geologic Inference
- Ø Other

LAKE WATER

Type of Lake (55)
- N Natural
- M Manmade

Lake Area (56, 57, 58, 59) (sq km)

REMARKS (Card 4)

Table C-2, Continued

OAK RIDGE GEOCHEMICAL SAMPLING FORM SHOWING FIELD DATA RECORDED ON MICROFICHE

OAK RIDGE GEOCHEMICAL SAMPLING FORM

FIELD DATA SUPPLEMENT

Attach Identical Sample Number Here

1	2	3	4	5	6

Sequence Number

7
1

Procedure Number

8	9

Results for Procedure 31

16	17	18	19	20

Total Gamma - Scintillometer (counts/minute)

Results for Procedures 34-41

16	17	18	19	20
			•	

Variables and Procedures are listed below

Results for Procedure 32 Gamma Spectrometer

TOTAL COUNTS (CPM)

e POTASSIUM (%)

POTASSIUM (CPM)

e URANIUM (ppm)

URANIUM (CPM)

e THORIUM (ppm)

THORIUM (CPM)

Note To Sampler: Blocks 16-20 Not Used Should Be Marked Out.

DO NOT KEYPUNCH

Procedures 34—41

34 Uranium (ppb)
35 Fluoride (ppm)
36 Nitrate (ppm)
37 Sulphate (ppm)
38 Phosphate (ppm)
39 Ferrous Iron (ppm)
40 Total Iron (ppm)
41 Turbidity (% T)

Readings made in Counts per ______

VARIABLE	READING		BACKGROUND		RESULTS
	ACTUAL	CPM	ACTUAL	CPM	
TOTAL COUNTS					
POTASSIUM					
URANIUM					
THORIUM					

UCN-11992A
(1 3-79)

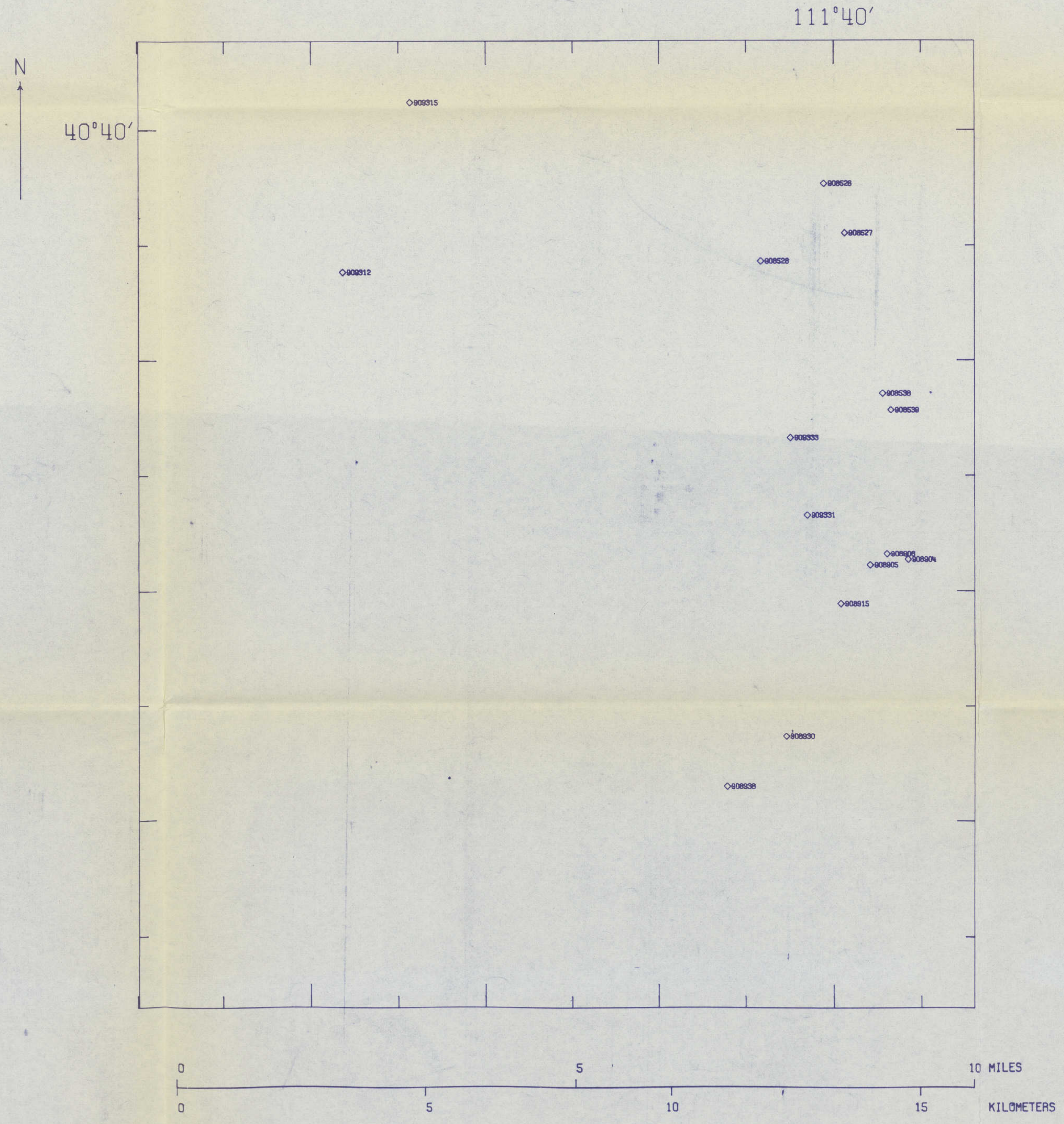
APPENDIX D

MICROFICHE OF FIELD AND LABORATORY DATA

APPENDIX D

MICROFICHE OF FIELD AND LABORATORY DATA

CONTENTS



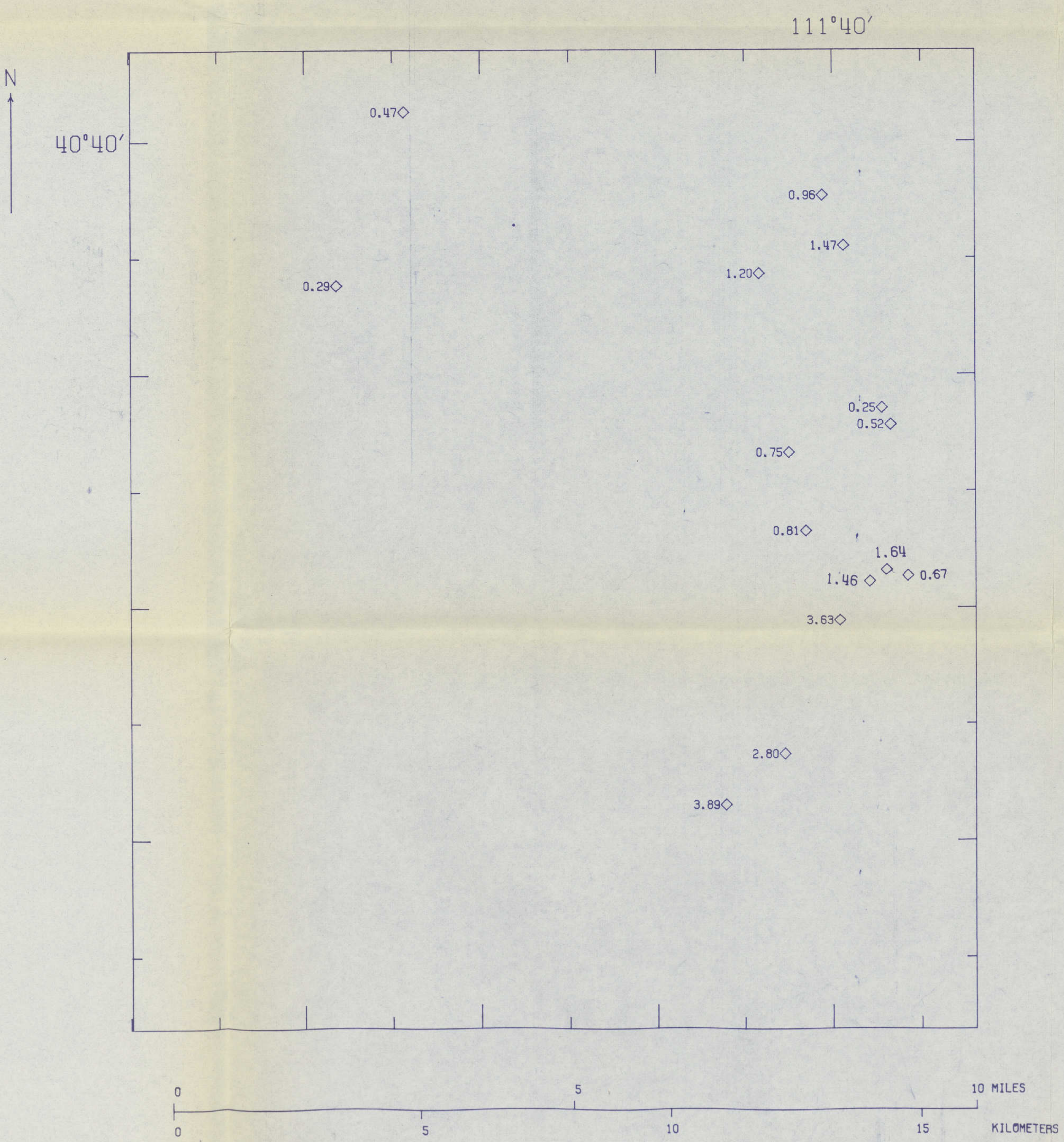
LEGEND

◇ SPRING WATER

PLATE I
COTTONWOOD PROJECT AREA
THOMAS RANGE-WASATCH
DETAILED GEOCHEMICAL SURVEY
SAMPLE LOCATION MAP

SCALE 1: 62500

15 SAMPLES PLOTTED



LEGEND

◇ SPRING WATER

PLATE 2
COTTONWOOD PROJECT AREA
THOMAS RANGE-WASATCH
DETAILED GEOCHEMICAL SURVEY
GROUNDWATER CONCENTRATION MAP

URANIUM (PPB)

SCALE 1: 62500

15 SAMPLES PLOTTED

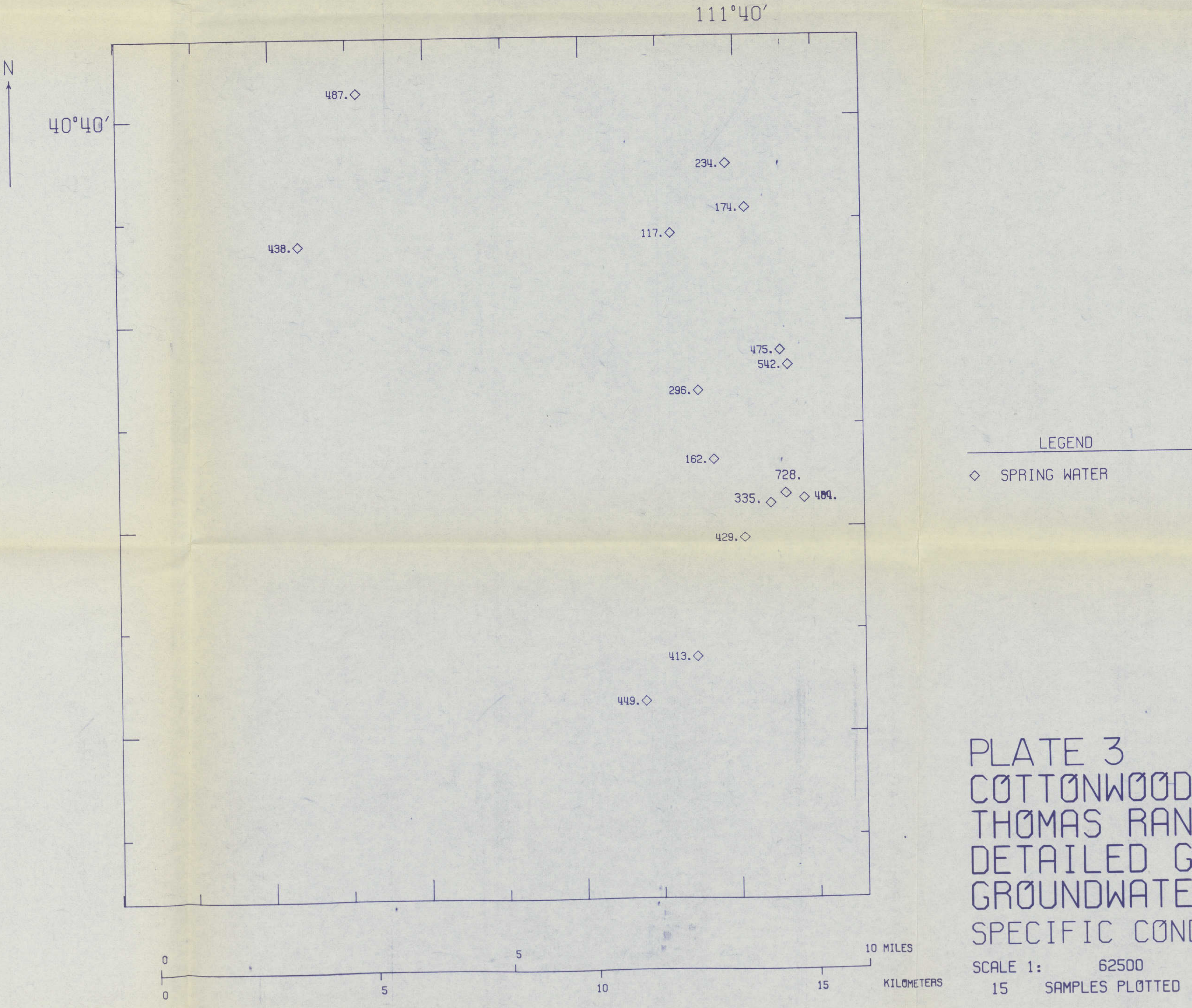
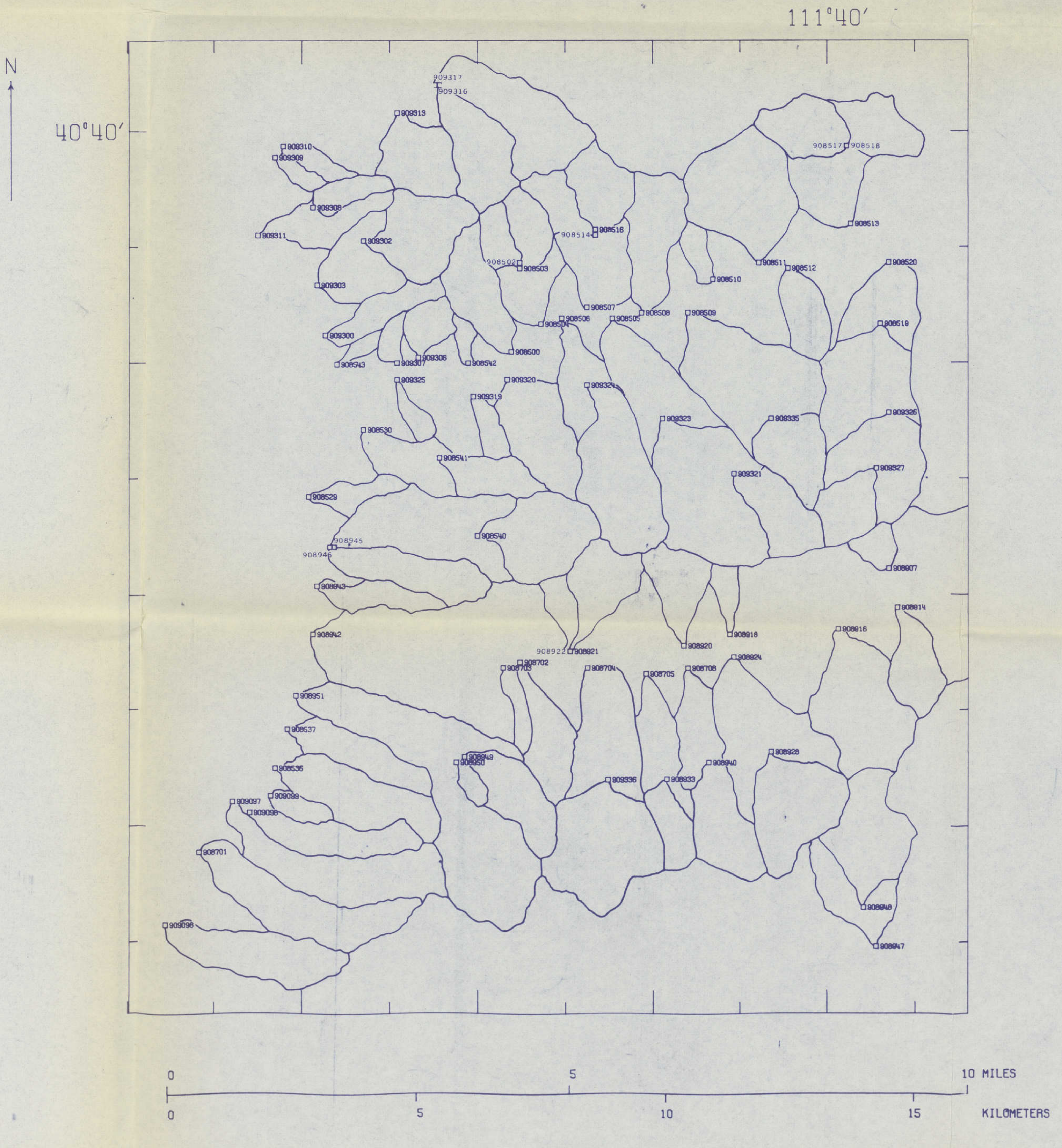


PLATE 3
COTTONWOOD PROJECT AREA
THOMAS RANGE-WASATCH
DETAILED GEOCHEMICAL SURVEY
GROUNDWATER CONCENTRATION MAP
SPECIFIC CONDUCTANCE (UMHOS/CM)

SCALE 1: 62500

15 SAMPLES PLOTTED



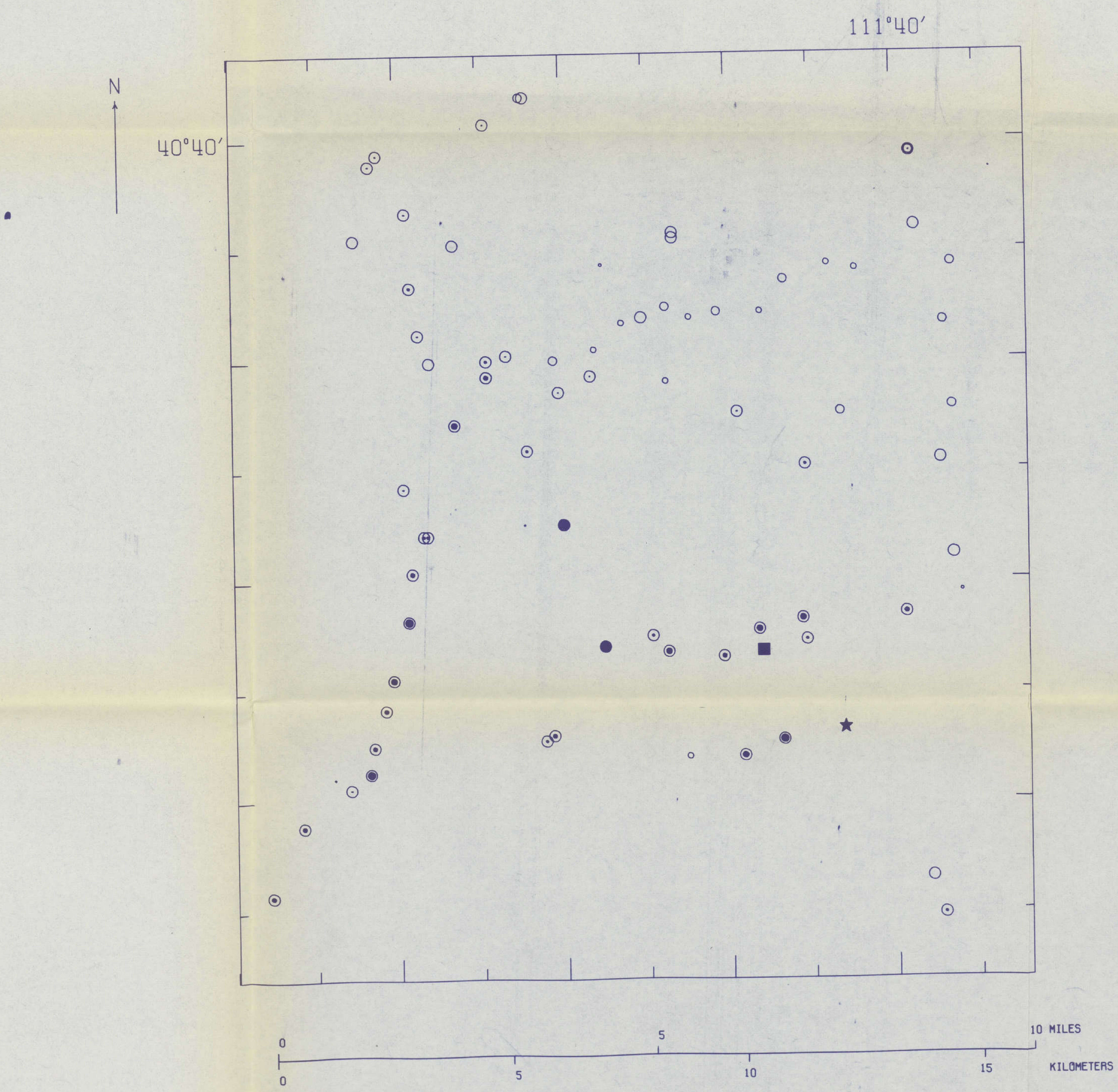
LEGEND

▫ STREAM SEDIMENT

PLATE 4
COTTONWOOD PROJECT AREA
THOMAS RANGE-WASATCH
DETAILED GEOCHEMICAL SURVEY
SAMPLE LOCATION AND
DRAINAGE BASIN MAP

SCALE 1: 62500

79 SAMPLES PLOTTED



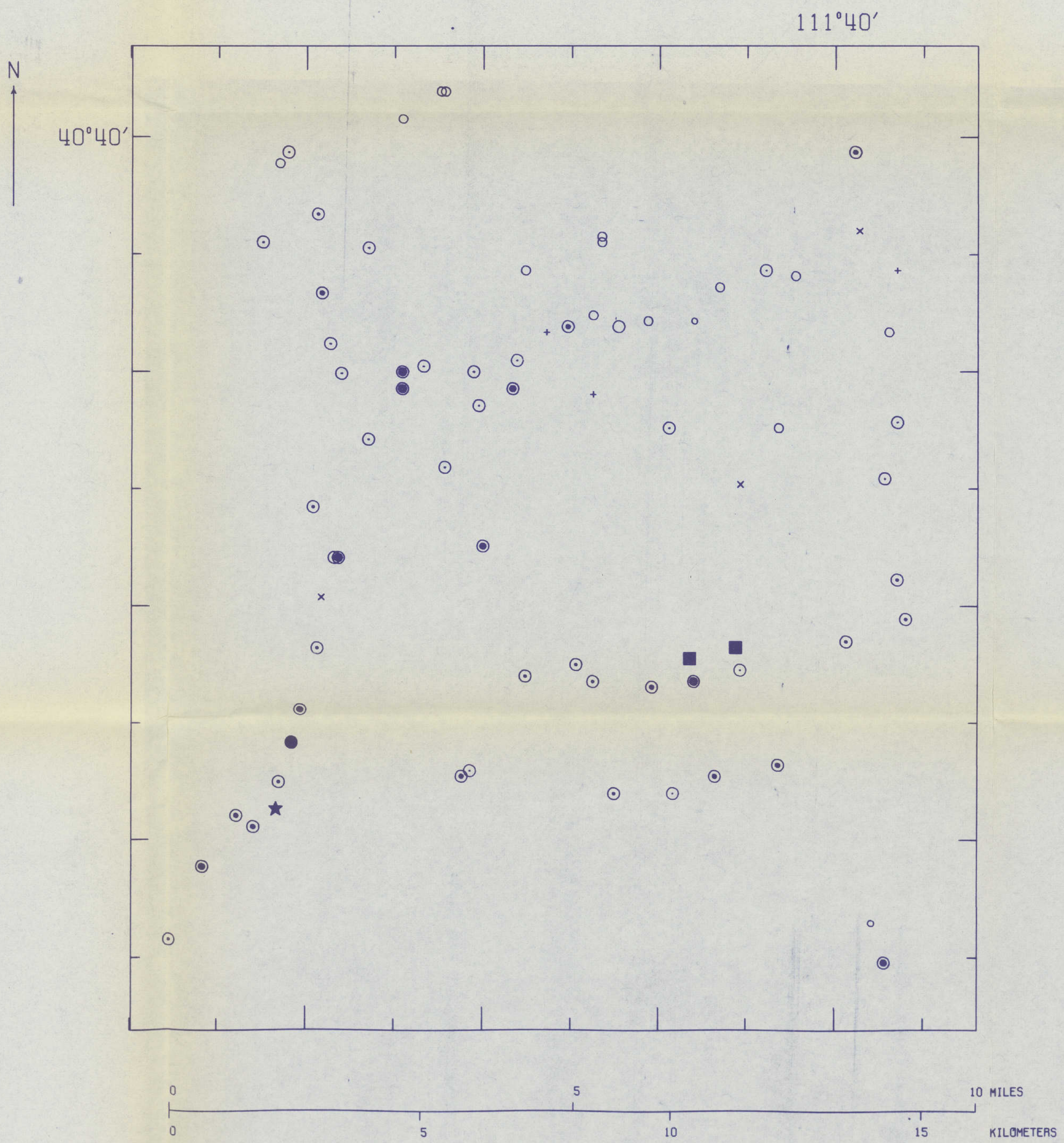
SYMBOL RANGES FOR PLOTTED VARIABLE (X)

0.31 ≤ X < 0.78
0.78 ≤ X < 1.36
1.36 ≤ X < 2.06
2.06 ≤ X < 2.47
2.47 ≤ X < 3.22
3.22 ≤ X < 4.23
4.23 ≤ X < 7.26
7.26 ≤ X < 15.34
15.34 ≤ X < 23.06
23.06 ≤ X < 32.37
32.37 ≤ X < 44.48
44.48 ≤ X < 63.44
X ≥ 63.44

PLATE 5
COTTONWOOD PROJECT AREA
THOMAS RANGE-WASATCH
DETAILED GEOCHMMICAL SURVEY
STREAM SEDIMENT SYMBOL PLOT

URANIUM, FLUOROMETRIC (PPM)

SCALE 1: 62500
77 SAMPLES PLOTTED



SYMBOL RANGES FOR
PLOTTED VARIABLE (X)

+	0 ≤ X < 2
×	2 ≤ X < 3
∘	3 ≤ X < 4
○	4 ≤ X < 7
◯	7 ≤ X < 8
⊙	8 ≤ X < 12
⊙	12 ≤ X < 15
⊙	15 ≤ X < 19
◉	19 ≤ X < 24
◉	24 ≤ X < 30
●	30 ≤ X < 37
■	37 ≤ X < 44
★	X ≥ 44

PLATE 6
COTTONWOOD PROJECT AREA
THOMAS RANGE-WASATCH
DETAILED GEOCHMMICAL SURVEY
STREAM SEDIMENT SYMBOL PLOT

THORIUM (PPM)

SCALE 1: 62500
77 SAMPLES PLOTTED

STRATIGRAPHIC COLUMN FOR THE COTTONWOOD PROJECT AREA

ERA	SYSTEM	SERIES	NURE CODE MAP	NURE CODE FIELD	GEOLOGIC UNIT
CENOZOIC	QUATERNARY		QUD	QAL	ALLUVIUM
				QTL	TALUS, COLLUVIUM, AND LANDSLIDE DEPOSITS
				QPLB	LAKE BONNEVILLE DEPOSITS
				QPGM	GLACIAL MORAINE
	TERTIARY OR CRETACEOUS		TGD	TGD	GRANODIORITIC TO GRANITIC INTRUSIVE DIKES
			TAD	TAD	DIORITES OF ARGENTA INTRUSIVE COMPLEX AND INTERMEDIATE DIKES
			TLD	TLD	LAMPROPHYE INTRUSIVE DIKES
			TQM	TQM	QUARTZ MONZONITE OF LITTLE COTTONWOOD AND FERGUSON CANYON
MESOZOIC	JURASSIC		MJFU	MJFU	JURASSIC UNITS, UNDIVIDED INCLUDES: MORRISON FORMATION, PREUSS FORMATION, TWIN CREEK LIMESTONE, NUGGET SANDSTONE
	TRIASSIC		MTFU	MTFU	TRIASSIC UNITS, UNDIVIDED INCLUDES: ANKAREH FORMATION, THAYNES FORMATION, WOODSIDE SHALE
PALEOZOIC	PERMIAN		PPC	PPC	PARK CITY FORMATION
	PENNSYLVANIAN	UPPER PENNSYLVANIAN	PWQ	PWQ	WEBER QUARTZITE
		LOWER PENNSYLVANIAN	PLSU	PRV	ROUND VALLEY LIMESTONE
	MISSISSIPPIAN	UPPER MISSISSIPPIAN		MDS	DOUGHNUT FORMATION
				MHF	HUMBUG FORMATION
				MDL	DESERET LIMESTONE
		LOWER MISSISSIPPIAN		MGL	GARDISON LIMESTONE
				MFD	FITCHVILLE FORMATION
	CAMBRIAN	MIDDLE CAMBRIAN		CML	MAXFIELD LIMESTONE
			CTQ	COS	OPHIR FORMATION
		LOWER CAMBRIAN		CTQ	TINTIC QUARTZITE
PRECAMBRIAN	Z		ZMI	ZMI	MUTUAL FORMATION
	Z OR Y		YMFT	YMFT	MINERAL FORK TILLITE
	Y		YBC	YBC	BIG COTTONWOOD FORMATION
	X		XLW	XLW	LITTLE WILLOW FORMATION

SOURCES:

1. CRITTENDEN, MAX D., JR.; GEOLOGY OF DRAPER QUADRANGLE, U.S.G.S. MAP CQ-377 (1965).
2. ________; GEOLOGY OF DROMEDARY PEAK QUADRANGLE, U.S.G.S. MAP CQ-378 (1965).
3. ________; GEOLOGY OF MOUNT AIRE QUADRANGLE, U.S.G.S. MAP CQ-379 (1965).
4. ________; GEOLOGY OF SUGAR HOUSE QUADRANGLE, U.S.G.S. MAP CQ-380 (1965).
5. JAMES, L. P.; GEOLOGY, ORE DEPOSITS, AND HISTORY OF THE BIG COTTONWOOD MINING DISTRICT (1979).

LEGEND

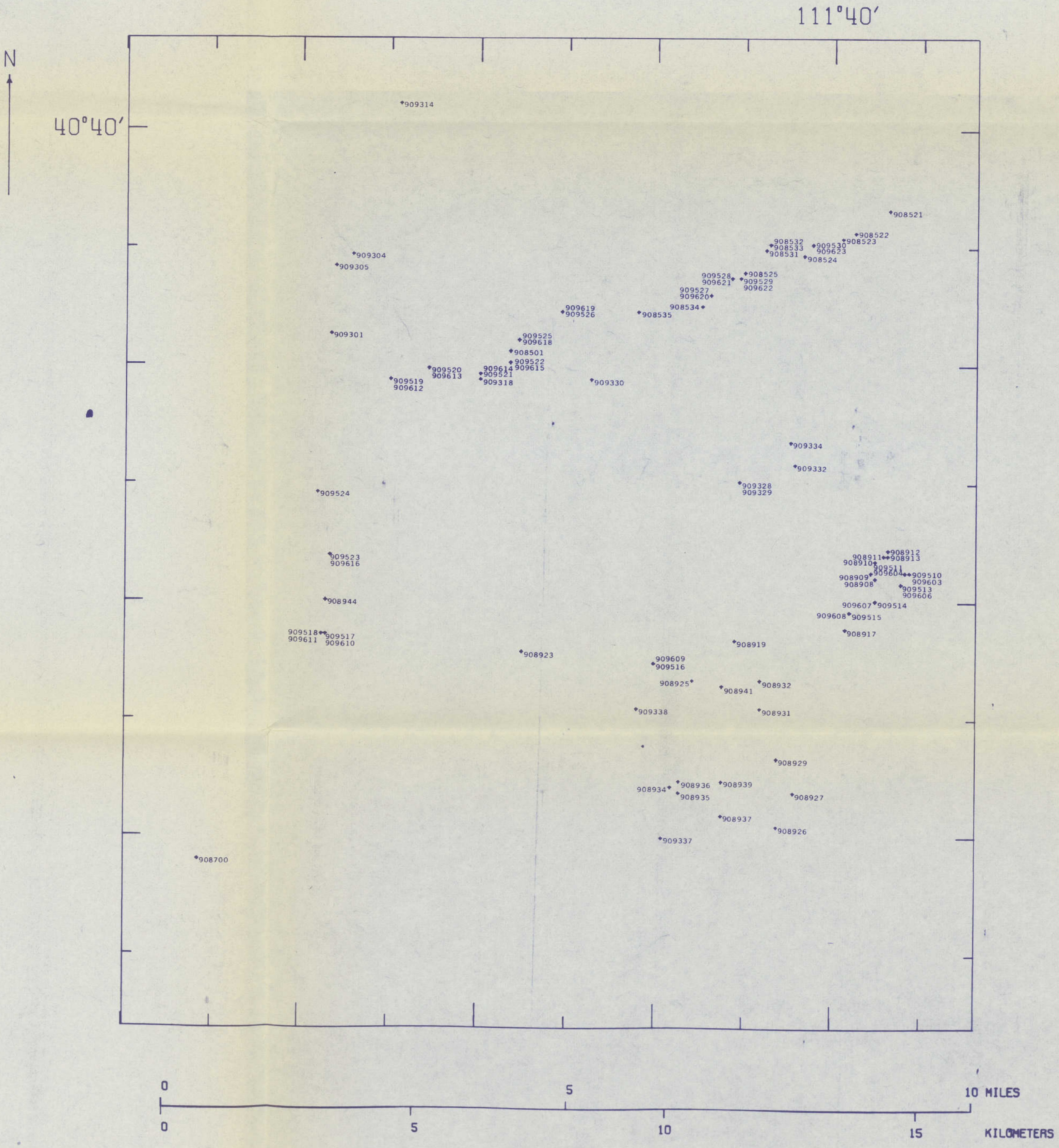
GEOLOGIC CONTACT ————————

GEOLOGIC FAULT ————————

GEOLOGIC FAULT (INFERRED) – – – – – – – –

PLATE 7

GENERALIZED GEOLOGIC MAP OF THE COTTONWOOD PROJECT AREA, THOMAS RANGE-WASATCH DETAILED GEOCHEMICAL SURVEY, UTAH



LEGEND

+ SOIL, ROCK, AND OTHER

PLATE 8
COTTONWOOD PROJECT AREA
THOMAS RANGE-WASATCH
DETAILED GEOCHEMICAL SURVEY
RADIOMETRIC SAMPLE LOCATION MAP

SCALE 1: 62500

85 SAMPLES PLOTTED