CHAPTER 15

HYDROLOGIC DESCRIPTION

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PREFACE

Since the submittal of the 1981-1985 Mining and Reclamation Plan (MRP), Peabody has submitted annual Hydrologic Data reports to expand and further detail the data base which was presented in the MRP. To date, four annual reports have been submitted to OSM. They are entitled the "1980-1981 Hydrological Data" report, the "1981-1982 Hydrological Data" report, the "1983 Hydrological Data" report, and the "1984 Hydrological Data" report. Throughout this Chapter, these four reports will be referred to as the HDR's. All data plots referred to in this Chapter can be found in the HDR's or the original MRP. In those sections of the Chapter where it is felt necessary for the sake of clarity, data plots or tables will be included with the text.

CHAPTER 15

HYDROLOGIC DESCRIPTION

Introduction

Chapter 15 has been structured to present both the regional and site specific hydrologic systems and settings. A more thorough understanding of the local surface- and ground-water conditions can be achieved by considering the local hydrologic situation as an integral part of the regional hydrologic system.

The quantity, distribution and quality of the surface- and ground-water systems are influenced by the structure, stratigraphy, erosional stage and climate of the region. Ground-water storage, recharge, movement and quality are partially to totally controlled by: facies changes and stratigraphic position (stratigraphy); anticlines, synclines, monoclines, basins and upwarps (structure); downcutting of drainage systems (erosional stage); and the average amount of precipitation available for recharge (climate). Surface-water drainage development, quantity and quality are partly to totally controlled by: physical and chemical characteristics of rock units (stratigraphy); folding, faulting and uplift (structure); degree of drainage network entrenchment (erosional stage); frequency, intensity and long-term average amount of precipitation for the region (climate); soil characteristics; and vegetation types and density.

Ground- and surface-water data for the leasehold have been obtained, in part, from studies by the USGS. The USGS studies have generated precipitation, streamflow and stream-water quality data for three small watersheds tributary to the main channel stem of Coal Mine Wash and for Yellow Water Canyon, Coal Mine and Moenkopi Washes. Ground-water studies by the USGS have been directed at defining the quantity, movement and quality of water in the Navajo Sandstone aquifer. An environmental monitorng program was initiated by Peabody Coal Company in 1979. The Peabody environmental monitoring program has generated meteorologic, surface-water quantity and quality and ground-water quantity and quality data for the leasehold and will be operated throughout the life of the mining operation.

Regional Surface-Water Hydrology

Drainage Development. The present Colorado River system was developed in late Cenozoic time and has maintained its course despite different pre-existing lithologies and structures encountered as it eroded downward into the underlying rocks. This superimposed drainage is exemplified by the east-west course of the San Juan River, across upturned and upwarped strata, and by the southwest courses of tributaries of the Little Colorado River, over gentle folds on Black Mesa basin. As downcutting and entrenchment has continued, the drainage system is adjusting to the geologic structure. The extent of adjustment is dependent on the depth of downcutting, average annual river discharge and types of geologic structures. The Colorado River is the least affected by geologic structure while the San Juan and Little Colorado River systems are partly adjusted to the larger folds.

Streamflow and Runoff. All runoff from the Navajo and Hopi Indian Reservations (from now on referred to as the region) is to the Colorado River. Most of the region is drained by two principal tributaries to the Colorado River, the San Juan and the Little Colorado Rivers. Washes draining Black Mesa basin are part of the Little Colorado River drainage. Most runoff is ephemeral and intermittent in nature and is in response to sporadic precipitation events. Other than in the Colorado and San Juan Rivers, perennial flows occur only below sections where stream channels intersect large springs and the water table. Figure 1 shows those sections of the drainage network for the reservations that were identified as perennial during surveys and monitoring conducted by the USGS between 1909-1913 and 1950-1960.

Busby (1966) prepared a map showing the relationship of runoff to precipitation in the region. Busby indicated that the average annual runoff originating in the reservations is approximately 450,000 acre-feet. Streamflow measurements at the mouths of Moenkopi Wash and other tributaries to the Little Colorado River indicate that about 50 percent of the runoff calculated from the runoff map is lost in transmission to the major streams. If these streamflows are indicative of the annual transmission losses for all streams leaving the reservations, the remaining runoff reaching the Colorado and San Juan Rivers is less than 250,000 acre-feet (Cooley et al. 1969).

The primary factors affecting runoff include: (1) interception; (2) infiltration; (3) transmission; (4) noncontribution by internal drainages; and (5) the effect of convectional and frontal storm systems. According to Cooley et al. 1969: "The

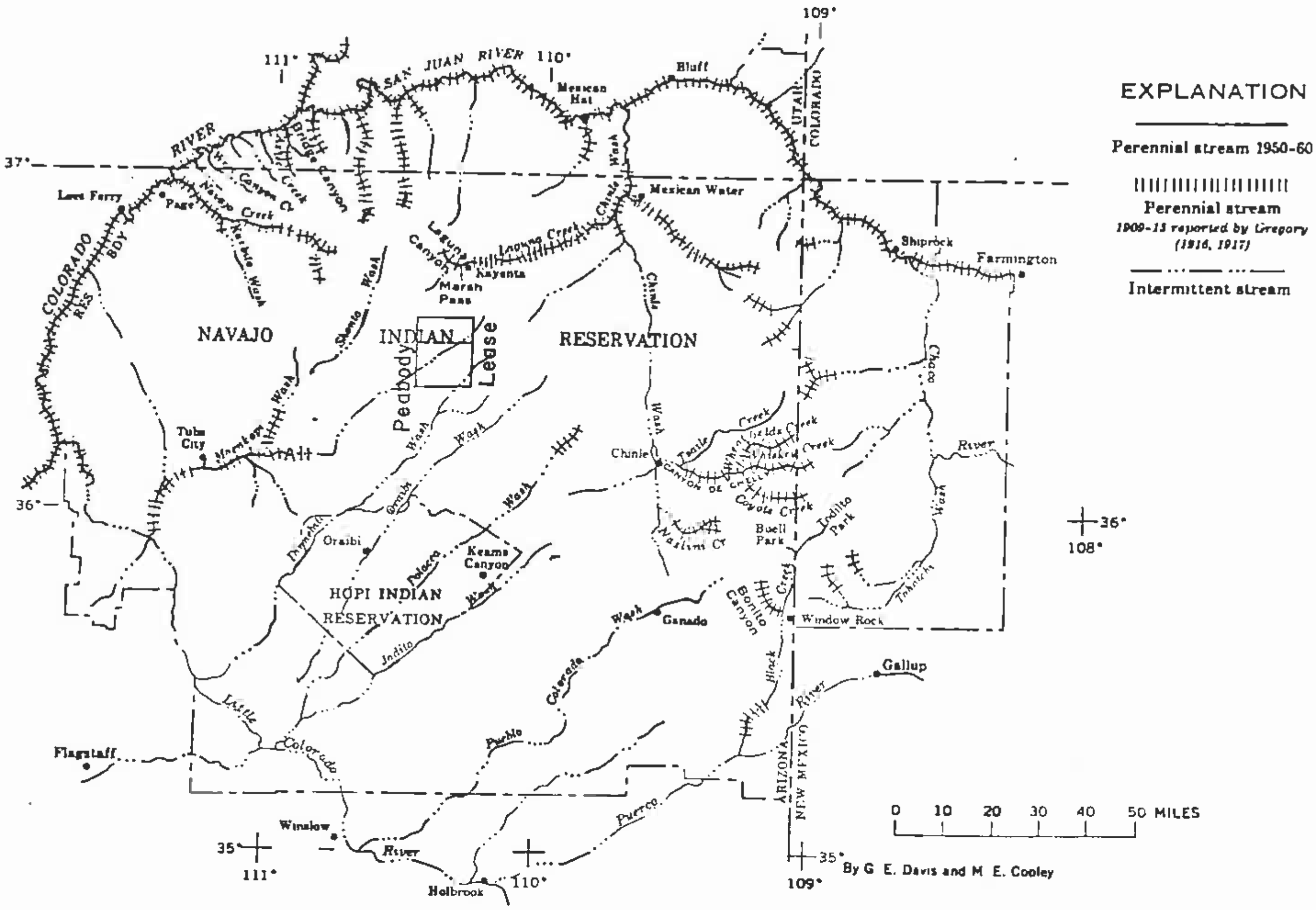


Figure 1

Perennial Streams During 1909 - 1913 and 1950 - 1960
(Cooley et al, 1969)

unconsolidated surficial deposits intercept and absorb much of the precipitation and the accompanying overland and channel flow. Much of the water thus intercepted is retained near the surface and is evaporated and transpired. Most streams are influent, and their channels are underlain by relatively permeable rocks; therefore, their transmission losses are high. The areas of internal drainage reduce the total runoff substantially, although these areas are favorable for ground-water recharge. As a result, almost no water runs off from large areas in the Navajo Uplands, and the runoff in other areas may decrease locally. Most of the runoff below 7,000 feet results from convectional storms; that from low-intensity frontal storms is small and usually is absorbed by the surficial deposits and permeable bedrock units or is evaporated."

Average annual streamflow in the Colorado River, at the Grand Canyon, is 12,310,000 acre-feet. Of this total, 2,014,000 acre-feet per year is discharged by the San Juan River at Bluff, Utah and 147,000 acre-feet per year by the Little Colorado River at Grand Falls. Streamflow in the San Juan and Colorado Rivers is usually greatest during the months of May and June as a result of snowmelt in the mountainous portions of their drainages. Peak flows recorded during these two months for the San Juan and Colorado River have been as high as 21,250 cfs and 133,000 cfs respectively. Streamflow in the Little Colorado River is highest during the months of March, April, August and September. Approximately 85 percent of the average annual flow occurs during these months.

Recent Fluctuations of the Stream Regimen. There have been several episodes of downcutting and alluviation in all the washes or arroyos draining the region since the present drainage system was established. The latest episodes of arroyo cutting began around 1850 (Cooley et al. 1969). The result of these episodes of alluviation and downcutting has resulted in the formation of one or more terraces above the present streambeds. Most arroyos have been continually widening and downcutting, however, in some areas they are aggrading. Figure 2.shows the present areas of aggradation and the amount of terrace development for perennial streams and arroyos in the region.

Other recent fluctuations in the stream regimen of the region include changes in the length of perennial reaches of streams and a general decline of streamflow. The perennial reaches of Moenkopi Wash, Canyon de Chelly and other streams identified during a 1909-1913 survey were considerably longer than those identified during the 1950-1960 USGS stream survey (Figure 1). In other sections of the region, arroyo trenching below the water table has extended perennial reaches of several streams, especially along Laguna Creek

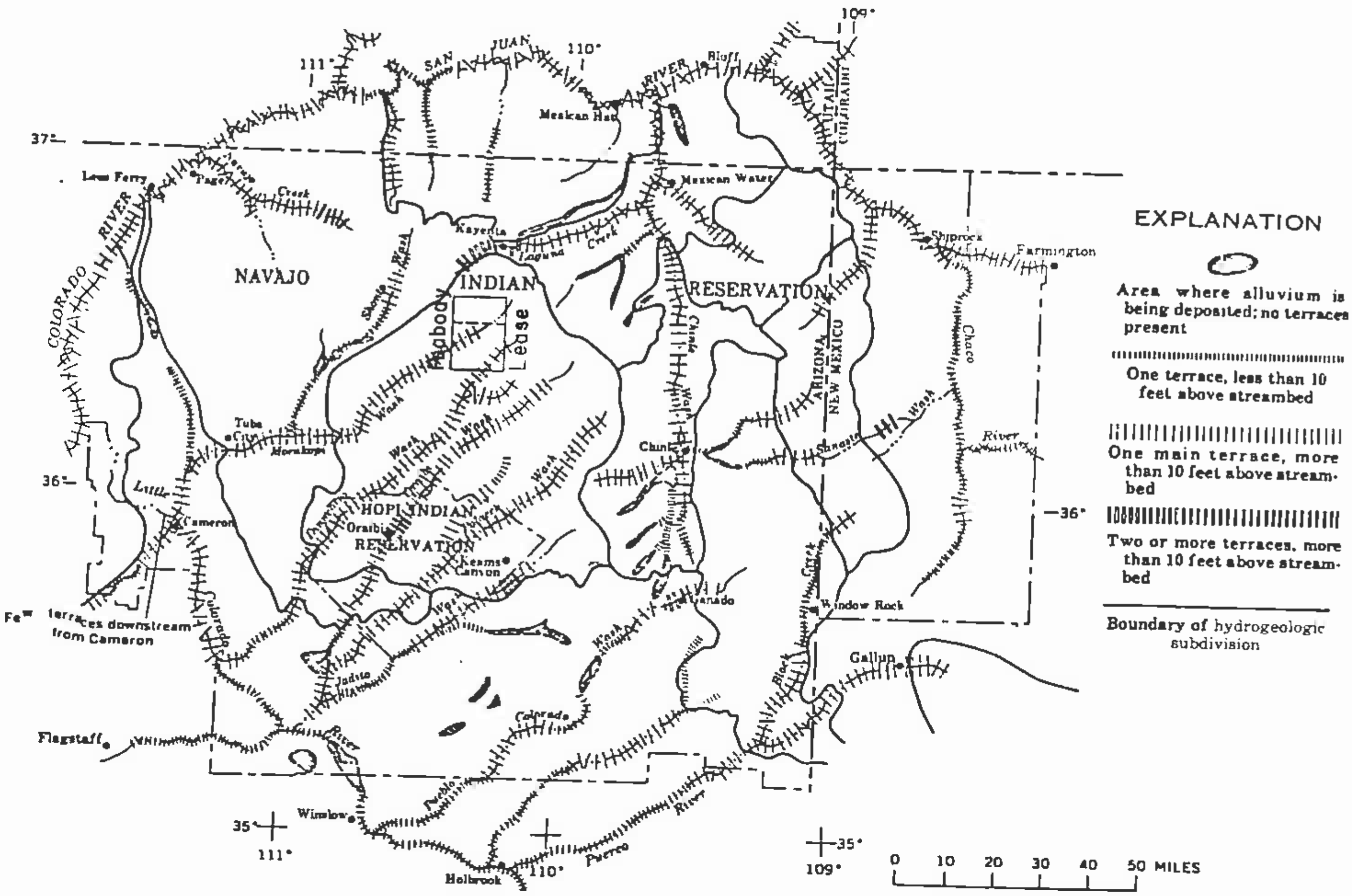


Figure 2

Existing Terraces and Areas of Alluvial Deposition
(Cooley et al, 1969)

(Cooley et al. 1969). USGS streamflow records of the Colorado River at Lees Ferry indicate that there has been a continuous decline in streamflow during the 20th century. Records indicate that flows during the period of 1930-1955 were above the 1897-1955 median flow only eight of those years and below the median flow the other eighteen years.

Regional Ground-Water Hydrology

Setting. The hydrogeologic setting of the Navajo-Hopi Indian Reservations is in the south-central part of the Colorado Plateau's Physiographic Province. The landforms of the reservations are characterized by alternating resistant and weak rock strata. The resistant beds form ledges, cliffs, mesas and benches that are separated by slopes, valleys and badlands eroded in the weak shaly beds (Cooley et al. 1969). The topographic elevation ranges from less than 3,000 feet, in some of the deep canyons, to more than 8,000 feet on some of the plateaus and mesas.

Geologic Controls on Ground Water. The region is characterized by an absence of severe deformation and has been relatively stable since late Precambrian time. The area experienced some moderate folding (basins, uplifts, monoclines, anticlines and synclines) during the Laramide Orogeny of late Cretaceous and early Tertiary time. During late Tertiary and Quaternary time, the region was upwarped and locally faulted (Cooley et al. 1969).

The larger folds (basins and uplifts) control the movement of ground water through the region and divide the area into five hydrologic systems. The five systems are referred to as hydrologic basins and are shown in Figure 3. The hydrologic basins are named after the structural basin in the lowest part of each. According to Todd (1959), a hydrologic or ground-water basin is a physiographic unit containing one large aquifer or several connected and interrelated aquifers. Each ground-water basin functions primarily as an individual system and has little or no hydraulic connection with surrounding basins.

The smaller folds (monoclines, anticlines and synclines) only control the occurrence and movement of ground water locally. The occurrence of ground water in relation to monoclines is shown in Figure 4. Four basic situations may exist: (1) water table conditions may exist on the upthrown and downthrown sides of the monoclines; (2) the upthrown side may be dry; (3) a transition from water table to artesian conditions can occur along the monoclines; and (4) artesian conditions may occur on both sides of the

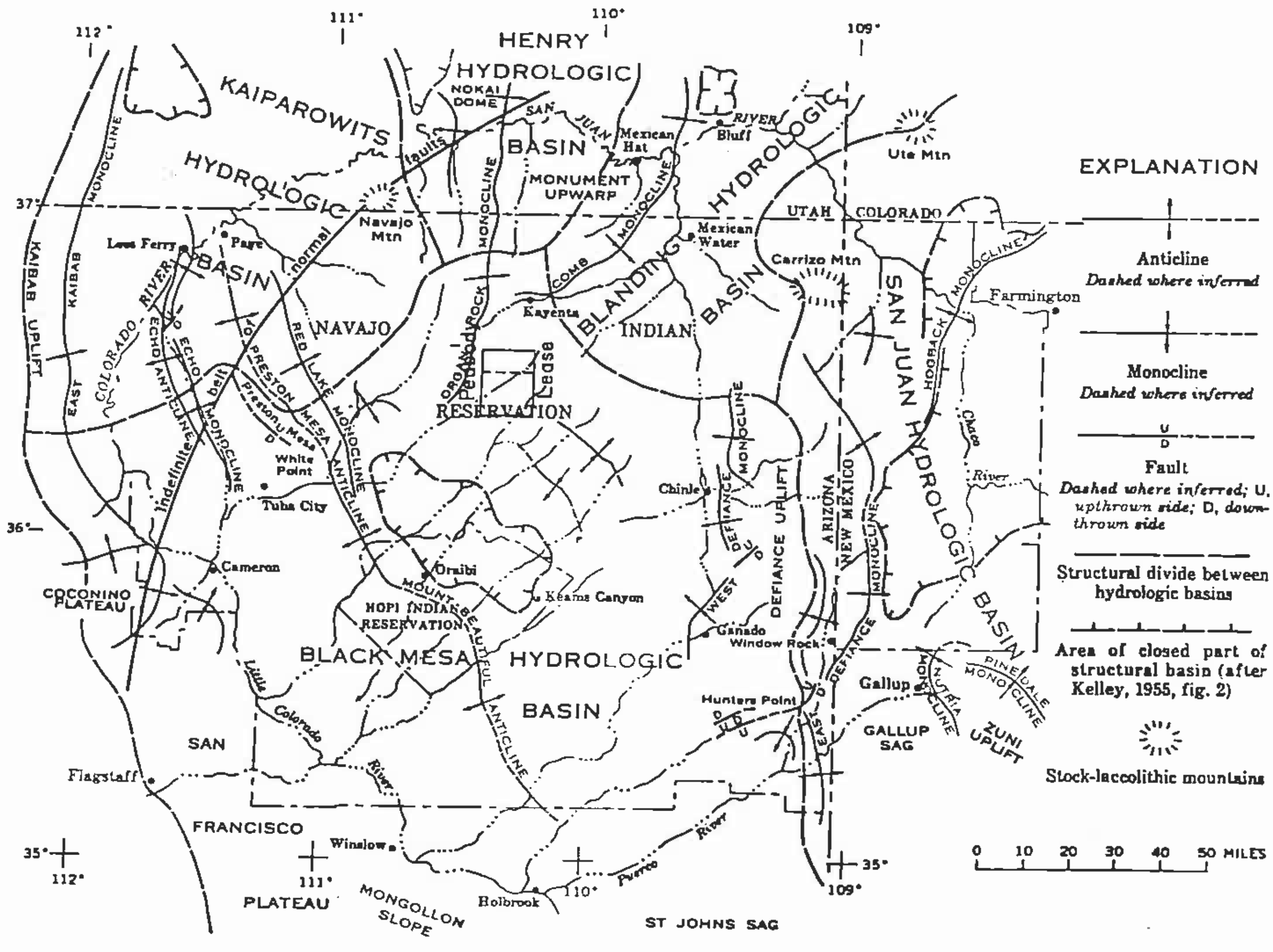


Figure 3

Hydrologic Basins and Principal Structural Features That Control the Movement of Ground Water (Cooley et al, 1969)

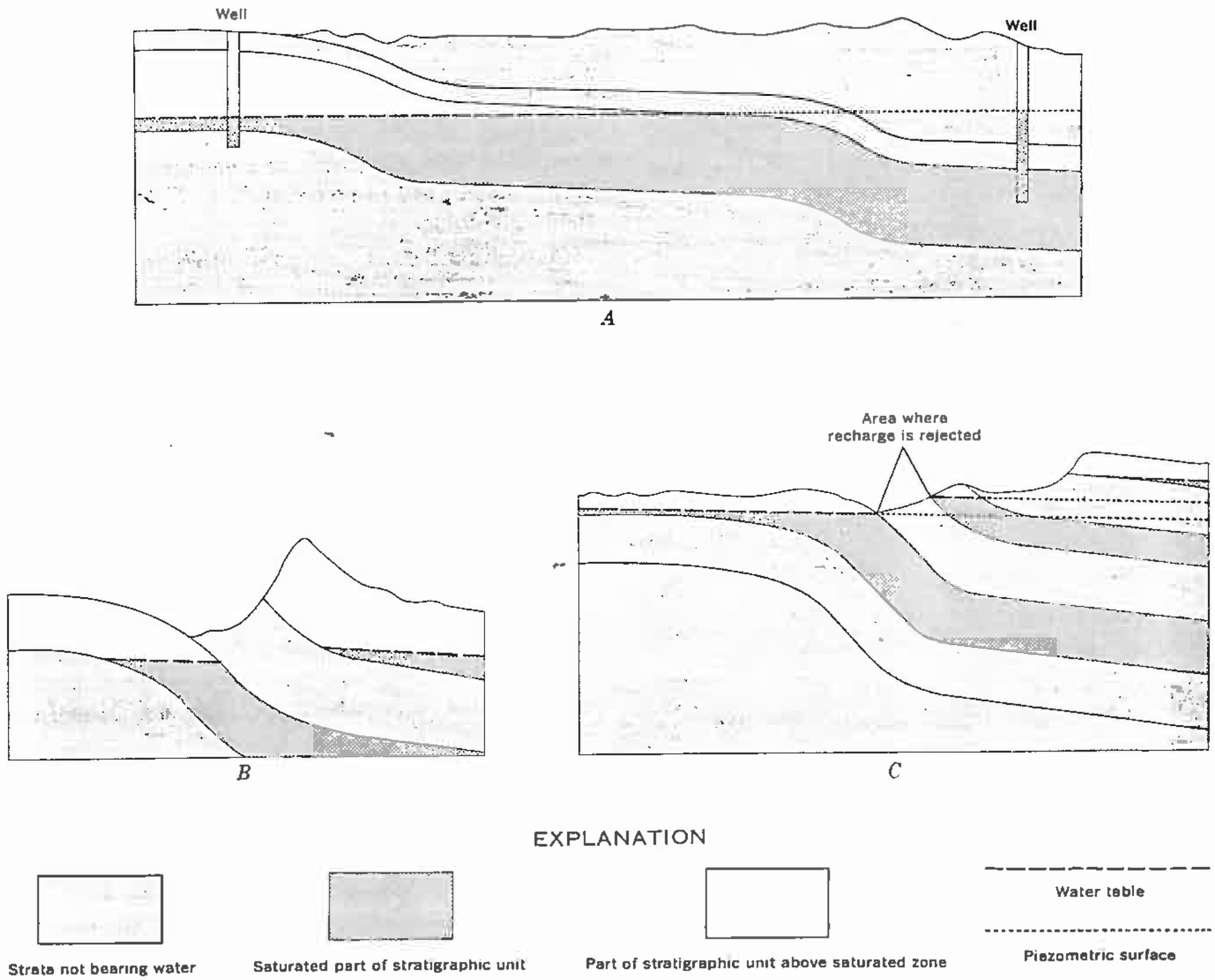


Figure 4

The Occurrence of Ground Water in Relation to Monoclines
(Cooley et al, 1969)

monoclines (Cooley et al. 1969). The condition which exists depends on the dip and degree of folding of the beds, position of the recharge areas and location of impermeable units (refer to Figure 4).

Anticlines and synclines tend to exert a lesser influence on the occurrence and movement of ground water in the hydrologic basins. Sufficient quantities of ground water can normally be obtained on the crests and flanks of anticlines, as long as the saturated thickness of the aquifers is not exceeded by the structural relief. If the structural relief of the anticlines is significant, the crests will normally yield little if any water, unless artesian conditions occur under the crest.

Faults probably exert the least overall effect on ground-water occurrence and movement in the region. This is largely due to the fact that faults are uncommon except in the western part of the region. Depending on the orientation of the faults, their effect on ground-water movement can be either minimal or significant. If the faults are oriented parallel to the direction of ground-water flow, they will have minimal effect on the flow system. If the fault planes cut diagonally across the prevailing ground-water flow direction, they may either partially or totally disrupt the flow depending on the amount of displacement and the saturated thicknesses of the aquifers. With the exception of a few cases, most of the faults in the region have displacements of only 50 - 150 feet (Cooley et al. 1969). Since most of the significant aquifers in the region are approximately 200 feet or greater in thickness, only partial disruption, if any, occurs in the ground-water flow system due to faults oriented diagonally to the direction of flow. In some instances, the faulting has created areas of ground-water discharge in the form of springs and seeps. This occurs mainly on the Defiance Plateau and near the Colorado and San Juan Rivers. Unlike the faults, joints are quite prevalent in the region. This type of fracturing in the rock occurs with no appreciable movement and quite often increases the permeability of rock units.

Hydrogeologic Subdivisions. The region is further divided into eleven hydrogeologic subdivisions based on similarities in sedimentary rock outcrop distribution, geologic structure and drainage patterns. Figure 5 shows the outlines of the various hydrogeologic subdivisions and a generalized distribution for artesian and water table areas. Ground water in the region occurs under water table conditions near outcrops in the uplands provided depth of burial is not too great. The principal artesian zones correspond with the flanks of basins and in the valleys of the larger rivers and washes. The general

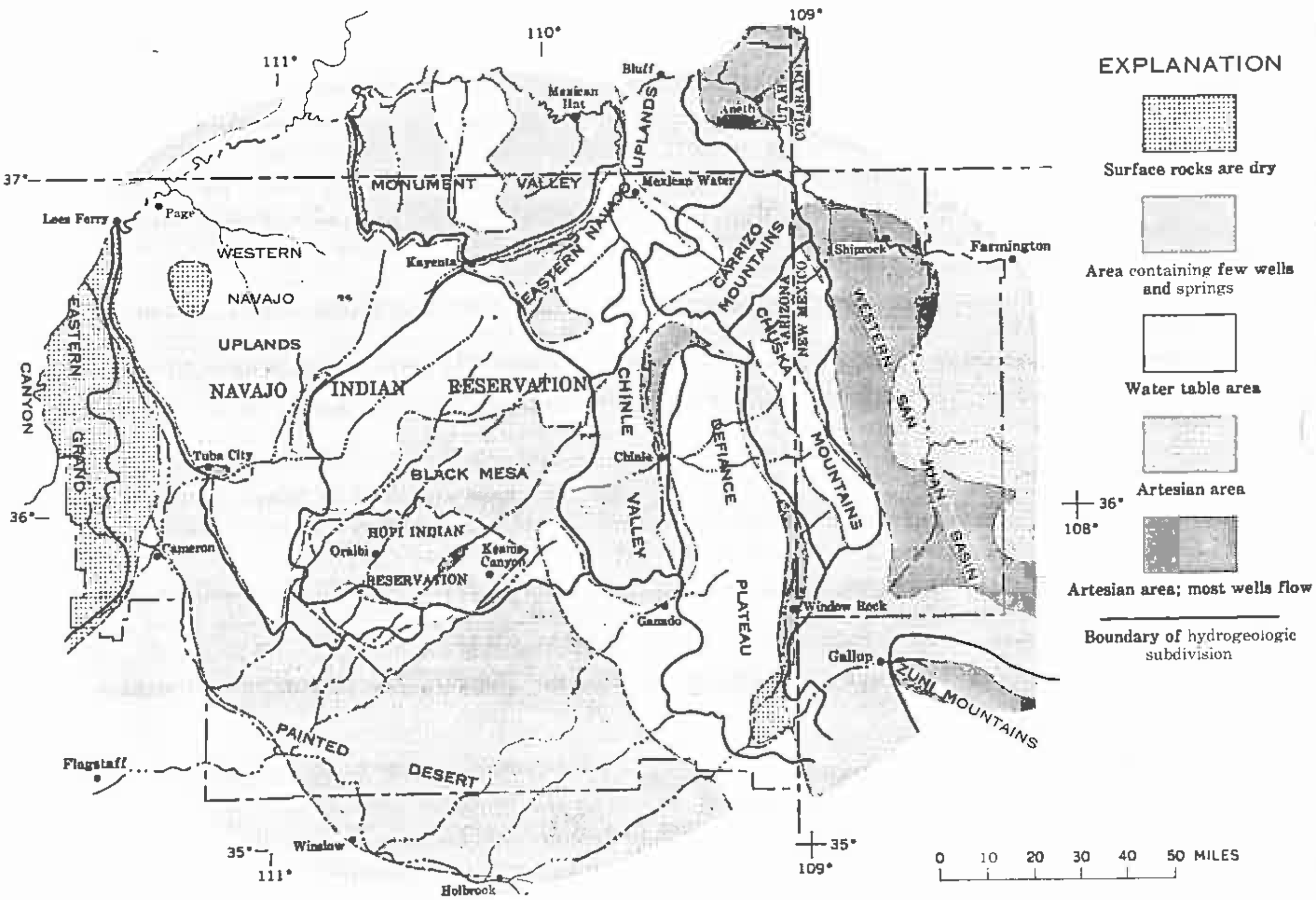


Figure 5

Eleven Hydrogeologic Subdivisions and
Generalized Artesian and Water Table Areas
(Cooley et al, 1969)

distribution of artesian and water table conditions suggests a close relationship between geology and the occurrence of ground water. In the same way, areas with similar depths to ground water and depths of wells (Figures 6 and 7 respectively) roughly outline the general physiographic and structural features of the region.

Geologic Formations and Aquifers. The sedimentary rocks overlying the impermeable granitic and metamorphic Precambrian basement rocks are the principal sources of ground water in the region. Most of the sedimentary units contain some water, but only a few yield sizeable quantities to wells. For the purpose of this discussion, the ground-water potential of the various units of the Coconino, Navajo and Dakota aquifer systems; the Toreva and Wepo Formations of the Cretaceous Mesaverde Group; and the Quaternary alluvium will be covered, as they comprise the important water yielding units underlying or exposed at Black Mesa.

The major water yielding units are the Coconino and Navajo Sandstone aquifer systems. Minor water yielding units in the Black Mesa Basin in ascending stratigraphic order are: the Entrada Sandstone; the Cow Springs Sandstone; the sandstone members of the Morrison Formation; the Dakota Sandstone (these comprise the D-aquifer system); the Toreva Formation; the Wepo Formation; and the alluvium.

The region was once part of two major geosynclines. During the Paleozoic and early part of the Mesozoic Era, the region was part of the eastern shelf area of the Cordilleran Geosyncline. During the latter part of the Mesozoic Era, the region marked the southwestern shelf area of the Rocky Mountain Geosyncline. These shelf areas were frequently inundated by seas extending from the central parts of the geosynclines. As a result, the rock units deposited during this time exhibit complex intertonguing and rapid facies changes. These features form some of the principal controls on ground-water occurrence and movement in the various rock units, in addition to the regional and local structural control previously mentioned. These stratigraphic controls on the ground-water hydrology will be noted in the following discussion of specific aquifers.

Aquifer Descriptions and Hydrology. The aquifer descriptions will progress in stratigraphic order from the oldest units to the youngest starting with the Coconino Sandstone of Permian age. The reader should refer to Table 1 for the stratigraphic sequence and corresponding ages expressed as geologic systems.

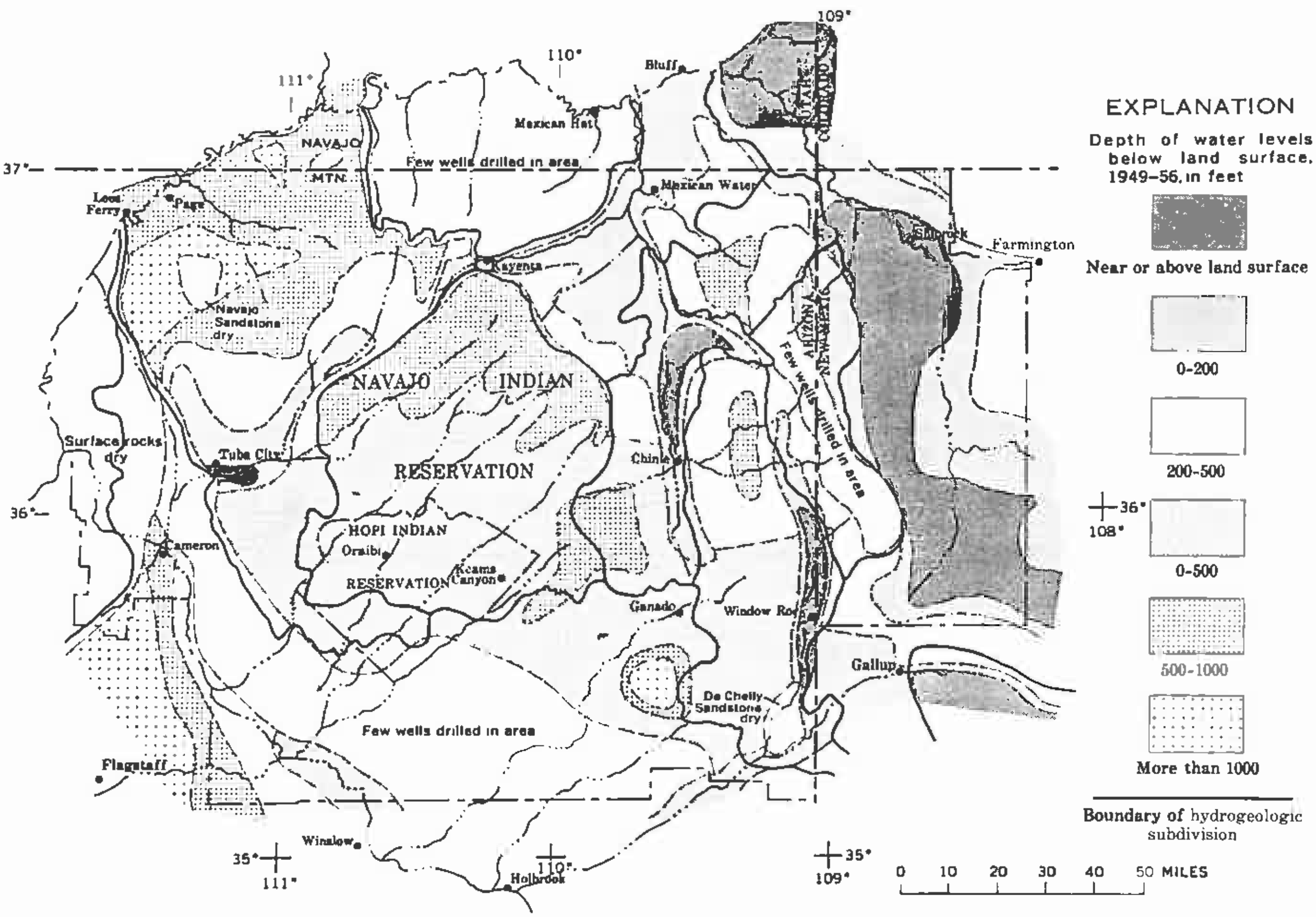


Figure 6

Generalized Depth of Water Levels in Wells Completed in Consolidated Aquifers (Cooley et al, 1969)

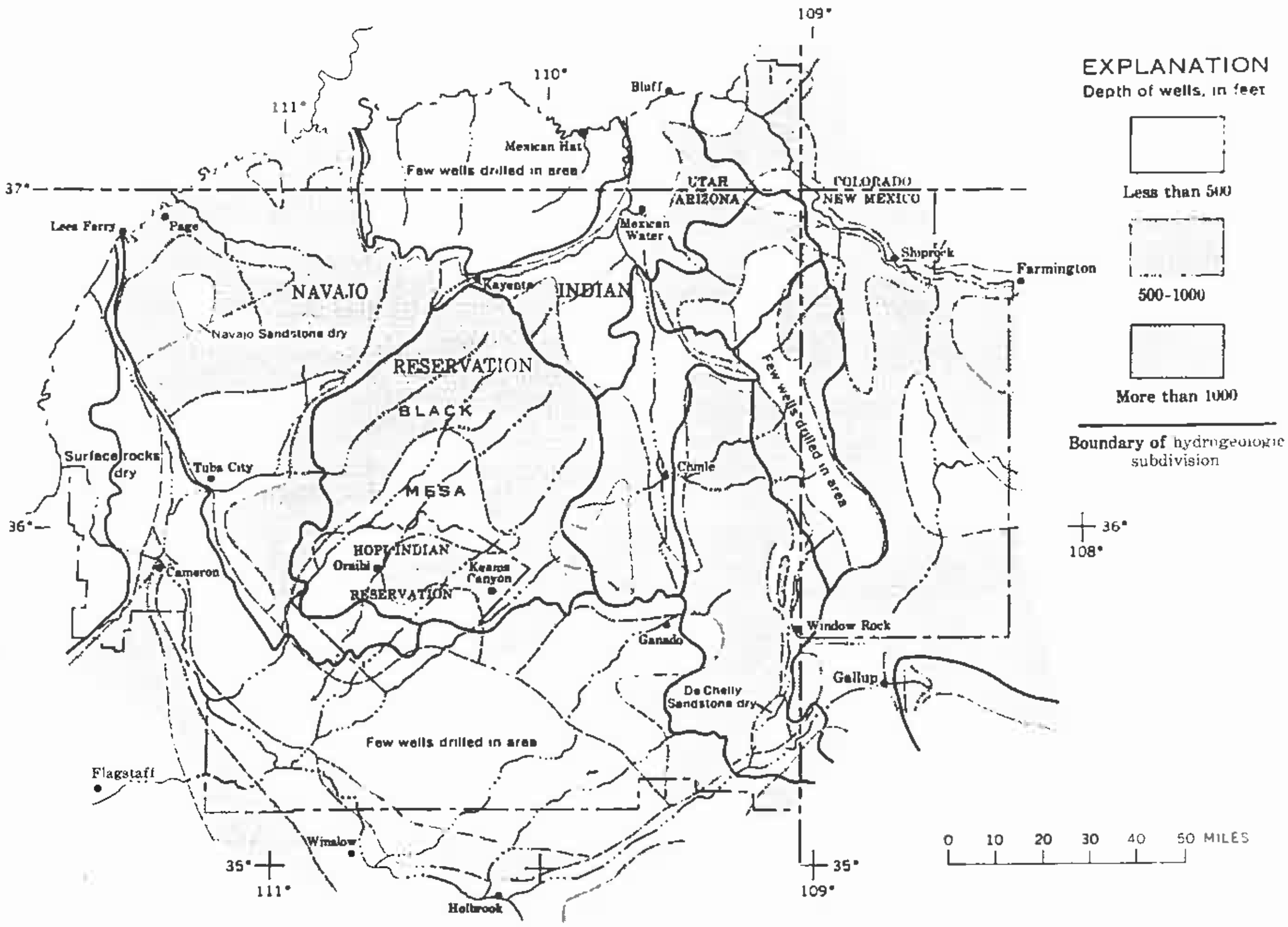


Figure 7

Generalized Range of Well Depths for All Aquifers
(Cooley et al, 1969)

Table 1. Aquifers listed in Time-Stratigraphic Sequence and Corresponding Geologic Systems.

System		Aquifer (Formation or Member)
Quaternary		Alluvium
Cretaceous		Wepo Formation Toreva Formation Dakota Sandstone
Jurassic	D-Aquifer System	Morrison Formation Cow Springs Sandstone Entrada Sandstone
Jurassic-Triassic		Navajo Sandstone
Triassic	N-Aquifer System	Kayenta Formation Moenave Formation Wingate Sandstone Lukachukai Member
	C-Aquifer System	Chinle Formation Shinarump Member Moenkopi Formation
Permian		Cutler Formation De Chelly-Coconino Sandstone Members

The C-Aquifer System. The C-aquifer system is comprised of the Coconino Sandstone and its lateral equivalent the De Chelly Sandstone, the Moenkopi Formation and the Shinarump Member of the Chinle Formation. The Coconino Sandstone consists of very fine to medium-grained well sorted quartz grains (Irwin et al. 1971). The grains are coarse near the southern extent of the unit along the Mogollon Rim and grade into a finer grain size to the north.

The lateral equivalent of the Coconino, the De Chelly Sandstone, is a thick-bedded fine to medium grained sandstone (Levings and Farrar, 1977) and is hydraulically connected with the Coconino and the Shinarump Member of the Chinle Formation. The Chinle and Moenkopi Formations consist primarily of mudstone and siltstone beds. These rock units are 1,100 - 1,600 feet thick and form the upper confining layer of the C-aquifer system. The lithologies of both formations change to the southeastern part of the region. Here the sediments are coarser grained, and several thin beds of sandstone and conglomerate yield small amounts of ground water.

Figure 8 shows the thickness of the C-aquifer system and transmissivities throughout the region. Two cross sections are included to show the facies changes and hydraulic connection of the various units. The Shinarump Member of the Chinle Formation and the De Chelly and Coconino Sandstones are the primary sources of ground water. The other members of the Chinle Formation and the Moenkopi Formation are too fine grained and act as aquicludes. Figure 8 shows that transmissivities are greatest in the southern part of the region where formation thicknesses are greatest and the grain sizes are coarser. The C-aquifer system thins rapidly to the north and pinches out along the Utah-Arizona border. The C-aquifer system yields water of good chemical quality, except southwest of Leupp and in the northern part of the Black Mesa basin where excessive amounts of dissolved solids could render it unfit for any use (Irwin et al. 1971).

The N-Aquifer System. The Lukachukai Member of the Wingate Sandstone, the Moenave Formation, the Kayenta Formation and the Navajo Sandstone comprise what is referred to as the N-aquifer system. The Lukachukai Member of the Wingate Sandstone consists of a fine to very fine-grained quartz sandstone, and this lithology is homogeneous throughout the region (Harshbarger et al. 1957). Figure 9 shows the extent of the region over which the Lukachukai Member was deposited and its thickness variations. The Lukachukai tends to intertongue with the finer grained Rock Point Member of the Wingate Sandstone along the New Mexico-Arizona border which changes its hydraulic character in that area. The

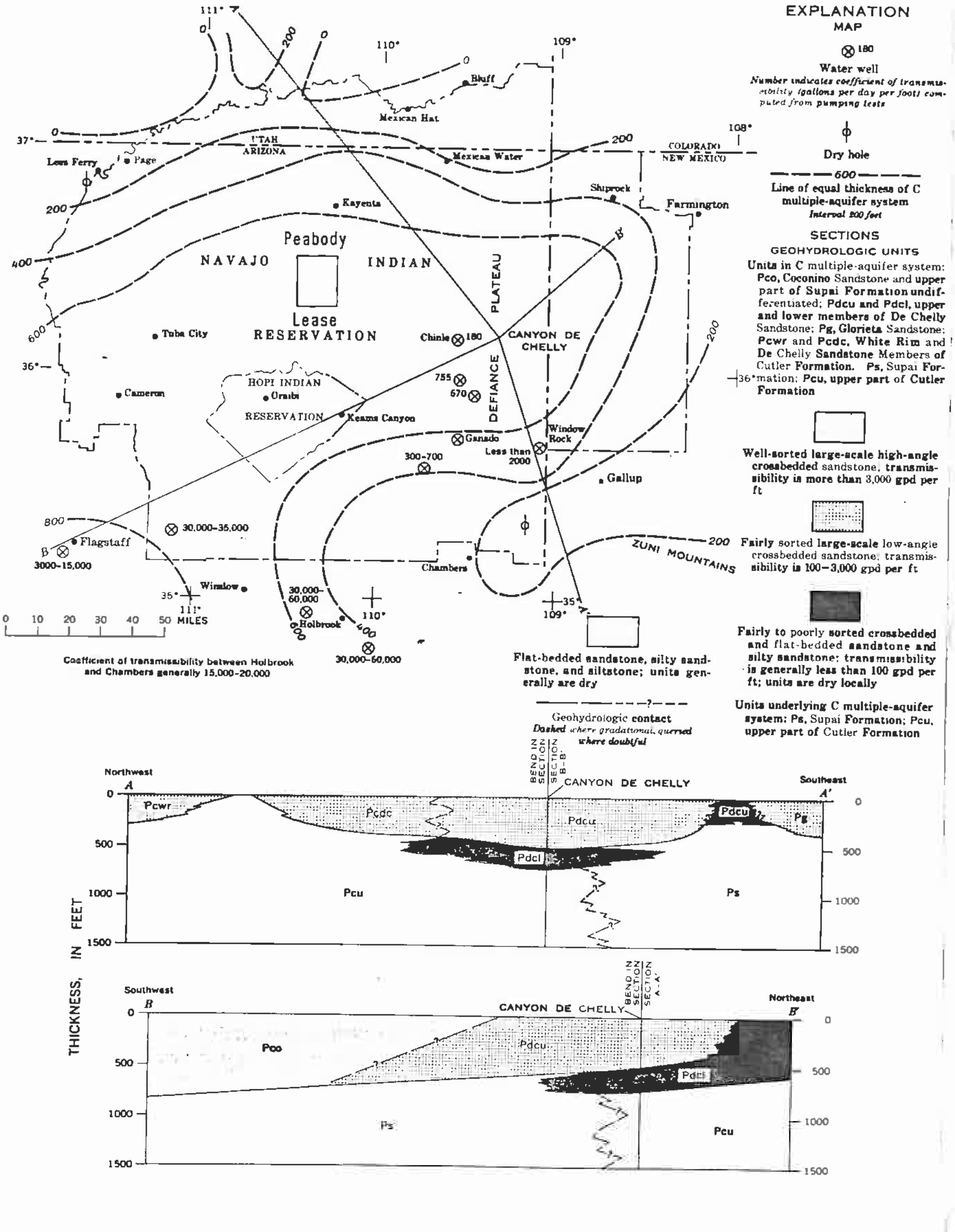


Figure 8.

Generalized Aquifer Thicknesses and Cross Sections of the C-Aquifer System (Cooley et al, 1969)

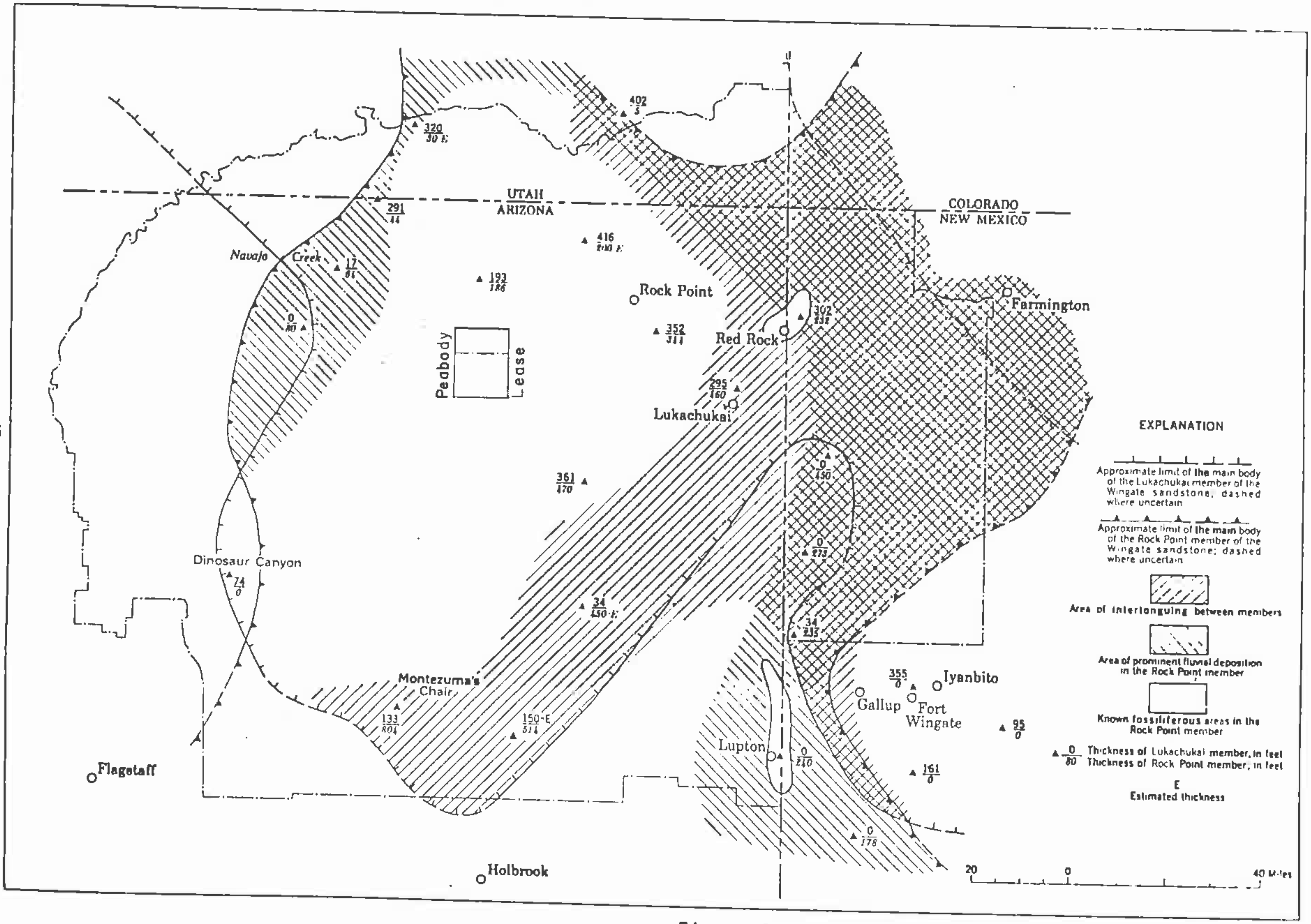


Figure 9

Approximate Depositional Area of the Lukachukai Member of the Wingate Sandstone
(Harshbarger et al, 1957)

Lukachukai is thickest to the north and northeast and tends to thin or pinch out to the east and southeast in the region.

The Moenave Formation is comprised of two sandstone members: the Dinosaur Canyon Member and the Springdale Member. The Dinosaur Canyon Member consists of coarse to very fine-grained quartz sandstone, with a large percentage of silt concentrated in the finer grained portions of the sandstone. The silt content tends to increase from east to west. In addition, the sandstone is poorly-sorted and has a firm calcareous cement (Harshbarger et al. 1957). The Springdale Member consists of a fine to medium-grained quartz sandstone also with a firm calcareous cement. Near the town of Moenave, the Springdale Member grades into the upper part of the Dinosaur Canyon Member, and near Marsh Pass it grades into the Kayenta Formation.

Figure 10 shows approximate depositional limits of the two members and their thickness variations. The Springdale Member is present only in the northwest corner of the region, whereas the Dinosaur Canyon Member is present over most of the western half of the region. The Moenave Formation generally increases in thickness to the west.

The Kayenta Formation consists of two facies: a sandstone facies and a silty facies. The sandstone facies is a fine-grained quartz sandstone bonded with calcareous cement and interbedded with mudstone (Harshbarger et al. 1957). The silty facies consists of interstratified siltstone, mudstone and silty sandstone. Figure 11 shows the approximate limits of the two facies and the thickness variations in the Kayenta Formation throughout the region. The transition from a sandstone to a siltstone facies occurs in a northeast to southwest direction. The approximate northeast boundary of the siltstone facies is near Tuba City. The thickness of the formation tends to increase in a south-west direction. Thicknesses range from 74 feet near Rock Point to 678 feet at Dinosaur Canyon.

The Navajo Sandstone is composed of medium to fine-grained quartz sandstone and is bonded with a weak calcareous cement. The sandstone contains many lenticular beds of cherty limestone, but the lithology is homogeneous throughout the region (Harshbarger et al. 1957). The thickness variations and approximate aerial extent of the sandstone is shown in Figure 12. The Navajo Sandstone is deposited over all of the region except the southeast portion. The sandstone reaches its greatest thickness in the northwest part of the region (approximately 1,400 feet thick) and pinches out rapidly to the east and southeast.

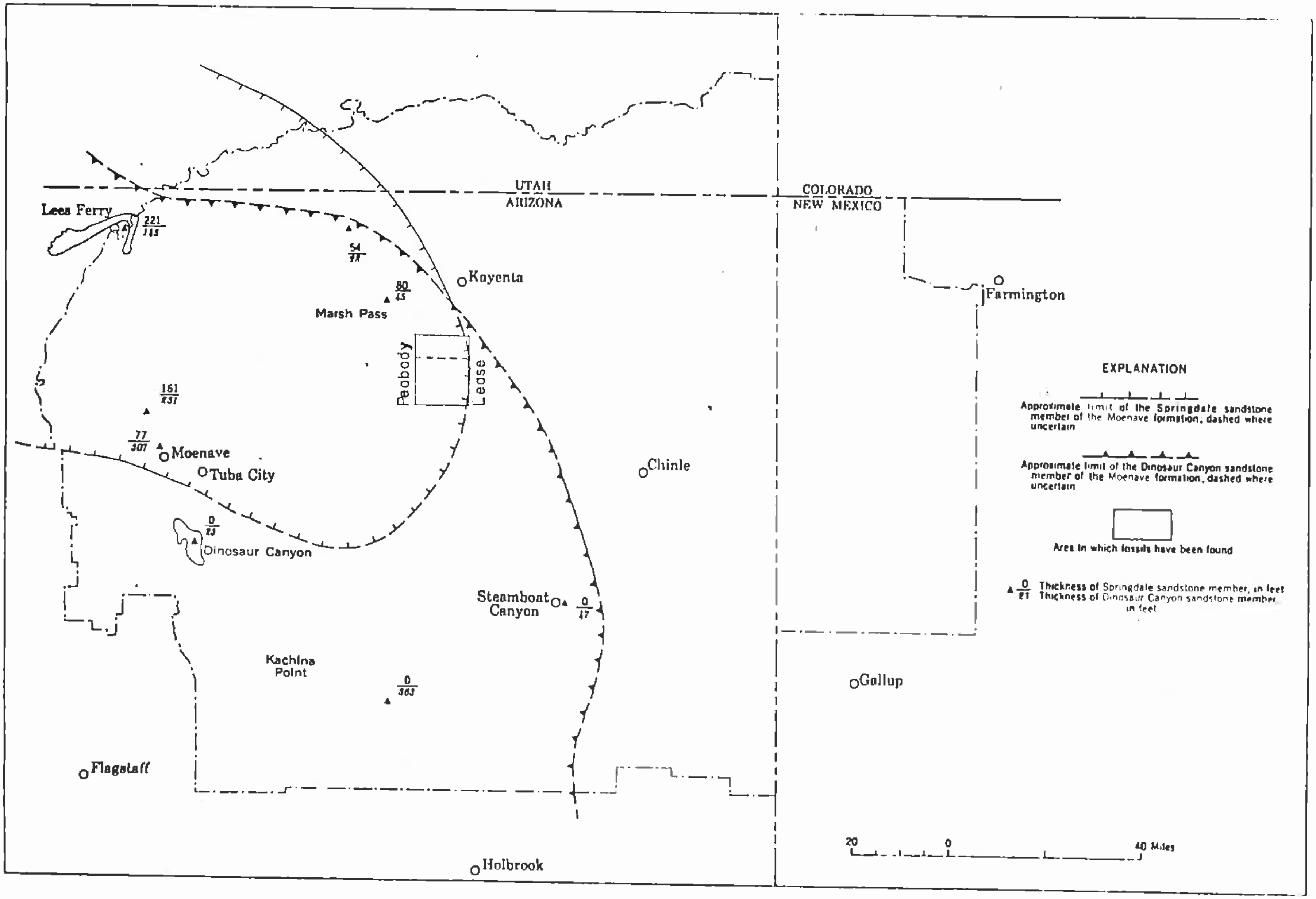


Figure 10

Approximate Depositional Areas of the Dinosaur Canyon and Springdale Sandstone Members of the Moenave Formation (Harshbarger et al, 1957)

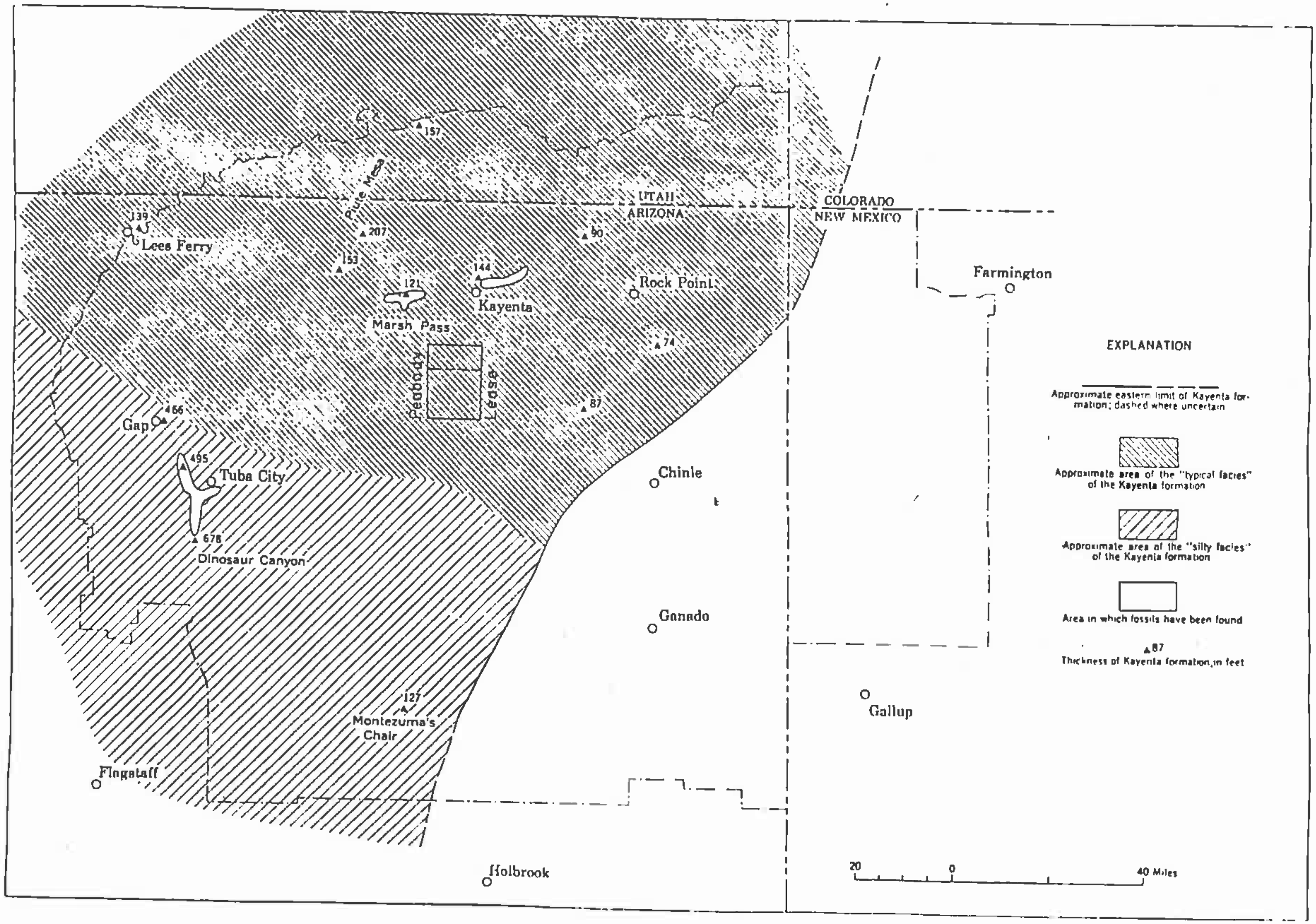


Figure 11

Approximate Depositional Area of the Kayenta Formation
(Harshbarger it al, 1957)

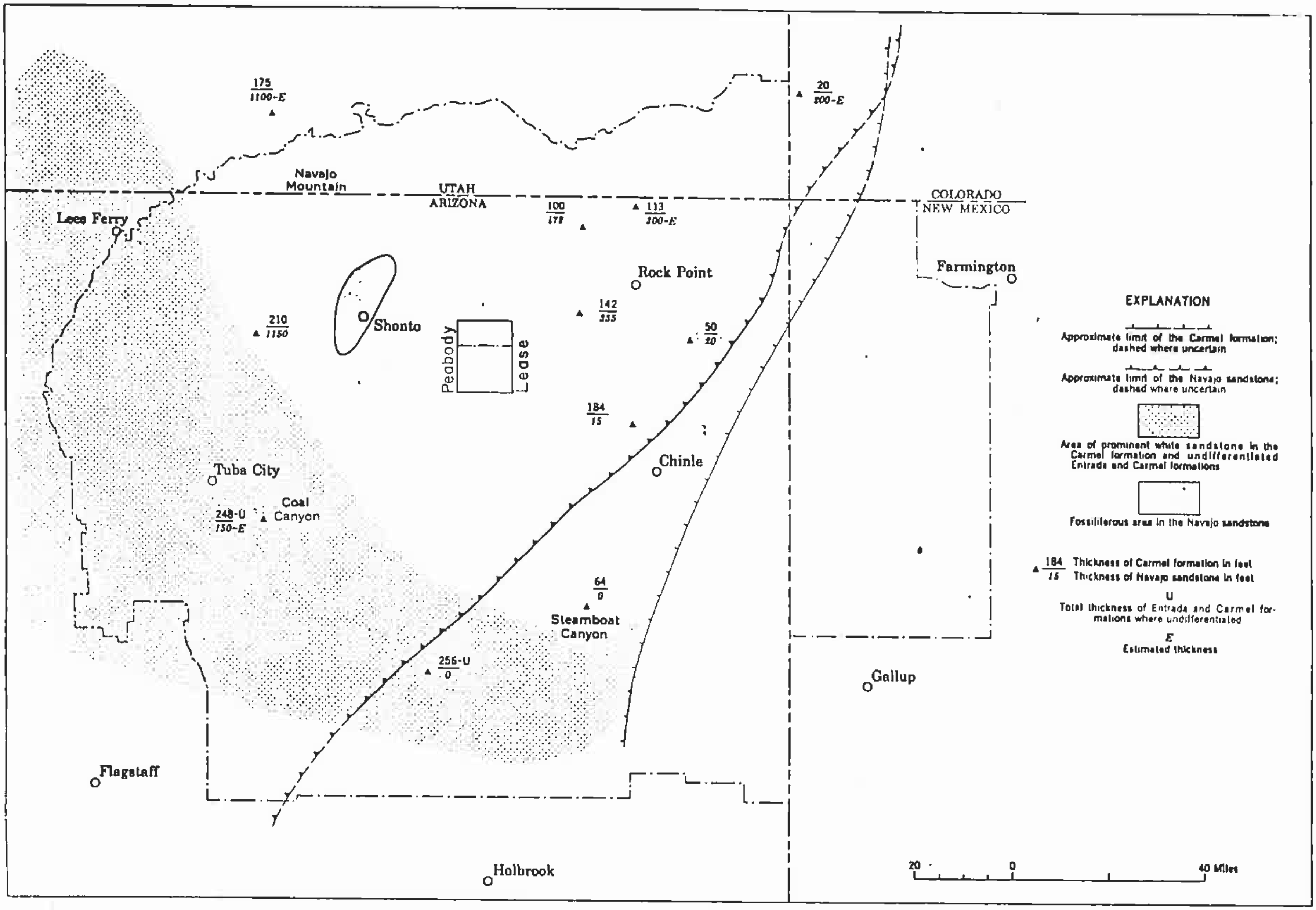


Figure 12

Approximate Depositional Areas of Navajo Sandstone and Carmel Formation
(Harshbarger et al, 1957)

Because of their homogeneous lithologies and loose cementation, the Navajo Sandstone and the Lukachukai Member of the Wingate Sandstone are the primary water producing units in the N-aquifer system. In the north-central part of the reservations, the Navajo Sandstone combines hydraulically with the sandy facies of the Kayenta Formation and the Lukachukai Member of the Wingate Sandstone; however, in the western part of the region, the silty facies of the Kayenta Formation acts as an aquiclude and precludes any hydraulic connection between the Navajo Sandstone and the Lukachukai Member.

The quality of the N-aquifer water in the Monument Valley - Northern Black Mesa area is quite good. The total dissolved solids is less than 500 mg/l, and the water is of a sodium bicarbonate type. Based on an annual average maximum daily air temperature of 67^{o}, water with fluoride concentrations greater than 1.8 ppm is grounds for rejection. Fluoride concentrations have been found in the Monument Valley - Northern Black Mesa area to range from 0 - 2.4 ppm (Levings and Farrar, 1977).

The D-Aquifer System. The D-aquifer system is comprised of the Entrada Sandstone, the Summerville Formation, the Cow Springs Sandstone, the sandstone members of the Morrison Formation and the Dakota Sandstone. The Entrada Sandstone consists of three members which are represented by two facies: the clean sandstone facies and the silty sandstone facies. The clean sandstone facies form the upper and lower members and are composed of medium to fine-grained quartz sandstone. The silty facies forms the middle member and is composed of a well cemented silty very fine-grained sandstone (Harshbarger et al. 1957).

The limits of deposition and thickness variations of the three members of the Entrada Sandstone are shown in Figure 13. The lower sandstone member extends over the northwest portions of the region and pinches out to the east. The middle silty member is present over most of the eastern and central portion of the region. The thickest portion of the silty facies occurs to the southwest in the vicinity of Coal Canyon and Steamboat Canyon. The upper sandstone member extends only over the eastern part of the region and pinches out along a north-south line running through Mexican Water and Steamboat Canyon. The greatest thickness of the upper sandstone member is in the vicinity of Lupton and Fort Wingate.

The Summerville Formation is comprised of an upper sandy facies and a lower silty facies. The lower silty member consists of poorly sorted, firmly cemented, fine-grained silty

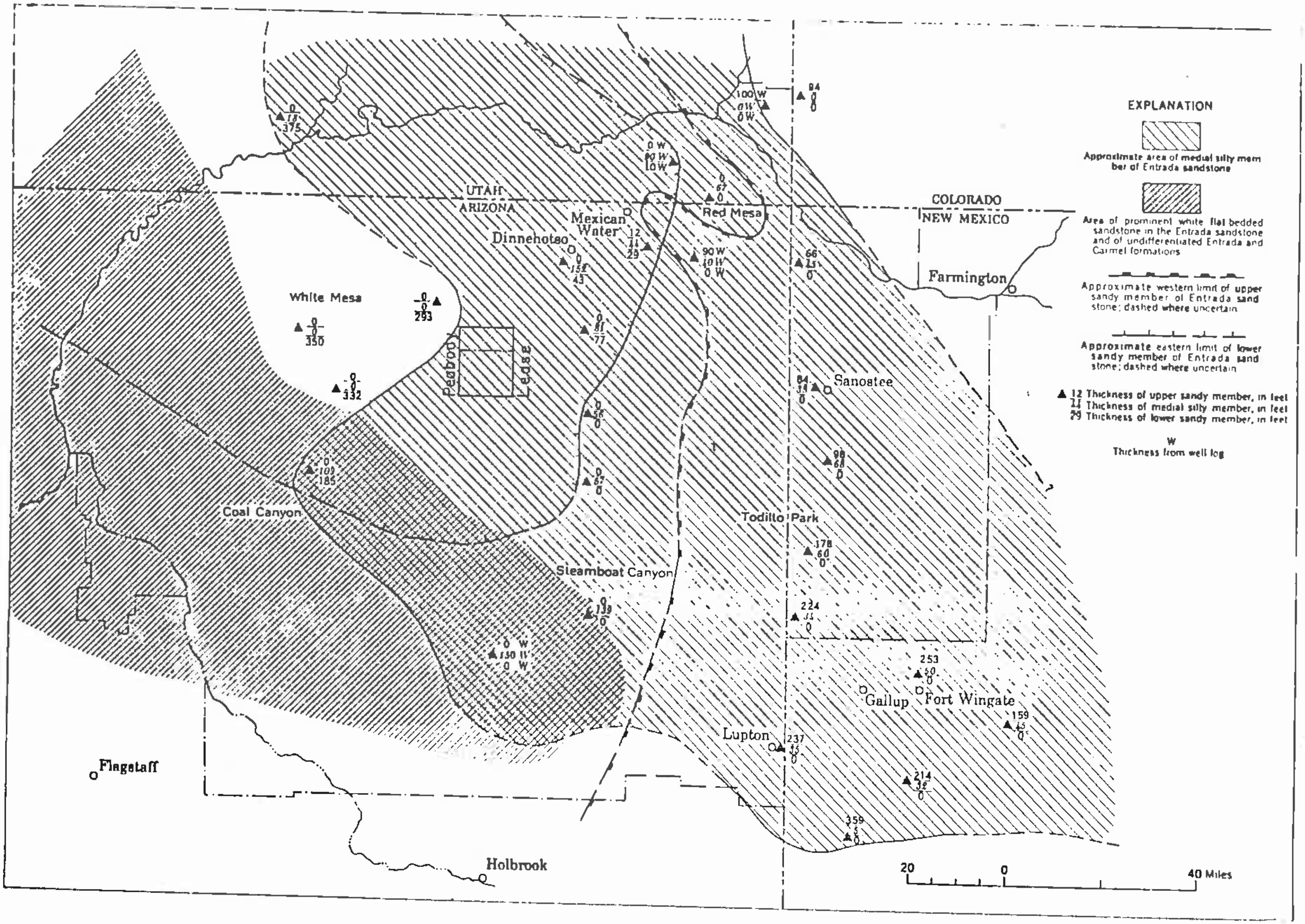


Figure 13

Approximate Depositional Areas of Members of the Entrada Sandstone
(Harshbarger et al, 1957)

sandstone beds interbedded with mudstone strata. The upper sandstone member consists of a fine-grained quartz sandstone (Harshbarger et al. 1957). The southern limit of the lower silty member extends only into the very northeastern part of Navajo country. The upper sandstone member is more extensive, covering most of the eastern and northeastern section of the region (Figure 14). The thickness of the Summerville Formation tends to decrease in a south to southwest direction. The stratigraphically younger Cow Springs Sandstone intertongues and is hydraulically connected with the upper sandstone member of the Summerville Formation. The thickness of the Summerville Formation is variable where tongues of the Cow Springs Sandstone constitute part of the formation.

The Cow Springs Sandstone is a well-sorted, firmly cemented, fine-grained quartz sandstone (Harshbarger et al. 1957). The Cow Springs Sandstone deposits are quite extensive, encompassing the southern half and western portion of the region. The tongues of the sandstone are quite extensive and interlap with members of the Morrison Formation. Figure 15 shows the approximate boundaries of the Cow Springs Sandstone and its tongues in relation to members of the Morrison Formation. Towards the close of the Jurassic Period, there was an extensive period of erosion during which parts of the overlying Morrison Formation and the Cow Springs Sandstone were removed, making it difficult to interpret thickness variations. The extreme intertonguing also makes it impossible in some areas to determine the thickness of the Cow Springs Sandstone. Within the main portion of the Cow Springs, in the southwest part of the region, thicknesses range from 230 to 449 feet. In the northeast part of Navajo country, the Cow Springs is hydraulically connected with the Recapture and Salt Wash Members of the Morrison Formation, due to the intertonguing of the three units. In the southwestern part of the region, the Cow Springs is hydraulically connected with the Dakota Formation and the Entrada Sandstone, as the Morrison is absent in this area.

The Morrison Formation marks the last Jurassic deposition in the region. The Morrison Formation is comprised of four members. These are from oldest to youngest: (1) the Salt Wash Member, which consists of fine to coarse-grained lenticular sandstone beds and mudstone beds; (2) the Recapture Member, which consists of friable fine to medium-grained sandstone interstratified with shaly mudstone; (3) the Westwater Canyon Member, which consists of fine to coarse-grained sandstone and minor shaly mudstone; and (4) the Brushy Basin Member, which consists of a shale interbedded with some mudstone and fine to medium-grained sandstone (Harshbarger et al. 1957).

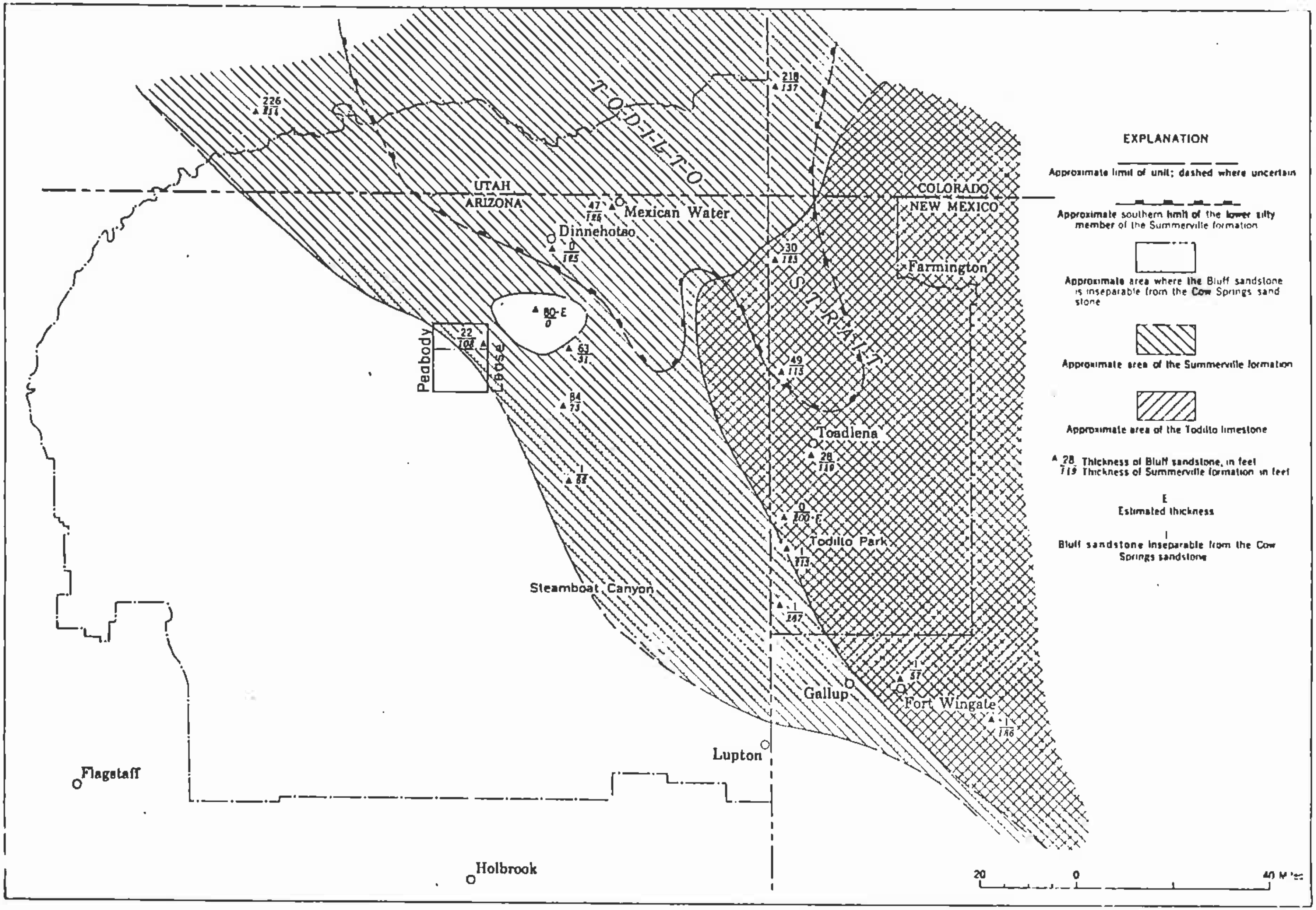


Figure 14

Approximate Depositional Areas of Todilto Limestone and Summerville Formation
(Harshbarger et al, 1957)

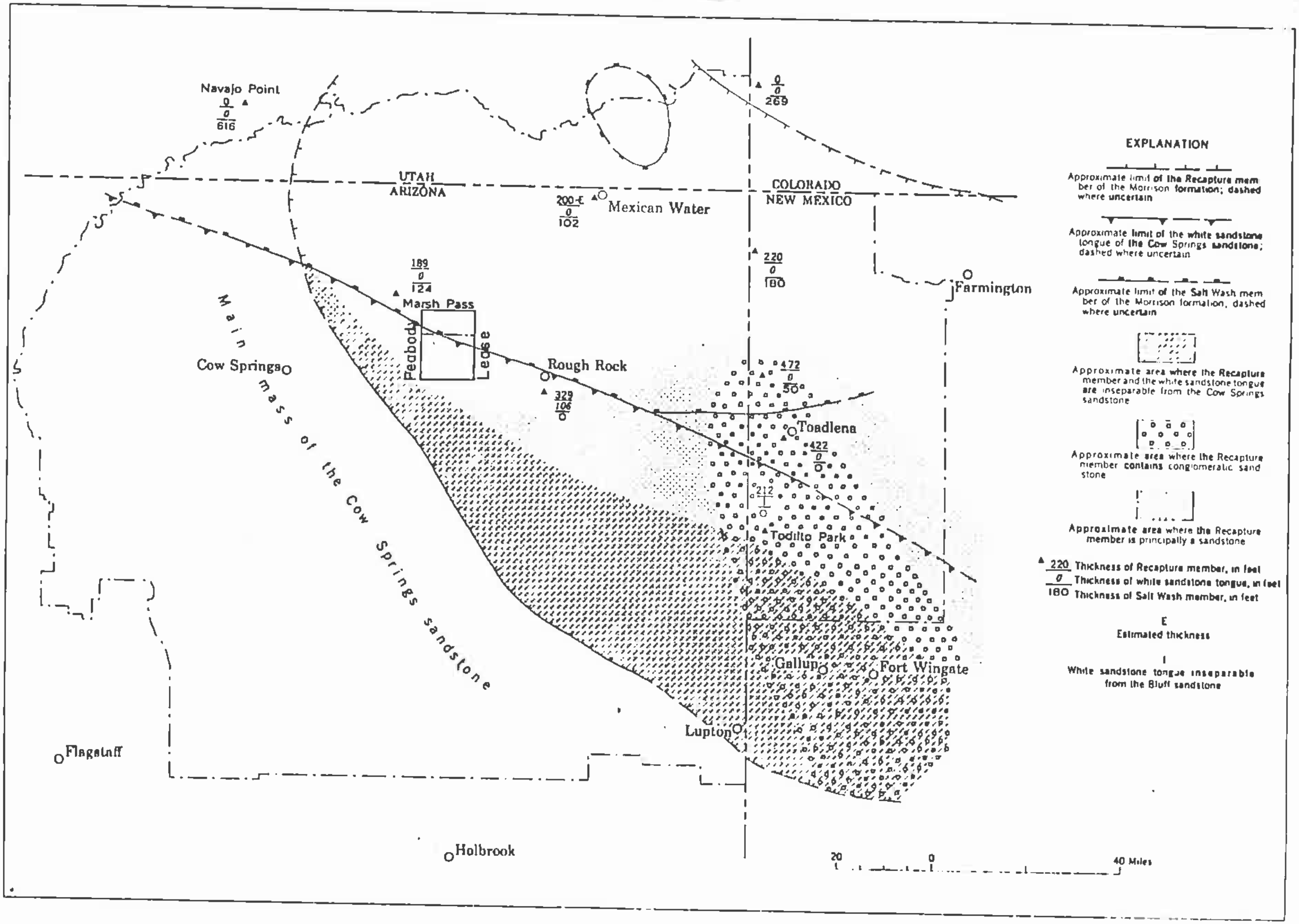


Figure 15

Approximate Depositional Areas of Cow Springs Sandstone and Salt Wash and Recapture Members of the Morrison Formation (Harshbarger it al, 1957)

The Salt Wash Member is present in the northern half of the region (Figure 15). To the south it intertongues and is hydraulically connected with the Recapture Member. Near Marsh Pass, the Salt Wash intertongues and is hydraulically connected with the Cow Spring Sandstone. The maximum thickness of the Salt Wash in the region is 616 feet at Navajo Point. The member thins to the southeast.

The Recapture Member extends over most of the eastern and north central part of the region (Figure 15). In the southeast part of the region, and along the Arizona-New Mexico border, the Recapture Member consists of a conglomeratic sandstone with higher yield and transmissive properties. The Recapture Member intertongues with the Salt Wash Member all along their contact. In addition, the upper part of the Recapture Member intertongues with the Westwater Canyon Member. This relationship provides for good hydraulic connection in areas between the three members. The Recapture Member is 483 feet thick near the northern end of the Chuska Mountains and thins to the south (Harshbarger et al. 1957).

The Westwater Canyon Member extends roughly across the eastern half of the region (Figure 16). The member does not occur in the southwest part of the region and was probably removed by pre-Dakota erosion. In the northern part of the region it intertongues with the Brushy Basin Member, and, as was previously mentioned, the Westwater Canyon and the Recapture Member intertongue throughout the area. In the area between Todilto Park and Lupton, the Westwater Canyon appears to intertongue with the Cow Springs Sandstone.

Hydraulic connection with the Brushy Basin Member is not of any significance since it is relatively impermeable; whereas hydraulic connection with the Recapture and Cow Springs Sandstones would indicate better water yield potential. The Westwater Canyon Member reaches a maximum thickness of 277 feet at Todilto Park and thins in a southeast direction (Harshbarger et al. 1957).

The Brushy Basin Member extends throughout the northeast part of the region (Figure 16). As was previously mentioned, the Brushy Basin intertongues with the upper part of the Westwater Canyon. Near the southwest boundary of the Brushy Member deposition, the lower Cretaceous units were removed by pre-Dakota erosion, and the Dakota Sandstone immediately overlies the Brushy Member. The Brushy Basin Member has a thickness of 194 feet at McElmo Creek and 157 feet southeast of Rough Rock on the northeast corner of Black Mesa, where it is presumed to underlie the Dakota Sandstone (Harshbarger et al. 1957).

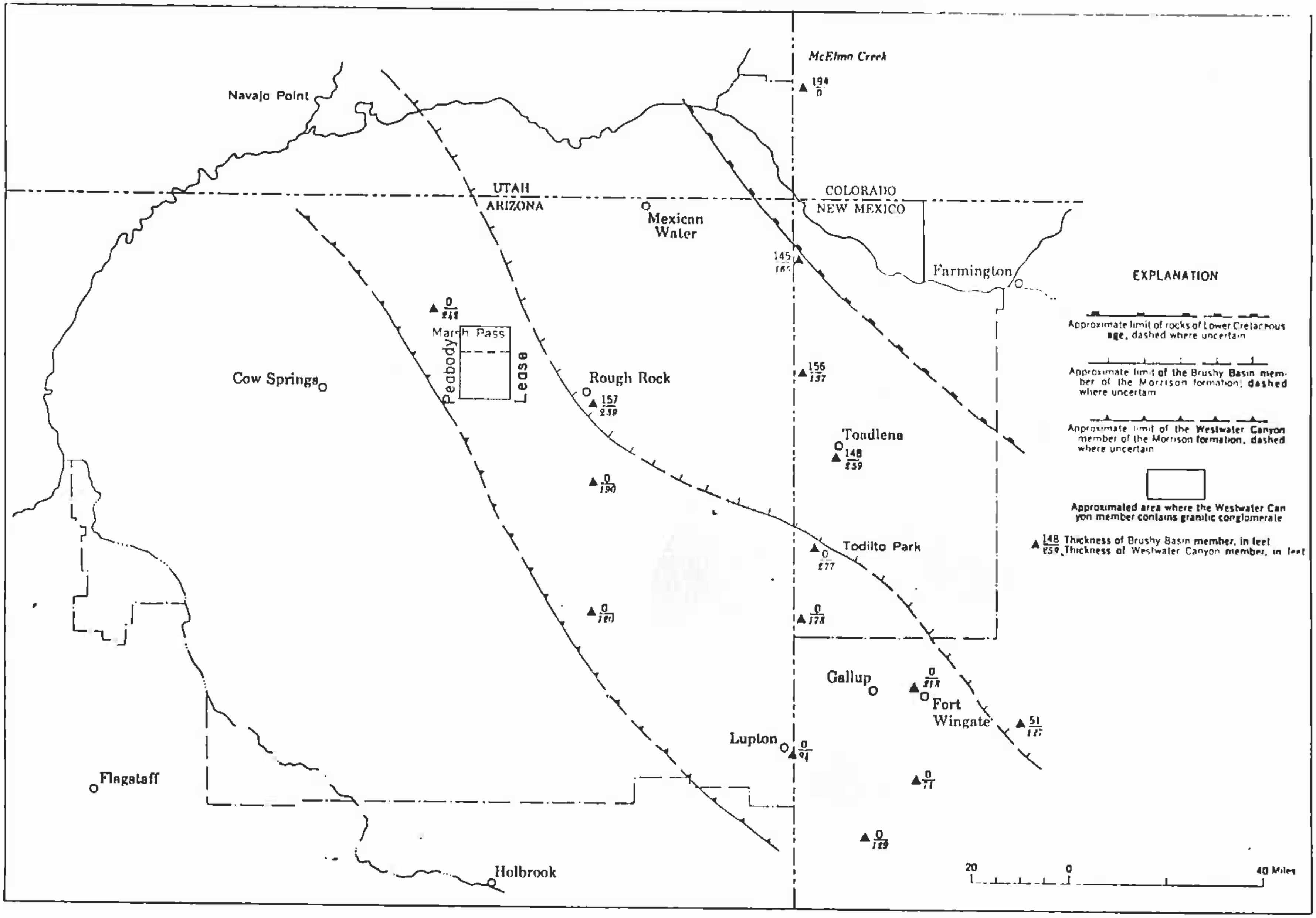


Figure 16

Approximate Depositional Areas of Westwater Canyon and
Brushy Basin Members of the Morrison Formation (Harshbarger it al, 1957)

The Dakota Formation is comprised of three lithologic types of strata deposited under fluvial, lagoonal and shallow marine conditions. The lower fluvial member consists of a well-cemented, medium to fine-grained quartz sandstone (O'Sullivan et al. 1972). The member has a basal conglomerate in some places, and conglomeratic lenses are common in other areas. The average thickness of the lower member is 20 feet.

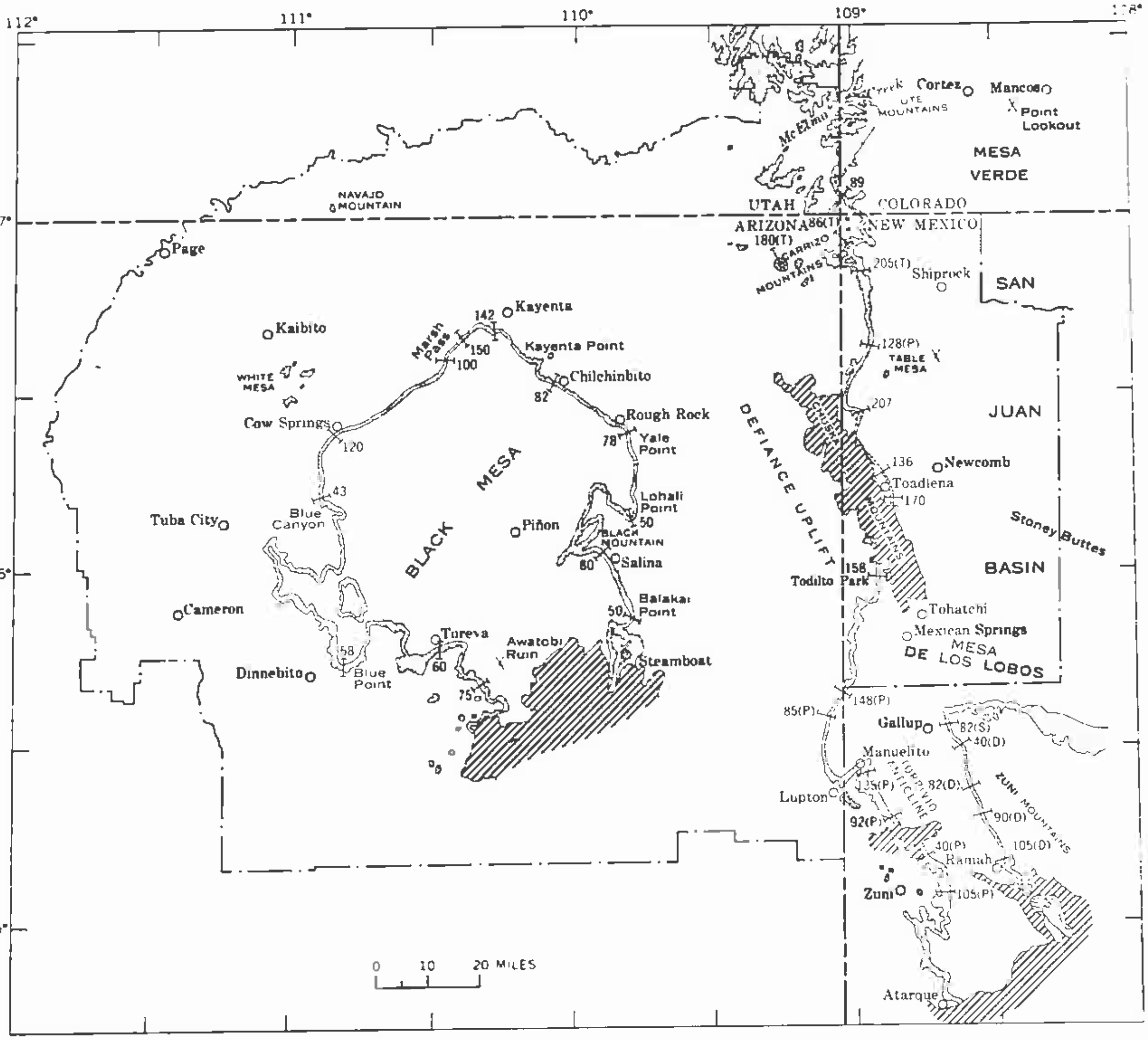
The middle member consists of carbonaceous flatbedded mudstone and siltstone, coal and interbedded sandstone lenses (O'Sullivan et al. 1972). The middle member grades downward into the lower sandstone member, and the two members intertongue in several areas. The middle member is approximately 20-40 feet thick.

The upper shallow marine sandstone member differs somewhat in lithology from the lower fluvial sandstone member. The upper member contains a greater amount of very fine sand and silt, and in several areas it consists of alternating thin sandstone ledges and intercalated shaly beds (Repenning and Page, 1956). The upper member unconformably overlies an irregular erosion surface cut into the top of the middle member. The upper member splits to the southeast and intertongues with the overlying Mancos Shale.

The thickness of the Dakota Sandstone is quite variable (Figure 17). In some areas, the upper and lower members thin and the middle member thickens, while in other areas the middle member is absent and the upper and lower sandstone units coalesce into a single unit. One final relationship exists where the upper member is missing, and the middle carbonaceous shale and the marine shale of the overlying Mancos form a continuous impermeable sequence. In the Black Mesa area, the thickness of the Dakota Sandstone ranges from 43-150 feet and averages about 80 feet (O'Sullivan et al. 1972). Regionally, the Dakota Sandstone thins to the south and southwest.

The Dakota Sandstone is a significant aquifer in the region. The lower fluvial sandstone member and the lenticular sandstone beds of the middle member have fairly high permeabilities and ground-water yields. In most localities, the upper sandstone has low permeabilities due to its high silt content. Most wells completed in the Dakota Sandstone are obtaining yields of less than 20 gallons per minute (gpm).

Because of their large degree of intertonguing, coarser grain sizes, better sorting and smaller amounts of silt, the Cow Springs Sandstone, the Westwater Canyon Sandstone Member of the Morrison Formation and the Dakota Sandstone form the principal aquifers in the



EXPLANATION

Younger rocks
Shown only where they form extensive cover

Dakota Sandstone

⊢80
Location of measured section
Showing thickness of Dakota Sandstone, in feet. Letter in parentheses refers to source of information.
(D) *Dane and Bachman (1957a)*
(P) *Pike (1947)*
(S) *Sears (1934)*
(T) *J. D. Strobell (oral commun., 1963)*

FIGURE 17

Generalized Distribution and Thickness of the Dakota Sandstone

D-aquifer system. The Salt Wash and Recapture Members of the Morrison Formation yield some water, but their firmly cemented, fine-grained composition and high degree of interbedding with mudstone and shale layers make them of minor importance, except where they intertongue and are hydraulically connected with the Westwater Canyon Member and the Cow Springs Sandstone.

The upper sandstone member of the Summerville Formation yields some water, but is only of minor importance due to its fine-grained nature and lower silty member. Greater ground-water yields are expected where the upper sandstone member intertongues with the Cow Springs Sandstone. The Entrada Sandstone is also only of minor importance as an aquifer. The upper and lower sandstone members are poorly sorted, fine-grained and of limited extent. In some areas, the upper sandstone member is hydraulically connected with the Summerville Formation and Cow Springs Sandstone, and better ground-water yields are expected at these locations. Figure 18 shows a generalized stratigraphic cross section of the D-aquifer system emphasizing the intertonguing nature of the various aquifers and their position in relation to the overlying Mesa Verde Group.

Well yields in the D-aquifer system range from 10-25 gpm. The water quality is marginal to unsuitable for drinking. Sulfate and dissolved solids concentrations usually exceed the U.S. Public Health Service's recommended drinking water limits. As much as 1,600 ppm sulfate is found in water obtained from the D-aquifer system in the southeastern part of Black Mesa, near the town of Tochee (Akers and Harshbarger, 1958). Fluoride concentrations have been found to range from 0.2 to 3.4 ppm in Monument Valley and northern Black Mesa Basin. Concentrations above 1.8 ppm are grounds for rejection as drinking water (Levings and Farrar, 1977).

Overlying the D-aquifer system is a thick impermeable shale sequence called the Mancos Shale. On Black Mesa, the Mancos Shale reaches a thickness of 670 feet and hydraulically isolates the D-aquifer system from the overlying Mesaverde Group. The Mesaverde Group consists of the Toreva Formation, the Wepo Formation and the Yale Point Sandstone. All three formations are present only on Black Mesa. Lateral stratigraphic correlatives to these formations have been determined in other basins in the region.

Upper Cretaceous Aquifers. The Toreva Formation is comprised of three members in the south half of Black Mesa which differ from the three subdivisions that are recognized in the north half of the mesa. The three members of the Toreva Formation in the south half

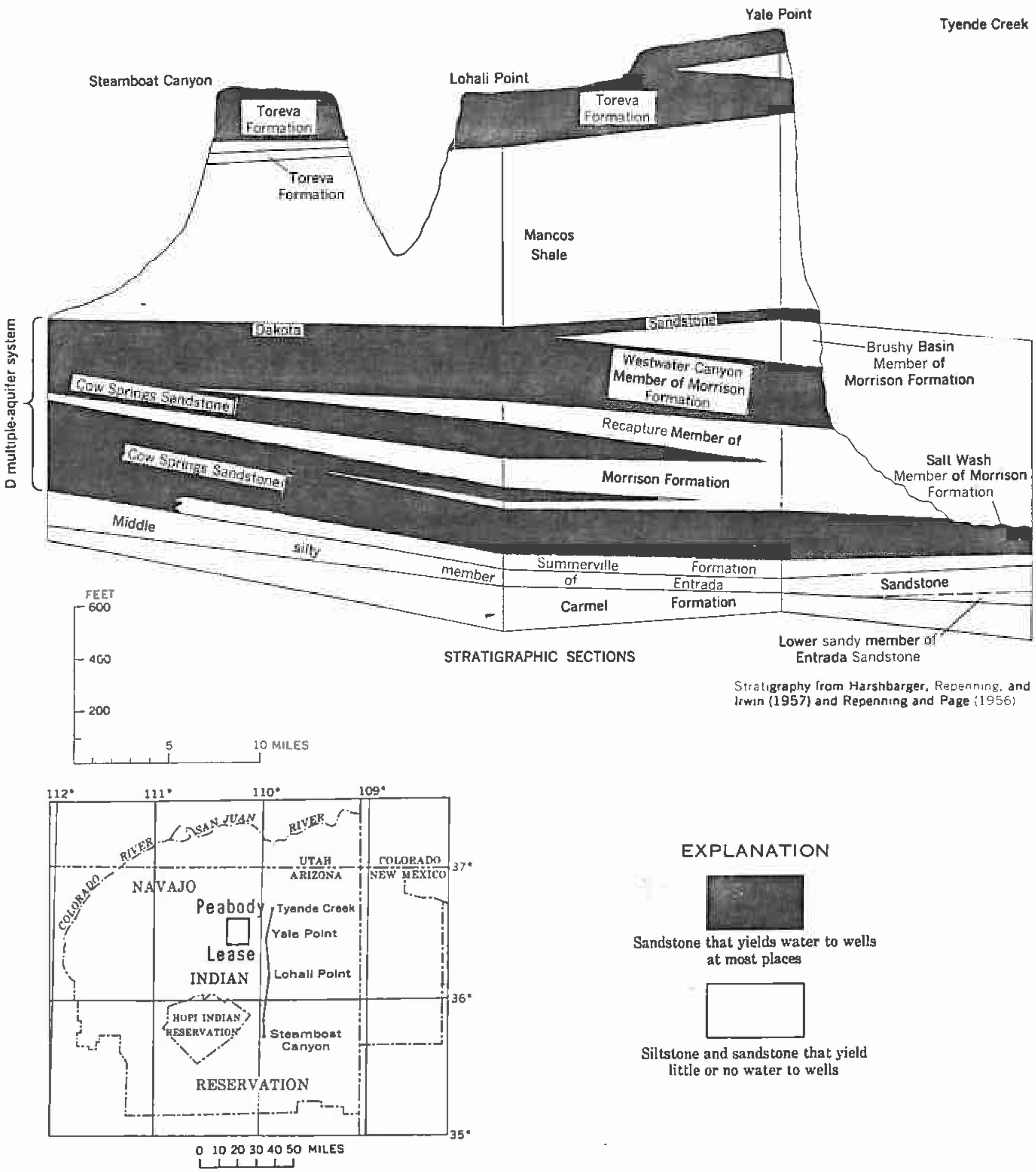


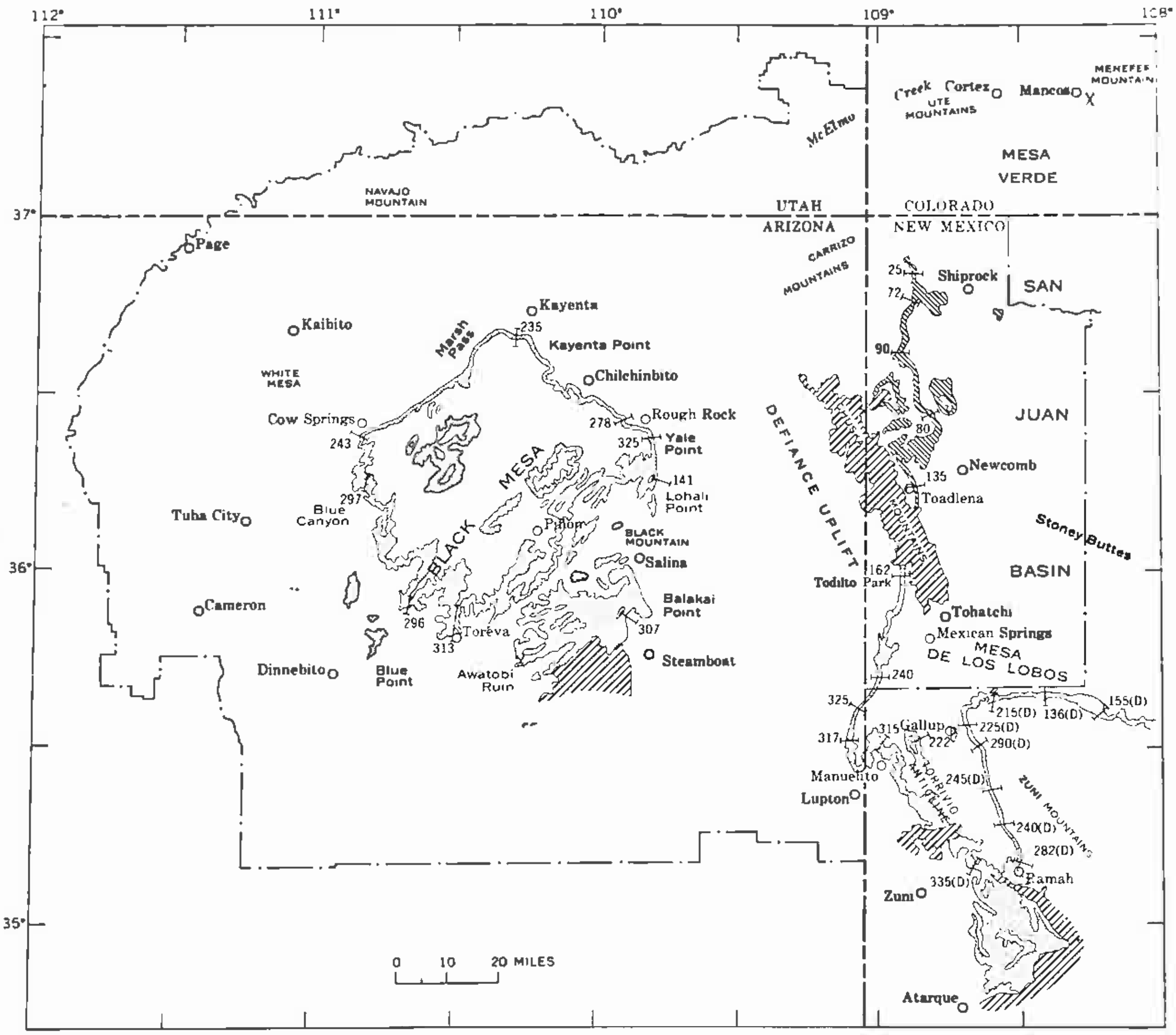
Figure 18

Generalized Stratigraphic Cross Section of D-Aquifer System and Cretaceous Aquifers (Cooley et al, 1969) of Black Mesa are: (1) a lower sandstone member consisting of fine to medium-grained quartz sandstone with thin beds of mudstone in the lower part of the member; (2) a middle member consisting of carbonaceous mudstone, siltstone, coal and lenses of fine to coarse-grained, poorly sorted quartz sandstone; and (3) an upper member consisting of fine to coarse-grained, poorly sorted quartz sandstone (O'Sullivan et al. 1972).

The subdivisions of the Toreva Formation in the north half of Black Mesa are: (1) a basal unit which consists primarily of fine to medium-grained quartz sandstone, some coal, carbonaceous shale and thin-bedded siltstone; (2) a middle shale unit consisting of firmly-cemented siltstone and a few sandstone ledges; and (3) an upper unit which consists of very coarse to medium-grained poorly sorted sandstone (O'Sullivan et al. 1972).

Ground-water yields from the Toreva Formation in both sections of Black Mesa are dependent on the degree of lensing of the sandstone units with the shale, silstone, and mudstone, the grain sizes and degree of sorting of the sand grains. In the southern half of Black Mesa, the better water yielding units are: (1) the upper part of the lower sandstone member which contains no mudstone; (2) sections of the middle carbonaceous member which, unlike most of the member contains almost all sandstone; and (3) the upper part of the upper sandstone member, which is very coarse-grained and conglomeratic. In the northern half of Black Mesa, the best water yielding units are the upper parts of the lower and upper sandstone subdivision, due to their coarser grain size and smaller percentage of silt (O'Sullivan et al. 1972). The locations of outcrops of the Toreva Formation on Black Mesa and approximate thicknesses of the formation are shown in Figure 19. Formation thicknesses range from 141 to 325 feet.

The Wepo Formation consists of a thick sequence of interbedded mudstone, siltstone, sandstone and coal. The sandstone is composed of poorly sorted, fine to very coarse quartz grains. The degree of cementation of the quartz grains varies from weakly to firmly-cemented. The weakly-cemented beds have a high percentage of silt in them. The thicker sandstone beds tend to have conglomeratic bases of chert and silicified limestone pebbles. The coal beds are usually interbedded with siltstone and form a hard, red, baked shale where these beds have burnt. Ground-water potential in the Wepo Formation is low. The conglomeratic zones, where saturated, should yield some water to wells. Thicknesses and outcrops of the Wepo Formation and its stratigraphic equivalents are shown in Figure 20. Thicknesses range from 304 feet near Yale Point to 743 feet east of Cow Springs (O'Sullivan et al. 1972). The formation thins to the northeast.



EXPLANATION

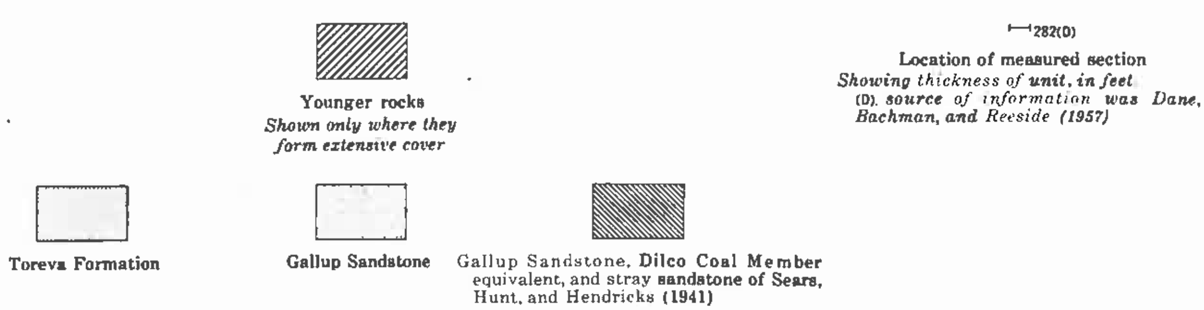
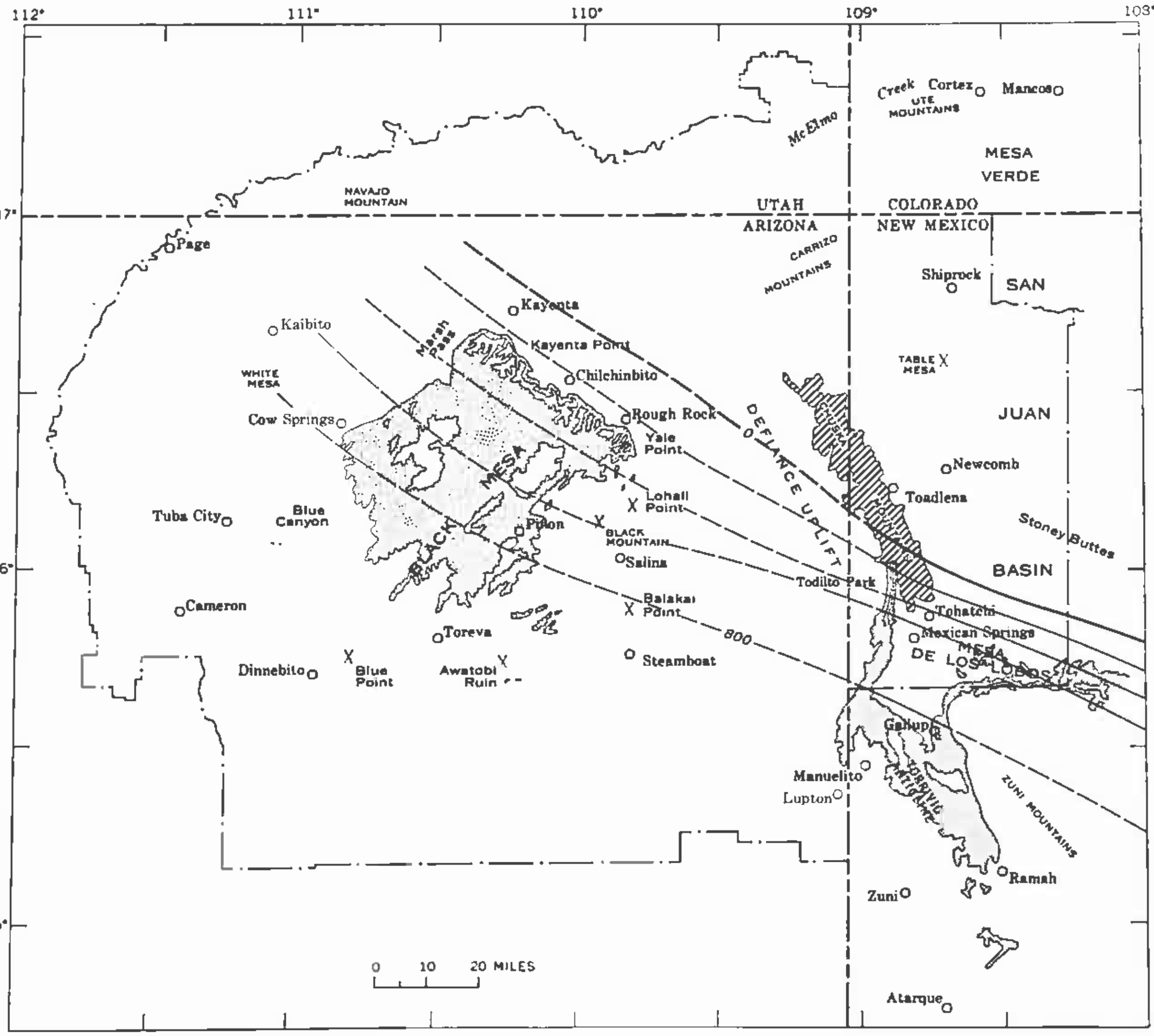


Figure 19

Generalized Distribution and Thickness of the Toreva Formation



EXPLANATION

Younger rocks
Shown only where they form extensive cover

Wepo Formation

Crevasse Canyon Formation

Isopachs
Dashed where uncertain. Interval 200 feet

Figure 20

Generalized Distribution and Thickness of the Wepo Formation

Overlying the Wepo Formation, and representing the last unit of the Mesaverde Group deposited on Black Mesa, is the Yale Point Sandstone. This unit consists of coarse to medium-grained, fairly sorted quartz sandstone with widely spaced, thin siltstone units. The Yale Point Sandstone is permeable enough to transmit water, but no wells are completed in the unit because its topographic position prevents it from accumulating much water, and its areal distribution is quite limited. In most places, the unit is present only as a very narrow ridge along its area of outcrop and is eroded away to the south or intertongues with the underlying Wepo Formation (Repenning and Page, 1956).

Ground water in the Wepo and Toreva Formations is present under both water table and artesian conditions. Artesian conditions occur in the Wepo and Toreva Formations away from their outcrops. Along the perimeter of the Mesa, unconfined conditions prevail. Ground water is primarily obtained from sandstone units within the formations, especially where these sandstone beds are hydraulically connected. Due to the interbedding nature of the sandstone units with siltstone and mudstone beds, depths to ground water can be variable from place to place. In places where sandstone units are underlain by coal, siltstone, or mudstone beds, perched water tables of limited storage and hydraulic connection exist. In several areas where the contact between the Toreva Formation and the impermeable Mancos Shale is exposed, ground-water discharges in the form of springs and provides an important source of domestic water (Akers and Harshbarger, 1958). Ground-water movement and well yields in the Wepo and Toreva Formations are in part controlled or limited by depths of erosion along Polacca and other principal washes on Black Mesa, which could act as ground-water sinks.

Ground water is primarily obtained from the Toreva Formation and only secondarily from the Wepo Formation. Well yields range from 10-15 gpm. The ground water is of marginal to unsuitable drinking water quality. Sulfate and total dissolved solids concentrations usually exceed the recommended drinking water limits, and the range of fluoride concentrations (0.1-2.1 ppm) exceeds the recommended limit of 1.8 ppm for fluoride in drinking water supplies in the Black Mesa area (Levings and Farrar, 1977).

The final water yielding units to be discussed are the Quaternary alluvial deposits. Regionally, the alluvium is an important source of domestic ground water. Along some of the larger washes, deposits more than 200 feet thick exist from which water yields of from 10 to 1,000 gpm are obtained. Along the smaller washes, alluvial thicknesses range from 25-80 feet, and water yields are on the order of 10 to 50 gpm. In the northern part of

Black Mesa, the alluvial veneer is very thin, and the well yields are small. During times of drought, many of these wells may be dry.

The alluvial wells are located in the southeast part of Black Mesa, along Polacca Wash (Levings and Farrar, 1977). Water quality for the wells is expressed in terms of specific conductance. The specific conductance multiplied by the factor .6 is approximately equivalent to total dissolved solids (E.E. Johnson, Inc., 1972). Using this factor for those alluvial wells located on Black Mesa gave a range of 107-2,400 ppm for total dissolved solids. Values for fluoride in alluvial wells ranged from 0-0.9 ppm and were well below the recommended drinking water limit of 1.8 ppm.

Regional Ground-Water Recharge, Movement and Discharge. The principal areas of recharge to the five ground-water basins of the region (Figure 3) are the highlands along the divides between the basins. These highlands include the Navajo Uplands, Defiance Plateau, the Chuska Mountains and the Carrizo Mountains. Most of the recharge to the Black Mesa and San Juan basins is from highlands to the south. This recharge area includes the Zuni Mountains, the Mogollon Slope and the San Francisco Plateau (Cooley et al. 1969).

"Recharge to aquifers in the Navajo country is directly from precipitation and from ephemeral streams or indirectly from interformational leakage. Direct recharge to the aquifers in the consolidated sedimentary rocks is controlled principally by the permeability of the rocks, the structural and physiographic expression, the amount of fracturing and the altitude of the water bearing strata, by the presence or absence of surficial deposits and the duration, type and amount of precipitation. The mantles of surficial deposits are recharged by direct precipitation, by influent streams, and by discharge from the consolidated aquifers. Recharge from interformational leakage is common, especially between the water bearing units adjoining the N, C, and D multiple aquifer systems (which are mainly in the Navajo, Coconino, and Dakota Sandstone) ..." (Cooley et al. 1969).

Due to the fine-grained nature of the sandstone aquifers, most recharge to the aquifers occurs through fractures and along bedding planes. Large fractures are located primarily along monoclines, tightly folded anticlines and shattered zones in and adjacent to laccolithic domes. Recharge is principally a seasonal phenomena and occurs primarily in the winter and spring. Maximum discharge of springs and higher well water levels usually occur in the spring and then decline throughout the summer. Summer precipitation usually consists of intense downpours, of short duration, resulting in high volumes of runoff and little contribution to ground-water recharge.

Regional ground-water movement occurs in the C, D and N-aquifer systems underlying Black Mesa Basin. Recharge to the C-aquifer system is from the Defiance Plateau to the west and the Mogollon Slope, San Francisco Plateau and Zuni Mountains to the south. Ground water from these recharge areas converges in the southern part of Black Mesa Basin and flows in a west-northwest direction along the southwest flank of the basin. Ground-water discharge from the C-aquifer system is to the Little Colorado River system and Chinle Wash (Cooley et al. 1969).

Recharge to the N-aquifer system underlying Black Mesa is from an area of outcrop of the Navajo Sandstone to the north between Monument upwarp and Echo Cliffs. Recharge from the south is minimal because of the aquifer's deeper burial and thinning and wedging out to the south and southeast. Ground-water movement in the N-aquifer system is in two directions because the formation pinches out to the southeast. Initial movement from the area of recharge is to the south. Ground-water flow in the east half of the basin then swings to the northeast where part of it moves into Blanding Basin and discharges into Chinle Wash. The main part of the flow in the N-aquifer system is to the southwest where it discharges along Moenkopi Wash near Tuba City and into the alluvium along lower Dinnebito and Oraibi Washes (Cooley et al. 1969).

The recharge areas for the D-aquifer system are limited to narrow bands where the formations crop out around the perimeter of Black Mesa and from pre-Cretaceous rocks in the southwestern part of San Juan Basin. Since most of the outcrops consist of thin sandstone units separated by thick mudstone and siltstone sequences, recharge to the D-aquifer system is limited. Movement of ground water in the D-aquifer system is restricted in areas by anticlines and the tonguing-out of the sandstone units. Generally, flow is basinward and toward discharge points along tributaries to the Little Colorado River and Chinle Wash.

The Wepo and Toreva Formations are recharged directly from precipitation and infiltration from influent streams. Ground-water movement in the Wepo and Toreva Formations is controlled to a large extent by small folds and the degree of channel downcutting. Where the stream channels truncate, the aquifers' artesian conditions are disrupted and water table conditions prevail. Water levels are variable owing to the lensing nature of the rock units and the high degree of intertonguing with impermeable mudstone and siltstone units and the alluvium. The preferred ground-water flow direction within the Wepo Formation on the mine site has been determined (Figure 59). A discussion of flow and directions of flow is covered under the section on Ground-Water Hydrology of the Mine Site and Adjacent Areas.

Almost all of the discharge from Black Mesa Basin occurs at Blue Spring and several other springs near the confluence of the Little Colorado with the Colorado River. According to Cooley et al. (1969), "The yield of the springs measured intermittently near the mouth of the Little Colorado River averages 223 cubic feet per second (cfs) or about 161,000 acre-feet per year, which represents the total discharge into the Colorado River from Black Mesa Basin, an area of about 28,000 square miles. Perhaps 95 percent or more of this water is from the C-aquifer system because a substantial part of the water discharging from the other aquifers in the basin is evaporated or is used for irrigation, principally near Tuba City".

Other than those mentioned above, few springs in the region yield more than 10 gpm and most of this is lost to evaporation. Most of these springs are gravity springs occurring where the water table intersects the land surface. Cooley et al. (1969) has identified four types of gravity springs: contact, fracture, depression and tubular. Contact springs occur along the lower contacts of the Navajo Sandstone, Shinarump Member of the Chinle Formation, Lukachukai Member of the Wingate Sandstone, the Dakota Sandstone and the sandstone units of the Mesaverde Group. Fracture springs flow from faults, joints and bedding planes of the Navajo, Wingate and other thick sandstone units. Depression springs occur where concave sections in bedding planes in the Navajo Sandstone and the Shinarump Member of the Chinle Formation concentrate downward percolating ground water and discharge it as perched springs or seeps well above the regional water table. Only a few tubular springs exist. These include Blue Spring and associated springs that flow from limestone hydraulically connected to the C-aquifer system in the canyon of the Little Colorado River. A few artesian springs flow through openings in confining beds overlying aquifers along the west side of San Juan Basin. No thermal springs have been found in the region.

Hydraulic Properties of Aquifers. The hydraulic properties of the principal aquifers in the region have been determined for wells completed as of 1956. Table 2 presents a summary of the test data for approximately two-fifths of the wells. Table 2 is subdivided into three types of analyses and tests: field pumping, bailing and pressure tests;

Table 2. Range of the Hydraulic Properties of Aquifers in the Navajo and Hopi Indian Reservations (Cooley et al, 1969)

Geologic source	Sedimentary laboratory analyses: Samples	Solubles (percent): Range	Solubles (percent): Weighted average	Median diameter (mm): Range	Median diameter (mm): Weighted average	Coefficient of sorting: Range	Coefficient of sorting: Weighted average	Hydrologic laboratory tests: Number of cores	Porosity (percent)	Specific retention (percent)	Specific yield (percent)	Coefficient of permeability (gpd per sq ft)	Pumping tests: Number of tests	Coefficient of transmissibility (gpd per ft)	Coefficient of storage	Specific capacity (gpm per ft of drawdown)	Yield (gpm)	Bailing tests: Number of tests	Specific capacity (gpm per ft): Range	Specific capacity (gpm per ft): Average	Yield (gpm): Range	Yield (gpm): Average	Pressure tests: Number of tests	Specific capacity (gpm per ft)	Flow (gpm)	Remarks
Alluvium	0																									
Wepo Formation	6	1.0–2.9	1.3	.21–.35	.27	1.63–1.23	1.44	2	1–2	1.2	0	0.0009–.02	12	325–63,800	5×10⁻⁴–0.25	0.60–68.86	10–241	48	0.12–75		5–275	45				Specific capacity usually is 0.5–3.0 gpm per ft.
Gallup Sandstone	2		.6		.21		1.36	2	23	7	16–17	.4–2	9					1	.37		15					
Toreva Formation	0							4	29–34	4–7	22–30	0–584	1	18		.03–4.78	13–264	20	.02–4.84	.55	4–150	38	2	.04–.28	7–11	Specific capacity average does not include highest figure.
Dakota Sandstone	29	0–10.0	1.5	.10–1.88	.24	5.88–1.12	1.24	4	23–28	4.10	17–19	0.7–25				.12	15	27	.05–1.20	.32	4–60	18				
Morrison Formation:																		20	.02–.40	.13	3–36	16	2	.16–.06	3–8	Upper and lower members.
Westwater Canyon Member.	23	0–21.7	3.7	.13–.58	.26	3.76–1.14	1.56	2	20–21	10	10–11	.1–15	5	677												
Recapture Member.	24	0–81.8	7.4	Silt–.28	.15	1.85–1.12	1.32									0.45–0.92	13–350	10	.02–2.20	.43	6–19	11	1	0–44	15	Coefficient of transmissibility computed from one test.
Salt Wash Member.	1		27.6		.17		1.20																			
Cow Springs Sandstone.	31	.02–33.8	6.9	.11–.23	.17	1.47–1.01	1.21	4	19–25	10–20	4–10	.4–2	2	20.7		.07–.16	9–16	8	.07–.27		8–40					Coefficient of transmissibility computed from one test.
Summerville Formation.	8	.7–19.8	4.6	.09–.16	.14	1.28–1.13	1.20																			
Entrada Sandstone and Entrada Sandstone and Carmel Formation undifferentiated.	36	.9–18.5	6.5	.07–.41	.13	1.11–1.89	1.27	4	25–31	8–10	14–26	1–65						6	.02–3.50		5–35					
Carmel Formation	6	.2–33.7	17.0	.06–.13	.14	1.22–1.12	1.16																			Sandstone units only.
Navajo Sandstone	16	0–2.3	.5	.13–.31	.18	1.45–1.03	1.18	24	25–35	3–6	18–29	3–494	4	450–3,800	.005	.74–3.24	80–150	74	.4–7.0	.85	5–170	28				Coefficient of transmissibility computed from three tests; coefficient of storage computed from one test; reported yields of 1,100 gpm north of Colorado River near Page.
Kayenta Formation	7	.3–16	5.0	.04–1.47	.11	1.23–1.08	1.16																			
Moenave Formation	13	.1–16		.04–.30		1.65–1.19																				
Wingate Sandstone:																										Both members.
Lukachukai Member.	21	.4–20.2	6.2	.06–.25	.21	1.66–1.06	1.23																			
Rock Point Member.	21	5.2–31.9		.04–.33		1.66–1.06												5	.02–.70		7–8					
Chinle Formation: Sandstone units	0												2	150		.25–1.1	50–100	12	.03–.50	.12	8–50	14				Coefficient of transmissibility computed from one test.
Shinarump Member.	6	.4–1.8		.16–1.35		1.76–1.16							1	2,000		1.35	50	7	.02–3.33		1–60					
Shinarump Member of the Chinle Formation and De Chelly Sandstone.	0																	25	.03–2.93	.67	8–135	39				
De Chelly Sandstone.	6	0–3.5	.9	.17–.27	.22	1.28–1.13	1.19	6	13.6–27.2			4.2–40	5	310–755		.21–1.21	25–150	36	.01–2.0	.66	3–200	23				Coefficients of transmissibility and specific capacity computed from three pumping tests.
Glorieta Sandstone	0							2	15.5–15.8			.2–.9	1	6,600–15,800			228	4	.05–.23		5–34		1	.03	2	
Coconino Sandstone	0							1	27.6			42	1	35,000	1.8×10^{-4}–7.4×10^{-4}	13.3	200	1	.31		15					

hydrologic laboratory tests of drill cores; and sedimentary laboratory analyses. The hydraulic data measured in the pumping, bailing and pressure tests include the yield, drawdown, specific capacity, and the coefficients of permeability, transmissibility and storage. Permeability and transmissibility were determined from 30 pumping tests made at scattered locations in the region. Owing to the absence of nearby observation wells, values for storage coefficient could only be determined in a few places. Specific capacity values were determined from 450 bailing tests and 30 pressure tests.

The coefficients of transmissibility for the various sandstone aquifers, with the exception of the Coconino Sandstone, are low, ranging from only 500 to 1,000 gallons per day per foot (gpd/ft). In contrast, values for the Coconino Sandstone in the southwestern part of the region range from 15,000 to 35,000 gpd per foot. Transmissibility values in the alluvial deposits along the main washes are the highest in the region, ranging from 300 to 60,000 gpd per foot. Coefficients of storage for the alluvium and Navajo and Coconino Sandstones range from 10^{-3} to 10^{-4}. Specific capacity values were determined to provide a comparison of the productivity of the various wells. Values ranged from 0.3 to 5 gpm per foot of drawdown, with most being less than 1 gpm. Once again, exceptions to this were for wells completed in the Coconino Sandstone and alluvium. Some wells penetrating these aquifers have specific capacities greater than 15 gpm per foot of drawdown (Cooley et al. 1969).

Hydraulic laboratory tests were performed on core samples taken at various locations in eleven of the aquifers of the region. Tests and measurements for porosity, specific yield, specific retention and coefficient of permeability help define the storage, yield and transmissive characteristics of the aquifers. Porosity values ranged from 25 to 35 percent for cores from the Navajo Sandstone, while values for the other aquifers showed a wide range from 1 to 34 percent. Values for specific retention, specific yield and coefficient of permeability ranged from 1.2 to 20 percent, 0 to 30 percent and 0.0009 to 534 gpd per square foot respectively. Laboratory determinations of coefficients of permeability from all aquifers except the Coconino showed wide variations. This variability is summarized in Table 3 below:

TABLE 3

Coefficients of Permeability from Core Samples

(Cooley et al. 1969)

	Number of Cores Having Indicated Coefficients of Permeability (gpd per Square Foot):				
	< 10	10-20	21-50	51-100	> 100
All Aquifers	20	9	13	7	3
Aquifer in Navajo Sandstone	2	3	10	6	3
Aquifer Other Than in Navajo Sandstone	18	6	3	1	0

Permeabilities were determined from cores taken both parallel and perpendicular to the bedding and this seems to account for some of the variation. Permeability values determined from cores taken parallel to the bedding were higher in 18 cases and lower in 8. The deviation between parallel and perpendicular permeabilities is 11 gpd per square foot. These permeability values are considerably higher than those determined from pumping tests (permeability X aquifer thickness = transmissibility). This is probably accounted for by the fact that most of the cores were obtained from outcrops of the various rock units where permeabilities are higher due to weathering and leaching (Cooley et al. 1969).

Sedimentary laboratory analyses for grain size, coefficient of sorting and percentage of soluble material help to further define the hydraulic characteristics of the aquifers. Grain size gives an indication of available pore space and the rate of water movement through an aquifer. The diameter of most sand grains measured ranged from 0.06 to 0.35 mm (very fine to medium-grained). Only the Chinle, Kayenta and Morrison Formations, the Dakota Sandstone and the alluvium contain grains coarser than medium size. The arrangement of the sand grains affects the percentage of available pore space. Generally, the better the degree of sorting the higher the percentage of pore space. In consolidated aquifers there is usually some cementing material filling the pore spaces; therefore, sorting provides only an indication of the potential open pore space for ground-water storage and transmission. The sorting for most of the aquifers is classified as good to fair. The soluble material in the sandstone aquifers is primarily the calcium carbonate part of the cementing material and can constitute a large percentage of calcareous sandstone beds. The effects of grain size and sorting are often masked by the percentage of soluble material present. In fact, soluble material quite often affects permeability more than fracturing. The Wingate, Moenave, Kayenta, Entrada, Summerville, Cow Springs, Morrison and Dakota Sandstone units and formations commonly contain more than 10 percent of soluble material (Cooley et al. 1969).

Data from Table 2 indicate that well yields are low throughout the region. A few wells yield more than 250 gpm, but most are less than 20 gpm and in some areas less than 5 gpm. Because of the low aquifer yields, few wells are used for irrigation. Most municipal, industrial, and institutional wells have yields in the range of from 5 to 200 gpm. Water level measurements in rural areas indicate that water levels generally have not declined. Heavy pumping in urban areas, such as Window Rock, has caused a permanent lowering of ground-water levels. Continued expansion and growth in Tuba City, Kayenta, Rough Rock, Chinle, Pinon and the Hopi villages may also cause overdrafts of the aquifers locally (Cooley et al. 1969).

Regional Ground-Water Quality. The general chemical character of ground water in the region is a hard to very hard bicarbonate type. Total dissolved solids (TDS) concentrations for the region range from 100 to 47,000 ppm. TDS concentrations in the shallow Cretaceous aquifers in the San Juan Basin and the Permian, Triassic and Jurassic aquifers (Table 1) in the Black Mesa Basin north of the Little Colorado River range from 2,000 to more than 10,000 ppm (Figure 21). The primary dissolved constituents of ground water in the region are bicarbonate, sodium, calcium, chloride and sulfate ions. Depending on the TDS concentrations, ground water in the region can be classified as one of four types or a combination of two types. Ground water containing less than 700 ppm TDS is classified as either calcium bicarbonate or sodium bicarbonate and ground water containing more than 700 ppm TDS as sodium sulfate, calcium sulfate or sodium chloride. Minor chemical constituents in the ground water of the region are magnesium, iron, fluoride, nitrate and silica (Cooley et al. 1969). Table 4 is a compilation of the concentrations of various ions in aquifers of the region.

Bicarbonate is abundant in ground water throughout the region. It ranges in concentration from 50 to 300 ppm, but does not limit the use of ground water to the extent other ions do. Calcium, magnesium and sodium concentrations in ground water are usually less than 300 ppm each. Calcium concentrations appear to be controlled by distance from recharge areas. Calcium concentrations are highest near areas of ground-water recharge and

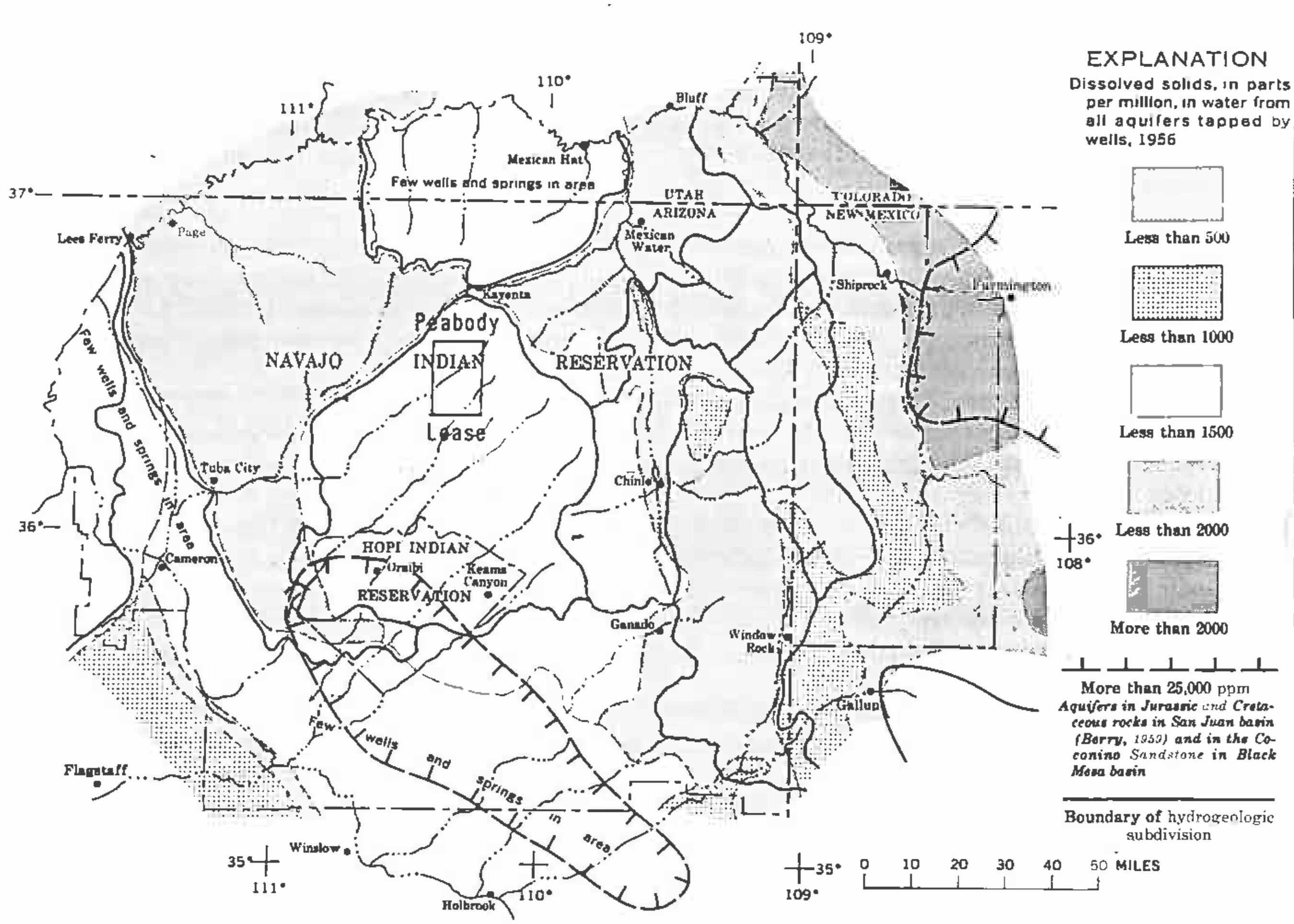


Figure 21

Distribution of Dissolved Solids in Ground Water (Cooley et al, 1969)

Geologic source	Number of analyses	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (parts per million)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate
Alluvium	301	4.1-63	4-2,870	1.1-2,040	6.5-12,000	34-1,000	0-79	2.6-8,890	2-27,600	0-11	0-439	143-47,100	18-15,600	0-15,600
Bidahochi Formation	18	3.2-28	2-80	.9-16	8.7-360	127-292	0-39	6.4-492	5-157	0-2.8	.1-16	132-1,070	8-244	0-63
Chuska Sandstone	13	20-61	23-71	4.8-11	3.4-23	48-278	0-5	2.7-24	3-12	.1-.4	.1-11	138-299	43-222	0-9
Cliff House Sandstone	6	10-19	5.8-276	1.7-91	141-6,140	270-1,140	0-14	303-8,230	7-4,210	0-8	.1-2.5	1,190-3,120	22-1,600	0-1,150
Menefee Formation	60	5.1-21	1-168	.7-34	37-2,020	93-1,600	0-100	6.2-3,930	3-950	0-12	0-19	129-7,780	5-634	0-350
Point Lookout Sandstone	16	3.9-33	1.2-684	.5-207	28-833	167-672	0-45	14-3,410	3-113	.2-3.4	.1-8.6	249-5,080	0-2,800	0-2,630
Crevasse Canyon Formation	9	7.5-19	3-64	.9-231	.9-661	122-1,030	0-9	38-2,980	4-94	0-1.9	0-92	208-3,120	11-3,100	0-3,000
Gallup Sandstone	33	10-39	1.0-456	.5-268	16-710	85-763	0-28	17-2,650	4-482	0-4.8	0-13	285-4,140	4-2,240	0-2,720
Toreva Formation	71	7.1-26	2.8-298	1.2-90	5.8-228	79-479	0-10	12-1,200	3-100	.1-1.8	.1-154	130-1,690	12-1,140	0-940
Dakota Sandstone	33	6.5-42	1.5-330	.9-103	5.8-1,430	130-1,550	0-39	7.8-3,640	6-500	.1-10	.2-10	165-5,560	9-1,080	0-1,210
Morrison Formation	60	6.2-29	5.2-373	1.7-188	9.2-695	81-1,200	0-73	11-1,980	3-374	.1-4.0	0-200	168-2,960	20-1,700	0-1,520
Cow Springs Sandstone	11	7.4-18	7.5-221	2.2-106	24-949	208-898	0-18	17-2,380	12-118	.2-5.1	.1-18	264-3,760	20-988	0-672
Entrada Sandstone	10	9.1-27	2.5-262	1.2-64	16-543	83-639	0-16	8.8-1,930	5-2,230	.2-1.2	.3-33	196-2,870	11-916	0-848
Navajo Sandstone	140	6.7-29	.8-135	.4-64	1.2-295	67-2,300	0-45	3.7-625	1-171	0-2.4	0-80	90-1,030	6-599	0-612
Lukachukai Member of Wingate Sandstone	25	9.3-29	2-67	1.3-21	6.2-309	99-470	0-247	7.6-250	3-121	.1-1.2	.1-18	122-809	10-254	0-42
Sonsela Sandstone Bed of Petrified Forest Member of Chinle Formation	8	8.7-45	1.2-98	.5-34	76-621	244-740	0-33	23-864	19-61	.2-1.3	.3-3	353-1,810	6-384	0-174
Shinarump Member of Chinle Formation	21	3.9-28	.8-304	2.9-597	6.2-871	135-648	0-0	10-4,110	5-375	.2-1.6	.2-9.8	171-6,410	14-3,170	0-2,820
Other units of Chinle Formation	44	5.6-36	3.6-141	.7-40	1.2-1,420	114-1,160	0-402	17-1,670	7-4,050	.1-5.9	.3-129	238-3,810	8-640	0-290
Coconino Sandstone	15	10-14	67-924	40-100	23-5,900	148-299	0-0	219-1,360	22-10,100	.2-.6	.2-5.6	855-30,000	334-2,990	166-392
De Chelly Sandstone	49	7.6-20	18-457	7.4-147	5.5-190	117-532	0-6	9.6-1,660	3-122	0-2	0-17	126-2,270	90-1,740	0-1,640
Glorieta Sandstone	6	8.2-13	116-264	15-87	9.2-1,330	184-265	0-0	246-637	5-1,980	.1-.8	0-1.7	508-4,330	458-779	242-576

Table 4. Range of Chemical Constituents of Ground Water in the Navajo and Hopi Indian Reservations (Cooley et al, 1969)

decrease downdip from the recharge areas. In the San Juan and Black Mesa basins, sodium is the dominant cation or is proportionately equal to the calcium concentrations. Calcium and magnesium ions are chiefly responsible for the hardness of water. The USGS has classified water hardness as follows:

Soft	0-60 ppm
Moderately Hard	61-120 ppm
Hard	121-180 ppm
Very Hard	180 ppm

Based on this hardness classification scheme, most of the ground water in the region is hard to very hard. Figure 22 shows the distribution of hardness expressed as calcium carbonate for ground water in the region. A general range of hardness in the area is from 2 to 15,500 ppm. Figure 22 does not suggest any regional hydrogeologic controls on hardness. A general trend is that ground-water discharge from springs and shallow wells is not as hard as that from deep wells (Cooley et al. 1969).

Sulfate, chloride, nitrate and fluoride concentrations preclude the use of ground water for drinking purposes in several parts of the region. Sulfate concentrations are usually over 200 ppm and range as high as 4,000 ppm. Aquifers in the Entrada and Coconino Sandstones and Upper Cretaceous rocks of the San Juan Basin contain especially high concentrations of sulfate. Ground water containing more than 10,000 ppm chloride is encountered in the Coconino Sandstone, near Hopi Buttes, and in the alluvium in various places. Nitrate concentrations of water from springs and drilled wells is low, usually less than 5 ppm and rarely over 20 ppm. Water from dug wells often contains more than 45 ppm nitrate, probably due to runoff draining into the wells. Alluvial wells also tend to yield water with high nitrate concentrations because of the presence of decaying vegetable matter. Fluoride concentrations in the ground water of the region are shown in Figure 23. For most of the region fluoride concentrations are less than 1.5 ppm; however, several aquifers in the San Juan and Black Mesa Basins are high in fluoride. Specifically, ground water in the Dakota Sandstone and upper Jurassic aquifers used by some of the Hopi villages have fluoride concentrations as high as 6 ppm. Other aquifers in the Black Mesa Basin with high fluoride concentrations are the Chinle and Wepo Formations and the alluvium (Cooley et al. 1969).

The lithology and hydrogeology of rock units has a significant effect on the quality of ground water contained in these units. Clean, well-sorted sandstones of eolian origin, such as the Navajo, Wingate and De Chelly Sandstones, tend to have less soluble material

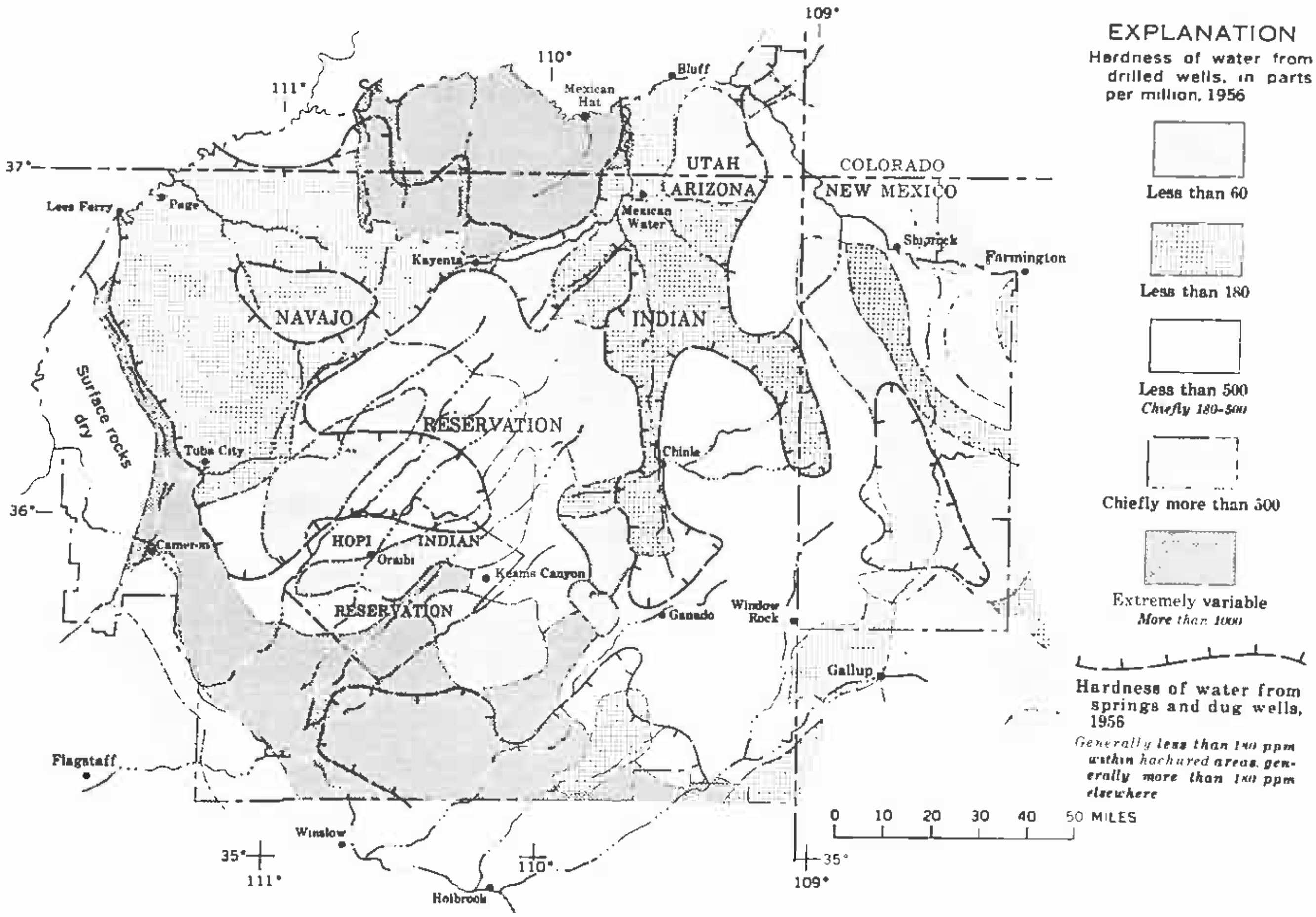


Figure 22

Distribution of Hardness in the Ground Water (Cooley et al, 1969)

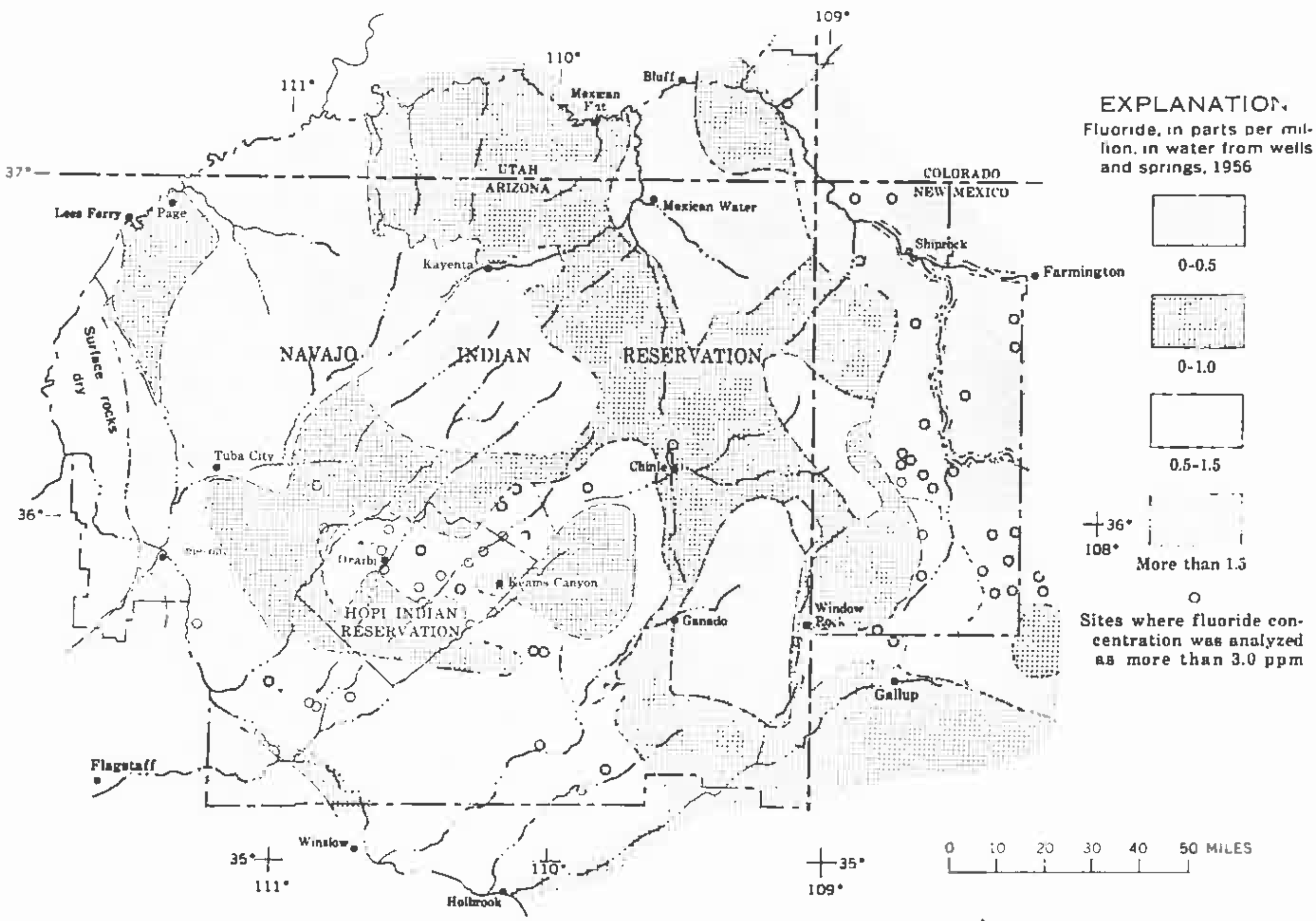


Figure 23

Distribution of Fluoride in the Ground Water (Cooley et al, 1969) in them and, therefore, lower TDS values. Where an aquifer is overlain or underlain by shale units, the TDS values for the aquifer will be higher due to solution of soluble materials from the shale. Most of Black Mesa Basin ground water in the Coconino Sandstone has a very high TDS concentration where the sandstone unit is underlain by the Supai Formation, which contains soluble salt beds. Other factors affecting the chemical quality of ground water are the distance water has moved from the area of recharge and restriction of circulation. Most of the chemical analyses for ground water obtained near recharge areas indicate TDS values of less than 1,000 ppm and in many cases, less than 300 ppm. TDS concentrations increase downdip from the recharge areas. This is in part due to the limited ground-water movement in the central parts of the basins. Regional ground-water movement and flushing primarily occurs around the periphery of basins, accounting for a more uniform water quality in these areas (Cooley et al. 1969).

Surface-Water Hydrology of the Mine Site and Adjacent Areas

Drainage Description. Four principal washes drain the 64,858 acres comprising the Peabody Coal Company Black Mesa leasehold. They are: (1) Yellow Water Canyon; (2) Coal Mine; (3) Moenkopi; and (4) Dinnebito (Drawing No. 85635). Yellow Water Canyon and Coal Mine Wash are tributaries to Moenkopi Wash, merging into Moenkopi in the vicinity of the J-2 and J-15 mining areas and 1¼ miles southwest of the leasehold boundary, respectively. Moenkopi and Dinnebito Washes are the main stems of the mine drainage network.

In addition to the four principal washes, there are three major tributaries to Moenkopi Wash upstream of its confluence with Coal Mine Wash: (1) Yucca Flat; (2) Red Peak Valley; and (3) Reed Valley Wash. Drainage across the leasehold is in a south-southwesterly direction. Both Moenkopi Wash and Dinnebito Wash ultimately drain into the Little Colorado River 13½ miles south of the intersection of Highways 160 and 89, and approximately 30 miles south (upstream) of the junction of the Little Colorado with Moenkopi Wash, respectively (Drawing No. 85630).

Geomorphic Relationships. These washes exhibit a parallel drainage pattern suggesting slope and structural control on the drainage development. Within the leasehold, channel gradients are greater and channel meandering is not as pronounced in the upper reaches of the washes. This is reflected in the narrower valley profiles and more deeply entrenched drainage channels. In the lower reaches of the washes, channel gradients lessen, meandering is more pronounced and valley bottoms and flood plains are wider in relation to valley depths. The valley width to channel meander width ratio in upper Dinnebito Wash suggests that it may be a remnant of an ancestral San Juan River drainage system.

A useful parameter in comparing the geomorphic relationships of channels is stream order. Stream order values were determined for each of the principal washes and tributaries using the smallest drainage division on 1 inch = 2,000 foot USGS topographic maps as 1st order tributaries and following Strahler's method. Stream orders determined for the various channels are: (1) Yellow Water, 6th order; (2) Coal Mine Wash, 7th order; (3) Reed Valley, 6th order; (4) Red Peak Valley, 6th order; (5) Yucca Flat, 6th order; (6) Moenkopi, 8th order; and (7) Dinnebito, 6th order.

Because the maximum stream length is a function of drainage basin area, it follows that there is a definite relation between drainage area and stream order. Figure 24 is a semi-plot of this relationship for the washes on the leasehold. All stream order values and drainge areas have been determined to the downstream leasehold boundaries only. The drainage area measured for Moenkopi Wash included Reed Valley, Red Peak Valley and Yucca Flat Wash. Drainage areas determined to the leasehold boundaries for Dinnebito and Moenkopi Washes represent only a small portion of their total watersheds. Table 4a presents the washes and their respective values that are plotted in Figure 24.

The equation defining the regression line for the relationship between drainage area and stream order was calculated as:

$$\log y = -.568 + .326(x)$$

Most of the scatter can be attributed to the fact that only partial watersheds were ordered in some cases and that most of these were grouped at the 6th order category.

Another useful relationship is stream order versus the hydraulic variables of channel width and channel slope. The general relationships would be defined by the equations: order = k log width and order = k log slope. In dry arroyos where flood plains are the exception and alluvial terraces are quite common, it is difficult to determine bank full elevations from which to compute widths (Leopold and Miller, 1956). Therefore, only the semi-log plot of slope versus stream order is presented (Figure 25). Values plotted in Figure 25 are presented in Table 4b. The equation defining the regression line for the relationship between slope and stream order was calculated as:

TABLE 4a

Stream Order and Drainage Areas for
Washes on the Leasehold

Wash	Stream Order	Drainage Area
Yellow Water Canyon	6	42
Coal Mine	7	43
Reed Valley	6	13.9
Red Peak Valley	6	16
Yucca Flat	6	29
Moenkopi	8	120
Dinnebito	6	35

TABLE 4b

Stream Order and Channel Slopes for
Washes on the Leasehold

Wash	Stream Order	Ave. Channel Slope in the Higher Order Reach
Yellow Water Canyon	6	.020
Coal Mine	7	.019
Reed Valley	6	.021
Red Peak Valley	6	.016
Yucca Flat	6	.017
Moenkopi	8	.015
Dinnebito	6	.011

Revised 12/01/86

FIGURE 24. STREAM ORDER VERSUS DRAINAGE AREA FOR WASHES ON THE LEASEHOLD

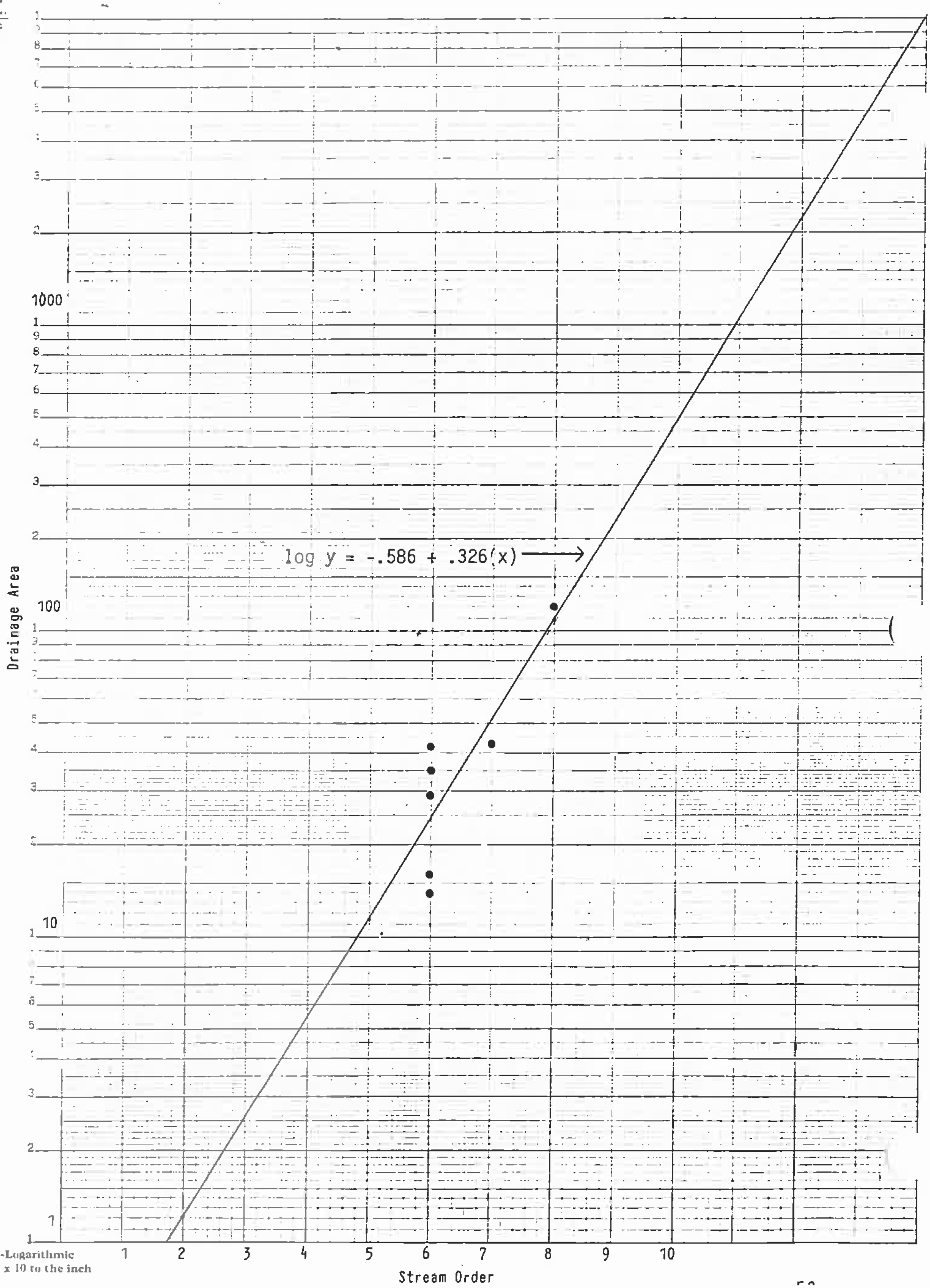
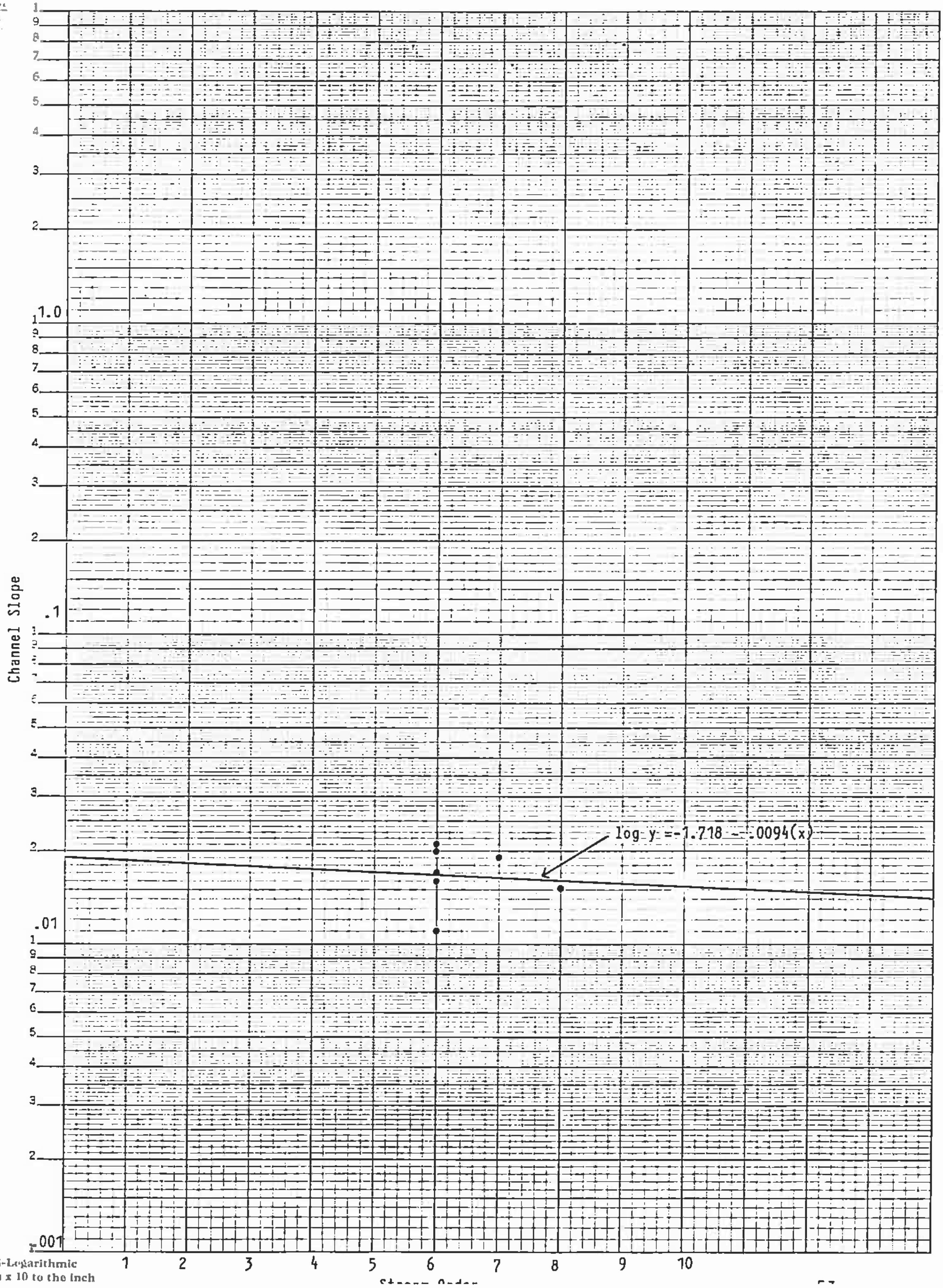


FIGURE 25. STREAM ORDER VERSUS CHANNEL SLOPE FOR WASHES ON THE LEASEHOLD



$$\log y = -1.718 - .0094(x)$$

It is interesting to note that the plot for Dinnebito Wash showed a very poor relation in comparison to the other washes. This lends more credibility to the assumption that its channel development has been primarily controlled by factors related to the ancestral drainage system; whereas the other washes show definite slope control on their development following the uplift of the Black Mesa area.

Ephemeral and Intermittent Characteristics. Based on OSM's definitions for intermittent and ephemeral (CFR 701.5), portions of the drainages on the leasehold can be classified as intermittent. Ephemeral reaches are those which flow only in direct response to precipitation or snowmelt and have a channel bottom always above the local water table. The definition for intermittent has an "or" in it so intermittent reaches or streams can be those with a watershed area greater than one square mile or a stream or reach that is below the local water table for part of the year and derives its flow from both surface runoff and ground water discharge or a stream or reach that exhibits both of the above characteristics.

The following discussion will focus on channel flow variability and seasonality. Since this is not something that can be readily quantified by drainage area, only flows (low flows) will be evaluated. For this discussion, those reaches of the channels whose channel beds are below the local water table irrespective of drainage area size shall be referred to as wet reaches.

The residence time of ground water in different portions of the alluvial aquifer, the amount of recharge influx to portions of the alluvium and shallowing or fluctuations in the bedrock can affect the frequency and spatial distribution of wet reaches. It is probable that all reaches would exhibit ephemeral flow characteristics during an extended period of drought.

Drawing No. 85640 documents the approximate maximum extent of wet reaches on the major washes and also shows reaches that were found to be flowing from an aerial survey and ground checking in October, 1985.

The wet reaches are as follows: (1) Yellow Water Wash in portions of the upper canyons, opposite N-9 above the mouth of Yazzie Wash and a portion off-lease below the main access road; (2) Coal Mine Wash in portions of the upper canyons, for a short reach opposite N-11 and from the channel realignment by the overland conveyor to its mouth; (3) Moenkopi Wash from the former Joint Use Area boundary to one-half mile above the lower haul road crossing and from the lower haul road crossing to several miles southwest of the leasehold; (4) Red Peak Valley Wash from 1000 feet upstream from its mouth for about three-fourths of a mile below J-7 Dam, for two short reaches near Navajo Well 3 and by Alluvial Well 32; (5) Reed Valley Wash at its mouth and in five short reaches upstream; (6) an unnamed tributary of Moenkopi Wash just north of J-16; and (7) most of Dinnebito Wash on the leasehold. The section of Wild Ram Valley Wash below the CWA Pond appears to be intermittent, but is an artificially created situation. Due to considerable pit pumpage from the J-1/N-6 pit, CW-A and B Ponds have discharged and seeped for extended

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periods creating an artificial wet reach in the wash. Foundation investigations at the time J16-A Dam (Wild Ram Valley Dam) was to be constructed indicated the channel alluvium was principally dry with a minor amount of saturation at the alluvial-bedrock contact. This does confirm in Wild Ram Valley that alluvial flow is subsurface and the surface flow is not a naturally occurring process.

Surveys to identify wet reaches were also conducted in 1980 and 1983. The results of these surveys are documented on Pages 68 and 69 in Volume 43 of the 1981-1985 Mine Plan. Wet reaches determined from these surveys are presented on Drawing No. 85640 as dashed lines, whereas the 1985 survey results are presented as dot-dash lines for comparison.

It should be emphasized that discharges in all of these wet reaches are very small. In April and May of 1985, Peabody's environmental personnel measured baseflows with a portable cutthroat flume. Those measurements are listed in Table 5. Discharges ranged from less than 0.002 cfs on Dinnebito Wash to 0.29 cfs at Site 25 on Coal Mine Wash.

Channel Cross Section Analyses. Channel bottoms and the banks of major drainages on Black Mesa consist of highly erodable, unconsolidated material. Studies have documented major cycles of arroyo cutting and filling in these channels during past centuries (Euler et al. 1979). To measure the extent of short-term changes in the channel beds and banks, Peabody began in 1983 to periodically survey selected channel cross sections on the leasehold in the vicinity of stream monitoring sites. Plots of these cross sections are presented in Attachment No. 1 and maps showing the locations of these cross sections are given in Chapter 16, Attachment No. 1.

The first surveys done in August of 1983 were compiled from aerial photographs. Later surveys were conducted using field surveying techniques. Some changes shown by the plots may be greater in magnitude than actually occurred because resolution using field surveying methods was greater than resolution obtained from aerial photography. In any long-term geomorphic cycle, there is considerable "noise" so changes noticed over a two-year time period do not necessarily indicate long-term trends.

The degree of vertical exaggeration in the plots is expressed by the proportion of vertical scale to horizontal scale. Grid lines show the amount of vertical exaggeration. Cross section line numbers at the various sites all increase upstream.

The types of changes shown in the plots of channel cross sections near stream station sites are summarized in Table 6. The "aggradation" and "degradation" column values in

TABLE 5

Base Flows Measured With a Portable Cutthroat Flume

*Wash/Nearest Monitoring Site	Date	Discharge (cfs)
Coal Mine Wash Near Site 42	4/25/85	.020
Coal Mine Wash at Site 18	5/10/85	.080
Coal Mine Wash Near Site 83	5/10/85	.054
Coal Mine Wash Near Site 81	5/10/85	.051
Coal Mine Wash at Site 25	5/10/85	.29
Moenkopi Wash at Site 26	5/15/85	.11
Moenkopi Wash Near Site 24	5/15/85	.12
Moenkopi Wash at Reed Valley Confluence	4/26/85	.17
Dinnebito Wash Near Site 33R	4/25/85	.002
Moenkopi Wash Near Site 88	4/26/85	.09
Reed Valley Wash ¼ Mile Below J-16L Dam	4/26/85	.08
Yellow Water Canyon Wash Near Site 71	4/25/85	.027
Red Peak Valley Wash at Site 155	5/15/85	.071

* Reference should be made to Drawing No. 85600 for approximate baseflow measurement locations which are adjacent to the listed monitoring site numbers.

TABLE 6

Summary of Measured Channel Changes

1983 - 1985

Number of Cross Sections Showing

Wash	Degradation	Aggradation	Widening or Bank Erosion	Constriction	Total Cross Sections in Wash
Yellow Water	4	3	7	1	10
Yazzie	1	0	1	0	1
Coal Mine	5	2	4	0	8
Moenkopi	1	5	3	0	10
Reed Valley	1	1	0	0	2
Red Peak Valley	2	0	3	0	3
Yucca Flat	5	0	5	0	5
Dinnebito	2	3	1	0	7
Total	21	14	24	1	46

Table 6 represent the number of cross sections showing a raising or lowering of the thalweg elevation. Cross sections not classified in one of those two columns had little change in the thalweg elevation with two exceptions. At Cross Section 10 near Site 35 in Moenkopi Wash, the changes were caused by heavy equipment used periodically to level uneven channel deposits in the stream bed around the stream monitoring station. At Cross Section 16 near Site 15, changes result from several large flows that caused the thalweg to shift laterally. All cross sections not classified under "widening or bank erosion" or "constriction" had relatively stable banks and little change in geometry.

The prominent trend leasewide is an increase in channel cross sectional area. Most of these cross sections exhibited degradation, but some of those that aggraded also widened, resulting in increased channel capacities. A possible explanation for this is that 1983 and 1984 were relatively "wet" summers, yielding more frequent and larger flows. These flows resulted in channel geometry changes due to scour and deposition.

On Yellow Water Wash, all five cross sections near Site 15 show an increase in channel capacity. In contrast, of the five cross sections near Site 50 (upstream from Site 15), only two cross sections widened, and three out of five aggraded. The channel bed at Cross Section 8 (at Stream Station 50) was kept at a fairly constant elevation by grading with heavy equipment.

The cross section established at Site 157 in the N-7/8 channel realignment shows downcutting of almost .7 feet in the thalweg. Widening in the channel at this site has also occurred.

Cross sections near Site 16 in Coal Mine Wash exhibited contrasting changes. Degradation has occurred in two cross sections, while one shows aggradation. Cross sections established downstream of Site 16 near Site 25 have mostly degraded over the same period. Of nine cross sections on Moenkopi Wash (Cross Section 10 near Site 35 was discussed earlier), five aggraded and only one downcut. Three cross sections near Site 35 did widen, however. The major change in cross sections located near Site 26 was a shift of the thalweg from the left side to the right.

Channel degradation near the downstream location of Site 37 above the mouth of Reed Valley Wash has occurred during the last two years. The newly established site near the mouth of Dugout Valley shows slight aggradation. Near Site 14 in Red Peak Valley, three channel cross sections widened and two degraded. This site has bedrock ledges in the channel bottom a few hundred feet both upstream and downstream. This exposed lithology limits the extent of degradation in this reach.

Cross sections established in the vicinity of Site 85 in Yucca Flat Wash had the most consistent results of any site in this study. All five cross sections degraded and widened. It is believed that this is principally due to two very large floods that occurred during the summer of 1984. The smaller of the two flows was measured at 3,900 cfs. The larger flow damaged the crest gauge and downcut the channel bed exposing the Black Mesa pipeline just below the confluence of Yucca Flat Wash and Red Peak Valley Wash. Cross section measurements made near Site 34 in Dinnebito Wash show shifting of the channel bottom elevation. The most recent cross section measurements indicate an aggrading channel bottom. The cross section changes at the 1984 established location of Site 78 can be largely attributed to one flood on August 23, 1984. This flood washed away 8 feet of the left bank, including the crest gauge, and 5 1/2 feet of the right bank. Cross Sections 1 through 4 near Site 78 show only minor changes in the channel.

Runoff Monitoring and Analysis. Runoff on Black Mesa occurs primarily during two seasons of the year. The great majority of runoff occurs in July, August, September, and occasionally, early October. This runoff results from intense, localized thunderstorms in July and August, and from more widespread frontal-type storms in September and October. A much smaller amount of runoff occurs some years in February and March and results from snowmelt or from rain falling on snow. Streamflow peaks resulting from this source are generally small since (1) the water is released slowly so much of it infiltrates into the soil and alluvium, and (2) the size of the snowpack on Black Mesa does not approach that of higher mountain peaks or more northern latitudes.

USGS Streamflow Monitoring. Monitoring of stream flows on the leasehold prior to 1980 was done by the USGS. Flow measurements were taken in conjunction with water quality sampling at several locations in and adjacent to the mine area (see Drawing Nos. 85635 and 85630). A summary of peak discharges for the various streamflow-gauging stations, comprising the USGS Black Mesa monitoring program, are listed in Table 7. Maximum discharges measured for Yellow Water Canyon, Coal Mine and Moenkopi Washes are 1,500, 1,480 and 5,400 cubic feet per second, respectively (USGS, 1977). A summary of all USGS flow data collected at the Moenkopi Wash, Chinle Wash and Laguna Creek stations from 1964 to 1984 is presented in Attachment 2.

Starting in 1980, both Peabody Coal Company and the USGS monitored stream flows and

TABLE 7

Data From Streamflow-Gauging Stations
In the Black Mesa Monitoring Program
(USGS, 1977)

Identifying Number on Maps	Number	Station Name	Record Began	Drainage Area (mi^2)	Water Year	Annual Peak Discharge (ft^3/s)	Date of Occurrence
		Continuous-Record Stations					
1	09401225	Coal Mine Wash tributary No. 3 near Kayenta	May 1975	0.41	1976	0	-
2	09401226	Coal Mine Wash tributary near Kayenta	December 1973	0.62	1974	E 63	08-04-74
					1975	772	07-10-75
					1976	8.4	09-25-76
3	09401229	Coal Mine Wash tributary No. 2 near Kayenta	December 1973	0.62	1974	E 15	07-16-74
					1975	0	-
					1976	0	-
4	09401250	Moenkopi Wash near Moenkopi	October 1973 (Discontinued June 30, 1976)	1,650	1974	E 2,340	07-19-74
					1975	2,380	09-13-75
5	09401260	Moenkopi Wash at Moenkopi	July 1, 1976	1,660	1976	5,400	09-25-76

TABLE 7 (Cont.)

Data From Streamflow-Gauging Stations
In the Black Mesa Monitoring Program
(USGS, 1977)

Identifying Number on Maps	Station Number	Station Name	Record Began	Drainage Area (mi^2)	Water Year	Annual Peak Discharge (ft^3/s)	Date of Occurrence
		Partial-Record Stations					
6	0941224	Coal Mine Wash near Kayenta	November 1973	34.1	1974	E 10	03-02-74
					1975	2,650	07-10-75
					1976	E 30	07-24-76 or 07-25-76
7	09401232	Coal Mine Wash near Shonto	November 1973	44.6	1974	E 12	03-02-74
					1975	1,480	09-08-75
					1976	E 2	09-25-76
8	09401234	Yellow Water Canyon near Kayenta	November 1973	18.6	1974	E 90	07-21-74
					1975	1,500	07-11-75
					1976	E 30	09-25-76
9	09401236	Yellow Water Canyon near Shonto	November 1973	49	1974	0	-

TABLE 7 (Cont.)

Data From Streamflow-Gauging Stations
In the Black Mesa Monitoring Program
(USGS, 1977)

Identifying Number on Maps	Station Number	Station Name	Date Record Began	Drainage Area (mi^2)	Water Year	Annual Peak Discharge (ft^3/s)	Date of Occurrence
9 (Cont.)					1975	1,420	07-11-75
					1976	25	09-25-76
Not Shown	09401238	Yellow Water Canyon above Coal Mine Wash near Shonto	November 1973 (Discontinued 1975)	-	-	-	-
10	09401240	Moenkopi Wash near Shonto	December 1973	270	1974	E 1,850	08-04-74
					1975	E 900	07-12-75
					1976	E 2,500	07-26-76
11	09401248	Begashibito Wash near Tonalea	August 1973	611	1974	E 280	08-04-74
					1975	E 260	09-13-76
					1976	E 100	09-25-76

E = Estimated

quality in the washes on and adjacent to the leasehold. The USGS monitoring on or immediately adjacent to the leasehold was limited to periodic monitoring at the mouth of Coal Mine Wash (Site No. 09401239). A stage discharge relation for this station was partially developed and is presented in Figure 26. A tabulation of daily flows for the period 5/12/78 to 9/31/82 is presented in Table 8. The USGS discontinued monitoring at this station in September, 1982.

Peabody Streamflow Monitoring and Analysis. The Peabody stream monitoring program consists of four types of measurement techniques: 1) mechanical suspended sediment and flow stage; 2) automated suspended sediment, water quality and flow stage; 3) manual water quality, suspended sediment and flow measurements; and 4) indirect flow measurements. The above measurements are obtained employing five types of monitoring installations: 1) crest-gages only; 2) single-stage sediment samplers only; 3) single stage sediment samplers in conjunction with stilling wells and/or crest-gages and with or without catwalks; 4) automated stations (diamond-shaped stream stage stations) with peristaltic pump type water quality and suspended sediment samplers in combination with stilling wells and crest-gages and with or without catwalks; and 5) automated stations (trapezoidal flumes) with peristaltic pump type water quality and suspended sediment samplers in combination with stilling wells, crest-gages and catwalks.

In total, stream monitoring is performed at 16 sites. Where crest-gages are located in a close proximity to other stream monitoring installations (Nos. 15, 16, 18, 25, 26, 35 and 50), the same monitoring site number has been used for both monitors. Descriptions of stream monitoring stations and instrumentation used for flow monitoring are discussed in more detail in Chapter 16, Hydrological Monitoring Program.

A statistical summary of all current meter and indirect flow measurements for the period 1980 through 1985 is presented in Table 9. Specific methods used to take these flow measurements are described in Chapter 16, Hydrological Monitoring Program. The maximum flow measured (4350 cfs) occurred on September 11, 1980 at Site 25 near the mouth of Coal Mine Wash. The maximum mean peak flow (696 cfs) was also at Site 25 while the minimum mean peak flow (10.7 cfs) for the above referenced period of record was recorded at Site 157 near the mouth of Yazzie Wash. In total 272 flows (greater than 1 cfs) have been monitored at the 14 stream sites where flow monitoring is conducted.

A typical graphic presentation of flow data consists of plots of stream stage versus discharge. Another approach is that of Leopold and Maddock (1953) who used plots of

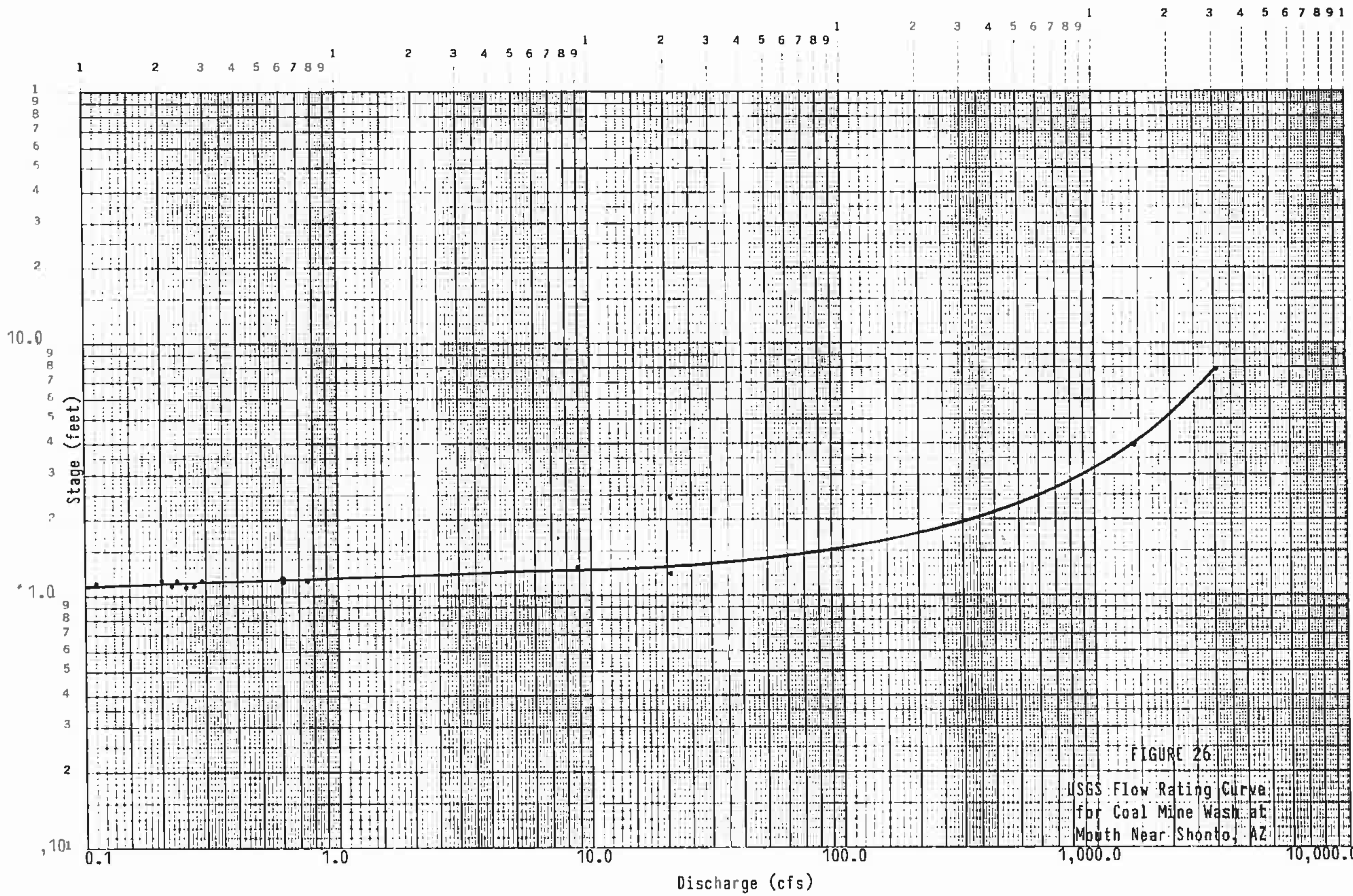


FIGURE 26

USGS Flow Rating Curve for Coal Mine Wash at Mouth Near Shonto, AZ

TABLE 8

Daily Average Flows for Coal Mine Wash Station
at Mouth Near Shonto, Arizona

STATION NUMBER 09401239 COAL MINE WASH NR MOUTH NR SHONTO, AZ STREAM SOURCE AGENCY USGS
LATITUDE 362534 LONGITUDE 1102632 DRAINAGE AREA DATUM STATE 04 COUNTY 001

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1								---	.00	.00	.00	.00
2								---	.00	.00	.00	.00
3								---	.00	.00	1.0	.00
4								---	.00	.00	.00	.00
5								---	.00	.00	.00	.00
6								---	.00	.00	.00	.00
7								---	.00	.00	.00	.00
8								---	.00	.00	.00	.00
9								---	.00	.00	10	.00
10								---	.00	.00	.00	.00
11								---	.00	.00	.00	.00
12								.03	.00	.00	.00	.00
13								.03	.00	.00	.00	.00
14								.00	.00	.00	.00	.00
15								.00	.00	.00	.00	.00
16								.03	.00	.00	.00	.00
17								.03	.00	.00	.00	.00
18								.00	.00	.00	.00	.00
19								.03	.00	.00	.00	.00
20								.03	.00	.00	.00	.00
21								.00	.00	.00	.00	.00
22								.00	.00	.00	.00	.00
23								.00	.00	.00	.00	.00
24								.00	.00	20	.00	.60
25								.00	.00	1.2	.00	.00
26								.00	.00	.00	.00	.00
27								.00	.00	.00	.00	.00
28								.00	.00	.00	.00	.00
29								.00	.00	.00	.00	.00
30								.00	.00	.00	.00	.00
31								.00	---	.00	.00	---
TOTAL								---	.00	21.20	11.00	.60
MEAN								---	.000	.68	.35	.020
MAX								---	.00	20	10	.60
MIN								---	.00	.00	.00	.00
AC-FT								---	.00	42	22	1.2

TABLE 8 (Cont.)

STATION NUMBER 09401239 COAL MINE WASH NR MOUTH NR SHONTO, AZ STREAM SOURCE AGENCY USGS
LATITUDE 362534 LONGITUDE 1102632 DRAINAGE AREA DATUM STATE 04 COUNTY 001

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.00	.00	.10	.10	.10	.10	.38	.22	.00	.00	.00	.00
2	.00	.00	.10	.10	.10	.10	.44	.18	.00	.00	.00	.00
3	.00	10	.10	.10	.10	.10	.14	.38	.00	.00	.00	.00
4	.00	5.0	2.5	.10	.10	.10	.08	.22	.00	.00	.00	.00
5	.00	3.0	2.0	.10	.10	.10	.06	.14	.00	.00	.00	.00
6	.00	.50	.10	.10	.10	.10	.00	.11	.00	.00	.00	.00
7	.00	.20	.10	.10	.10	.10	.06	.08	.00	.00	.00	.00
8	.00	.20	.10	.10	.10	.10	.14	.38	.00	.00	.00	.00
9	.00	.20	.10	.10	.10	.10	.22	.38	.00	.00	.00	.00
10	.00	.20	.10	.10	.10	.10	1.3	.38	.00	.00	.00	.00
11	.00	8.0	.10	.10	.10	.10	2.5	.22	.00	.00	.44	.00
12	.00	2.0	.10	.10	.10	.10	2.5	.14	.00	.00	.38	.00
13	.00	1.0	.10	.10	.10	.10	3.5	.14	.00	.00	.06	.00
14	.00	.50	.10	.10	.10	.10	1.3	.11	.00	.00	.00	.00
15	.00	.20	.10	.10	.10	.10	.26	.08	.00	.00	.44	.00
16	.00	.10	.10	.10	.10	.06	.26	.32	.00	.00	.08	.00
17	.00	.10	.10	.10	.10	.06	.32	.32	.00	.00	.00	.00
18	.00	.10	.10	.10	.10	.06	.08	.18	.00	.00	.00	.00
19	.00	.10	.10	.10	.10	.22	.11	.14	.00	.00	.00	.00
20	.00	.10	.10	.10	.10	.22	.44	.32	.00	.00	.00	.00
21	.00	.10	.10	.10	.10	2.0	.52	.32	.00	.00	.00	.00
22	.00	.10	.10	.10	.10	.96	.22	.08	.00	.00	.00	.00
23	.00	.10	.10	.10	.10	.44	.74	.06	.00	.00	.00	.00
24	.00	.10	.10	.10	.10	.96	.26	.38	.00	.00	.00	.00
25	.00	.10	.10	.10	.10	.52	.17	2.0	.00	.00	.00	.00
26	.00	.10	.10	.10	.10	.22	.22	.44	.00	.00	.00	.00
27	.00	.10	.10	.10	.10	.08	.22	.38	.00	.00	.84	.00
28	.00	.10	.10	.10	.10	.11	.22	.00	.00	.00	.00	.00
29	.00	.10	.10	.10	---	.61	.22	.00	.00	.00	.00	.00
30	.00	.10	.10	.10	---	.38	.22	.00	.00	.00	.00	.00
31	.00	---	.10	.10	---	.61	---	.00	---	.00	.00	---
TOTAL	.00	32.50	7.40	3.10	2.80	9.01	17.10	8.10	.00	.00	2.24	.00
MEAN	.000	1.08	.24	.10	.10	.29	.57	.26	.000	.000	.072	.000
MAX	.00	10	2.5	.10	.10	2.0	3.5	2.0	.00	.00	.84	.00
MIN	.00	.00	.10	.10	.10	.06	.00	.00	.00	.00	.00	.00
AC-FT	.00	64	15	6.1	5.6	18	34	16	.00	.00	4.4	.00

WTR YR 1979 TOTAL 82.25 MEAN .23 MAX 10 MIN .00 AC-FT 163

NOTE.--No gage-height record Oct. 17 to Nov. 30 and Dec. 12 to Mar. 16.

TABLE 8 (Cont.)

STATION NUMBER 09401239 COAL MINE WASH NR MOUTH NR SHONTO, AZ STREAM SOURCE AGENCY USGS
LATITUDE 362534 LONGITUDE 1102632 DRAINAGE AREA DATUM STATE 04 COUNTY 001

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1979 TO SEPTEMBER 1980
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.00	.00	.10	5.5	.20	2.5	3.0	.41	.06	.00	.00	.00
2	.00	.00	.10	3.0	.20	2.6	3.0	.57	.06	.00	.00	.00
3	.00	.00	.10	4.8	.20	6.9	2.7	.57	.04	.00	.00	.00
4	.00	.00	.10	4.8	.20	8.1	2.4	.95	.00	.00	.00	.00
5	.00	.00	.10	4.1	.20	4.8	2.1	.61	.00	.00	.00	4.8
6	.00	.00	.10	4.1	.20	16	1.7	.53	.00	.00	.00	.00
7	.00	14	.10	5.5	.20	6.6	1.4	12	.00	.00	.00	.02
8	.00	41	.10	5.5	.20	9.5	1.1	8.8	.00	.00	.00	170
9	.00	11	.10	.61	.20	3.3	.80	3.8	.00	.00	.00	46
10	.00	.00	.10	2.5	.20	1.9	.33	3.0	.00	.00	.00	72
11	.00	.00	.10	6.4	.20	3.9	.92	4.8	.00	.00	.00	5.2
12	.00	.00	.10	12	.20	7.2	1.3	3.9	.00	.00	.00	.00
13	.00	.00	.10	4.1	.20	5.0	.57	3.9	.00	.00	.00	.00
14	.00	.00	.10	2.5	.20	3.0	.51	3.7	.00	.00	.00	.00
15	.00	.00	.10	.20	.40	2.0	.50	3.8	.00	.00	.00	.00
16	.00	.00	.10	.66	.40	2.0	.49	3.4	.00	.00	.00	.00
17	.00	.00	.10	1.6	1.3	1.0	.85	2.7	.00	.00	.00	.00
18	.00	.00	.10	4.7	.40	.60	.38	2.2	.00	.00	.00	.00
19	.00	.00	.10	7.6	.40	6.5	.32	1.9	.00	.00	.00	.00
20	23	.10	.74	11	.60	1.7	.36	2.4	.00	.00	.00	.00
21	64	.10	.52	3.0	1.3	.59	.32	.62	.00	.00	.00	.00
22	.00	.10	.52	.20	.40	3.1	.31	.37	.00	.00	.00	.00
23	.00	.10	.44	.20	.20	5.9	.64	.44	.00	.00	.00	.00
24	.00	.10	.61	.20	.20	3.9	.40	.39	.00	.00	11	.00
25	.00	.10	2.0	.20	.20	4.1	.38	.06	.00	.00	3.0	.00
26	.00	.10	2.5	.20	.20	4.0	.38	.06	.00	.00	.00	.00
27	.00	.10	3.0	.20	.20	4.0	.48	.06	.00	.00	.00	.00
28	.00	.10	3.0	.20	.47	3.7	.46	.06	.00	.00	.00	.00
29	.00	.10	2.0	.20	2.1	3.7	.77	.06	.00	.00	.00	.00
30	.00	.10	2.5	.20	----	3.5	.31	.06	.00	.00	.00	.00
31	.00	---	2.0	.20	---	3.5	---	.06	---	.00	.00	---
TOTAL	87.00	67.10	21.73	96.17	11.57	135.09	29.18	66.18	.16	.00	14.00	298.02
MEAN	2.81	2.24	.70	3.10	.40	4.36	.97	2.13	.005	.000	.45	9.93
MAX	64	41	3.0	12	2.1	16	3.0	12	.06	.00	11	170
MIN	.00	.00	.10	.20	.20	.59	.31	.06	.00	.00	.00	.00
AC-FT	173	133	43	191	23	268	58	131	.3	.00	28	591

CAL YR 1979 TOTAL 218.18 MEAN .60 MAX 64 MIN .00 AC-FT 433
WTR YR 1980 TOTAL 826.20 MEAN 2.26 MAX 170 MIN .00 AC-FT 1640

NOTE.--No gage-height record Nov. 20 to Dec. 19, Jan. 22 to Feb. 26 and Sept. 8.

TABLE 8 (Cont.)

STATION NUMBER 09401239 COAL MINE WASH NR MOUTH NR SHONTO, AZ STREAM SOURCE AGENCY USGS
LATITUDE 362534 LONGITUDE 1102632 DRAINAGE AREA DATUM STATE 04 COUNTY 001

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1980 TO SEPTEMBER 1981
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.00	.30	.50	.20	.60	.20	.52	1.0	.00	.06	2.0	.00
2	.00	.30	.30	.20	.60	.14	.44	.80	.00	.00	.03	.03
3	.00	.30	.20	.30	.60	.29	.44	.40	.00	.00	.00	.00
4	.00	.50	.10	.30	.60	.22	.32	.20	.00	.00	.00	.60
5	.00	.50	.50	.40	.60	.15	.26	.20	.00	.00	.00	.03
6	.00	.50	.20	.40	.60	.29	.44	.20	.00	.00	.00	.44
7	.00	.50	.20	.80	.60	.19	.22	.20	.00	.00	.00	.00
8	.00	.50	.40	5.0	.80	.45	.22	.20	.00	.22	.00	.96
9	.00	.50	.20	2.0	1.0	.24	.26	.20	.00	.22	.03	.52
10	.00	1.0	.10	2.0	1.0	.19	.26	.20	.00	.00	.14	3.6
11	.00	1.0	.10	2.0	1.0	.22	.18	.20	.00	2.5	.14	.21
12	.00	1.0	.10	2.0	1.0	.20	.18	.20	.00	18	2.8	.18
13	.00	1.3	.10	2.0	1.0	.17	.22	.20	.00	16	.00	.14
14	.36	3.5	.10	1.0	1.0	.22	.20	.20	.00	1.1	.10	.14
15	.62	5.0	.10	1.0	1.0	.20	.20	.20	.00	4.5	.59	13
16	.04	2.0	.10	1.0	2.0	.19	.20	30	.00	27	.00	.23
17	.00	2.0	.10	1.0	2.0	.20	.20	10	.00	2.3	.00	.02
18	.00	1.0	.10	1.0	2.0	.23	.20	2.0	.00	2.3	.00	.00
19	.00	1.0	.10	.80	3.0	.17	.80	.40	.00	.28	.00	.00
20	.00	1.0	.10	.80	2.0	.15	.40	.20	.00	.05	.00	.00
21	.00	1.0	.10	.60	4.1	.23	.22	.20	.00	.02	.00	.00
22	.00	1.0	.10	.60	2.9	.22	.52	.20	.00	.00	.60	.00
23	.00	1.0	.10	.60	.12	.20	.61	.20	.00	.23	1.0	4.7
24	.00	1.0	.10	.60	.13	.18	.52	.20	.00	6.9	.20	.47
25	.00	1.0	.10	.60	.13	.19	.32	.20	.00	.06	1.5	.11
26	.00	.50	.10	.60	.13	.32	.52	.20	.00	.26	.20	.05
27	.10	.50	.10	.60	.17	.74	.74	.20	.00	.02	.00	.01
28	.20	.50	.10	.60	.17	.74	1.5	.11	.00	.00	.60	.00
29	.20	.50	.10	.60	---	.61	1.2	.00	.00	.00	.00	.00
30	.20	.50	.10	.60	---	.38	1.2	.00	.61	.00	.00	.00
31	.20	---	.10	.60	---	.38	---	.00	---	.00	1.5	---
TOTAL	1.92	31.20	4.80	30.80	30.85	8.50	13.51	48.71	.61	82.02	11.43	25.41
MEAN	.062	1.04	.15	.99	1.10	.27	.45	1.57	.020	2.65	.37	.85
MAX	.62	5.0	.50	5.0	4.1	.74	1.5	30	.61	27	2.8	13
MIN	.00	.30	.10	.20	.12	.14	.18	.00	.00	.00	.00	.00
AC-FT	3.8	62	9.5	61	61	17	27	97	1.2	163	23	50

CAL YR 1980 TOTAL 685.29 MEAN 1.88 MAX 170 MIN .00 AC-FT 1370
WTR YR 1981 TOTAL 289.76 MEAN .79 MAX 30 MIN .00 AC-FT 575

NOTE.--No gage-height record Oct. 19 to Nov. 13, Nov. 15 to Feb. 18 and Apr. 28 to May 28.

TABLE 8 (Cont.)

STATION NUMBER 09401239 COAL MINE WASH NR MOUTH NR SHONTO, AZ STREAM SOURCE AGENCY USGS
LATITUDE 362534 LONGITUDE 1102632 DRAINAGE AREA DATUM STATE 04 COUNTY 001

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1981 TO SEPTEMBER 1982
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.3	.22	.45	.50	.74	.00	1.7	.15	.00	.00	.00	.03
2	104	.22	.41	.40	1.4	.00	4.1	.16	.00	.00	.00	.00
3	2.3	.22	.17	.20	.68	.00	.41	.19	.00	.00	.00	.00
4	.24	.22	.03	.10	.45	.03	.27	.26	.00	.00	.00	.22
5	.22	.22	.00	.10	.40	.35	.26	.72	.00	.00	.00	.14
6	.22	.22	.00	.10	.10	.05	.20	.02	.00	.00	.00	23
7	.22	.22	.00	.10	.10	.03	.13	.03	.00	.00	.00	13
8	.22	.22	.01	.10	.10	.00	.11	.04	.00	.00	.18	3.0
9	.22	.22	.01	.10	.10	.00	.15	.02	.00	.00	.00	23
10	.22	.22	.00	.10	.10	.00	.40	.05	.00	.00	.00	6.4
11	.22	.22	.00	.10	.10	.07	.16	.04	.00	.00	.00	47
12	.22	.23	.10	.10	.10	1.0	.09	1.9	.00	.00	.44	31
13	.22	.22	.10	.10	.10	.65	.11	.20	.00	.00	.61	3.5
14	.22	.22	.25	.10	.10	.47	.15	.00	.00	.00	.00	12
15	.22	.22	.26	.10	.10	.64	.14	.00	.00	.00	66	14
16	.22	.22	.26	.10	.10	.00	.18	.00	.00	.00	13	8.2
17	.22	.25	.52	.10	.10	.02	.28	.00	.00	.00	.14	4.8
18	.22	.23	.36	.10	.10	.11	.19	.00	.00	.00	.00	4.2
19	.22	.24	.50	.10	.10	1.4	.21	.00	.00	.00	.00	3.0
20	.22	.40	.59	.10	.40	25	.10	.00	.00	.00	4.2	45
21	.22	.75	.15	.10	.30	5.0	.25	.00	.00	.00	1.3	13
22	.22	1.2	.28	.10	.30	1.0	.31	.00	.00	.50	37	10
23	.22	.92	.20	.10	.30	.50	.61	.00	.00	.00	10	5.5
24	.22	.53	.20	.10	.20	.50	.82	.00	.00	.00	5.5	.52
25	.22	.39	.20	.10	.09	.30	.16	.00	.00	.00	38	.44
26	.22	1.4	.20	.10	.00	.30	.86	.00	.00	.00	37	.26
27	.22	2.3	.20	.10	.00	.30	.53	.00	.00	.00	31	86
28	.22	1.5	.20	.10	.00	.30	.28	.00	.00	.00	4.1	4.8
29	.22	1.9	.20	1.6	---	.30	.07	.00	.00	.00	.52	3.0
30	.22	.68	.20	.77	---	.30	.13	.00	.00	.00	9.3	2.5
31	.22	---	.12	.70	---	.30	---	.00	---	.00	15	---
TOTAL	115.78	16.22	6.17	6.67	6.66	38.92	13.36	3.78	.00	.50	273.29	367.51
MEAN	3.73	.54	.20	.22	.24	1.26	.45	.12	.000	.016	8.82	12.3
MAX	104	2.3	.59	1.6	1.4	25	4.1	1.9	.00	.50	66	86
MIN	.22	.22	.00	.10	.00	.00	.07	.00	.00	.00	.00	.00
AC-FT	230	32	12	13	13	77	26	7.5	.00	1.0	542	729

CAL YR 1981 TOTAL 390.01 MEAN 1.07 MAX 104 MIN .00 AC-FT 774
WTR YR 1982 TOTAL 848.86 MEAN 2.33 MAX 104 MIN .00 AC-FT 1680

TABLE 9

Summary of Stream Flow Measurements

Site	Max. Flow (cfs)	Min. Flow (cfs)	Mean Peak Flow (cfs)	No. of Measurements
14	530	1.3	103	13
15	530	1.2	64	35
16	3432	2.3	263	43
18	290	1.6	27.6	22
25	4350	4.9	696	10
26	1220	6.9	199	11
34	1160	6.6	440	6
35	1940	1.6	176	40
37	500	10.0	124	8
50	1576	1.3	273	58
78	557	2.3	191	8
85	3900	10.4	658	8
155	343	12.1	140	3
157	27.4	1.3	10.7	7

Revised 12/01/86

average velocity and depth versus discharge to describe part of the "hydraulic geometry" of stream channels. Dawdy (1961) pointed out that in sandbed channels, with their easily erodible banks and channel bottoms (which describes the washes on Black Mesa), there may not be a good correlation between stage and discharge. He suggests using hydraulic radius to eliminate the effect of variations in bottom elevation and mean velocity to counteract effects of changing channel bank positions. Plots of hydraulic radius versus velocity, hydraulic radius versus discharge and velocity versus discharge for 11 stream sites are presented in Attachment 3. Parameter values were converted to logarithms for plotting; for example, a discharge of 10 cfs plots as 1, 100 cfs plots as 2, 1000 cfs as 3, and so on. Velocity is plotted as the logarithm of feet per second and hydraulic radius as the log of feet. Straight lines were best fit to the data plots to indicate trends. There are no graphs for Sites 15 and 18 because supercritical flow flumes at these sites control the hydraulic properties. Site 155 also has no graphs since it is a relatively new site and has too few measurements to show any significant relationships.

Dawdy (1961) found that in alluvial channels, a discontinuity sometimes occurs in the hydraulic radius versus velocity relationship. This happens when the Froude number approaches 1 and resistance to flow decreases as a result of bed forms changing from dunes to plane beds. Because of the decreased resistance, velocity will increase and hydraulic radius will decrease at a constant discharge. The hydraulic radius versus velocity and hydraulic radius versus discharge plots will shift to the right when this occurs, while the velocity versus discharge plot will shift upwards.

One would expect to see that same phenomenon on Black Mesa. Channel gradients on the leasehold are steep (typically around one percent), which causes high velocities and promotes supercritical flow.

The plots in Attachment 3 generally show considerable scatter as do the ones presented by Dawdy (1961) and Leopold and Maddock (1953). Some of the scatter is probably due to the fact that the measurements were not all taken at the exact same cross section. Measurement locations varied due to access difficulties (particularly at Sites 35 and 85), site locations being changed, such as 37 and 78, and unfavorable hydraulics in a particular spot at low flows. Simons and Richardson (1962) demonstrated in flume experiments another possible source of scatter. They found that if the discharge changes faster than the bed forms can adjust to the new flow regime, the depth:discharge ratio at the same discharge can be different on the rising and falling limbs of the hydrograph. This is due to different residual roughness conditions when the flow is rising and falling. A small amount of the scatter may also be caused by measurement error.

Even with the scatter, a distinct discontinuity can be seen in the hydraulic radius versus velocity plots for Sites 37 and 26. At Site 37, the discontinuity is also clearly evident in the velocity versus discharge plot. A discontinuity may be present in the hydraulic radius versus discharge relationship at Site 37, but, if so, it is much less distinct. At Site 26, the discontinuity is not evident in the hydraulic radius versus discharge plot. Too much scatter exists in the velocity versus discharge plot for Site 26 to show a clear trend. Possible discontinuities occur in the hydraulic radius versus velocity and hydraulic radius versus discharge plots for Sites 85 and 157. However, Site 85 only has two points defining the upper range, and Site 157 has a wide scatter.

Several of the plots appear to form a concave-upwards curve. These include the hydraulic radius versus velocity and hydraulic radius versus discharge plots at Site 25 and the velocity versus discharge plots at Sites 78 and 157. These might actually be discontinuities when more points are measured, or they might just signify a change in slope in the relationships as the flow regime changes.

At Site 16, the hydraulic radius versus velocity plot clearly shows a reverse discontinuity. At an average velocity of about 4 fps, the hydraulic radius increases while the velocity remains the same or decreases slightly. An increase in roughness is necessary to explain such a jump in the graph. The channel thalweg being against the side of a bend at this monitoring point might be a possible explanation. Many of the plots form relatively straight lines on the logarithmic scale, which means that the parameters can be related by simple power functions. This type of relationship also occurred on the rivers investigated by Leopold and Maddock (1953).

Channel Transmission Losses. The fact that channel transmission losses (losses to streamflow from water seeping into the alluvium) occur on Black Mesa is known from water level rises in Peabody's alluvial monitoring wells during and after streamflows, and also from observed downstream decreases in individual flow volumes. Channel transmission losses provide recharge to the alluvial aquifer, and reduction in flood peaks and volumes.

The effect of transmission losses on streamflow volumes and peaks has been estimated for the major washes on the leasehold using a technique developed by Lane (1983). The method is based on regression analyses of streamflow data, including data from southern and central Arizona. In the absence of up and downstream flow data, the method takes as inputs the reach length, and an average inflow volume, inflow peak, duration, channel width and hydraulic conductivity. The result is equations relating inflow volumes and peaks to predicted outflow volumes and peaks. The difference between inflow and outflow volumes is transmission loss.

As with any technique that attempts to predict natural phenomena, certain simplifying assumptions have been made. The principal assumptions are: that an average infiltration rate, width, and duration are representative of the entire reach; and outflow volumes and peaks are linear with inflow volumes and peaks, once a threshold volume is satisfied and channel storage effects are insignificant.

Table 12 lists the predictive regression equations for each major wash on the leasehold, and the input parameters from which they were derived. All equations are for the case where there is no lateral inflow along the reach. The average durations and inflow peaks at Sites 15, 16, 35 and 50 were taken from Tables 13 and 13a. The average inflow volumes at these sites were computed by digitizing continuously recorded hydrograph volumes. Average peak discharges were determined from slope area and current meter measurements. Mean flow durations were determined by extending flow recessions and measuring hydrograph bases. Average inflow volumes, flow durations and peak discharges for other channel reaches were determined from regression plots of watershed area versus mean flow volumes, mean peak discharges and mean flow durations. Where watershed areas deviated significantly from those upon which the regression plots were developed, "hydrologic judgment" was used in determining the above-referenced parameters.

Average widths were based on active channel widths and on cross section surveys near stream monitoring sites. Hydraulic conductivities were estimated from particle-size analyses of channel bed material and an empirical table compiled by Lane (1983, p. 19-5).

It is easier to make comparisons between the washes when the equations are graphed as in Figure 27. With no lateral inflows, a certain threshold input volume, P_o, is needed for a flow to reach the downstream end of the reach. This threshold volume for each reach is the X intercept of the estimated regression line for the reach in Figure 27. The slope of the line reflects the loss rate once this threshold volume is satisfied.

As we can see in Figure 27, Moenkopi Wash has the largest estimated threshold volume and the flattest estimated regression slope of the major washes excepting upper Coal Mine Wash. Upper Coal Mine Wash is significantly affected by artificial controls (haul road and access road crossings) which account for its flow behavior. The large threshold volume in Moenkopi Wash is principally due to the length of the selected reach, which was

TABLE 12

Transmission Loss Equations and Input Parameters for the Major Washes on the Leasehold

Wash	Reach	Input Parameters P (AF)	p (cfs)	D (hrs)	X (mi)	W (ft)	K (in/hr)	Po (AF)	Regression Equations	Predicted Outflows for Average Input Volume and Peak Q AF	q cfs
Yellow Water	Site 50 to Site 15	35	282	4.6	5.4	35	1.5	6.8	$Q = -5.4 + .80P$ $q = -14.2 - 2.1P + .80p$	23	138
Coal Mine	Site 16 to Site 18	9.8	195	4.7	5.7	50	2	29	$Q = -5.8 + .20P$ $q = -14.9 - 2.1P + .20p$	0	0
Coal Mine	Confluence with Yellow Water to Site 25	7	65	6.2	6.2	45	1.5	15	$Q = -9.9 + .67P$ $q = -19.3 - .64P + .67p$	0	0
Moenkopi	Site 35 to Site 26	22	218	3.4	14.4	40	2	32	$Q = -11.2 + .35P$ $q = -3.6 - 2.3P + .35p$	0	0
Reed Valley	J-21 Haul Road Crossing to Site 37	2.5	60	1.0	2.3	15	1	.16	$Q = -.15 + .92P$ $q = -1.8 - .96P + .92p$	2.2	55
Red Peak Valley	Road Crossing Near Met. Site 12 to Site 14	2.5	60	1.0	4.0	35	2	1.9	$Q = -.96 + .51P$ $q = -11.6 - 5.9P + .51p$	.32	4.2

TABLE 12 (Cont.)

Transmission Loss Equations and Input Parameters for the Major Washes on the Leasehold

Wash	Reach	Input Parameters P (AF)	p (cfs)	D (hrs)	X (mi)	W (ft)	K (in/hr)	Po (AF)	Regression Equations	Predicted Outflows for Average Input Volume and Peak Q AF	q cfs
Yucca Flat and lower Red Peak Valley	Yucca Flat-Sagebrush Wash Confluence to Red Peak Valley - Moenkopi Wash Confluence	36	325	3.1	4.4	50	4	16	Q = -10.1 + .64P q = -39.4 - 1.4P + .64p	13	118
Dinnebito	Well 107 to Site 34	14	153	5.1	6.1	35	1	6.5	Q = -4.1 + .63P q = -9.7 - .88P + .63p	4.7	74

P = Average Inflow Volume
p = Average Inflow Peak
D = Average Flow Duration
X = Length of Reach
W = Average Width
K = Average Effective Hydraulic Conductivity

Po = Threshold Volume Necessary for Flow to Reach End of Reach
Q = Outflow Volume when P > Po
q = Outflow Peak When Q > 0

TABLE 13

Summary of Single Peak Hydrograph Parameters
for Summer and Fall Runoff Events

Site	Season[1]	N[2]	Peak Discharge (cfs) Mean	S.D.	Min.	Max.	Drainage Area (mi^2)	Mean Peak Discharge per mi^2	Time to Peak, Tp (mins.) Mean	S.D.	Min.	Max.	Flow Duration (hrs.) Mean	S.D.	Min.	Max.	Tp/Duration (%) Mean	S.D.	Min.	Max.	Flow Volumes (acre-feet) Mean	S.D.	Min.	Max.
15	Summer	14	67.3	90.6	4.2	325		1.55	28.9	17.2	5	60	3.99	1.98	1.5	9.08	16.2	14.5	2	50	8.22	14.63	.57	56.73
	Fall	3	2.2	0.8	1.2	2.8		0.05	67.7	54.1	33	130	3.35	2.31	0.83	5.38	44.7	33.2	14	80	.30	.14	.14	.40
	Total	17	55.8	85.6	1.2	325	43.4	1.29	35.7	28.9	5	130	3.88	1.98	0.83	9.08	21.2	20.8	2	80	6.82	13.55	.14	56.73
16	Summer	4	56.5	72.7	10	165		1.78	14.3	8.1	5	22	3.51	1.08	2.5	5	7.0	4.3	3	13	2.67	3.81	.16	8.33
	Fall	2	17.5	10.7	9.9	25		0.55	28.5	23.3	12	45	7.24	8.97	.9	13.58	14.0	11.3	6	22	3.44	4.37	.35	6.53
	Total	6	43.5	60.0	9.9	165	31.7	1.37	19.0	14.2	5	45	4.75	4.53	.9	13.58	9.3	7.1	3	22	2.92	3.56	.16	8.33
18	Summer	6	54.1	115.8	1.6	290		1.27	33.5	28.1	5	70	4.35	2.43	1	7.58	17.2	19.5	2	54	4.13	8.42	.08	21.26
	Fall	3	2.6	0.9	1.7	3.5		0.06	21.7	28.9	5	55	1.70	0.33	1.5	2.08	23.3	32.6	4	61	0.20	0.04	.16	.24
	Total	9	36.9	95.1	1.6	290	42.5	0.87	29.6	27.1	5	70	3.47	2.34	1	7.58	19.2	22.7	2	61	2.82	6.94	.08	21.26

TABLE 13 (Cont.)

Summary of Single Peak Hydrograph Parameters
for Summer and Fall Runoff Events

Site	Season[1]	N[2]	Peak Discharge (cfs)				Drainage Area (mi^2)	Mean Peak Discharge per mi^2	Time to Peak, Tp (mins.)				Flow Duration (hrs.)				Tp/Duration (%)				Flow Volumes (acre-feet)			
			Mean	S.D.	Min.	Max.			Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
35	Summer	10	313.2	587.1	18.5	1940		16.4	13.5	10.8	5	40	3.48	2.17	0.7	8	7	8	2	24	26.8	37.6	1.07	107.2
	Fall	1	N/A	N/A	15	15		N/A	N/A	N/A	25	25	N/A	N/A	1.75	1.75	N/A	N/A	24	24	N/A	N/A	1.3	1.3
	Total	11	286.0	564.2	15.	1940	19.1	15.0	14.5	10.8	5	40	3.32	2.13	0.7	8	23.2	50.8	2	24	24.5	36.5	1.07	107.2
50	Summer	16	276.8	416.0	5	1165		15.1	25.4	18.7	5	120	3.9	2.3	0.67	11.67	11.9	12.8	3	54	22.9	38.5	0.26	146.2
	Fall	4	23.8	28.0	3.7	64.7		1.3	13.5	8.1	5	24	4.7	5.5	1.08	12.8	7.5	3.3	3	11	14.1	26.9	0.44	54.4
	Total	20	226.2	384.1	3.7	1165	18.3	12.4	23.1	26.1	5	120	4.1	3.0	0.67	11.67	11.0	11.6	3	54	21.2	36.0	0.26	146.2

[1] Summer Flow Events correspond to the Time Period (June 30-Aug. 31, Variable Sept.).
Fall Flow Events correspond to the Time Period (Variable Sept.-Oct. 31).
[2] Number of Flow Hydrographs from 1981 through 1985, Excluding flows <1 cfs.

TABLE 13a

Summary of Multiple Peak Hydrograph Parameters
for Summer and Fall Runoff Events

Site	Season[1]	N[2]	Peak Discharge (cfs)				Drainage Area	Mean Peak Discharge	Time to Peak, Tp (mins.)				Flow Duration (hrs.)				Tp/Duration (%)				% of Multiple Peak Flows w/ More	Flow Volumes (acre-feet)			
			Mean	S.D.	Min.	Max.	(mi^2)	per mi^2	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Than Two Peaks	Mean	S.D.	Min.	Max.
15	Summer	12	86.4	155.0	3.5	530		1.99	81.7	100.7	10	310	6.56	2.73	3.5	12	21	22.6	3	70	25	6.81	12.22	.73	41.18
	Fall	2	16.6	16.2	5.1	28		0.38	410	268.7	220	600	21.84	13.91	12	31.67	31.5	0.7	31	32	50	5.56	.64	5.11	6.02
	Total	14	76.5	144.9	3.5	530	43.4	1.76	128.6	168.4	10	600	8.74	7.21	3.5	31.67	22.6	21.1	3	70	28.6	6.63	11.25	.73	41.18
16	Summer	20	285.1	745.2	19	3432		9.0	32.7	26.0	5	85	4.0	1.62	1.7	8.0	13.6	9.1	2	35	75	13.3	15.95	1.22	75.53
	Fall	5	15.3	21.4	2.3	52.6		0.48	52.8	32.1	10	84	7.61	3.71	3.58	11.5	11.0	4.1	4	14	40	3.89	7.21	0.13	16.76
	Total	25	231.1	672.1	2.3	3432	31.7	7.29	36.7	27.8	5	85	4.72	2.55	1.7	11.5	13.1	8.3	2	35	68	11.42	14.99	0.13	75.53
18	Summer	10	25.6	35.8	1.7	120		0.60	41.2	39.7	10	120	8.58	3.30	4.17	14.0	8.7	9.5	2	33	70	3.06	2.90	.26	9.46
	Fall	3	6.4	4.7	3.3	11.8		0.15	47.0	24.0	20	66	5.22	5.13	1.72	11.1	25.0	24.3	10	53	33	0.56	0.35	.27	.95
	Total	13	21.2	32.2	1.7	120	42.5	0.50	42.5	35.8	10	120	7.80	3.84	1.72	14.0	12.5	14.7	2	53	61.5	2.48	2.74	.26	9.46

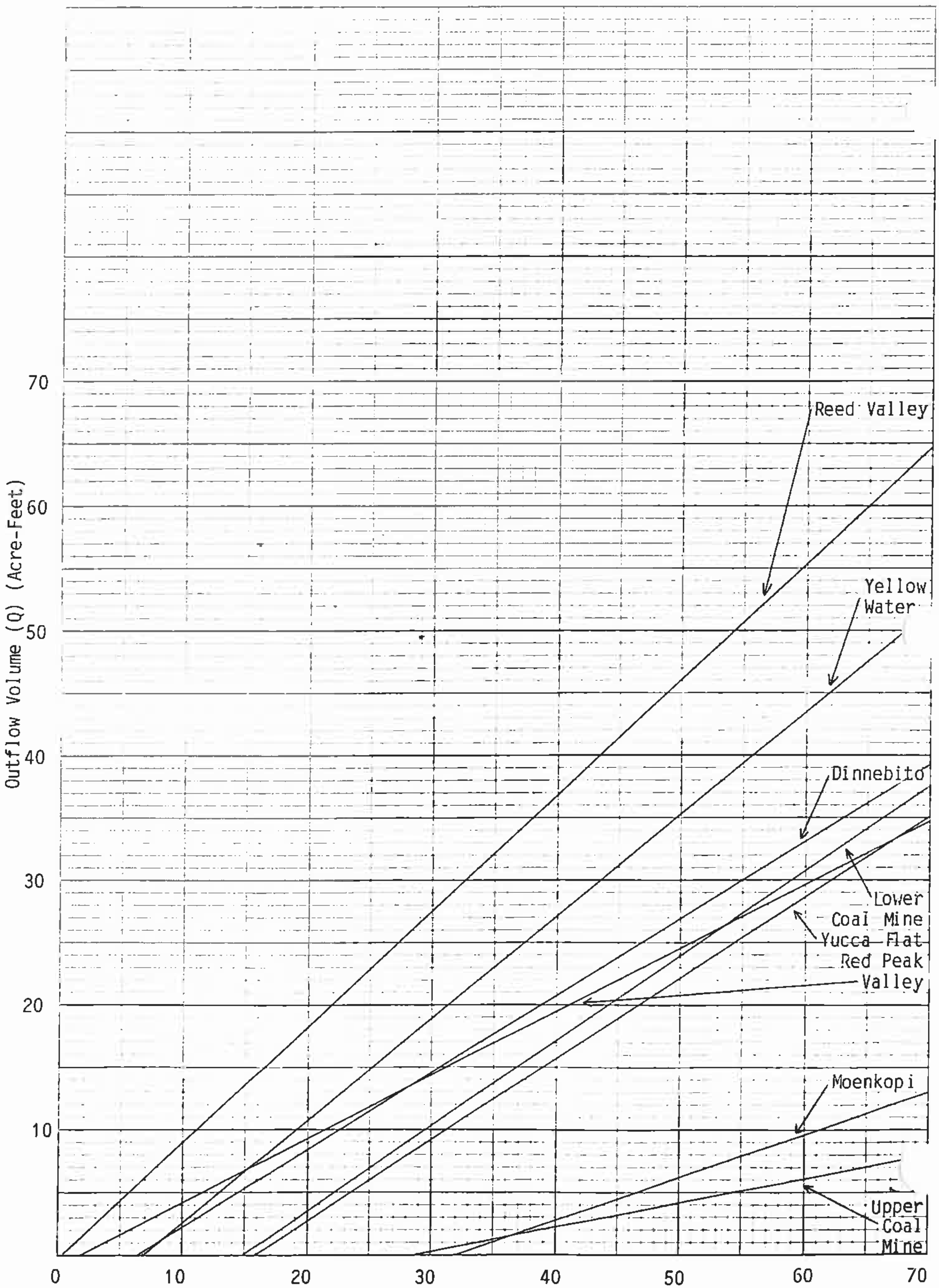
TABLE 13a (Cont.)

Summary of Multiple Peak Hydrograph Parameters
for Summer and Fall Runoff Events

			Peak Discharge (cfs)				Drainage Area	Mean Peak Discharge	Time to Peak, Tp (mins.)				Flow Duration (hrs.)				Tp/Duration (%)				% of Multiple Peak Flows w/ More	Flow Volumes (acre-feet)			
Site	Season[1]	N[2]	Mean	S.D.	Min.	Max.	(mi^2)	per mi^2	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Than Two Peaks	Mean	S.D.	Min.	Max.
35	Summer	15	172.8	185.5	40	773.7		9.05	27.9	20.3	5	70	3.17	1.12	1.8	6	15.1	9.3	3	30	26.7	20.4	27.7	2.1	112.9
	Fall	3	127.5	125.3	33	269.6		6.68	116.5	135.9	10	96	4.31	0.60	3.92	5	21.7	15.4	4	32	66.7	22.7	29.5	3.2	56.6
	Total	18	165.2	174.6	33	773.7	19.1	8.65	33.1	26.6	5	96	3.36	1.12	1.8	6	16.2	10.3	3	32	33.3	20.8	27.1	2.1	112.9
50	Summer	22	352.4	401.1	15.5	1576.5		19.3	39.5	36.8	5	140	4.49	1.65	0.5	7.08	15.1	11.3	2	33	45.5	43.2	44.3	1.84	158.4
	Fall	5	198.9	156.0	80	464.4		10.9	106.0	116.3	10	300	7.58	4.92	3.08	14.9	19.2	12.3	5	34	100	55.6	90.6	8.31	216.7
	Total	27	324.0	370.6	15.5	1576.5	18.3	17.7	51.9	62.2	5	300	5.06	2.72	0.5	14.9	15.9	11.4	2	34	55.6	45.5	53.6	1.84	216.7

[1]Summer Flow Events correspond to the Time Period (June 30-Aug. 31, Variable Sept.).
Fall Flow Events correspond to the Time Period (Variable Sept.-Oct. 31).
[2]Number of Flow Hydrographs from 1981 through 1985, excluding flows 1 cfs.

FIGURE 27. GRAPH OF TRANSMISSION LOSS EQUATIONS FROM TABLE 12



chosen to make use of stream monitoring data at sites 35 and 26. Another cause is the relatively low silt-clay content of the bed material in Moenkopi Wash which suggests a fairly high infiltration rate. Reed Valley, Yellow Water Canyon and Dinnebito Washes have large percentages of silt-clay in the bed material and thus the smallest predicted transmission losses. Although the absence of lateral inflows was not documented, flow volumes for same day storms were plotted for Sites 15 and 50 (Figure 27a). The regression plot indicates that even higher amounts of channel transmission loss are occurring than was calculated for the same two sites using Lane's techniques (Table 12 and Figure 27). The transmission loss plots in Figure 27 are conservative estimates.

Flow Hydrograph Analyses. Peabody has measured streamflow hydrographs since 1981 at five automated stream stations on the leasehold. The individual hydrographs are published in the quarterly and annual Hydrologic Data Reports. A statistical summary of hydrograph parameters are presented in Tables 13, 13a and 14. To assess any seasonal variability, Tables 13 and 13a include both summer and fall statistical summaries of runoff hydrograph parameters. Winter and early spring runoff events are usually minimal, because of the limited snowpack and low intensity precipitation events. For the period of record, only eleven winter and early spring runoff events of any significance have been recorded at the five automated station stilling wells (see Table 14).

Peak Discharges. The average peak discharges shown in Tables 13, 13a and 14 were obtained by calculating the mean of all peak discharges recorded at a stream monitoring site for a particular season. Any flows too small to register in the stilling wells were not considered for computing the average peak discharge.

Considering all recorded hydrographs, Sites 50 and 35 have the largest mean flow peaks of the five sites. The average flow peak at Site 16 is somewhat less, while peaks at Sites 15 and 18 tend to be considerably smaller than at the other sites. The large standard deviations for the peak flows indicate the great variability in flows that occur on the leasehold.

Precipitation in September and October is generated from frontal-type storms rather than the convective storms that occur in July and August. Rainfall intensities from the frontal storms tend to be less and durations tend to be larger. This is reflected to some degree in the flows. According to the statistics in Tables 13, 13a, the average flow peaks in September and October are slightly less than the overall average at Site 35 and considerably less at Sites 15, 16, 18 and 50.

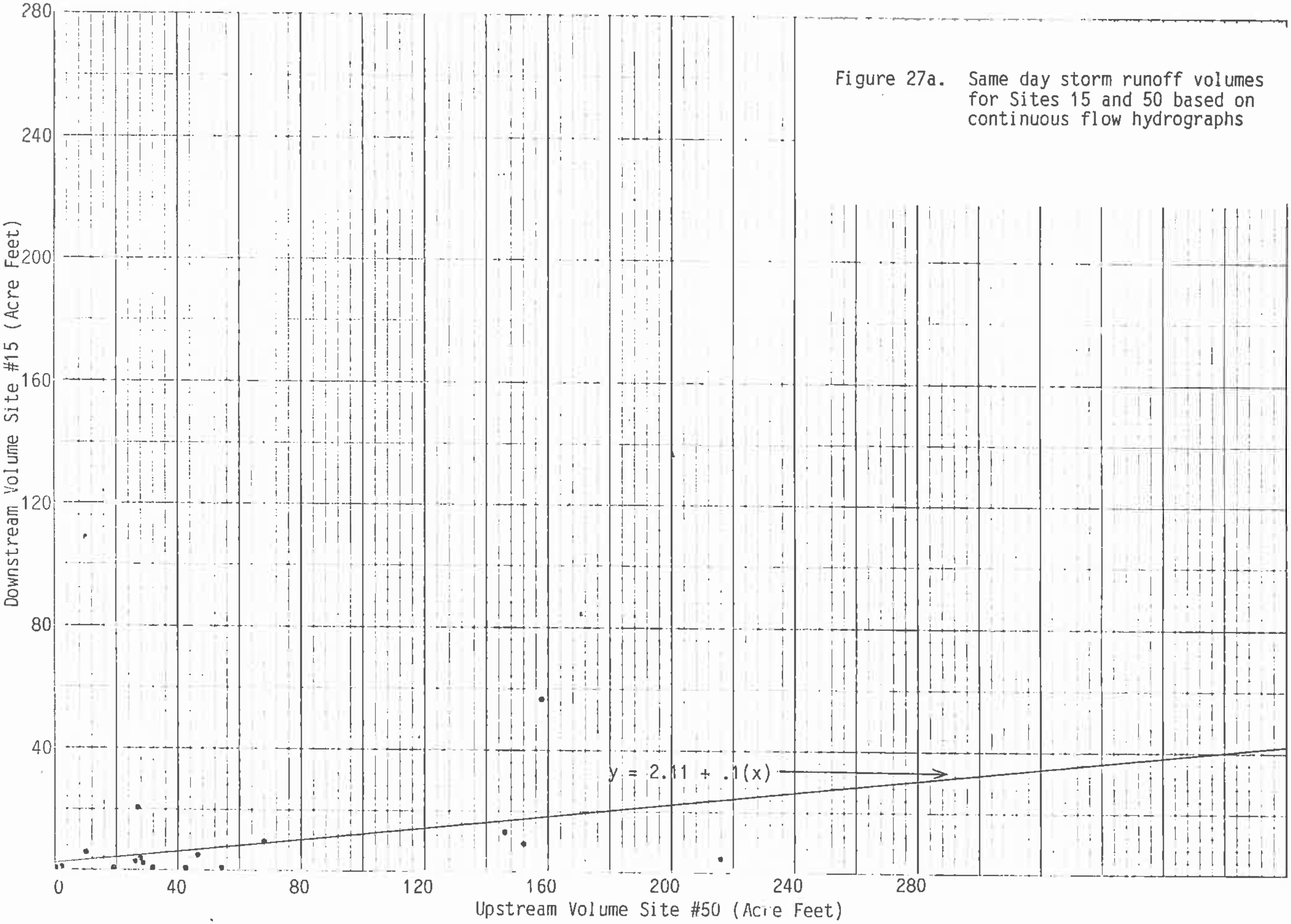


Figure 27a. Same day storm runoff volumes for Sites 15 and 50 based on continuous flow hydrographs

TABLE 14

Summary of Single and Multiple Peak Hydrograph
Parameters for Winter Runoff Events

			Peak Discharge (cfs)				Drainage Area	Mean Peak Discharge	Time to Peak, Tp (mins.)				Flow Duration (hrs.)				Tp/Duration (%)				% of Multiple Peak Flows w/ More Than Two Peaks	Flow Volumes (acre-feet)			
Site	Season	N	Mean	S.D.	Min.	Max.	(mi^2)	per mi^2	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.		Mean	S.D.	Min.	Max.
15	Winter	1	-	-	-	-	43.4	-	-	-	390	390	-	-	33.25	33.25	-	-	20	20	100	-	-	-	-
16	Winter	1	-	-	-	-	31.7	-	-	-	70	70	-	-	4.33	4.33	-	-	27	27	100	-	-	-	-
18	Winter	2	-	-	-	-	42.5	-	297.5	406.6	10	585	9.38	11.84	1.0	17.75	36	26.9	17	55	0	-	-	-	-
35	Winter	0	+	+	+	+	19.1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
50	Winter	7	77.05	10.69	63.3	93.4	18.3	4.21	87.1	70.2	6	186	7.77	3.67	3.33	13.0	25.6	24.8	1	65	57.1	35.33	26.08	15.37	72.94

\- Stage values were too low to convert to cfs.

\+ No flows have been recorded for this season at this site.

Both Tables 13 and 13a show large decreases in average peak discharges in a downstream direction on Coal Mine Wash between Sites 16 and 18 and on Yellow Water Wash between Sites 50 and 15. The decrease on Coal Mine Wash can be largely attributed to the N-5 culvert crossing which causes considerable backwater. Summer flow durations downstream at Site 18 are longer on the average than at the other sites as water stored behind the N-5 crossing is slowly released through the small culvert. That crossing is also the reason why suspended sediment concentrations are considerably lower at Site 18 than elsewhere on the lease. Much of the sediment settles out when the water is temporarily impounded behind the crossing.

Another factor contributing to the decreased peak flows at Sites 15 and 18 is channel transmission losses, magnified by reduced lateral inflows due to sediment ponds. Using estimation techniques developed by Lane (1983) (see Channel Transmission Losses), the average peak flow at Site 16 of 195 cfs would be reduced to a negligible volume because of channel transmission losses and backwater effects at the N-5 and main access road crossings.

The reasons for the large decrease in average peak discharge on Yellow Water Canyon Wash from Site 50 to Site 15 are more complex. Several factors contribute. Since 1981, 15 streamflows have been recorded at Site 15 but not Site 50, having originated in tributaries that enter downstream of Site 50. These flows were generally smaller than the average for Site 15, and thus reduced the size of the average peak somewhat.

However, there is also considerable attenuation of flow peaks that pass by both sites, as one can see in Table 15. The three possible causes of this are channel storage effects, channel transmission losses and flow computation errors. The BIA road crossing of Yellow Water Canyon Wash above Site 15 causes significant backwater until the flows overtop the road. This creates some excessive channel storage and probably reduces the peak somewhat, but the effect does not manifest itself in longer average flow duration at Site 15 as is the case at Site 18. Channel transmission losses can account for a significant portion of the decrease in flow peaks at Site 15. Using equations developed by Lane (1983), it is estimated that the average peak of 282 cfs at Site 50 would be reduced to 138 cfs at Site 15 by transmission losses. Intake pipes to the stilling wells at the flumes are sloped slightly and can result in 0.3 foot stage height errors and channel roughness coefficients can vary with flows. These factors can also contribute partly to the up- and downstream peak flow differences.

Times to Peak. The average times to peak discharge listed in Tables 13 and 13a are

TABLE 15

Comparison of Peak Flows Between Sites 15 and 50

For the Same Flow Dates in 1984

(1) Date	(2) Peak at Site 50 (cfs)	(3) Peak at Site 15 (cfs)	(4) Col.3/Col.2
7/28/84	146	4.2	.029
7/29/84	1050	530.0	.50
8/05/84	150	5.2	.035
8/19/84	210	7.2	.034
8/20/84	550	220.0	.40
8/21/84	154	62.0	.40
8/27/84	360	30.0	.083
9/16/84	425	5.0	.012

Average of Column (4) = .19

probably biased on the high side due to the time resolution of our stage recorders. Comparisons between recorded hydrographs and the clocks connected to our automated sampling equipment have shown that it is not uncommon for the time to peak to be as little as two or three minutes. The smallest time resolution obtainable from the Stevens F Model water level recorders used prior to 1984 was ten or twelve minutes, while the digital water level recorders used in 1984 and 1985 have five minute resolution. Values used to compute the averages were taken strictly from the Type F and digital recorder charts. Additionally, there often were one or more smaller spikes in the hydrograph, each with a steep rise, before the highest peak. If all of those cases were treated as separate flow events, the average times to peak would have been lower.

For single peak hydrographs, Sites 16 and 35 have the shortest times to peak for summer runoff events while Site 18 has the longest. Summer storm times to peak for Sites 15 and 50 are very similar. For fall storms, Site 50 has the shortest times to peak while Site 15 has the longest (approximately twice as long as at Sites 18 and 16). Sites 16 and 35 also have the shortest times to peak for summer runoff events with multiple flow peaks. Times to peak at Site 15 for these same flows were at least twice as long as those for the other automated stream sites. Sites 16 and 18 have the shortest times to peak for fall runoff events with multiple flow peaks. Sites 35 and 50 have very similar fall times to peak while Site 15 has a fall time to peak at least four times as long as at the other stream monitoring sites.

Flow Durations. The flow durations used for Tables 13, 13a and 14 are based on stilling well stage recordings. The actual flow durations were somewhat longer because the stage recorders are insensitive to the lowest flows and debris and sediment from the higher flows often fill a portion of the stilling basin preventing the stage recording from returning to zero.

The average flow duration considering all flows is the shortest at Site 35 and the longest at Sites 15 and 18. The other two sites are grouped together in the middle of the ranking.

For fall streamflows only, average flow durations are the longest at Site 15, increase at Sites 16 and 50, decrease at Site 18 and increase slightly at Site 35 in comparison to average flow durations considering all flows. The longer durations in September and October are probably a reflection of frontal storms; however, the variability is great. Nearly the full range of durations has occurred in September and October.

Times to Peak:Duration Ratio. The ratio of time to peak to flow duration is a measure of the hydrograph shape and is used in synthetic hydrograph techniques. The SCS considers a ratio of 20 percent as typical and uses that value for their dimensionless curvilinear unit hydrograph (SCS, 1972). The average ratios on Black Mesa for all flows, listed in Tables 13 and 13a, range from 9 to 23 percent. Average ratios for summer flow single peak hydrographs (Table 13) range from 7 to 17 percent. Summer, multiple peak hydrograph ratios were very similar to this percentage range.

For all fall streamflows, the ratios (time to peak:duration) range from 7.5 to 45 percent. Single peak fall hydrograph ratios had the same range; whereas, multiple peak fall hydrograph ratios fell within a tighter range of from 11 to 31.5 percent. The greatest mean fall ratios were at Site 15 and the smallest mean fall ratios were at Sites 16 and 50.

Multiple Peaks. Multiple hydrograph peaks occur in 29 to 68 percent of the recorded hydrographs at the five sites. This is another characteristic, in addition to short times to peak and small time to peak duration ratios, that is relatively unique about Black Mesa hydrology.

The multiple peaks are thought to be caused primarily by the localized nature, movement and varying intensity of the thunderstorms that cause runoff. Typically, a thunderstorm cell might move across the parallel upper tributaries of one of the watersheds, producing intense rain on only a small portion of the watershed at any one time and changing in intensity as it moves. This type of precipitation scenario can produce a surge of runoff from one area, lessen in intensity, move and then pour on another tributary producing a later surge.

The percentage of multiple peak flows occurring in the fall ranged from 33 to 100 percent. Increased percentages of multiple peak flows occurred at Sites 15, 35 and 50 and smaller percentages occurred at Sites 16 and 18 in comparison to summer flows. These percentages are based on flows with more than two peaks. The number of multiple peaks ranged from 2 to 6.

Flow Volumes. Flow volumes have been determined by digitizing continuously recorded hydrograph volumes at the 5 automated stream monitoring sites. Considering all flows, Sites 35 and 50 have the largest mean flow volumes. Mean flow volumes at Site 50 are at least 3.5 times larger than those at the other automated sites. Site 18 had the smallest mean flow volumes because of the road crossings discussed previously. For flows with single peaks, Sites 35 and 50 had the largest volumes. Summer single peak mean flow volumes were greater than mean fall volumes at all sites except Site 16. At this site the single peak mean flow volumes were similar for the two seasons. For flows with multiple peaks once again Sites 35 and 50 had the largest mean volumes and Site 18 the smallest. The multiple peak mean fall flow volumes were larger than the mean summer volumes at Sites 35 and 50, whereas they were smaller than the mean summer volumes at Sites 15, 16 and 18.

Peak Flow Estimates. Because of the cellular, localized nature of thunderstorms on the Black Mesa leasehold and adjacent rim area, it is virtually impossible to assign return periods to individual storms which generated peak flows. Rainfall intensities are so variable and storm durations and spatial distribution are so erratic that quantification of the precipitation input to respective flows is precluded. In lieu of this, peak flows generated from rainfall events of specified return periods and durations have been simulated using SEDIMOT II. The necessary assumptions and procedures are explained in the following discussion.

Estimates of peak flows resulting from 2, 5, 10, 25, 50 and 100-year return periods and 1, 2, 3, 6 and 24-hour duration precipitation events have been determined for the principal washes and tributaries on the Black Mesa leasehold. Estimates were calculated using the hydrology portion of the computer model Sedimot II, developed by the Department of Agricultural Engineering of the University of Kentucky in Lexington. Modeling techniques and input parameter determinations used for these peak flow estimates are documented in the Sedimot II Design Manual (Warner, et al. 1981, Wilson et al. 1981).

Return period precipitation depths for durations of 24 and 6 hours on Black Mesa were taken from precipitation maps found in "Hydrologic Design for Highway Drainage in Arizona" (Jencsok, 1968). These values were plotted on nomographs of precipitation versus return period, and corrected values were used to calculate return period precipitation depths for one-hour durations using the following relationships:

$$y_2 = -0.011 + 0.942(x_1^{\,2}/x_2)$$

$$y_{100} = 0.494 + 0.755$$

where,

y_2 = 2-year, 1-hour depth

y_{100} = 100-year, 1-hour depth

x_1 = 2-year, 6-hour depth

x_2 = 2-year, 24-hour depth

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x_3 = 100-year, 6-hour depth

x_4 = 100-year, 24-hour depth

The 2 and 100-year one-hour depths were then plotted on a precipitation versus return period nomograph to obtain 5, 10, 25 and 50-year return period depths for one-hour storm durations. Precipitation depths of 2, 5, 10, 25, 50 and 100-year return periods for two and three-hour durations were calculated using the following relationships:

$$\text{2-hour} = 0.341(x_1) + 0.659(x_2)$$

$$\text{3-hour} = 0.569(x_1) + 0.431(x_2)$$

where,

2-hour = 2-hour duration for a particular return period

3-hour = 3-hour duration for a particular return period

x_1 = 6-hour duration precipitation for a particular return period

x_2 = 1-hour duration precipitation for a particular return period

Two and three-hour duration precipitation depths were obtained by selecting previously determined one and six-hour values for a particular return period, and inserting them in the above equations to obtain depths for all recurrence intervals for two and three-hour durations. Point precipitation depths for all return periods for durations of 1, 2, 3 and 6-hours were corrected according to drainage areas. Depths for the 2, 5, 10, 25, 50 and 100-year return periods for durations of 1, 2, 3, 6 and 24-hours on Black Mesa can be found in Table 17. A Type II rainfall distribution was assumed in all peak flow calculations.

All six watersheds of the principal washes on Black Mesa (Red Peak, Yucca Flat, Yellow Water, Coal Mine, Dinnebito and Moenkopi) were subdivided into smaller watersheds and subwatersheds by locating junctions, branches and structures (Warner, et al. 1981) on 1:2000' scale maps. Yazzie Wash was included in the subdivision of Yellow Water Watershed, and Reed Valley Wash was included in the subdivision of Moenkopi Watershed. For purposes of illustration, the subdivision of Moenkopi Watershed is shown on Drawing No. 85700.

No smaller watershed or subwatershed created during the subdivision process exceeded 5,000 acres. Whenever possible, attempts were made to delineate subwatersheds of similar size. Multiple subwatersheds were created in significant tributaries to the main drainages such as in Yazzie and Reed Valley Washes.

A maximum of 15 junctions were created in the Moenkopi and Dinnebito watersheds, whereas only seven junctions were used for peak flow calculations in Red Peak. A maximum of two

TABLE 17

Summary of Precipitation Depths For

2, 5, 10, 25, 50 and 100-Year Return Periods For

1, 2, 3, 6 and 24-Hour Durations on the Black Mesa Leasehold

Return			Duration		
Period	1-Hr	2-Hr	3-Hr	6-Hr	24-Hr
2-yr	.74	.85	.92	1.06	1.41
5-yr	1.03	1.16	1.24	1.40	1.81
10-yr	1.22	1.35	1.44	1.61	2.09
25-yr	1.50	1.64	1.73	1.90	2.40
50-yr	1.71	1.86	1.97	2.16	2.71
100-yr	1.95	2.11	2.21	2.41	3.01

branches per junction were used, and null structures were assigned to each branch to provide a mechanism for combining hydrographs.

Time of Concentration is defined as the time required for water to flow from the hydraulically most remote point to the watershed outlet (Wilson, et al. 1981). Several empirical formulas were investigated for their respective conservatism with regard to predicting times of concentration. Prakash (1983) shows that "Kirpich's" formula:

$$t_c = \frac{[11.9L^3]^{0.385}}{H}$$

where,

t_c = time of concentration (hr)

L = length of longest flowpath (mi)

and,

H = drainage relief (ft)

yields the smallest result of "tc" compared with the S.C.S. "upland" and Snyder's method for predicting "tc". After evaluating several methods for calculating "tc", and comparing results with P.C.C."s monitoring station hydrograph characteristics (relatively short times to peak indicating small times of concentration), Peabody selected Kirpich's formula for calculating "tc" as input to each subdivided watershed using Sedimot II. This formula yields relatively short times of concentrations for subdivided watersheds (5,000 acres), which is a conservative approach to empirical estimates of peak flows on Black Mesa.

Curve Numbers were selected by delineating vegetation boundaries on a 1:2000' scale map. Vegetation types (cover description) delineated on the map and in each watershed include pinyon-juniper, sagebrush grassland, oak-aspen and chained pinyon-juniper areas. Curve number values for these vegetation types were obtained from the Soil Conservation Service and will be published in the revised version of TR-55 during the first part of 1986. The land use typifying these vegetation classifications is range. Poor to fair hydrologic conditions and hydrologic soil group classifications no better than "C" were assumptions used to select conservative curve numbers. Table 18 lists curve number selections according to vegetation types (cover descriptions) that were used to calculate weighted curve numbers for each small watershed and subwatershed. From Table 18 it can be seen that curve number values ranged between 76 and 85. Final selection of vegetation boundaries on the 1:2000' scale map were determined from 1:1000' scale aerial photographs and by consulting with Peabody biologists.

TABLE 18

Curve Numbers for Delineated Vegetation Areas

Used in Sedimot II Peak Flow Analyses on Black Mesa

Cover Description	Hydrologic Condition	Soil Group	CN
Pinyon-Juniper (uplands)	Fair	C-D	80
Pinyon-Juniper (lowlands)	Poor	C	85
Sagebrush (uplands)	Fair	C-D	76
Sagebrush (lowlands)	Poor	C-D	82
Oak-Aspen	Fair	D	79
Pinyon-Juniper (chained)	Fair	C-D	85

Hydrograph routing between junctions was performed using Muskingum routing techniques. Muskingum "K" values were assumed to be equal to the travel time between junctions, which is the horizontal distance divided by the average velocity. Attempts were made to calculate average velocities for channels in all six main drainages using S.C.S. upland curves (SCS, 1972). However, comparing velocities determined from these curves with velocities actually measured at monitoring sites in the channels on the leasehold showed that measured velocities are consistently higher. Manning's equation can be used to estimate average velocities in the channels using surveyed cross section data. However, estimates of some of the input parameters to the Manning equation offered no advantages or additional resolution in computing typical flow velocities. Hence, average velocities used to estimate Muskingum "K" values were determined from current meter and indirect flow measurements made at monitoring sites on the Black Mesa leasehold since 1980.

An average velocity of ten feet per second was used to calculate Muskingum's "K" in the lower, main channels of all six watersheds. Four feet per second was selected as a representative average velocity for the upper, small channels at the headwaters of each watershed. A velocity of six feet per second was assigned to the intermediate channel reaches of each watershed.

Values for Muskingum "x" were determined using the following relationship:

$$x = \frac{.5Vw}{1.7 + Vw}$$

where,

x = Muskingum's x

Vw = average velocity (10f/s, 6 f/s, 4 f/s)

In all cases, an agricultural unit hydrograph option was selected. The forest unit hydrograph option is not applicable on Black Mesa using Sedimot II, and peak flows were calculated assuming no mining disturbance, which eliminates using the disturbed unit hydrograph option. Tables 19a through 19f are input files for calculating peak flows in Moenkopi, Coal Mine, Yellow Water, Dinnebito, Red Peak and Yucca Flat Washes. All model inputs remained constant for each watershed for the range of storms modeled, with the exception of storm depths and durations. Card Code numbers and titles have been included in the Tables to provide identification of each row of numbers. Card Code input values for each watershed have been labeled with roman numerals that correspond to each watershed number. The reader should refer to the Sedimot II Users Guide (Wilson et al, 1981) for a more detailed explanation of each card code.

Tabl 1. Input Data for SEDIMOT II Moenkopi Wash Flow Analysis

```
MOENKOPI WASH PEAK FLOW ANALYSIS  (CC1)
      2        2  (CC2)
   3.01       24.       .1        1.  (CC3)
     15        1  (CC4)
      1        2        2        2        2  (CC5)
      2        2        2        2        2  (CC5)
      2        2        2        2        1  (CC5)
      1  (CC10)
     0.       0.       0.  (CC11)I
      1        1  (CC10)
    .19      .19      .39  (CC11)II
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .03      .03      .43  (CC11)III
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .09      .09      .43  (CC11)IV
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .21      .21      .43  (CC11)V
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .07     -.07      .43  (CC11)VI
     0.       0.       0.  (CC11)
      1        1  (CC10)
   -.11     -.11      .43  (CC11)VII
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .13     -.13      .43  (CC11)VIII
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .24      .24      .43  (CC11)IX
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .09      .09      .43  (CC11)X
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .29      .29      .43  (CC11)XI
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .44      .44      .43  (CC11)XII
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .32      .32      .43  (CC11)XIII
     0.       0.       0.  (CC11)
      1        1  (CC10)
    .44      .44      .43  (CC11)XIV
     0.       0.       0.  (CC11)
      1  (CC10)
     0.       0.       0.  (CC11)XV
      2        1        3        3        2  (CC12)I
 3824.0     79.7      .78      .49      .49      .39       1.       2.  (CC13)IA
 3121.9     79.5      .92       0.       0.       0.       1.       2.  (CC13)IB
      0        1        3        3        2  (CC12)II
      1        1        3        3        2  (CC12)
```

Ta[illegible] 19a(cont.). Input Data for SEDIMOT II Moenkop[illegible] Wash Peak Flow Analysis

15	79.7	.88	0.	0.	0.		2.	(CC13)II
0	1	3	3	2	(CC12)III			
1	1	3	3	2	(CC12)			
1628.9	79.3	1.18	0.	0.	0.	1.	2.	(CC13)III
0	1	3	3	2	(CC12)IV			
1	1	3	3	2	(CC12)			
1668.1	79.7	.80	0.	0.	0.	1.	2.	(CC13)IV
0	1	3	3	2	(CC12)V			
1	1	3	3	2	(CC12)			
2372.1	79.4	1.21	0.	0.	0.	1.	2.	(CC13)V
0	1	3	3	2	(CC12)VI			
2	1	3	3	2	(CC12)			
2681.1	79.7	1.25	.64	.64	.39	1.	2.	(CC13)VIA
2633.4	84.2	1.45	0.	0.	0.	1.	2.	(CC13)VIB
0	1	3	3	2	(CC12)VII			
1	1	3	3	2	(CC12)			
1748.9	79.4	.98	0.	0.	0.	1.	2.	(CC13)VII
0	1	3	3	2	(CC12)VIII			
2	1	3	3	2	(CC12)			
1607.5	78.4	1.08	.44	.44	.39	1.	2.	(CC13)VIIIA
1522.3	83.8	.81	0.	0.	0.	1.	2.	(CC13)VIIIB
0	1	3	3	2	(CC12)IX			
2	1	3	3	2	(CC12)			
2966.0	84.3	1.11	.18	.18	.43	1.	2.	(CC13)IXA
1887.1	84.5	.98	0.	0.	0.	1.	2.	(CC13)IXB
0	1	3	3	2	(CC12)X			
4	1	3	3	2	(CC12)			
1876.4	79.0	.88	1.28	1.28	.35	1.	2.	(CC13)XA
2861.3	77.7	1.10	.68	.68	.39	1.	2.	(CC13)XB
2240.0	84.3	.94	.33	.33	.43	1.	2.	(CC13)XC
1872.9	84.2	1.14	0.	0.	0.	1.	2.	(CC13)XD
0	1	3	3	2	(CC12)XI			
2	1	3	3	2	(CC12)			
1910.6	84.9	1.24	.29	.29	.39	1.	2.	(CC13)XIA
1943.5	84.5	.63	0.	0.	0.	1.	2.	(CC13)XIB
0	1	3	3	2	(CC12)XII			
1	1	3	3	2	(CC12)			
3630.4	83.4	1.42	0.	0.	0.	1.	2.	(CC13)XII
0	1	3	3	2	(CC12)XIII			
1	1	3	3	2	(CC12)			
1927.7	82.0	.87	0.	0.	0.	1.	2.	(CC13)XIII
0	1	3	3	2	(CC12)XIV			
1	1	3	3	2	(CC12)			
1625.6	82.0	1.08	0.	0.	0.	1.	2.	(CC13)XIV
0	1.	2	3	2	(CC12)XV			

************************************ END OF FILE ************************************

CARD CODE LEGEND

CARD CODE 1 - WATERSHED IDENTIFICATION CODE (CC1)
CARD CODE 2 - STORM TYPE (CC2)
CARD CODE 3 - STORM DATA (CC3)
CARD CODE 4 - NUMBER OF JUNCTIONS (CC4)
CARD CODE 5 - NUMBER OF BRANCHES/JUNCTIONS (CC5)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION (CC12)
CARD CODE 13 - SUBWATERSHED DATA (CC13)

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Tab b. Input Data for SEDIMOT II Coal Mine Wash Flow Analysis

```
COAL MINE WASH PEAK FLOW ANALYSIS   (CC1)
      2       2   (CC2)
   3.01     24.      .1      1.     (CC3)
     15       1   (CC4)
      1       2       2       2       2   (CC5)
      2       2       2       2       2   (CC5)
      2       2       2       2       1   (CC5)
      1   (CC10)
     0.      0.      0.   (CC11)I
      1       1   (CC10)
    .03     .03     .39   (CC11)II
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .19     .19     .39   (CC11)III
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .39     .39     .39   (CC11)IV
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .06     .06     .43   (CC11)V
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .22     .22     .43   (CC11)VI
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .14     .14     .43   (CC11)VII
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .26     .26     .43   (CC11)VIII
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .13     .13     .43   (CC11)IX
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .28     .28     .43   (CC11)X
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .62     .62     .43   (CC11)XI
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .08     .08     .43   (CC11)XII
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .28     .28     .43   (CC11)XIII
     0.      0.      0.   (CC11)
      1       1   (CC10)
    .43     .43     .43   (CC11)XIV
     0.      0.      0.   (CC11)
      1   (CC10)
     0.      0.      0.   (CC11)XV
      1       1       3       3       2   (CC12)I
 3491.0    79.1    1.14      0.      0.      0.      1.      2.   (CC13)I
      0       1       3       3       2   (CC12)II
      1       1       3       3       2   (CC12)
 3499.2    79.6    1.21      0.      0.      0.      1.      2.   (CC13)II
```

: 19b(cont.). Input Data for SEDIMOT II Coal Wash Peak Flow Analysis

0	1	3.	3	2	(CC12)III		
3	1	3	3	2	(CC12)		
2019.4	79.6	.88	1.00	1.00	.35	1.	2. (CC13)IIIA
1958.1	79.6	.92	.35	.35	.39	1.	2. (CC13)IIIB
1698.8	79.6	1.00	0.	0.	0.	1.	2. (CC13)IIIC
0	1	3	3	2	(CC12)IV		
1	1	3	3	2	(CC12)		
2220.9	79.6	.91	0.	0.	0.	1.	2. (CC13)IV
0	1	3	3	2	(CC12)V		
1	1	3	3	2	(CC12)		
1559.3	79.5	.82	0.	0.	0.	1.	2. (CC13)V
0	1	3	3	2	(CC12)VI		
1	1	3	3	2	(CC12)		
1814.4	79.3	.75	0.	0.	0.	1.	2. (CC13)VI
0	1	3	3	2	(CC12)VII		
1	1	3	3	2	(CC12)		
1989.3	84.6	.62	0.	0.	0.	1.	2. (CC13)VII
0	1	3	3	2	(CC12)VIII		
1	1	3	3	2	(CC12)		
2152.0	84.4	.89	0.	0.	0.	1.	2. (CC13)VIII
0	1	3	3	2	(CC12)IX		
1	1	3	3	2	(CC12)		
1792.9	84.7	1.04	0.	0.	0.	1.	2. (CC13)IX
0	1	3	3	2	(CC12)X		
1	1	3	3	2	(CC12)		
2289.5	84.4	.97	0.	0.	0.	1.	2. (CC13)X
0	1	3	3	2	(CC12)XI		
2	1	3	3	2	(CC12)		
1480.7	83.8	.76	.57	.57	.39	1.	2. (CC13)XIA
3154.2	83.7	1.27	0.	0.	0.	1.	2. (CC13)XIB
0	1	3	3	2	(CC12)XII		
1	1	3	3	2	(CC12)		
2184.7	84.3	1.09	0.	0.	0.	1.	2. (CC13)XII
0	1	3	3	2	(CC12)XIII		
3	1	3	3	2	(CC12)		
1770.1	85.0	.61	1.09	1.09	.35	1.	2. (CC13)XIIIA
2365.7	84.2	.78	.38	.38	.39	1.	2. (CC13)XIIIB
2585.2	82.1	1.11	0.	0.	0.	1.	2. (CC13)XIIIC
0	1	3	3	2	(CC12)XIV		
1	1	3	3	2	(CC12)		
3732.1	83.3	1.41	0.	0.	0.	1.	2. (CC13)XIV
0	1	2	3	2	(CC12)XV		

** END OF FILE ************************************

CARD CODE 1 - WATERSHED IDENTIFICATION CODE (CC1)
CARD CODE 2 - STORM TYPE (CC2)
CARD CODE 3 - STORM DATA (CC3)
CARD CODE 4 - NUMBER OF JUNCTIONS (CC4)
CARD CODE 5 - NUMBER OF BRANCHES/JUNCTIONS (CC5)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION (CC12)
CARD CODE 13 - SUBWATERSHED DATA (CC13)

Tab' 19c Input Data for SEDIMOT II Yellow Water Ca- -n Wash Peak Flow Analysis

```
YE      WATER CANYON PEAK FLOW ANALYSIS (CC1)
       2       2   (CC2)
    3.01     24.     .1       1.   (CC3)
       8       1   (CC4)
       1       2       2       2        2    (CC5)
       2       2       1   (CC5)
       1   (CC10)
      0.      0.      0.   (CC11)I
       1       1   (CC10)
     .04     .04     .39   (CC11)II
      0.      0.      0.   (CC11)
       1       1   (CC10)
     .17     .17     .43   (CC11)III
      0.      0.      0.   (CC11)
       1       1   (CC10)
     .28     .28     .43   (CC11)IV
      0.      0.      0.   (CC11)
       1       1   (CC10)
     .32     .32     .43   (CC11)V
      0.      0.      0.   (CC11)
       1       1   (CC10)
     .19     .19     .43   (CC11)VI
      0.      0.      0.   (CC11)
       1       1   (CC10)
     .46     .46     .43   (CC11)VII
      0.      0.      0.   (CC11)
       1   (CC10)
      0.      0.      0.   (CC11)VIII
       2       1       3       3        2   (CC12)I
  1378.0    80.3     .78     .63      .63     .35     1.     2.   (CC13)IA
  2487.3    80.8    1.08      0.       0.      0.     1.     2.   (CC13)IB
       0       1       3       3        2   (CC12)II
       1       1       3       3        2   (CC12)
  1803.1    80.5     .86      0.       0.      0.     1.     2.   (CC13)II
       0       1       3       3        2   (CC12)III
       3       1       3       3        2   (CC12)
  1934.8    79.6     .72    1.17     1.17     .39     1.     2.   (CC13)IIIA
  2135.2    79.6    1.17     .31      .31     .39     1.     2.   (CC13)IIIB
  1939.9    79.6     .79      0.       0.      0.     1.     2.   (CC13)IIIC
       0       1       3       3        2   (CC12)IV
       1       1       3       3        2   (CC12)
  2052.8    79.4     .94      0.       0.      0.     1.     2.   (CC13)IV
       0       1       3       3        2   (CC12)V
       5       1       3       3        2   (CC12)
  2682.2    80.3     .94    1.95     1.95     .35     1.     2.   (CC13)VA
  1901.3    79.6     .69    1.11     1.11     .39     1.     2.   (CC13)VB
  2751.0    79.8     .98     .87      .87     .39     1.     2.   (CC13)VC
  2544.7    84.8     .60     .56      .56     .39     1.     2.   (CC13)VD
  3101.1    79.3     .85      0.       0.      0.     1.     2.   (CC13)VE
       0       1       3       3        2   (CC12)VI
       1       1       3       3        2   (CC12)
  1427.2    84.6     .54      0.       0.      0.     1.     2.   (CC13)VI
       0       1       3       3        2   (CC12)VII
       3       1       3       3        2   (CC12)
  3410.0    79.3     .95    1.21     1.21     .35     1.     2.   (CC13)VIIA
```


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. ..le 19c(cont.). Input Data for SEDIMOT II Yellow ..ater Canyon Wash Peak Flow Analysis

```
 4102.1     84.9     1.68      .88      .88      .39       1.        2.     (CC13)VIIB
 3563.9     83.7     1.38      0.       0.       0.        1.        2.     (CC13)VIIC
      0        1        2        3        2   (CC12)VIII
********************************************* END OF FILE ****************************************
CARD CODE  1 - WATERSHED IDENTIFICATION CODE  (CC1)
CARD CODE  2 - STORM TYPE (CC2)
CARD CODE  3 - STORM DATA (CC3)
CARD CODE  4 - NUMBER OF JUNCTIONS  (CC4)
CARD CODE  5 - NUMBER OF BRANCHES/JUNCTIONS  (CC5)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH  (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS  (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION  (CC12)
CARD CODE 13 - SUBWATERSHED DATA  (CC13)
```

Tab' ?d. Input Data for SEDIMOT II Dinnebito Wash : Flow Analysis

```
DINNEBITO WASH PEAK FLOW ANALYSIS (CC1)
        2         2   (CC2)
     3.01       24.     .1       1.    (CC3)
       15         1   (CC4)
        1         2      2       2       2    (CC5)
        2         2      2       2       2    (CC5)
        2         2      2       2       1    (CC5)
        1   (CC10)
       0.        0.     0.   (CC11)I
        1         1 (CC10)
      .03       .03    .39   (CC11)II
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .23       .23    .39   (CC11)III
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .22       .22    .39   (CC11)IV
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .18       .18    .43   (CC11)V
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .12       .12    .43   (CC11)VI
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .01       .01    .43   (CC11)VII
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .07       .07    .43   (CC11)VIII
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .15       .15    .43   (CC11) IX
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .13       .13    .43   (CC11)X
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .06       .06    .43   (CC11)XI
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .32       .32    .43   (CC11)XII
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .12       .12    .43   (CC11)XIII
       0.        0.     0.   (CC11)
        1         1  (CC10)
      .02       .02    .43   (CC11)XIV
       0.        0.     0.   (CC11)
        1   (CC10)
       0.        0.     0.   (CC11)XV
        1         1      3       3       2     (CC12)I
   3366.5      79.9   1.18      0.      0.      0.      1.      2.     (CC13)I
        0         1      3       3       2     (CC12)II
        1         1      3       3       2     (CC12)
   1650.8      79.5    .76      0.      0.      0.      1.      2.     (CC13)II
```

e 19d(cont.). Input Data for SEDIMOT II Dinne' Wash Peak Flow Analysis

```
      0         1       3       3       2   (CC12)III
      1         1       3       3       2   (CC12)
 2693.1      79.6    1.32      0.      0.       0.      1.      2.   (CC13)III
      0         1       3       3       2   (CC12)IV .
      1         1       3       3       2   (CC12)
 2850.6      79.7    1.21      0.      0.       0.      1.      2.   (CC13)IV
      0         1       3       3       2   (CC12)V
      1         1       3       3       2   (CC12)
 3121.5      79.7    1.68      0.      0.       0.      1.      2.   (CC13)V
      0         1       3       3       2   (CC12)VI
      1         1       3       3       2   (CC12)
 1490.9      79.4     .91      0.      0.       0.      1.      2.   (CC13)VI
      0         1       3       3       2   (CC12)VII
      1         1       3       3       2   (CC12)
 1589.3      84.1    1.02      0.      0.       0.      1.      2.   (CC13)VII
      0         1       3       3       2   (CC12)VIII
      1         1       3       3       2   (CC12)
 1139.8      83.7     .93      0.      0.       0.      1.      2.   (CC13)VIII
      0         1       3       3       2   (CC12)IX
      1         1       3       3       2   (CC12)
  887.1      83.5     .72      0.      0.       0.      1.      2.   (CC13)IX
      0         1       3       3       2   (CC12)X
      1         1       3       3       2   (CC12)
 1854.4      83.8     .63      0.      0.       0.      1.      2.   (CC13)X
      0         1       3       3       2   (CC12)XI
      1         1       3       3       2   (CC12)
  409.4      83.6     .53      0.      0.       0.      1.      2.   (CC13)XI
      0         1       3       3       2   (CC12)XII
      2         1       3       3       2   (CC12)
 2519.0      85.0     .85     .56     .56      .39      1.      2.   (CC13)XIIA
 3249.9      84.2     .97      0.      0.       0.      1.      2.   (CC13)XIIB
      0         1       3       3       2   (CC12)XIII
      1         1       3       3       2   (CC12)
 4585.0      84.6    1.47      0.      0.       0.      1.      2.   (CC13)XIII
      0         1       3       3       2   (CC12)XIV
      2         1       3       3       2   (CC12)
  824.9      84.5     .61     .17     .17      .43      1.      2.   (CC13)XIVA
 1342.2      84.4     .58      0.      0.       0.      1.      2.   (CC13)XIVB
      0         1       2       3       2   (CC12)XV
************************************************** END OF FILE **********************************
```

CARD CODE 1 - WATERSHED IDENTIFICATION CODE (CC1)
CARD CODE 2 - STORM TYPE (CC2)
CARD CODE 3 - STORM DATA (CC3)
CARD CODE 4 - NUMBER OF JUNCTIONS (CC4)
CARD CODE 5 - NUMBER OF BRANCHES/JUNCTIONS (CC5)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION (CC12)
CARD CODE 13 - SUBWATERSHED DATA (CC13)

Table 19e. Input Data for SEDIMOT II Red Peak Wash Peak Flow Analysis

```
     2       2     (CC2)
     1.     24.       1          1.   (CC3)
     8       1     (CC4)
     1       2        2       2        2      (CC5)
     2       2        1    (CC5)
     1   (CC10)
    0.      0.       0.    (CC11)I
     1       1     (CC10)
   .20     .20      .39    (CC11)II
    0.      0.       0.    (CC11)
     1       1     (CC10)
   .30     .30      .39    (CC11)III
    0.      0.       0.    (CC11)
     1       1     (CC10)
   .18     .18      .39    (CC11)IV
    0.      0.       0.    (CC11)
     1       1     (CC10)
   .23     .23      .43    (CC11)V
    0.      0.       0.    (CC11)
     1       1     (CC10)
   .25     .25      .43    (CC11)VI
    0.      0.       0.    (CC11)
     1       1     (CC10)
   .39     .39      .43    (CC11)VII
    0.      0.       0.    (CC11)
     1   (CC10)
    0.      0.       0.    (CC11)VIII
     1       1       3       3       2    (CC12)I
2033.2    78.5     .92      0.      0.      0.      1.      2.  (CC13)I
     0       1       3       3       2    (CC12)II
     1       1       3       3       2    (CC12)
1509.2    79.7     .69      0.      0.      0.      1.      2.  (CC13)II
     0       1       3       3       2    (CC12)III
     1       1       3       3       2    (CC12)
 998.9    84.6     .75      0.      0.      0.      1.      2.  (CC13)III
     0       1       3       3       2    (CC12)IV
     1       1       3       3       2    (CC12)
 931.7    84.6     .43      0.      0.      0.      1.      2.  (CC13)IV
     0       1       3       3       2    (CC12)V
     1       1       3       3       2    (CC12)
1691.9    84.5     .30      0.      0.      0.      1.      2.  (CC13)V
     0       1       3       3       2    (CC12)VI
     1       1       3       3       2    (CC12)
1950.0    83.0     .66      0.      0.      0.      1.      2.  (CC13)VI
     0       1       3       3       2    (CC12)VII
     1       1       3       3       2    (CC12)
1627.3    82.0    1.06      0.      0.      0.      1.      2.  (CC13)VII
     0       1       2       3       2    (CC12)VIII
********************************** END OF FILE **********************************
CARD CODE  1 - WATERSHED IDENTIFICATION CODE  (CC1)
CARD CODE  2 - STORM TYPE  (CC2)
CARD CODE  3 - STORM DATA  (CC3)
CARD CODE  4 - NUMBER OF JUNCTIONS  (CC4)
CARD CODE  5 - NUMBER OF BRANCHES/JUNCTIONS  (CC5)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH  (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS  (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION  (CC12)
CARD CODE 13 - SUBWATERSHED DATA  (CC13)
```


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Ta   19f. Input Data for SEDIMOT II Yucca Flat Wash   Flow Analysis

```
Yu     FLAT PEAK FLOW ANALYSIS    (CC1)
        2          2    (CC2)
     3.01        24.        .1         1.   (CC3)
        7          1    (CC4)
        1          2        2          2          2   (CC5)
        2          1    (CC5)
        1    (CC10)
       0.         0.         0.  (CC11)I
        1          1    (CC10)
      .26        .26        .39  (CC11)II
       0.         0.         0.  (CC11)
        1          1    (CC10)
      .34        .34        .39  (CC11)III
       0.         0.         0.  (CC11)
        1          1    (CC10)
      .16        .16        .43  (CC11)IV
       0.         0.         0.  (CC11)
        1          1    (CC10)
      .10        .10        .43  (CC11)V
       0.         0.         0.  (CC11)
        1          1    (CC10)
      .26        .26        .43  (CC11)VI
       0.         0.         0.  (CC11)
        1    (CC10)
       0.         0.         0.  (CC11)VII
        1          1          3          3          2   (CC12)I
   2741.3       79.7        .57         0.         0.        0.       1.        2.    (CC13)I
        0          1          3          3          2   (CC12)II
        1          1          3          3          2   (CC12)
   2521.6       79.1        .86         0.         0.        0.       1.        2.    (CC13)II
        0          1          3          3          2   (CC12)III
        1          1          3          3          2   (CC12)
   2904.1       83.7        .60         0.         0.        0.       1.        2.    (CC13)III
        0          1          3          3          2   (CC12)IV
        3          1          3          3          2   (CC12)
   2528.6       79.6        .55        .39        .39       .39       1.        2.    (CC13)IVA
   1738.3       78.1       1.31        .11        .11       .39       1.        2.    (CC13)IVB
   1962.7       83.7       1.23         0.         0.        0.       1.        2.    (CC13)IVC
        0          1          3          3          2   (CC12)V
        2          1          3          3          2   (CC12)
   1256.5       79.3        .67        .35        .35       .39       1.        2.    (CC13)VA
   1458.2       82.5        .76         0.         0.        0.       1.        2.    (CC13)VB
        0          1          3          3          2   (CC12)VI
        1          1          3          3          2   (CC12)
   1480.4       82.0        .86         0.         0.        0.       1.        2.    (CC13)VI
        0          1          2          3          2   (CC12)VII
****************************************************** END OF FILE ******************************
```

CARD CODE 1 - WATERSHED IDENTIFICATION CODE (CC1)
CARD CODE 2 - STORM TYPE (CC2)
CARD CODE 3 - STORM DATA (CC3)
CARD CODE 4 - NUMBER OF JUNCTIONS (CC4)
CARD CODE 5 - NUMBER OF BRANCHES/JUNCTIONS (CC5)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION (CC12)
CARD CODE 13 - SUBWATERSHED DATA (CC13)

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Peak discharges were taken as the highest discharge value for the runoff hydrograph calculated at the last junction in each major drainage. The peak discharges for each major drainage were summarized for all return periods and durations and can be found in Table 20.

The peak discharges predicted in each wash for each of the storm recurrence intervals are displayed graphically on Log-Log paper in Figures 28 through 33a. The two sets of data points represent predicted peak discharges and corresponding recurrence intervals for the 6- and 24-hour duration storms. Regression lines defining the relationship among each data point set have been calculated and are labeled on Figures 28 through 33a. Figure 33b is a graph of recurrence interval versus storm depths used in peak flow predictions for the 6- and 24-hour duration storms (see Table 17, Chapter 15). Regression lines for these two data point sets have been determined and are labeled on Figure 33b.

In Figures 28 through 33a, the peak discharge versus recurrence interval plots for the 6-hour duration storm show good similarity with the 24-hour duration storm plots. In each Figure, the 5-, 10- and 25-year recurrence interval points for both the 6- and 24-hour duration storms plot to the right of the regression lines. Also, the 2- and 100-year recurrence interval points plot to the left. In Figure 33b, the 5-, 10- and 25-year recurrence interval storm depths for both storm durations also plot to the right of the regression line, while the 2- and 100-year points plot to the left. The plot patterns in relation to the regression lines determined in Figure 28 through 33a are similar to the same relationship in Figure 33b. This similarity indicates that the relationship between predicted peak flows and recurrence intervals determined for each drainage is driven by the storm depth versus recurrence interval relationship.

A graph of drainage area versus predicted peak discharge is shown in Figure 34. Two groups of data plots were included in this figure, the 10-year, 24-hour peak discharges and the 100-year, 24-hour peak discharges for the six principal drainages. Regression lines defining each relationship have been determined and are labeled on Figure 34. The relationships indicate that increasing size of drainage basins are accompanied by a downstream increase in discharge.

USGS Sediment Monitoring. As part of their Black Mesa monitoring program, the USGS has established several suspended sediment and surface water quality sampling stations in and downstream of the mine site (Drawing Nos. 85630 and 85635). Suspended sediment sampling has mainly been done along Moenkopi Wash at Moenkopi. Single-stage sediment samplers, as

TABLE 20

Summary of Estimated Peak Flows (in C.F.S.)

For All Major Washes Within the Black Mesa Leasehold

		Coal Mine	Dinnebito	Red Peak	Yellow Water	Yucca Flat	Moenkopi
2-Yr	1-Hr	183	245	200	124	162	160
	2-Hr	480	509	304	372	336	430
	3-Hr	782	753	377	586	485	776
	6-Hr	1134	1062	487	1023	680	1248
	24-Hr	2198	2033	905	2152	1316	2641
5-Yr	1-Hr	819	973	651	750	770	815
	2-Hr	1448	1553	799	1389	1099	1474
	3-Hr	1960	1925	939	1802	1362	2174
	6-Hr	2483	2342	1135	2515	1715	2988
	24-Hr	4000	3767	1630	4291	2736	5170
10-Yr	1-Hr	1390	1610	1027	1468	1400	1486
	2-Hr	2153	2321	1224	2268	1775	2461
	3-Hr	2892	2827	1419	2799	2146	3430
	6-Hr	3546	3338	1603	3650	2510	4382
	24-Hr	5414	5180	2232	6058	3931	7366
25-Yr	1-Hr	2420	2807	1765	2697	2525	2877

TABLE 20 (Cont.)

Summary of Estimated Peak Flows (in C.F.S.)

For All Major Washes Within the Black Mesa Leasehold

		Coal Mine	Dinnebito	Red Peak	Yellow Water	Yucca Flat	Moenkopi
25-Yr	2-Hr	3517	3669	2012	3808	3033	4261
	3-Hr	4384	4351	2163	4523	3470	5558
	6-Hr	5064	4802	2408	5580	3821	6550
	24-Hr	7115	6918	2909	8156	5369	9989
50-Yr	1-Hr	3361	3864	2448	4047	3502	4111
	2-Hr	4644	4884	2637	5315	4161	5880
	3-Hr	5825	5737	2912	6230	4643	7423
	6-Hr	6627	6372	3080	7496	5167	8806
	24-Hr	8964	8692	3665	10,458	6831	12,747
100-Yr	1-Hr	4614	5195	3235	5465	4861	5760
	2-Hr	6086	6265	3409	7082	5451	7835
	3-Hr	7334	7267	3677	8105	6115	9601
	6-Hr	8151	8005	3743	9452	6598	11,044
	24-Hr	10,802	10,478	4438	12,860	8358	15,617

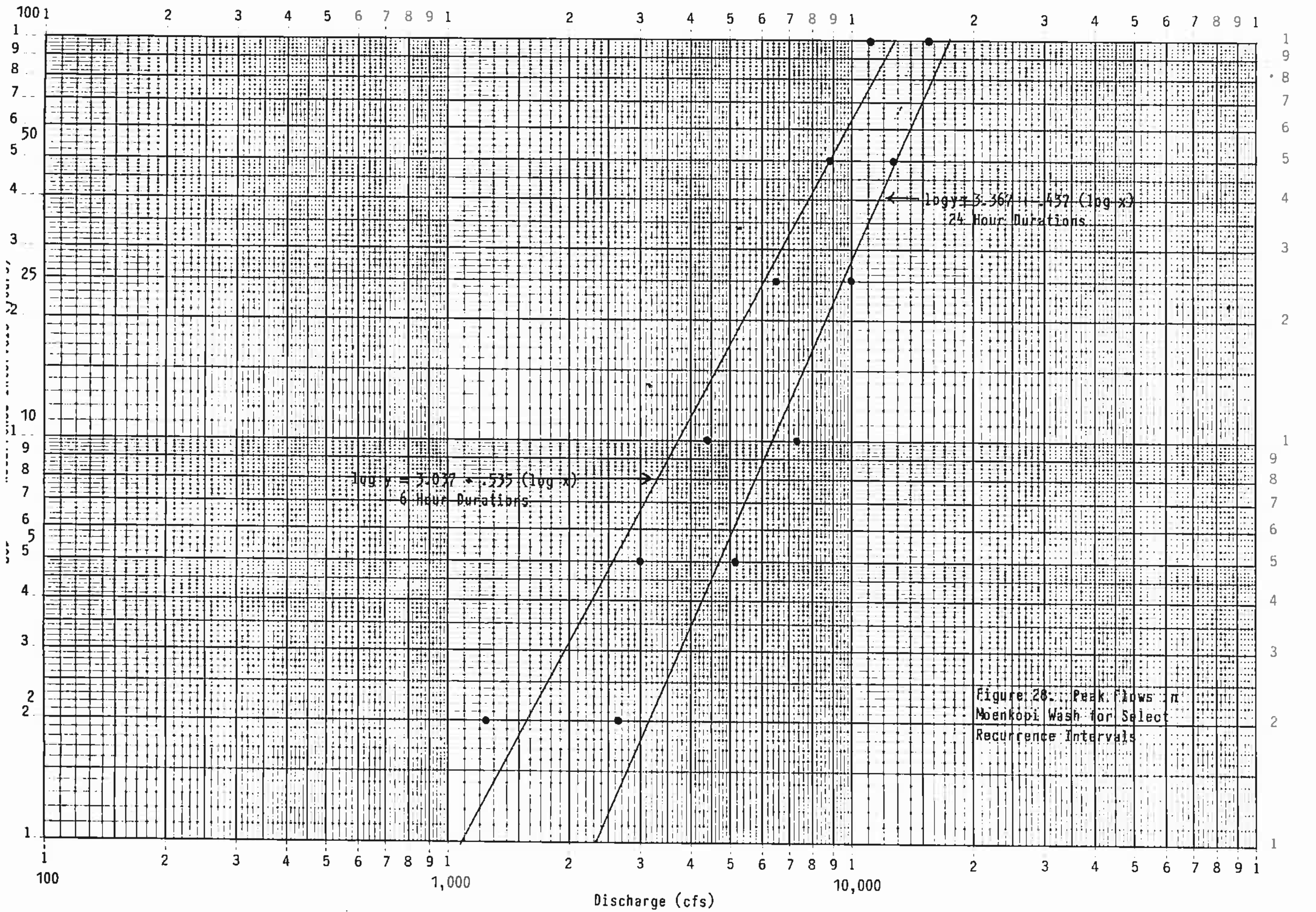


Figure 28. Peak Flows in Moenkopi Wash for Select Recurrence Intervals

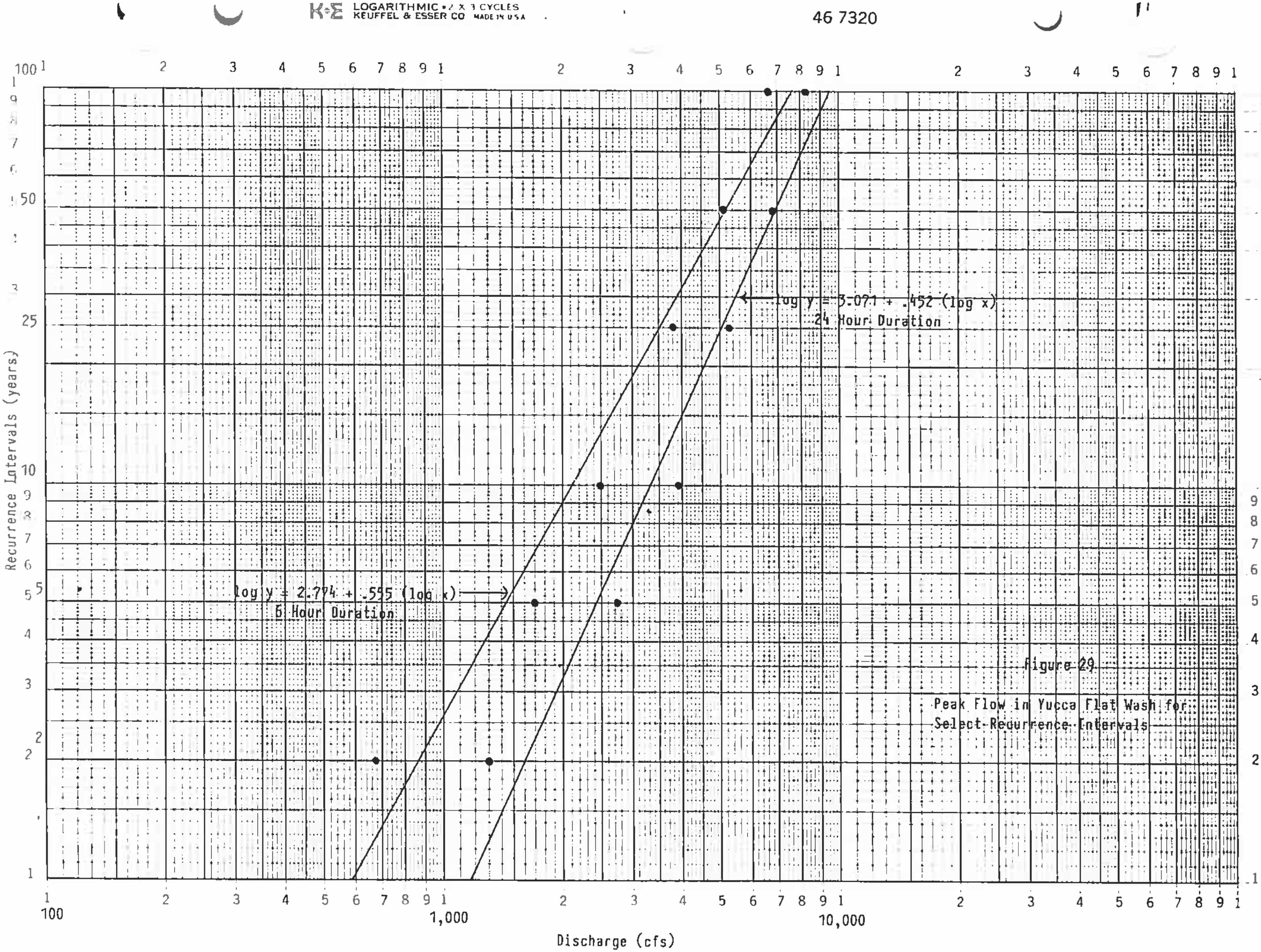


Figure 29

Peak Flow in Yucca Flat Wash for Select Recurrence Intervals

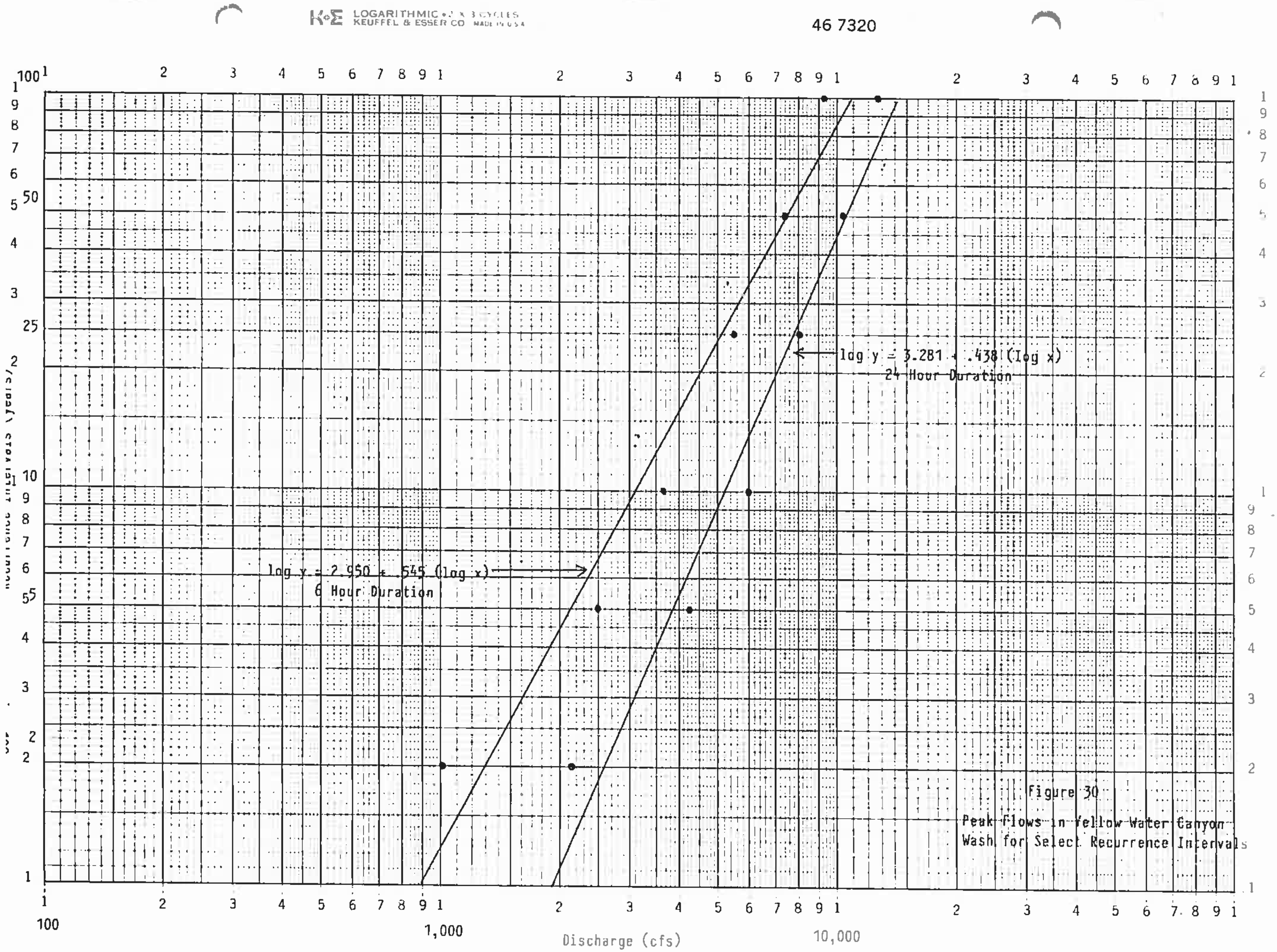


Figure 30

Peak Flows in Yellow Water Canyon Wash for Select Recurrence Intervals

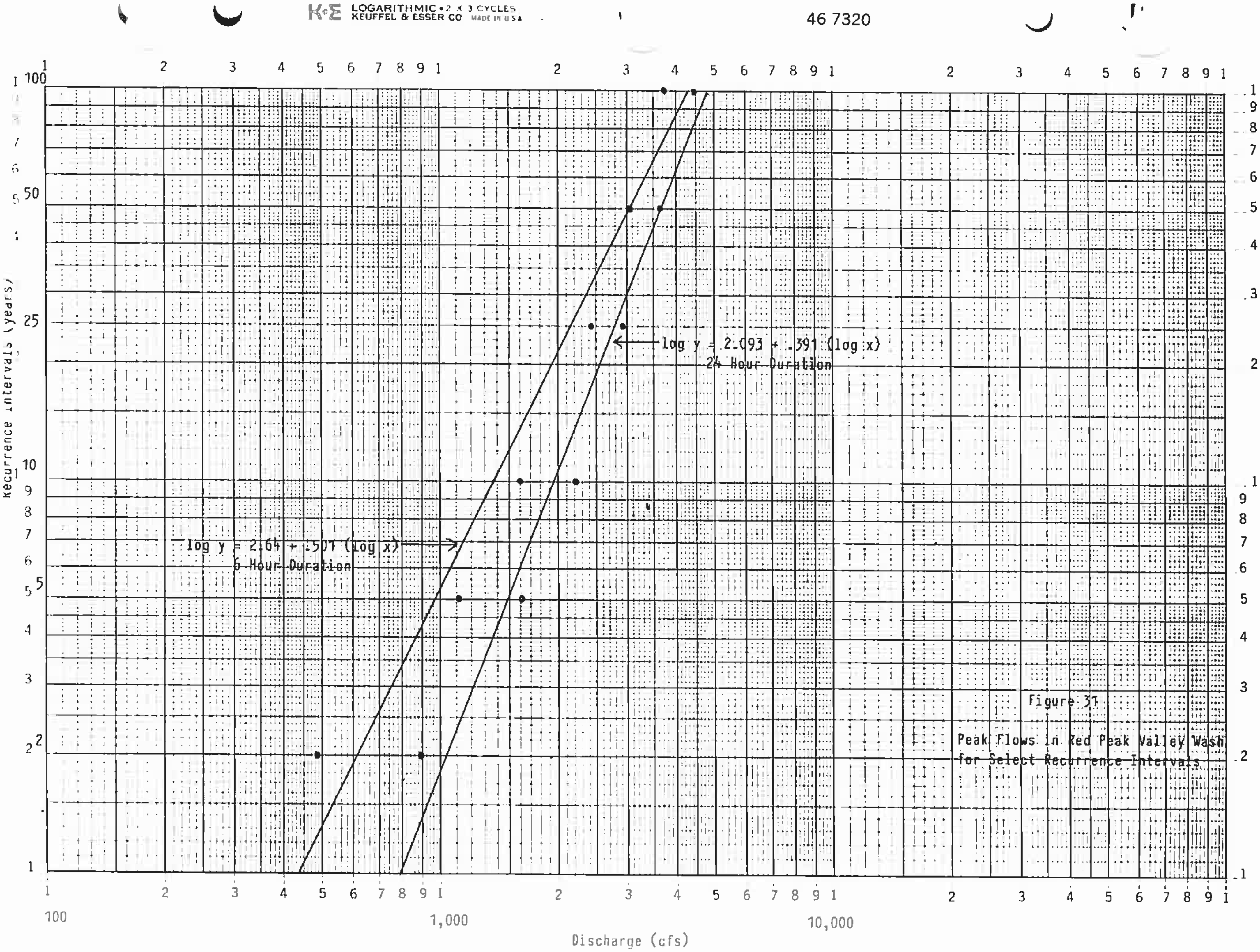


Figure 31

Peak Flows in Red Peak Valley Wash for Select Recurrence Intervals

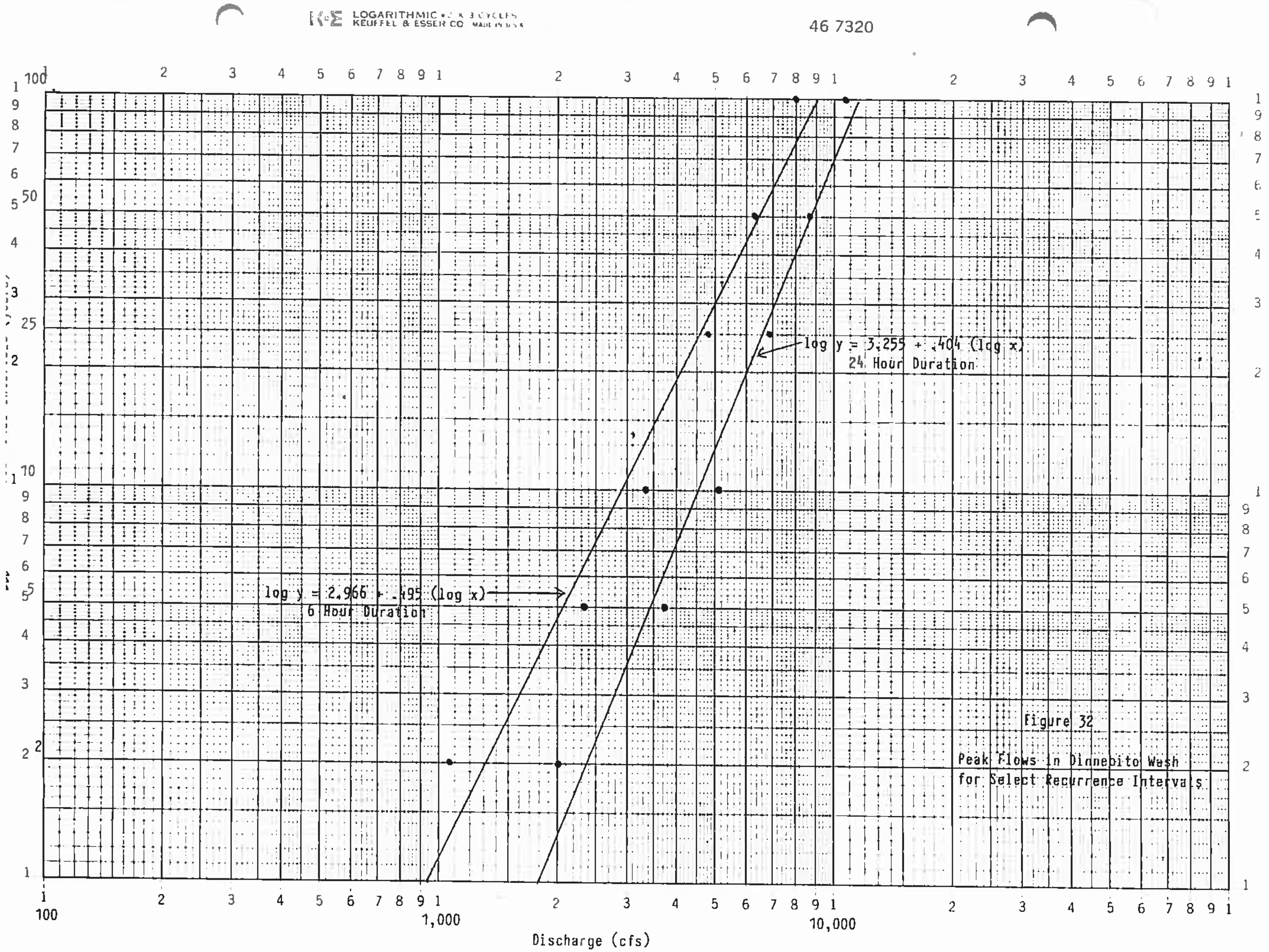


Figure 32

Peak Flows in Dinnebito Wash for Select Recurrence Intervals

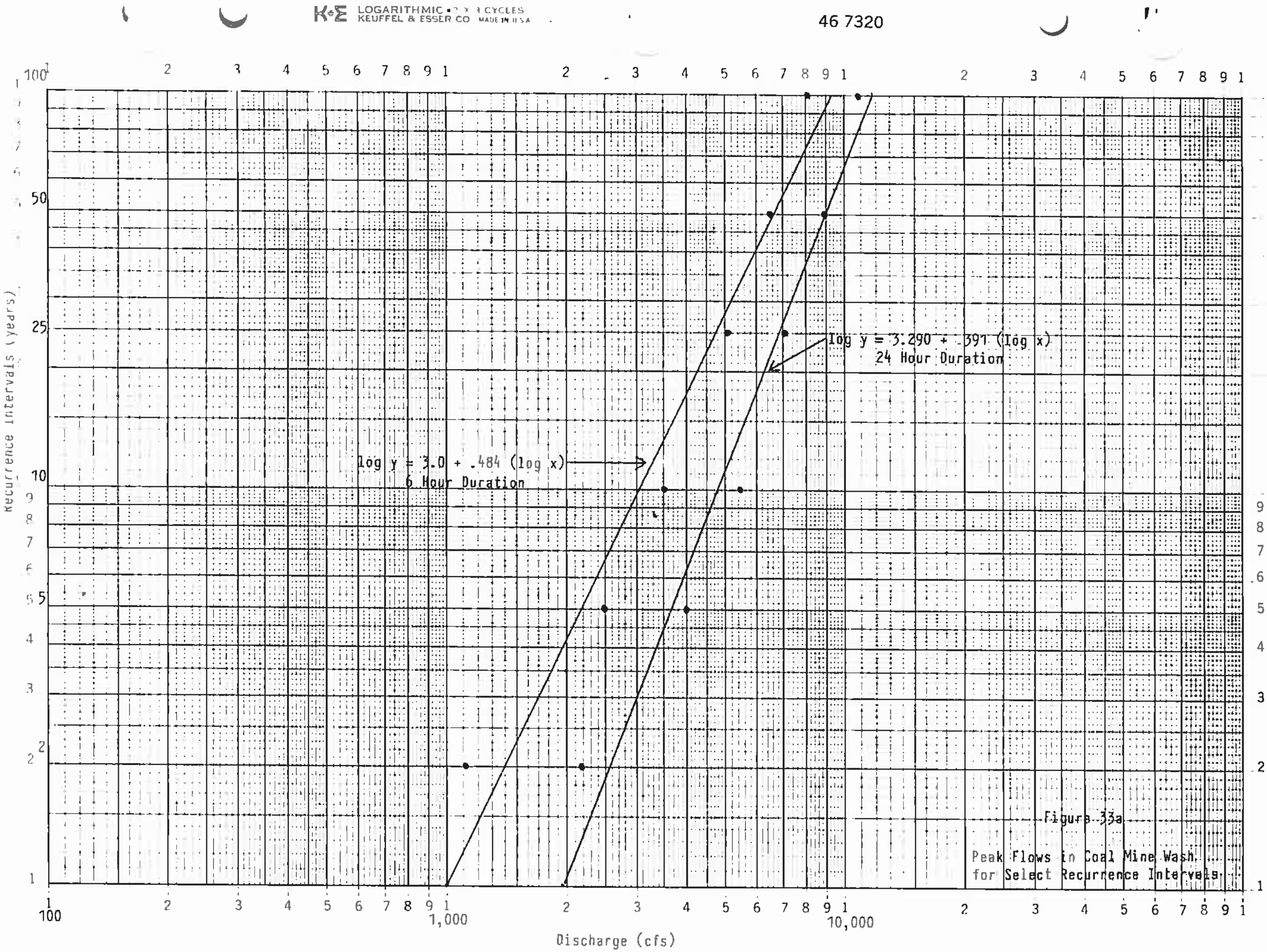


Figure 33a

Peak Flows in Coal Mine Wash for Select Recurrence Intervals

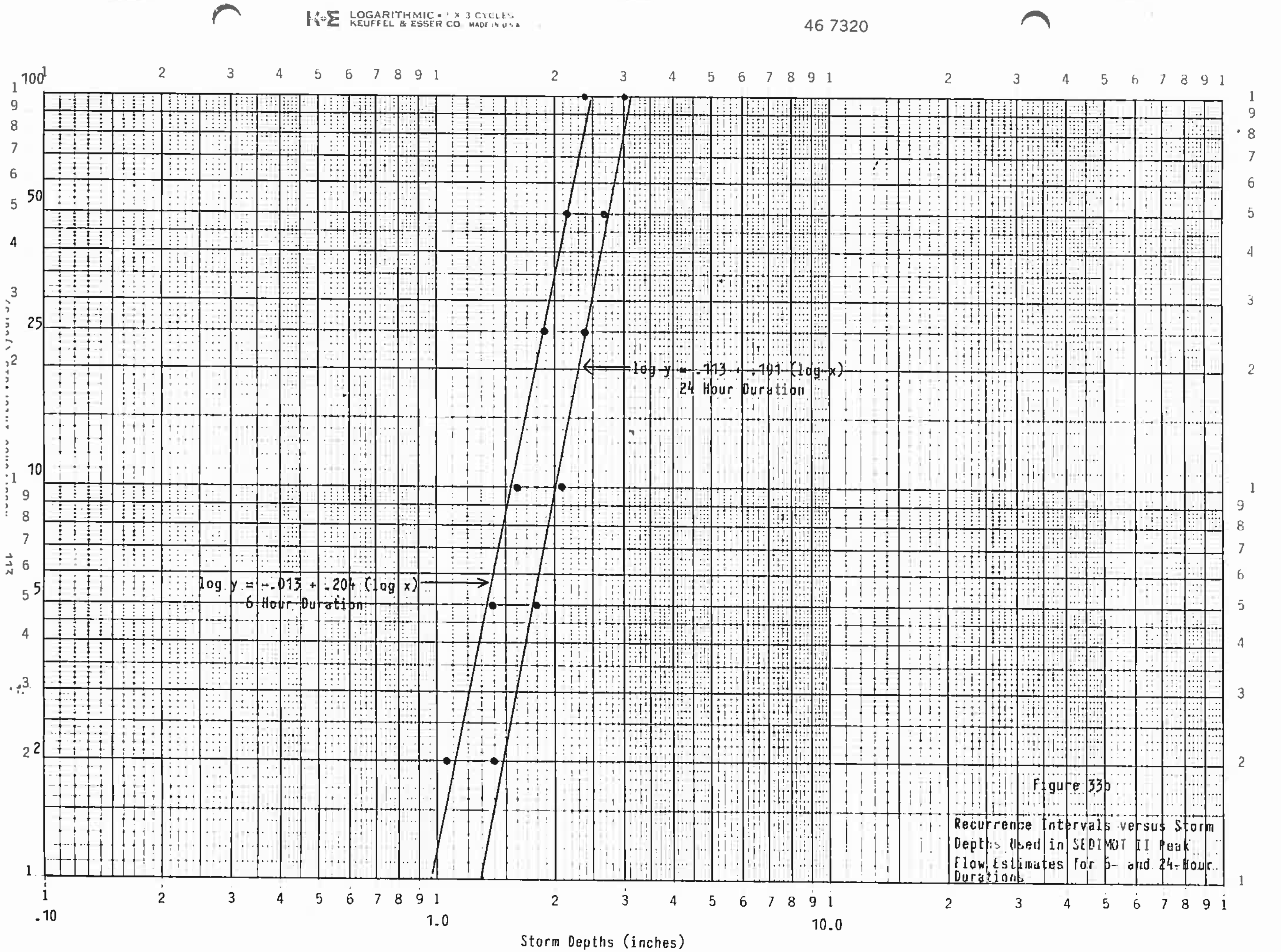
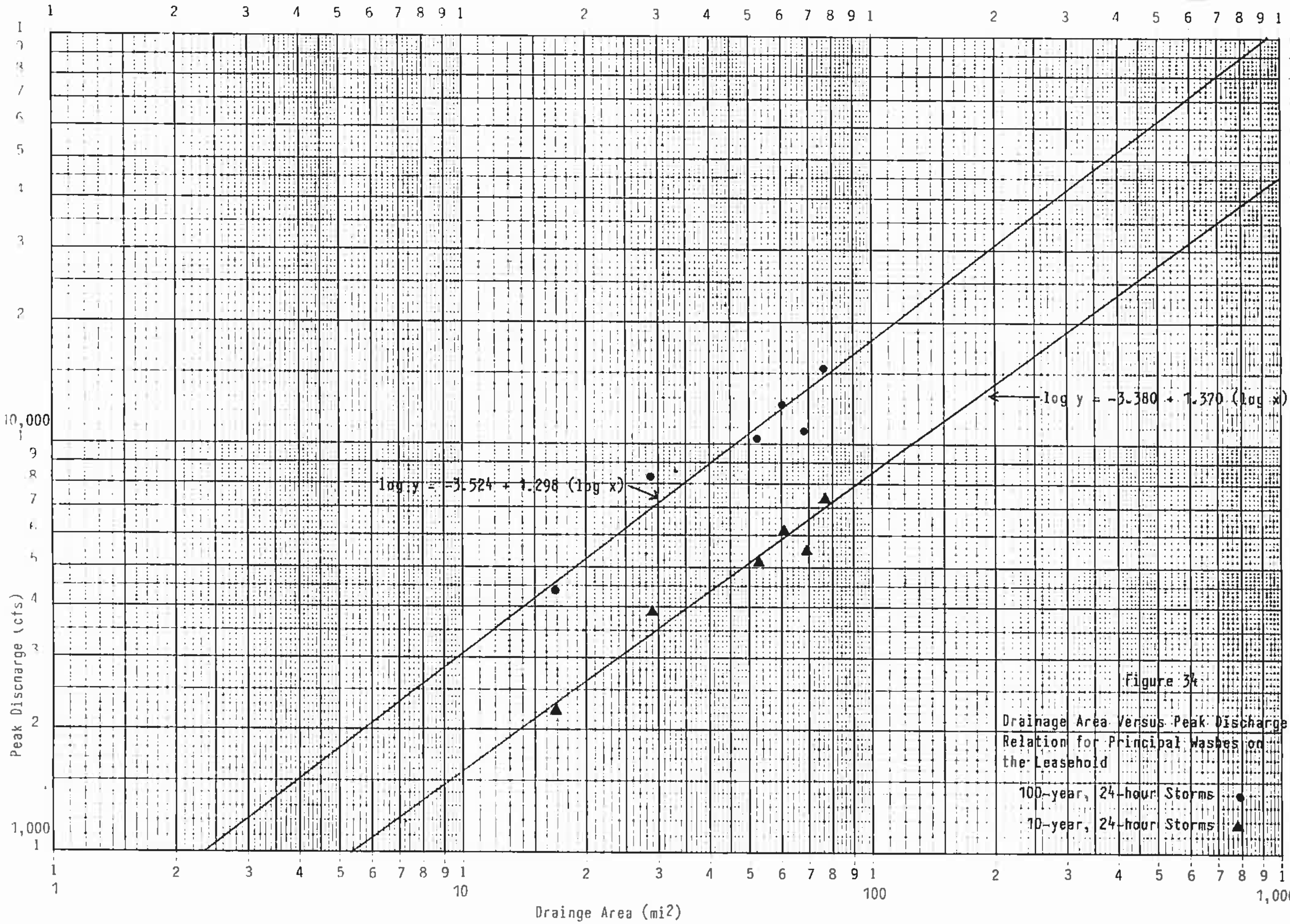


Figure 33b

Recurrence Intervals versus Storm Depths Used in SEDIMOT II Peak Flow Estimates for 6- and 24-Hour Durations


log y = -3.380 + 1.370 (log x)
log y = -3.524 + 1.298 (log x)
Figure 34
Drainage Area Versus Peak Discharge
Relation for Principal Washes on
the Leasehold
100-year, 24-hour Storms
10-year, 24-hour Storms
Peak Discharge (cfs)
10,000
1,000
Drainge Area (mi2)
1
10
100
1,000

well as automatic sediment samplers, have been installed on Yellow Water Canyon and Coal Mine Wash within the mine lease boundary. No results of analyses have been published excepting one flow on Coal Mine Wash tributary near Kayenta (Station 09401226), on September 25, 1976. Figure 35 presents a plot of suspended sediment concentration and stream stage versus time for the flow event. Suspended sediment data for Moenkopi Wash at Moenkopi during water years 1974-1980 are presented in Attachment 4. The maximum recorded sediment concentration and sediment load were 262,000 mg/l (milligrams per liter) and 1,600,000 tons/day, respectively. All of the major sediment yields appear to be the result of intense convective storms during the months of July, August and September.

Peabody Sediment Monitoring. Since 1980, suspended sediment monitoring has been conducted as part of the Peabody environmental monitoring program. Sediment samples have been obtained using four techniques and/or types of instrumentation. These are: (1) manual depth-integrated sampling; (2) single-stage sediment sampling; (3) automated sediment sampling with peristaltic pump samplers; and (4) grab sampling. Sixteen stream monitoring stations have been established at which one or a combination of the sediment sampling techniques or instrumentation are employed. At the remote stream monitoring stations, sediment samples are obtained using depth integration in those flows that are wadable, grab samples and single-stage sediment samplers. At the automated stations, all four types of sediment sampling are utilized. The following two sections discuss the results of the remote and automated station sediment sampling to date.

Remote Site Sediment Analyses. Of the sixteen stream monitoring sites, eleven were installed at remote locations and are monitored either manually or using single-stage samplers for sediment. Table 21 is a summary of the range of suspended sediment concentrations measured at each of the remote sites. Sites 150 and 151 are unique in that they are located off the leasehold near the coal silos. At present, they are the only two sites at which single-stage sediment samplers are used. A Revocable Use Permit was applied for with the Navajo Tribe in 1982 which would permit the installation of single-stage sediment samplers (stipulated by OSM Western Technical Center) at Stream Monitoring Sites 25, 26 and 155. Peabody has just recently been informed by the Navajo Tribe that the permit will be issued. These additional samplers will be installed at the above-mentioned sites during 1986.

Automated Site Sediment Analyses. Five stream monitoring sites (15, 16, 18, 35 and 50) have been equipped with automated peristaltic pump sediment samplers. Four of these

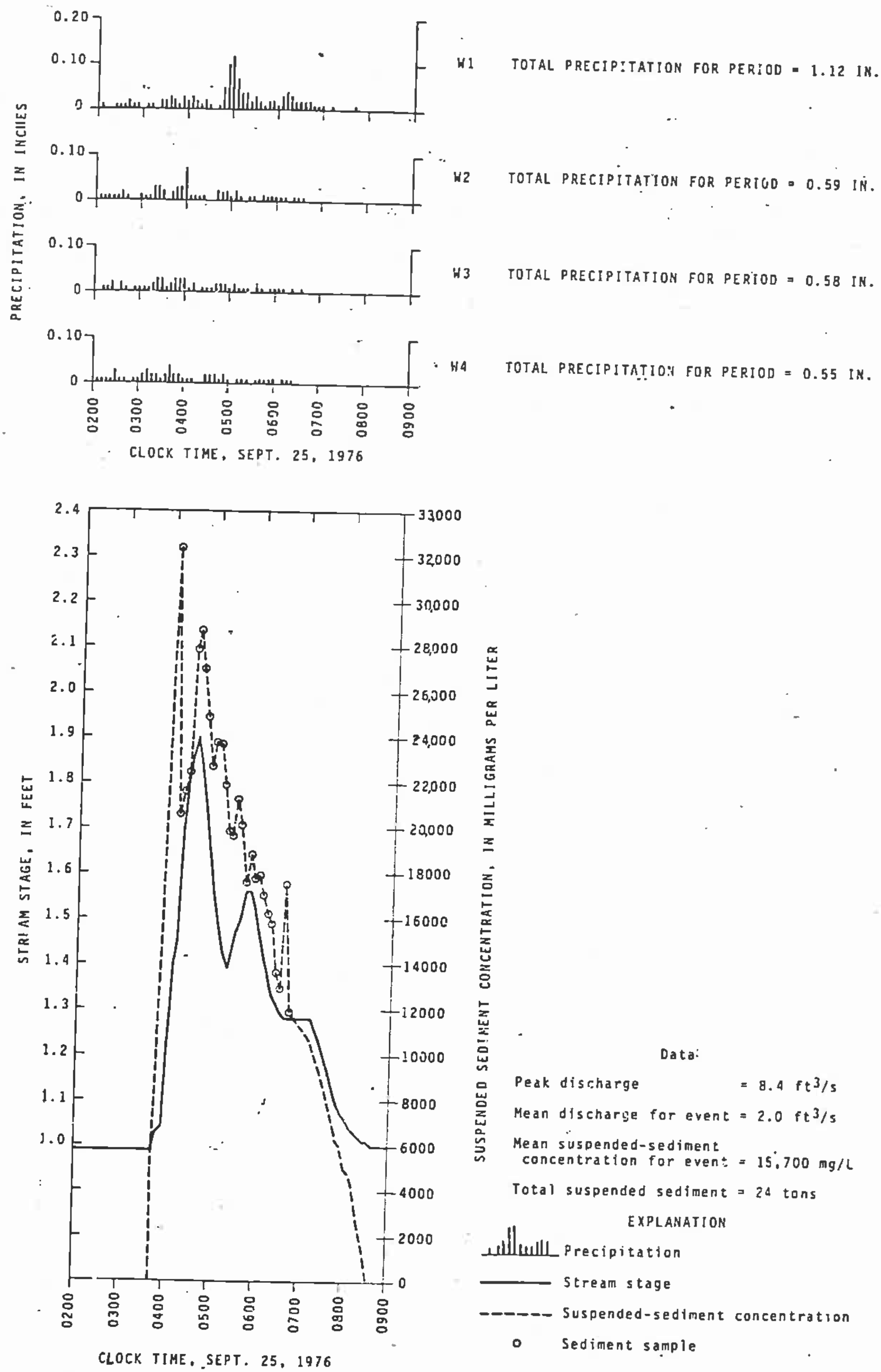


FIGURE 35

Suspended Sediment and Flow Stage Data for
Runoff Event at USGS Station 09401226,
Coal Mine Wash Tributary near Kayenta, Arizona

TABLE 21

Range of Suspended Sediment Concentrations Measured
At The Remote Stream Monitoring Stations

Stream Monitoring Site No.	Suspended Sediment Concentration Range (mg/l)
14	1 - 156,000
25	4 - 91,100
26	7 - 125,000
34	13 - 146,000
37	35 - 173,000
78	226 - 128,250
85	2,923 - 66,700
150	4,860 - 10,040
151	570 - 650
155	300 - 77,600
157	13,100 - 59,200

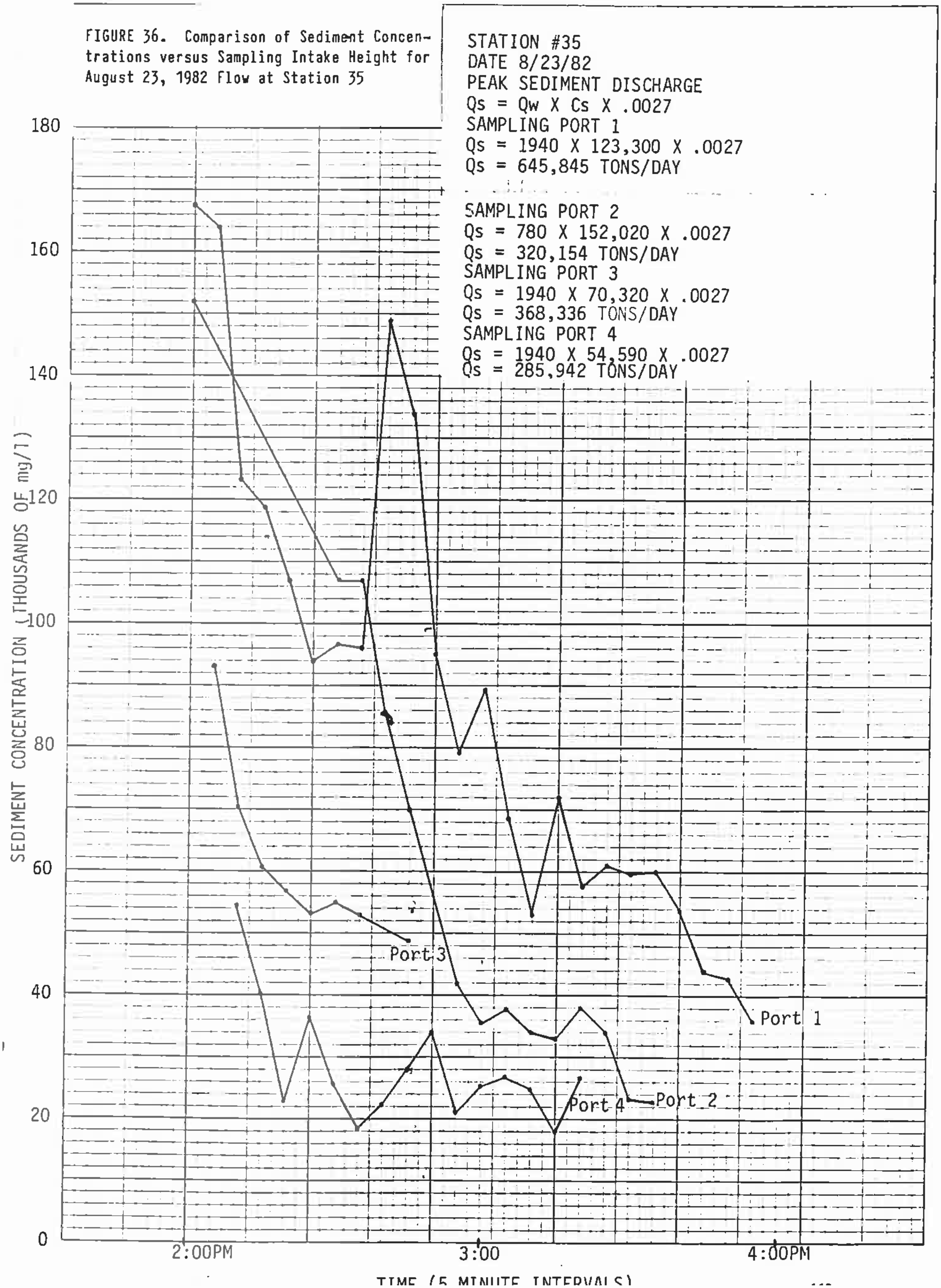
stations, 50, 15, 16 and 18, allow up- and downstream comparisons of the same flow or a variety of flows to be made on Yellow Water Canyon and Coal Mine Washes, respectively. The fifth station is located on Upper Moenkopi Wash. An automated station on Lower Moenkopi for comparison purposes could not be constructed because the channel is too wide at that location.

The automated sediment sampling stations were positioned in the channels near the thalweg and equipped to sample sediment at four different stage heights. Though relations between sediment concentration and stage are poorly defined, concentrations are higher in the lower portions of flows. Stronger relations have been demonstrated between mean velocity and sediment concentrations. In flows with rapidly changing stage, such as those on the leasehold, mean velocities are at approximately 0.6 of the total depth of flow. The sediment sampling ports are designed so that they will begin sampling when the flow height above the sampling ports is approximately 0.5 of the total depth of flow. Thus, during the peak part of the flow, the highest activated sediment sampling port would be more representative of the mean concentration in that vertical of the flow. In contrast, during the low portion of the flow the lowest sampling port (Port 1) would be more representative of the mean concentration. Figure 36 is shown to demonstrate this general relationship. The flow was of sufficient stage height to trigger all four sediment sampling ports. A plot of the sediment concentration versus time for each of the sediment sampling ports is presented in Figure 36. Concentration differences on the order of 40 to 60 percent can be seen depending on where in the flow recession curve samples are taken.

When flow discharges are measured concurrently with sediment concentrations, suspended sediment rating curves can be developed which present sediment load-flow discharge relationships representative of the channel reaches and watersheds above the sampling points. Figures 37 through 41 are the suspended sediment rating curves for each of the automated stations based on sediment sampling from 1981 to 1985. Sediment rating curve comparisons are useful as they incorporate the differences in watershed characteristics as well as the impacts from mining.

Comparison of the sediment rating curves for Yellow Water Canyon Wash (Stations 50 and 15) indicate that sediment loads at the upstream Site 50 are higher than those at Site 15 for all recorded flows. At the higher flows, Site 15 sediment loads increase at a higher rate than those at Site 50 with the difference between them being a factor of five; whereas, at the lower flows, the sediment load difference is a factor of ten. Comparison of sediment rating curves for Coal Mine Wash (Stations 16 and 18) indicate that sediment loads at the

FIGURE 36. Comparison of Sediment Concentrations versus Sampling Intake Height for August 23, 1982 Flow at Station 35



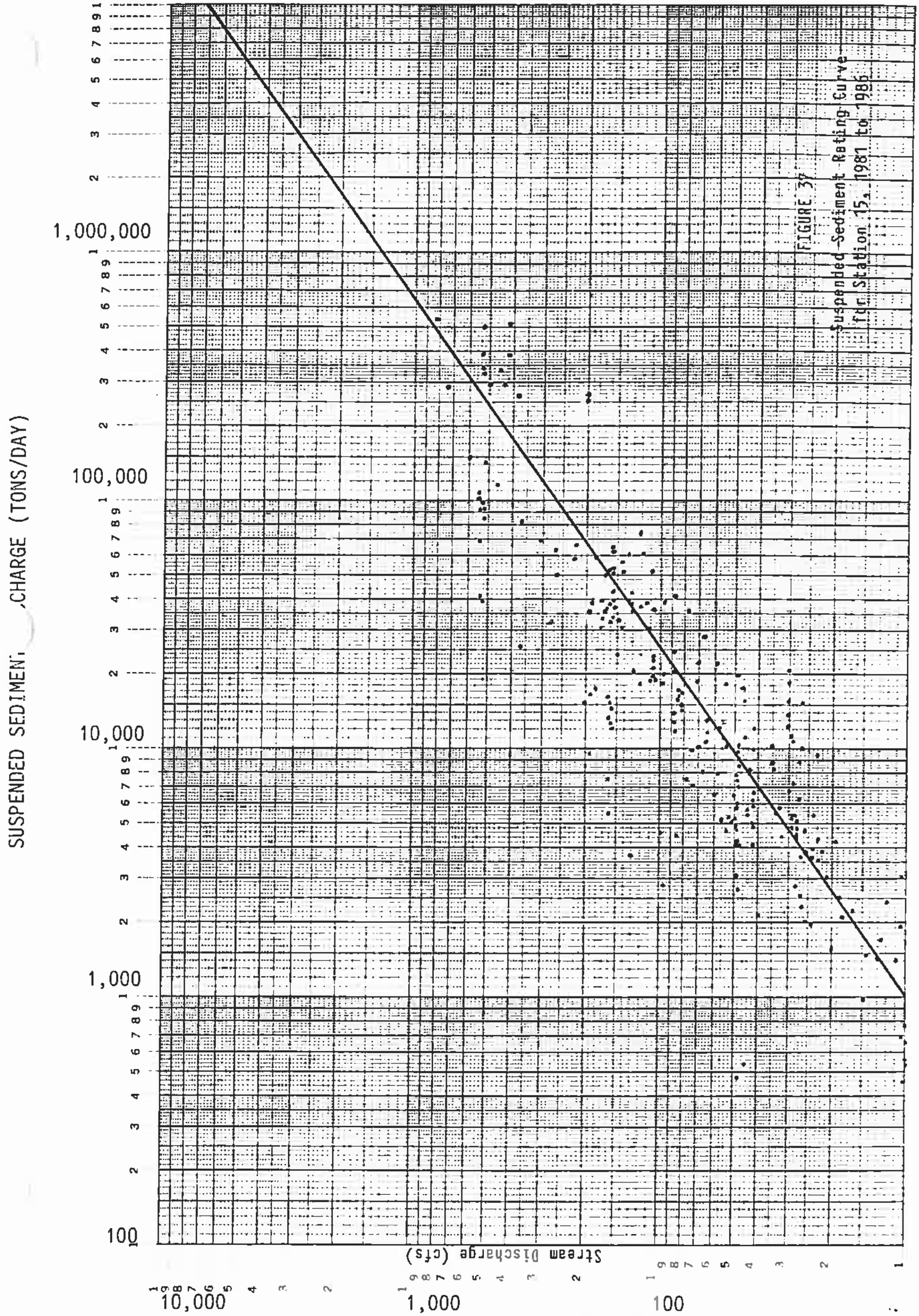


FIGURE 37
Suspended-Sediment Rating Curve
for Station 15, 1981 to 1986

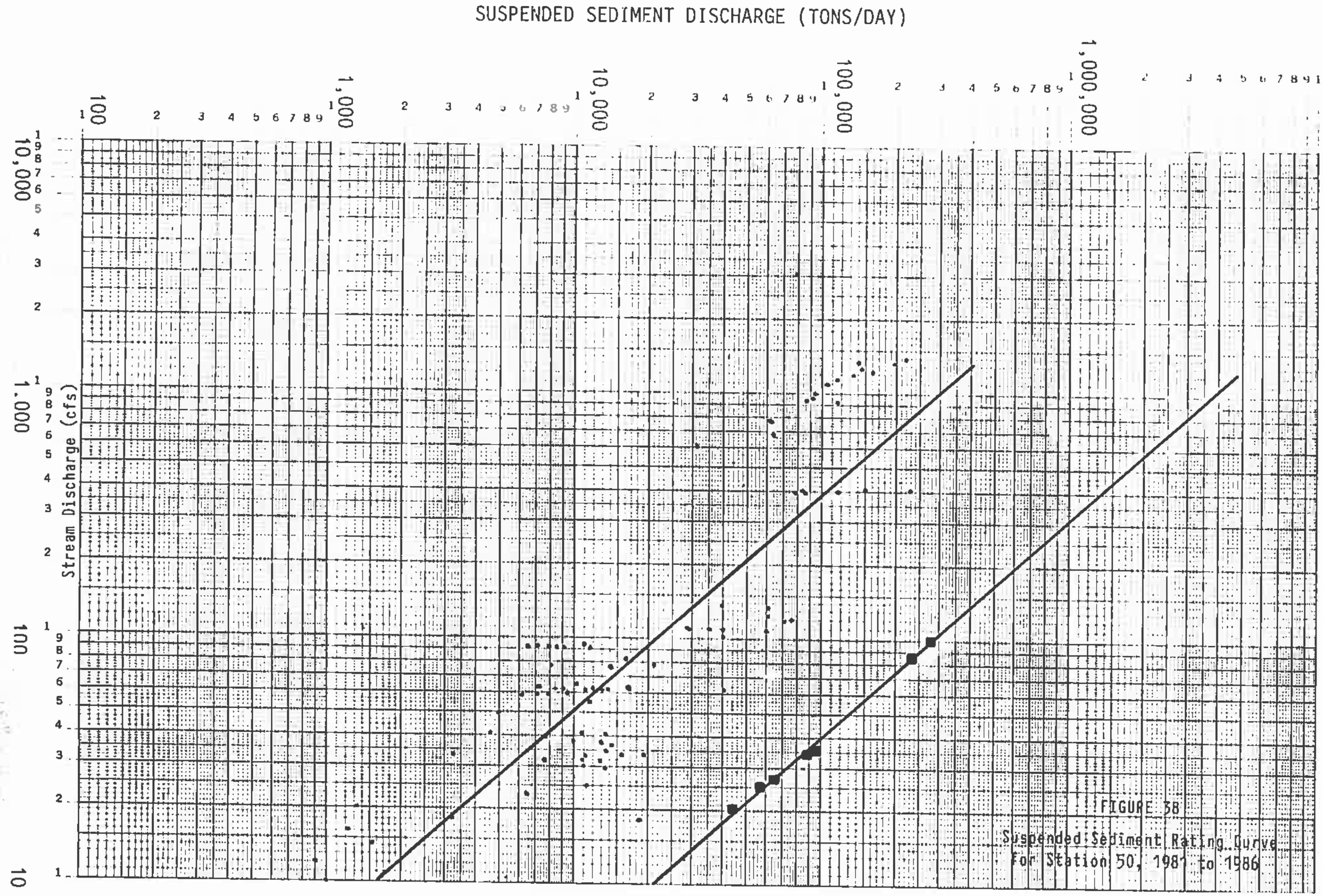


FIGURE 38

Suspended Sediment Rating Curve
For Station 50, 1981 to 1986

■ Analysis using Entire Sediment Sample

• Analysis using Partial Sediment Sample

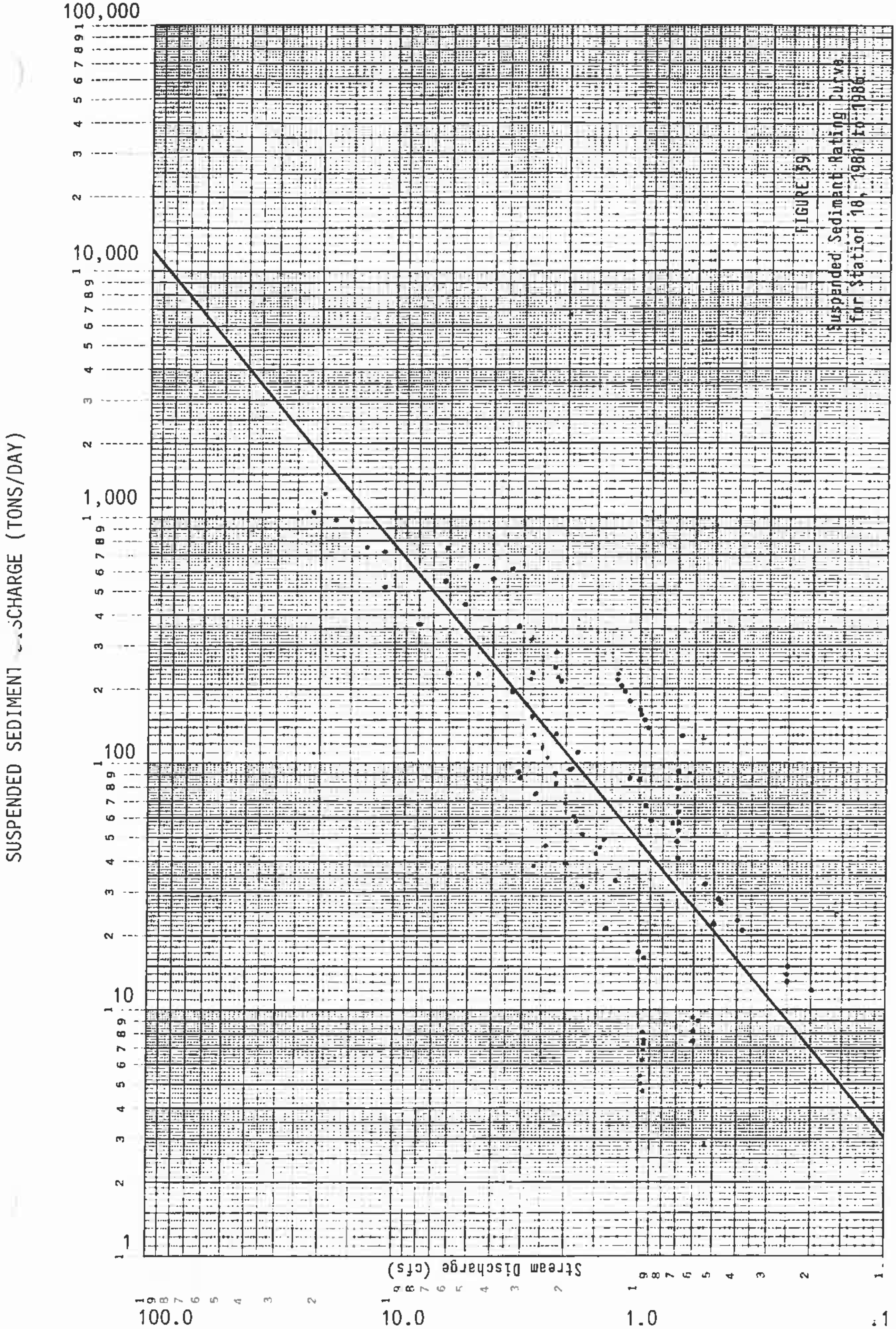
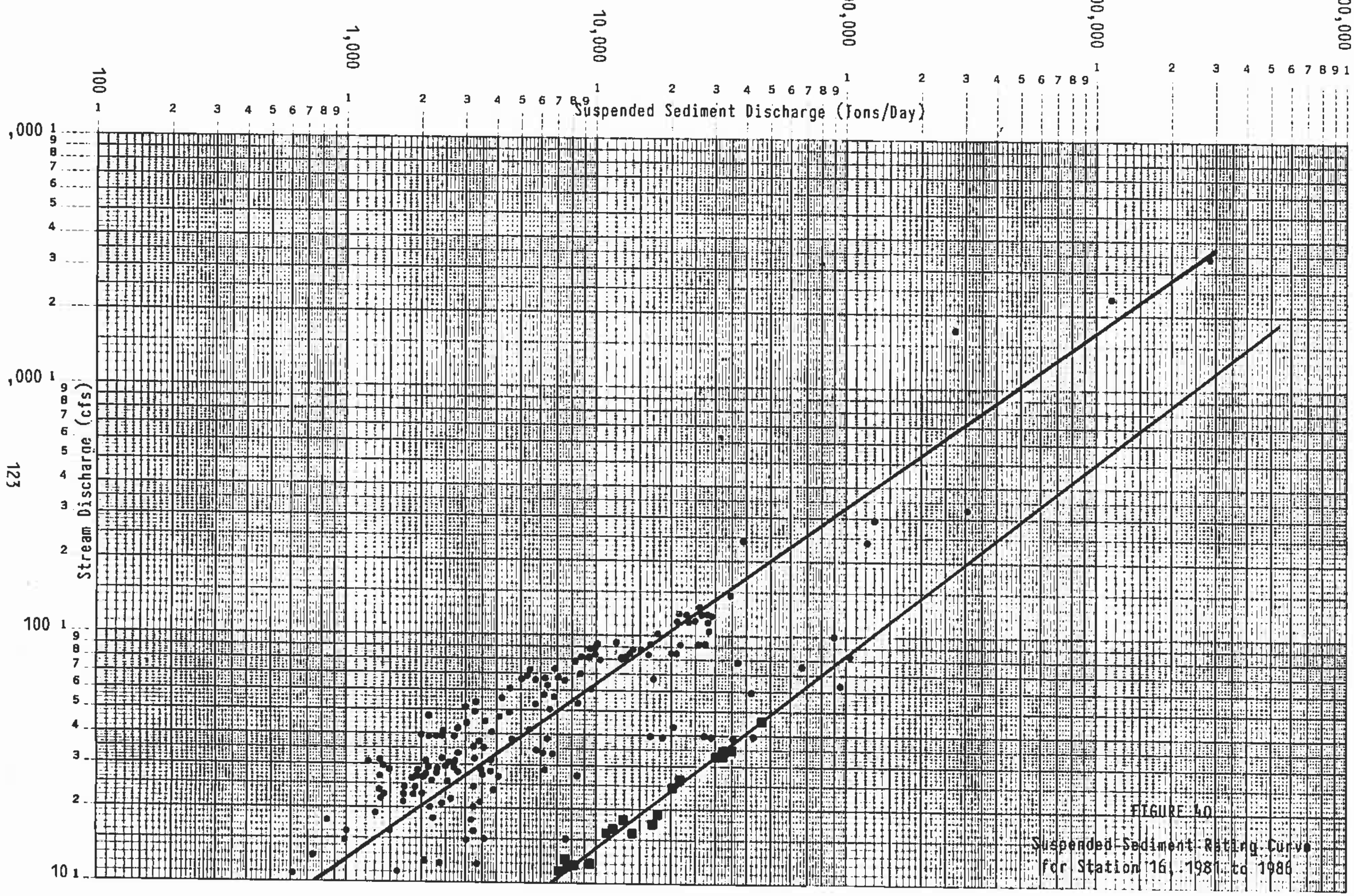


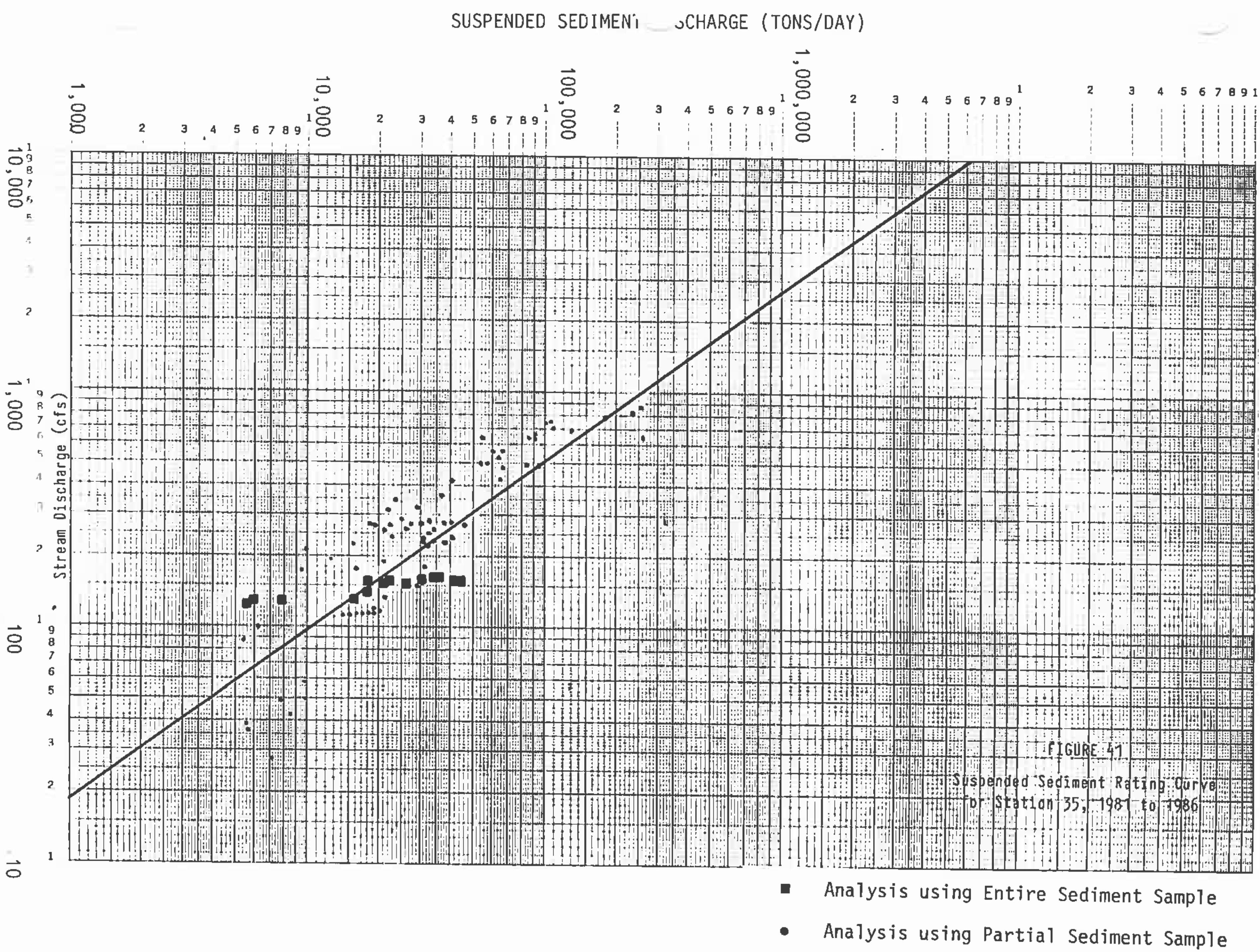
FIGURE 39
Suspended Sediment Rating Curve
for Station 18, 1981 to 1986

46 7520



■ Analysis using Entire Sediment Sample

● Analysis using Partial Sediment Sample


SUSPENDED SEDIMENT DISCHARGE (TONS/DAY)
1,000
10,000
100,000
1,000,000
Stream Discharge (cfs)
10,000
1,000
100
10
FIGURE 41
Suspended Sediment Rating Curve
for Station 35, 1981 to 1986
■ Analysis using Entire Sediment Sample
● Analysis using Partial Sediment Sample

upstream Site 16 are higher than those at Site 18 for all recorded flows. The difference in sediment loads between the two sites is a factor of nine for the range of flows. In a comparison of sediment rating curves at all five automated sites, Site 50 shows the highest sediment loads and Sites 35, 18 and 15 have the lowest sediment loads for comparable discharges. Finally, for the five monitors, the highest sediment load of 2,700,000 tons/day was measured at Site 16 and the lowest sediment load of 2.8 tons/day was measured at Site 18.

Typical laboratory procedures followed by Western Technologies, Inc. were to analyze portions of the sediment samples for determining sediment concentrations. Because the volumes of sediment from which the portions were obtained are so large, significant errors can occur if the entire sample is not analyzed. Peabody has investigated this concern in 1985 and have demonstrated for Sites 16 and 50 that analyses for total sediment samples will yield sediment load value factors of 8 and 13 higher, respectively (see upper best fit lines and square symbols on Figures 38 and 40). All future sediment concentrations will be determined based on the total sample. As more data points are plotted to document the total suspended sediment loads, correction factors will be developed to permit adjustment of the previous data.

These suspended sediment rating curves will be utilized in the future to document natural channel conditions to be used as criteria at bond release. Following the removal of sediment ponds around reclaimed areas, these rating curves will be used to document any changes in the sediment loads transported by the channels.

Sediment Yield Estimates.

General Leasehold Sediment Yield Estimates. Sediment yields for the seven watersheds transecting the Peabody leasehold were calculated by using the Universal Soil Loss Equation (USLE) and taking into account the sediment increase from the main channels.

The USLE shown below was used to calculate the sediment loss for each watershed.

$$E = RKLSCP$$

where:

E = soil loss per unit area ton/acre/year

R = index of erosivity

K = soil erodibility factor ton/acre/unit of erosion index

LS = slope length and slope

C = cover or cropping factor

P = support practice factor

The erosivity index (R) was taken from two-year, six-hour isopluvial maps prepared by the Soil Conservation Service (1976). Isopluvial values used included snowmelt. The erosivity index value determined for the leasehold is 40. Soil erodibility (K) values were determined for each watershed using Order 1, 3 and 4 soil survey maps prepared by Espey, Huston and Associates (EHA). The Order 3 and 4 soils maps are at a scale of 1" = 2000' while the Order 1 maps have a scale of 1" = 400'. These maps were used to calculate the percentage of the different soil types in each watershed. Percentages of different soil types were multiplied by the respective "K" factor for the respective soil type to determine weighted "K" values. These weighted values were then summed to determine mean weighted "K" values for each watershed.

Average watershed slope and slope lengths were determined following procedures outlined by Williams and Berndt (1976). The equation for computing average watershed slope is as follows:

$$S = \frac{.25z\ (LC_{25} + LC_{50} + LC_{75})}{DA}$$

where,

S = average watershed slope

z = total watershed relief (ft)

LC_z = contour length at 25, 50 and 75 percent of (ft)

DA = watershed drainage area (ft^2)

Average watershed slope lengths were determined using:

SL = average watershed slope length (ft)

LC = contour length (ft)

LB = base length of LC (ft)

EP = number of extreme points or drainages between LC and LB

Length-slope (LS) values were then determined using procedures and the nomograph developed by Wischmeier and Smith (1978).

Three separate calculations of average watershed slope length were made for values of LC and LB measured at 25 percent, 50 percent and 75 percent of the total elevation change for each watershed. The three values were then averaged to obtain the mean watershed slope length for each watershed.

The cover factors (C) were determined from aerial photos. Based on the percentages of different "C" values, total weighted cover factors were computed for each watershed. Support practice factors (P) values of 1 were assigned to all watersheds. The "P" factor was developed to account for supporting conservation practices such as contour furrowing. Since these sediment yield estimates assumed only undisturbed areas, a maximum "P" value of 1 was used to account for the absence of conservation practices.

Table 22 summarizes the estimated annual sediment yields for each of the major watersheds to the points where their drainage system exits the west tract of the leasehold or where their drainage system merges with one of a higher order near the leasehold boundary. Table 22 also shows a comparison of the five variables in the USLE for each watershed. The soil erodibility and the length-slope factors appear to account for a majority of the differences observed between watersheds with the LS factor by far the most significant. The LS factor values for the Yellow Water Canyon, Coal Mine and Moenkopi watersheds are two to three times greater than the other four watersheds. This large difference is principally due to the fact that Yellow Water Canyon, Coal Mine and Moenkopi watersheds are longer, narrower and include significant portions of the rim. Comparatively, the rim country includes a large percentage of deep, steep-sided canyons. Yucca Flat watershed has the lowest overall relief and consequently the lowest tons/acre/year soil loss estimate.

The USLE only estimates the gross annual erosion occurring on the watershed. For Black Mesa, gross annual erosion rates predicted for the principal watersheds on an acreage basis range between 7.3 and 22.6 tons/acre/year. Common practice is to multiply the gross erosion values by sediment delivery ratios to account for sediment losses (deposition) en route to the downstream measuring points. For this region, sediment delivery ratios are a misnomer. Sediment monitoring results on the leasehold suggest that a sediment delivery coefficient would be more appropriate (refer to Peabody Sediment Monitoring section). The channels are so unstable (consist of loose, very fine sand and silts) that order of magnitude sediment load increases can occur as a result of additional entrainment of channel bank and bed material as flows concentrate and increase in a downstream direction.

TABLE 22

Estimated Annual Sediment Yields for the Significant

Watersheds Within the Leasehold and Their Respective Upper Watersheds to the Rim

Watershed	R	K	LS	C	P	E Tons/Acre/Year	Area Acre	E Tons/Year	Sediment Yield Tons/Year
Yellow Water Canyon Wash	40	.19	9.3	.32	1	22.62	27,927	631,709	884,393
Coal Mine Wash	40	.18	9.6	.26	1	17.97	27,825	500,015	700,021
Moenkopi Wash	40	.20	9.0	.31	1	22.32	39,964	891,996	1,248,794
Reed Valley Wash	40	.28	4.2	.32	1	15.05	8,839	133,027	186,238
Red Peak Valley Wash	40	.26	4.3	.31	1	13.86	10,406	144,227	201,918
Yucca Flat Wash	40	.21	2.8	.31	1	7.29	18,618	135,725	190,015
Dinnebito Wash	40	.22	4.0	.34	1	11.97	33,802	404,610	566,454

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Comparisons of SEDIMOT II sediment load estimates with sediment monitoring data (Site 16 suspended sediment rating curve) for Coal Mine Wash suggests that sediment load increases from channel sediment contributions range between 4 percent at low flows (100 cfs) and 45 percent at higher flows (3000 cfs) (see Coal Mine Wash Pre- and Postmining Sediment Yield Estimates). Using a conservative estimate of 40 percent for channel contributions to sediment loads in the main channels (sediment delivery coefficient), sediment yields from the principal washes on the leasehold could actually be as high as 186,000 to 1,200,000 tons per year (see Table 22). It is emphasized that the channel increases in sediment load are limited to the main stems and the significant sandbed portions of the larger tributaries. Elsewhere in the system, overland flow is significant, and the USLE values are probably a reasonable estimate of sediment yield.

Coal Mine Wash Pre- and Postmining Sediment Yield Estimates. SEDIMOT II is a computer model designed to predict runoff and sediment loads from watersheds that have been mined or are in the process of active mining. Input parameters take into account precipitation, soils, topography and vegetation. Adjustment of these parameters allows for the evaluation of watershed changes resulting from mining activities.

Selection of the representative watershed in which SEDIMOT II has been applied for evaluating pre- and postmining conditions involved several criteria. The watershed selected must be of sufficient size to encorporate the range of soil, topographic and vegetative conditions encountered on Black Mesa. Also, the watershed must contain established reclaimed coal resource areas (RCRA's). Finally, the watershed must contain a similar distribution of soils, topographic features and vegetation as other principal watersheds.

Three large watersheds disect the major portion of the Black Mesa leasehold: 1) Yellow Water Canyon; 2) Coal Mine Wash; and 3) Moenkopi Wash. To their respective confluences with the lower permit boundary, Coal Mine Wash drains 42.9 square miles, and Moenkopi drains 62.1 square miles. Yellow Water Canyon Wash watershed encompasses 43.5 square miles, to its confluence with Coal Mine Wash.

Active mining on Black Mesa is presently occurring in the J1/N6, J7, J16, J21 and N-14 Coal Resource Areas (CRA's). Portions of each are in the process of, or have been reclaimed. Of the three watersheds (Yellow Water, Coal Mine and Moenkopi), Coal Mine Wash has the largest portion of established RCRA's (see Drawing No. 85405). The J3, N1 and N2 CRA's, contained in the Coal Mine Wash watershed, have been mined out, and reclamation activities have been completed in each, with the exception of small areas in the J3 CRA (i.e. solid waste landfill). Completion of reclamation activities in the N1 CRA occurred in 1983, and final reseeding of the N2 CRA was accomplished during the first part of 1986. Total acreage of these two areas is approximately 2,000 acres, or 7 percent of the Coal Mine Wash drainage.

A discussion of soils, slopes, slope lengths, vegetative cover types, channel gradients and stream orders in Yellow Water Canyon, Coal Mine Wash and Moenkopi Wash follows.

Soils surveys conducted in 1985 by Intermountain Soils, Inc. included order 3 and order 4 mapping of various soil complexes (see Appendix 1). Areal distributions of order 3 and 4 complexes in each watershed have been compiled and are presented in Table 23a.
The order 4 Torriorthents and the order 3 Zyme complexes make up the greatest areal percent of the mapped units in each watershed. All three watersheds contain more than 47 percent of the Torriorthent soils, and have a minimum of 10 percent of the Zyme complex soils.

Average watershed slopes and slope lengths for the three large watersheds have been determined using methods outlined by Williams and Berndt, 1976 (see General Leasehold Sediment Yield Estimates, Chapter 15). They have been compiled and are presented below:

	Average Slope (%)	Average Slope Length (ft.)
Yellow Water Canyon	19.2	590
Coal Mine Wash	20.4	550
Moenkopi Wash	19.3	530

The average watershed slope calculated for Coal Mine Wash is only 1 percent greater than watershed slopes determined in the Yellow Water Canyon and Moenkopi Wash drainages. The average slope length of Coal Mine Wash is approximately the average value of the slope length range determined for all three watersheds.

Pinyon-Juniper, Sagebrush and Oak-Aspen are the three principal cover types used for determining S.C.S. curve numbers (see Peak Flow Estimates, Chapter 15). The percent distribution of these cover types in each watershed have been summarized and are presented below:

TABLE 23a

Percentages of Order 3 and 4 Soil Complexes as
Mapped by Intermountain Soils, Inc. in
Yellow Water Canyon Wash, Coal Mine Wash and Moenkopi Wash

		Percentages		
Soil Complex	Map Unit Number	Yellow Water Canyon Wash	Coal Mine Wash	Moenkopi Wash
Zyme-Cahona-Dulce	20	0	0	0
Zyme Complexes	21-25	10.0	13.4	24.2
Cahona-Zyme	26	0	0	1.5
Begay-Las Lucas	27	2.1	3.8	3.1
Las Lucas- Zyme-Dulce	28	0	2.2	0
Dulce Complexes	29-33	6.2	2.0	16.0
San Mateo	36	0	0	1.2
Haplargids-Torriorthents	40	0	0	0
Torriofluvents	41	3.3	1.9	2.4
Torriorthents	42,43	75.1	57.9	47.5

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Cover Type	Yellow Water	Coal Mine	Moenkopi
Pinyon-Juniper	76.3	59.5	67.7
Sagebrush	9.0	10.6	25.0
Oak-Aspen	8.7	28.2	6.3

Coal Mine Wash has the lowest percentage of Pinyon-Juniper and the highest percentage of Oak-Aspen cover type. The Oak-Aspen cover type is found principally in the upland area of this watershed, several miles above the permit boundary. Moenkopi Wash has the highest percentage of Sagebrush cover type, mostly distributed along the lower portions of the watershed. The percentage of Sagebrush cover is approximately the same in the Yellow Water and Coal Mine Wash watersheds.

Gradients of the main stream channels in each of the watersheds have been determined and are .0076 ft/ft for Yellow Water Canyon Wash, .0080 ft/ft for Coal Mine Wash and .0077 ft/ft for Moenkopi Wash.

Stream orders for the three drainages have been discussed (see Geomorphic Relationships, Chapter 15), and are indicative of each drainage's relationship to the larger drainage network from the Black Mesa Region. Yellow Water Canyon, a tributary to Coal Mine Wash, has a stream order of 6. Coal Mine Wash, a tributary to Moenkopi Wash has a stream order of 7, and Moenkopi Wash, the principal wash draining the region has a stream order of 8.

Based on the parameters compared in the previous paragraphs, Peabody feels that the similarity between the Coal Mine Wash watershed and the Yellow Water Canyon and Moenkopi watersheds has been demonstrated. Coal Mine Wash watershed also contains a large portion of established reclamation, the N-1 and N-2 CRA's. Thus, Coal Mine Wash watershed was selected for comparing the differences in runoff and sediment yield between premining and postmining conditions using SEDIMOT II.

For modeling purposes, Coal Mine Wash was subdivided into fourteen primary watersheds of similar sizes and shapes (see Drawings 85710R and 85720R). Roman numerals were used to designate each primary watershed. SEDIMOT II junction locations were established at each primary watershed area outlet. The outlet of the entire Coal Mine Wash watershed area (includes primary watersheds I-XIV) was established at the location of Stream Station 18, and corresponds to the junction location of primary watershed XIV.

Watershed boundaries and junction locations for primary watersheds I through VII were established during the subdivision process involved in estimating peak flows using SEDIMOT II (see Peak Flow Estimates, Chapter 15). Due to its large area, primary watershed III was subdivided into three subwatersheds, and null structures were established at each subwatershed outlet. Watershed boundaries, junction locations and input parameters determined for primary watersheds I through VII under premining conditions were not altered for postmining conditions, as these watersheds all lie upstream of the leasehold boundary and mining activity. Computed runoff and sediment from these watersheds provided input to the main Coal Mine Wash channel below junction VII.

Watershed boundaries and junction locations for primary watersheds VIII through XIV were established in order to create watersheds with similar shapes and sizes. Primary watersheds VIII, IX, XI, XII, XIII and XIV were further subdivided into subwatersheds, with null structures established at each subwatershed outlet. This further subdivision was performed in order to partition areas with a predominance of postmining reclaimed areas into separate subwatersheds. Junction and null structure locations established for premining conditions were not altered for postmining conditions, insuring common points at each primary watershed outlet at which comparisons of runoff and sediment were made. No more than two branches per junction were used.

However, due to changes in topographic features in some primary watersheds and subwatersheds resulting from mining and reclamation activities, watershed areas (acreages) for postmining conditions were altered. Table 23b is a tabulation of percent change in watershed area (acreages) from premining conditions to postmining conditions and percent of reclaimed areas contained in primary watersheds and subwatersheds VIII through XIV under postmining conditions.

Two sets of peak discharge, runoff volume, peak sediment concentration and sediment yield values were generated. The first set was calculated assuming no mining activities had begun in the Coal Mine Wash drainage above Stream Station 18 (Junction XIV). The second set of estimates were generated accounting for the establishment of the N-1 and N-2 reclaimed coal resource areas within the Coal Mine Wash drainage (postmining conditions). Postmining conditions include the assumption that the internally draining impoundments in N-1 and N-2 have not been established, and that the established subwatersheds in which these impoundments have been created have a theoretically continuous drainage to the main Coal Mine Wash channel. Also, postmining conditions include the assumption that all sediment structures have been removed, providing flow paths from the N-1 and N-2 reclaimed

TABLE 23b

Percent Change in Watershed Area (Acreage) and
Percent of Reclaimed Area (Acreage) in Primary Watersheds and
Subwatersheds VIII through XIV for Postmining Conditions
Established in Coal Mine Wash Using SEDIMOT II

Primary Watershed or Subwatershed Number	Percent Change in Area From Premining to Postmining Conditions	Percent Reclaimed Area Encompassed
VIII A	-27.6	11.7
VIII B	+ 8.0	23.5
IX A	- .6	0
IX B	-23.3	61.8
X	- 6.2	0
XI A	-19.0	100.0
XI B	+22.0	74.3
XII A	- 9.6	11.7
XII B	+52.4	87.0
XIII A	+20.0	65.1
XIII B	- 2.3	1.0
XIII C	-26.1	33.7
XIV A	+ 7.5	6.6
XIV B	- 1.5	0
XIV C	+ 3.3	0

areas to the main Coal Mine Wash channel. Finally, all hydrology and sedimentology parameters used for inputs to the SEDIMOT II postmining runs take into account reclaimed area topography, soils and vegetation. The following discussion describes methods and techniques used to determine model inputs to the hydrology and sedimentology portions of SEDIMOT II.

A precipitation depth of 2.09 inches corresponding to the 10-year, 24-hour recurrence interval storm with a Type-II distribution was used to generate runoff for the entire Coal Mine Wash watershed under both premining and postmining conditions. This value was determined using Arizona Department of Transportation criteria, outlined in the "Peak Flow Estimates" section of the Hydrologic Description, Chapter 15, PAP.

Time of concentration for each watershed was calculated using Kirpich's formula (see Peak Flow Estimates). Peabody's engineering staff have utilized this method for time of concentration calculations involved in sediment control facility design. Estimates made using this method yield conservative values.

Curve numbers were determined by weighting the areal distribution of the vegetation/soil group complexes in each watershed. Curve numbers for each selected vegetation/soil group complex were calculated by Peabody Engineers using criteria developed by the Soil Conservation Service (see "General Report" Geotechnic, Hydrologic and Hydraulic Evaluation of Sediment Structures, Attachment D of Chapter 6, PAP). A more detailed discussion on the selection of curve numbers can be found in the Peak Flow Estimates section of Chapter 15, PAP. Curve number values for each complex have been compiled and are presented in Table 24.

Flow routing between junctions and structures is performed in SEDIMOT II using Muskingum routing techniques. Muskingum "K" and "x" parameters for channel reaches between junctions and structures established in Coal Mine Wash were determined by using formulas previously discussed at length in the "Peak Flow Estimates" section, Chapter 15, PAP.

Input values for the sedimentology portion of SEDIMOT II were determined from engineering tests on soils by PCC personnel, soil survey information collected by Intermountain Soils, Inc. (see Appendix 1), or by selecting default values provided by SEDIMOT II.

An average specific gravity value of 2.68 has been determined from analyses of a representative number of soil series types sampled on Black Mesa. The default value of

TABLE 24

Curve Numbers for Vegetation/Soil Group

Complexes Used in SEDIMOT II Calculations

for Coal Mine Wash

Vegetation/Soil Group	CN
Pinyon-Juniper	
Average Mine Conditions	
C-D Soil Group	80
Pinyon-Juniper	
Poor Mine Conditions	
C Soil Group	85
Chained Areas	
Fair Hydrologic Conditions	
C-D Soil Group	85
Sagebrush-Grass	
Average Mine Conditions	
C-D Soil Group	76
Sagebrush-Grass	
Poor Mine Conditions	
C-D Soil Group	82
Oak-Aspen	
Poor Hydrologic Conditions	
D-Soil Group	79
Reclaimed Areas	
Post-Law (1977) Contoured	81

1.5 was selected for the coefficient for distributing sediment loads. The default value of 1.25 was chosen for submerged bulk specific gravity.

Particle size values and percent finer values used for sediment yield calculations are presented in Table 25a. Fifteen particle size values were chosen for establishing percent finer values for each soil series. These particle size distributions were utilized to obtain representative distributions in each watershed for modeling purposes. Particle size distributions in each watershed for both pre- and postmining conditions were determined by areally weighting soil series mapped by Intermountain Soils, Inc.

The MUSLE sedimentology subroutine was used for all sediment yield estimates. Inputs required for using this subroutine are soil erodibility ("K"), average watershed slope ("S"), average watershed slope length ("L"), control practice factor ("C") and particle size distribution number.

"K" factors for each soil series mapped in the Coal Mine Wash drainage were determined by Intermountain Soils, Inc. (Appendix 1). "K" factors for each watershed were calculated by weighting the areal distributions of each soil series and respective "K" value. Reclaimed areas were assigned "K" values of .42 by Intermountain Soils, Inc. personnel.

Average watershed slopes ("S") for each watershed (both pre- and postmining) were calculated using the contour-length method (Williams and Berndt 1976). The relationship is as follows:

$$S = \frac{.25\ z\ (LC_{25} + LC_{50} + LC_{75})}{DA}$$

where,

S = average watershed slope

Z = total watershed relief (ft)

LC_x = contour length at 25, 50 and 75 percent of Z (ft)

and,

DA = watershed drainage area (ft^2)

Average watershed slope lengths for each watershed (both pre- and postmining) were calculated using the extreme point method (Williams and Berndt 1976). The relationship is as follows:

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TABLE 25a

Particle Size Values and Percent Finer Values

For Soils on the Black Mesa Leasehold

Particle Size	Percent Finer Values									
Values	Cahona	Bond	Begay	Oelop	San Mateo	Las Lucas	Sharps	Zyme	Dulce	Travesilla
38.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4.76	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0	75.0	79.0
2.38	100.0	100.0	100.0	100.0	100.0	100.0	100.0	92.0	64.0	73.0
1.19	100.0	99.5	99.5	100.0	99.5	99.5	99.5	90.0	60.0	69.0
.590	99.0	99.2	99.0	100.0	98.0	99.0	99.5	90.0	58.0	67.0
.297	98.0	99.0	98.0	99.0	96.0	98.0	98.0	90.0	55.0	64.0
.149	94.0	94.0	90.0	96.0	90.0	87.0	95.0	90.0	50.0	48.0
.074	63.0	70.0	68.0	77.0	81.0	72.0	81.0	89.0	41.0	39.0
.037	40.0	43.0	46.0	59.0	69.0	66.0	55.0	88.0	31.0	35.0
.019	26.0	29.0	33.0	42.0	53.0	52.0	37.0	77.0	23.0	30.0
.009	24.0	23.0	26.0	36.0	44.0	42.0	29.0	64.0	18.0	27.0
.005	21.0	18.0	22.0	33.0	36.0	36.0	24.0	55.0	16.0	23.0
.002	18.0	15.0	17.0	25.0	26.0	26.0	17.0	43.0	11.0	17.0
.001	16.0	13.0	15.0	21.0	22.0	23.0	14.0	35.0	9.0	15.0
.0001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$SL = \frac{LC \times LB}{2EP[(LC)^2 - (LB)^2]^{1/2}}$$

where,

SL = average watershed slope length (ft)

LC = contour length (ft)

LB = base length of LC (ft)

and,

EP = number of extreme points or drainages between LC and LB

Contours measured in each watershed were used to calculate both average slope and slope lengths. The maximum slope length value allowable using SEDIMOT II is 800 feet. Therefore, those watersheds in which the calculated slope length exceeded the maximum value were assigned an average watershed slope of 800 feet.

Control practice factors were determined by assigning a "C" value to similar vegetation cover descriptions used for curve number selections. Control practice factors for all vegetation cover descriptions other than reclaimed areas were selected using criteria outlined in the S.C.S. table "C Values for Permanent Pasture, Rangeland and Idle Land" (S.C.S. 1972). Reclaimed areas were assigned a "C" value of .15 by Peabody and consulting engineers (see "General Report" Geotechnic, Hydrologic and Hydraulic Evaluation of Sediment Structures", Attachment D, Chapter 6, PAP). "C" factors for each subwatershed were calculated by weighting the areal distribution of each vegetation cover type. Table 25b is a compilation of the assigned "C" value for each vegetation cover type.

Tables 26 and 27 are SEDIMOT II input files used to evaluate the effects of pre- and postmining conditions in Coal Mine Wash on runoff and sediment. Each row of numbers corresponds to a specific Card Code number included in the tables. Also, a brief title for each card code has been provided. The reader should refer to the SEDIMOT II User's Manual (Wilson et al. 1981) for a complete explanation of each card code.

Tables 28a and 28b present junction results of the SEDIMOT II runs for the individual primary watersheds VIII through XIV under premining and postmining conditions. Both tables also present the cumulative results of all primary watershed and subwatershed contributions down to junction XIV (I-XIV results in Tables 28a and 28b).

Reclaimed soils, topographies and vegetation modeled under postmining conditions resulted

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Table 25b

Control Practice Values for Vegetation

Cover Descriptions Used in SEDIMOT II

Calculations for Coal Mine Wash

Cover Descriptions	"C" Value
Pinyon-Juniper	.386
Oak-Aspen	.040
Sagebrush	.170
Chained Areas	.100
Reclaimed Areas	.150

T 26. Input Data for SEDIMOT II Coal Mine Wash ·ining Conditions

```
C.. .. MINE WASH SEDIMENT ANALYSES (PRE-MINING CONL..IONS)  (CC1)
     2      2   (CC2)
  2.09    24.       .1       1.   (CC3)
    15      2   (CC4)
     1      2        2       2        2     (CC5)
     2      2        2       2        2     (CC5)
     2      2        2       2        1     (CC5)
  2.68    1.5     1.25   (CC6)
    10     15   (CC7)
  38.1   4.76     2.38    1.19    0.590   0.297   0.149   0.074   0.037   0.019
 0.009  0.005    0.002   0.001   0.0001   (CC8)
 100.0   84.0     76.6    73.5     72.4    70.7    68.0    62.6    56.6    47.3
  38.7   33.5     25.4    20.7      0.0   (CC9)
 100.0   81.8     73.5    70.2     68.9    66.8    63.6    57.3    50.3    41.4
  33.6   29.2     21.9    17.8      0.0   (CC9)
 100.0   73.0     64.1    60.6     59.1    56.7    52.9    45.7    37.8    29.9
  24.0   21.0     15.2    12.5      0.0   (CC9)
 100.0   83.5     77.3    74.4     73.2    71.4    67.2    58.7    50.1    40.4
  32.8   28.5     21.3    17.5      0.0   (CC9)
 100.0   91.5     87.3    85.2     94.7    83.7    80.1    73.2    67.5    56.5
  46.5   40.0     30.6    25.3      0.0   (CC9)
 100.0   92.0     88.3    86.6     85.7    84.6    79.2    69.7    63.1    51.8
  42.4   36.7     27.5    23.2      0.0   (CC9)
 100.0   97.9     96.6    95.5     95.2    94.6    88.7    76.4    66.6    54.1
  44.2   37.8     28.9    24.4      0.0   (CC9)
 100.0   89.2     84.1    81.7     81.0    79.9    76.6    70.7    65.4    55.0
  45.1   39.0     29.8    24.5      0.0   (CC9)
 100.0   91.0     86.6    84.4     83.8    82.9    79.5    73.4    68.6    57.7
  47.4   40.9     31.3    25.9      0.0   (CC9)
 100.0   95.9     93.8    92.2     92.0    91.3    86.4    77.5    71.8    59.7
  49.1   42.2     32.1    26.9      0.0   (CC9)
     1  (CC10)
    0.     0.       0.   (CC11)I
     1      1   (CC10)
   .00    .03      .39   (CC11)II
    0.     0.       0.   (CC11)
     1      1   (CC10)
   .00    .19      .39   (CC11)III
    0.     0.       0.   (CC11)
     1      1   (CC10)
   .00    .39      .39   (CC11)IV
    0.     0.       0.   (CC11)
     1      1   (CC10)
   .00    .06      .43   (CC11)V
    0.     0.       0.   (CC11)
     1      1   (CC10)
   .00    .22      .43   (CC11)VI
    0.     0.       0.   (CC11)
     1      1   (CC10)
   .00    .14      .43   (CC11)VII
    0.     0.       0.   (CC11)
     1      1   (CC10)
   .00    .11      .43   (CC11)VIII
    0.     0.       0.   (CC11)
     1      1   (CC10)
```

Table 26(cont.). Input Data for SEDIMOT II Coal Mine Wash Premining Conditions

0	.12	.43	(CC11)IX					
0.	0.	0.	(CC11)					
1	1	(CC10)						
.00	.04	.43	(CC11)X					
0.	0.	0.	(CC11)					
1	1	(CC10)						
.00	.09	.43	(CC11)XI					
0.	0.	0.	(CC11)					
1	1	(CC10)						
.00	.14	.43	(CC11)XII					
0.	0.	0.	(CC11)					
1	1	(CC10)						
.00	.15	.43	(CC11)XIII					
0.	0.	0.	(CC11)					
1	1	(CC10)						
.00	.26	.43	(CC11)XIV					
0.	0.	0.	(CC11)					
1	(CC10)							
0.	0.	0.	(CC11)XV					
1	1	3	3	2	(CC12)I			
3491.0	76.5	1.14	0.	0.	0.	1.	2.	(CC13)I
.172	800.	33.9	.177	1.0	(CC14)I			
0	1	3	3	2	(CC12)II			
1	1	3	3	2	(CC12)			
3499.2	79.6	1.21	0.	0.	0.	1.	2.	(CC13)II
.173	740.	28.0	.177	1.0	(CC14)II			
0	1	3	3	2	(CC12)III			
3	1	3	3	2	(CC12)			
2019.4	79.6	.88	0.	1.00	.35	1.	2.	(CC13)IIIA
.170	720.	41.7	.151	1.0	(CC14) IIIA			
1958.1	79.6	.92	0.	.35	.39	1.	2.	(CC13)IIIB
.172	800.	30.4	.211	1.0	(CC14) IIIB			
1698.8	79.6	1.00	0.	0.	0.	1.	2.	(CC13)IIIC
.178	370.	27.2	.205	2.0	(CC14) IIIC			
0	1	3	3	2	(CC12)IV			
1	1	3	3	2	(CC12)			
2220.9	79.6	.91	0.	0.	0.	1.	2.	(CC13)IV
.170	730.	31.0	.242	3.0	(CC14)IV			
0	1	3	3	2	(CC12)V			
1	1	3	3	2	(CC12)			
1559.3	79.5	.82	0.	0.	0.	1.	2.	(CC13)V
.183	380.	21.7	.299	2.0	(CC14)V			
0	1	3	3	2	(CC12)VI			
1	1	3	3	2	(CC12)			
1814.4	79.3	.75	0.	0.	0.	1.	2.	(CC13)VI
.192	420.	19.6	.330	1.0	(CC14)VI			
0	1	3	3	2	(CC12)VII			
1	1	3	3	2	(CC12)			
2008.2	84.6	.62	0.	0.	0.	1.	2.	(CC13)VII
.207	530.	18.3	.356	1.0	(CC14)VII			
0	1	1	1	2	(CC12)VIII			
2	1	1	1	2	(CC12)			
635.6	84.7	.42	0.	.20	.39	1.	2.	(CC13)VIIIA
.195	560.	9.9	.363	4.0	(CC14)VIIIA			
469.0	83.9	.38	0.	0.	0.	1.	2.	(CC13)VIIIB

'able 26(cont.). Input Data for SEDIMOT II Coal ıe Wash Premining Conditions

```
 .256   660.   14.9   .305   6.0  (CC14)VIIIB
    0      1      1      1     2  (CC12)IX
    2      1      1      1     2  (CC12)
787.8   84.6    .53    0.     0.     0.     1.     2.  (CC13)IXA
 .225   470.   21.1   .355   5.0  (CC14)IXA
242.3   85.0    .39    0.     0.     0.     1.     2.  (CC13)IXB
 .238   530.   12.0   .374   5.0  (CC14)IXB
    0      1      1      1     2  (CC12)X
    1      1      1      1     2  (CC12)
792.5   84.8    .81    0.     0.     0.     1.     2.  (CC13)X
 .234   440.    9.9   .371   5.0  (CC14)X
    0      1      1      1     2  (CC12)XI
    2      1      1      1     2  (CC12)
583.5   85.0    .55    0.    .12    .39     1.     2.  (CC13)XIA
 .243   660.    7.2   .383   5.0  (CC14)XIA
435.6   84.2    .51    0.     0.     0.     1.     2.  (CC13)XIB
 .344   560.    9.4   .329   7.0  (CC14)XIB
    0      1      1      1     2  (CC12)XII
    2      1      1      1     2  (CC12)
566.9   84.1    .48    0.    .11    .39     1.     2.  (CC13)XIIA
 .259   480.    9.1   .321  10.0  (CC14)XIIA
474.5   84.5    .45    0.     0.     0.     1.     2.  (CC13)XIIB
 .300   470.    7.9   .348   7.0  (CC14)XIIB
    0      1      1      1     2  (CC12)XIII
    3      1      1      1     2  (CC12)
450.7   84.5    .40    0.    .08    .43     1.     2.  (CC13)XIIIA
 .262   480.    8.8   .351  10.0  (CC14)XIIIA
621.1   84.6    .54    0.    .01    .43     1.     2.  (CC13)XIIIB
 .260   540.    8.1   .358   6.0  (CC14)XIIIB
178.6   84.8    .32    0.     0.     0.     1.     2.  (CC13)XIIIC
 .215   410.    9.5   .374   9.0  (CC14)XIIIC
    0      1      1      1     2  (CC12)XIV
    3      1      1      1     2  (CC12)
294.5   84.3    .28    0.    .19    .43     1.     2.  (CC13)XIVA
 .227   480.    8.6   .335   9.0  (CC14)XIVA
420.4   84.2    .33    0.    .06    .43     1.     2.  (CC13)XIVB
 .199   480.   10.8   .327   8.0  (CC14)XIVB
252.9   83.6    .44    0.     0.     0.     1.     2.  (CC13)XIVC
 .204   450.   11.3   .284   8.0  (CC14)XIVC
    0      1      1      1     2  (CC12)XV
********************************** END OF FILE ******************
                              CARD CODE LEGEND
CARD CODE  1 - WATERSHED IDENTIFICATION CODE (CC1)
CARD CODE  2 - STORM TYPE    (CC2)
CARD CODE  3 - STORM DATA    (CC3)
CARD CODE  4 - NUMBER OF JUNCTIONS  (CC4)
CARD CODE  5 - NUMBER OF BRANCHES/JUNCTIONS  (CC5)
CARD CODE  6 - SEDIMENTOLOGY PARAMETERS (CC6)
CARD CODE  7 - NUMBER OF PARTICLE SIZE DISTRIBUTIONS   (CC7)
CARD CODE  8 - SEDIMENT PARTICLE SIZES   (CC8)
CARD CODE  9 - PERCENT FINER  (CC9)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH  (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS   (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION   (CC12)
CARD CODE 13 - SUBWATERSHED DATA  (CC13)
```

Table 27. Input Data for SEDIMOT II Coal Mine Wash Postmining Conditions

```
CC    'INE WASH SEDIMENT ANALYSES (POST-MINING CC     IONS)  (CC1)
     2        2     (CC2)
  2.09       24.        .1       1.     (CC3)
    15        2     (CC4)
     1        2         2        2        2     (CC5)
     2        2         2        2        2     (CC5)
     2        2         2        2        1     (CC5)
  2.68      1.5      1.25    (CC6)
    10       15     (CC7)
  38.1     4.76      2.38     1.19    0.590    0.297    0.149    0.074    0.037    0.019
 0.009    0.005     0.002    0.001   0.0001    (CC8)
 100.0     84.0      76.6     73.5     72.4     70.7     68.0     62.6     56.6     47.3
  38.7     33.5      25.4     20.7      0.0    (CC9)
 100.0     81.8      73.5     70.2     68.9     66.8     63.6     57.3     50.3     41.4
  33.6     29.2      21.9     17.8      0.0    (CC9)
 100.0     73.0      64.1     60.6     59.1     56.7     52.9     45.7     37.8     29.9
  24.0     21.0      15.2     12.5      0.0    (CC9)
 100.0     98.7      98.0     97.2     96.7     96.1     90.1     71.7     53.2     40.3
  32.4     27.2      21.2     18.2      0.0    (CC9)
 100.0     93.4      90.4     88.7     88.1     87.0     81.5     69.8     60.7     48.7
  39.8     34.3      25.8     21.8      0.0    (CC9)
 100.0     92.8      89.3     87.3     86.9     86.0     82.1     75.0     69.5     58.2
  47.8     41.1      31.4     26.0      0.0    (CC9)
 100.0    100.0     100.0     99.6     99.1     98.5     92.0     69.0     44.5     31.0
  24.5     20.0      16.0     14.0      0.0    (CC9)
 100.0     89.7      84.8     82.5     81.7     80.7     77.3     71.1     65.6     55.0
  45.1     38.9      29.8     24.5      0.0    (CC9)
 100.0     95.7      93.6     92.3     91.8     91.1     86.0     71.1     55.9     43.7
  35.5     30.0      23.2     19.7      0.0    (CC9)
 100.0     86.3      80.2     77.6     76.5     74.8     70.4     60.0     49.5     39.3
  31.8     27.4      20.6     17.2      0.0    (CC9)
     1   (CC10)
    0.       0.        0.   (CC11)I
     1        1     (CC10)
   .00      .03      ..39    (CC11)II
    0.       0.        0.    (CC11)
     1        1     (CC10)
   .00      .19       .39    (CC11)III
    0.       0.        0.    (CC11)
     1        1     (CC10)
   .00      .39       .39    (CC11)IV
    0.       0.        0.    (CC11)
     1        1     (CC10)
   .00      .06       .43    (CC11)V
    0.       0.        0.    (CC11)
     1        1     (CC10)
   .00      .22       .43    (CC11)VI
    0.       0.        0.    (CC11)
     1        1     (CC10)
   .00      .14       .43    (CC11)VII
    0.       0.        0.    (CC11)
     1        1     (CC10)
   .00      .11       .43    (CC11)VIII
    0.       0.        0.    (CC11)
     1        1     (CC10)
```


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e 27(cont.). Input Data for SEDIMOT II Coal M ash Postmining Conditions

```
   .00      .12       .43  (CC11)IX
   0.       0.        0.   (CC11)
    1        1   (CC10)
   .00      .04       .43  (CC11)X
   0.       0.        0.   (CC11)
    1        1   (CC10)
   .00      .09       .43  (CC11)XI
   0.       0.        0.   (CC11)
    1        1   (CC10)
   .00      .14       .43  (CC11)XII
   0.       0.        0.   (CC11)
    1        1   (CC10)
   .00      .15       .43  (CC11)XIII
   0.       0.        0.   (CC11)
    1        1   (CC10)
   .00      .26       .43  (CC11)XIV
   0.       0.        0.   (CC11)
    1  (CC10)
   0.       0.        0.   (CC11)XV
    1        1        3      3       2  (CC12)I
3491.0     76.5     1.14     0.      0.         0.       1.      2.  (CC13)I
  .172     800.     33.9    .177    1.0  (CC14)I
    0        1        3      3       2  (CC12)II
    1        1        3      3       2  (CC12)
3499.2     79.6     1.21     0.      0.         0.       1.      2.  (CC13)II
  .173     740.     28.0    .177    1.0  (CC14)II
    0        1        3      3       2  (CC12)III
    3        1        3      3       2  (CC12)
2019.4     79.6      .88     0.     1.00       .35       1.      2.  (CC13)IIIA
  .170     720.     41.7    .151    1.0  (CC14)IIIA
1958.1     79.6      .92     0.      .35       .39       1.      2.  (CC13)IIIB
  .172     800.     30.4    .211    1.0  (CC14)IIIB
1698.8     79.6     1.00     0.      0.         0.       1.      2.  (CC13)IIIC
  .178     370.     27.2    .205    2.0  (CC14)IIIC
    0        1        3      3       2  (CC12)IV
    1        1        3      3       2  (CC12)
2220.9     79.6      .91     0.      0.         0.       1.      2.  (CC13)IV
  .170     730.     31.0    .242    3.0  (CC14)IV
    0        1        3      3       2  (CC12)V
    1        1        3      3       2  (CC12)
1559.3     79.5      .82     0.      0.         0.       1.      2.  (CC13)V
  .183     380.     21.7    .299    2.0  (CC14)V
    0        1        3      3       2  (CC12)VI
    1        1        3      3       2  (CC12)
1814.4     79.3      .75     0.      0.         0.       1.      2.  (CC13)VI
  .192     420.     19.6    .330    1.0  (CC14)VI
    0        1        3      3       2  (CC12)VII
    1        1        3      3       2  (CC12)
2008.2     84.6      .62     0.      0.         0.       1.      2.  (CC13)VII
  .207     530.     18.3    .356    1.0  (CC14)VII
    0        1        1      1       1  (CC12)VIII
    2        1        1      1       1  (CC12)
 460.3     84.5      .38     0.      .22       .39       1.      2.  (CC13)VIIIA
  .225     400.     12.7    .358    10.0  (CC14)VIIIA
 509.6     82.6      .42     0.      0.         0.       1.      2.  (CC13)VIIIB
```


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Table 27(cont.). Input Data for SEDIMOT II Coal Mine Wash Postmining Conditions

```
    .87    540.    11.0    .227    5.0  (CC14)VI
      0       1       1       1      1  (CC12)IX
      2       1       1       1      1  (CC12)
  783.3    84.5     .54      0.     0.        0.      1.      2. (CC13)IXA
   .226    470.    21.1    .354    6.0  (CC14)IXA
  185.9    82.4     .41      0.     0.        0.      1.      2. (CC13)IXB
   .344    420.     9.7    .230    9.0  (CC14)IXB
      0       1       1       1      1  (CC12)X
      1       1       1       1      1  (CC12)
  743.1    84.8     .73      0.     0.        0.      1.      2. (CC13)X
   .233    440.     9.9    .373    6.0  (CC14)X
      0       1       1       1      1  (CC12)XI
      2       1       1       1      1  (CC12)
  472.6    81.0     .41      0.    .29       .39      1.      2. (CC13)XIA
   .430    800.     8.0    .150    7.0  (CC14)XIA
  531.7    81.6     .44      0.     0.        0.      1.      2. (CC13)XIB
   .393    800.     9.3    .177    4.0  (CC14)XIB
      0       1       1       1      1  (CC12)XII
      2       1       1       1      1  (CC12)
  512.6    83.7     .47      0.    .11       .39      1.      2. (CC13)XIIA
   .276    410.     8.0    .297    9.0  (CC14)XIIA
  723.3    81.3     .65      0.     0.        0.      1.      2. (CC13)XIIB
   .418    690.     8.5    .165    4.0  (CC14)XIIB
      0       1       1       1      1  (CC12)XIII
      3       1       1       1      1  (CC12)
  541.0    82.0     .35      0.    .08       .43      1.      2. (CC13)XIIIA
   .374    500.     7.3    .205    4.0  (CC14)XIIIA
  606.9    84.5     .53      0.    .01       .43      1.      2. (CC13)XIIIB
   .267    540.     8.1    .350    5.0  (CC14)XIIIB
  132.0    83.5     .27      0.     0.        0.      1.      2. (CC13)XIIIC
   .328    390.     9.3    .294    9.0  (CC14)XIIIC
      0       1       1       1      1  (CC12)XIV
      3       1       1       1      1  (CC12)
  316.6    84.2     .30      0.    .19       .43      1.      2. (CC13)XIVA
   .272    480.    10.4    .329    5.0  (CC14)XIVA
  414.1    84.3     .32      0.    .06       .43      1.      2. (CC13)XIVB
   .208    480.    10.8    .332    8.0  (CC14)XIVB
  261.3    83.5     .39      0.     0.        0.      1.      2. (CC13)XIVC
   .210    450.    11.3    .279    8.0  (CC14)XIVC
      0       1       1       1      1  (CC12)XV
********************************** END OF FILE **************************
                              CARD CODE LEGEND
CARD CODE  1 - WATERSHED IDENTIFICATION CODE (CC1)
CARD CODE  2 - STORM TYPE (CC2)
CARD CODE  3 - STORM DATA (CC3)
CARD CODE  4 - NUMBER OF JUNCTIONS (CC4)
CARD CODE  5 - NUMBER OF BRANCHES/JUNCTIONS (CC5)
CARD CODE  6 - SEDIMENTOLOGY PARAMETERS (CC6)
CARD CODE  7 - NUMBER OF PARTICLE SIZE DISTRIBUTIONS (CC7)
CARD CODE  8 - SEDIMENT PARTICLE SIZES (CC8)
CARD CODE  9 - PERCENT FINER (CC9)
CARD CODE 10 - NUMBER OF STRUCTURES PER BRANCH (CC10)
CARD CODE 11 - BETWEEN STRUCTURE ROUTING PARAMETERS (CC11)
CARD CODE 12 - SUBWATERSHED/STRUCTURE INFORMATION (CC12)
CARD CODE 13 - SUBWATERSHED DATA (CC13)
CARD CODE 14 - SEDIMENTOLOGY DATA (CC14)
```

TABLE 28a

Peak Discharge, Runoff Volume, Peak Sediment Concentration and Sediment Yield[1] Calculated Using SEDIMOT II for Premining Conditions in Watersheds of Coal Mine Wash

Primary Watershed	Peak Discharge (cfs)	Runoff Volume (acre-ft)	Peak Sediment Concentration (mg/l)	Sediment Yield (tons)
XIII	514	76.2	225,897	13,585
IX	489	72.5	393,284	26,440
X	285	56.2	110,660	5,290
XI	425	71.6	129,119	7,682
XII	474	71.4	115,032	6,725
XIII	589	87.5	115,451	8,272
XIV	496	65.5	128,662	6,759
I-XIV[2,3]	3324	1518.1	280,071	434,517

[1] Using a 10-year, 24-hour storm input.

[2] Reported values include contributions from all modeled watersheds within the Coal Mine Wash drainage down to the location of Junction XIV.

[3] Total drainage area = 42.9 mi^2.

TABLE 28b

Peak Discharge, Runoff Volume, Peak Sediment Concentration and Sediment Yield[1] Calculated Using SEDIMOT II for Postmining Conditions in Watersheds of Coal Mine Wash

Primary Watershed	Peak Discharge (cfs)	Runoff Volume (acre-ft)	Peak Sediment Concentration (mg/l)	Sediment Yield (tons)
XIII	417	63.3	176,752	9,391
IX	430	65.8	388,659	23,658
X	285	52.7	114,896	5,103
XI	325	56.7	110,178	5,082
XII	443	74.6	88,681	5,440
XIII	580	82.8	103,264	6,891
XIV	513	67.1	160,460	8,753
I-XIV[2,3]	3274	1480.0	281,623	424,083

[1] Using a 10-year, 24-hour storm input.

[2] Reported values include contributions from all modelled watersheds within the Coal Mine Wash drainage down to the location of Junction XIV.

[3] Total drainage area = 42.9 mi^2.

in reduced peak discharges predicted for primary watersheds VIII, IX, XI, XII and XIII. Reductions ranged between 2 percent (XIII) and 24 percent (XI). All of subwatershed XIA and more than 74 percent of subwatershed XIB are established reclaimed areas under postmining conditions. Reductions in weighted curve numbers and changes in time of concentration values for reclaimed watersheds contributed to predicted decreases in peak discharge.

Reduced runoff volumes were predicted under postmining conditions in primary watersheds VIII, IX, X, XI and XIII. Reduced runoff volumes ranged between 21 percent (XI) and 5 percent (XIII). As mentioned previously, both subwatersheds delineated within primary watershed XI have significant percentages of reclaimed areas in postmining conditions. Primary watersheds XII and XIV both showed slight increases in predicted runoff volume (4 percent and 2 percent, respectively). Subwatershed XIIB appears anomalous to the conclusions reached above. A high percentage of the subwatershed has been reclaimed and yet the predicted runoff is higher. This exception can be explained by the fact that boundaries in subwatershed VIIB were altered to compensate for topographic changes caused by reclamation. This resulted in the largest change (greater than 52 percent) in watershed boundaries and acreages for postmining conditions. Predicted reductions in runoff volumes from postmining watersheds mostly comprised of reclaimed areas resulted from lower weighted curve numbers, and changes in routing parameters and times of concentration.

Model results under postmining conditions show reduced peak sediment concentrations in primary watersheds VIII, IX, XI, XII and XIII. Concentration reductions range between 1 percent (IX) and 23 percent (XII). Decreases in sediment concentrations predicted for postmining conditions are largely attributed to reduced "C" values determined in watersheds with largely reclaimed areas. Considering the order of magnitudes in which peak sediment concentrations have been modeled by SEDIMOT II (10^5), differences in predicted sediment concentrations between pre- and postmining conditions are not pronounced.

SEDIMOT II results for postmining conditions show a decrease in sediment yields for primary watersheds VIII, IX, X, XI, XII and XIII. Decreased yields range between 4 percent (X) and 34 percent (XI). An increase in sediment yield was predicted for watershed XIV. Reduced predictions in sediment yield result primarily from lower "C" values determined for reclaimed areas, and to some extent, changes in topography reflected in different watershed slopes and slope lengths. The 29 percent increase in predicted sediment yield for watershed XIV can largely be attributed to watershed shape changes.

Decreases in predicted sediment loads and runoff from postmining watersheds are largely attributed to the establishment of reclaimed areas. Adjustments of model input parameters, primarily lowered curve numbers and cover (C) values, resulted in lower prediction results from the largely reclaimed tributary watersheds in Coal Mine Wash. The anomolous differences in predicted runoff volume, sediment concentration and sediment yield for pre- and postmining conditions from primary watershed X are due to changes in watershed shape. No reclaimed areas were established in this primary watershed under postmining conditions.

On a larger scale (the Coal Mine watershed down to junction XIV), comparisons between the effects of pre- and postmining conditions on predicted runoff and sediment yield are less pronounced. SEDIMOT II combines runoff and sediment hydrographs at each junction as runoff progresses downstream. Total contributions from the entire Coal Mine Wash watershed up to junction XIV for both pre- and postmining conditions are reported in Tables 28a and 28b (see values for I-XIV). Postmining soils, topographies and vegetation resulted in a 2 percent and 3 percent reduction in predicted peak discharge and runoff volume, respectively. Sediment yields were also lower by 5 percent. An increase in sediment concentration of less than 1 percent was predicted for postmining conditions. These results suggest that although reductions in runoff and sediment loads from largely reclaimed tributary watersheds may be measurable, runoff and sediment yield reductions in the main channel are less pronounced as the flow progresses downstream.

It should be noted that the MUSLE subroutine option in SEDIMOT II does not account for sediment deposition, nor does it predict sediment contributions from channels.

Sediment rating curves have been developed from measured sediment concentrations and discharge at stream station monitoring sites on PCC's Black Mesa leasehold (see "Automated Site Sediment Yield Analyses" section). Two automated sites (16 and 18) are located on Coal Mine Wash. Stream Station 16 is located several miles upstream from Station 18.

Junction 7, established as part of modeling sediment and runoff in Coal Mine Wash with SEDIMOT II, was located at the same position in the main channel as Stream Station 16. Peak discharges and peak sediment concentrations were calculated at junction 7 using the 2-, 10-, 25- and 100-year return period storms of 1-, 2-, 6- and 24-hour durations (see

Table 17). Boundaries, junction locations and input parameters determined for the watersheds established above junction 7 were identical to those selected for pre- and postmining analysis (see "Coal Mine Wash Pre- and Postmining Sediment Yield Estimates").

Discharge and sediment results from junction 7 were calculated to tons per day sediment values using the relationship:

$$\text{Tons/Day} = Q_p \times C_p \times k$$

where,

Q_p = peak discharge (cfs)

C_p = peak sediment concentration (mg/l)

and,

k = is a constant (.0027) for converting English units to tons per day and assumes a specific weight of 2.65 for sediment.

Predicted peak discharge and corresponding tons/day calculations are presented in Table 28c.

Measured discharge and sediment data monitored at Stream Station 16 during 1985 were converted to tons per day values and are presented in Table 28d. These data were analyzed using all sediment samples obtained during each flow event (see Automated Site Sediment Analysis). Measured data values, along with SEDIMOT II predicted values, have been plotted on the Sediment Rating Graph for Site 16 (see Figure 42).

Least-squares equations defining the "best-fit" lines through each set of data were calculated after transforming each discharge and sediment value into logarithms. The calculated equations are as follows:

$$\log y = 2.66 + 1.07 (\log x) \quad \text{(SEDIMOT II predicted values)}$$

$$\log y = 2.36 + 1.23 (\log x) \quad \text{(Measured values at Site 16 (1985))}$$

Straight lines defining each equation have been constructed on Figure 42, and are labeled accordingly.

SEDIMOT II sediment yield estimates using the MUSLE sediment subroutine do not account for deposition or channel contributions to sediment loading due to scour. Obviously, measured

TABLE 28c

Peak Discharges and Sediment Yields (tons/day)

Predicted Using SEDIMOT II at Stream Station 16

Storm	Peak Discharge (cfs)	Sediment Yield (tons/day)
2-yr, 1-hr	69	47,701
10-yr, 1-hr	788	605,664
25-yr, 1-hr	1518	1,245,601
100-yr, 1-hr	3024	2,691,730
2-yr, 2-hr	170	104,402
10-yr, 2-hr	1154	862,005
25-yr, 2-hr	2075	1,670,834
100-yr, 2-hr	3865	3,312,322
2-yr, 6-hr	488	296,830
10-yr, 6-hr	1859	1,300,721
25-yr, 6-hr	2858	2,117,697
100-yr, 6-hr	4883	3,945,474
2-yr, 24-hr	955	663,721
10-yr, 24-hr	2859	2,234,606
25-yr, 24-hr	3953	3,246,138
100-yr, 24-hr	6308	5,565,859

TABLE 28d

Discharges and Sediment Yields (tons/day)

Measured During 1985 at Stream Station 16

Flow Date	Discharge (cfs)	Sediment Yield (tons/day)
7/18/85	195	99,780
	159	81,843
	143	65,979
	87	32,557
	85	26,193
	66	15,615
	48	10,623
7/19/85	23	11,213
	17	7,420
	15	7,501
	15	7,309
	11.5	5,524
7/29/85 (Port 1)	124	102,436
	170	138,764
	250	248,285
	275	258,112
	85	73,936
	100	71,993
	115	110,873
	122	123,491
	118	108,819
	110	100,941
	98	93,597
	93	65,967
	89	61,029
	85	59,468
	52	34,255

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TABLE 28d (Cont.)

Discharges and Sediment Yields (tons/day)

Measured During 1985 at Stream Station 16

Flow Date	Discharge (cfs)	Sediment Yield (tons/day)
7/29/85 (Port 1) (cont.)	53.5	37,439
	54	43,713
	51	32,254
	53	32,106
7/29/85 (Port 2)	153	98,932
	75	60,396
	119	100,186
	121	124,439
	115	87,991
	96	84,509
	54	31,379
	50	25,012
	55	23,591

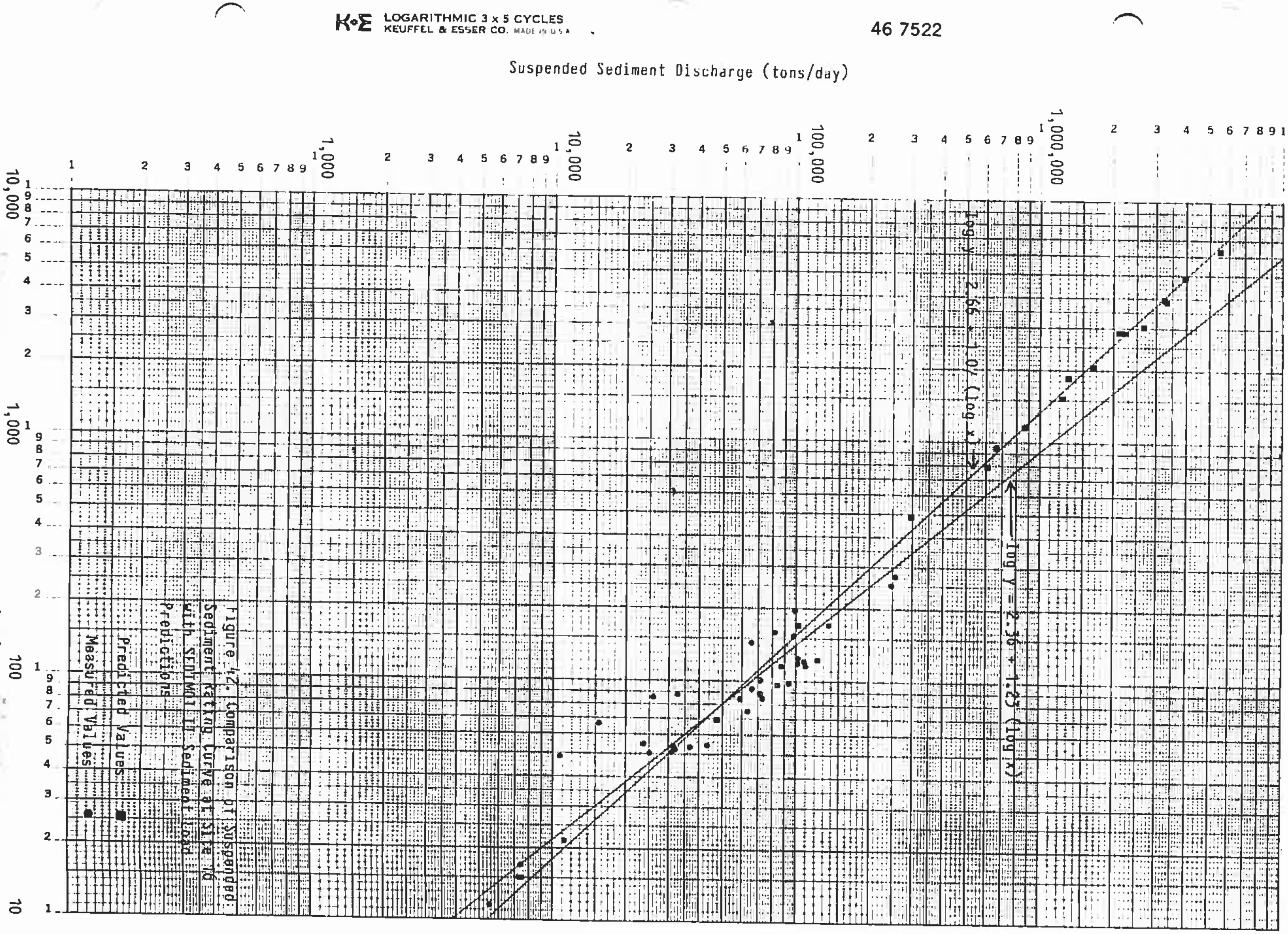


Figure 42. Comparison of Suspended Sediment Rating Curve at Site 16 with SEDIMOT II Sediment Load Predictions

sediment at Site 16 does reflect sediment contributions from the main, highly erodible channel. Assuming that SEDIMOT II values are representative of largely overland flow sediment contributions, it is inferred that the difference between the two lines at larger discharges is a measure of channel contributions to sediment load.

For discharges greater than 70 cfs, the separation between the two lines becomes pronounced. At 100 cfs, SEDIMOT II accounts for 96 percent of the measured load, which suggests that at low discharges, only 4 percent of the total sediment load is contributed from the main channel. For discharges of 1,000 and 3,000 cfs, SEDIMOT II accounts for 66 and 55 percent of the respective total sediment loads. This suggests that at higher discharges ($\geqq$ 1000 cfs), the active main channel in Coal Mine Wash could contribute from 34 to 45 percent of the total sediment load. Since Stream Station 16 is located well above mining operations, it can be concluded that natural contributions to sediment yields on Black Mesa from ephemeral channels may approach 45 percent for flow in the range of 1,000 to 3,000 cfs.

Surface-Water Quality Analysis. Stream water quality monitoring has been conducted from September, 1980 to the present. Chemical analysis of this water indicates that the dominant dissolved ions are calcium, magnesium, sometimes sodium, bicarbonate and sulfate. Trilinear diagrams showing plots of average values for the major ions by drainage are presented in Figures 43 through 50.

While the dominant water types are calcium-magnesium sulfate and calcium-magnesium bicarbonate, significant variability is apparent at each site. This variability can be largely attributed to the time of year the runoff occurs. Those events sampled from late fall through late spring are usually the result of light, persistent frontal storm events and are generally infrequent. During the sometimes extensive dry periods between storms, the more soluble ions (sodium, bicarbonate, calcium and magnesium) are concentrated near the soil surface by evaporation and capillary action. Subsequent runoff producing precipitation or snowmelt dissolves this residue which adds to the total dissolved solids (TDS) of the water.

The runoff events during these time periods tend to occur at a slower rate and over a longer period of time thus enhancing the dissolution potential. Simply stated, dissolution is enhanced by the relatively long period of interaction between the water and mineral sources, adding further to the TDS content of the runoff.

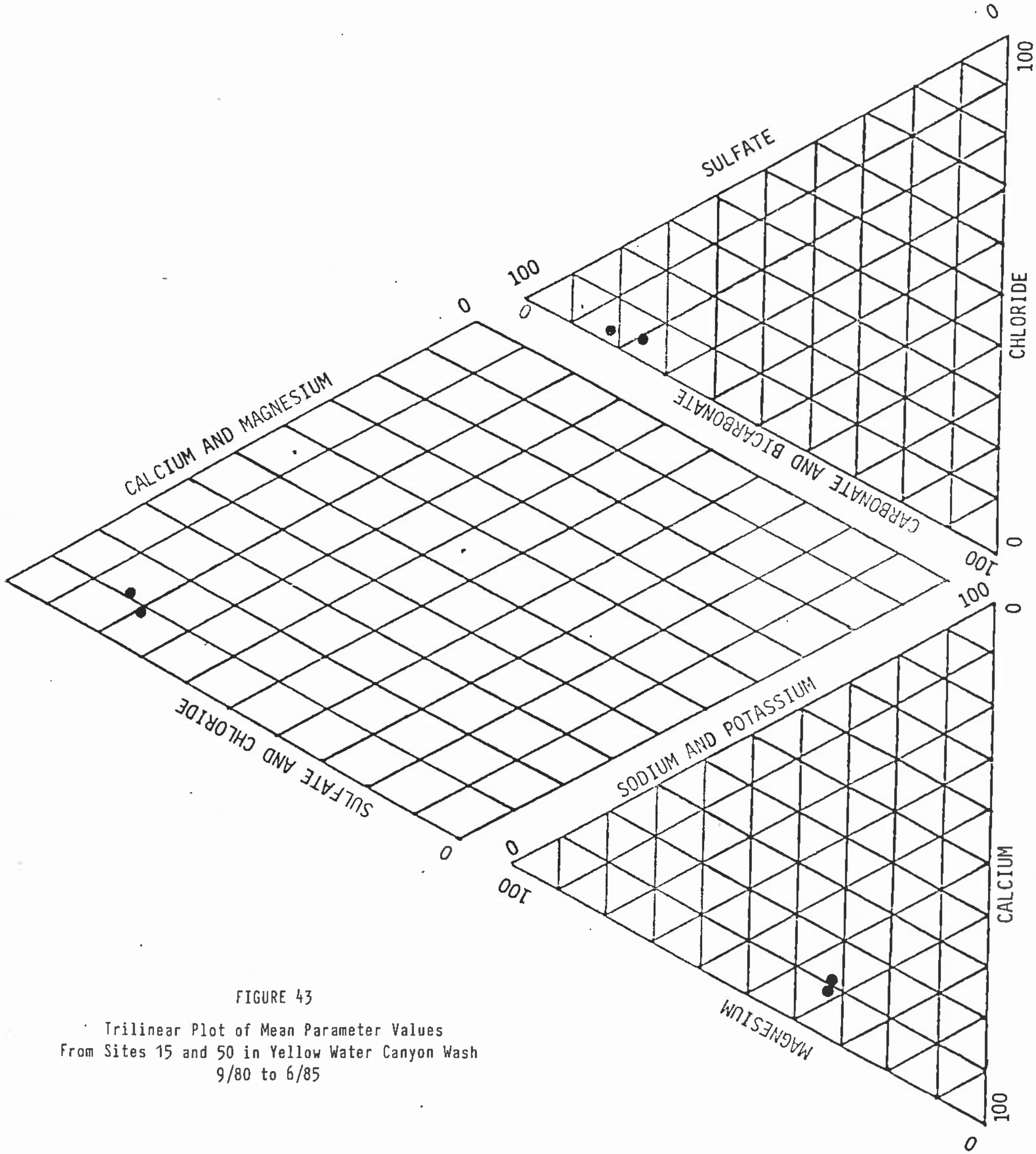


FIGURE 43

Trilinear Plot of Mean Parameter Values
From Sites 15 and 50 in Yellow Water Canyon Wash
9/80 to 6/85

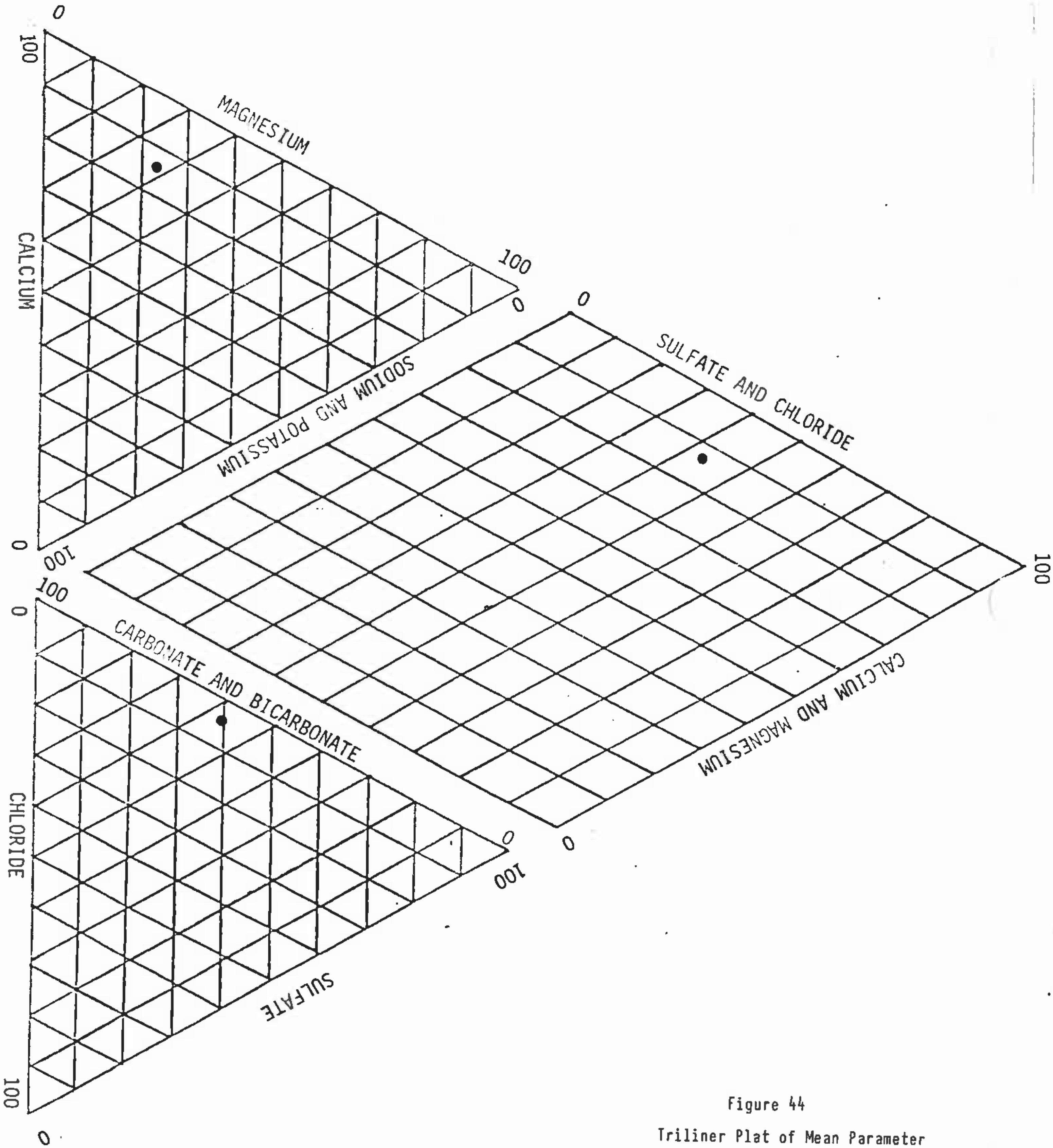


Figure 44

Triliner Plat of Mean Parameter

Values From Site 157 in Yazzie Wash

9/30 to 6/85

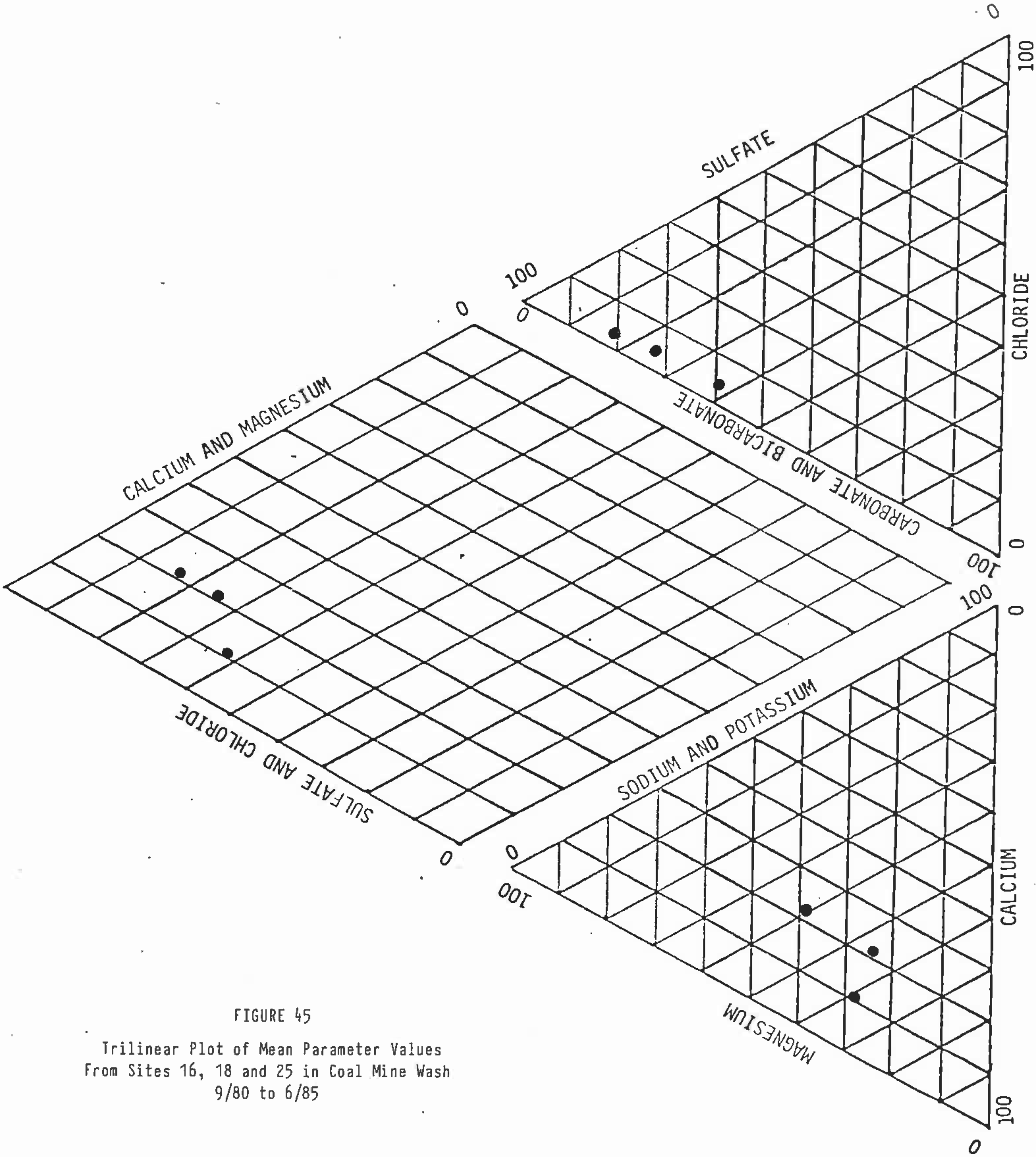


FIGURE 45

Trilinear Plot of Mean Parameter Values
From Sites 16, 18 and 25 in Coal Mine Wash
9/80 to 6/85

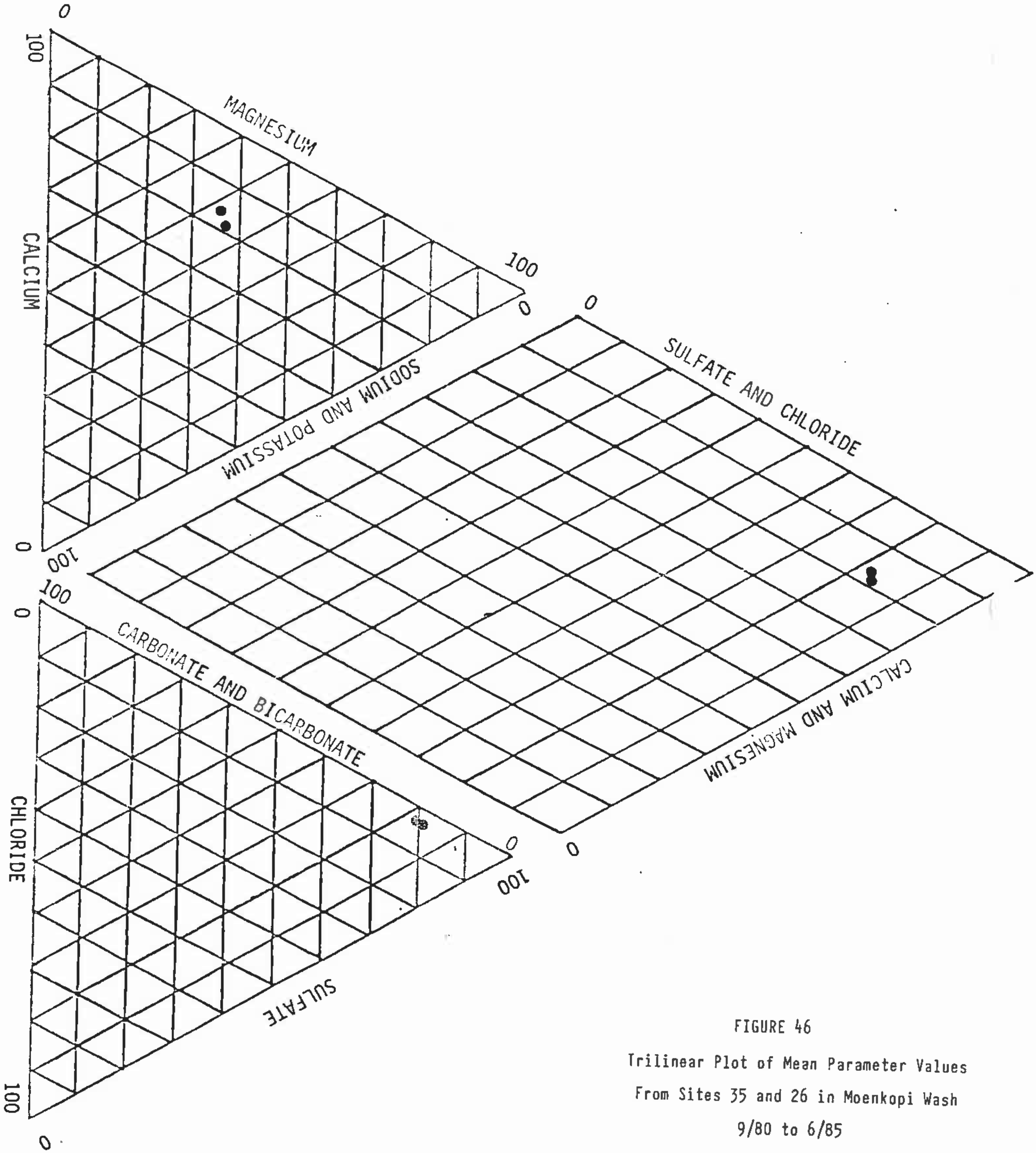


FIGURE 46

Trilinear Plot of Mean Parameter Values

From Sites 35 and 26 in Moenkopi Wash

9/80 to 6/85

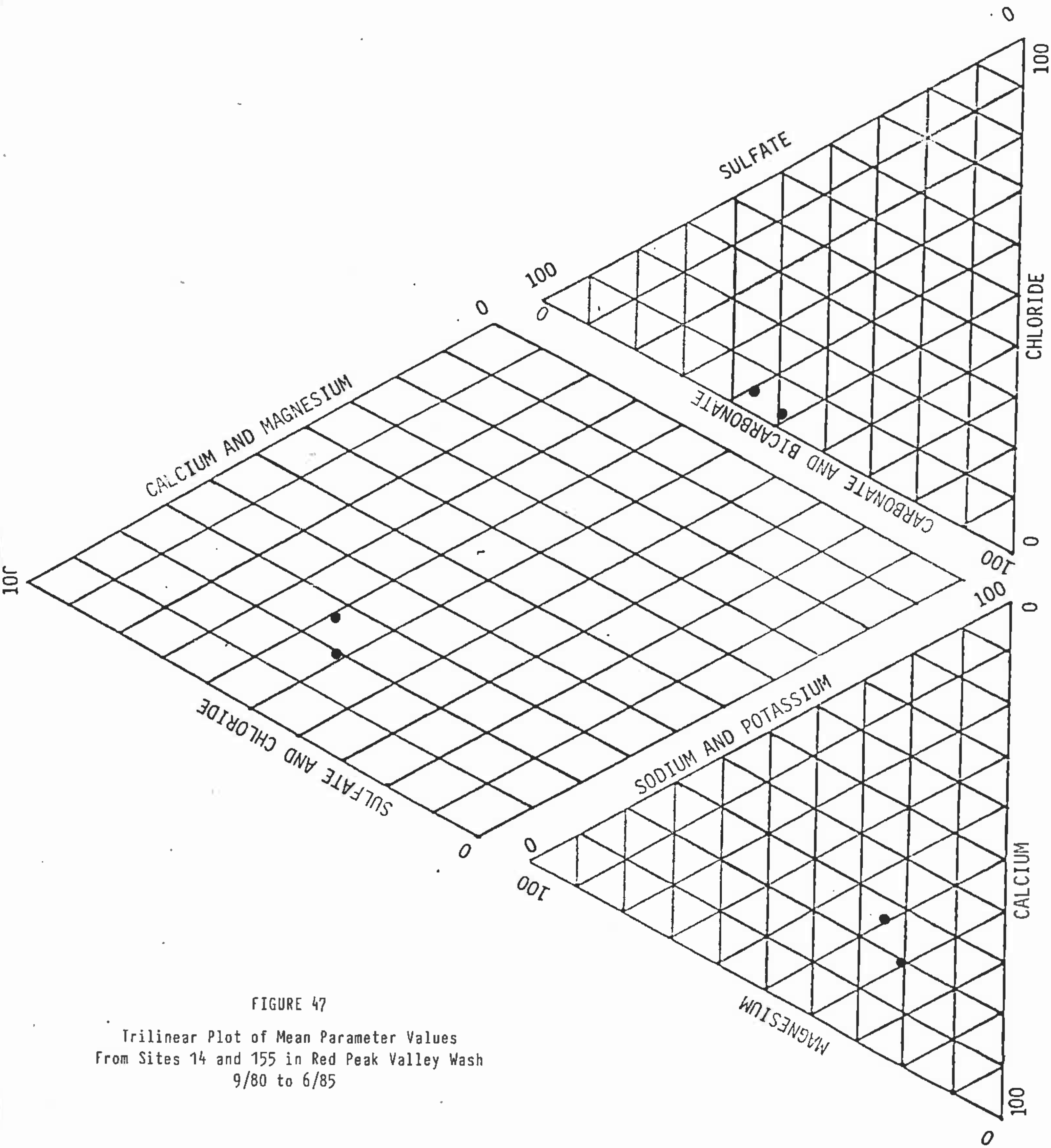


FIGURE 47

Trilinear Plot of Mean Parameter Values
From Sites 14 and 155 in Red Peak Valley Wash
9/80 to 6/85

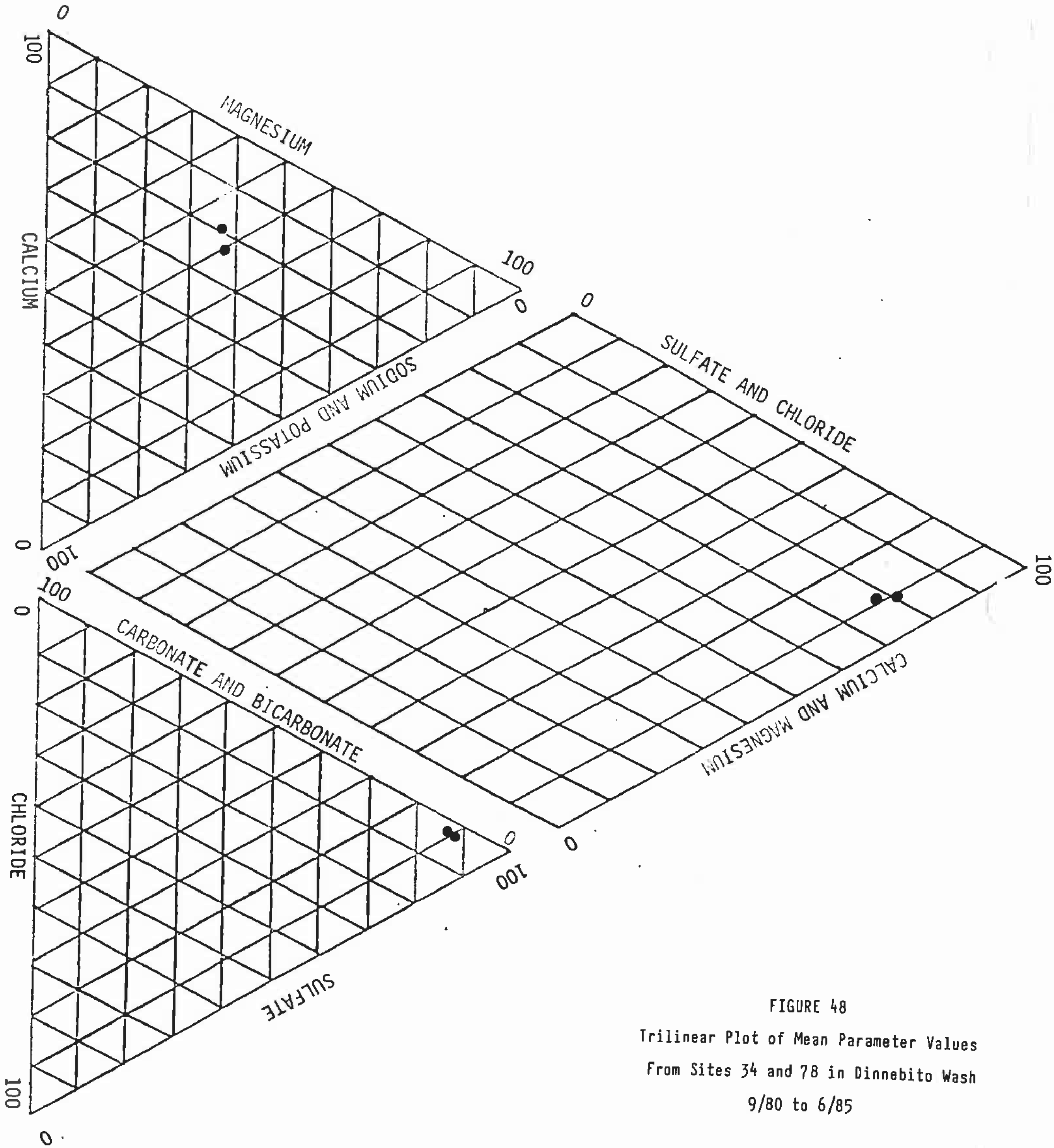


FIGURE 48

Trilinear Plot of Mean Parameter Values
From Sites 34 and 78 in Dinnebito Wash
9/80 to 6/85

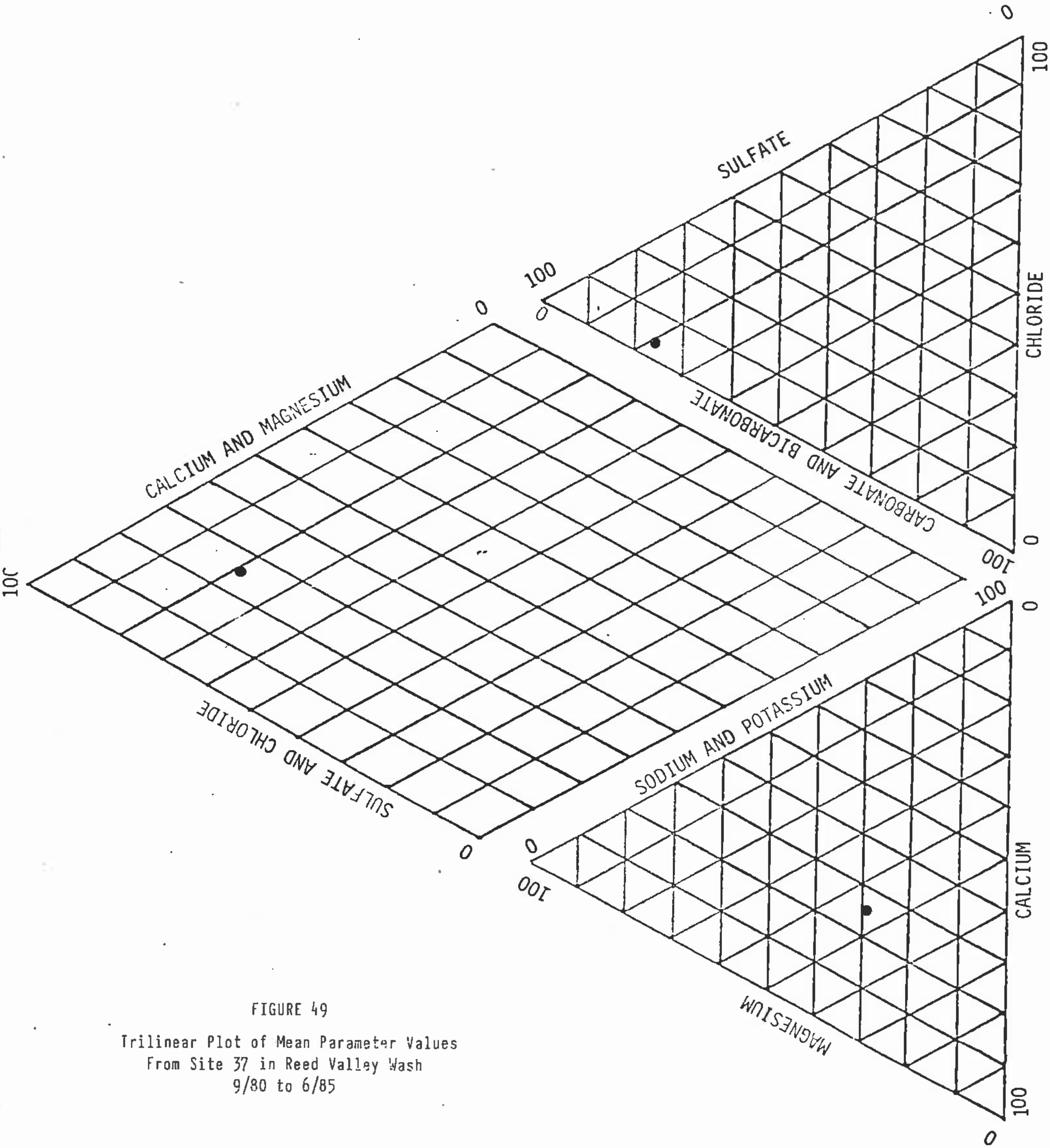


FIGURE 49

Trilinear Plot of Mean Parameter Values
From Site 37 in Reed Valley Wash
9/80 to 6/85

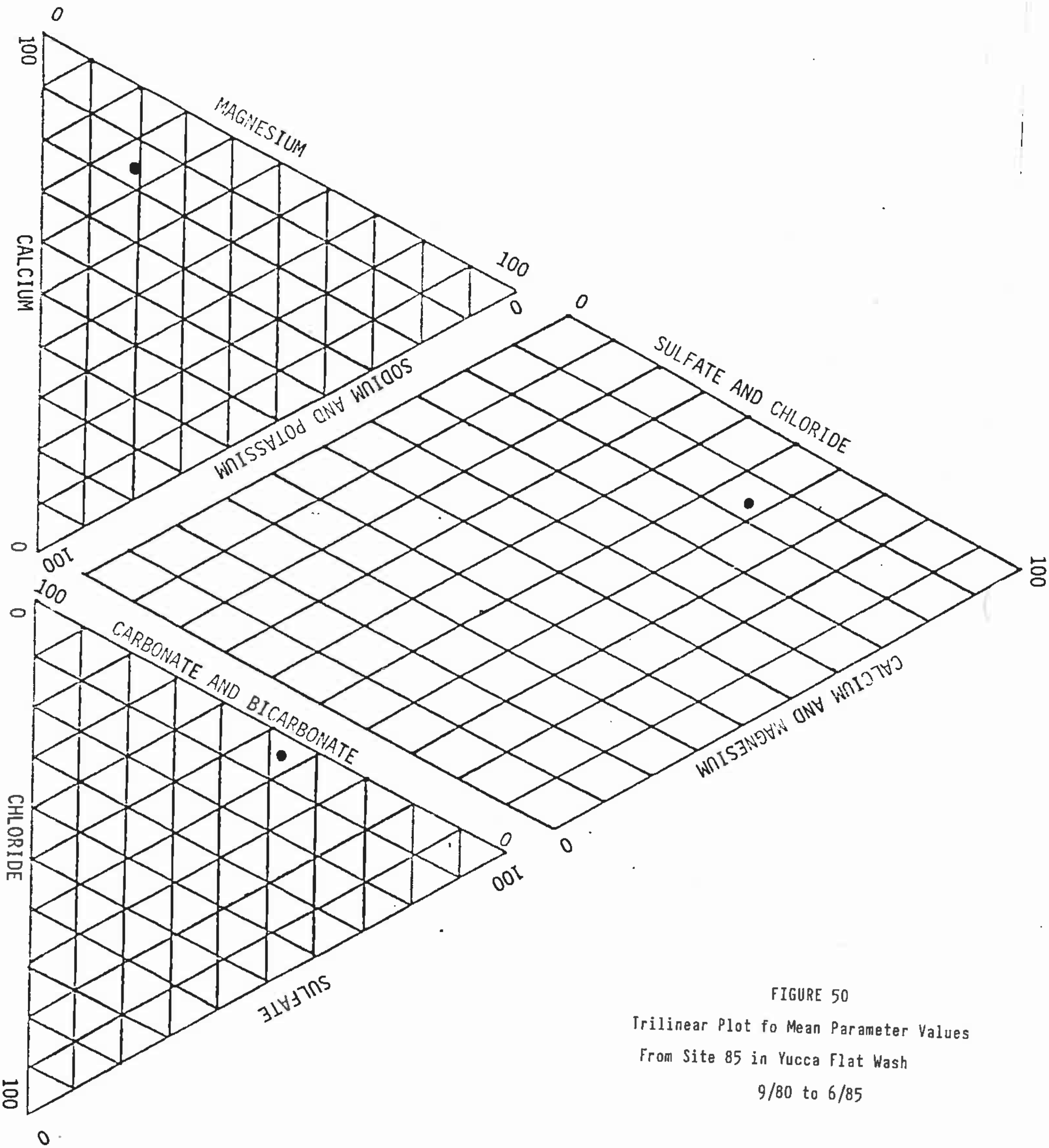


FIGURE 50

Trilinear Plot fo Mean Parameter Values
From Site 85 in Yucca Flat Wash
9/80 to 6/85

During the summer and early fall, precipitation is monsoonal in nature. Storms are commonly brief, intense and involve smaller portions of watersheds than those previously described. Resulting flows can be classified as flash floods of varying magnitude. Because these flows last a shorter period of time, interaction of the water with mineral sources is limited and TDS concentrations are reduced. Table 29 demonstrates this relationship by showing TDS values associated with flows from the different seasons of the year.

Another related factor controlling stream flow water quality is the suspended sediment concentration expressed as total suspended solids (TSS). TSS can generally be directly related to discharge. That is, as the flow discharge in cubic feet per second increases so does the TSS concentration. Table 29 shows this relationship.

Suspended sediment impacts stream water quality by virtue of its ability to selectively absorb chemical constituents thereby removing them from solution. This property is known as cation exchange capacity (CEC). CEC increases with decreasing particle size so that silts and clays exercise the greatest effect on water quality. Small organic particles, such as leaf fragments, also exhibit this property. Table 30 shows the cation exchange capacities and particle size distributions of samples collected from two drainages on Peabody's lease. The absorption of ions from solution acts to reduce the TDS concentration in runoff. Also, as the TSS of a flow increases with increasing discharge, the effect of cation exchange is amplified. This results in the relationship of TSS to TDS depicted graphically in Figures 51 and 52. In general, as discharge increases, both TSS and TDS increase. However, due to the mechanism of cation exchange, TSS increases much more rapidly and, while the total chemical load of the flow is conserved, the proportion of the total chemical load that is dissolved is less than that occurring in lower flows.

Several additional interrelated factors can affect runoff water quality either directly or indirectly. The most obvious is the nature of surface materials in a particular drainage basin. For example, Site 157 (Yazzie Wash) is located at the mouth of a watershed which contains a proportionally large amount of exposed sandstone. Water sampled here is commonly high in the ion pair calcium-bicarbonate. Other watersheds whose channels truncate coal seams yield runoff which is high in iron and sulfate.

Another factor affecting water quality is the distance between the monitoring site and the point of origin of runoff. Flows which originate close to the sampling point are more

TABLE 29

Selected Flows and Associated TDS & TSS

Concentrations From All Stream Monitoring Sites

Site	Drainage	Date	TDS (Mg/l)	TSS (Mg/l)	Discharge (CFS)
14	Red Peak	11/14/80	3700	16	0.004
		02/10/81	3514	1	0.15
		08/23/82	225	28570	11.0
		08/25/82	283	38950	20.0
		08/11/83	292	21470	288.0
		09/29/83	728	9720	23.2
		08/13/84	202	58000	385.0
		10/12/84	140	4580	10.7
15	Yellow Water	09/08/80	1017	90280	140.0
		04/14/81	6102	1490	1.2
		07/12/81	445	15433	142.0
		03/15/82	4401	496	0.3
		08/27/82	1635	156050	24.0
		08/09/83	1472	137600	141
		09/30/83	956	18270	6.0
		07/21/84	2310	37210	7.9
		08/21/84	308	37900	3.8
16	Coal Mine	05/05/82	383	11280	0.134
		08/23/82	567	46730	500.0
		09/27/82	274	81	12.0
		07/23/83	648	44865	597.0
		09/29/83	366	16400	4.1
		07/23/84	410	57900	3300.0
		09/16/84	296	34800	55.0
18	Coal Mine	09/08/80	672	23800	350.0
		02/10/81	7484	2	0.09
		08/25/82	673	930	1.7
		08/11/83	334	12520	22.0
		9/30/83	1228	35850	4.2
25	Coal Mine	11/13/80	3439	24	1.05

TABLE 29 (Cont.)

Selected Flows and Associated TDS & TSS

Concentrations From All Stream Monitoring Sites

Site	Drainage	Date	TDS (Mg/l)	TSS (Mg/l)	Discharge (CFS)
25	Coal Mine	02/19/82	1093	4043	20.0
		08/08/82	1676	17925	205.0
		09/30/83	1008	9530	49.8
		07/27/84	560	45500	980.0
26	Moenkopi	11/12/80	3574	7	0.21
		08/23/82	1772	57540	190.0
		08/11/83	677	54340	249.0
		09/30/83	1016	4520	138.0
34	Dinnebito	07/21/81	1836	3204	N/A
		08/23/82	788	77040	N/A
		07/16/84	688	128000	6.6
		08/27/84	1740	146000	175.0
37	Reed Valley	07/22/82	2361	28450	0.36
		08/25/82	1019	99400	17.0
		08/11/83	224	61300	303.0
		09/23/83	586	10960	2.0
		07/16/84	856	62500	500.0
		09/01/84	723	173000	240.0
35	Moenkopi	09/09/80	2612	54500	1350.0
		05/05/82	4456	7293	0.135
		07/08/83	390	176000	98.0
		09/29/83	556	4060	22.0
		06/30/84	1406	10550	1.6
50	Yellow Water	04/14/81	2393	2400	0.8
		08/23/82	468	84020	33.0
		09/27/82	376	79	18.0
		07/08/83	6620	994000	960.0
		09/29/83	1096	3750	583.0
		04/09/84	824	15770	0.2
		08/21/84	692	36600	45.0

TABLE 29 (Cont.)

Selected Flows and Associated TDS & TSS

Concentrations From All Stream Monitoring Sites

Site	Drainage	Date	TDS (Mg/l)	TSS (Mg/l)	Discharge (CFS)
78	Dinnebito	05/05/82	6564	12520	1.4
		08/12/82	1119	128250	384.0
		08/11/83	1238	100960	137.0
		09/30/83	1112	44750	557.0
		08/27/84	396	20300	9.0
85	Yucca Flat	02/19/82	2923	303	6.0
		08/23/82	187	13780	470.0
		09/30/83	814	19490	583.0
		08/05/84	138	36100	1300.0
157	Yazzie	08/10/83	225	13330	1.3
		09/28/83	282	3660	11.0
		09/30/83	294	5374	16.5
		07/21/84	160	46690	4.1
		07/27/84	180	59200	27.4
155	Red Peak	09/28/83	358	29760	79.4
		07/26/84	350	48800	12.1
		08/05/84	180	52300	343.0

TABLE 30

Cation Exchange Capacities (C.E.C.)

And Particle Size Analysis of Streamflow TSS

Site #	Location	Date	Sampler	Sand		Silt		Clay	
				% By Wt.	C.E.C.	% By Wt.	C.E.C.	% By Wt.	C.E.C.
15	Yellow Water	9/29/83	1	10.30	7.63	43.60	8.33	46.10	24.67
15	Yellow Water	9/30/83	1	16.30	1.96	46.40	5.65	37.30	25.82
15	Yellow Water	9/30/83	2	33.00	2.60	36.90	6.93	30.10	20.12
16	Coal Mine	9/30/83	1	34.90	3.49	37.80	7.30	27.30	23.63
16	Coal Mine	9/30/83	2	50.40	6.37	24.60	8.00	25.00	16.84
16	Coal Mine	9/30/83	3	48.30	1.65	26.40	6.02	25.30	29.69

Note: C.E.C. was determined by sodium saturation of prepared fractions and is presented as Meq Sodium per 100 grams of sample.

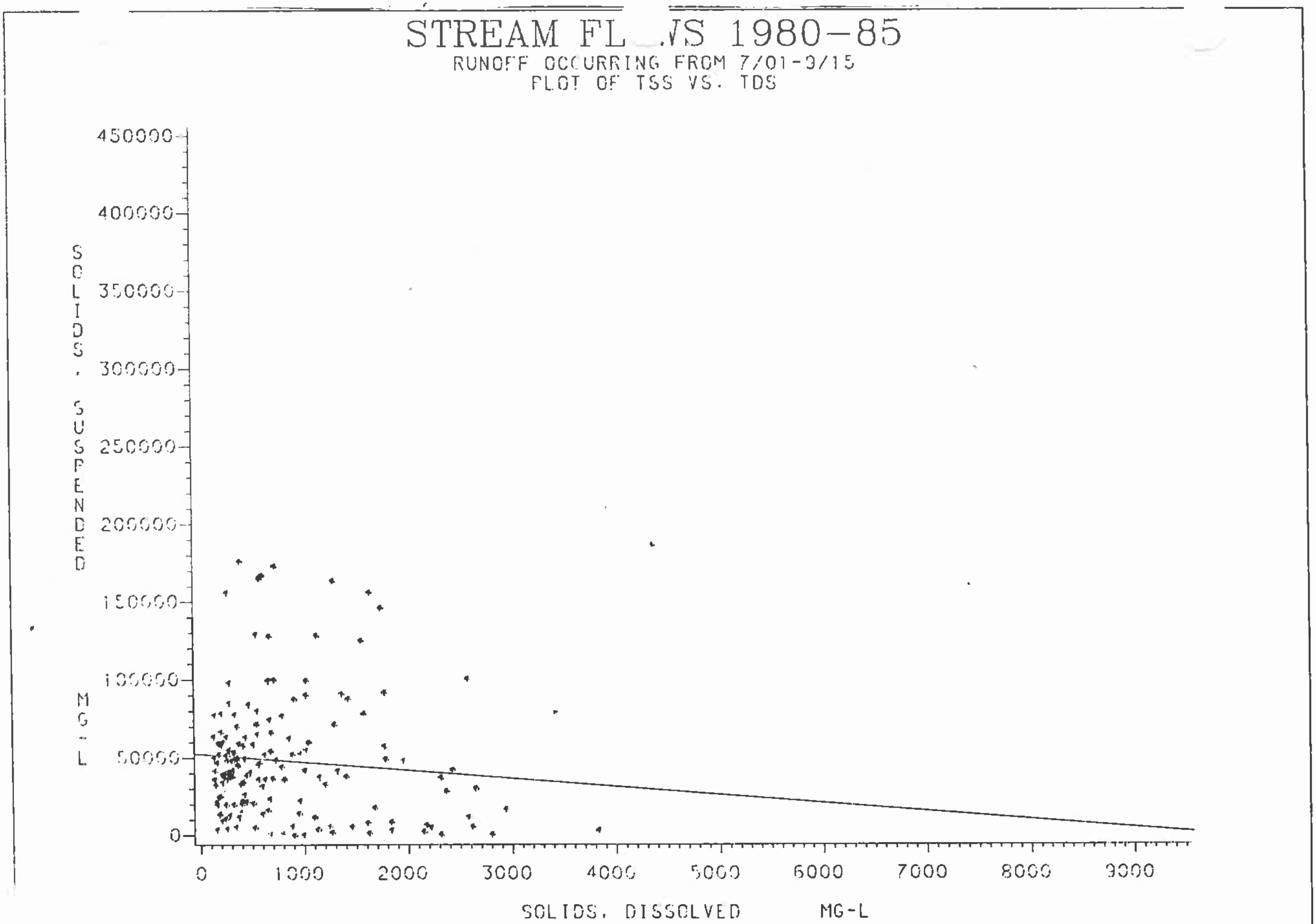


FIGURE 51

Relation Between TSS and TDS For Stream Flows

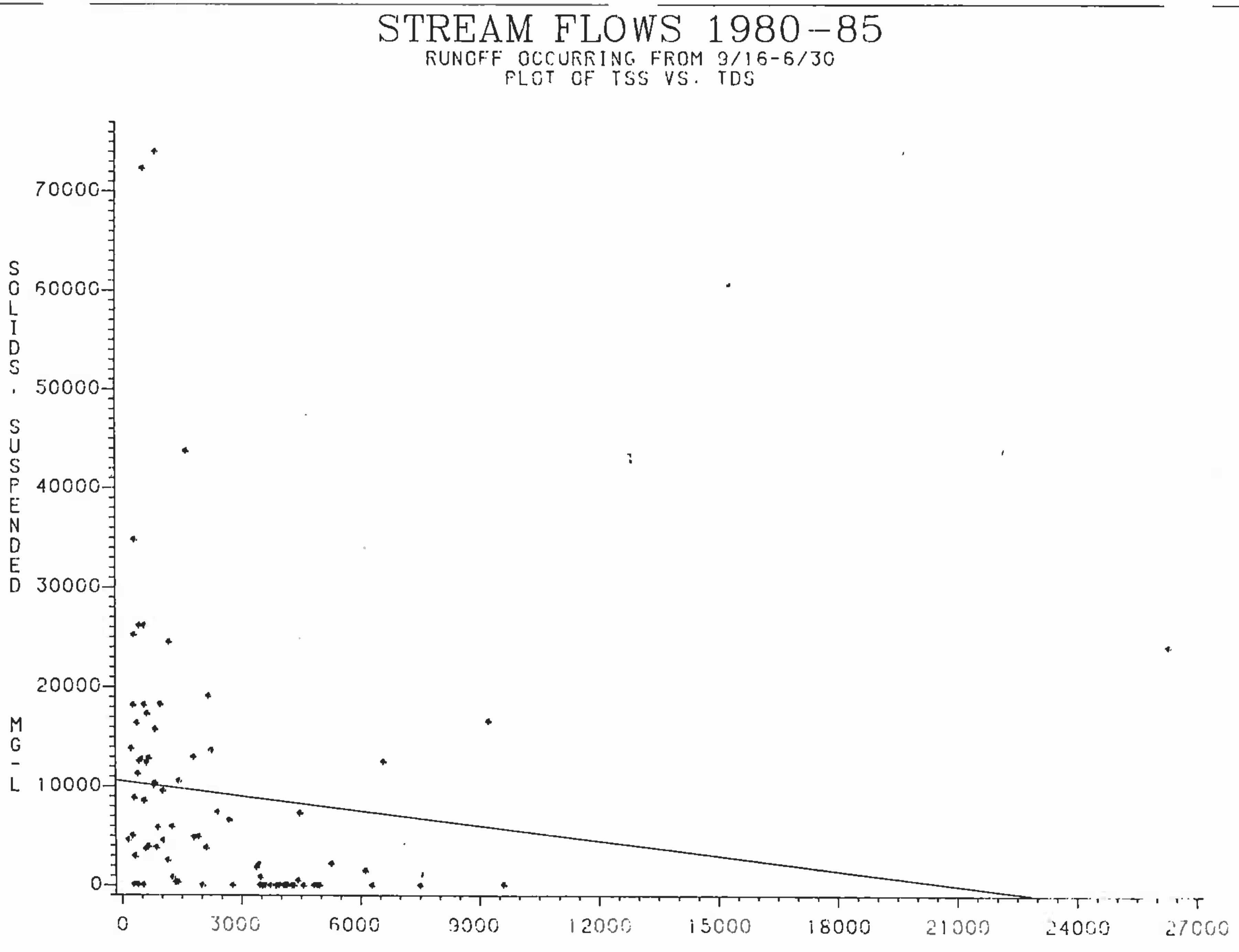


FIGURE 52

Relation Between TSS and TDS For Stream Flows dilute than those traveling longer distances. This accounts for a significant portion of the observed water quality variation at a given site.

The relationship of sample acquisition to peak discharge also affects the observed water quality. A sample obtained prior to or following the peak represents water which may have been flowing at a lower rate and/or originated at a different location than water sampled at the peak. Commonly, runoff has a much higher TSS and lower TDS prior to the flow peak than after.

All of the above factors are related to the precipitation characteristics responsible for runoff. The temperature of runoff also controls the amount of dissolved constituents it can carry. As temperatures decrease, the solubilities of individual constituents also decrease. The effect of this relationship is that with all variables held constant, varying the water temperature will vary TDS concentration.

One final variable which can affect runoff water quality is man-caused disturbance. When a channel is realigned, as in the case of Coal Mine Wash and Yazzie Wash, fresh mineral sources are exposed. In addition, the rearranged channels usually have slightly higher transport velocities and, therefore, are subject to greater erosion initially. This results in increased sediment and chemical loads of subsequent runoff. The sediment load increase is temporary and has not changed the water use potential.

A statistical summary of selected parameters for the Peabody stream monitoring sites is presented in Attachment 5. In addition, water quality maps showing mean concentrations of several parameters by site are presented in the 1980-1981, 1981-1982, 1983 and 1984 Hydrological Data Reports.

The USGS monitored local runoff quality on Black Mesa from 1971 through 1976. Figures 53 through 56 show trilinear plots of data from USGS stations together with data from nearby Peabody stream monitoring sites. In almost all cases, the two data sets agree closely in defining water types and dominant ions. In the case of Figure 53, the variation may be explained by water temperature differences at the time of sampling. The USGS samples shown had temperatures of 1° and 4° C, respectively, while the Peabody samples were both 17° C. Temperature affects solubility such that at lower temperatures the least soluble species (calcium and magnesium) precipitate out of the solution, leaving higher proportions of more soluble constituents (sodium and potassium). In addition, the USGS has monitored water quality periodically at several locations off the leasehold from 1972 to 1981. A summary of this surface water quality data is presented in Attachment 6.

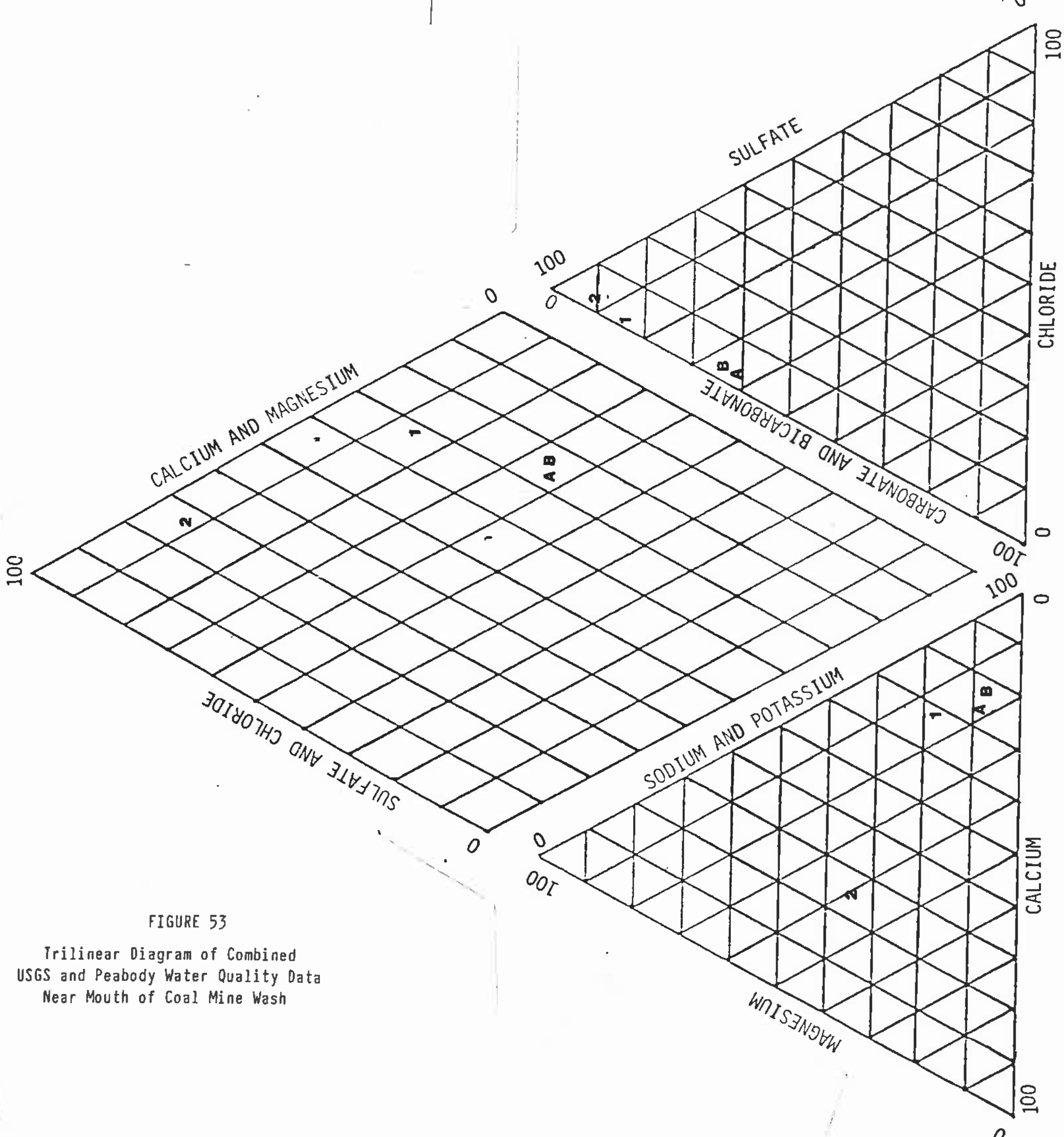


FIGURE 53

Trilinear Diagram of Combined
USGS and Peabody Water Quality Data
Near Mouth of Coal Mine Wash

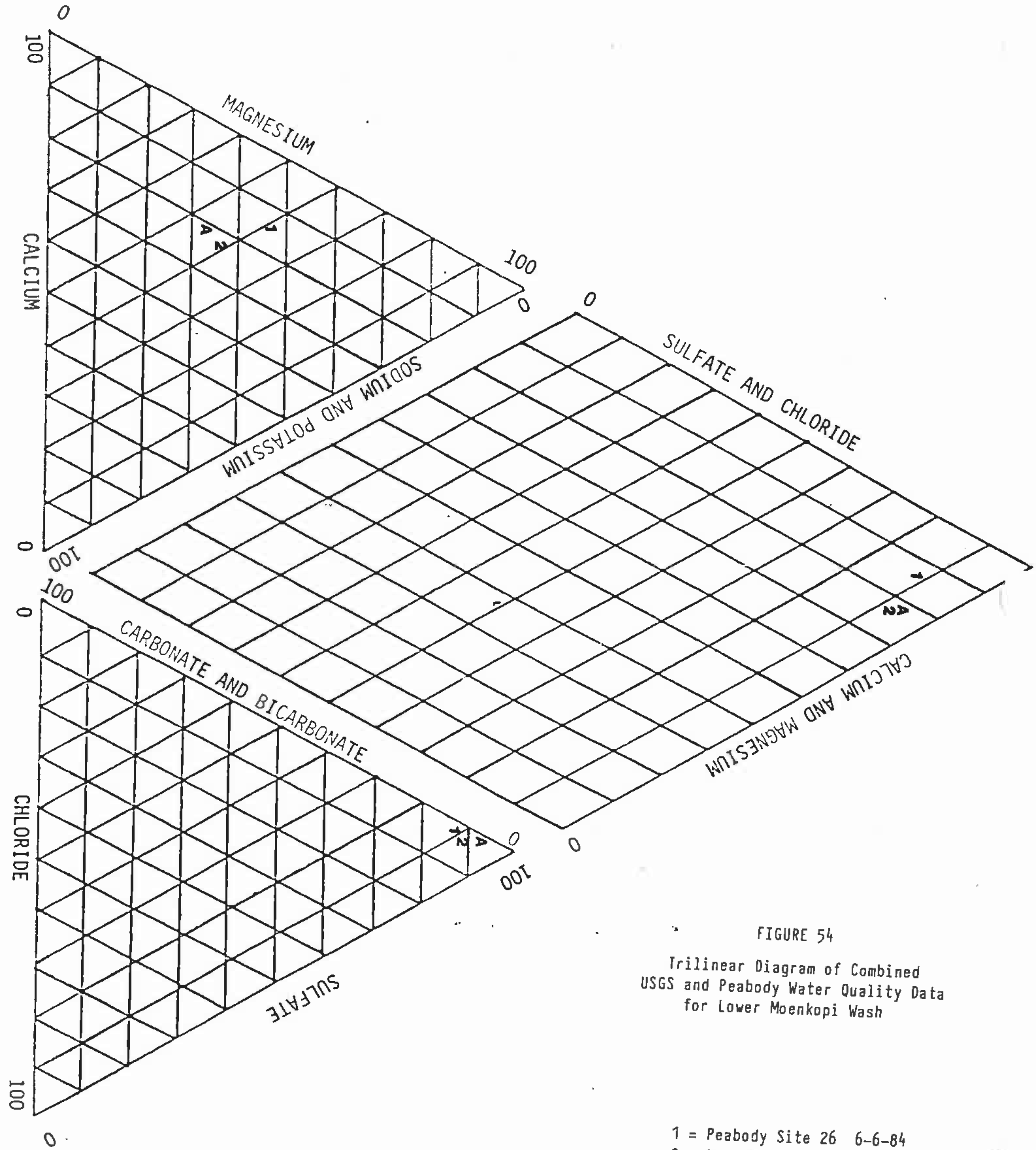


FIGURE 54

Trilinear Diagram of Combined
USGS and Peabody Water Quality Data
for Lower Moenkopi Wash

1 = Peabody Site 26 6-6-84
2 = Peabody Site 26 5-15-85
A = USGS Site 362728110234200 11-10-71

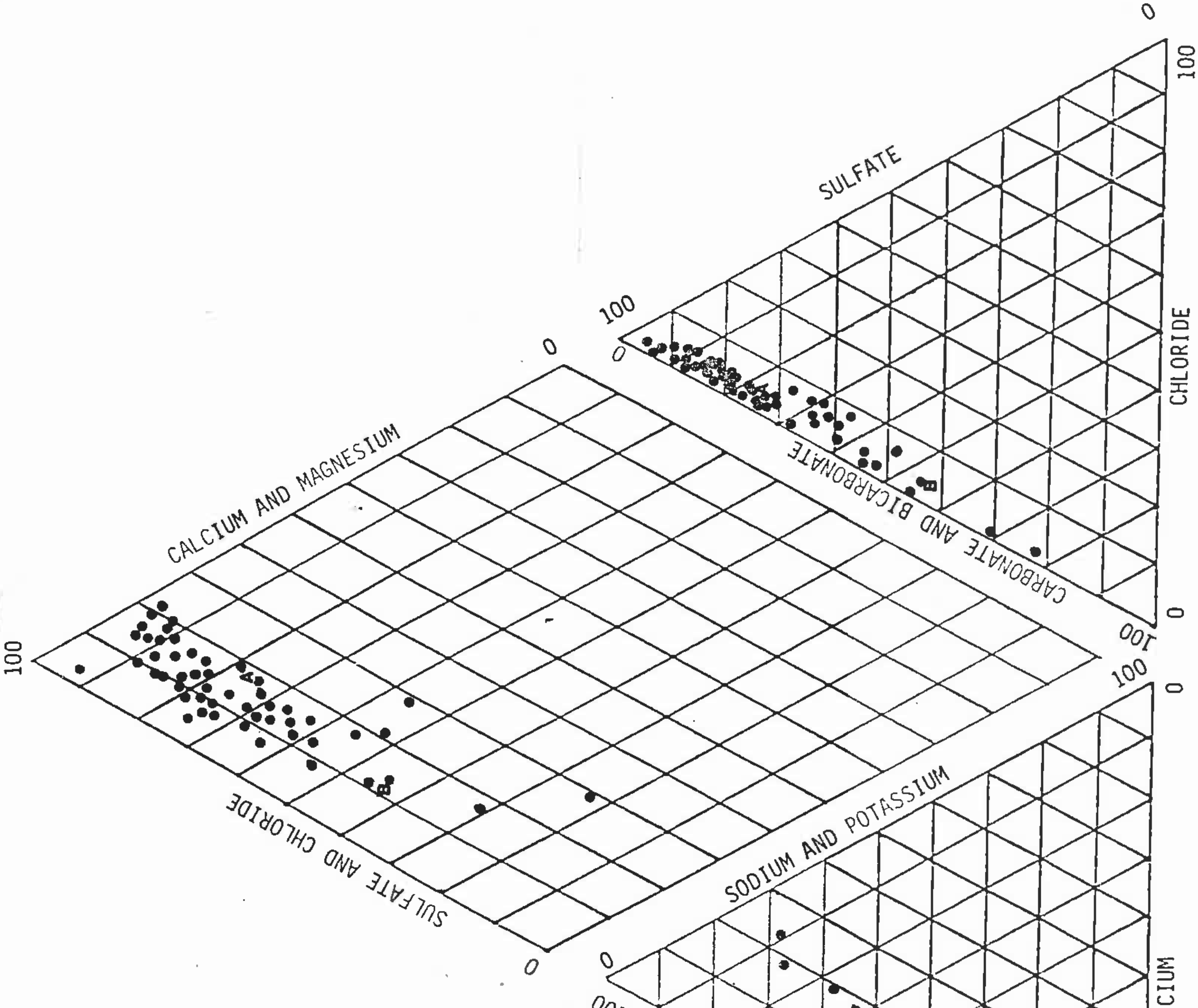


FIGURE 55

Trilinear Diagram of Combined
USGS and Peabody Water Quality Data
For Yellow Water Canyon Wash

. = Peabody Site 14 1980-1984
A = USGS Site 09401236 7-15-75
B = USGS Site 363243110252200 7-15-75

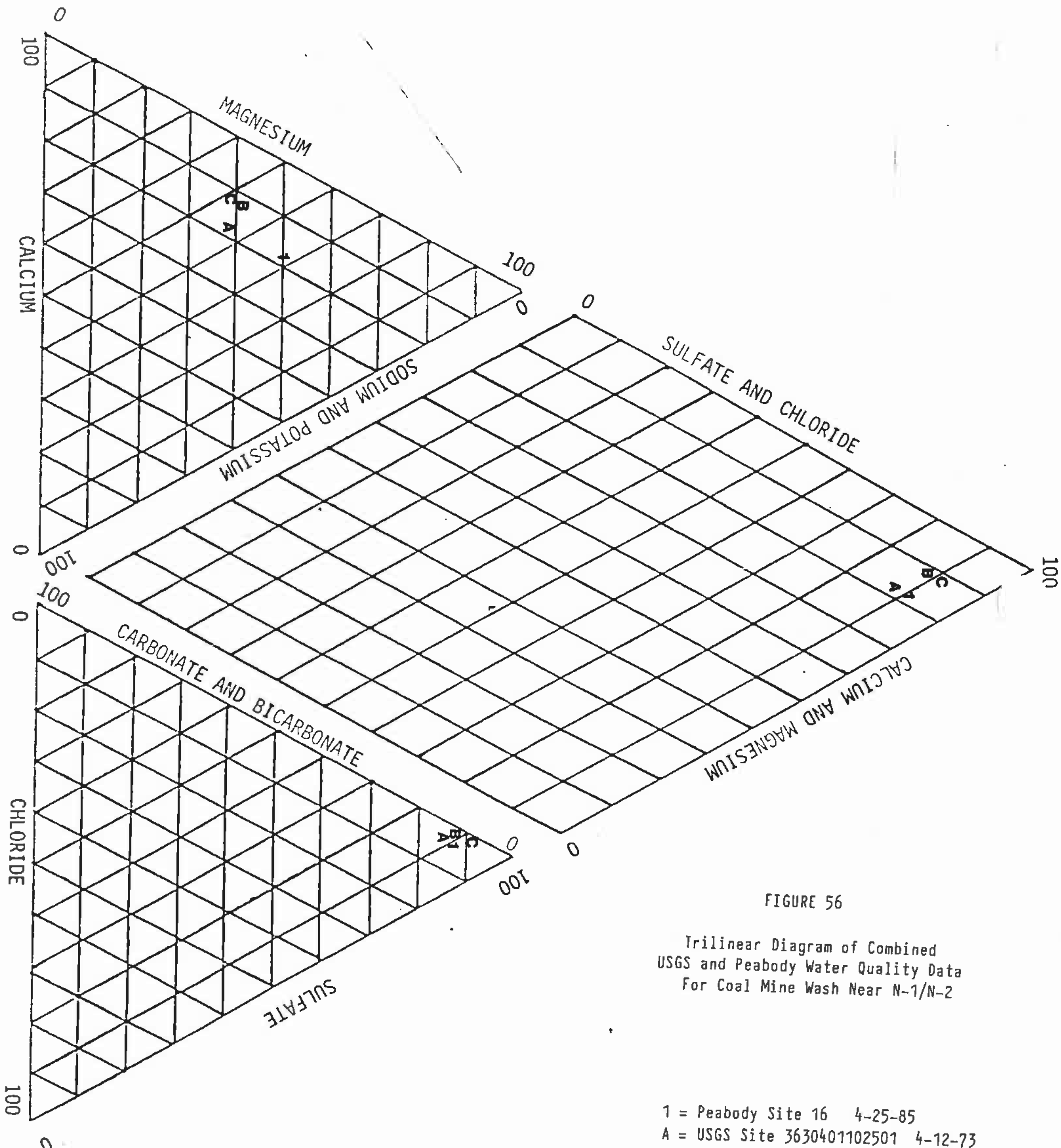


FIGURE 56

Trilinear Diagram of Combined
USGS and Peabody Water Quality Data
For Coal Mine Wash Near N-1/N-2

1 = Peabody Site 16   4-25-85
A = USGS Site 363040110250l   4-12-73
B = USGS Site 363142110243200   1-21-75
C = USGS Site 363142110243200   11-6-75

Ground-Water Hydrology Of The Mine Site And Adjacent Areas

Ground Water in the Wepo Formation. As reported by Repenning and Page (1956), three distinct formations have been recognized and mapped in the Mesaverde Group of Black Mesa. They are, in ascending order, the Toreva Formation, the Wepo Formation, and the Yale Point Sandstone.

Of these, the Wepo Formation contains all coal mined by Peabody Coal Company. Any disturbance to the ground-water system from mining activities will be confined to the Wepo aquifer system and any hydraulically connected alluvial aquifers.

O'Sullivan, et al. (1972), mention that the thickness of the Wepo Formation ranges from 743 feet east of Cow Springs to 318 feet near Rough Rock. The formation thins northeast across Black Mesa and intertongues with the underlying Toreva Formation and the overlying Yale Point Sandstone.

The Wepo Formation consists of a thick sequence of intercalated siltstone, mudstone, sandstone and coal. The siltstone and mudstone units are carbonaceous in many areas and do contain some sandstone lenses. The sandstone units are composed of poorly sorted, fine to very coarse quartz grains. The degree of cemetation of the quartz grains varies from weakly to firmly cemented. The weakly cemented sandstone beds have high percentages of silt, and the thicker sandstone beds tend to have conglomeratic bases of chert and silicified limestone pebbles. Coal beds are usually interbedded with siltstone and shale. A hard-baked shale is formed where these beds have burned in the past. This baked shale, or "clinker", is a probable pathway of recharge to the Wepo aquifer, especially where this material is highly fractured and weathered.

The sequence of beds characterizing the Wepo Formation is composed mainly of continental shale and sandstone, but includes some marine sandstone. Most of the Wepo Formation was deposited during a regressive stage of the continental Cretaceous Sea which bordered the region to the east. These predominantly fluvial deposits contrast with the near shore sandstone units of the Toreva Formation. Except for a few marine sandstone lenses in its northern extent which reflect minor transgressions of the sea, the Wepo consists of continental fluvial and paludal deposits.

Structural features of the Wepo Formation within the leasehold are characterized by gentle folding (monoclines, anticlines and synclines). This moderate deformation occurred during the Laramide Orogeny of late Cretaceous and early Tertiary time. During late Tertiary and Quaternary time, the region was locally upwarped and faulted (Cooley et al. 1969).

Principal structural features for the Black Mesa and adjacent areas are shown in Figure 57 The Oljeto syncline is the most pronounced structural feature running through the Black Mesa leasehold. More site specific detailed structural mapping of the area was performed by Intrasearch, Inc. Their work indicated the presence of several smaller synclines and anticlines throughout the leasehold, as well as small linear features such as faults and fractures. These structural features are predominantly oriented in a northeast to southwest direction, indicative of deformation resulting from the compressional and tensional forces generated during the Laramide Orogeny.

The thickness of the Wepo aquifer varies across the leasehold and the lower portion of the unit often intertongues with the upper member of the Toreva Formation. As a consequence of this, the contact between the two formations is variable and difficult to clearly define. Depending on where in the Wepo Formation (i.e. middle or bottom coal sequence) mining occurred, it was necessary to partially complete monitoring wells in the upper Toreva to insure monitoring of ground water beneath the lowest mineable coal seam. This appears to have occurred at Well 42, 49, 54 and 59. Lithologic, transmissivity and water quality data supporting this conclusion are discussed in the following sections.

Wepo Aquifer Monitoring. A network of 31 monitoring wells was installed during 1979 and 1980 to obtain water level, water quality and aquifer parameter information for the Wepo aquifer (Drawing No. 85600). Criteria for locating the wells, drilling and completion information is detailed in Chapter 16, "Hydrological Monitoring Program". Between 1980 and the present, water level monitoring has been on at least a monthly basis for all wells. In addition, approximately 80 percent (see Figure 58) of the wells have been monitored continuously for water levels during part of or all of the last six years. The continuous monitoring has allowed for better resolution of recharge, discharge and response times of the Wepo aquifer to these storage changes. In the future, continuous monitoring will be replaced with monthly and quarterly monitoring.

In October 1985, two additional Wepo monitoring wells (63R and 64R, Drawing No. 85600) were drilled and completed to replace Wepo Wells 63 and 64 for monitoring water levels in the vicinity of the J21 and J19 pits. The replacement wells were added because Wells 63 and 64 were giving anamolously low water level reading. The geology and structure in this portion of the leasehold (numerous folds, faults and buried channels) lends itself to

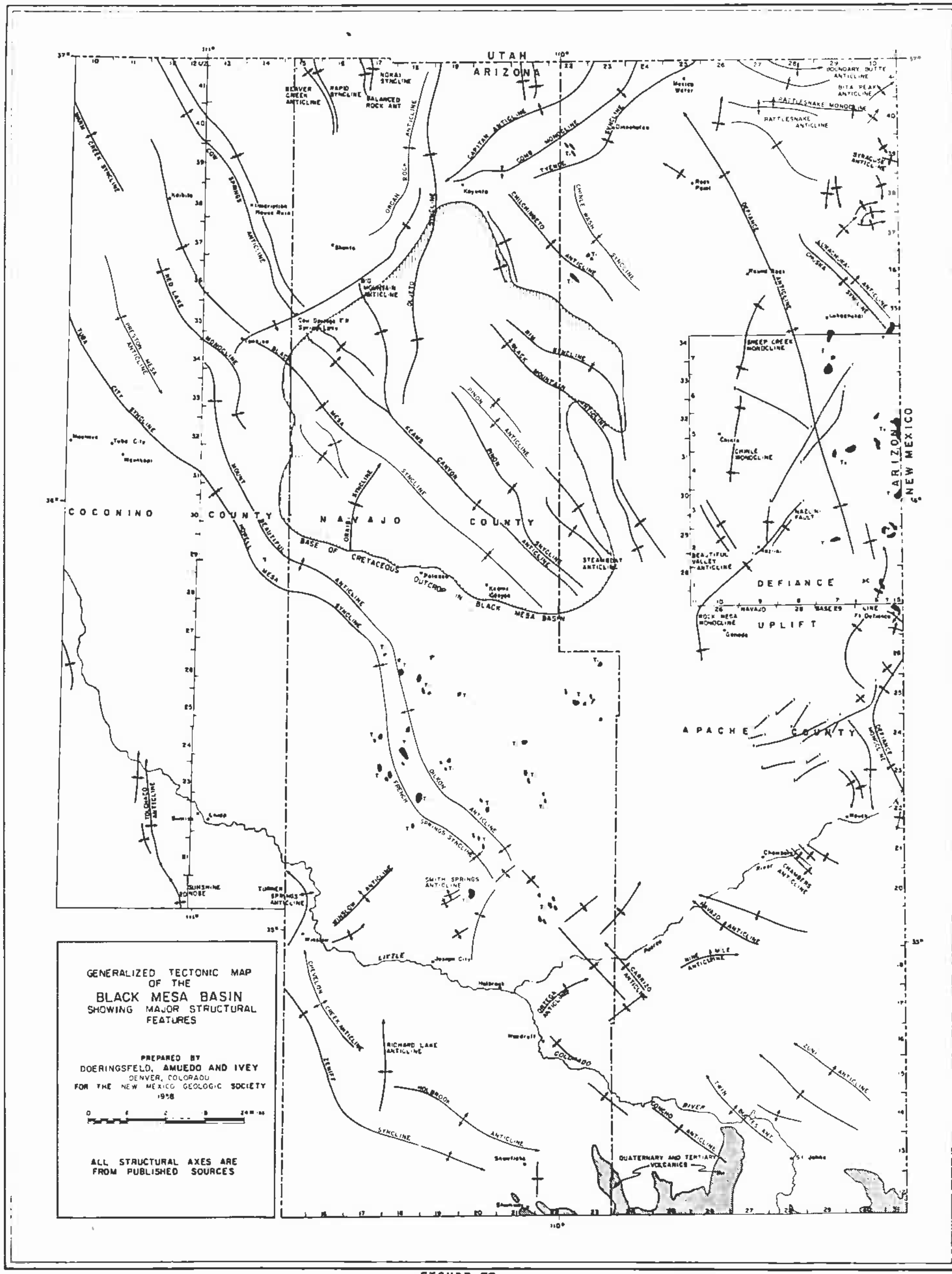
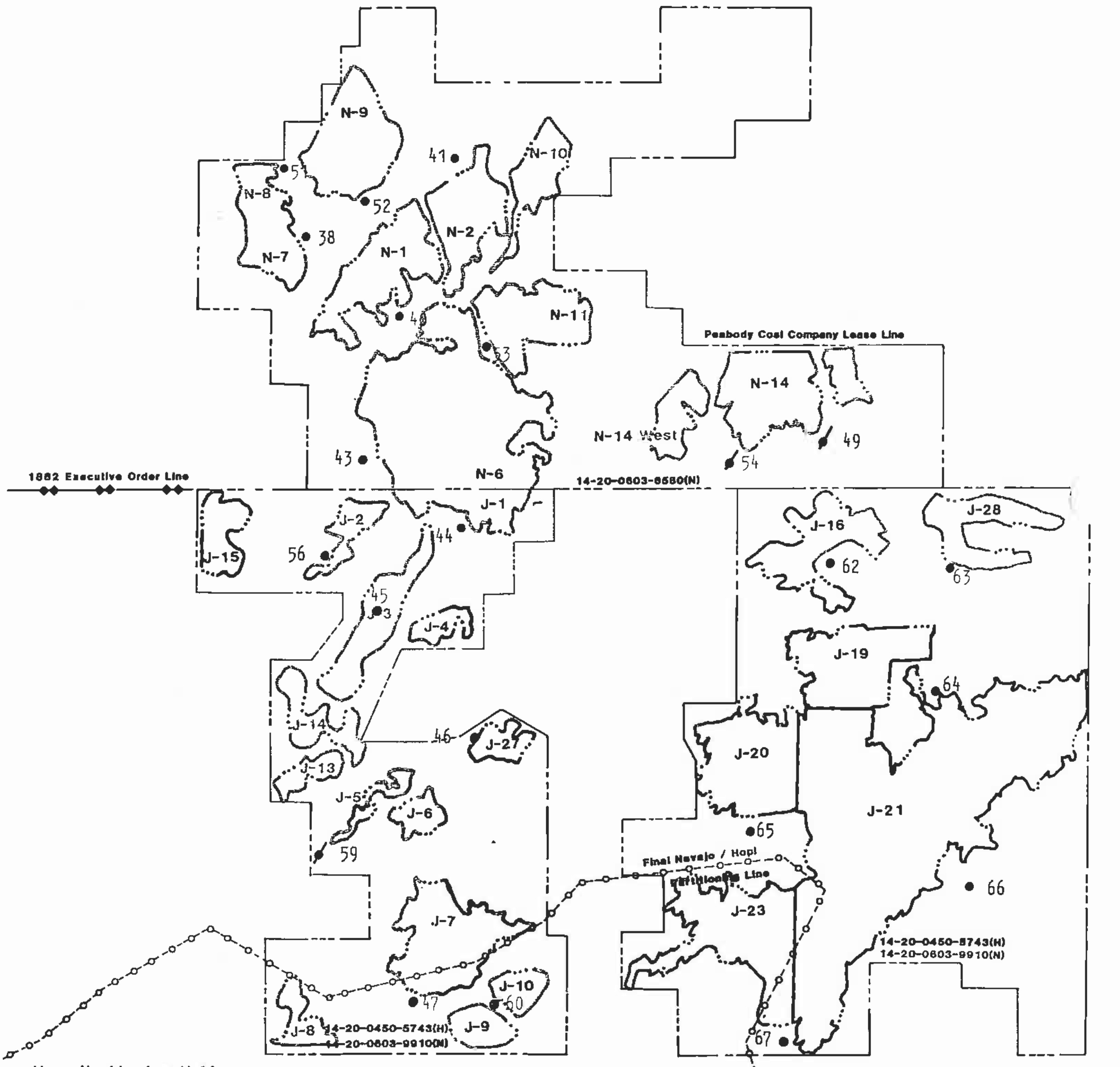


FIGURE 57

Principal Structural Features for the
Black Mesa Region



● Wepo Monitoring Well
Wepo/Toreva Monitoring Well
57 Monitoring Well Site Number

FIGURE 58

Wepo and Wepo/Toreva Wells That Have Been Monitored Continuously For Water Levels for All or Part of the Period, 1980 to 1986 downward hydraulic gradients with depth. Thus Wells 63 and 64 (350 feet in depth) behave as sinks in comparison to surrounding shallower borings (100-200 feet). The replacement Wells 63R and 64R were drilled and completed to depths of 160 feet and 130 feet, respectively. These depths are sufficient to penetrate through the lowest mineable coal seam and permit representative monitoring of water level declines associated with pit pumpage.

Wepo Well Hydrograph Analyses. For purposes of the following discussion, five year Wepo water level plots for 28 of the Wepo wells should be referenced and can be found in Attachment 7. In addition, Table A, found in Attachment 7, should also be referenced as it details, for each well, ranges of water level changes associated with aquifer testing and water quality sampling, recharge and recharge deficits.

There are four principal reasons for the occurrence of water level fluctuations in Wepo wells: (1) aquifer testing and water quality sampling; (2) recharge associated with significant precipitation events; (3) extended dry periods or dry periods in between precipitation events; and (4) residual drilling effects.

From the third quarter of 1980 through 1984, Wepo monitoring wells were sampled for water quality analyses. In addition, pumping tests for aquifer parameter determinations were performed. Hydrograph fluctuations due to these aquifer stresses range from 0.05 to 0.35 feet over a period of several days to more than 34 feet over a period of several months.

A 34.6 foot decrease in water level occurred at Well 53 in mid-October, 1981, as a result of aquifer testing activities. A gradual return towards prepumping water level occurred during 1982. Subsequent aquifer testing and water quality sampling in 1983 and 1984 have consistently lowered the water level 7 to 18 feet for extended periods of time. Aquifer responses of this magnitude make it virtually impossible to define natural recharge and dry period fluctuations. This problem is not just limited to Well 53. The magnitude of drawdowns associated with aquifer testing or water quality sampling in Wells 38, 41, 44, 45, 49, 52, 58, 60, 62, 63, 65 and 67 equals or exceeds the magnitude of natural water level fluctuations, often masking them. Sampling frequency alternatives to minimize this problem are discussed in Chapter 16, Hydrological Monitoring Program.

Both rainfall and snowmelt are significant forms of recharge to the Wepo aquifer. Greater water level changes due to snowmelt recharge have occurred at nine of the wells, whereas greater water level changes due to rainfall recharge have occurred at ten of the wells.

At the other wells, the magnitude of change from either form of recharge has been fairly equal. Water level shallowing as a result of rainfall recharge ranges from .05 to 12.6 feet, whereas that from snowmelt recharge ranges from .05 to 20.6 feet. Rainfall is assumed to occur from July through October, while snowmelt is assumed to predominate from January through March.

Water level shallowing during November through December and April through June is assumed to be in response to rainfall, snowmelt or a combination of the two. At only four of the Wepo monitoring wells has greater water level shallowing occurred during the spring or fall seasons. Water level shallowing during these seasons ranges from .1 to 12 feet. It should be pointed out that the maximum water level changes for each type or combination of recharge are atypical of most of the Wepo wells. The four wells exhibiting the greatest changes (46, 62, 65 and 67) are suspected of being open to perched water table zones, thus accounting for the radical fluctuations. Typical Wepo responses as a result of precipitation recharge are on the order of .5 to 3 feet.

Ground-water level drops in Wepo wells between periods of recharge or during extended dry periods (i.e. May - June) are of approximately the same order of magnitude as the water level changes in response to recharge. Typically, the greatest drops are in the latter winter and summer months following periods of significant recharge. Ground-water level drops associated with recharge deficits ranged from .05 to 21.2 feet. Once again, the wells showing anomously high water level drops are those believed to be open to perched water table layers. The typical range of water level drops excluding these four wells are in the range of .1 to 3.7 feet.

A potential future impact on Wepo water levels is the pit interception of portions of the Wepo aquifer and concurrent pumpage. To date only Wepo Well 38 has been near a pit area of significant pumpage. Though Well 38 has shown a six foot decline in water level while N7/8 has been mined, it is not believed that this has been a result of N7 pit pumpage for the following two reasons. First, Well 38 lies upgradient from the area of N7 pit Wepo aquifer interception and only the top portion of the aquifer was truncated. Secondly, Wells 51 and 52 have shown similar water level declines for the same time period and they are totally isolated from the N7 pit pumpage. All three wells appear to be showing similar effects from aquifer testing and water quality sampling.

A final water level change category to be discussed are those changes associated with residual drilling effects. Wepo Wells 43, 45 and 67 have all experienced significant evidence of residual drilling effects. Whenever possible, all wells were drilled using Revert or some organic polymer that would biodegrade. When problems occurred because of lost circulation, it was necessary to introduce cotton seed hulls and bentonite into the drill hole to bridge over zones with significant voids. This usually is necessary when drilling through burn or loose spoil material which occurred with these three wells. Once introduced, these lost circulation materials are difficult to clean from the well bore and gravel pack.

In September, 1982, an aquifer test on Well 43 resulted in a 2.2 foot increase in water level over an 18 day period. This is probably a result of dissolution during pumping of the drilling muds between the borehole and gravel pack and/or removal of drilling fluids that had invaded the formation. Wells 67 and 45 have shown steady increases in water following periods of pumpage. This water level behavior was not exhibited in the wells prior to 1982. These delayed water level changes are also believed to be a result of the effects of residual drilling fluids.

Wepo Aquifer Gradients and Potentiometric Head Distribution. Ground-water movement in the Wepo Formation beneath the Black Mesa leasehold is predominantly in a westerly to southwesterly direction (see Table 31 and Figure 59). Ground water in the Wepo Formation is under confining pressure, except at the edges of Black Mesa and where channel degradation has truncated portions of the Wepo aquifer. At these locations, ground water would occur under unconfined conditions. Confined ground-water conditions are substantiated by hourly fluctuations in continuous hydrograph records and storage coefficient values determined from aquifer tests. Hourly water level fluctuations result from changes in piezometric head due to barometric pressure changes. Storage coefficients on the order of 10^{-4} and 10^{-5} indicate confined conditions.

Piezometric head (water level) contours presented on Drawing No. 85610 were constructed based upon four criteria: (1) five year average water levels in 28 Wepo monitoring wells; (2) strike and dip of locally continuous coal seams in the Wepo Formation; (3) locally controlling structural features such as folds or faults; and (4) alluvial well five year average water levels. Gradients of Wepo ground-water flow were determined by dividing potentiometric water surface elevation changes by the horizontal distances over which the changes occurred. Flow gradients range from .010 ft./ft. in the J-5 area to .035 ft./ft. in the J-19 mining area. Average gradients have been calculated for most of the designated mining areas and are also presented in Table 31.

TABLE 31

Wepo Aquifer Gradients and Flow

Directions by Mining Area

Mine Area	Avg. Gradient (Ft/Ft)	Flow Direction
J-1, N-6	.013	SW
J-2	.020	W
J-3	.024	S
J-4	.034	S
J-5, J-6, J-11, J-12	.019	W
J-7	.020	W
J-8	.020	NNE
J-9	.017	W
J-10	.018	W
J-13	.020	S
J-14	.023	SW, S
J-15	.010	S
J-16	.030	NW, SW
J-19	.035	NW
J-20	.017	NWW
J-21	.017	NW, W, SW
J-23	.011	W
J-27	.027	W
J-28	.019	NW
N-1	.017	S
N-2	.017	SSW
N-3	.027	NW
N-4	.024	NWW
N-5	.017	SW
N-7, N-8	.016	SE
N-9	.016	S
N-10	.018	SSW
N-11	.025	NWW
N-12	.018	NW
N-13	.018	SW

TABLE 31 (Cont.)

Wepo Aquifer Gradients and Flow

Directions by Mining Area

Mine Area	Avg. Gradient (Ft/Ft)	Flow Direction
N-14 Main	.029	S
N-14 East	.035	SE

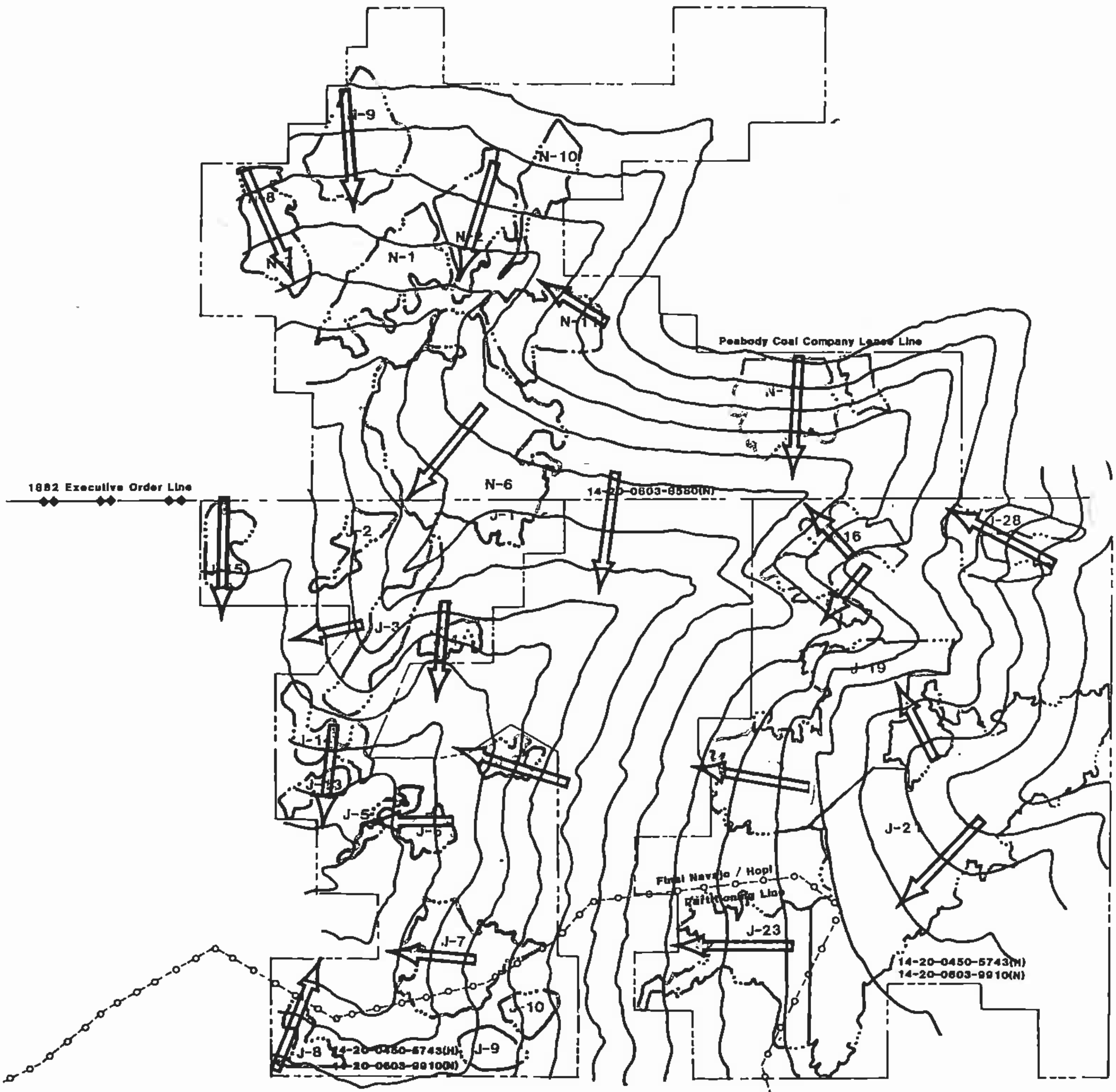


FIGURE 59

Wepo Ground-Water Flow Directions for the Different Mining Areas Within the Leasehold

Contour Lines of Equal Ground-Water Level

Direction of Wepo Ground-Water Flow

Revised 12/01/86

Some structural deformation within the Wepo Formation exerts both regional and local control on the direction of ground-water flow. Regional structure of alternating synclines and anticlines trending in a southwesterly direction cause a sinuous pattern throughout the lease.

This sequence starts in Coal Mine Wash with a syncline and trends southeast. Localized anticlines, synclines and minor faults affect the direction and gradient of the ground-water flow on a smaller scale. The result of these anticlines and synclines can be observed throughout the lease causing sinuous patterns in a southeasterly, southerly, southwesterly, westerly and northwesterly direction. Minor faulting can influence the continuity of the ground-water flow and cause the gradient to be lower than average as shown by Wepo Well No. 44. Areas that have high gradients are the result of tight synclines and anticlines or high topographic relief.

Wepo Aquifer Recharge and Discharge. Recharge to the Wepo aquifer system is derived from both rainfall and snowmelt. The amounts of recharge contributed from each type of precipitation are fairly equal. This point has been further clarified in the previous discussion "Wepo Well Hydrograph Analyses". Average annual precipitation on the leasehold ranges from 9 to 12 inches (recorded at nonheated precipitation gauges).

Because of the fairly rapid water level responses and the known low transmissivities in the Wepo aquifer, principal avenues of recharge must be via areas of burn or clinker. This material is highly fractured, quite porous, extensive both laterally and in depth, and occurs throughout the leasehold. To a lesser degree, other recharge avenues to the Wepo aquifer are where permeable or fractured and jointed rocks are exposed at the ground surface or on the sides of valleys and at the edge of the mesa. Hydraulic communication with the overlying Yale Point Sandstone may occur in the rim area; however, no water or core data exists for the Yale Point from which projections could be made.

Hydraulic communication with the Toreva aquifer occurs because the two formations intertongue in the northern Black Mesa area. Water level data from the four monitoring wells partially completed in the Toreva suggests that there is little difference in the potentiometric heads in both aquifers.

Precipitation falling elsewhere on the lease will be retained by the tight clayey soils or the impermeable confining rock units overlying the saturated portion of the Wepo Formation.

The principal form of discharge from the Wepo aquifer is discharge to the alluvial aquifer. Water levels in the alluvial aquifer, to a large extent, particularly during the extended dry periods, are maintained by recharge from the Wepo aquifer. Wepo discharge to the alluvial aquifer occurs along all of the washes and significant tributaries. The amount of discharge at a given point may vary and to some extent is reflected on Drawing 85610 by the steepness of water level gradients and the degree of bending of the contours around reaches of the washes. Other forms of discharge from the Wepo aquifer are springs, intermittent reaches of the washes and evapotranspiration at recharge outcrop areas.

Wepo and Toreva Aquifer Characteristics. Lithologic logs for each monitoring well are presented in Attachment 8. These logs detail the presence and proportion of sandstone, shale, coal and silt and mudstone units.

The water yielding and transmitting units comprising the Wepo aquifer consist of single sandstone units, multiple sandstone beds which are hydraulically connected, fractured coal seams and, to a limited extent, sandy shales. Cooley et al. 1969 showed the results of laboratory analyses performed on samples collected from sandstone units in the Wepo Formation (refer to Table 2, Range of the Hydraulic Properties of Aquifers in the Navajo and Hopi Indian Reservations). Results include a weighted average mean diameter of .27 millimeters, porosity values of one to two percent, and a range of coefficient of permeability from .0009 to 0.02 gal./day/ft^2.

To evaluate the Wepo aquifer characteristics beneath the leasehold, pumping tests were performed on 26 of the 31 Wepo monitoring wells. The wells at which aquifer tests have been performed are representative of the Wepo aquifer, excepting Wells 42, 49, 54 and 59. Lithologic and water quality information suggest that these wells are partly completed in the Toreva aquifer.

The type of aquifer test technique selected to evaluate the Wepo aquifer characteristics was dependent on whether observation wells were present and whether well bore storage effects could be overcome before the water level was drawn below the pump intake.

Multiple well time drawdown tests were employed at Wells 38 and 39 and 47 and 48. The observation wells in these two cases were Wells 39 and 48. These tests were the only two where storage coefficient values could be determined. In addition, these two pairs of wells were used to calculate transmissivity values and compute well efficiencies in the pumping wells.

Single well time drawdown and recovery tests were performed in Wells 42, 49, 51, 52, 54, 59 and 66. Factors limiting which wells could be analyzed using this technique appear to be whether transmissivities are above 170 gal./day/ft. and/or whether at least half the well depth is completed in the saturated zone.

The remaining 17 wells were analyzed using a modified slug test technique as described by McWhorter, 1982. This aquifer testing technique allows for maximum drawdowns to occur away from the well bore as a function of pumping rate and well specific capacities. It is felt that more representative transmissivity values of the aquifer in the vicinity of the wells were obtained by this approach. Documentation of the applicability and testing of this approach are given in Appendix H, Volume 44, Hydrological Monitoring Program.

Transmissivity and storage coefficient values determined from the above-referenced aquifer test techniques are shown in Table 32 and presented in Figure 60. Plots of the time drawdown and recovery values, tables of water levels and residual water levels versus time, as well as tables of pumping rates versus time for each aquifer test are presented in Attachment 9.

All transmissivity and storage coefficient values have been corrected for well efficiency estimates using the results of the multiple well time drawdown aquifer tests. The well efficiency corrections were determined by comparing transmissivity values calculated from the pumping well (inefficient) and the observation well (100 percent efficient) and taking the ratio of the two. The same transmissivity comparison was used for a recovery analysis in the same wells. For the type of well completion used (saw slot perforations and a pea gravel pack) it was determined that the pumping well is 32 percent efficient during drawdown tests and 46 percent efficient during recovery tests.

Average pumping rates maintained during aquifer tests ranged from 22.6 gallons per minute at Well 42 to 3.5 gallons per minute at Well 38. Specific capacities for monitoring wells partially completed in the Toreva aquifer range from .063 gpm/ft. at Well 54 to .327 gpm/ft. at Well 49. Specific capacities for monitoring wells completed in the Wepo aquifer ranged from .05 gpm/ft. at Well 52 to .322 gpm/ft. at Well 47.

Transmissivity values determined for the monitoring wells ranged over four orders of magnitude. Transmissivity values for those wells partially completed in the Toreva aquifer ranged from 347 gal./day/ft. at Well 54 to 1,990 gal./day/ft. at Well 59. Transmissivity ranges for those wells completed in the Wepo aquifer ranged from 0.1 gal./day/ft. to 666 gal./day/ft. at Wells 62 and 51, respectively.

TABLE 32

Transmissivity and Storage Coefficient Values Determined at
Wells Completed in the Wepo and Toreva Formations

Monitoring Well Number Wepo	Monitoring Well Number Wepo/Toreva	Transmissivity (gpd/Ft)	Storage Coefficient	Specific Capacity
38	-	480	1.9×10^{-5}	.111
40	-	84	-	-
41	-	46	-	-
-	42	956	-	.285
43	-	132	-	-
44	-	.25	-	-
45	-	12	-	-
46	-	19	-	-
47	-	170	1.45×10^{-4}	.322
-	49	1297	-	.327
51	-	666	-	.163
52	-	205	-	.048
53	-	7	-	-
-	54	347	-	.063
55	-	40	-	-
56	-	21	-	-
57	-	39	-	-
58	-	38	-	-
-	59	1990	-	-
60	-	12	-	.224
61	-	50	-	-
62	-	.1	-	-
63	-	204	-	-
64	-	36	-	-
64R	-	26	-	-
65	-	72	-	-
66	-	322	-	.081

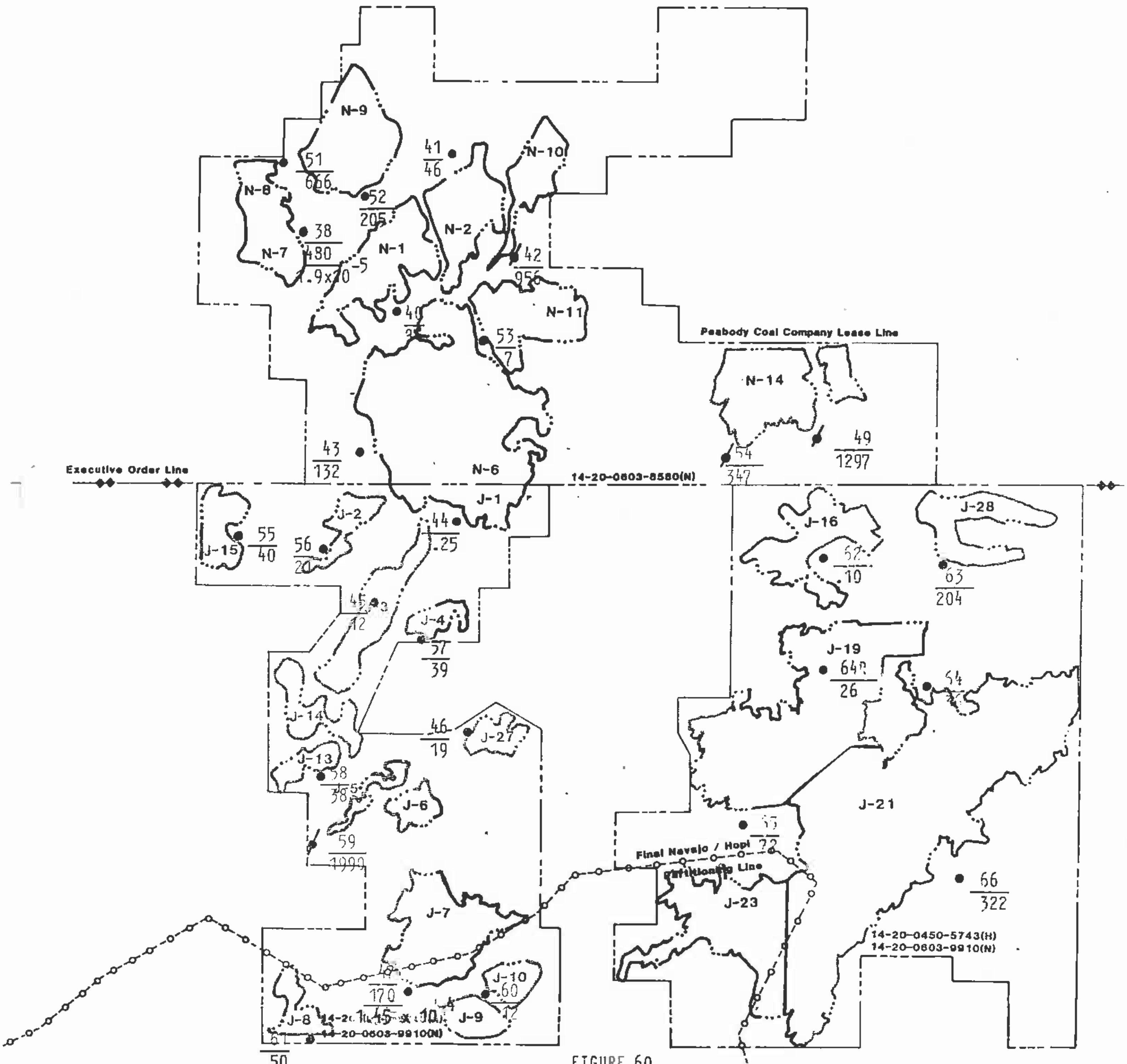


FIGURE 60

Aquifer Characteristics Determined For Wepo and Wepo/Toreva Monitoring Wells on the Leasehold

Wepo Monitoring Well
Wepo/Toreva Monitoring Well
47 — Monitoring Site Number
170 — Transmissivity (gal/day-ft)
1.45×10^{-4} Storage Coefficient

Wepo and Toreva Aquifer Water Quality. Water in the Wepo aquifer is characterized by a high degree of variability. The Wepo wells on Peabody's lease yield water which can be grouped into three water types, sodium-bicarbonate, sodium-sulfate and calcium/magnesium-sulfate. Chemical variability within these water types is documented in Figures 61, 62 and 63, which are trilinear diagrams depicting averaged major ion values for each of the twenty-nine 6" wells by water type. As can be seen, the relative proportions of the major ions (calcium, magnesium, sodium, potassium, bicarbonate, carbonate, chloride and sulfate) determine the water types.

The Wepo aquifer is typically composed of relatively thin sandstone layers interbedded with shale and coal layers. The sequence, proportion and thickness of these layers is highly variable. This lithologic variability is documented, by well, in the lithologic logs presented in Attachment 8.

The water type in a particular well is determined by which lithologic units are yielding water. For example, a well receiving water primarily from coal seams will have a calcium/magnesium-sulfate water type. If the coal is layered with shale, the water type may be shifted to sodium/potassium-sulfate. Sandstone units yield water dominated by the ion pair calcium bicarbonate (calcium/magnesium-bicarbonate water type). However, the quality of this water may be altered by soluble minerals in bordering lithologic units. Since any combination of lithologic units may contribute varying amounts of water to the well bores water quality variability is high.

The distance of sampling point from recharge zones also affects local water quality. Wells in close proximity to areas of local recharge are generally more concentrated with respect to calcium (Cooley et al. 1969). Also, total dissolved solids (TDS) tend to increase with distance from recharge areas.

Variability in aquifer transmissivity (T) also impacts ground-water quality. Table 33 shows that those wells with higher "T" values generally have lower TDS concentrations. Slower moving water is in contact with soluble mineral facies for a longer period of time which enhances dissolution and increases TDS concentrations. Where exceptions to this are noted, proximity to areas of recharge and other lithologic factors are probably more significant.

Figures 64 through 71 show some chemical relationships of Wepo ground water by water type. Calcium and magnesium (Figures 64, 67 and 70) are strongly linked in all water types

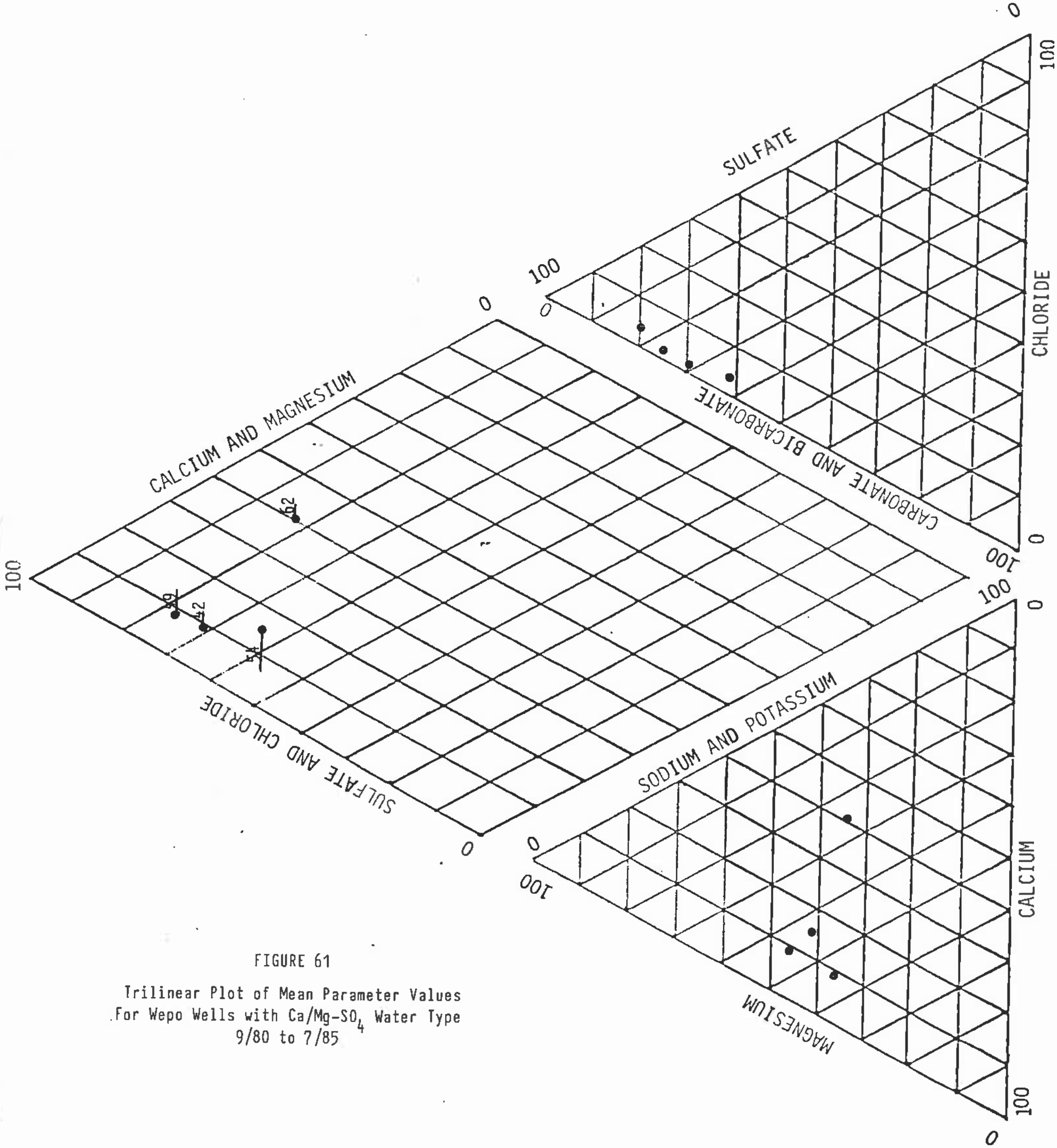


FIGURE 61

Trilinear Plot of Mean Parameter Values
For Wepo Wells with Ca/Mg-SO_4 Water Type
9/80 to 7/85

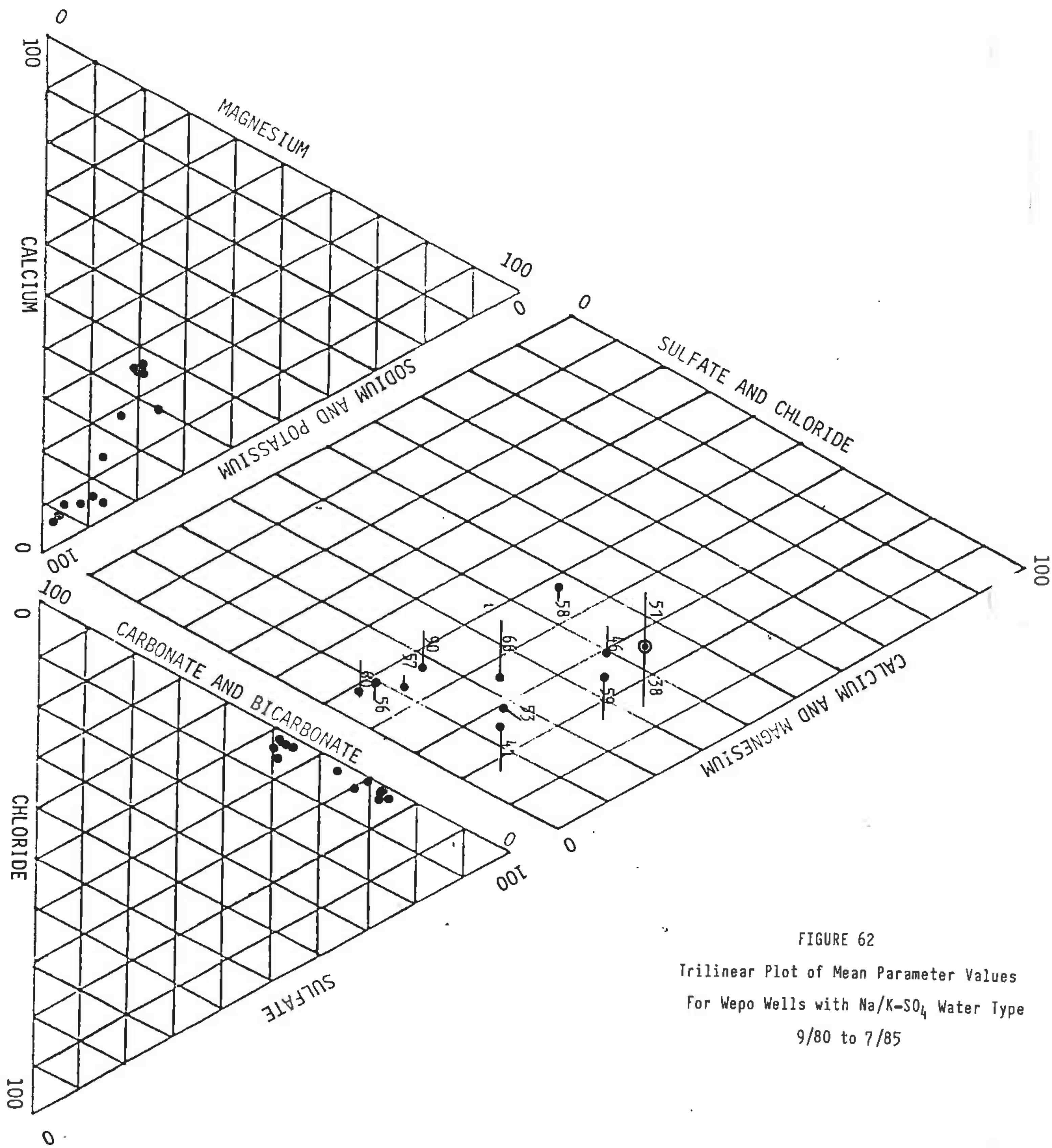


FIGURE 62

Trilinear Plot of Mean Parameter Values
For Wepo Wells with $Na/K-SO_4$ Water Type
9/80 to 7/85

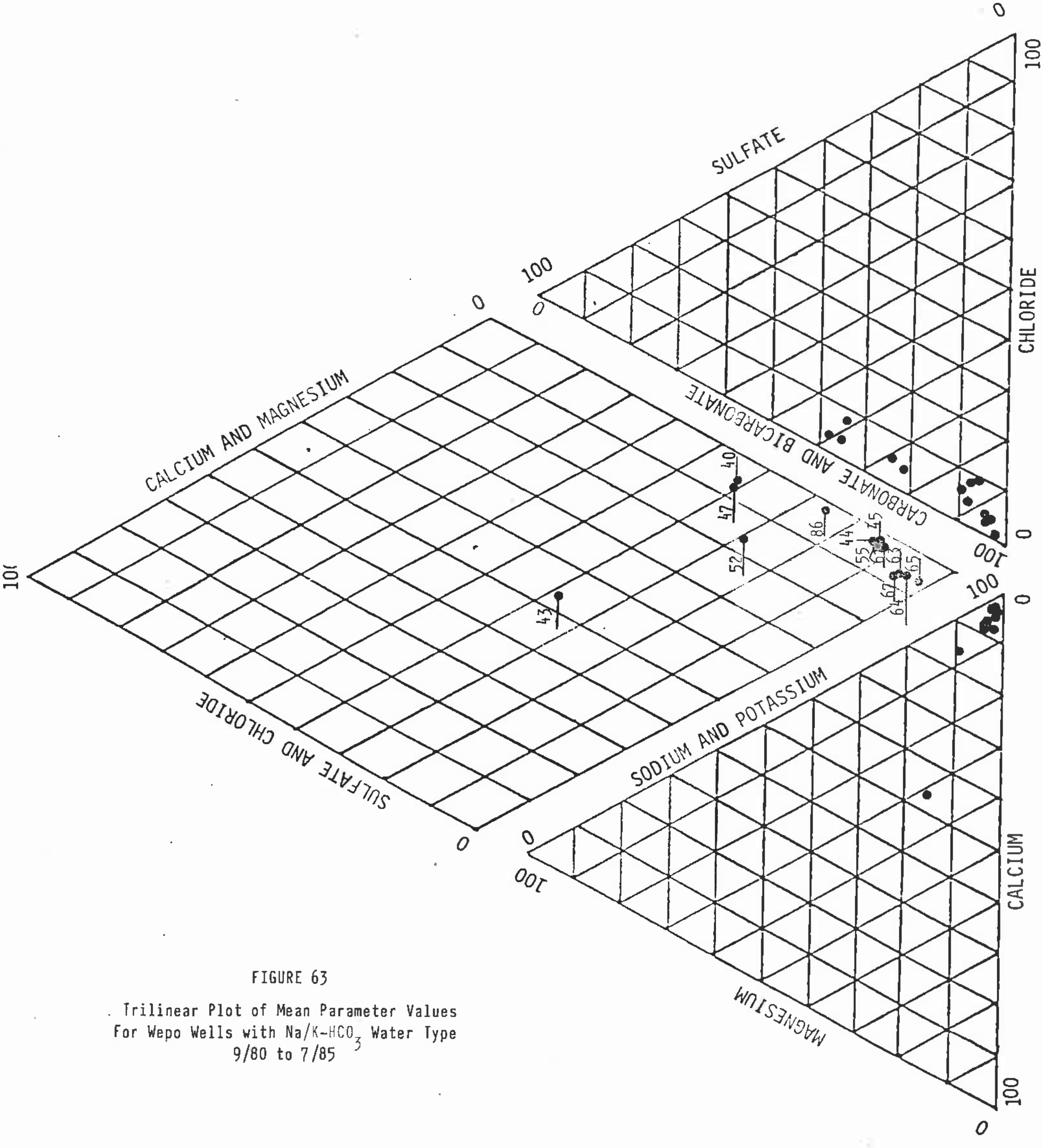


FIGURE 63

Trilinear Plot of Mean Parameter Values For Wepo Wells with Na/K-HCO_3 Water Type 9/80 to 7/85

TABLE 33

Transmissivities of the Wepo and Wepo/Toreva Wells

With Associated Averaged TDS Values

Well #	Transmissivity (T) (G.P.D. per Foot)	Total Dissolved Solids (TDS) (mg/l)
38	480	2049
39	N/A	2643
40	84	1175
41	46	2829
42	956	1242
43	132	965
44	0.25	1527
45	12	1015
46	19	3062
47	170	1117
48	N/A	N/A
49	1297	1289
51	666	2171
52	205	800
53	7	2636
54	347	1380
55	40	1052
56	21	585
57	39	864
58	38	961
59	1990	1818
60	12	1817
61	50	722
62	0.10	5503
63	204	1113
64	36	1521
65	72	1810
66	322	3564

TABLE 33 (Cont.)

Transmissivities of the Wepo and Wepo/Toreva Wells

With Associated Averaged TDS Values

Well #	Transmissivity (T) (G.P.D. per Foot)	Total Dissolved Solids (TDS) (mg/l)
67	N/A	1254
86	N/A	2404
90	N/A	4350

WEPO WELLS WITH N K-SO4 WATER TYPE

PLOT OF CA VS. MG

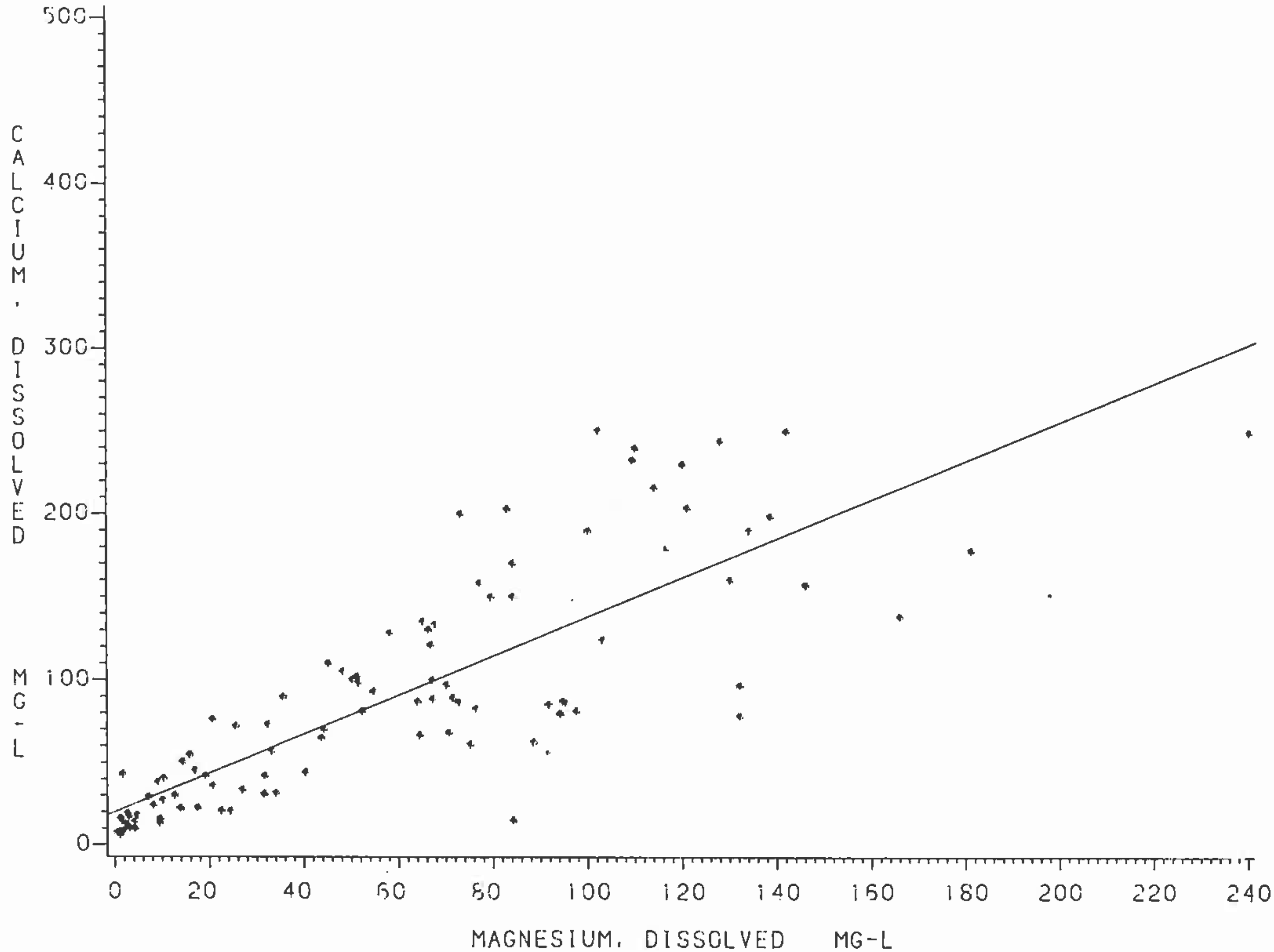


FIGURE 64

Relation Between Ca and Mg
For Wepo Wells With $Na/K-SO_4$ Water Type

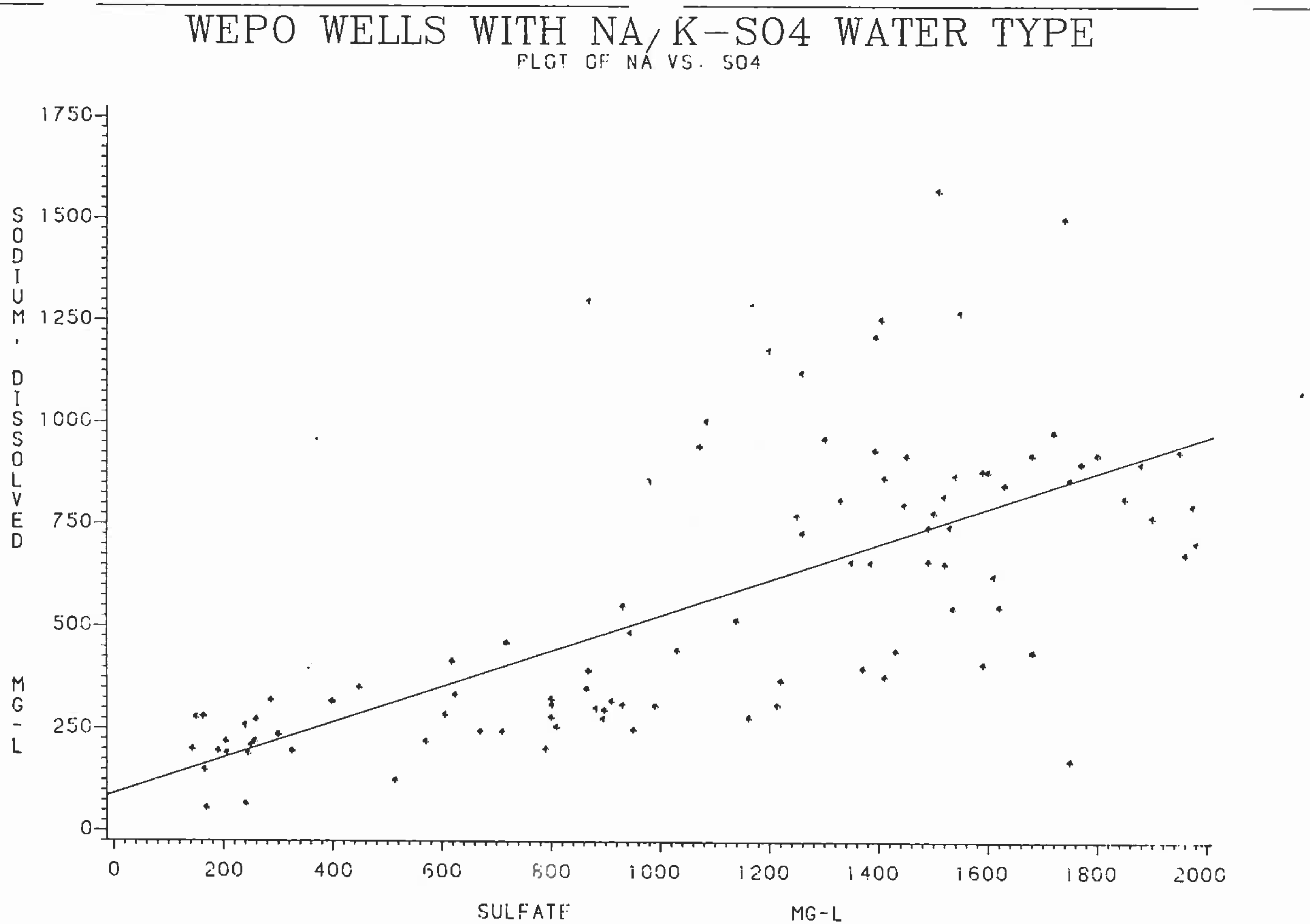


FIGURE 65

Relation of Na and SO_4

For Wepo Wells With Na/K-SO_4 Water Type

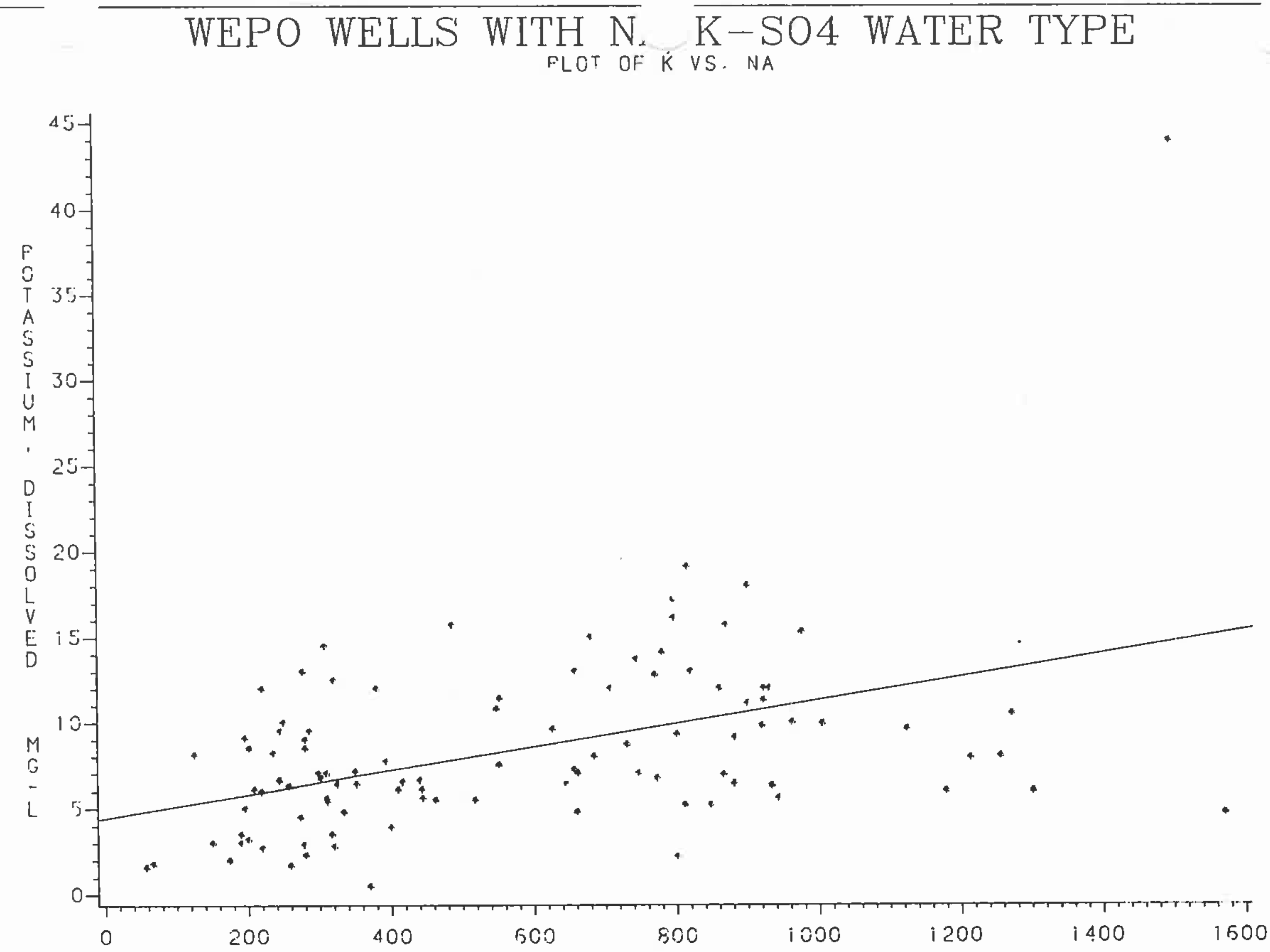


FIGURE 66

Relation Between K and Na
For Wepo Wells With $Na/K-SO_4$ Water Type

WEPO WELLS WITH NA/K-HCO3 WATER TYPE

PLOT OF CA VS. MG

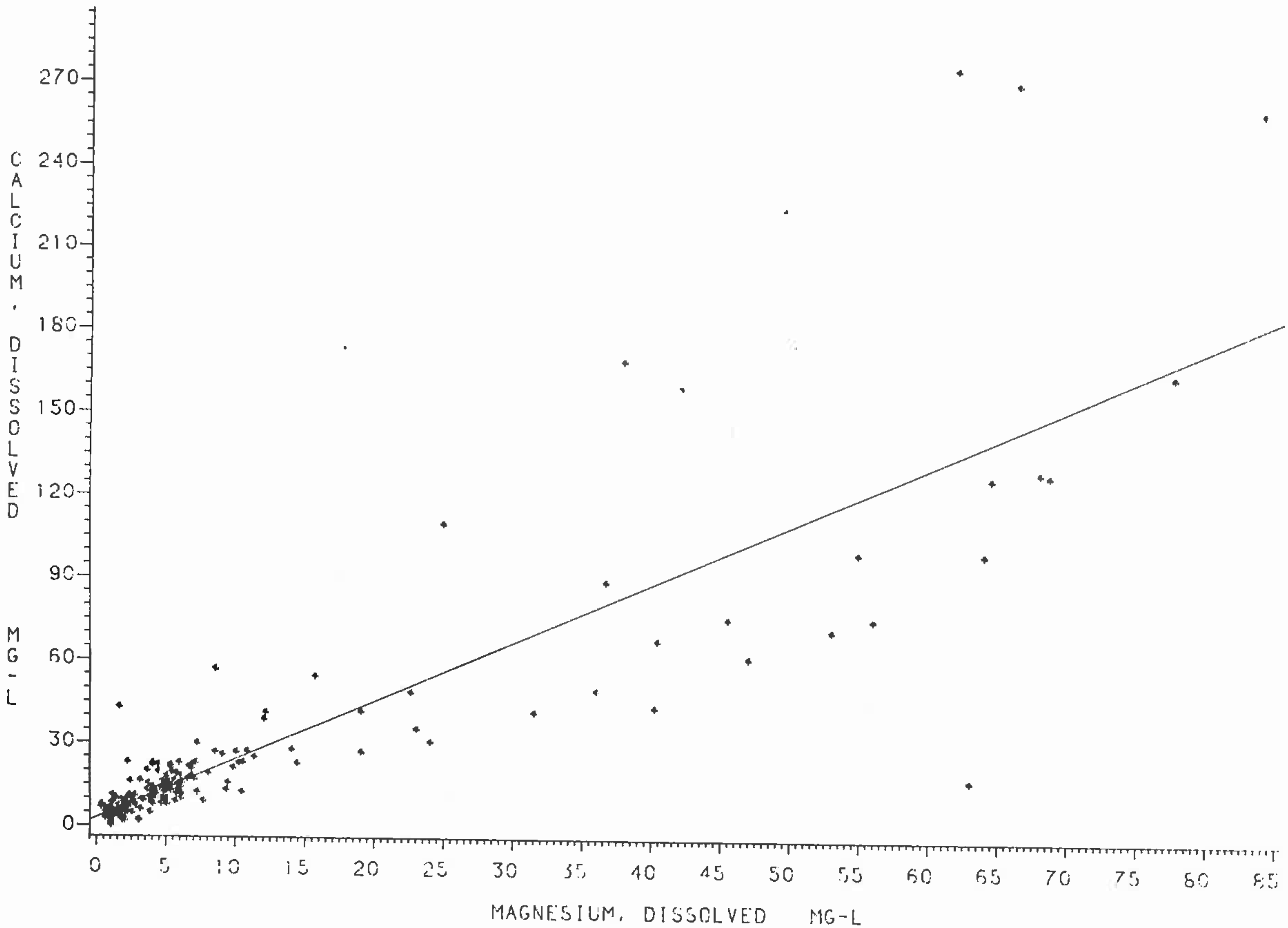


FIGURE 67

Relation Between Ca and Mg For Wepo Wells With $Na/K-HCO_3$ Water Type

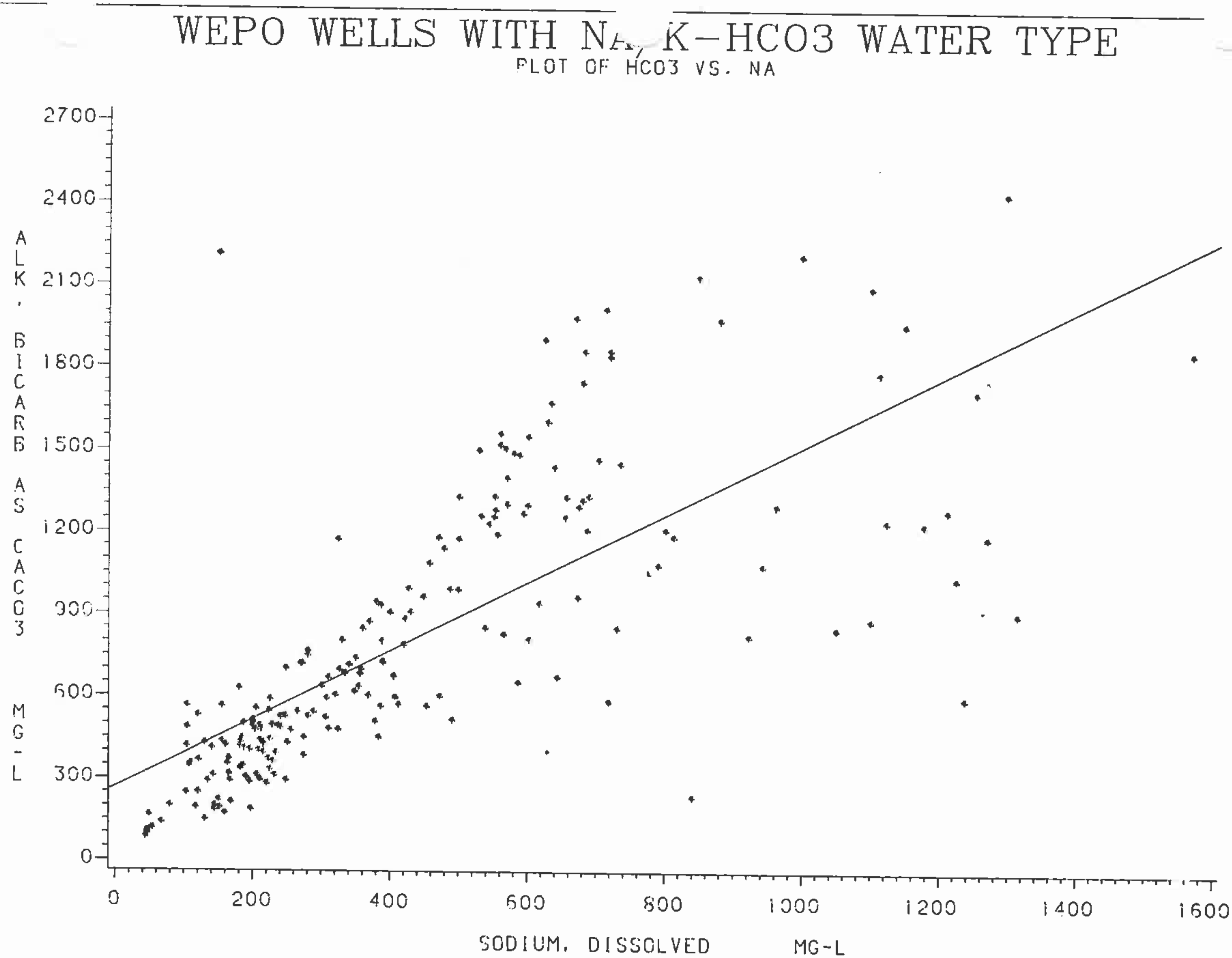


FIGURE 68

Relation Between HCO_3 and Na

For Wepo Wells With Na/K-HCO_3 Water Type

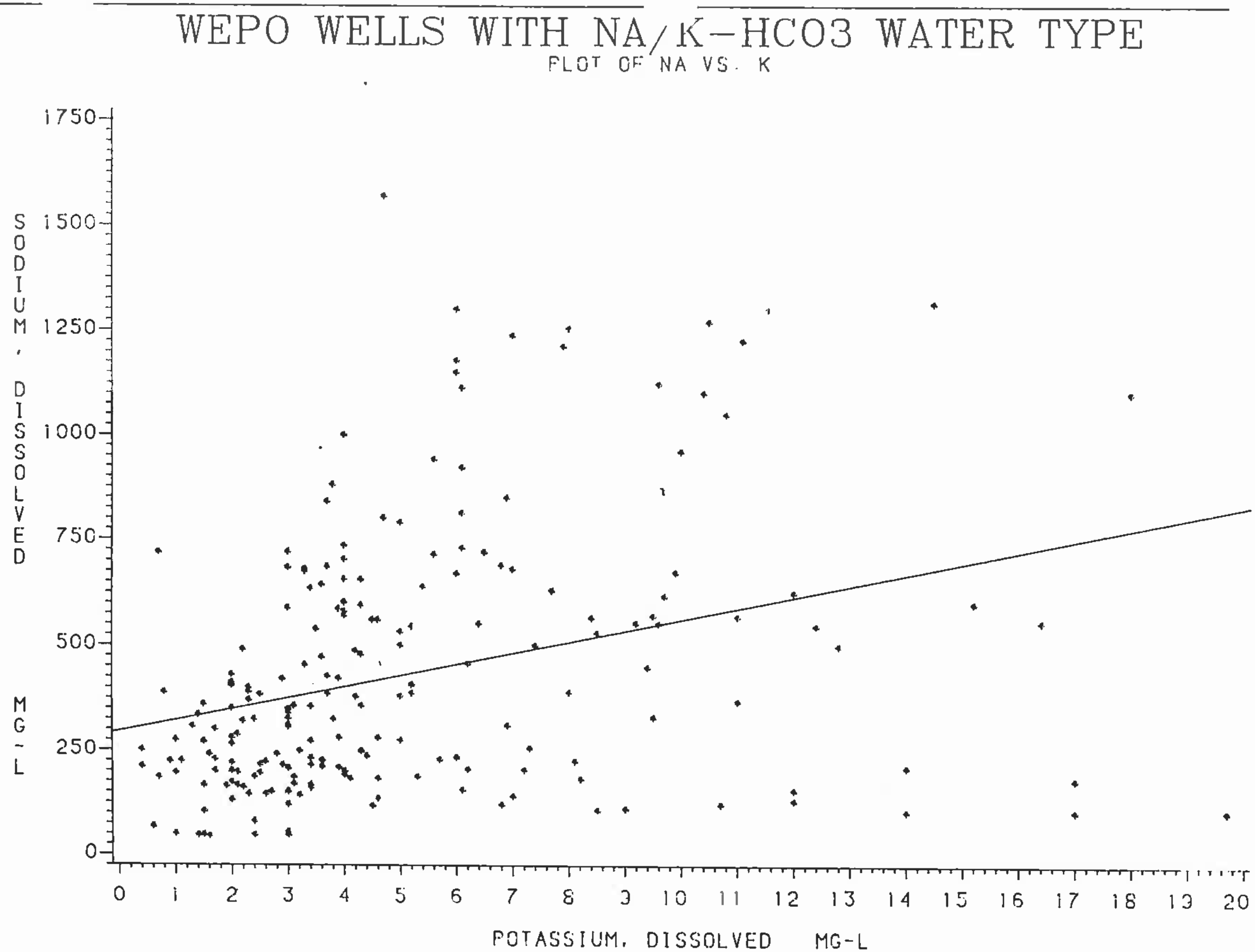


FIGURE 69

Relation Between Na and K
For Wepo Wells With $Na/K-HCO_3$ Water Type

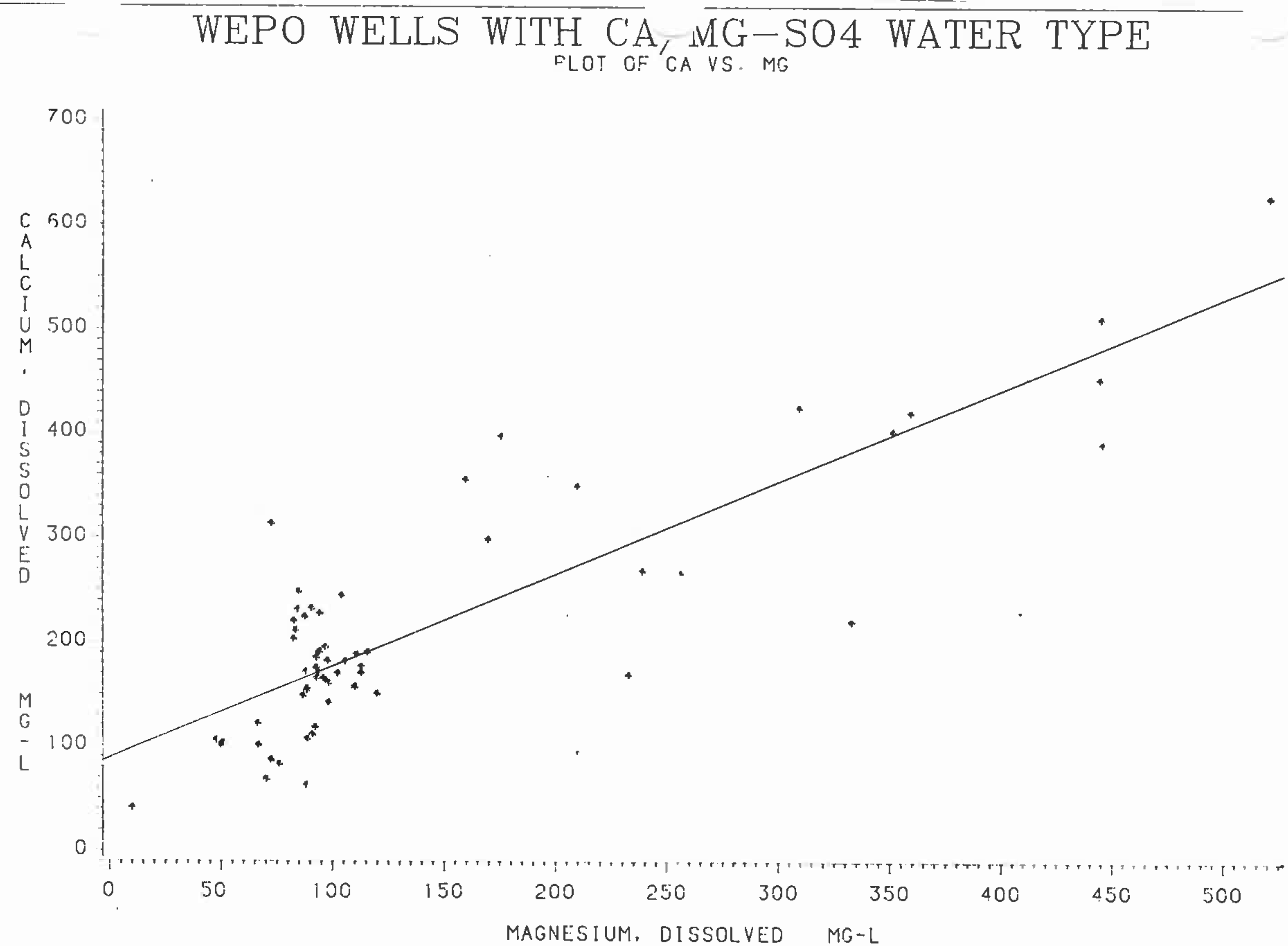


FIGURE 70

Relation Between Ca and Mg
For Wepo Wells With Ca/Mg-SO_4 Water Type

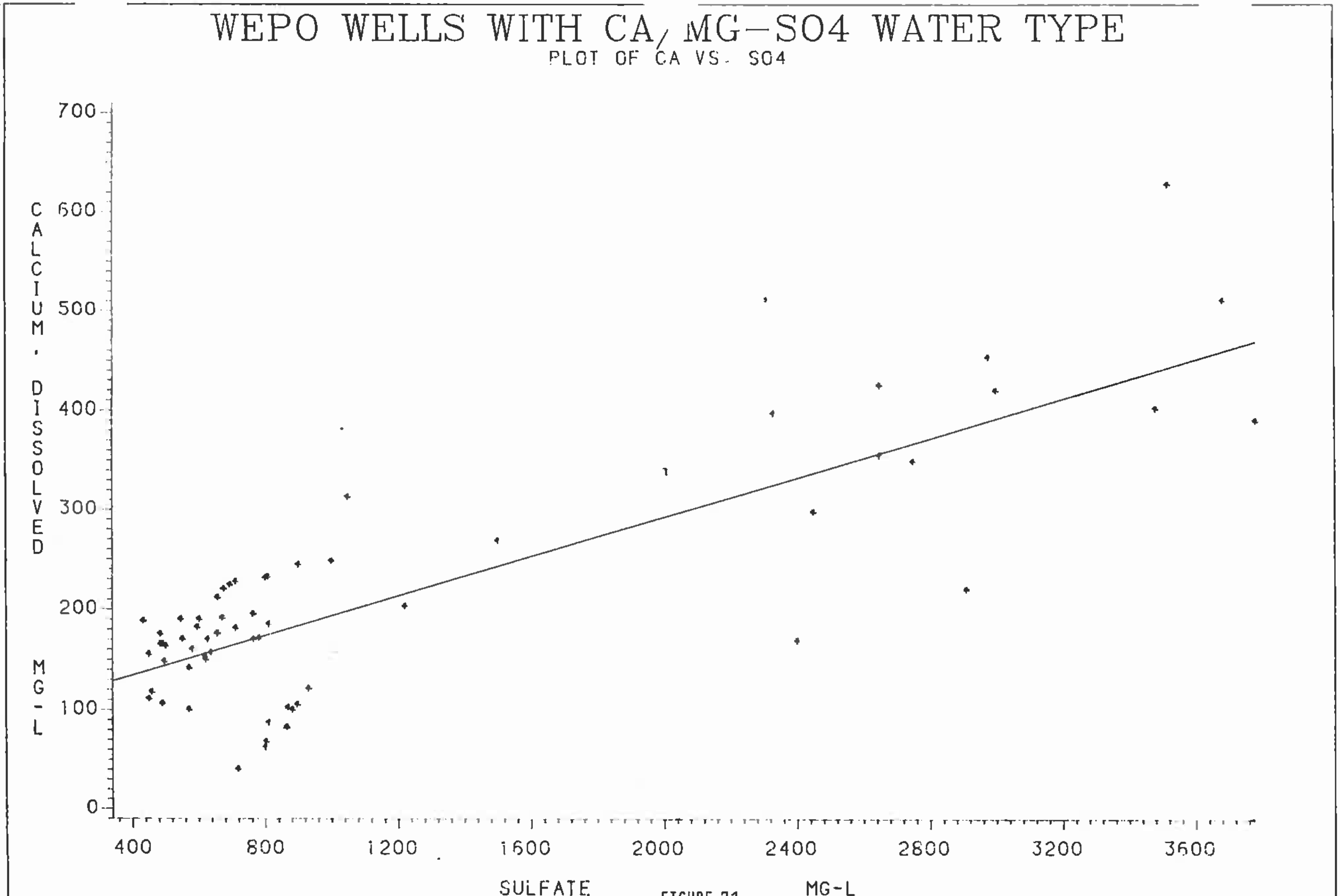


FIGURE 71

Relation Between Ca and SO_4

For Wepo Wells With Ca/Mg-SO_4 Water Type suggesting a common, widespread mineral source. Figures 65, 68 and 71 show regression plots of the major ion pair for each water type. Figures 66, 69 and 70 depict the relationship between the two dominant cations for each water type. The trend lines for Figures 64 through 71 were fitted to the data using the least-squares technique.

Four of the Wepo wells in Peabody's monitoring network partially penetrate the Toreva Formation (Wepo Wells 42, 49, 54 and 59). Although waters from the Toreva Formation mix with Wepo waters in the well bores of these wells, two distinct water types have been documented in the four wells. Well 59 water type plots as Sodium/Potassium-Sulfate (Figure 62). This water type is typical of water yielding coal or sandstone units with interlayered shales. Wells 42, 49 and 54 water types plot as Calcium/Magnesium-Sulfate (Figure 61). The uppermost unit of the Toreva Formation is largely a massive sandstone with some coal seams which correlates well with the water types above, excepting Well 59. Interlayered shales in the Wepo aquifer must affect the water type to a degree.

Fluoride levels in several of the Wepo wells exceed the USEPA maximum permissible concentration (1.4 to 2.4 mg/l). Table 34 shows that this exceedance occurs almost exclusively in those wells with Na HCO_3^- water type. While no discrete fluoride source has been identified from drill cores, Hem (1970) states that fluorite (CaF_2) is a common fluoride mineral in sedimentary rock. Two other possible sources are Apatite and some members of the Amphibole group. Being similar in size to the hydroxide ion (OH-) fluoride (F-) can enter these crystal structures by substitution.

A statistical summary of selected chemical constituents in Wepo ground water is presented in Attachment 10. The ranges of the various parameters (Table 35) will be those which any future water quality analyses are compared against for mining impact assessments. Water quality maps showing the spatial distributions of mean concentrations of several parameters by site are presented in the annual Hydrological Data Reports.

Lithology of the Alluvium. A network of 46 alluvial monitoring wells was installed in June, 1980. Nine additional and replacement alluvial wells were added to the monitoring network in June, 1983. Locations of all the alluvial wells are shown on Drawing No. 85600. Lithologic descriptions of auger cuttings and well completion information are presented in Attachment 11.

Lithologic characteristics of the alluvium within the leasehold range from cross-bedded sand and gravel beds that alternate with beds of silt and sandy silt to thin-bedded mud

TABLE 34

Averaged Wepo Fluoride Levels

By Well and Water Type 9/80 to 7/85

Site	F mg/l	Water Type Classification
42	2.02	Ca/Mg-SO_4
49	0.24	Ca/Mg-SO_4
54	0.28	Ca/Mg-SO_4
62	0.80	Ca/Mg-SO_4
38	3.16	Na-SO_4
41	2.49	Na-SO_4
46	1.07	Na-SO_4
51	1.07	Na-SO_4
53	2.22	Na-SO_4
56	0.33	Na-SO_4
57	1.04	Na-SO_4
58	0.21	Na-SO_4
59	0.91	Na-SO_4
60	1.41	Na-SO_4
66	1.04	Na-SO_4
90	1.77	Na-SO_4
40	8.33	Na-HCO_3
43	1.22	Na-HCO_3
44	7.32	Na-HCO_3
45	6.45	Na-HCO_3
47	2.68	Na-HCO_3
52	1.80	Na-HCO_3
55	7.07	Na-HCO_3
61	1.55	Na-HCO_3
63	5.13	Na-HCO_3
64	5.68	Na-HCO_3
65	2.15	Na-HCO_3
67	2.24	Na-HCO_3
86	3.05	Na-HCO_3

TABLE 35

Minimum and Maximum Values of the Key
Parameters Used to Assess Mining Impact to the Wepo Aquifer

Parameter	Minimum Value (mg/l)	Maximum Value (mg/l)
Bicarbonate	85	2440
Sulfate	1.0	4450
Calcium	0.1	627.6
Magnesium	0.3	1204
Sodium	24	2526
Dissolved Iron	0.02	19.0
Dissolved Manganese	0.02	2.31

Minimum and maximum values for the key parameters used for impact assessment in the Wepo Aquifer are presented in Table 35. These ranges were taken from a 5-year data base consisting of approximately 350 analyses for each parameter. These values represent the upper and lower control limits for all future analyses.

and silt sequences that contain considerable carbonaceous material. The differences in lithologic characteristics reflect slightly to significantly different environments of deposition.

Alluvial Well Hydrograph Analyses. For purposes of the following discussion, five year (one year for the redrilled wells) alluvial water level plots for 53 of the alluvial wells should be referenced and can be found in Attachment 12. In addition, Table A, found in Attachment 12, should also be referenced as it details for each well ranges of water level changes associated with aquifer and water quality sampling, recharge and recharge deficits.

There are four principal reasons for the occurrence of water level fluctuations in alluvial wells: (1) aquifer testing and water quality sampling; (2) recharge associated with significant precipitation events; (3) extended dry periods or dry periods between precipitation events; and (4) mining interception of upgradient ground-water recharge to the alluvial aquifer.

Alluvial water level declines as a result of aquifer testing and water quality sampling range from .05 to 3.25 feet (Site 27) in a given quarter of the year. From 1980 until 1982, only the nine four-inch alluvial wells were sampled for water quality. Following the purchase of a 1.75-inch bladder pump in 1982, all alluvial wells with at least five feet of water in them have been sampled for water quality. Alluvial wells are typically prepumped a week before actual water quality samples are obtained so the stress to the aquifer is effectively doubled. The range of water level declines is of the same magnitude as the water level shallowings as a result of recharge or declines as a result of extended dry periods. This makes defining natural alluvial water level fluctuations very qualitative at best. Reduced sampling has been proposed to help minimize this problem. Proposed sampling frequency changes and rationale for such frequencies are discussed in Chapter 16, Hydrological Monitoring Program.

Both rainfall and snowmelt runoff are significant forms of recharge to the alluvial aquifer system. Of the two forms of recharge, rainfall causes the greater water level changes in the alluvial monitoring wells. Greater water level shallowings have occurred as a result of rainfall runoff recharge at 28 of the alluvial monitoring wells. Since 1980, alluvial water level shallowings from rainfall recharge have ranged from .05 to 5.8 feet. Alluvial water level shallowings since 1980, as a result of snowmelt recharge, range from .05 to 4.1 feet. The maximum water level shallowings from rainfall and snowmelt recharge occurred at Sites 87 in Moenkopi Wash and 106 in Yucca Flat Wash, respectively. Rainfall is assumed to occur from July through October while snowmelt is assumed to predominate from January through March.

Water level shallowing in the alluvial wells during November through December and April through June is assumed to be in response to rainfall, snowmelt or a combination of the two. At only eight of the alluvial wells has a greater range of water level shallowing in response to recharge occurred during the spring or fall seasons. The documented range of water level shallowings during these two seasons are from .05 to 2.35 feet.

Ground-water level drops in alluvial wells between periods of recharge or during extended dry periods (i.e. May - June) are of approximately the same order of magnitude as the water level changes in response to recharge. Typically, the greatest drops are in the late summer and spring months. Alluvial ground-water level drops associated with recharge deficits ranged from .05 to 7.1 feet. The 7.1 feet was at Well 29 which is located immediately below J-7 dam and fluctuates in direct response to water storage changes in the dam. Typical alluvial water level declines in response to recharge deficits range from .05 to 4.0 feet. Table A in Attachment 12 lists alluvial water level changes on a quarterly basis. Wells such as 13, 70 and 73 along Yellow Water Canyon Wash showed water level declines ranging from 2 to 4.5 feet from 1980 until 1982. These water level drops were not a result of the N-7 pit pumpage because they are well upgradient from N-7. Wepo Wells 51 and 52, located in the Yellow Water Canyon Watershed, but well upgradient from N-7, showed similar water level declines, suggesting that this portion of the ground-water system received very little recharge during 1981.

A final alluvial water level change category to be discussed is water level changes in response to pit interception of the Wepo aquifer upgradient from the alluvial aquifer. From 1980 to the present, only one pit has intercepted the Wepo aquifer in a close enough proximity to the alluvial aquifer to produce a significant drawdown. From 1980 to 1983, interception and pumpage of Wepo ground water in the N-7 pit caused 8 to 8.5 foot water level declines in Alluvial Wells 74 and 75. Since cessation of pit pumpage in 1983, water level recoveries have been slow, suggesting that resaturation of the spoil material and reestablishment of the Wepo aquifer gradient will require several years. The extent of the impact to the alluvial aquifer system was very localized as Alluvial Wells 19 and 84, which are a couple of miles downgradient from 74 and 75, have shown gradual water level shallowing of approximately three feet in each well since 1980.

Alluvial Aquifer Gradients, Saturated Thicknesses and Cross Sectional Areas. Alluvial aquifer gradients have been determined on both the macro and micro scale. On the macro scale, gradients were measured along the various reaches of each of the principal washes and tributaries (see Drawing No. 85620 and Table 36). Alluvial aquifer gradients measured over several thousand feet in the various channels ranged from .007 to .025 feet/feet. The largest gradient was along Dugout Wash and the smallest was along lower Dinnebito Wash. On the micro scale, alluvial aquifer gradients were determined at 15 alluvial well locations using 180 foot seismic refraction spreads. Micro gradients ranged from .002 to .028 feet/feet. The lowest micro alluvial gradient was measured on lower Yellow Water Canyon Wash near Well 74. The highest gradient was measured at lower Coal Mine and Red Peak Valley Washes and upper Red Peak Valley Wash at Wells 19, 31 and 32, respectively.

Alluvial saturated thicknesses and saturated cross-sectional areas were determined for seven major washes using seismic refraction methods. Attachment 13 presents these data for 15 selected sites on an adjacent to the lease. Average saturated thicknesses range from three feet to over 34 feet, while saturated cross-sectional areas range from 900 sq. ft. to over 40,000 sq. ft. Thinnest saturated thicknesses are present at Upper Red Peak Wash, Upper Yellow Water Wash and Upper Yucca Flat Wash, while greatest saturated thicknesses were found at Lower Yellow Water Wash, Lower Coal Mine Wash, Lower and Upper Dinnebito Wash, and Middle Reed Valley Wash. Greatest saturated cross-sectional areas are found along Dinnebito, Lower Moenkopi and Coal Mine Washes.

In general, the greatest saturated thickness and saturated cross-sectional areas are to be found along the lower portions of each wash, while their upper reaches are comparatively dry. Exceptions to this are Reed Valley and Upper Coal Mine Wash. In the first case, Reed Valley is rather deeply incised near Site 100R, and probable localized faulting may account for what appears to be a "ponding" of alluvial ground water in that area. Upper Coal Mine Wash displays a greater thickness of alluvium than is present along the upper reaches of most of the other washes, which may explain the higher values for saturated thickness and saturated cross-sectional area present there. Table 37 summarizes the above data.

Alluvial Aquifer Recharge and Discharge. Recharge to the alluvial aquifer is derived from rainfall runoff, snowmelt runoff, ground-water flow from the Wepo aquifer and the Yale Point Sandstone and seepage from springs. Rainfall runoff appears to be the most significant form of recharge to the alluvial aquifer besides ground-water flow from the Wepo aquifer. As much as 5.8 feet of change in water level has resulted from rainfall runoff recharge through the channel bottoms to the alluvial aquifer. In comparison,

TABLE 36

Alluvial Aquifer Gradients and Flow

Directions by Channels and Reaches

Watershed Containing Alluvial Aquifer	Gradient (Ft/Ft)	Flow Direction
Yazzie Wash	.015	South
Upper Yellow Water Canyon Wash	.010	SW
Lower Yellow Water Canyon Wash	.012	SSW
Upper Coal Mine Wash	.010	SW
Middle Coal Mine Wash	.011	SW
Lower Coal Mine Wash	.010	SSW
Upper Moenkopi Wash	.010	SW
Middle Moenkopi Wash	.009	SW
Lower Moenkopi Wash	.009	SW
Tributary to Moenkopi Wash	.019	NW
Upper Reed Valley Wash	.020	NWW
Lower Reed Valley Wash	.016	NWW
Dugout Valley Wash	.025	NNW
Upper Red Peak Valley Wash	.012	NWW
Lower Red Peak Valley Wash	.015	SW
Upper Yucca Flat Wash	.015	NWW
Lower Yucca Flat Wash	.010	NNW
Sagebrush Wash	.015	SW
Upper Dinnebito Wash	.009	SW
Lower Dinnebito Wash	.007	SW

TABLE 37

Alluvial Aquifer Saturated Thickness

And Cross Sectional Areas

Determined by Seismic Refraction and Drilling Logs

Site	Location	Saturated[1] Thickness (ft) (max.)	(avg.)	Saturated Cross[2] Sectional Area (ft^2)
27	Lower Reed Valley Wash	26	12	5900
31R	Lower Red Peak Wash	27	16	5200
32	Upper Red Peak Wash	14	8	1700
70	Upper Yellow Water Wash	10	5	2200
74	Lower Yellow Water Wash	44	20	9000
77	Upper Coal Mine Wash	30	14	11,600
84R	Lower Coal Mine Wash	37	21	20,000
88	Middle Moenkopi Wash	25	14	7500
95	Lower Moenkopi Wash	32	17	16,500
100R	Middle Reed Valley Wash	40	20	7000
103	Middle Red Peak Wash	18	9	3300
105	Middle Yucca Flat Wash	24	12	3200
107	Upper Dinnebito Wash	60	20	24,400
110R	Lower Dinnebito Wash	50	34	40,300
114	Upper Yucca Flat Wash	8	3	900

[1] Minimum saturated thickness is zero in each case. Average saturated thickness is determined by the following formula: $D = \frac{\sum_1^n d_n}{n} = \frac{10\sum_1^n d_n}{L}$,

where D is average saturated thickness; L is lateral surface distance between points along each cross-section where d = 0; d_n is the vertical saturated thickness in the plane of each cross-section; and n = 0.1 L (to the nearest intergral value).

[2] These values were derived directly from each cross-section, using standard planimetric analysis techniques.

snowmelt runoff recharge has amounted to water level changes as much as 4.1 feet. Volumes of water associated with these types of recharge are estimated in the section on "Channel Transmission Losses".

Recharge to the allluvial aquifer from the Wepo aquifer is the principal form of recharge and accounts for the maintenance of alluvial water levels during the extended dry periods. Water level gradients indicating flow from the Wepo aquifer into the alluvial aquifer were noted at six of the 15 sites studied using refraction seismic techniques (Sites 31R, 77, 100R, 103, 107 and 110R, Refer to Attachment 13).

In the northern and northeastern areas of Black Mesa above the leasehold, the drainage channels truncate portions of the Yale Point Sandstone and recharge to the alluvium from the Yale Point Sandstone is highly probable. Aerial surveys flown to document intermittent or wet channel reaches confirm that there is ground-water flow in these portions of the alluvial aquifer system. Because the alluvial veneer is considerably thinner in these reaches, total recharge from the Yale Point Sandstone is probably less significant in comparison to Wepo recharge to the alluvial aquifer on the leasehold. The drainage systems have not downcut to elevations where they would be truncating the Toreva aquifer on the leasehold. Thus, there is no recharge from the Toreva aquifer to the alluvium on the leasehold. Flow rates documented at springs on the leasehold are small enough to infer that recharge from springs to the alluvial aquifer is relatively insignificant.

Discharge from the alluvial aquifer system is in the form of ground-water throughflow and evapotranspiration. Ground-water throughflow through the alluvial aquifer system occurs along each wash as a function of the aquifer transmissivity, the water table gradient and the saturated alluvial cross sectional areas. Evapotranspiration losses are primarily from capillary rise and phreatophyte water consumption. It is estimated that appreciable capillary rise will occur wherever the alluvial aquifer water level is within four feet or less of the channel bed surface. The significance of this phenomena is substantiated by the extensive salt crusts that build up along these channel reaches during the extended dry periods.

Alluvial water consumption by phreatophytes is quite significant. Continuously recorded alluvial wells located in a close proximity to phreatophytes (i.e. 33, 83, 84 and 95) show distinct diurnal water level fluctuations during the late spring and summer months. The two principal phreatophytes occurring on the leasehold are saltcedar and greasewood.

According to Robinson (1958), the annual use of water by phreatophytes in the western states ranges from several thousand cubic feet to more than seven acre-feet/acre of phreatophytes.

Alluvial Aquifer Characteristics. Cooley et al. 1969, as part of their hydroeologic study of Black Mesa, performed twelve pumping tests at different alluvial locations around the Black Mesa region. Results of these tests show that alluvial aquifer transmissivities ranged from 325 to 63,800 gpd/foot and storage coefficients ranged from $5x10^{-4}$ to 0.25.

To evaluate the alluvial aquifer characteristics specific to the leasehold, time-distance-drawdown aquifer tests were performed in pits excavated into the alluvial aquifer and slug injection tests were performed in the alluvial well bores. Time-drawdown pit tests were employed because meaningful drawdown responses could not be obtained in the alluvial wells prior to completely depleting all the water from the well bores. Where the alluvial aquifer water levels were shallow and permeabilities large enough, pit pumping tests were performed. Successful pit tests were performed near Alluvial Wells 74, 84, 88 and 95. The range of average transmissivity values determined from these tests was from 1870-5100 gpd/ft. The transmissivity values were computed using techniques and type curves presented by Neuman (1975).

Problems with pit or well bore storage effects were minimal. Deviations of the data plots from the theoretical response curves were usually overcome within the first 100 minutes of the aquifer test. Even with the use of pits, pumping rates (7 to 10 gpm) maintained in order to avoid draining the pits were not sufficient to induce delayed yield responses from the alluvial aquifer in the two to three-day test periods. Time projections estimated for delayed yield responses at these pumping rates were on the order of weeks. Thus, the early portions of the theoretical response curve (Type A curves) were used to compute transmissivity values. According to Neuman 1975, reasonable transmissivity values can be obtained using the Type A curves; however, storage coefficient values should be determined using the delayed yield (Type B) curves. Storage coefficient values had to be determined from slug tests performed at 15 of the remaining alluvial well sites.

Injection type slug tests were performed at 15 alluvial wells according to the procedures described by Cooper et al. 1967. Transmissivity values were determined by overlaying the data plots on response type curves developed by Cooper et al. 1967 and Papadopulos et al. 1973. Transmissivity values computed ranged from 21 to 1517 gpd/ft (Table 38). Data plots, time versus water level measurement tables and pumping rate tables for all alluvial

TABLE 38

Alluvial Aquifer Characteristics

Well No.	Transmissivity (gpd/ft)	Storage Coefficient
17	310	10^{-2}
27	128	10^{-1}
31R	988	10^{-3}
69	1517	10^{-5}
72	37	10^{-1}
75	3508	*
76	53	10^{-8}
82	46	10^{-1}
84	2062	*
87	219	10^{-3}
88	5100	*
95	1870	*
100R	531	10^{-7}
102	316	10^{-8}
103	59	10^{-8}
104	232	10^{-8}
105	39	10^{-8}
108	68	10^{-3}
110R	21	10^{-2}

* Pit test, storage coefficient could not be determined.

well aquifer tests are presented in Attachment 14.

As was mentioned above, storage coefficient values could not be calculated directly from the time-drawdown alluvial aquifer tests. According to Cooper et al. 1967, storage coefficients can be estimated from the relationship $X = \frac{r_x^2}{r^2_c} S$. Since the r_s and r_c terms cancel out in the case of the alluvial wells, storage coefficients (S) are approximated by the "x" order of magnitude assigned to each type curve. Estimated storage coefficients from the slug tests show a large amount of variability ranging from 10^{-1} to 10^{-8}.

Transmissivities are low in the alluvial aquifer probably due to the fine, poorly sorted nature of the alluvial material and to the limited extent of the aquifer. Ground-water development potential in the alluvial aquifer on the leasehold is low. Figure 72 is provided to show where alluvial aquifer characteristics were determined on the leasehold by the three aquifer testing techniques.

Alluvial Aquifer Water Quality. Water in the alluvium is characterized by a high degree of spatial chemical variability. Hydrologic variables which affect water quality include tranmissivities, hydraulic gradients, nature of recharge and the proximity of recharge sources to alluvial wells. All of these variables interact to some extent to produce the observed water quality.

Hydraulic gradients together with transmissivities determine the residence time of a volume of water in a portion of an aquifer. These aquifer characteristics were compared to TDS in Table 39 to establish the significance of this relationship. As can be seen from Table 39, factors other than gradients and transmissivities exert greater control over TDS levels in the alluvial aquifer.

There are two principal sources of recharge to the alluvial aquifer: discharge from the Wepo aquifer and rainfall and snowmelt runoff. Rainfall runoff and snowmelt recharge through the channel bed appears to be more immediate, based on alluvial hydrograph analysis. As such, it has the potential to significantly affect water quality during wet periods. During the dryer periods, chemical characteristics of Wepo recharge are expected to more strongly affect alluvial water quality.

Table 40 below shows the seasonal recharge-related TDS variability.

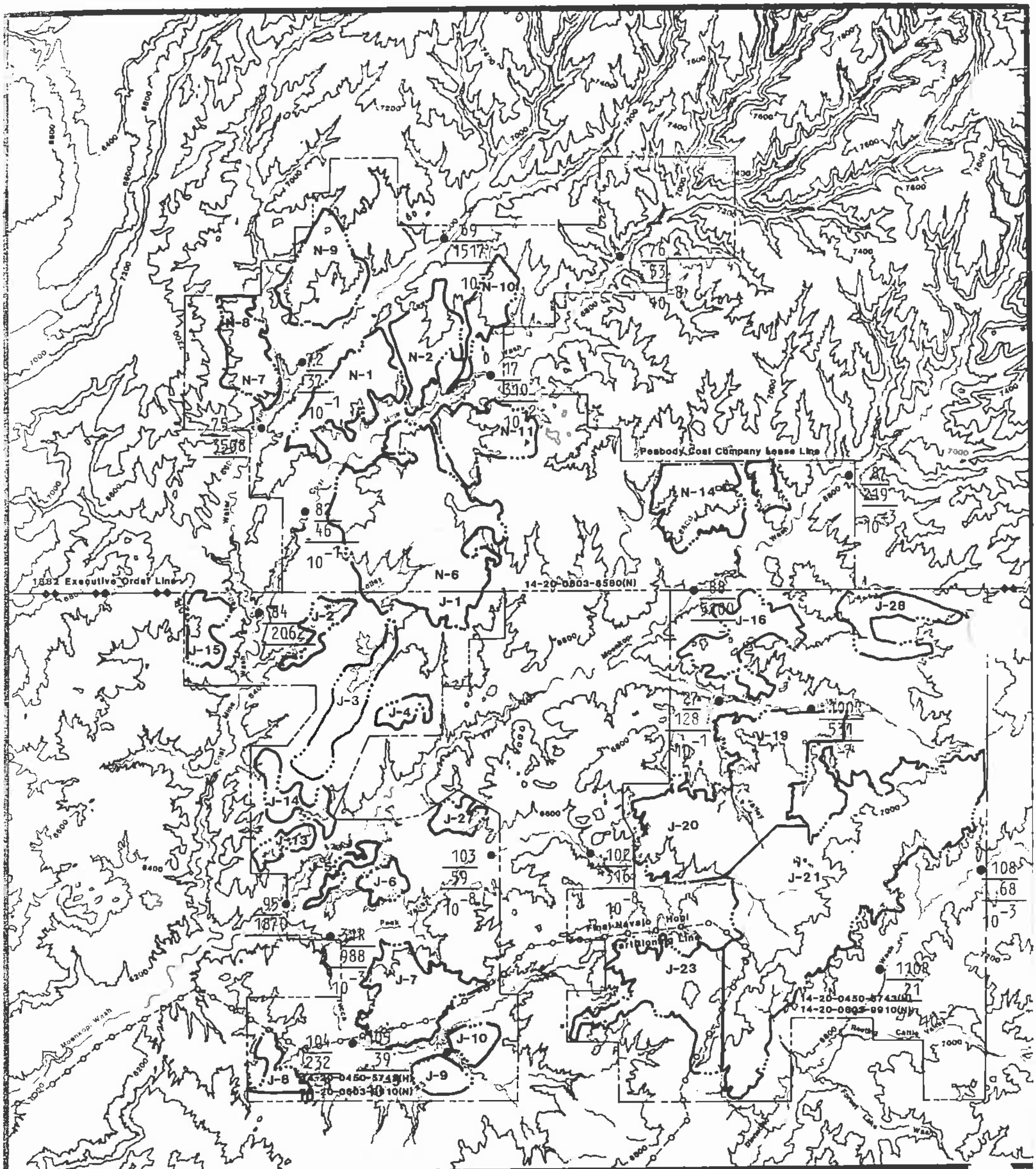


FIGURE 72

Summary of Alluvial Aquifer Characteristics and Leasehold Locations at Which These Characteristics Were Determined

● Well Completed in Alluvial Aquifer

103 Monitoring Site Number

68 Transmissivity (gal/day-ft)

10^{-3} Storage Coefficient

Revised 12/01/86

TABLE 39

Average TDS Values

For the Alluvial Wells

Well	Watershed *	TDS (mg/l)	Well	Watershed *	TDS (mg/l)
13	YW	3992	93	MO	4064
17	CM	1233	94	MO	4028
19	CM	4574	95	MO	3503
23	MO	1320	96	MO	4905
27	RV	1856	98	MO	62,264
29	RP	3984	99	RV	8834
32	RP	3023	100	RV	18,826
68	YW	4771	101	RV	8379
69	YW	3875	102	RP	2568
70	YW	24,185	103	RP	1057
71	YW	5119	104	YU	1916
72	YW	5775	105	YU	3189
73	YW	5452	106	YU	2364
74	YW	5986	107	DI	5921
75	YW	4318	108	DI	3804
76	CM	1051	109	DI	4487
77	CM	628	31R	RP	1195
79	CM	1335	33R	DI	5625
80	CM	4154	70R	YW	N/A
81	CM	2967	74R	YW	3710
82	CM	4948	84R	CM	3830
83	CM	4710	100R	RV	11,370
84	CM	3780	107R	DI	3030
87	MO	2851	110R	DI	5800
88	MO	4239	114R	Y	1490
89	MO	2450			

* Watershed Abbreviations

YW = Yellow Water   CM = Coal Mine   MO = Moenkopi

RV = Reed Valley   RP = Red Peak   DI = Dinnebito   YU = Yucca

TABLE 40

Mean Seasonal TDS Values for the Alluvial Wells

	May-June	July-Oct	Jan-April
TDS mg/l	4755	2932	4252

As can be seen from the data in Table 40, rainfall recharge (July-Oct) has a diluting effect on alluvial water quality. Recharge from the Wepo aquifer dominant during the period May-June is more concentrated. Snowmelt recharge (January-April) is higher in TDS concentration due to the increased time of interaction of slowly melting snow with mineral facies.

The proximity of an alluvial well to recharge sources has an effect on observed water quality. An alluvial well located more proximate to the active stream channel should receive more recharge from runoff than one located at the edge of the alluvium. Consequently, wells closest to areas of channel bed recharge show lower TDS levels due to dilution from runoff events. The same relationship appears to hold for alluvial well proximity to the Wepo aquifer. The further the water travels from the Wepo source, the more it is chemically altered by contact with soluble alluvial materials and mixing with water from different sources.

Alluvial ground water is generally classified as a calcium-magnesium sulfate type following Piper's methods (Piper 1944). High levels of dissolved salts render this water unacceptable for drinking and livestock watering and poor to unsatisfactory for irrigation (McKee & Wolf 1963).

Water samples have been collected periodically from the nine 4-inch alluvial wells since August 1980. In May 1982, sampling was initiated for the sampleable 2-inch wells. Individual chemical analyses from the alluvial wells can be found in the annual Hydrological Data Reports.

The eight principal ions (Ca, Mg, Na, K, HCO_3, CO_3, Cl, & SO_4) plotted on trilinear diagrams, are used to compare water quality between alluvial wells on the same drainage in different portions of the alluvial aquifer system. The trilinear diagrams are presented with the discussions of each drainage. Since trilinear diagrams show only the relative percentages of chemical constituents, certain water quality characteristics may be masked. For example, Table 41 shows that while Site 70 water quality appears proportionally similar to the other Yellow Water alluvial well sites, its water chemistry is actually 5 times more concentrated with respect to TDS. For this reason, the trilinear diagrams should be examined in conjunction with Table 41 when assessing alluvial water quality.

In some cases nitrate (NO_3) occurs in appreciable concentrations in the alluvium. The sources of NO_3 are decaying organic matter and livestock waste. Table 41 shows the ranges of the major ions, including NO_3, for each alluvial well. These values will be used as upper and lower control limits for comparison to future analyses. Samples with values falling significantly outside these ranges will be considered to suggest a possible impact. If the next sampling period values are still in exceedance, the possible causes will be investigated. A statistical summary of selected chemical constituents for all alluvial wells is presented in Attachment 15.

The relationship of calcium to magnesium, calcium to sulfate and magnesium to sulfate (Figures 73 through 78) in the alluvial wells are depicted in two sets of figures, those wells with an average TDS >8000 (98, 99, 100, 100R and 101) and those with an average TDS below 8000. The strongest relationship is between magnesium and sulfate (Figures 75 and 78) and, from the data, appear to be from the same mineral source. The same, but somewhat weaker relationship exists for calcium and magnesium and calcium and sulfate.

The poorest water quality in the leasehold alluvial aquifer system comes from several wells located near the J-28 mining area (Wells 98, 99, 100, 101 and 100R). Exploration core samples from this mining area show very poor quality coal seams. Pyrites and organic sulfur associated with these coal seams yield elevated levels of sulfides which in turn oxidize to form acid. Neutralization of this acid by carbonates in the overburden results in the dissolution of significant amounts of calcium, magnesium and sodium.

Alluvial Well 70 also has very high concentrations of principal ions. In this situation, the elevated levels appear to be a function of the well completion. The well is completed approximately 1.5 feet into a coal seam. Because the saturated thickness at the well bore is minimal, the water yielded from the coal seam has a significant affect on the well water chemistry. Successful slug tests could not be achieved at this well which suggests that the transmissivity is extremely low. This would account for why the poorer coal

TABLE 41

Ranges For the Major Chemical

Constituents in Alluvial Ground Water

Well	Calcium Range mg/l	Magnesium Range mg/l	Sodium Range mg/l	Sulfate Range mg/l	Nitrate Range mg/l
13	245.90-515.00	135.80- 493.00	125.00- 411.80	1566.00- 2870.00	0.50-13.00
17	136.80-230.70	56.00- 78.10	20.00- 55.00	340.00- 550.00	0.20-47.00
19	333.20-637.00	169.00- 335.00	148.00- 380.00	1670.00- 2930.00	12.40-38.80
23	140.00-234.80	35.60- 133.00	29.90- 125.00	390.00- 1020.00	0.20- 3.50
27	120.00-157.80	47.00- 104.00	148.00- 229.00	671.00- 880.00	0.10- 2.50
29	124.20-336.00	98.90- 345.00	378.00- 744.00	1450.00- 2185.00	0.20-42.00
32	89.80-444.00	49.80- 187.00	267.40- 410.00	590.00- 2200.00	0.10- 2.70
68	352.30-662.00	252.00- 370.00	184.90- 299.00	1870.00- 2990.00	0.40- 7.50
69	104.40-425.00	112.00- 490.00	129.90- 275.20	905.00- 2800.00	1.30-19.10
70	398.30-605.00	2500.00-3353.00	193.00-2200.00	14950.00-16700.00	4.60-11.20
71	277.10-638.00	276.40- 514.00	140.60- 260.00	1750.00- 3000.00	0.60-21.50
72	392.70-640.60	330.00- 586.00	221.10- 379.00	2520.00- 3820.00	0.20- 7.20
73	380.00-693.00	332.00- 571.00	282.00- 485.00	2760.00- 4408.00	0.20-27.20
74	431.00-537.00	314.00- 351.00	325.00- 509.00	2650.00- 3070.00	0.20-51.60
75	241.00-511.00	159.00- 370.00	177.00- 458.00	250.00- 2858.00	0.77-13.20
76	160.00-232.60	33.00- 51.50	12.00- 32.10	268.00- 428.00	0.20- 0.80
77	79.00-166.00	17.50- 27.70	7.00- 19.00	119.00- 320.00	0.70- 3.20
79	66.50-182.00	37.00- 68.00	168.00- 215.20	465.00- 830.00	0.10- 1.25
80	344.00-514.00	173.00- 370.00	126.00- 241.00	1705.00- 2710.00	0.04-11.30
81	275.00-495.30	123.60- 208.00	120.00- 198.70	1375.00- 2020.00	1.10- 6.60
82	330.50-700.00	222.90- 590.00	203.70- 469.00	1625.00- 3750.00	19.70-43.10
83	307.00-730.00	180.00- 440.00	181.20- 483.00	1575.00- 3840.00	2.41-35.20
84	270.00-861.00	130.00- 347.00	141.00- 433.00	1410.00- 3570.00	0.10-540.0
87	197.00-370.00	57.00- 430.00	64.70- 379.00	735.00- 2775.00	2.70-26.00
88	245.00-434.00	109.00- 441.00	112.50- 415.00	1290.00- 3380.00	0.01- 6.98
89	186.00-238.00	109.00- 281.00	45.00- 220.00	607.00- 1930.00	0.20- 0.80
93	299.60-540.00	108.50- 273.00	142.50- 322.70	1350.00- 2502.00	0.20- 6.60
94	316.00-501.00	217.80- 288.00	154.00- 278.00	1820.00- 2420.00	0.10- 1.80
95	130.50-509.00	158.00- 261.00	132.00- 454.00	1380.00- 2380.00	0.00- 0.37

TABLE 41 (Cont.)

Ranges For the Major Chemical

Constituents in Alluvial Ground Water

Well	Calcium Range mg/l	Magnesium Range mg/l	Sodium Range mg/l	Sulfate Range mg/l	Nitrate Range mg/l
96	351.80-572.00	214.90- 387.00	200.50- 472.00	1870.00- 3395.00	0.10- 1.30
98	342.00-536.00	854.70-9960.00	5900.00-10000.00	15550.00-60100.00	0.10- 1.80
99	119.20-254.00	544.20-1060.00	84.00- 992.00	3355.00- 6030.00	0.00- 0.60
100	157.10-495.00	653.00-2880.00	749.80- 3190.00	3500.00-17250.00	3.80-10.80
101	116.00-537.00	622.20- 944.00	82.00- 937.00	3750.00- 6210.00	0.16- 0.80
102	220.00-380.00	81.60- 100.10	76.00- 120.00	780.00- 1060.00	0.10- 2.00
103	61.90-190.00	19.30- 240.00	16.30- 61.40	158.00- 1070.00	0.10- 3.40
104	90.80-410.00	32.00- 150.00	89.40- 280.00	282.00- 1830.00	0.10-56.70
105	104.00-269.60	27.00- 250.00	272.90- 1500.00	524.00- 2230.00	0.10- 2.00
106	76.10-210.00	46.70- 100.00	192.00- 419.00	442.00- 1140.00	0.10- 1.80
107	393.80-660.00	300.00- 502.00	321.00- 1037.00	2570.00- 4410.00	0.00- 0.69
108	155.60-622.00	75.30- 280.00	104.00- 242.20	850.00- 2520.00	0.03- 0.21
109	440.00-502.00	270.00- 353.00	175.00- 313.00	2375.00- 2707.00	0.10- 0.90
31R	150.00-180.00	52.00- 55.00	95.00- 100.00	402.00- 540.00	0.20- 3.00
33R	430.00-430.00	353.00- 470.00	620.00- 650.00	2920.00- 3700.00	9.00-12.50
70R	*	*	*	*	*
74R	*	*	*	*	*
84R	517.00-530.00	170.00- 300.00	172.00- 340.00	1920.00- 2800.00	0.24-22.90
100R	265.00-360.00	610.00-1300.00	580.00- 1500.00	4020.00- 7870.00	0.20- 9.70
107R	300.00-430.00	220.00- 265.00	13.00- 250.00	1240.00- 1760.00	0.20- 0.20
110R	520.00-600.00	370.00- 430.00	480.00- 510.00	2820.00- 3300.00	0.20- 0.20
114R	6.50- 15.00	3.00- 23.00	490.00- 560.00	70.00- 250.00	0.80- 1.00

* Alluvial Wells 70R and 74R have not been sampled enough times to establish ranges.

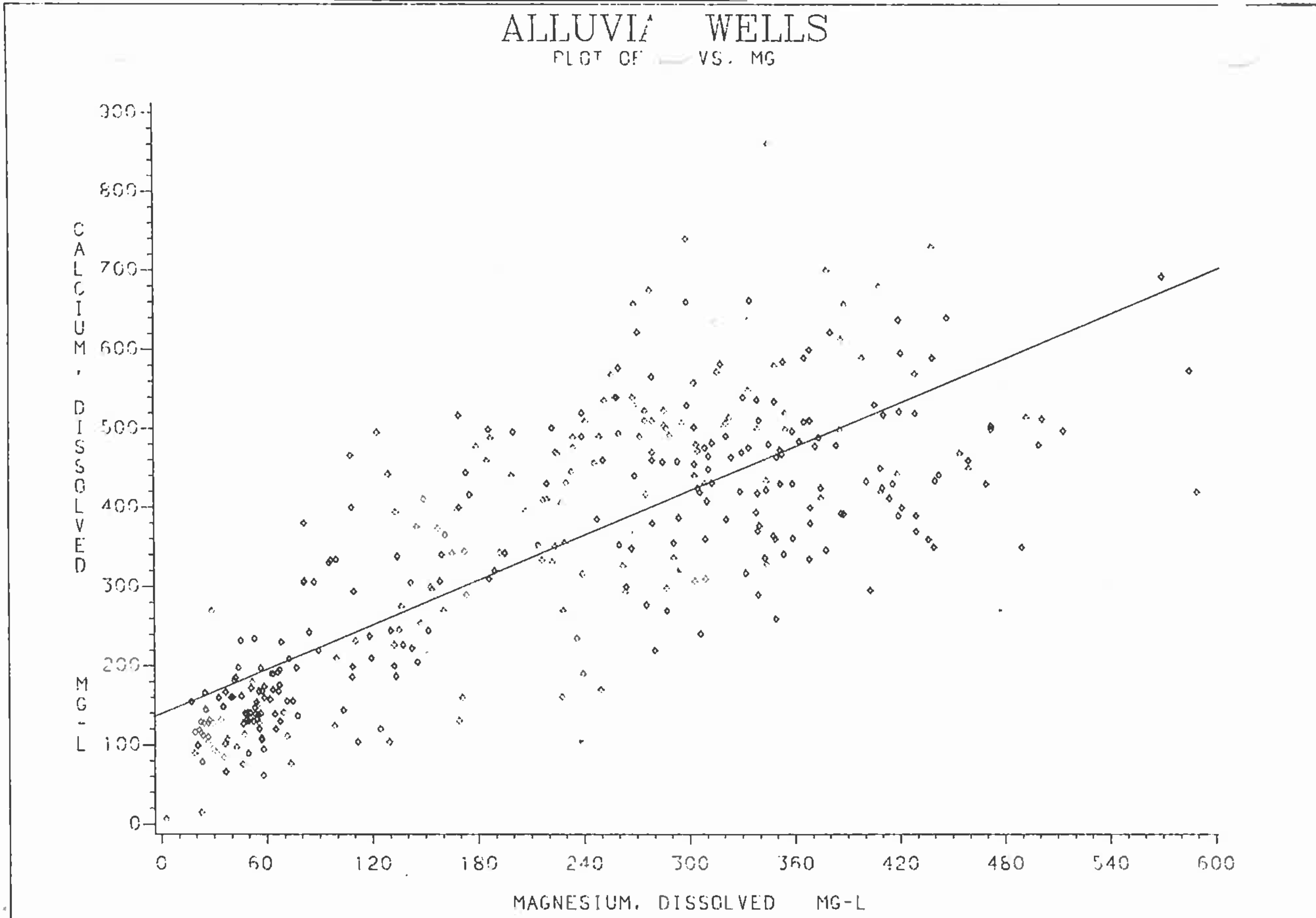


FIGURE 73

Relation between Ca and Mg for Alluvial Wells

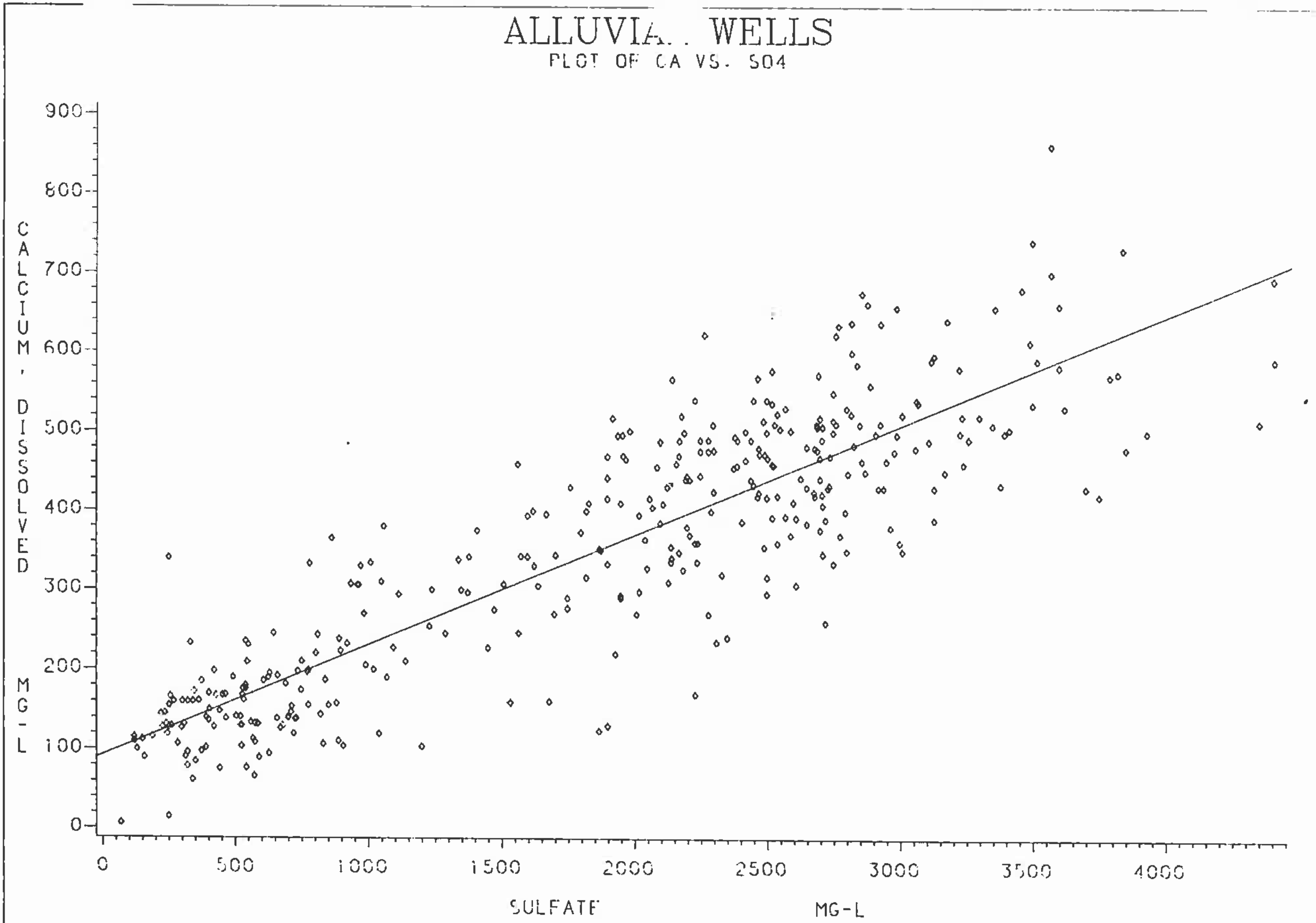


FIGURE 74

Relation between Ca and SO_4 for Alluvial Wells

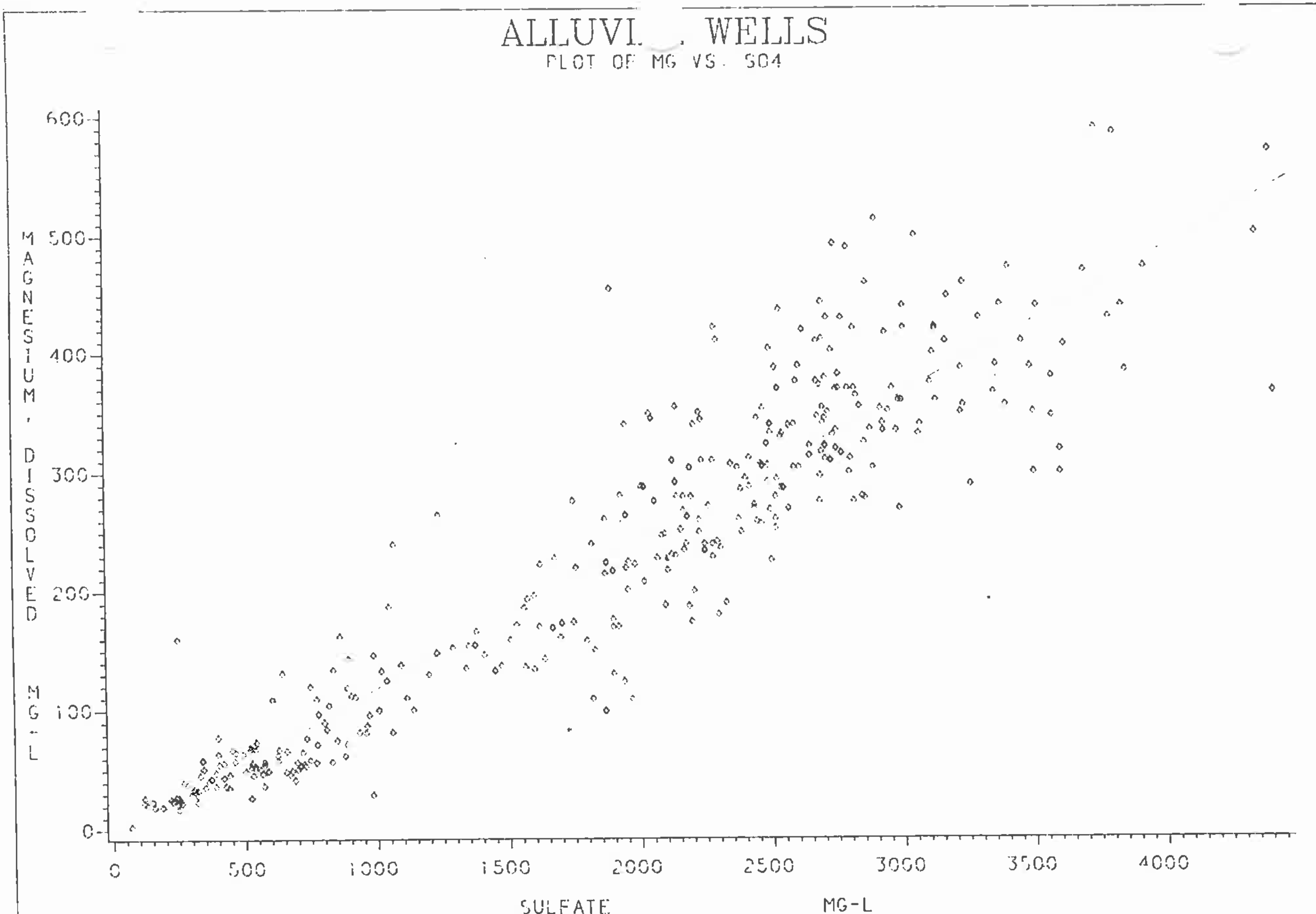


FIGURE 75

Relation between Mg and SO_4 for Alluvial Wells

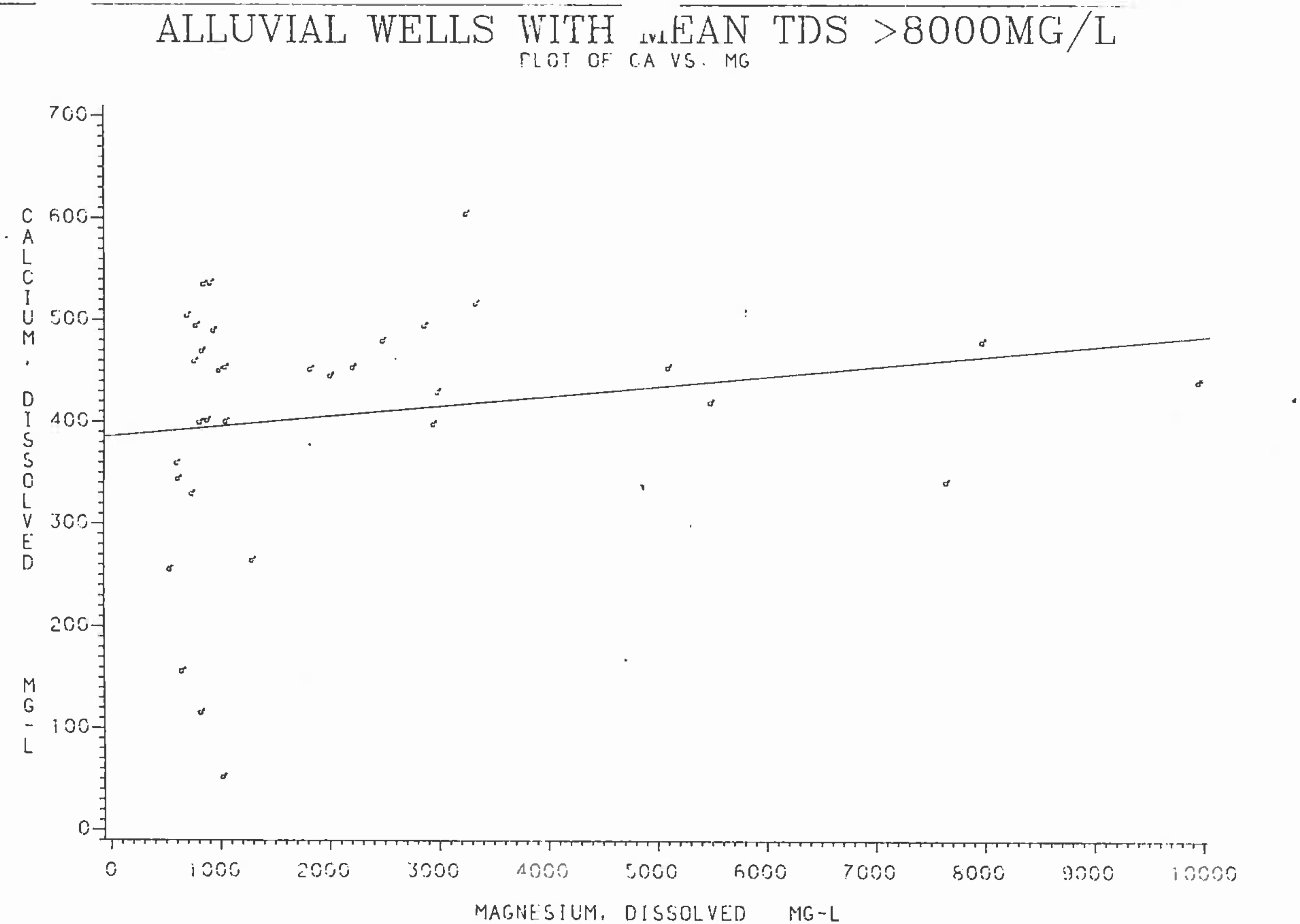


FIGURE 76

Relation between Ca and Mg for
Alluvial Wells with Mean TDS > 8000 mg/l

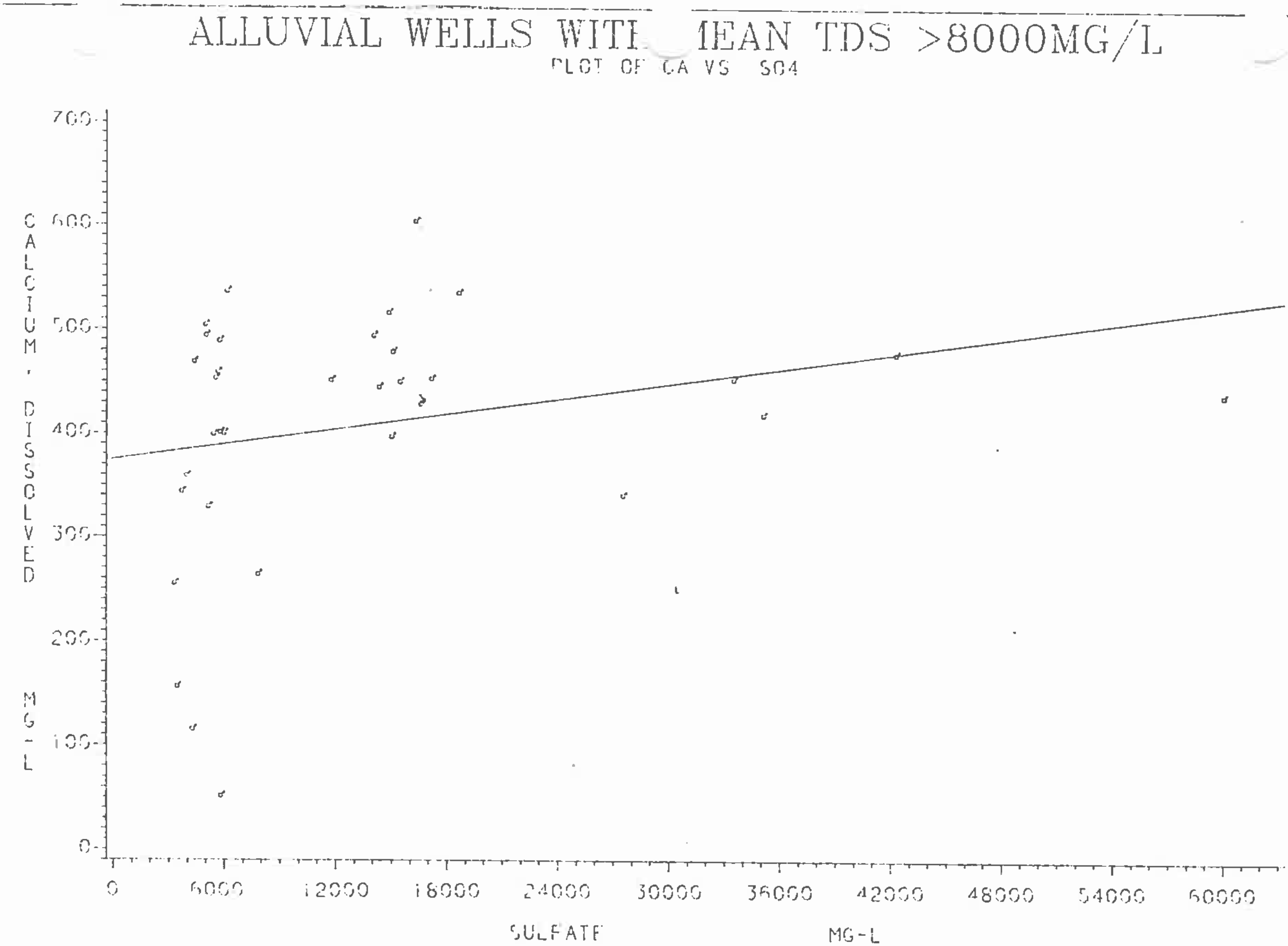


FIGURE 77

Relation between Ca and SO_4 for
Alluvial Wells with Mean TDS > 8000 mg/l

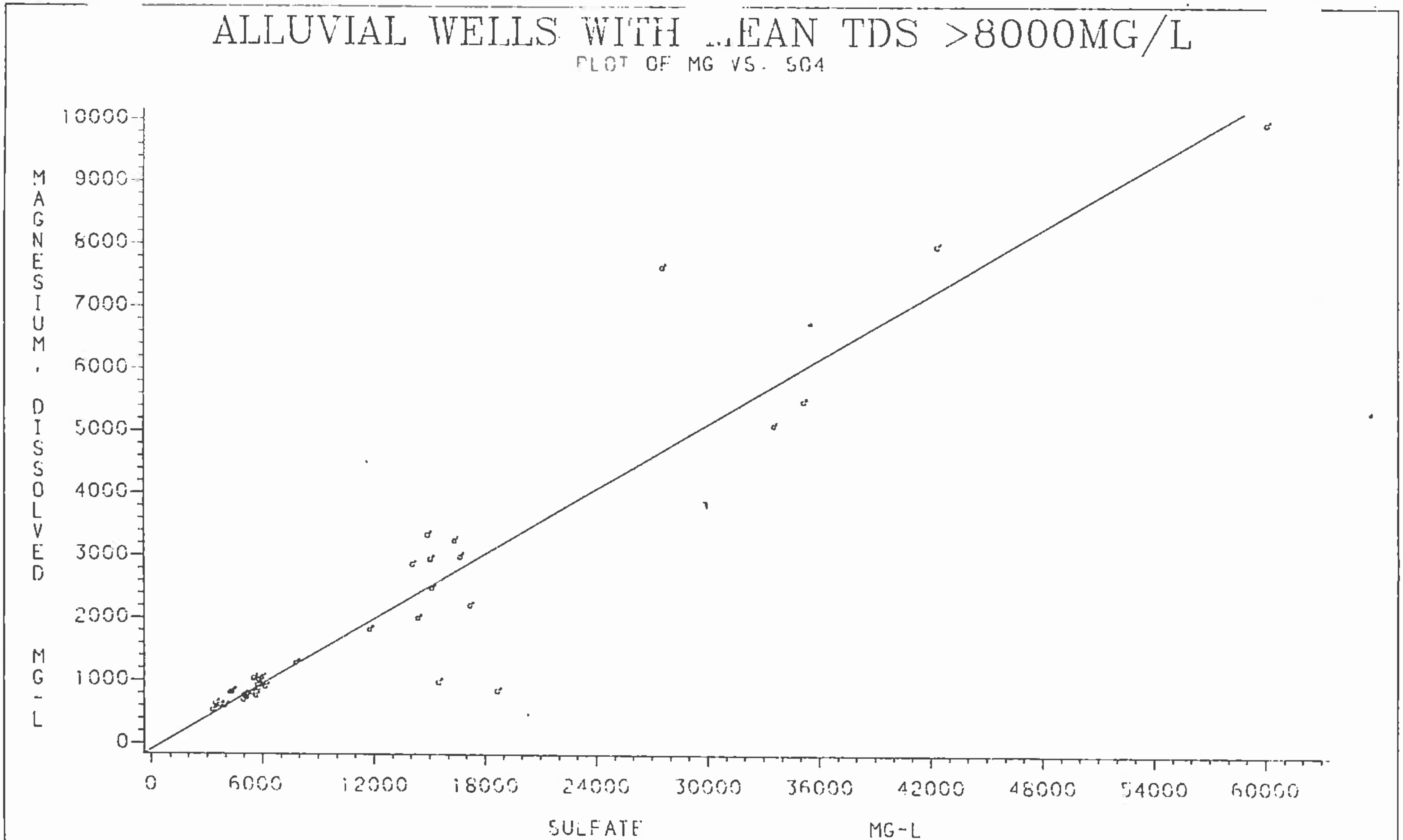


FIGURE 78

Relation between Mg and SO_4 for Alluvial Wells with Mean TDS >8000 mg/l quality dominated water is not readily diluted by alluvial water.

Yellow Water Canyon Wash Alluvial Aquifer Water Quality

The Yellow Water Canyon Wash drainage contains 10 alluvial wells. Eight sites (69, 70, 70R, 71, 72, 74, 74R and 75) are located along the main stem of Yellow Water Wash while two sites (68 and 73) are located in Yazzie Wash, a tributary to Yellow Water. The trilinear diagram for these sites, Figure 79, shows that all wells have a similar water type (calcium-magnesium).

With the exception of Sites 70, 70R and 74R, the alluvial hydrographs show that the Yellow Water alluvial aquifer receives considerable runoff recharge. In the case of Sites 69 and 75, the water level response to runoff is almost immediate. The drillers logs document mostly sand with gravel and cobbles in their lithologic profiles, which accounts for this rapid response. In addition, an aquifer test at Site 75 shows the transmissivity to be 3,508 gpd/ft. Removal of a portion of the Wepo aquifer upgradient from Sites 74, 75 and 74R, in the N-7 mining area is expected to temporarily affect the water quality in these alluvial wells. As spoil materials are resaturated, following reclamation of the N-7 pit, a slight increase in TDS in the local alluvial aquifer is anticipated.

The water quality variation among the remaining wells in the Yellow Water Wash drainage (13, 68, 71, 72 and 74) can be attributed to their locations relative to the active channel and corresponding amounts of runoff recharge.

Alluvial Wells 70, 70R and 74R all slightly penetrate the Wepo aquifer. While no samples have been obtained from Site 70R, water quality from the adjacent well Site 70, is among the poorest on the lease. Recharge is from a coal unit in the Wepo Formation which was partially penetrated by Well 70.

Coal Mine Wash Alluvial Aquifer Water Quality

The Coal Mine Wash drainage contains 11 alluvial wells. All are located in the main stem of Coal Mine Wash. Three sites (19, 84 and 84R) are located immediately below the confluence with Yellow Water Wash. The trilinear diagram, Figure 80, shows that all the wells fall within two water type groupings, with Well 79 offset from the rest because of a higher percentage of sodium.

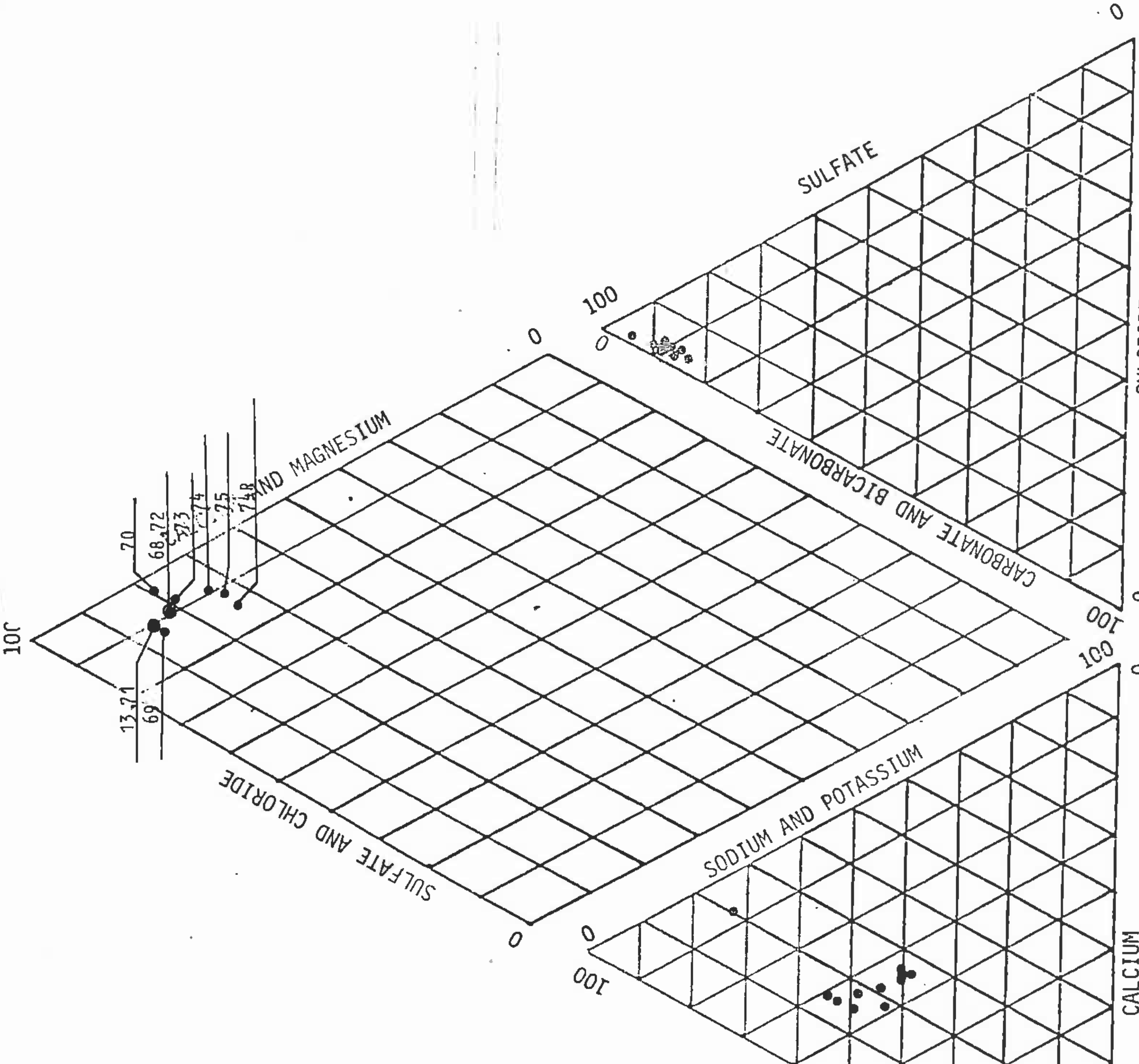


FIGURE 79

Trilinear Plot of Mean Parameter Values for Alluvial Wells in Yellow Water Canyon Wash, 1980 to 1985

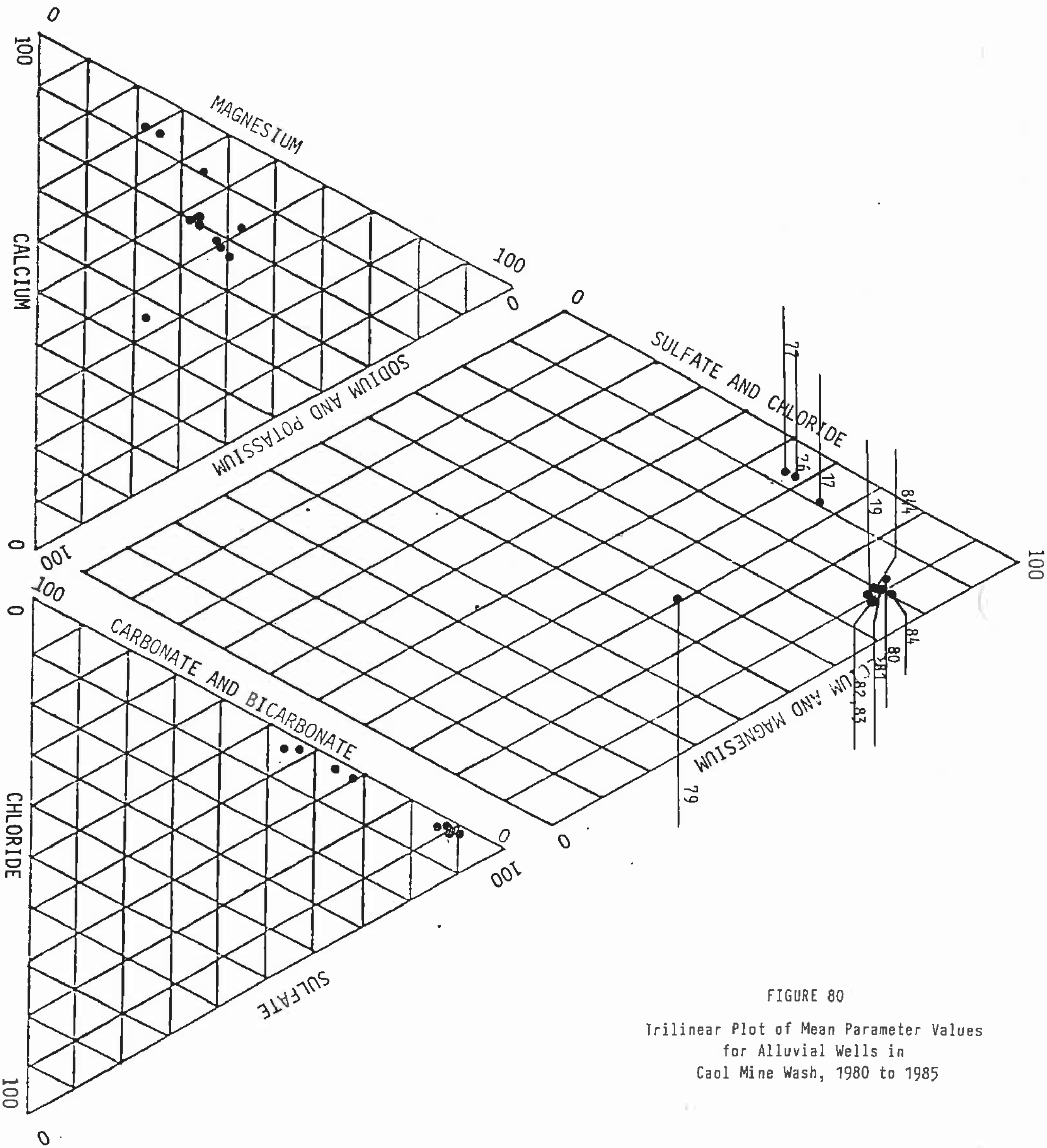


FIGURE 80

Trilinear Plot of Mean Parameter Values
for Alluvial Wells in
Caol Mine Wash, 1980 to 1985

Sites 17, 76 and 77 indicate a calcium-magnesium sulfate and bicarbonate water type (Figure 80). Sites 76 and 77 are within 150 yards of each other while site 17 is approximately 5 miles down stream. The hydrographs for these alluvial wells suggest that they all respond to runoff recharge but that the response is attenuated at Site 76. The comparatively high levels of calcium and bicarbonate from these sites indicate a nearby significant Wepo recharge source. The dominant ions suggest that the recharge source is a sandstone unit (Hem 1970). These wells yield the highest quality alluvial water on the lease.

Site 79 is located within 200 yards from Site 17 but exhibits higher levels of sodium. The hydrograph for Site 79 shows minimal water level response to runoff recharge. Elevated sodium levels at Site 79 suggests local recharge from the Wepo aquifer through a shale unit. The water quality of two nearby Wepo wells (Sites 41 and 52) are similar to that of Site 79.

The remaining wells, (Sites 19, 80, 81, 82, 83, 84 and 84R) plot as a calcium-magnesium sulfate water type. The hydrographs for these sites show that all respond significantly to runoff recharge. Sites 84 and 84R were lost in 1984 due to lateral channel erosion shortly after Site 84R was installed. A new 84R well has subsequently been completed in a more protected area. Both the original and the new 84R were within 75 meters of Site 84. Wells 80 and 81 are located adjacent and below a channel realignment that was completed in the spring of 1981. The impact of this channel change on water quality at these sites has been minimal, with only small increases in the concentrations of the major cations. The water use potential in this portion of alluvium remains unchanged.

The water quality variations between wells (19, 80, 81, 82, 83, 84 and 84R) are probably a function of their distances from the active channel and corresponding degrees of runoff recharge. In addition, Site 84 shows notable water quality variation between samples. This is due to mixing of water from both Yellow Water and Coal Mine watersheds (Well 84 is at the confluence of the two washes). The quality of water at this site is affected by the relative proportions of water contributed by each watershed.

Moenkopi Wash Alluvial Aquifer Water Quality

The Moenkopi Wash drainage contains 9 alluvial wells. Eight sites (23, 87, 88, 89, 93, 94, 95 and 96) are located in the main stem of Moenkopi Wash while one (Site 98) is

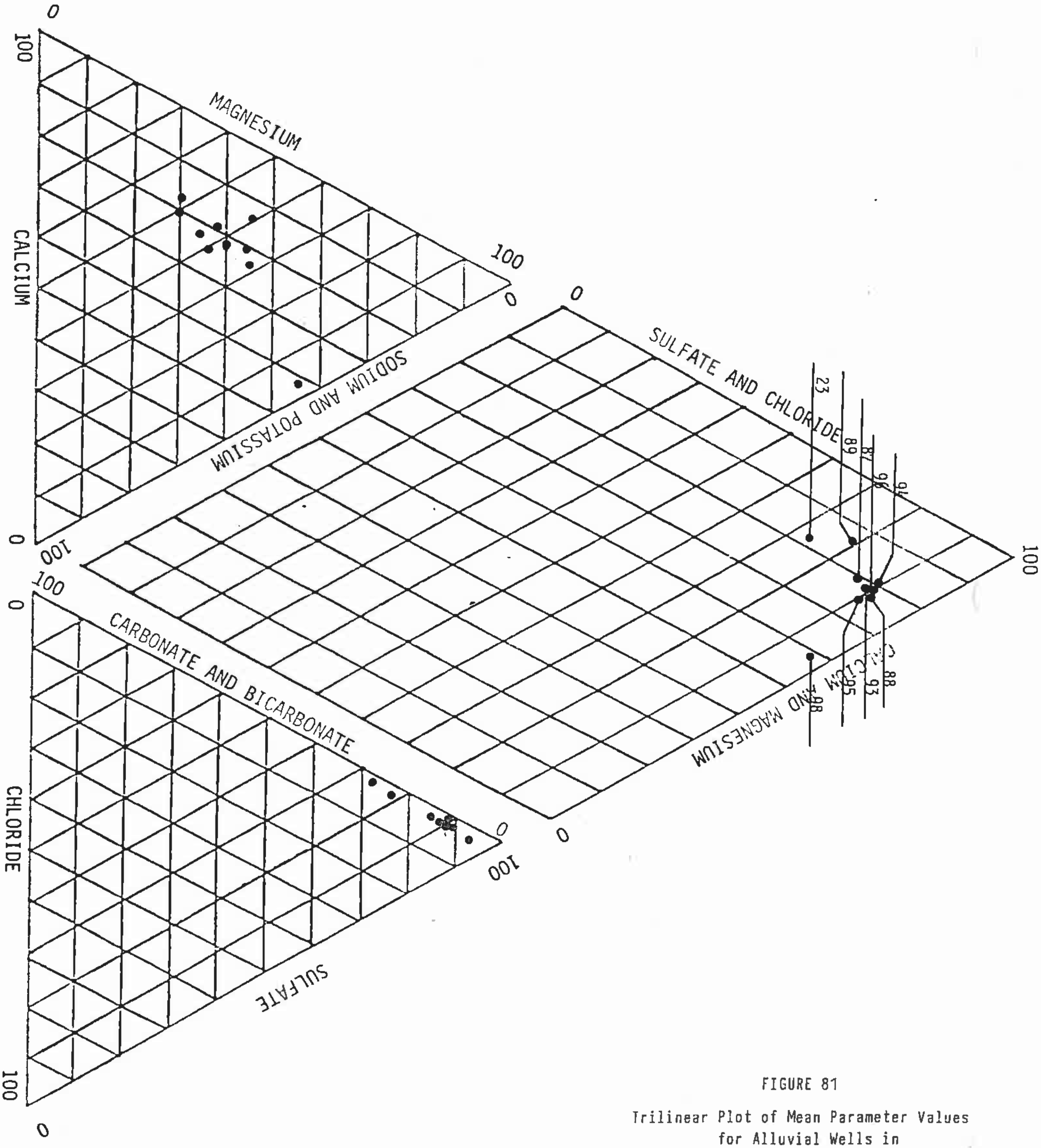


FIGURE 81

Trilinear Plot of Mean Parameter Values
for Alluvial Wells in
Moenkopi Wash, 1980 to 1985

located in a tributary to Moenkopi. The trilinear diagram for Moenkopi Wash drainage (Figure 81) shows that all wells are of a calcium-magnesium sulfate water type.

The water quality at all sites except 23 and 98 appears to be related to the distances the wells are from the active channel. Wells located at the edges of the alluvium exhibit the least variation in water quality between samples. This can be attributed to reduced seasonal input from runoff recharge.

The generally higher cation concentrations found in alluvial wells in lower Moenkopi Wash (Sites 93, 94, 95 and 96) can probably be related to the presence of phreatophytes. In arid areas, there are significant concentrations of dissolved constituents near phreatophytes as they utilize moisture while leaving salts behind (Bouwer 1978). These riparian stands are most prevalent along the lower reaches of Moenkopi Wash.

Site 23 appears to reflect the presence of a significant Wepo recharge source. It also appears to receive considerable surface runoff recharge. The increased calcium and bicarbonate levels noted here suggest local recharge from the Wepo via a sandstone unit.

Site 98 will be discussed in the next section of Reed Valley Wash drainage because of water quality similarites.

Reed Valley Wash Alluvial Aquifer Water Quality

The Reed Valley Wash drainage contains 5 alluvial wells. Four sites (99, 100, 100R and 27) are located along the main stem of Reed Valley Wash while one site (27) is located in Dugout Wash, a tributary to Reed Valley. The trilinear diagram (Figure 82) for this drainage shows that all wells except Site 27 plot in a group.

Site 27 water quality is characterized by comparatively higher levels of calcium and bicarbonate while magnesium and sodium levels are reduced. The higher calcium and bicarbonate levels suggest that a sandstone unit is supplying recharge to this portion of the alluvium.

Site 70 in the Yellow Water Canyon alluvial aquifer and Site 98 in an unnamed tributary alluvial aquifer have very similar ion concentrations (TDS >8000) and water types to Reed Valley Alluvial Wells 99, 100, 100R and 101. An explanation tying their water chemistry

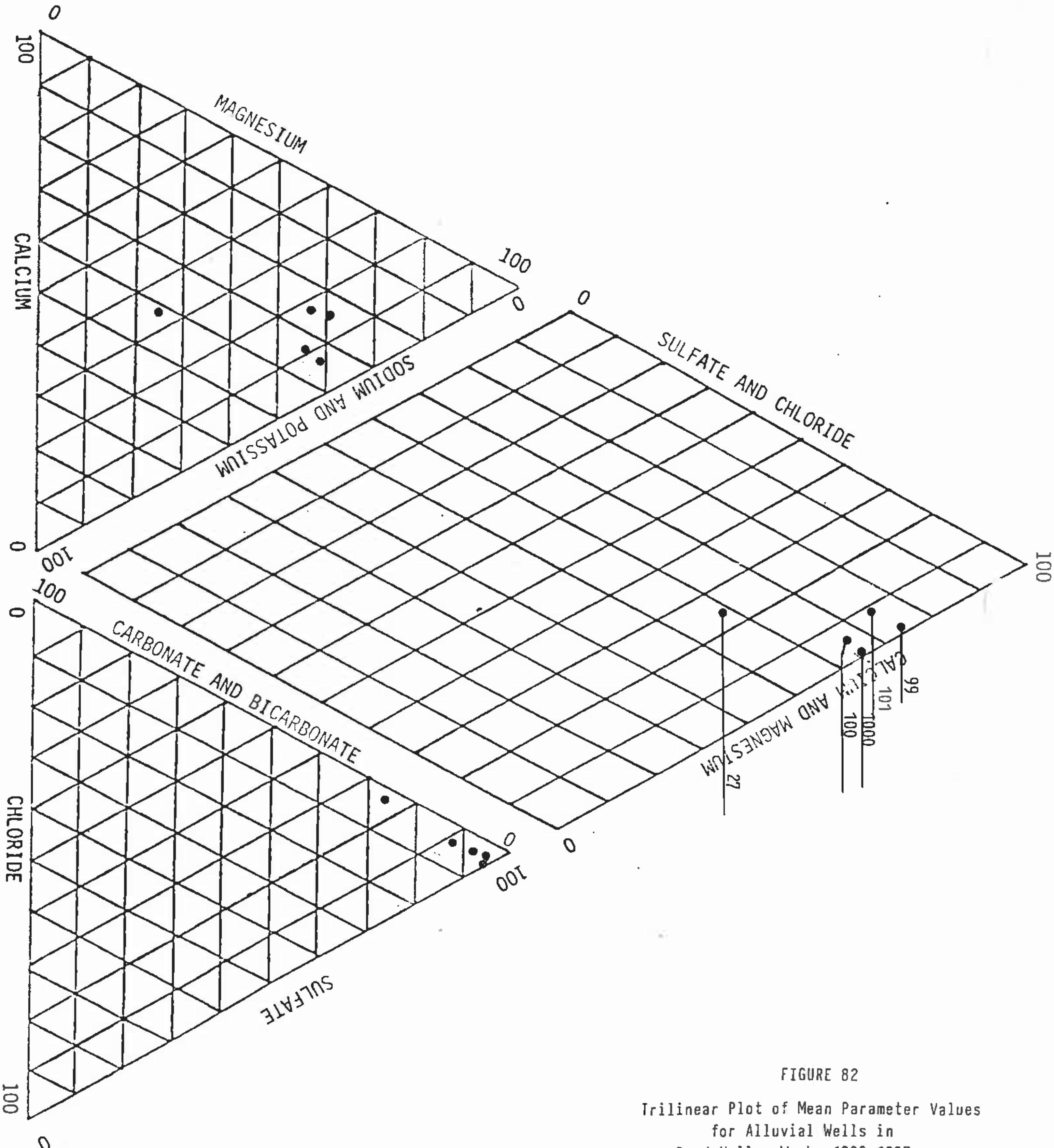


FIGURE 82

Trilinear Plot of Mean Parameter Values
for Alluvial Wells in
Reed Valley Wash, 1980-1985

to environment of deposition lithologic differences has been discussed previously. In addition, Well 70 water chemistry is highly influenced by its well completion.

Red Peak Valley Wash Alluvial Aquifer Water Quality

The Red Peak Valley Wash drainage contains 5 alluvial wells. All sites (29, 32, 102, 103 and 311) are located along the main stem of Red Peak Valley Wash. The trilinear diagram for this drainage, Figure 83, shows that all sites plot in different areas within the same water type - calcium-magnesium sulfate.

Site 32 water quality is dominated by sodium and sulfate. The drillers log indicates that only moist alluvium was encountered above bedrock. Well 32 was completed through 12 feet of weathered shale and coal in the Wepo Formation.

Runoff recharge occurs as lateral flow over the semi-confining weathered shale beds. The water quality type does suggest flow from the weathered shale. During periods of pumping stress, the shale yields limited amounts of water and recovers quite slowly.

Sites 31R, 102 and 103 all show considerable response to runoff recharge. The drillers logs document that the alluvial profile at these sites is predominantly composed of sand. The water quality at these sites reflects that of surface runoff.

Site 29 is located immediately below J-7 dam. As such, it receives very little overland runoff recharge. The area around this well is perennially saturated and running water is evident during a portion of the year. Water quality at this site is probably affected by seepage recharge from J-7 dam and phreatophyte salt concentration.

Yucca Flat Wash Alluvial Aquifer Water Quality

The Yucca Flat Wash drainage has 4 alluvial monitoring wells. Three sites (104, 105 and 114R) are located along the main stem of Yucca Flat Wash while one site (106) is located in Sagebrush Wash a tributary to Yucca Flat. The trilinear diagram for this drainage, Figure 84, shows that it contains the only alluvial wells (105, 106 and 114R) on the leasehold which deviate from the calcium-magnesium sulfate water type. The exception is Site 104 which exhibits a calcium-magnesium sulfate water type dominated by runoff

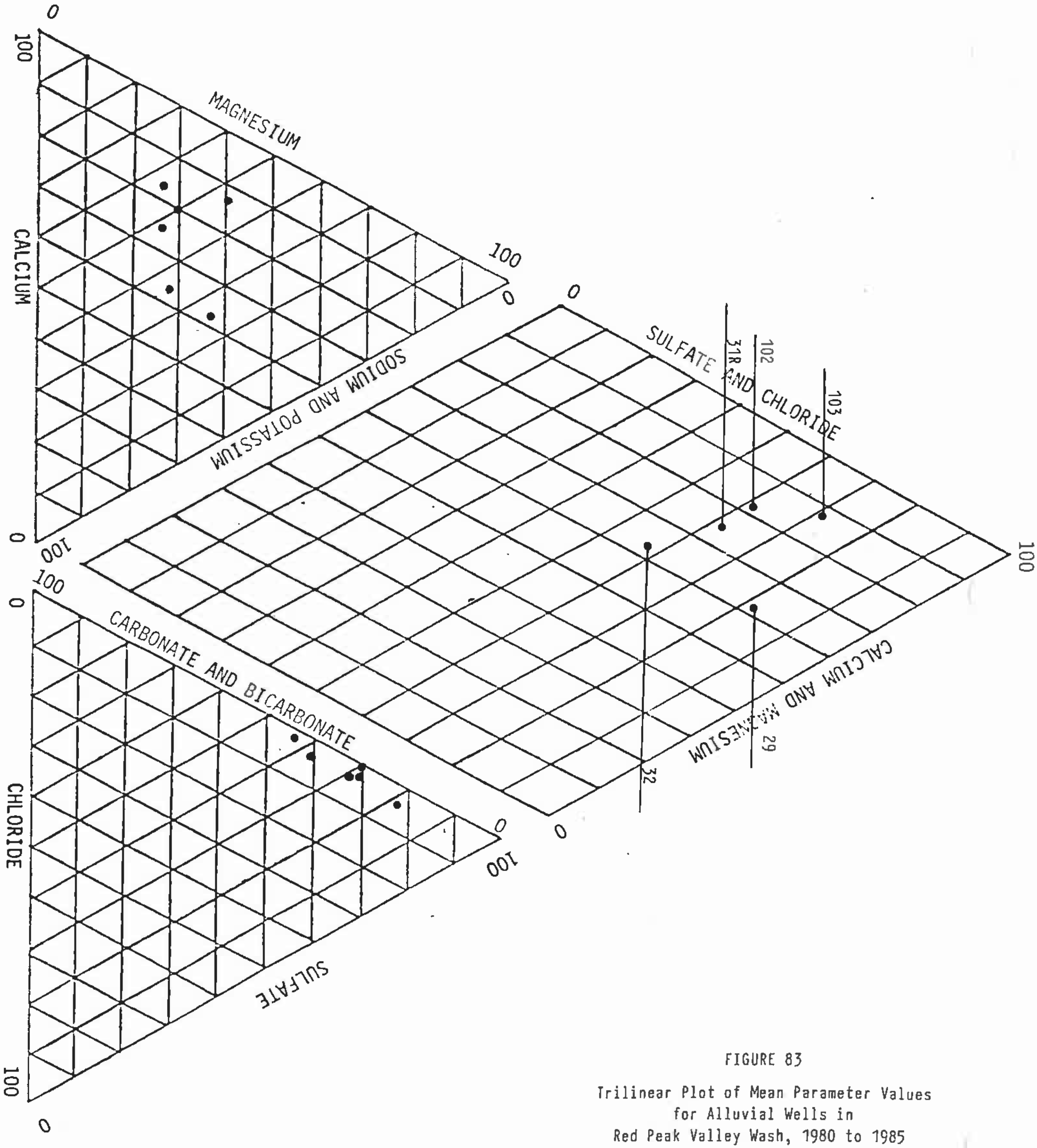


FIGURE 83

Trilinear Plot of Mean Parameter Values
for Alluvial Wells in
Red Peak Valley Wash, 1980 to 1985

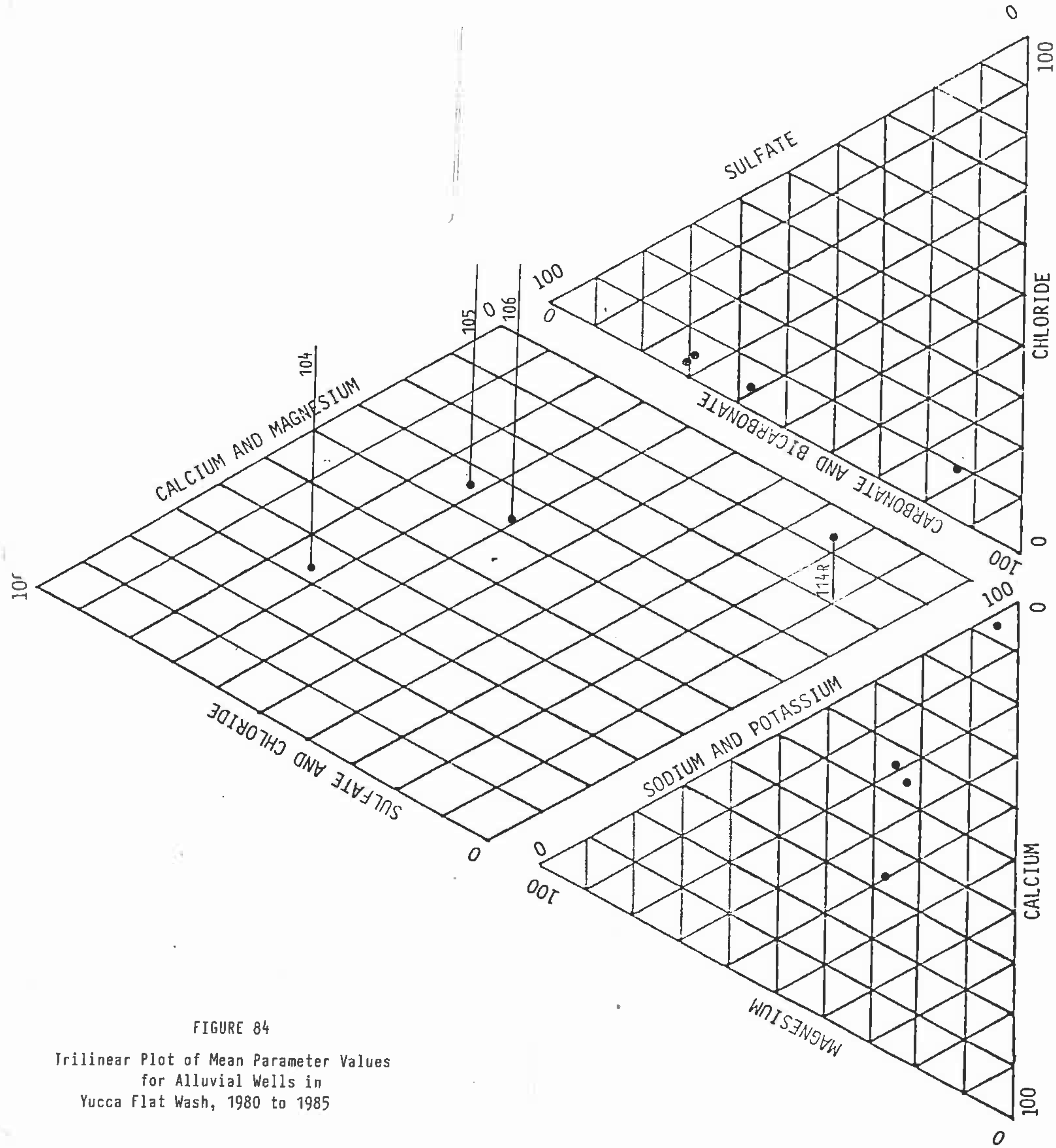


FIGURE 84

Trilinear Plot of Mean Parameter Values
for Alluvial Wells in
Yucca Flat Wash, 1980 to 1985

recharge.

Wells 105 and 106 yield a sodium sulfate water type. This type of water is typical of alluvial wells with very limited saturated thicknesses or partially completed in the underlying Wepo units. Well 105 may partially penetrate some weathered bedrock. Seismic traverses run along Yucca Flat Wash indicate that alluvial saturated thicknesses range from 0 at Well 114R to only 5 feet at Well 105. Under this type of scenario there is very limited potential for cation exchange reactions to occur in the higher cation exchange capacity (CEC) alluvial material.

Site 114R was completed in the Wepo aquifer. The Wepo units penetrated are predominantly shale with some coal and sandstone. The water quality at this site merely reflects what is representative of the Wepo aquifer at that location.

Dinnebito Wash Alluvial Aquifer Water Quality

The Dinnebito Wash drainage contains 6 alluvial wells. All six sites (107, 108, 109, 33R, 107R and 110R) are located along the main stem of Dinnebito Wash. The trilinear diagram for this drainage, Figure 85, shows that all well water quality samples plot similarly and are of a calcium-magnesium sulfate water type.

The alluvial hydrographs for all sites show that water level response to runoff is considerable. The drillers' logs document that the lithologies for all wells along the wash are dominated by silty and sandy clays. This, combined with the lowest alluvial aquifer gradients on the leasehold (.009 - .007), suggests that water in this portion of the aquifer should have longer residence times.

The water quality of the Dinnebito wells is a function of their relative distances from the active stream channel, and alluvial aquifer lithology and gradient.

Permanent Internal Impoundments

The internally draining ponds discussed in this section are not to be confused with sediment ponds or other water control structures. These ponds are on the interior of reclaimed areas only. They have been created for the purpose of providing water for livestock and wildlife and to enhance the vegetation program. For the purposes of the

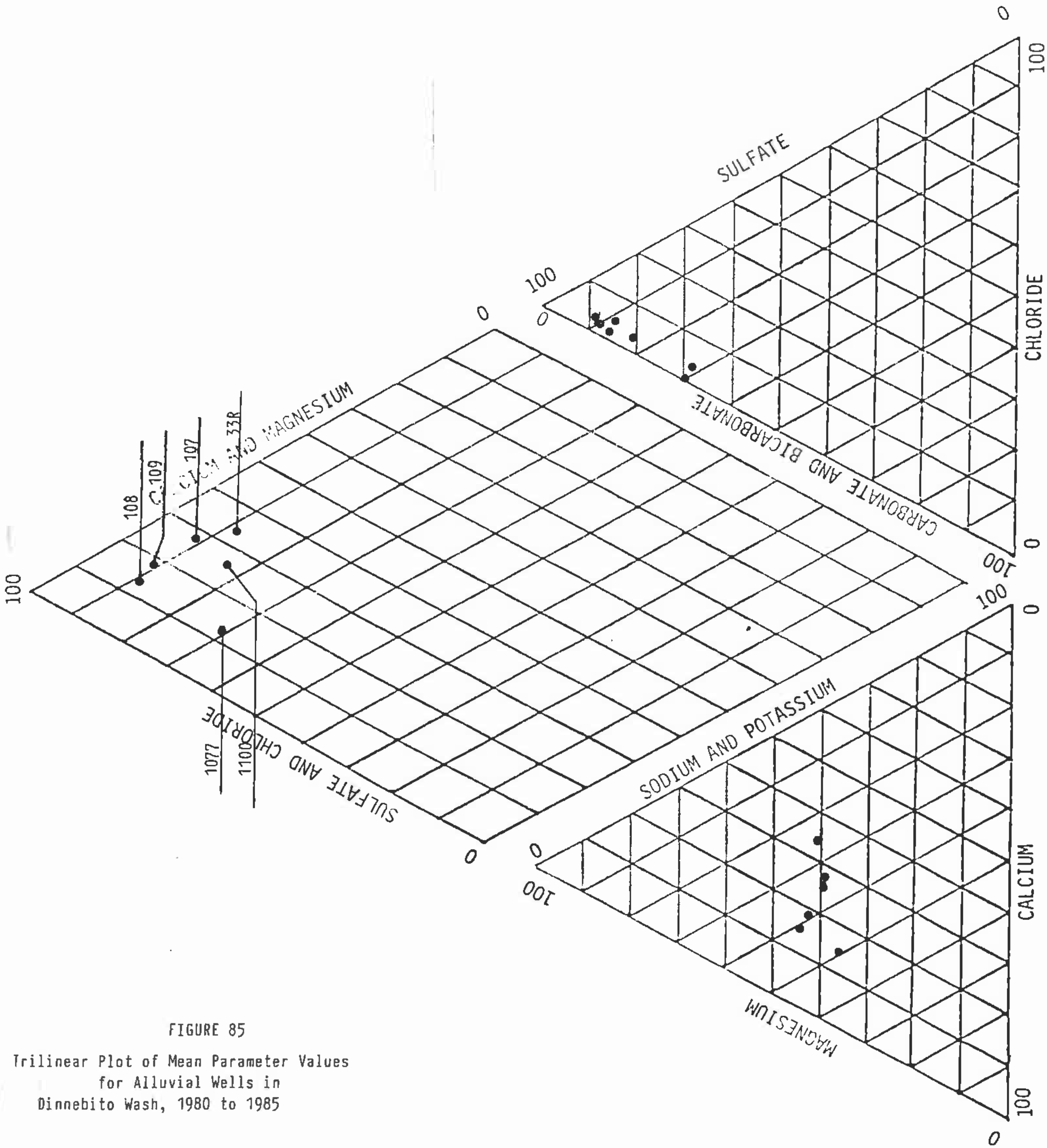


FIGURE 85

Trilinear Plot of Mean Parameter Values
for Alluvial Wells in
Dinnebito Wash, 1980 to 1985

following discussion, these ponds shall be referred to as permanent internal impoundments.

Several permanent internal impoundments have been created in pre-law mining areas and two have been constructed in the N-2 postlaw mining area. The SMCRA is very specific in defining the criteria for authorizing approval of permanent internal impoundments as part of the final reclamation plan.

To address the SMCRA criteria, Peabody retained Water, Waste and Land, Inc. of Fort Collins, Colorado (WWL) to perform hydrologic and engineering studies to assess the feasibility of incorporating permanent internal impoundments as part of the final reclamation plan. The study results are presented in considerable detail in Appendix E of this PAP. In addition to the WWL study, Peabody has incorporated as part of their monitoring program, the monitoring of the quality and quantity of water in both pre- and postlaw permanent internal impoundments. The following discussion will address the specific SMCRA pond criteria and will incorporate the results of the WWL study and the Peabody permanent internal impoundment (pond) monitoring program.

SMCRA Criteria. Section 515(b)(8) of SMCRA states that operators may:

(8) create, if authorized in the approved mining and reclamation plan and permit, permanent impoundments of water on mining sites as part of reclamation activities only when it is adequately demonstrated that -

(a) the size of the impoundment is adequate for its intended purposes;

(b) the impoundment dam construction will be so designed as to achieve necessary stability with an adequate margin of safety compatible with that of structures constructed under Public Law 83-566 (16 U.S.C. 1006);

(c) the quality of impounded water will be suitable on a permanent basis for its intended use and that discharges from the impoundment will not degrade the water quality below water quality standards established pursuant to applicable Federal and State law in the receiving stream;

(d) the level of water will be reasonably stable;

(e) final grading will provide adequate safety and access for proposed water users; and

(f) such water impoundments will not result in the diminution of the quality or quantity of water utilized by adjacent or surrounding landowners for agricultural, industrial, recreational, or domestic uses.

Impoundment Size. The intended purposes for permanent internal impoundments are stock watering and enhancement of wildlife habitat. A secondary purpose may be improvement of reclamation success. Since the postmining land use on the Black Mesa leasehold is rangeland, the presence of any surface water for livestock would be beneficial.

The wildlife baseline study found in Chapter 10 documents the benefits to wildlife of the existing J-7 impoundment. Similar benefits would be expected at additional impoundments. The presence of surface water would have the potential for improving plant species diversity in the immediate vicinity of an impoundment. Evidence of this effect can be found near several small permanent internal impoundments in the reclaimed, pre-law J-3 area.

It should be evident that the quantity of water available in an impoundment at a given time is not particularly critical to the intended purposes. The presence of any surface water would serve the purposes stated above. A wide range of impoundment sizes is available because of the way surface mining activities are conducted. For example, ramps can be used to create small to medium-sized watersheds and final cuts can be shaped to create relatively large watersheds.

To address the permanent internal impoundment size issue, WWL investigated the relationship between impoundment surface area and watershed area. Because the size of existing impoundments and watersheds was so variable, a dimensionless parameter, referred to as an area index, was used in the water persistence stochastic computer modeling. Area index was defined as the watershed area divided by the impoundment area. Appendices E and F in the WWL Study (PAP Appendix E) show the probability of water persistence as a function of area index and runoff curve number. An examination of Appendix F indicates that there is very little gain in water persistence probability beyond an area index of 150. There is a trade off between the probability of water persistence and impoundment size. In order to minimize evaporation losses, impoundment surface areas need to be minimized and depths maximized. There is a practical limit as to how deep impoundments can be excavated and certainly safety concerns apply to impoundment slopes and depths.

A survey of existing impoundments known to hold water for extensive periods of times showed that area indexes ranged from 10 to 126. Since large impoundments are not particularly required to serve the intended purposes of the surface water, it seems reasonable to create small to medium-sized impoundments and optimize the probability that water will be present. A few large watersheds would not be as beneficial as a larger number of smaller watersheds considering the nature of precipitation experienced on Black Mesa, the potential for improving vegetation diversity, grazing management and the potential for a wider distribution of wildlife habitat areas.

Impoundment Stability. The permanent internal impoundments closely resemble incised ponds. Embankments are very wide and gradually sloped down gradient. Section 3 and Appendices G and H in the WWL Study (PAP Appendix E) discuss field analyses, laboratory grain size and Atterberg limits tests and direct shear tests performed on spoil samples from test pits in the vicinity of impoundments in pre- and postlaw reclaimed areas. Safety factors were computed for static and earthquake loading conditions in excess of the most critical that could be expected to occur. The minimum safety factors of 1.9 for static loading conditions and 1.35 for earthquake loading conditions demonstrate that the creation of internal impoundments in spoil would not present any stability hazards.

Water Quality. Based on the results of chemical analyses of soil samples taken from reclaimed areas, WWL's water quality mass balance model projected that the water quality in impoundments would be better than the standards recommended for livestock by the U.S. Environmental Protection Agency and the Water Quality Bureau, Montana Department of Health and Environmental Sciences. As part of the environmental monitoring program on the leasehold, ten prelaw and two postlaw permanent internal impoundments have been sampled for water quality since 1981 (see Drawing No. 85600). In all, 61 impoundment samples have been analyzed representing all seasons of the year and a variety of water depths. A statistical summary of the principal ions analyzed for is presented in Attachment 16. A trilinear plot of average impoundment ion concentrations is shown in Figure 86. The plot indicates there are three water types represented by the impoundments: (1) calcium-magnesium sulfate (Impoundments 116, 119, 120, 121, 123, 206 and 212); (2) calcium-magnesium bicarbonate (Impoundments 117, 118 and 122); and (3) sodium-sulfate (Impoundments 112 and 113). Based on water quality criteria for livestock (Table 42, EPA, 1979), all impoundments are suitable for use as livestock drinking water. Historically, one analysis at Impoundment 116 was at the livestock limits for SO_4 and TDS. Three analyses at Impoundment 113 had high SO_4 values (3800-5400); however, the accuracy of these early analyses is questionable as these same analyses reported TDS ranges from 88 to 26,000. These early TDS values were either inordinately high or low in comparison to SO_4 concentrations since SO_4 is the major ion and is usually an order of magnitude higher than

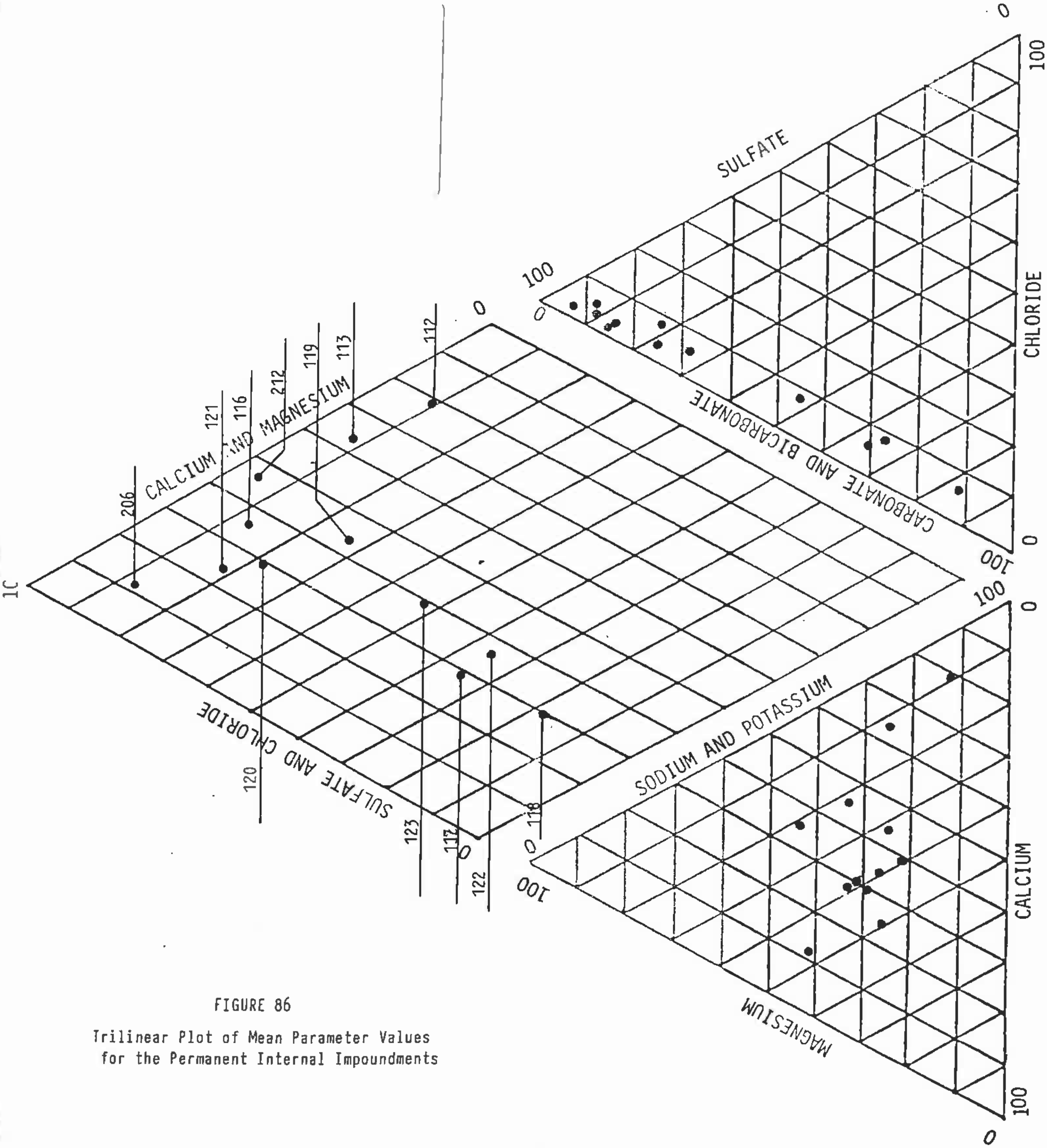


FIGURE 86

Trilinear Plot of Mean Parameter Values for the Permanent Internal Impoundments

TABLE 42

Water Quality Criteria

(National Academy of Sciences, 1974*)

Parameter (total form)	Criteria for: Drinking Water (mg/liter)	Livestock (mg/liter)	Aquatic Life (mg/liter)	Irrigation (mg/liter)
Aluminum	-	5.0	-	5.0
Antimony	-	-	-	-
Arsenic	0.05+	0.2	-	0.1++
Barium	1.0	-	-	-
Beryllium	-	-	0.011-1.100++	0.1-0.5++
Boron	-	5.0	-	0.75++
Bromine	-	-	-	-
Cadmium	0.01+	0.05	0.0004-0.012++	0.01
Chlorides	250++	2000.0+++	-	-
Chromium	0.05+	1.0	0.1++	0.1
Copper	1.0++	0.5	AF	0.2
Cyanide	0.2	-	0.005	-
Dissolved Oxygen	-	-	5.0	-
Fluoride	1.4-2.4+	2.0	-	1.0
Iron	0.3++	-	1.0++	5.0
Lead	0.05+	0.05-0.1	0.03	5.0
Lithium	-	-	-	2.5
Manganese	0.05++	-	-	0.2
Mercury	0.002+	0.01	0.05 ug/1++	-
Molybdenum	-	-	-	0.01
Nickel	-	-	AF	0.2
Nitrate Nitrogen	10.0+	100.0	-	-
Nitrite Nitrogen	1.0	10.0	-	-
pH	5.0-9.0	6.5-8.5+++	6.5-9.0	4.5-9.0++
Selenium	0.01+	0.05	-	0.02
Silver	0.05+	-	-	-
Sulfates	250++	3000+++	-	-
Total Dissolved Solids	500++	5000++	15,000++	AF++

TABLE 42 (Cont.)

Water Quality Criteria

(National Academy of Sciences, 1974*)

Parameter (total form)	Criteria for: Drinking Water (mg/liter)	Livestock (mg/liter)	Aquatic Life (mg/liter)	Irrigation (mg/liter)
Vanadium	-	0.1	0	0.1
Zinc	5.0++	25.0	AF	2.0

* Those parameters for which drinking water regulations (1978) or quality criteria (1979) have been established by the U.S. Environmental Protection Agency are specially indicated, and in this table replace the older NAS recommended levels.

\+ U.S. Environmental Protection Agency (1978)

++ U.S. Environmental Protection Agency (1979)

+++ Wyoming DEQ/LQD (1980)

AF Application factor; indicates criterion for this parameter must be separately established for each water body or irrigation use.

the other principal ions. It should be pointed out that these impoundments receive runoff from nontopsoiled reclaimed spoil.

Comparison of the impoundment water quality with streamflow water quality (Tables 43 and 44) demonstrates that impoundment water is of comparable quality or better. Although WWL concludes that water would not discharge from permanent internal impoundments to the washes, if discharges were to occur, streamflow water quality would not be degraded.

Permanent internal impoundment water quality degradation with time was investigated by sampling the impoundments over a period of years and timing some of the sampling with impoundment water level extremes. The impoundment water quality does not appear to be degrading with time. This is substantiated by the preceding water quality discussion and referenced tables.

Water quality degradation at low impoundment water levels was addressed by both the WWL study and Peabody monitoring. WWL concluded that impounded water would not have a large concentration of TDS except, possibly for short periods of time just prior to the time at which the impoundment becomes dry. High concentrations of TDS were not considered a potential problem as minimal impoundment water depths were reestablished from runoff following periods in which the pond had been dry. The rationale for this is as follows. Residual salts left on a dry pond bottom result from crystallization from the concentrated solution that exists as the volume of water in the pond approaches zero. These salt crystals are highly soluble and are quickly dissolved when contacted by precipitation and/or runoff (White, 1977). The infiltration capacity of the materials covering the pond bottom is greatest when the pond is dry. The first amounts of precipitation and/or runoff contacting the dry pond bottom infiltrate and carry the highly soluble salts below the surface. Thus, the large fraction of the residual salts are not solubilized by the water standing in the pond. Both capillary and gravitational gradients are oriented downward as long as water stands in the pond. Therefore, the only mechanism by which the salts carried below the surface can reenter the pond is by diffusion. Once ponded water is again depleted by evaporation and percolation, the capillary gradient reverses and water will move upward in response to the evaporative potential. Salts dissolved in this upward moving water are precipitated at or near the ground surface and are in addition to those precipitated from the pond water.

Two impoundments (113 and 118) were selected to represent worst and best case scenarios

TABLE 43

Mean Concentrations of Selected Chemical Parameters Measured In Permanent Internal Impoundments on Reclaimed Areas on Black Mesa

	Monitoring Site											
Parameter	116	117*	118*	121	122*	123*	112*	113*	119*	120*	206	212
pH	7.8	7.3	7.4	7.2	7.6	8.0	8.5	7.7	7.5	7.8	8.1	8.1
TDS	2085	279	239	490	308	549	2628	4816	411	724	915	4403
Alk	158	136	121	78	117	229	157	242	91	122	77	133
SO_4	1320	46	19	210	48	175	1213	2590	187	337	523	2973
Ca	119	31	26	66	27	69	52	155	37	80	123	278
Mg	148	16	13	21	11	24	39	189	17	35	66	258
Na	214	11	6	19	8	47	462	854	43	54	22	640

*Pre-law area ponds

TABLE 44

Mean Concentrations of Selected Chemical Parameters

Measured at Stream Station Sites on Black Mesa

(1980 - 1985)

	Monitoring Site													
	DN		RE	YC	YW			CM			RP		MK	
Parameter	34	78	37	85	50	15	157	16	18	25	14	155	35	26
pH	7.7	7.4	7.4	7.7	7.7	7.7	7.7	7.5	7.6	7.6	7.7	7.8	7.4	7.7
TDS	1998	1823	1205	289	1869	1396	229	449	1623	1853	783	470	1312	1987
Alk	192	168	303	141	198	189	83	117	194	199	144	122	170	308
SO_4	1187	1063	648	118	582	827	55	170	1157	1061	350	161	766	1170
Ca	234	207	150	52	175	178	38	71	149	187	67	62	158	224
Mg	131	105	61	9	66	88	9	20	139	119	46	18	89	126
Na	144	97	95	13	29	52	6	12	124	126	61	35	65	124

DN Dinnebito Wash

RE Reed Valley Wash

YC Yucca Flat Wash

YW Yellow Water Wash

CM Coal Mine Wash

RP Red Peak Wash

MK Moenkopi Wash

from a water quality persistence standpoint. Stevens digital water level recorders were installed at both impoundments so that water quality could be correlated with water levels. Table 45 presents a summary of water levels versus major chemical constituents and TDS. Over a three year period, only one TDS value exceeded the recommended livestock limit of 5000. A review of the concentrations of all the major ions makes this TDS value very suspect. Only 3,000 of the 10,000 mg/l can be accounted for and it is believed that the TDS value is a laboratory error. This data clearly supports WWL's conclusion that water quality degradation with time and with fluctuating water levels will not be a problem.

Water Level Stability. Four photographs of impoundments in the J-3, J-27 and N-1 prelaw reclaimed areas are included as Figures 87 through 90. The photos, taken during the summer of 1981, are included to show that undesigned impoundments of varying geometries and area indices can and do hold significant amounts of water even during dry years. The depths and surface areas of these impoundments were not designed to minimize evaporation and the impoundment bottoms were not compacted to minimize infiltration losses. With improved planning, properly designed impoundments in reclaimed areas will facilitate water persistence. Water levels will, of course, fluctuate and the fluctuations will depend upon area index, runoff curve number, time of year and the nature of precipitation events experienced on the watershed.

To address the issue of water persistence, WWL performed a stochastic water balance model incorporating a 30-year precipitation record at Betatakin, evaporation data from Many Farms, ring infiltration test results from tests run in impoundment bottoms, rainfall runoff curve numbers ranging from 70 to 90 and area indices ranging from 10 to 750. Table 46 has been provided to show the model results for area indices 10, 70 and 130 and curve numbers 70, 80 and 90. Complete results are presented in the WWL Study (PAP Appendix E, Volume 27), Appendices E and F.

Table 46 indicates that, regardless of the runoff curve number, the months of May and June have the lowest probability for impoundment water persistence. Area index size does make a significant difference in persistence probabilities in the 80 and 90 runoff curve number range. The greatest change in persistence probabilities was between area indices 10 and 70 for curve numbers of 80 and 90. The additional change between area indices 70 and 130 is considerably less, particularly at the runoff curve number level of 90. Realistically, curve numbers in the 70 to 80 range more closely match the postlaw reclaimed areas. Within this curve number range of 70 to 80, only three months out of any year have over a

TABLE 45

Water Quality Variation With Time and Water Levels

For the Permanent Internal Impoundments

Impoundment No.	113				118			
Sampling Date	Jan 83	Oct 83	Mar 84	Mar 85	Jan 83	Oct 83	Mar 84	Mar 85
Water Level	0.13 ft	1.42	0.10	N/A	1.30	2.61	0.57	N/A
Bicarbonate	206.1 mg/l	154.9	451.0	160.0	167.9	75.6	102.0	117.0
Calcium	330.0 mg/l	34.0	103.0	43.0	27.6	14.0	23.4	21.0
Chloride	157.0 mg/l	17.0	28.0	35.8	5.8	5.0	3.6	2.0
Magnesium	220.6 mg/l	15.0	76.0	26.0	14.2	6.0	9.6	9.0
Potassium	53.3 mg/l	15.0	31.3	27.0	16.5	8.0	10.8	14.0
Sodium	234.3 mg/l	157.0	724.0	240.0	3.8	1.0	2.0	3.0
Dissolved Solids (TDS)	10660.0 mg/l	854.0	3066.0	1020.0	260.0	130.0	164.0	172.0
Sulfate	2050.0 mg/l	382.0	1710.0	592.0	15.0	2.0	6.0	26.0

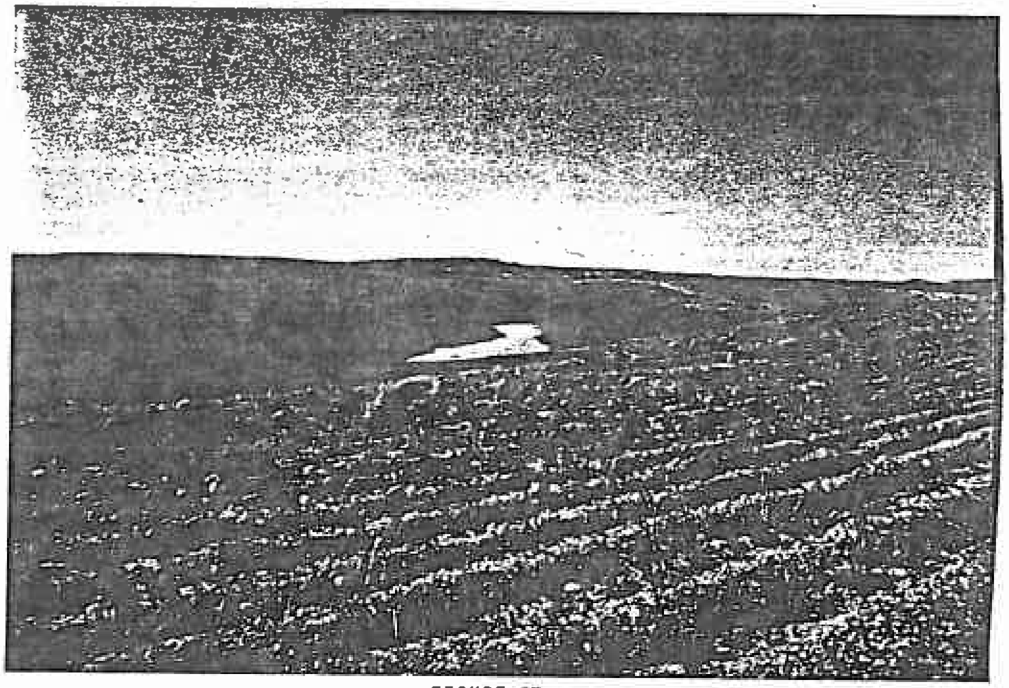


FIGURE 87

Permanent Internal Impoundment in the
Central Portion of J-3 Reclaimed Area

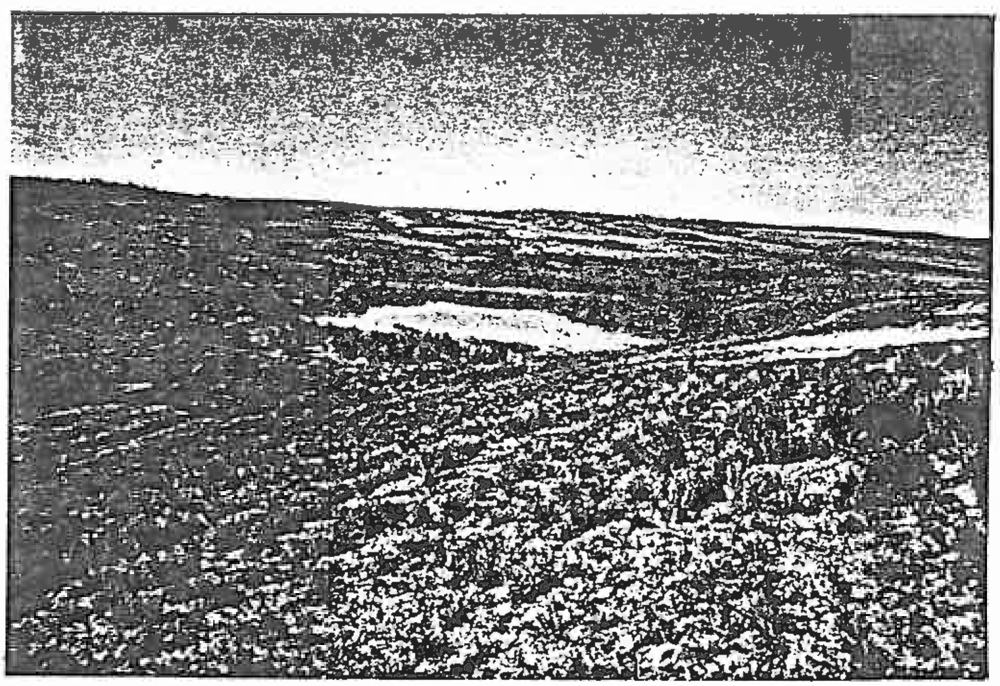


FIGURE 88

Permanent Internal Impoundment in the
Southern Portion of J-3 Reclaimed Area

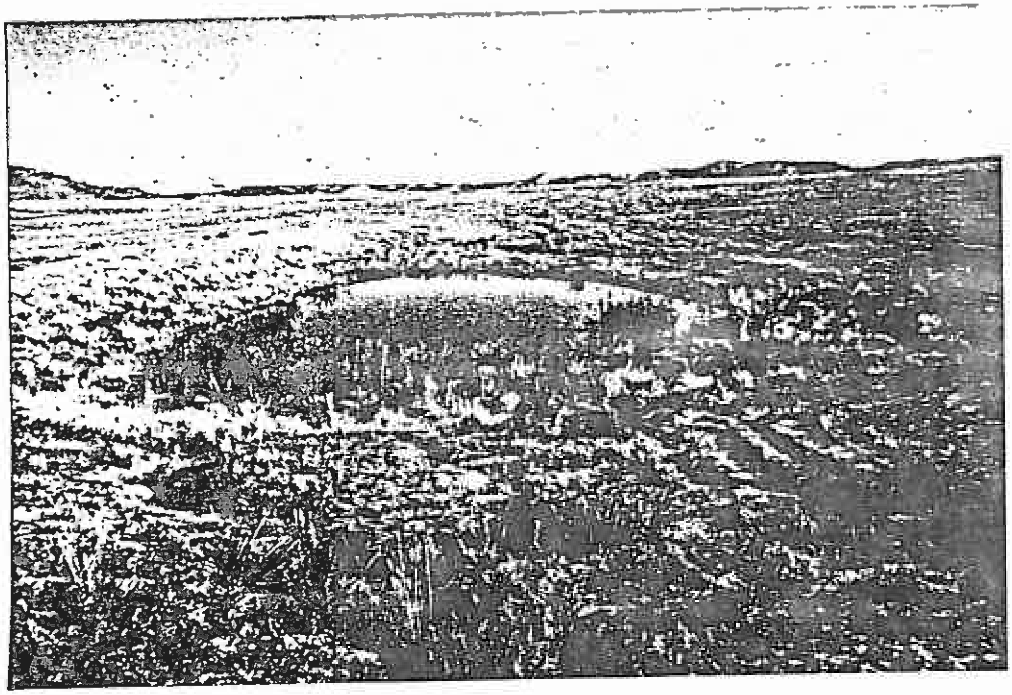


FIGURE 89

Permanent Internal Impoundment in the
Northern Portion of the J-27 Area

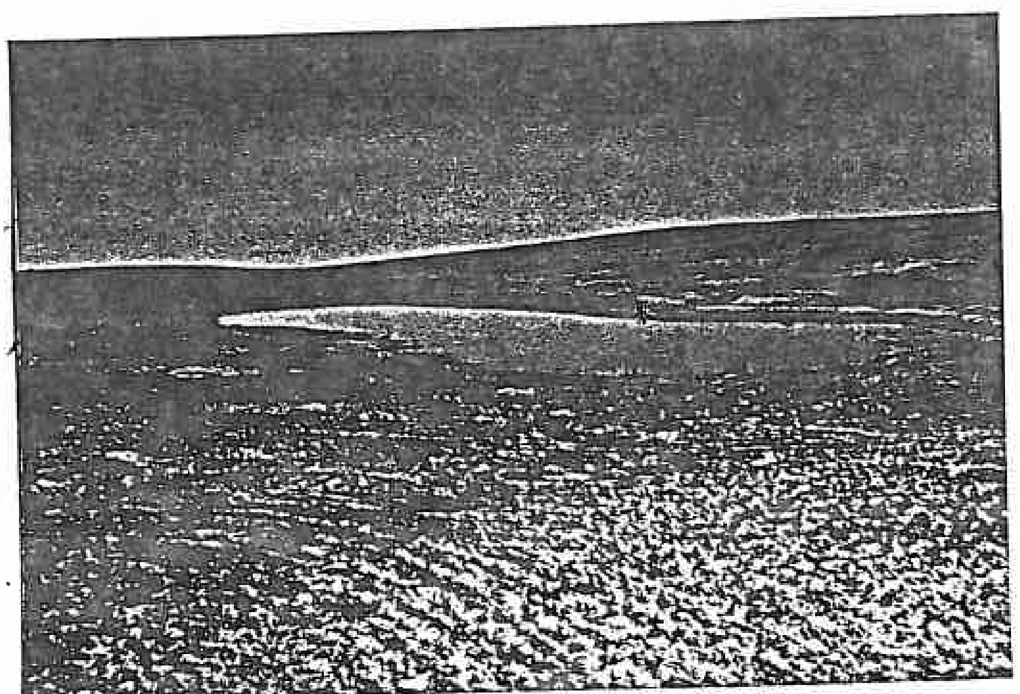


FIGURE 90

Permanent Internal Impoundment in the
South Central Portion of the N-1 Area

TABLE 46

Permanent Internal Impoundment Water Persistence Probabilities Expressed as Decimals by Month for Three Ranges of Curve Numbers And Area Indices (From Water, Waste and Land, 1981)

Area Index	10			70			130		
Month/Curve Number	70	80	90	70	80	90	70	80	90
Jan	.42	.48	.68	.48	.66	.99	.54	.73	.99
Feb	.22	.28	.45	.30	.53	1.0	.41	.65	1.0
Mar	.12	.16	.32	.20	.45	.98	.32	.58	1.0
Apr	.02	.05	.15	.11	.33	.96	.18	.54	.98
May	.01	.01	.05	.09	.19	.97	.12	.45	.98
Jun	.01	.01	.03	.09	.12	.97	.10	.41	.98
Jul	.05	.08	.16	.12	.24	.92	.17	.42	.98
Aug	.06	.08	.19	.10	.30	.95	.19	.48	.98
Sept	.07	.09	.17	.09	.30	.97	.17	.49	.99
Oct	.15	.18	.31	.18	.39	.98	.25	.56	1.0
Nov	.22	.27	.41	.27	.44	1.0	.36	.64	1.0
Dec	.37	.42	.55	.44	.59	1.0	.51	.68	1.0

50 percent probability of water persistence in impoundments with area indices up to 70. For an area index of 130, seven months have a probability of water persistence over 50 percent. Larger area indices by virtue of watershed area increases are not practical, so persistence probabilities and area indices can be optimized by reducing pond area sizes. As was stated previously, the presence of water in an impoundment is important; however, the size of the impoundment is not critical for its intended use.

To substantiate the WWL stochastic model water persistence results, Peabody performed continuous and periodic water persistence monitoring of nine prelaw impoundments from 1981 to 1984. Results of the continuous water level monitoring at Impoundments 113 and 118 in the N-1 and J-3 prelaw areas are presented in Tables 47 and 48. Monitoring results suggest that water persistence probabilities are well above 50 percent for these impoundments. Impoundment 113 has been dry once and very low three times, whereas Impoundment 118 has never been dry. It should be noted that neither stilling well is at the deepest part of the impoundments. Figure 91 has been included to show the surface area and cross sectional configuration of Impoundment 113.

Water persistence at impoundments has been further documented by periodic water persistence monitoring at seven permanent internal impoundments. Water persistence was documented for five different seasons at seven different impoundments during 1981 and 1982 and at ten impoundments during 1985. Table 49 summarizes the impoundments and dates at which the water persistence was documented.

Adequate Safety and Access. Safety and access can be specifically addressed in detail when a particular impoundment is proposed. The design information would be presented in detail allowing the regulatory authority to make a judgment as to whether or not any design changes are required with regard to these factors.

An attempt will be made to minimize evaporation while at the same time providing safe access for livestock. It is contemplated that the impoundments will be constructed in a rectangular shape. The two long sides of the rectangle will have 3:1 slopes and be fenced. The ends of the impoundments will have considerably flatter slopes and be open for access by livestock. Vegetative species adaptable to an impoundment environment and amenable to wildlife use will be planted along the long sides of the rectangle. Additionally, brush and rock piles will be utilized where appropriate. The bottoms of the impoundments will be compacted to minimize the potential for livestock to become mired

TABLE 47

Documentation of Water Persistence

At Permanent Internal Impoundment 113

Date	Water Level (ft. above bottom)
4/81	2.07-2.10
5/81	1.64-2.05
6/81	1.51-1.64
7/81	1.49-2.16
8/81	2.16-2.52
9/81	2.18 est.
10/81	1.67 est.
11/81	1.22-1.25
12/81	1.06-1.21
1/82	1.07-1.13
2/82	1.12-1.77
3/82	1.77-*
4/82	*
5/82	.96-1.04
6/82	.3-1.07
7/82	0-.29**
8/82	**
9/82	.01-.09
10/82	0-.06 residual water in deeper part of impoundment
11/82	.02-.03
12/82	.09-.14
1/83	.15-.23
2/83	.23-.76
3/83	.77-.93
4/83	.63-.88
5/83	.17-.61
6/83	**
7/83	dry
8/83	0-.39

TABLE 47 (Cont.)

Documentation of Water Persistence at

Permanent Internal Impoundment 113

Date	Water Level (ft. above bottom)
9/83	.17-.28
10/83	1.29-1.65
11/83	1.08-1.29
12/83	1.06-1.08
1/84	.89-1.05
2/84	.62-.88
3/84	.32-.61
4/84	.10-.31
5/84	Recorder disconnected

* Impoundment water surface freezing

** Impoundment dry at recorder, but some water in deeper sections

TABLE 48

Documentation of Water Persistence At

Permanent Internal Impoundment 118

Date	Water Level (ft. above bottom)
11/82	1.96-2.04
12/82	1.92-1.94
1/83	1.30-1.40
2/83	1.45-1.55
3/83	1.27-1.45
4/83	.82-1.25
5/83	.80-1.49
6/83	.84-1.46
7/83	.18-0.80
8/83	.15-1.85
9/83	1.44-1.82
10/83	2.30-2.95
11/83	2.02-2.29
12/83	1.69-2.01
1/84	1.36-1.68
2/84	.99-1.35
3/84	.52-0.97
4/84	Impoundment pumped dry to allow installation of recorder in the deepest section; however, monitoring was discontinued at this time.

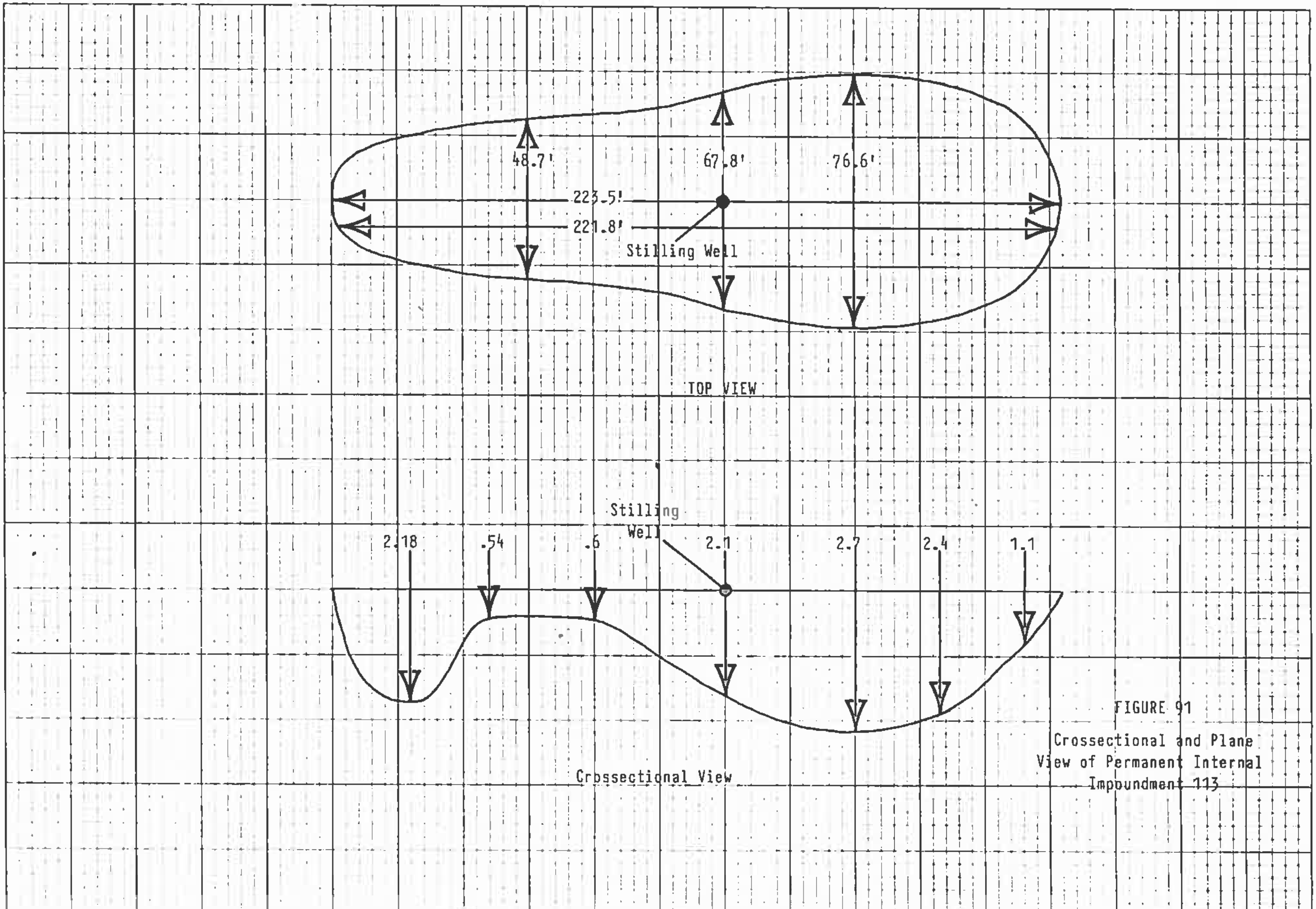


FIGURE 91

Crossectional and Plane View of Permanent Internal Impoundment 113

TABLE 49

Water Persistence and Water Depths Documented in

Prelaw Permanent Internal Impoundments

Pond	Date	Water Persistence Documented			
112	3/31/81	7/27/81	11/19/81	3/10/82	dry
113	3/31/81	6/30/81	11/19/81	3/10/82	9/3/82
116	3/25/81	8/19/81	11/12/81	3/10/82	9/3/82
117	3/25/81	7/27/81	11/19/81	3/10/82	9/3/82
118	3/25/81	7/27/81	11/19/81	3/10/82	9/3/82
119	3/31/81	7/27/81	11/19/81	3/10/82	9/3/82
120	3/31/81	8/19/81	11/19/81	3/10/82	9/30/82
121	Station not				
	Established	7/27/81	11/20/81	3/10/82	9/3/82
122	Station not				
	Established		11/24/81	dry	9/3/82

Pond	Water Depths Documented (ft) 8/85	9/85	10/85
112	.40	1.28	1.75
113	dry	dry	dry
116	dry	dry	dry
117	1.05	1.11	0.92
118	1.33	1.69	1.64
119	dry	0.64	1.42
120	1.21	1.09	1.48
121	dry	1.07	1.0
122	2.0	>2.5	> 2.5
123	2.22	3.1	3.2

should water levels be low. All of the above actions will create a livestock watering environment far better than the normal stockponds experienced on the Black Mesa leasehold.

Impact on Water Users. The permanent internal impoundments will not result in the diminution of the quality or quantity of water utilized by adjacent or surrounding land users. Alluvial valley floor farming has not and is not being practiced on or near the Black Mesa leasehold because of geologic limitations and the lack of water for both subirrigation and flood irrigation. All of the minor farming activities attempted locally rely strictly on direct rainfall and would, in no way, be affected by the limited amount of runoff retained in ponds.

Table 50 presents the estimated acreages draining to permanent internal impoundments in both pre- and postlaw areas. These acreages amount to only 14 percent of the Moenkopi watershed area to its confluence with Coal Mine Wash. Since there is no documented local use of the channel runoff on the leasehold, the significance of this minor amount of watershed area reduction amounts to only .13 percent of the total 1,728,000 acres in the entire Moenkopi watershed.

The potential for pond discharges impacting stream water quality has been previously discussed. The potential for degradation of the local ground water quality is also negligible. The bottom of ponds created due to internal drainage would be compacted to minimize infiltration loss and the height of the pond bottoms above the top of the Wepo aquifer would preclude, in most cases, infiltration of pond water into the ground water system. Support for this statement comes from the fact that a boring was drilled at the edge of an impoundment in the J-3 reclaimed area and moisture was not detected beyond 15 feet below the bottom of the impoundment. This impoundment has always held water for significant periods of time.

The quality of the water in the Wepo aquifer is no better than that in the impoundments and is limited to the same water use - livestock water. Any water that might infiltrate through the impoundment bottoms and reach the Wepo aquifer would not diminish the water quality in the Wepo aquifer. For a more current discussion of permanent internal impoundment monitoring data, comprising data collected from select permanent internal impoundments since the latter half of 1985 through the third quarter of 1988, refer to Chapter 14, Postmining Water Sources.

N-2 Permanent Internal Impoundment Study. The OSM Western Technical Center requested that

TABLE 50

Measured Acres Draining Into

Permanent Internal Impoundments

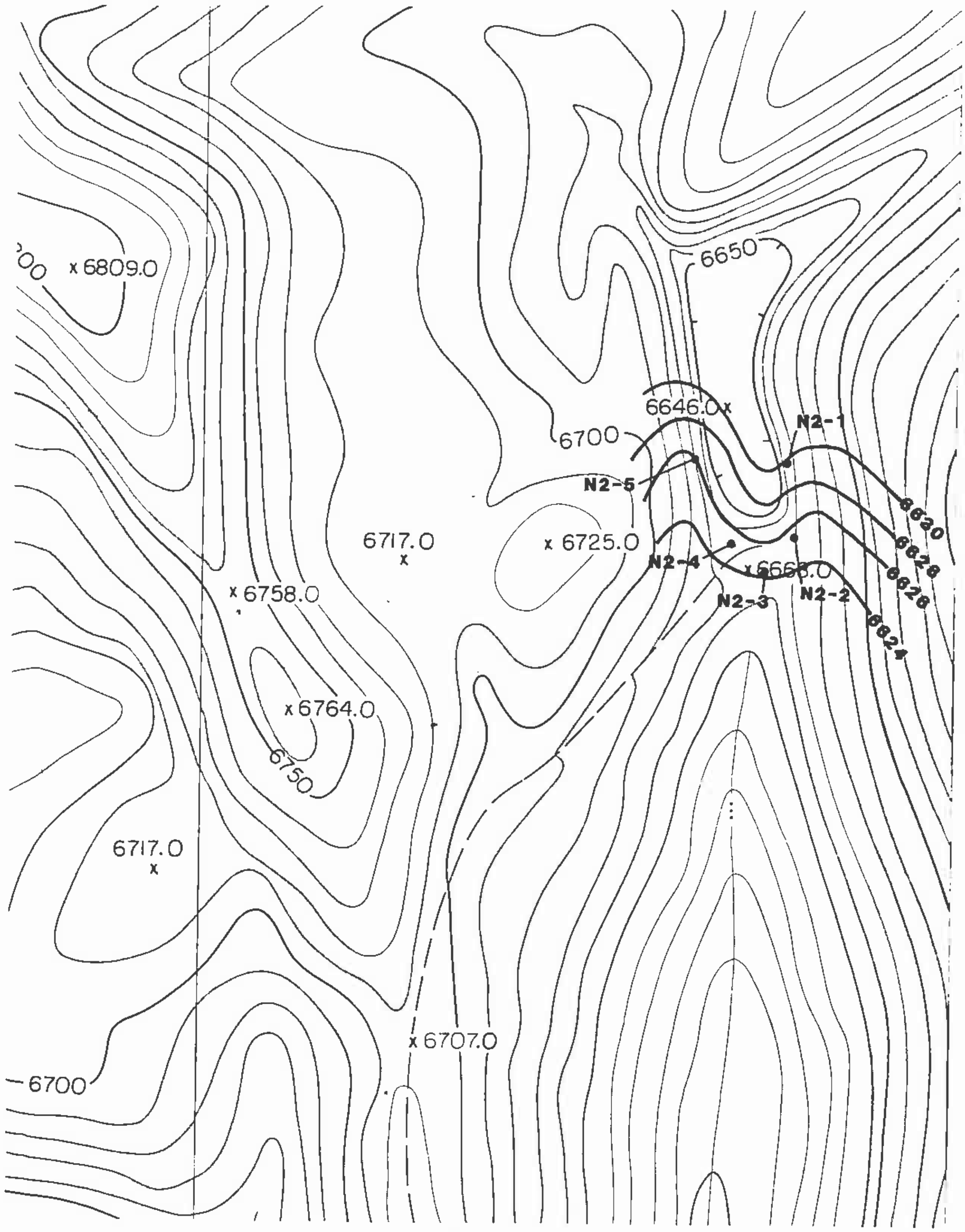
Mining Area	Area Draining Into Permanent Internal Impoundment (Acres)
J-7	49.92
J-27	41.60
J-3	423.04
N-1	858.24
N-2	727.04
J-1/N-6	110.08

permanent internal impoundment monitoring be concentrated in the N-2 postlaw reclaimed area. Details of the N-2 impoundment monitoring installations are given in Chapter 16, Hydrological Monitoring Program. Monitoring data suggests that Impoundment 206 is above the local water table and that the impoundment bottom has a high infiltration rate. Data from the five monitoring piezometers located around the impoundment indicates that water seeps from the impoundment to the water table approximately 20 feet below.

There is an approximate one month delay between the peak water level in Impoundment 206 and a peak water table elevation beneath the impoundment. Figure 92 represents the water table contours beneath the impoundment following a period of significant surface runoff recharge to the impoundment. Recharge to the water table from impoundment seepage forms a ridge in the water table. In contrast, Figure 93 shows the water level contours for August, 1985 after the impoundment had been dry for nearly four months. The ridge of recharge to the water table is gone and the direction of ground water flow is downgradient towards the lower N-2 Impoundment 212. Evaporation data also supports the fact that Impoundment 206 seepage rates are excessive. The average measured loss rate for the impoundment was 16.8 inches/month, which is considerably less than the maximum monthly pan evaporation recorded at all Peabody meteorology monitoring stations during this period (12.99 inches at Site 8, June 1985).

Impoundment 212 is located approximately one mile downgradient from Impoundment 206. Impoundment 212 has maintained a water depth of 15 feet in its deepest part in the twelve month period since monitoring began at this location. Water levels in the five monitoring piezometers around the impoundment indicate that the local water table is above the impoundment bottom. Impoundment 212 has always been suspected of intercepting the top of the Wepo aquifer because that end of the N-2 pit has always been wet, even after regrading.

Figures 94 and 95 show Wepo water level contours around Impoundment 212 for September, 1984 and August, 1985, respectively. Water level contour extensions were drawn assuming that they mirrored the topography. In September, 1984, water levels in the piezometers were rising as the impoundment had received large surface runoff inflows in the previous two months and was contributing water to the local water table. In August, 1985, the local water table had risen above the level of the impoundment and was feeding the impoundment. The greater rate of water level declines in Deptember, 1984, as determined from continuous impoundment water level monitoring, can be attributed to impoundment seepage and evaporation, whereas the slower rates of decline in August, 1985 can be attributed to Wepo feed to the impoundment offsetting evaporation.



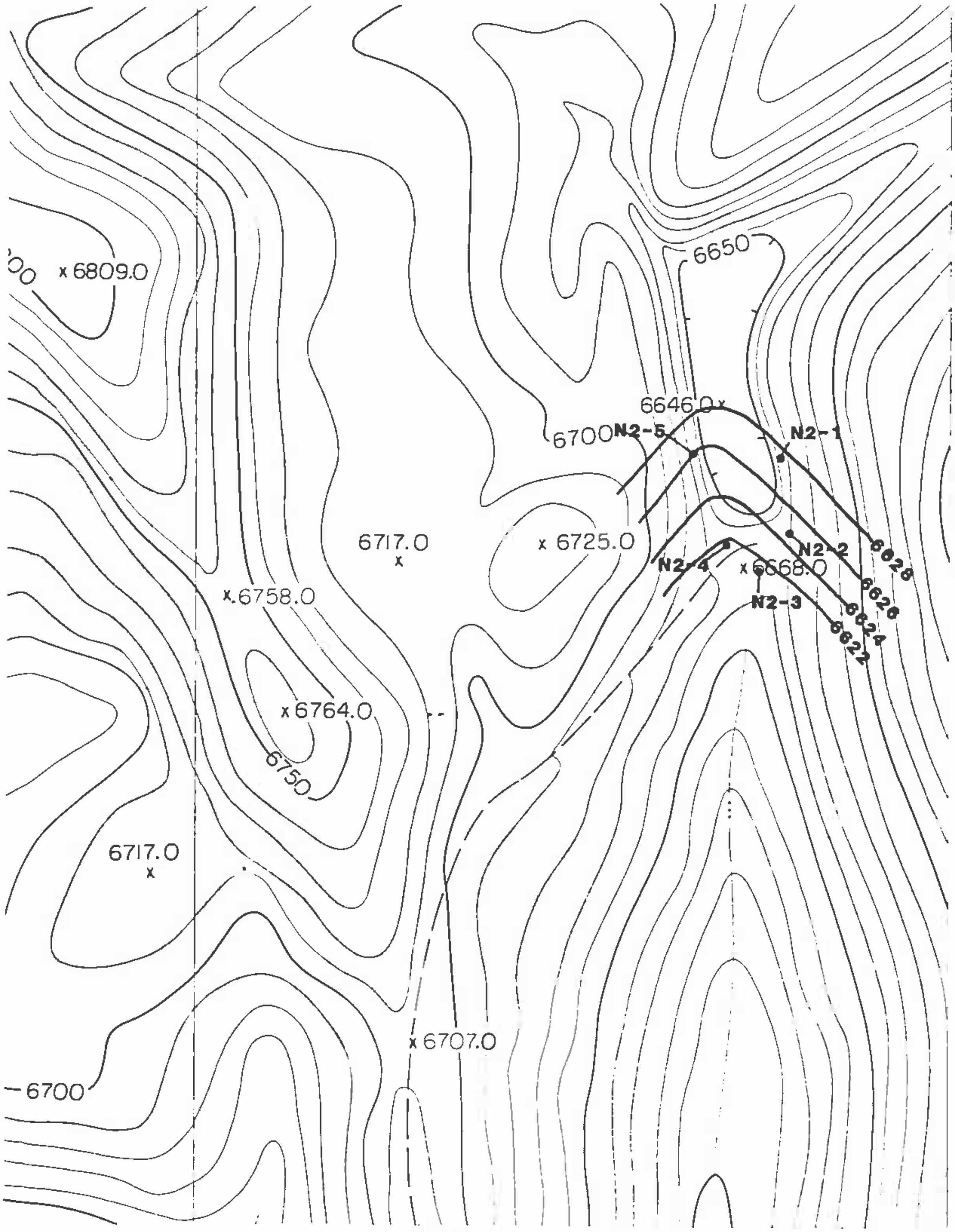
LEGEND:

Water Contour
Elevation
Piezometers

FIGURE 92

Water Table Contours Beneath Permanent Internal Impoundment 206 in 9/84

N2-1 = 6629.6
N2-2 = 6625.2
N2-3 = 6624.1
N2-4 = 6625.0
N2-5 = 6626.0



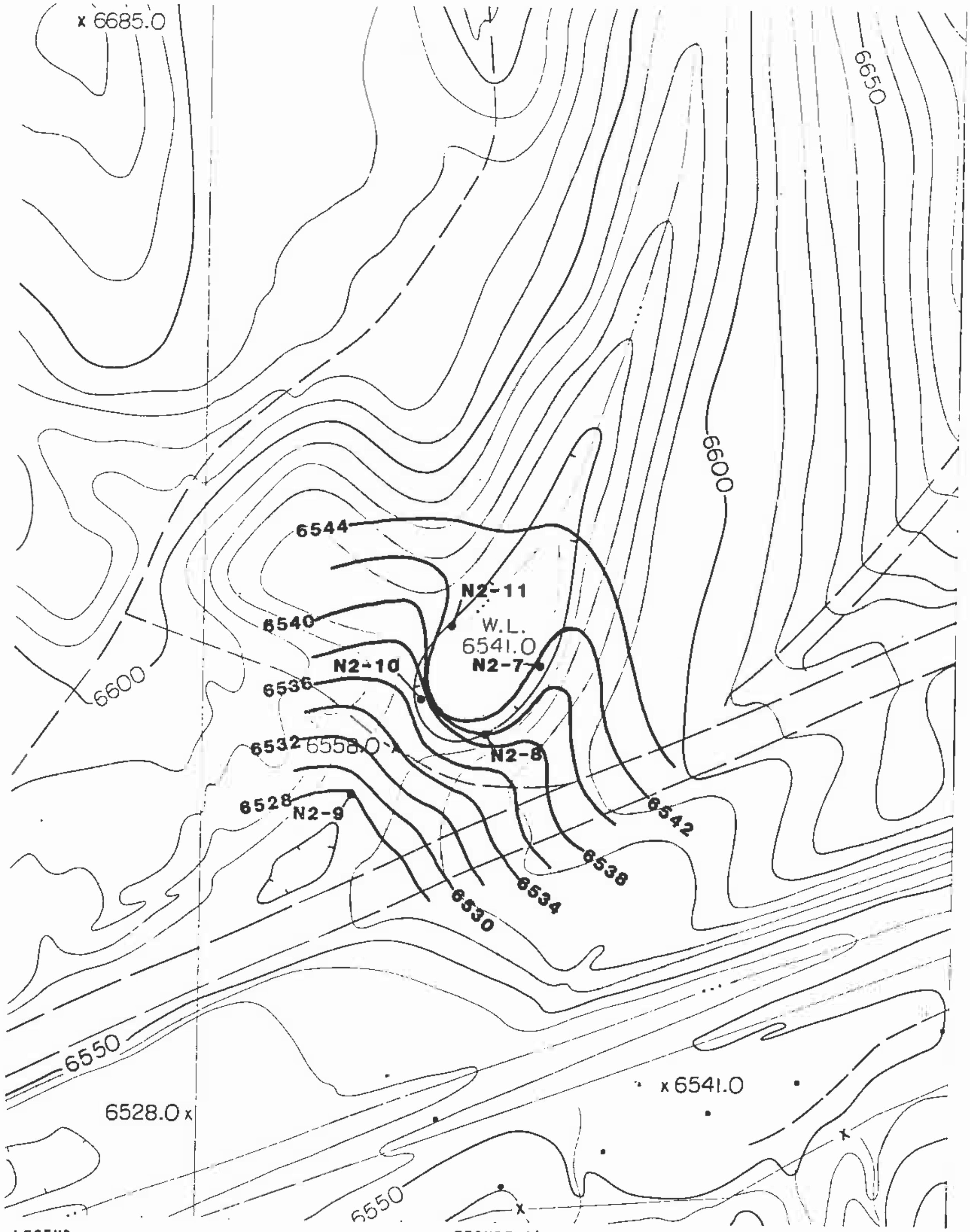
LEGEND:

Water Contour
Elevation
Piezometers

FIGURE 93

Water Table Contours Beneath Permanent Internal Impoundment 206 in 8/85

N2-1 = 6627.7
N2-2 = 6624.9
N2-3 = 6621.3
N2-4 = 6621.8
N2-5 = 6626.1



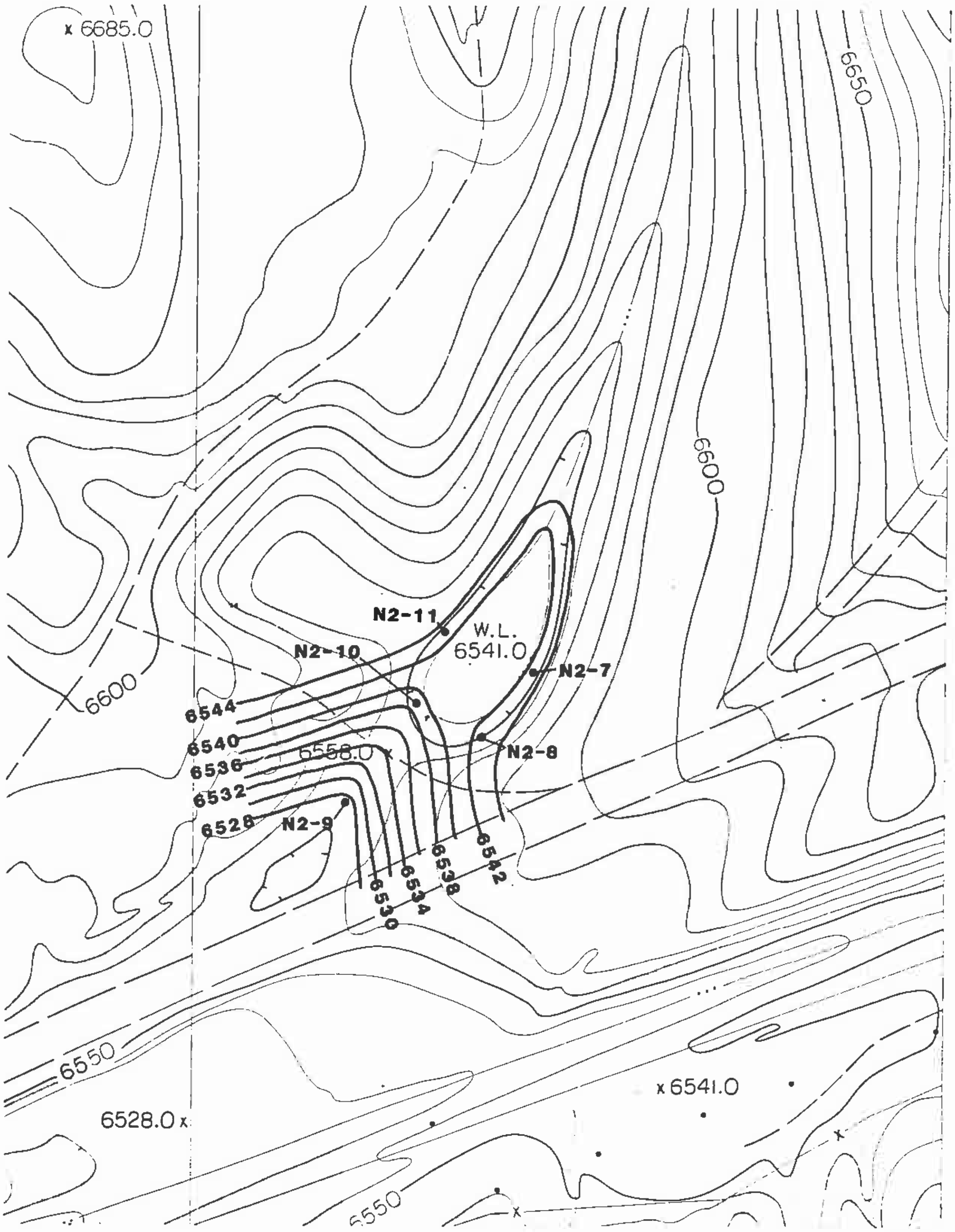
LEGEND:

Water Contour
Elevation
Piezometers

FIGURE 94

Water Table Contours Beneath Permanent Internal Impoundment 212 in 9/84

N2-7 = 6541.8
N2-8 = 6540.0
N2-9 = 6528.0
N2-10 = 6537.1
N2-11 = 6542.8



LEGEND:

Water Contour
Elevation
Piezometers

FIGURE 95

Water Table Contours Beneath Permanent Internal Impoundment 212 in 8/85

N2-7 = 6543.1
N2-8 = 6542.4
N2-9 = 6527.8
N2-10 = 6538.7
N2-11 = 6543.6

In light of the above discussion, the monitoring emphasis at the two N-2 impoundments does not appear warranted. Impoundment 206 was apparently not sealed, thus it loses water at a significant rate, which really is not indicative of water persistence probabilities. Impoundment 212 is fed by the Wepo aquifer and thus is also not indicative of true water persistence or true runoff water quality. These concerns were discussed with OSM Western Technical Center and it was agreed that future permanent internal impoundment monitoring would be shifted to prelaw areas and other postlaw impoundments which may be created.

Springs

All springs identified by Peabody personnel on or immediately adjacent to the leasehold are denoted on Drawing No. 85600. This includes Site Number 140, located in Yazzie Wash near the N-9 mining area, which was added to the spring monitoring network in October, 1981. In addition to these, Figure 2 in Chapter 17, Protection of the Hydrologic Balance, shows all springs located within a regional area around the leasehold. These were documented by the USGS during their late 1950 and early 1960 survey of the water resources of the Navajo and Hopi Indian Reservations. Table 51 is a summary of the geologic setting, yields and water quality of those springs located within the leasehold, and a 2 1/2 mile perimeter around the leasehold. Table 51 also includes information on those springs within the leasehold that have been assigned permanent monitoring site numbers and have been sampled for water quality as part of the monitoring program. Spring discharges and spring flows on the leasehold that could be obtained are summarized in Table 51. Individual discharge values can be found in the annual Hydrological Data Reports. Yields at the other springs were too small and diffuse to measure. Water quality sampling of the springs on the leasehold is accomplished by allowing the springs to gradually fill natural or artificial depressions. The springs identified to date all seep from the contact zones between the bottom of permeable sandstones and the top of relatively impermeable shale layers. All are exposed along the sides of washes and discharge into the alluvium. The N-14 channel change, completed to insure proper drainage along the west side of the N-14 pit, effectively removed Spring 97 in June, 1983.

The principal source of recharge to the springs is Wepo discharge along bedding planes of differing lithology and fractures that have been exposed by the drainage system.

Spring Water Quality. Average water quality parameters for the five springs in the monitoring network (91, 92, 97, 111 and 140) are presented in Attachment 17. In addition,

TABLE 51

Locations, Source, Yields and Water Quality for Springs Within the Black Mesa Leasehold and a 2.5 Mile Boundary Around the Leasehold (Davis et al. 1963; McGavock et al. 1966)

Spring Number	Quadrangle Location Number	Stratigraphic Unit Aquifer	Yield GPM	Water Quality
2A-7	11.65- 9.50	Landslide & Talus	1.5	Good
2A-8	11.00-10.45	Wepo	-	-
2A-10	10.00- 3.70	Wepo	0.2	Good
2A-11	8.10- 2.15	Landslide & Talus	0.1	Good
2A-50	5.60- 5.70	Landslide & Talus	-	-
2A-52	7.10- 7.85	Wepo	-	-
2A-54	8.15- 8.70	Wepo	-	-
2A-55	9.55-11.00	Toreva	-	-
2A-58	4.95-10.50	Toreva	3.0	Fair
2A-59	2.70- 9.50	Alluvium	-	-
2A-60	1.75- 8.30	Alluvium	-	-
2A-61	0.75- 7.55	Alluvium	-	-
2C-2	6.75- 1.45	Alluvium	3.0	Good

the averaged values for the principal ions determined in these analyses were plotted on the trilinear diagram depicted in Figure 96. The trilinear diagram shows a calcium-magnesium sulfate type of water for all the monitored springs. Water from these springs is classified as unsuitable for drinking and poor to unsatisfactory for use as irrigation or livestock water (McKee and Wolf 1963).

Spring water quality is characterized by considerable variability. This is not surprising considering that the source aquifer (the Wepo aquifer) also exhibits a high degree of variability.

High levels of sodium and sulfate noted in water from the springs can be attributed to the shale pathway of exit of water from the aquifer. Shale zones often yield water high in sodium (Bouwer 1978). The levels of sulfate in spring water may be ascribed to oxidation of pyrites and metal sulfides associated with shale (Hem 1983).

While the concentrations of the principal ions in water from each spring varies from one sampling period to the next, their proportions remain relatively constant. This variation in concentration affects the cations primarily and appears to be a function of the season during which samples were collected. Since samples are collected from depressions or small ponding areas, the water is exposed to the environment. Some of the variation noted in chemical concentrations may be the result of changes in solubilities related to seasonal ambient temperatures.

Navajo Aquifer

Geohydrologic Setting. Black Mesa is a prominent topographic high that stands from 500 to 1,000 feet above the surrounding area; the mesa occupies the structural center of Black Mesa basin (Figure 57). Triassic and Jurassic rocks dip gently toward the Mesa except along the west side, where several monoclines plunge 5° to 30° beneath the Mesa. The Navajo Sandstone crops out along the periphery of the mesa and is buried as much as 3,000 feet below Upper Cretaceous rocks that crop out on the mesa (Cooley et al. 1969).

In the Black Mesa area the Navajo Sandstone has a remarkably uniform lithology. The formation is composed of very fine to medium subrounded quartz grains bonded with a weak calcareous cement. Large-scale, high-angle eolian cross-beds are the most conspicuous feature of the formation. The Navajo sandstone thins progressively from the northwest to

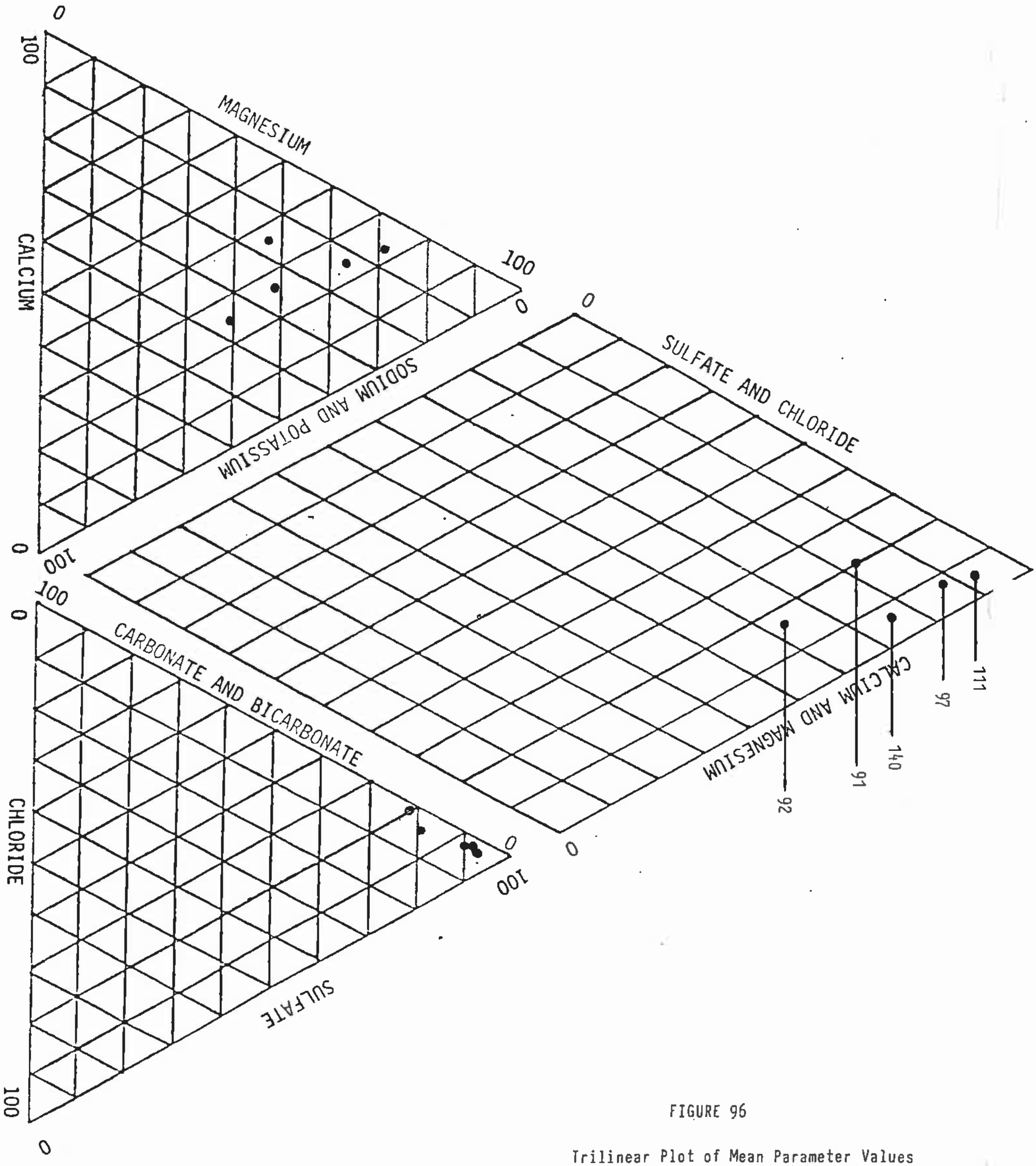


FIGURE 96

Trilinear Plot of Mean Parameter Values
for the Springs on Peabody's Leasehold
1980 to 1985

the southeast. The sandstone is about 950 feet thick near Tonalea and pinches out along a line that extends from near Keams Canyon to about 10 miles southeast of Rough Rock.

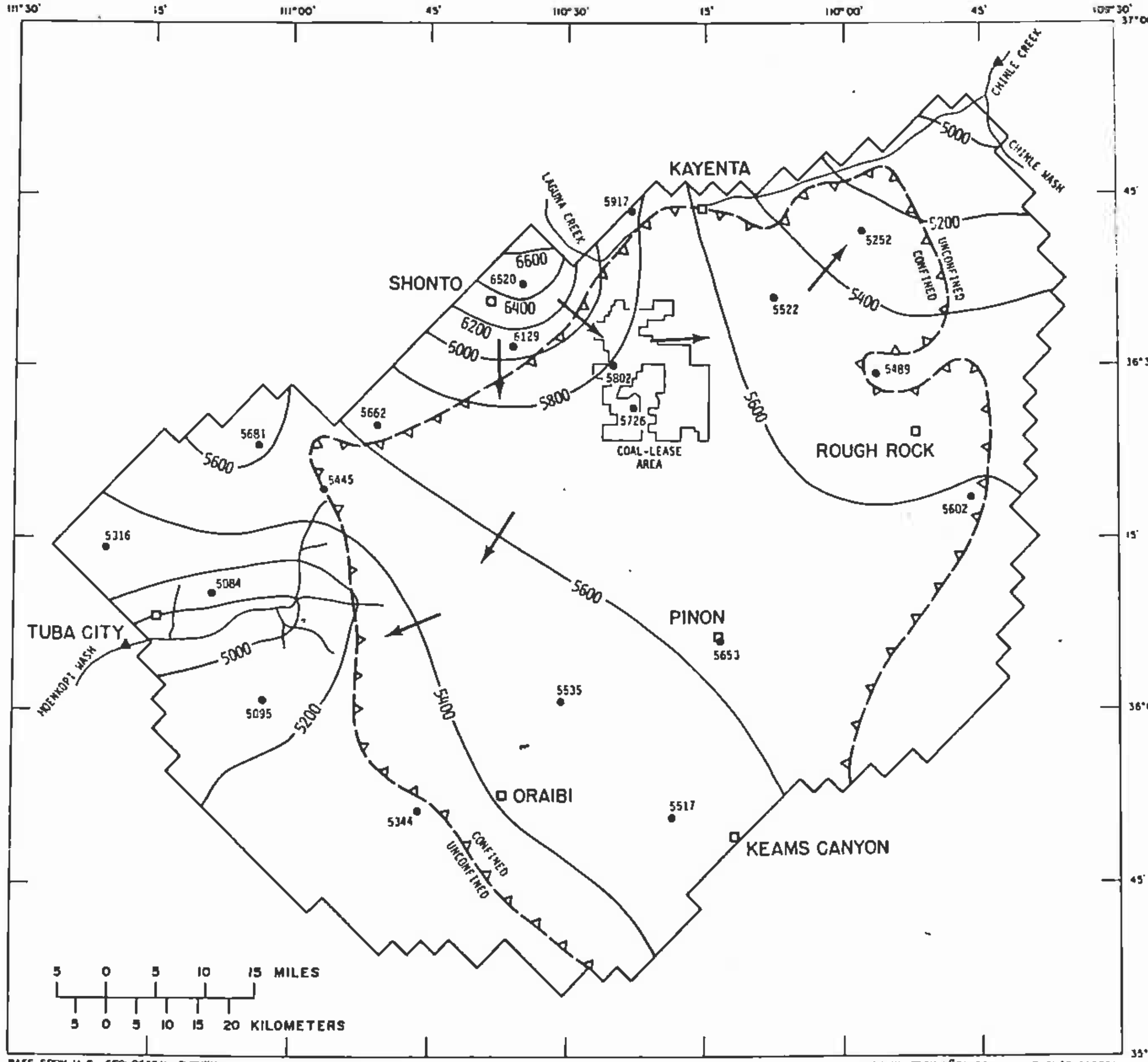
In the northern part of the area the Navajo Sandstone combines hydraulically with the underlying Triassic (?) Kayenta Formation and Triassic Wingate Sandstone to form a continuous aquifer system. In the southern part of the area the Kayenta is primarily a siltstone, which separates the water in the Navajo from that in the Wingate Sandstone. The Navajo Sandstone is unconformably overlain by the Jurassic Carmel Formation, which is predominantly a siltstone near Black Mesa. The Carmel acts as a confining bed and creates artesian conditions in the Navajo Sandstone beneath Black Mesa.

Characteristics of the Navajo Sandstone Aquifer at Black Mesa. Ground water in the Navajo Sandstone is under confined or artesian conditions in most of the Black Mesa area (Figure 97). The amount of artesian head ranges from zero in the areas of outcrop to about 2,000 feet near the Peabody wellfield. The area where unconfined or water-table conditions prevail coincides approximately with the area of outcrop of the aquifer.

Recharge to the artesian part of the aquifer takes place only in the area between Black Mesa and Shonto (Figure 97), where the aquifer crops out at altitudes of between 6,000 and 7,000 feet above mean sea level. The outcrop area comprises about 100 square miles and provides the only direct recharge to the Navajo Sandstone in the approximately 3,000 square miles underlying Black Mesa.

Ground water moves southeastward from the recharge area toward the center of the Mesa; there, the flow path diverges toward both the southwest and northeast, where the Navajo Sandstone crops out at an altitude of less than 5,500 feet. Ground-water movement toward the southeast is retarded by the pinchout of the aquifer. Although some water may move downward through the sandy facies of the Kayenta Formation into the Wingate Sandstone along the line of pinchout, the contours of the potentiometric surface indicate that the pinchout acts as a ground-water dam and retards ground-water movement toward the southeast (Figure 97).

Near Black Mesa, natural discharge from the Navajo Sandstone is primarily in the form of seeps and small springs along the contact of the Navajo Sandstone with the Kayenta Formation or as evapotranspiration in the area of outcrop. Near Kayenta, discharge from the Navajo Sandstone may maintain the flow in several short perennial reaches of Laguna



BASE FROM U.S. GEOLOGICAL SURVEY FLAGSTAFF 1:250,000, 1954-70, GALLUP 1:250,000, 1950-70, MARBLE CANYON 1:250,000, 1956-70, AND SHIPROCK 1:250,000, 1954-69

MODIFIED FROM McGAVOCK AND LEVINGS (1973), LEVINGS AND FARRAR (1977A, B, AND C), AND FARRAR (1979, 1980)

EXPLANATION

- 5600 — SIMULATED POTENTIOMETRIC CONTOUR—Shows water-level altitude simulated by equilibrium model. Contour interval 200 feet. National Geodetic Vertical Datum of 1929
- △ △ △ APPROXIMATE BOUNDARY BETWEEN CONFINED AND UNCONFINED CONDITIONS
- STREAM IN WHICH WINTER BASE FLOW REPRESENTS DISCHARGE FROM THE N AQUIFER
- • 5681 WELL IN WHICH DEPTH TO WATER WAS MEASURED—Measurement was made before 1965 or during assumed local equilibrium before 1972. Number, 5681, is altitude of water level in feet above National Geodetic Vertical Datum of 1929
- ▲ STREAMFLOW-GAGING STATION—Operated by U.S. Geological Survey
- → GENERALIZED DIRECTION OF GROUND-WATER FLOW
- BOUNDARY OF MATHEMATICAL MODEL

FIGURE 97

Approximate Altitude of the Potentiometric Surface of Water Contained in the N-aquifer, Black Mesa Area, Arizona

Creek.

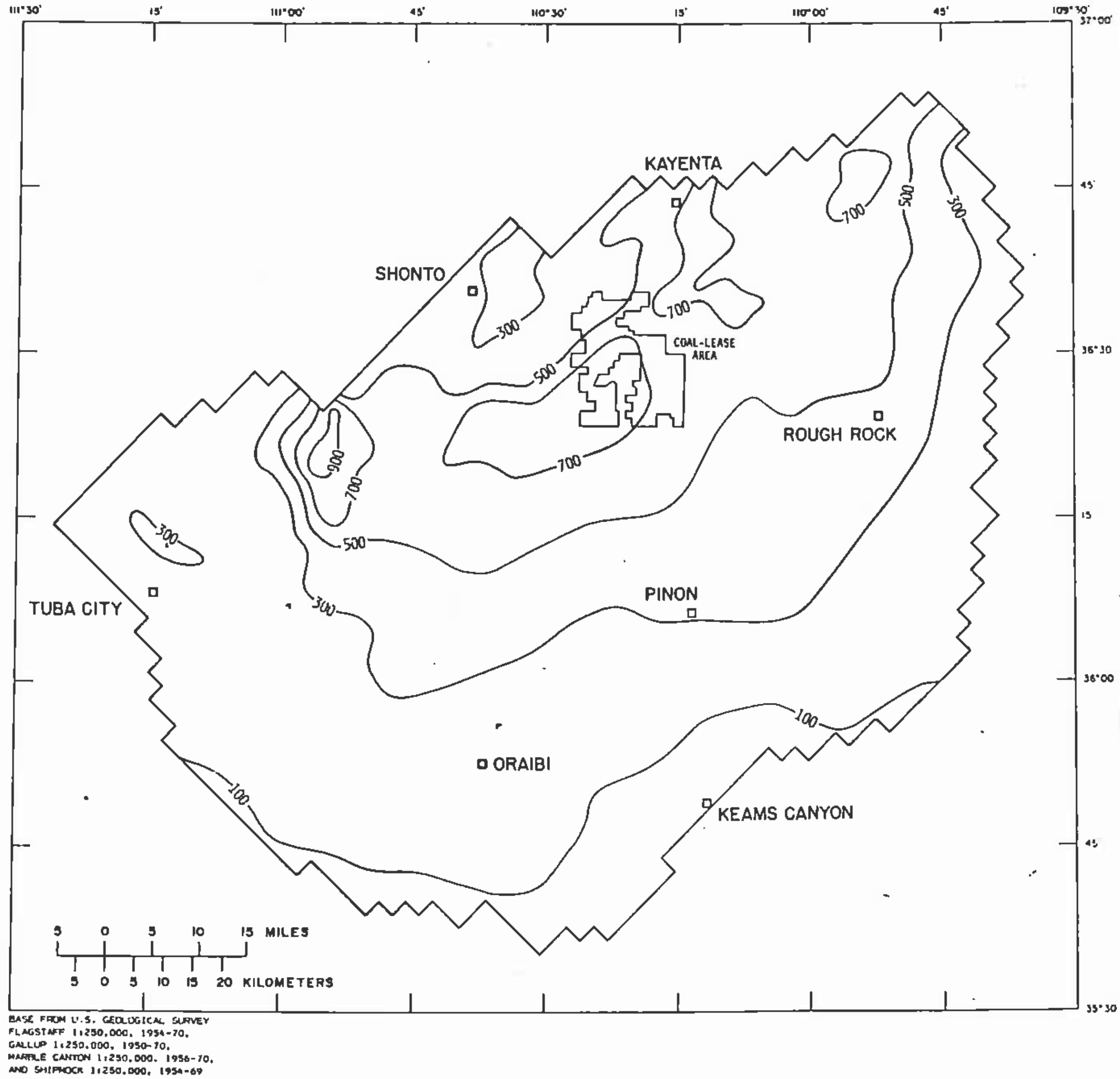
The amount of water recharged to the Navajo Sandstone is unknown, but the rate of ground-water movement is too slow for recharge to balance the withdrawal in the artesian part of the aquifer. The rate of ground-water movement in the recharge area is calculated to be from 2 to 4 feet per year; these rates are supported by an age of about 15,500 years for water withdrawn from the aquifer about 40,000 feet down-gradient from the recharge area (William Back, U.S. Geological Survey, written commun., 1972).

The transmissivity of the Navajo Sandstone from aquifer-test data at 12 wells around Black Mesa has been determined to range from 75 to 350 square feet per day (Figure 98). The transmissivity is governed primarily by the saturated thickness of the aquifer; in the Black Mesa area the maximum saturated thickness and transmissivity of the Navajo Sandstone are near Tonalea (Figure 99). The hydraulic conductivity ranges from about 0.40 foot per day on the northeast side of Black Mesa to about 0.70 foot per day in the southwestern part of the area near the Hopi villages. Although there is considerable variation in the computed hydraulic conductivity values, the values tend to increase from northeast to southwest.

The storage coefficient for the Navajo Sandstone has not been determined, but data from aquifer tests near Rough Rock and the performance of the Peabody wellfield on Black Mesa indicate that the storage coefficient for the artesian part of the aquifer probably ranges from about 10^{-3} to 10^{-4}. The storage coefficient in the unconfined part of the aquifer is virtually equal to the specific yield and is estimated to be between 0.10 and 0.15.

Ground-Water Development. The feasibility of developing ground water in the Navajo Sandstone is affected by several economic and physical factors, such as well depth, depth to water, well yield and the amount of available drawdown from the static water level to the base of the aquifer. Along the periphery of Black Mesa, the well depth required to penetrate the entire thickness of the Navajo Sandstone ranges from about 500 to 1,000 feet below the land surface; on the Mesa, the required depth ranges from about 2,500 to 4,000 feet below the land surface.

Along the periphery of Black Mesa, the static water levels in most wells that penetrate the Navajo Sandstone range from 250 to 750 feet below the land surface; on the Mesa, static water levels generally range from 500 to 1,500 feet below the land surface.



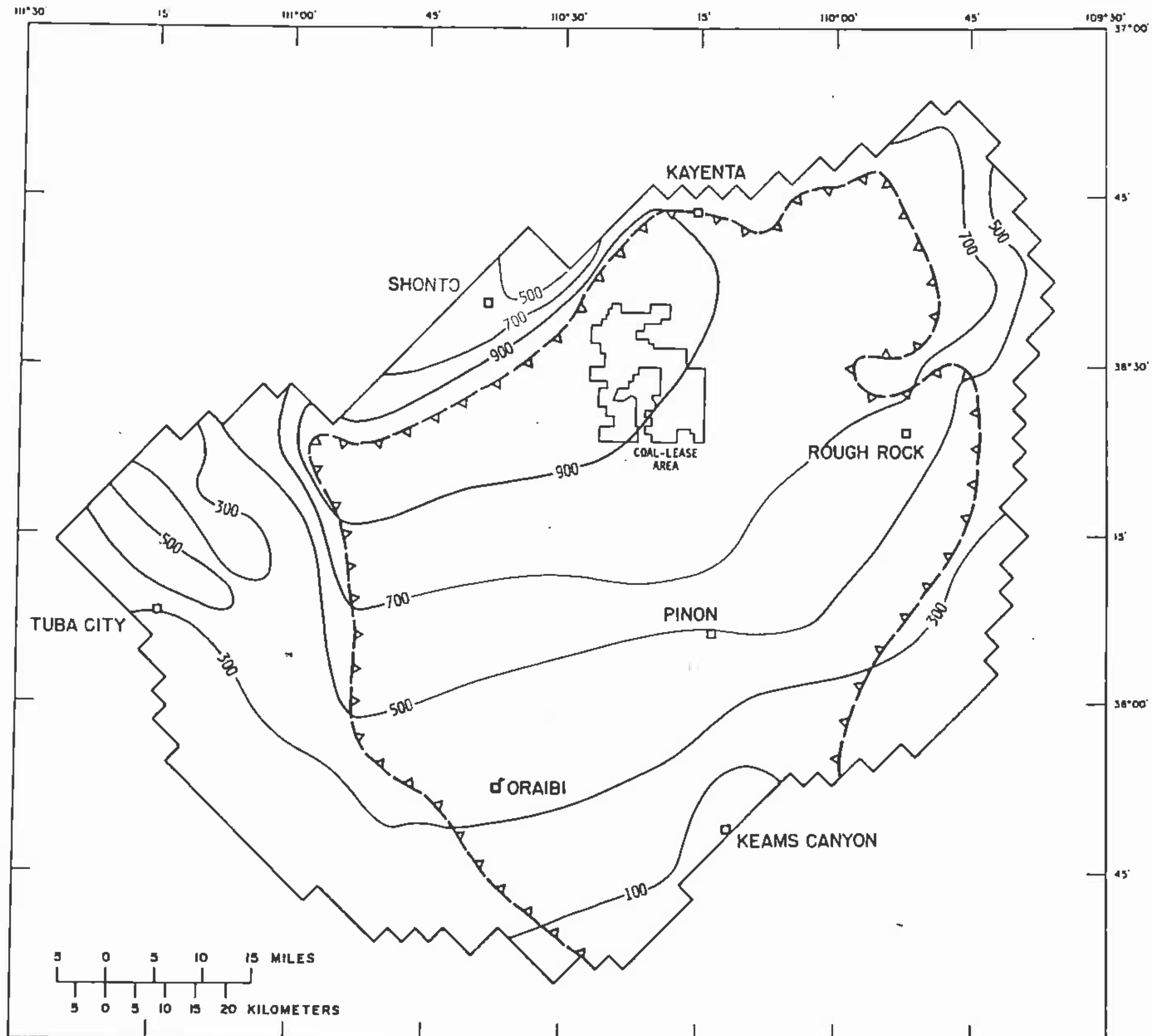
EXPLANATION

500 — APPROXIMATE LINE OF EQUAL TRANSMISSIVITY—Contour interval 200 feet squared per day

— BOUNDARY OF MATHEMATICAL MODEL

FIGURE 98

Generalized Transmissivity of the N-aquifer, Black Mesa Area, Arizona



BASE FROM U.S. GEOLOGICAL SURVEY
FLAGSTAFF 1:250,000, 1954-70,
GALLUP 1:250,000, 1950-70,
MARBLE CANYON 1:250,000, 1956-70,
AND SHIPROCK 1:250,000, 1954-69

MODIFIED FROM McGAVOCK AND LEVINGS (1973), LEVINGS AND FARRAR (1977A, B, AND C), AND FARRAR (1979, 1980)

EXPLANATION

——500—— APPROXIMATE LINE OF EQUAL SATURATED THICKNESS—Contour interval 200 feet

APPROXIMATE BOUNDARY BETWEEN CONFINED AND UNCONFINED CONDITIONS

BOUNDARY OF MATHEMATICAL MODEL

FIGURE 99

Saturated Thickness of the N-aquifer, Black Mesa Area, Arizona

Based on the factors presented above, the potential well yields from the Navajo sandstone aquifer for different parts of Black Mesa are shown in Figure 100.

Navajo Aquifer Wells.

Exploration Well and Testing. In June of 1965, Thomas Stetson Consulting Engineers were retained to perform a feasibility study for the development of a coal slurry water supply on the Black Mesa leasehold. Potential water bearing zones to be investigated included all the formations shown in Figure 101. To accomplish this, a test well, Navajo #1 (Figure 102) was drilled to a depth of 5,735 feet below ground surface in October and November, 1965. The well was completed utilizing grout plugs in the annular space to permit aquifer testing of specific aquifer zones. Zones selected for testing were the Dakota, upper Morrison and Entrada Formations, the Navajo Formation, the Wingate Formation and the Coconino Formation.

A series of single well recovery and water quality tests were performed in the above referenced isolated aquifer zones to determine their potential for development of the well field. The results of the aquifer and water quality tests are shown in Tables 52 and 53, respectively. Plots of the single well recovery tests are included as Attachment 18. The Coconino aquifer was found to have a low permeability, and it was decided to complete future wells only through the overlying Wingate Sandstone unit. It was also decided to seal off the Dakota Sandstone and Morrison Formation, because the water was of poor quality and contained dissolved gases which could cause casing corrosion problems.

Wellfield Lithologies and Aquifer Testing. Navajo Wells 2 though 6 were drilled in 1967 and 1968, Navajo #7 in 1972, Navajo #8 in 1980 and Navajo #9 in 1983. Navajo #2 was perforated from the lower Morrison through the Wingate Sandstone. Navajo Wells 3 though 7 were perforated from the Entrada Sandstone through the Wingate Sandstone. Navajo Well 8 was screened from the Entrada through the Navajo and Well 9 was screened from the Navajo through the Wingate. The aquifers comprise parts or all of what are referred to as the D and N aquifer systems. The aquifer systems are defined and explained in the regional ground-water section. Well construction and completion details are shown in Attachment 19 and Table 54. Tables 55 and 56 and Attachment 20 list and describe the lithologic units and formations penetrated by each well and their approximate elevations below ground surface. Time-drawdown tests were performed on Wells 2 through 7 to determine transmissivity and specific capacity values (Table 55). Plots of the time-drawdown tests

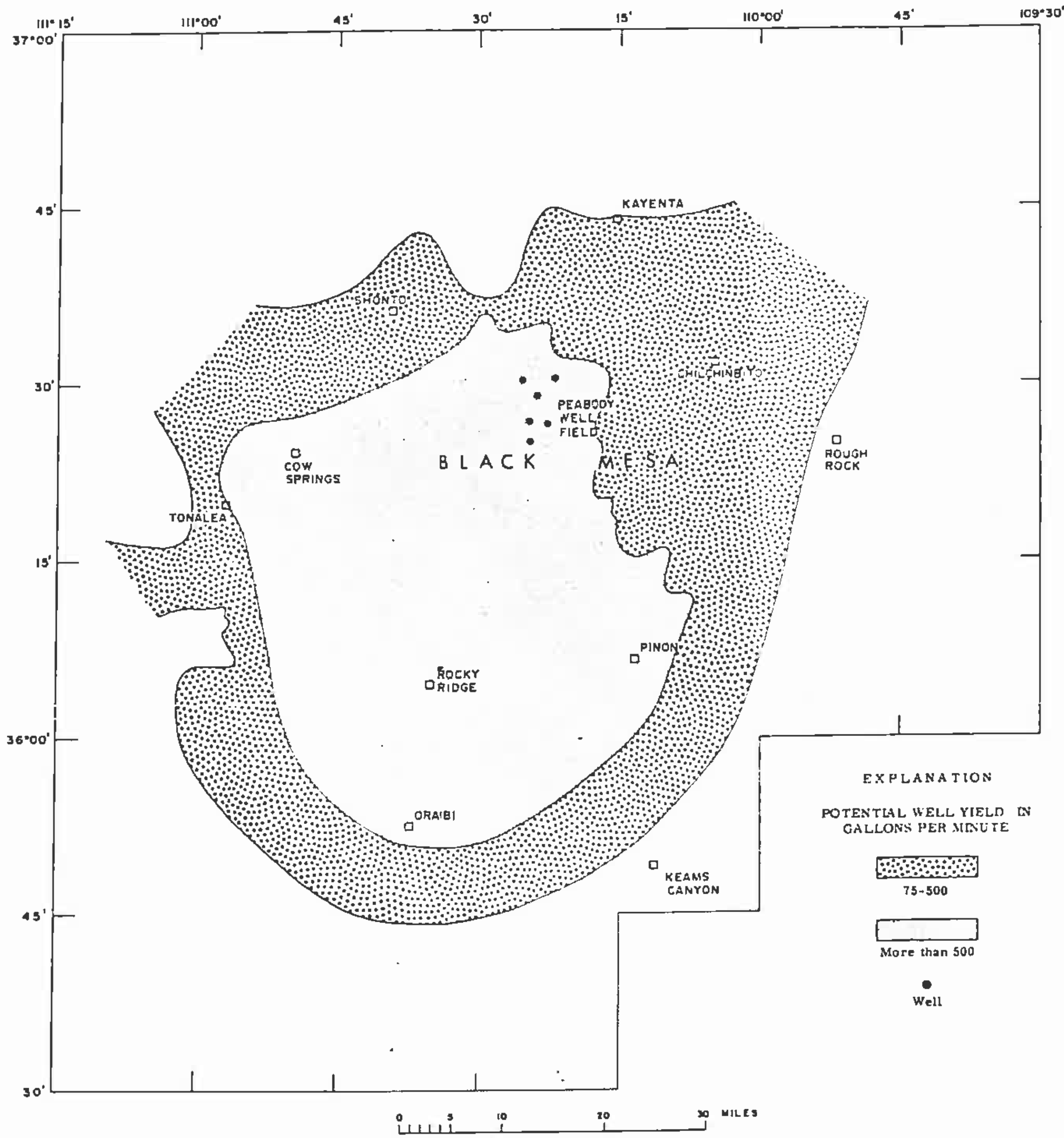


FIGURE 100

Potential Well Yields From the
Navajo Sandstone
Black Mesa Area, Arizona

SYSTEM	SERIES	UNIT	LITHOLOGY AND WATER BEARING PROPERTIES
RECENT		ALLUVIUM	
CRETACEOUS	UPPER	MESAVERDE GROUP	MEDIUM TO COARSE GRAINED SANDSTONE INTERBEDDED WITH SHALE. YIELDS SMALL QUANTITIES OF WATER TO WELLS ON THE MESA.
		MANCOS SHALE	BLACK SHALE WITH SEAMS OF BENTONITIC CLAY. EFFECTIVE AQUICLUDE.
	UPPER & LOWER	DAKOTA SANDSTONE	FINE TO COARSE GRAINED SANDSTONE. LOW TO MODERATE YIELDS.
JURASSIC	UPPER	MORRISON FORMATION	RED SILTSTONE AND FINE SANDSTONE
		COW SPRINGS SANDSTONE	MEDIUM GRAINED SANDSTONE HAVING LOW PERMEABILITIES AND LIMITED RECHARGE RESULTING IN LOW YIELDS.
		ENTRADA SANDSTONE	
	UPPER - MIDDLE	CARMEL FORMATION	RED SHALY SILTSTONE AND MASSIVE MUDSTONE
JURASSIC AND TRIASSIC (?)		NAVAJO SANDSTONE	POORLY CEMENTED FINE TO MEDIUM GRAINED WELL SORTED SANDSTONE. PRINCIPAL AQUIFER IN MANY AREAS.
TRIASSIC(?)	UPPER	KAYENTA FORMATION	INTERBEDDED MUDSTONE AND SANDSTONE.
TRIASSIC	UPPER	WINGATE FORMATION	VERY FINE GRAINED, WELL CEMENTED SANDSTONE LIMITED RECHARGE AND LOW YIELDS. SHALY SILTSTONE
		CHINLE FORMATION	VARIEGATED SILTSTONE, MUDSTONE AND CLAYSTONE. EFFECTIVE AQUICLUDE.
		SHINARUMP MEMBER	CONGLOMERATIC SANDSTONE. POOR AQUIFER
	MIDDLE - LOWER	MOENKOPI FORMATION	SILTSTONE
PERMIAN		KIABAB LIMESTONE	LIMESTONE
		COCONINO SANDSTONE	FINE TO MEDIUM GRAINED WELL SORTED SANDSTONE. EXCELLENT AQUIFER IN SOME LOCATIONS, YIELDS ARE VARIABLE.
		SUPAI FORMATION	

AFTER: AKERS AND HARSHBARGER, 1958, p. 173-183
COOLEY et. al., 1964, p. 5-6.

LEGEND

[stippled] POTENTIAL WATER BEARING ZONES

THOMAS M. STETSON
CIVIL AND CONSULTING ENGINEERS
LOS ANGELES, CALIFORNIA

FIGURE 101

POTENTIAL WATER BEARING ZONES OF BLACK MESA BASIN

FIGURE 102

Generalized Lithologic Log and
Construction Diagram for Navajo No. 1 Well

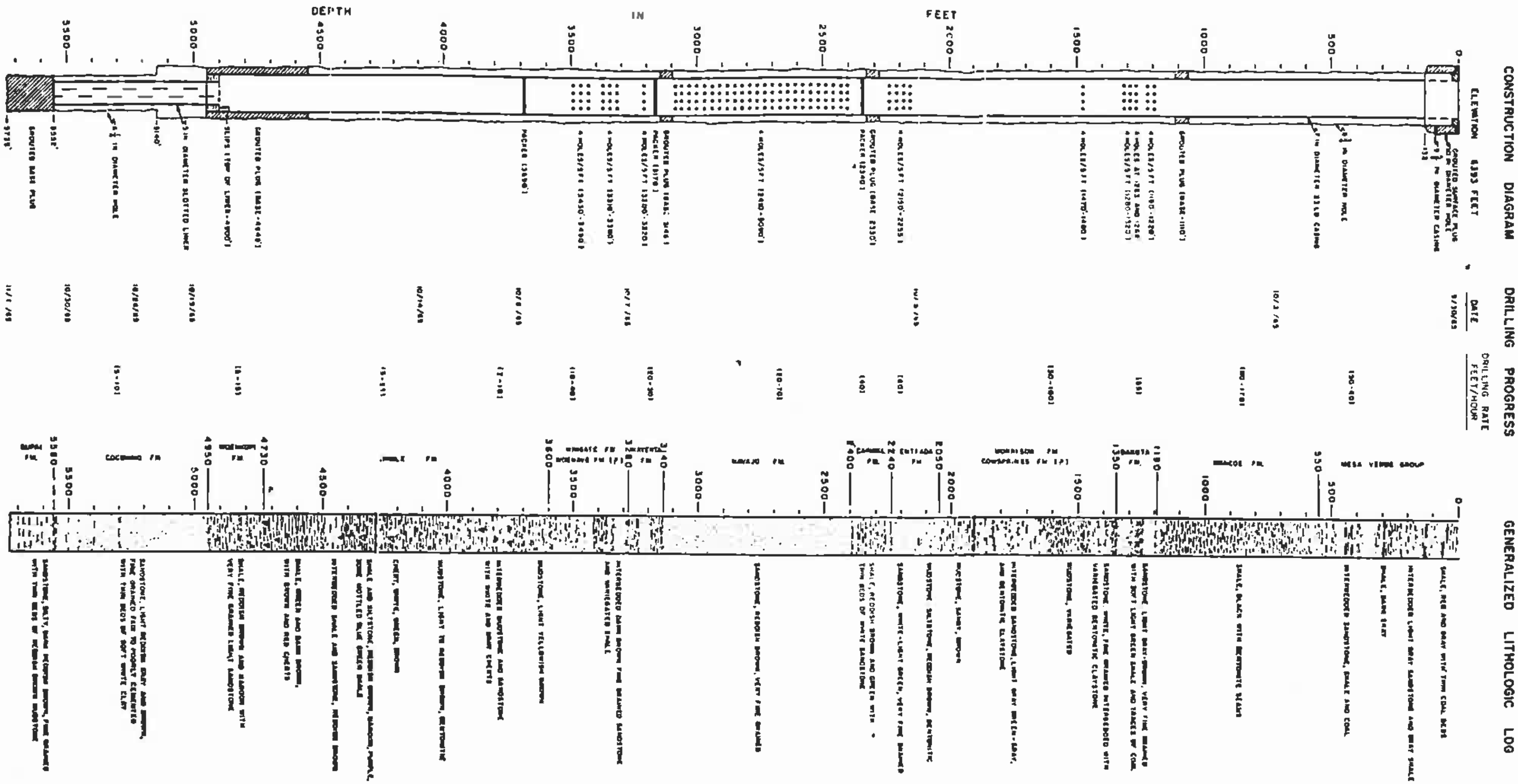


TABLE 52

Pump Test Data for Various Aquifers

Penetrated by Navajo Number 1 Well (Stetson, 1969)

Aquifer	Static Water Elevation (feet) 1/	Available Static Head	Pumping Rate (gpm)	Drawdown (feet)	Specific Capacity (gpm/foot of drawdown) 2/ 3/	Transmissivity (gpd/foot)
Dakota, Morrison and Entrada	5870	670	23	59	0.390	440
Navajo	5820	1830	87	119	0.730	1100
Kayenta-Wingate	5820	2570	15	71	0.210	740
Coconino	4944	3500	15	245	0.06	70

NOTE: 1/ Ground elevation is 6393 feet above sea level

2/ Specific capacity values are valid only for the indicated pumping rates over a 24-hour period

3/ The flow from the Coconino aquifer is from a 6 1/4 inch diameter hole, all others are from an 8 3/4 inch diameter hole

TABLE 53

Water Quality Data for Various Aquifers

Penetrated by Navajo Number 1 Well (Stetson, 1969)

Constituent	Coconino	Kayenta-Wingate	Navajo	Dakota-Morrison-Entrada
pH	9.4	9.4	9.07	7.8
Calcium, as $CaCO_3$	6	24	34	24 1/
Magnesium, as Mg (ppm)	0	14	26	9
Sodium, Na (ppm)	-	-	-	270
Potassium, K (ppm)	-	-	-	6.8
Iron, Fe (ppm)	0	0	0	2.6
Manganese, Mn (ppm)	0	0	0	0.06
Bicarbonate, as HCO_3 (ppm)	204	80	50	295
Sulfate, SO_4 (ppm)	20	35	0	402
Chloride, Cl (ppm)	36	27	10	17
Fluoride, F (ppm)	1.05	0.70	0.30	0.6
Nitrate, NO_3 (ppm)	0.02	4.25	2.75	1
Carbonate, CO_3 (ppm)	88	60	20	-
Carbon dioxide, CO_2 (ppm)	-	-	-	9
Hardness, as $CaCO_3$ (ppm)	6	38	60	97
Silica, as Si (ppm)	27	26	25	15 2/
Boron, B (ppm)	-	-	-	0.21
Total Dissolved Solids (ppm)	740	474	150	913
Alkalinity, as $CaCO_3$ (ppm)	292	140	70	-

1/ as Ca

2/ as SiO_2

TABLE 54

Construction Details of Peabody Coal Company Production Wells

Well Identification	Elevation of Land Surface (feet AMSL)	Elevation of Well Bottom (feet AMSL)	Telescopic Borehole Diameters (inches)	Telescopic Casing Diameters (inches)	Elevation Interval of Intermediate Casing (feet AMSL)	Elevation Interval of Slotted (St) or Screened (Sn) Casing (feet AMSL)	Slot Size (inches)	Average Open Area of Casing (Percent)[2]
Navajo 2	6539	2936	36/26/17.5*	30/20/9.625*	6432 - 4670	4723 - 2903 (St)	.030	.68
Navajo 2 Rehabilitation	6539	2900	36/26/20 *	30/20/13.375/7.0*	6432 - 4027	4122 - 2900 (Sn)	.050	17.0
Navajo 3	6446	2850	26/17.5/12.25*	20/13.375/5.5*	6323 - 4369	4499 - 2850 (St)	.030	2.48
Navajo 3 Rehabilitation	6446	2940	26/20/17.5*	22/13.375/10.75/10.8*	6376 - 4120	4189 - 2940 (Sn)	.060	11.
Navajo 4	6229	2771	26/17.5/12.25*	20/13.375/5.5*	6104 - 4286	4336 - 2694 (St)	.030	2.19
Navajo 5	6594	2859	26/17.5/12.25*	20/13.375/5.5*	6470 - 4503	4570 - 2857 (St)	.030	2.19

TABLE 54 (Cont.)

Construction Details of Peabody Coal Company Production Wells

Well Identification	Elevation of Land Surface (feet AMSL)	Elevation of Well Bottom (feet AMSL)	Telescopic Borehole Diameters (inches)	Telescopic Casing Diameters (inches)	Elevation Interval of Intermediate Casing (feet AMSL)	Elevation Interval of Slotted (St) or Screened (Sn) Casing (feet AMSL)	Slot Size (inches)	Average Open Area of Casing (Percent)^2
Navajo 5 Rehabilitation	6594	2861	26/17.5/17.5*	20/13.375/10.75/10.8*	6470 - 4564	4498 - 2861 (St)	.060	11.
Navajo 6	6674	3180	26/17.5/12.25*	20/13.375/5.5*	6516 - 4546	4627 - 3180 (St)	.030	3.80
Navajo 6 Rehabilitation	6674	3110	26/20/17.5*	22/16/13.375/12.8*	6519 - 4273	4376 - 3110 (Sn)		10.
Navajo 7	6385	2860	26/17.5/12.25*	20/13.375/5.5*	6254 - 4202	4374 - 2860 (St)	.030	3.37
Navajo 8	6662	3245	26/17.5/12.25*	20/14/5.9*	6502 - 4195	4257 - 4039 (St) 4039 - 3245 (Sn)	.030 .060	22.8

TABLE 54 (Cont.)

Construction Details of Peabody Coal Company Production Wells

Well Identification	Elevation of Land Surface (feet AMSL)	Elevation of Well Bottom (feet AMSL)	Telescopic Borehole Diameters (inches)	Telescopic Casing Diameters (inches)	Elevation Interval of Intermediate Casing (feet AMSL)	Elevation Interval of Slotted (St) or Screened (Sn) Casing (feet AMSL)	Slot Size (inches)	Average Open Area of Casing (Percent)[2]
Navajo 9	6391	2886	42/26/20*	32/16/13*	6323 - 3995	4059 - 2886 (Sn)	.060	10.0

[1]The diameter corresponding to the production zone is denoted with an asterisk (*).

[2]Two different types of slotted casing were used to complete the wells; a 128 slot per foot casing with 3.7% open area and a 2 slot per foot casing with .058% open area. The Johnson well screen used to complete Navajo 8 has a reported 22.8% open area.

[3]With current well and pump design the intake can only be lowered to within 57 feet of the top of the liner.

Sources: Thomas M. Stetson (1969); Thomas M. Stetson (1972); Peabody Coal Company (1982).

TABLE 55

Summary of Geologic and Hydraulic Characteristics Associated With Peabody Coal Company's Production Wells

Well Identification	Formations Open To Well[1]	Elevation of Static Water Level at Time of Well Completion (feet AMSL)	Elevation of Top of D Aquifer[2] (feet AMSL)	Elevation of Top of N Aquifer[3] (feet AMSL)	Calculated Transmissivity[4] (gpd/ft)	Initial Specific Capacity[4] gpm/ft	Initial Specific Capacity[4] year	Most Recently Estimated Specific Capacity[5] gpm/ft	Most Recently Estimated Specific Capacity[5] year
Navajo 2	Jm*,Je,Jca,Jna JTrk,Trwi*	5799	5184 [1]	4000	1850	1.08	1967	1.4	1985
Navajo 3	Je*,Jca,Jna, JTrk,Trwi,Trch*	5716	5311	4130	2250	1.15	1968	1.5	1985
Navajo 4	Je*,Jca,Jna, JTrk,Trwi,Trch*	5739	5124	3950	2200	1.32	1968	1.16	1985
Navajo 5	Jm*,Je,Jca,Jna JTrk,Trwi*	5764	5154	3995	2800	1.15	1968	1.34	1985
Navajo 6	Je*,Jca,Jna JTrk,Trwi,Trch*	5779	5464	4290	2300	1.31	1968	1.0 (Est)	1985
Navajo 7	Je*,Jca,Jna JTrk,Trwi*	5685	5085	3925	5100	1.46	1972	1.57	1985

TABLE 55 (Cont.)

Summary of Geologic and Hydraulic Characteristics Associated With Peabody Coal Company's Production Wells

Well Identification	Formations Open To Well[1]	Elevation of Static Water Level at Time of Well Completion (feet AMSL)	Elevation of Top of D Aquifer[2] (feet AMSL)	Elevation of Top of N Aquifer[3] (feet AMSL)	Calculated Transmissivity[4] (gpd/ft)	Initial Specific Capacity[4] gpm/ft	Initial Specific Capacity[4] year	Most Recently Estimated Specific Capacity[5] gpm/ft	Most Recently Estimated Specific Capacity[5] year
Navajo 8	Je*,Jca,Jna	5612	5275	4045	NA	NA	NA	.69	1985
Navajo 9	*JnA, JTrk, Trwi	5485	4225	3991	NA	NA	NA	1.37	1985

Key to Geologic Formations

Jm - Morrison Formation	JTrk - Kayenta Formation
Je - Entrada Sandstone	Trwi - Wingate Sandstone
Jca - Carmel Formation	Trch - Chinle Formation
Jna - Navajo Sandstone	

[1] See Key for Geologic Formation abbreviations. Asterisk (*) indicates that only a portion of the formation is open to the well.

[2] The D aquifer consists of, in ascending order, the Carmel Formation, the Entrada Sandstone, the Morrison Formation and the Dakota Sandstone.

[3] The N aquifer consists of, in ascending order, the Wingate Sandstone, the Kayenta Formation and the Navajo Sandstone.

[4] Source: Stetson 1976

[5] Estimated from available water level and pumping data.

TABLE 56

Peabody Wellfield Lithologic Information*

FORMATION	NAVAJO 1 6393	NAVAJO 2 6539	NAVAJO 3 6446	NAVAJO 4 6229	NAVAJO 5 6594	NAVAJO 6 6674	NAVAJO 7 6385	NAVAJO 8 6662	NAVAJO 9 6391
WEPO	EXPOSED AT GROUND SURFACE								
TOREVA		6149	6156	5909	6074	6354	6035	6372	6111
MANCOS	5835	5795	5920	5730	5795	6075	5680	5912	5791
DAKOTA	5205	5184	5811	5124	5154	5464	5085	5262	5131
MORRISON	5045	5030	5185	5010	5010	5270	4965	5122	4991
ENTRADA	4345	4350	4465	4260	4300	4630	4275	4462	4271
CARMEL	4160	4160	4290	4100	4145	4440	4080	4202	4131
NAVAJO	3995	4000	4130	3950	3995	4290	3925	4032	3991
KAYENTA	3255	3265	3440	3250	3270	3600	3235		3271
WINGATE	3110	3115	3265	3090	3115	3440	3070		3131
CHINLE	2795		2980	2775		3165			
MOENKOPI	1665								
COCONINO	1445								
SUPAI	833								

*Numbers represent the elevation of the top of respective geologic formations in feet above mean sea level.

are shown in Attachment 21.

Navajo well transmissivities ranged from 1,800 to 5,100 gpd/ft. and specific capacity values were initially between .78 and 1.46 gpm/ft. Specific capacities of all wells have shown a decrease with time. This is probably due to both scale buildup and a reduction in potentiometric head. The observed hydrogen ion concentrations are above the saturation hydrogen ion concentration, so there will be deposition of calcium scale on the casing with time.

Wellfield Pumpage. Prior to 1969 only limited pumpage for aquifer testing was conducted. In 1969 pumpage for the coal slurry line commenced. Pumpage was minimal until 1971 and reached 3,682 acre feet in 1972 with the addition of Navajo #7. Total wellfield pumpage has been in excess of 4,000 acre feet four of the last five years and has averaged 4,185 acre feet/year for the same time period. A summary of the wellfield pumpage from 1969 to 1985 is presented in Table 57.

Static Water Levels and Drawdowns. Static water level refers to the depth to or elevation of ground water either before pumpage began or between periods of pumpage. Static water level elevations prior to pumpage in Wells 2 through 7 ranged from elevation 5685 (700 feet below ground surface) in Well 7 to elevation 5799 (740 feet below ground surface) in Well 2. Static water levels between periods of pumpage in 1984 ranged from elevation 5284 (1310 feet below ground surface) in Well 5 to elevation 5532 (1130 feet below ground surface) in Well 8.

The change in static water level elevations with time is an indication of the decline in artesian head (pressure head that lifts the water level above the top of the aquifer in a well bore) since pumpage began. It must be reported as an indication only, since well efficiency, well interference and length of time the wells were off also effect the readings. Static head declines in those wells pumped since 1971 range from 295 to 560 feet.

Drawdown in a well is the difference between the static water level and the water level when the pump is on. Plots of daily drawdown and static head values for each well by year are presented in Attachment 22. Gaps in the record for an individual well are the result of transducer malfunctions.

TABLE 57

Summary of Quantity of Ground Water Pumped

At the Peabody Well Field Since 1969

Year	Quarter	Well Numbers (Acre Feet) 2	3	4	5	6	7	8	9	Totals
1969	1 - 2	175.8	42.3	50.0	45.5	42.4				356.0
	3 - 4	24.8	118.0	29.8	23.5	22.9				219.0
	Total	200.6	160.3	79.8	69.0	65.3				575.0
1970	Total	185.1	120.4	83.5	196.8	155.9				741.7
1971	1	81.4	62.7	38.1	83.7	89.3				355.2
	2	119.4	73.5	120.3	121.0	122.7				556.9
	3	110.4	93.1	89.7	79.2	85.0				457.4
	4	116.5	100.9	69.5	140.0	105.2				532.1
	Total	427.7	330.2	317.6	423.9	402.2				1,901.6
1972	1	169.6	173.3	138.8	196.3	191.1				869.1
	2	176.0	205.3	208.9	200.2	225.7				1,016.1
	3	171.7	213.7	206.6	162.2	204.2	125.3			1,083.7
	4	50.1	100.7	140.2	169.0	92.4	160.9			713.3
	Total	567.4	693.0	694.5	727.7	713.4	286.2			3,682.2
1973	1	107.7	117.9	166.4	181.4	41.0	207.1			821.5
	2	142.5	166.4	183.1	146.4	51.2	167.9			857.5
	3	193.1	55.7	190.5	175.5	164.2	223.4			1,002.4
	4	188.7	114.1	161.8	144.5	59.9	171.5			840.5
	Total	632.0	454.1	701.8	647.8	316.3	769.9			3,521.9
1974	1	183.4	142.0	184.2	134.3	25.7	183.5			853.1
	2	168.6	174.9	170.9	120.8	114.7	202.3			952.2
	3	203.1	124.9	169.5	162.4	171.5	173.9			1,005.3
	4	198.5	183.1	219.9	167.1	67.3	183.0			1,018.9
	Total	753.6	624.9	744.5	584.6	379.2	742.7			3,829.5

TABLE 57 (Cont.)

Summary of Quantity of Ground Water Pumped

At the Peabody Well Field Since 1969

		Well Numbers (Acre Feet)								
Year	Quarter	2	3	4	5	6	7	8	9	Totals
1975	1	97.1	77.9	104.1	74.0	4.8	96.4			454.3
	2	171.0	114.4	187.8	163.1	114.9	212.9			964.1
	3	197.4	199.7	217.1	136.3	94.8	217.3			1,062.6
	4	189.8	188.7	219.9	166.4	109.2	198.4			1,072.4
	Total	655.3	580.7	728.9	539.8	323.7	725.0			3,553.4
1976	1	179.7	106.3	143.3	133.3	81.6	171.4			815.6
	2	197.8	209.6	213.0	171.5	159.9	232.7			1,184.5
	3	186.9	214.0	213.7	124.1	167.9	205.7			1,112.3
	4	206.9	214.8	210.4	112.7	106.1	219.3			1,070.2
	Total	771.3	744.7	780.4	541.6	515.5	829.1			4,182.6
1977	1	182.6	203.5	203.9	142.3	40.5	235.7			1,008.5
	2	177.6	192.5	192.9	149.0	162.1	209.5			1,083.6
	3	174.1	209.0	207.8	171.7	180.4	225.1			1,168.1
	4	197.3	158.2	148.6	84.3	119.9	199.8			828.3
	Total	731.6	763.2	753.4	547.3	502.9	790.1			4,088.5
1978	1	133.4	68.9	30.2	48.4	28.4	83.8			393.1
	2	172.3	102.9	116.0	82.1	129.5	122.7			725.5
	3	185.3	170.5	170.8	140.0	163.6	176.6			1,006.8
	4	177.8	166.5	174.9	96.7	89.7	174.7			880.3
	Total	668.8	508.8	491.9	367.2	411.2	557.8			3,005.7
1979	1	138.1	149.1	148.6	98.2	27.9	145.4			707.3
	2	199.9	145.3	134.0	132.9	110.7	157.1			879.9
	3	193.0	180.0	185.6	154.4	173.7	215.5			1,102.2
	4	185.8	117.4	153.0	98.3	119.2	135.5			809.2
	Total	716.8	591.8	621.2	483.8	431.5	653.5			3,498.6
1980	1	193.8	100.1	106.6	106.5	59.0	92.1			658.1
	2	196.6	172.0	186.5	165.8	159.7	195.9			1,076.5
	3	165.7	178.1	180.5	132.4	138.5	161.7	73.5		1,030.4

TABLE 57 (Cont.)

Summary of Quantity of Ground Water Pumped

At the Peabody Well Field Since 1969

		Well Numbers (Acre Feet)								
Year	Quarter	2	3	4	5	6	7	8	9	Totals
1980	4	199.4	129.6	131.6	95.4	38.0	162.9	21.3		778.2
	Total	755.5	579.8	605.2	500.1	395.2	612.6	94.8		3,543.2
1981	1	73.7	119.6	114.5	69.5	47.9	144.9	109.6		679.7
	2	209.2	183.4	182.4	123.0	118.7	206.0	115.4		1,138.1
	3	201.9	186.0	184.0	95.2	171.8	225.8	169.4		1,234.1
	4	194.2	151.7	153.9	95.8	102.8	184.1	74.3		956.8
	Total	679.0	640.7	634.8	383.5	441.2	760.8	468.7		4,008.7
1982	1	191.3	133.0	181.9	102.1	137.0	219.2	56.0		1,020.5
	2	186.3	196.6	171.4	64.2	168.8	233.8	174.7		1,195.8
	3	203.6	196.7	180.1	161.0	183.2	254.3	234.9		1,413.8
	4	163.6	173.2	162.3	106.2	161.8	201.8	145.3		1,114.2
	Total	744.8	699.5	695.7	433.5	650.8	909.1	610.9		4,744.3
1983	1	199.2	167.0	165.2	97.8	126.7	187.6	40.0		983.5
	2	193.1	145.5	184.3	132.4	135.2	192.2	130.9		1,113.6
	3	79.5	151.6	195.3	96.7	164.4	211.3	221.4	137.1	1,257.3
	4	128.6	53.1	198.0	182.6	77.7	194.2	107.6	158.4	1,100.7
	Total	600.4	517.2	742.8	509.5	504.0	785.3	499.9	296.0	4,455.1
1984	1	194.7	174.1	196.9	107.2	145.3	28.0	8.0	212.3	1,066.5
	2	198.3	91.1	193.5	157.5	156.5	105.2	145.0	193.2	1,240.3
	3	179.1	52.0	170.5	100.0	139.0	187.5	131.1	187.3	1,146.5
	4	198.2	97.4	128.7	55.4	44.2	92.7	21.9	81.8	720.3
	Total	770.3	414.6	689.6	420.1	485.0	413.4	306.0	674.6	4,173.6
1985	1	216.2	218.2	184.5	108.4	105.1	217.1	0.1	15.5	1,065.1
	2	204.0	153.9	157.8	139.6	53.6	161.0	53.2	0.0	923.1
	3	180.8	0.0	17.9	0.0	0.0	0.0	22.0	0.0	220.7
Total		601.0	372.1	360.2	248.0	158.7	378.1	75.3	15.5	2,208.9

Static head values included in the drawdown plots presented in Attachment 22 were used to estimate the amount of aquifer water level decline in the vicinity of each well since pumping began.

A six-month shutdown of the Mohave Power Plant in the latter half of 1985 provided an opportunity to assess the response of the N-aquifer to the absence of wellfield pumpage stress. Although Well 2 pumpage and limited pumpage at Wells 8, 7 and 4 occurred during this period, positive aquifer responses were determined suggesting that wellfield pumpage has not damaged the structural integrity of the aquifers.

Total amounts of artesian head decline prior to the wellfield shutdown were determined by subtracting the difference between 1968 and 1984 or 1985 static water levels. Total amounts of artesian head recovery following the wellfield shutdown were determined by subtracting pre-shutdown static water levels from static levels as of October, 1985. Percent water level recoveries were determined by dividing the static water level recoveries for each well by the total artesian head declines at each well.

Table 58 presents estimates of water level recoveries, artesian head declines and the percent of total drawdown recovery for each well. Percent recoveries ranged between 9.1 and 24.7 percent. Considering these recoveries only represent a four month period, the rates of water level recovery appear to be well within those simulated in the USGS 2-D model following the conclusion of mining.

Analytical and Computer Model Drawdown Projections Beneath the Leasehold. Three organizations have investigated drawdowns immediately beneath the leasehold versus time. They are the USGS, Thomas Stetson Consultants and Dames and Moore. The USGS investigation employed a regional, 2-D finite difference model. Unfortunately, because of the scale of the model, no resolution could be obtained at the individual Peabody N-aquifer well sites for comparison with our transducer values. Drawdown projections through the year 2001 indicate 200+ feet of drawdown within a 2-mile radius of the leasehold.

Thomas Stetson Consultants and Dames and Moore performed site specific analytical and digital computer simulations of future drawdowns at the production wells. Thomas Stetson Consultants used an analytical approach to project drawdowns at the well bores for the first 27 years of pumping. Principal assumptions were: (1) there was no recharge to the

TABLE 58

Water Level Recoveries, Artesian Head Declines and Percent of Drawdown Recoveries in Navajo Wells

Well #	Water Level Recoveries (ft)	Artesian Head Declines (ft)	Drawdown Recoveries (%)
1	90	650*	13.8
3	75	405*	18.5
4	105	425*	24.7
5	40	420*	9.5
6	55	340*	16.2
7	60	395**	15.2
8	5	55***	9.1
9	15	75****	20.0

* total declines since 1968

** total decline since 1972

*** total decline since 1980

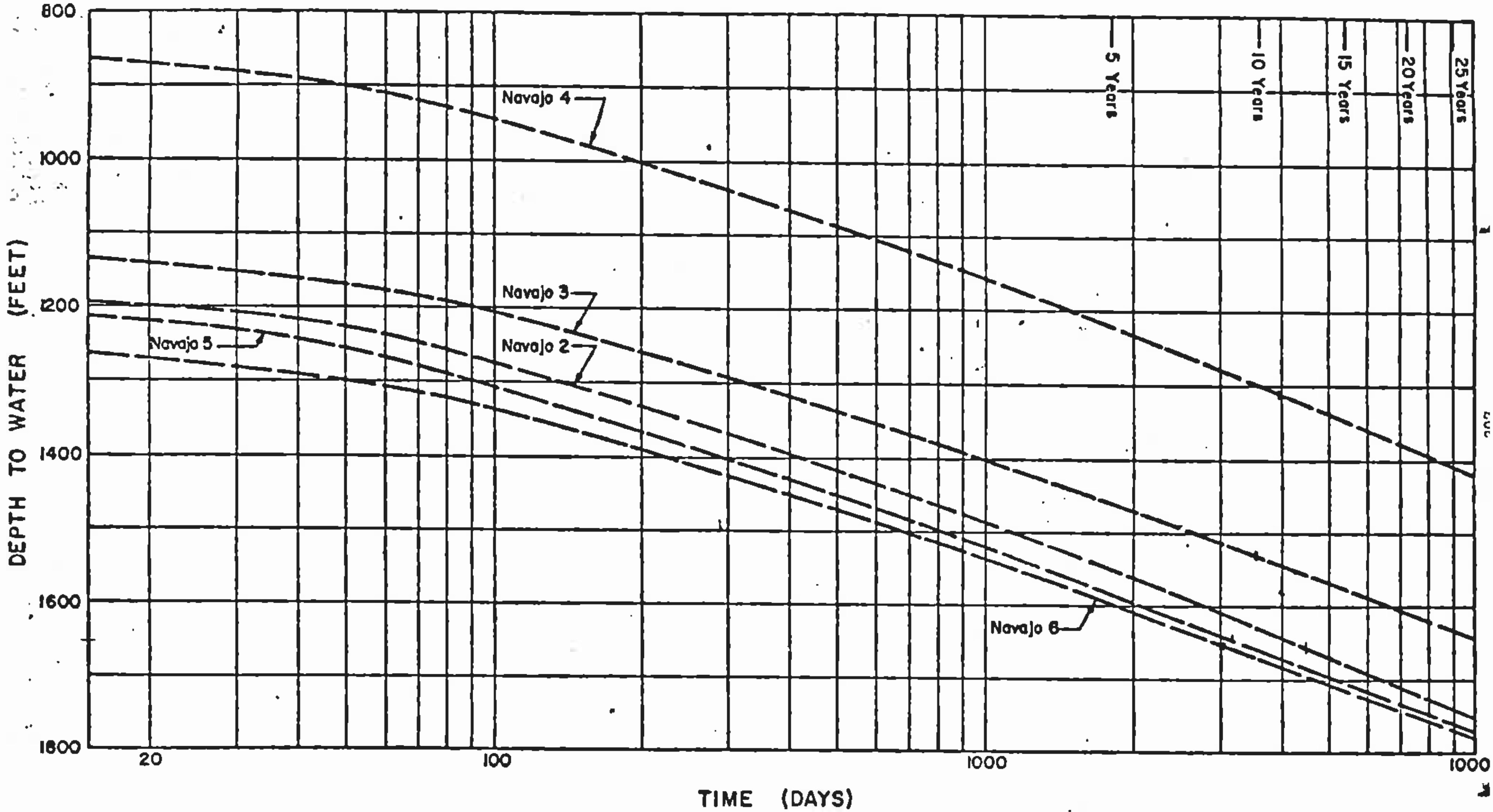
**** total decline since 1983

system; (2) no barrier boundaries were intercepted with prolonged pumpage; (3) a transmissivity value of 2,000 gpd/foot was representative of the wellfield; (4) pumpage from Wells 7, 8 and 9 did not occur; (5) a storage coefficient value of 3×10^{-4} was representative; and (6) an average overall pumping rate of 400 gpm occurred at each well. Drawdown plots versus time for wells 2 through 6 are shown in Figure 103.

As a check on the validity of their assumptions, Stetson compared their theoretical drawdowns against actual wellfield measurements. The results were very close (Table 59) suggesting that the necessary assumptions that were made for the theoretical calculations were reasonable. Since Well 7 was operational by this time and Well 8 was planned, new 35 year drawdown projections were made with and without Well 8. Assumptions for the two scenarios were the same as those previously discussed with the exception that the maximum pumpage rates and total withdrawals were higher. Maximum pumpage rates and total withdrawals were 3,150 gpm and 4,000 acre feet and 3,675 gpm and 4,650 acre feet for the scenario with Wells 2 through 7 and Wells 2 through 8, respectively. The results of the 35 year drawdown computations are presented in Table 60.

With the addition of Well 8, all of the existing well bore water levels would be below the lowest pump bowl settings before the term of the mining lease was completed. Based on this information and drawdown measurements in 1982, a well rehabilitation program was undertaken in 1983 and 1984. The rehabilitation program focused on enlarging the production zones to accommodate the pumps if necessary and increasing the percent open area of the production zone well screen to minimize well losses. Navajo Well 9 was drilled primarily to provide a back-up water supply should one of the reworked wells have been lost or significantly damaged during the rehabilitation work. Well 9 is now being utilized to allow other wells in the wellfield to recover longer. Future considerations have Well 9 being used to allow the other wells to be pumped at lower or variable rates. This is addressed further in the Dames and Moore modeling discussion.

In 1983 Dames and Moore was retained to perform finite difference ground water level simulations for the purpose of assisting in locating new well #9 and evaluating rehabilitated Wells 2, 3, 5 and 6, and local and adjacent area drawdown variations as a function of varying pumpage rates at the different wells. In all, 15 different pumpage rate scenarios, in combination with 9 alternate, new well locations, were investigated (Table 61 and Figures 104 and 117). Total pumpage rates assumed in all scenarios exceeded any annual pumpage to date, thus the results should represent a worst case situation. The



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LOS ANGELES — SAN FRANCISCO

FIGURE 103

Projected Water Levels of the Peabody Wellfield

TABLE 59

Measured and Theoretical Pumping Water Levels
In the Peabody Well Field

Well No.	Measured or Estimated Depth to Pumping Water Level (Feet)	Theoretical Depth to Pumping Water Level (Feet)
2	1,570	1,580
3	1,510	1,550
4	1,290	1,350
5	1,610	1,590
6	1,620	1,630
7	-	1,490

TABLE 60

Projected Water Levels in the Peabody
Well Field After 35 Years of Pumpage

Well No.	Maximum Depth of Pumping Water Level (Feet)	Projected Depth to Pumping Water Level After 35 Years (Feet)	
		Without New Well	With New Well
2	1,694	1,950	2,000
3	1,884	1,950	2,030
4	1,830	1,760	1,840
5	1,961	2,000	2,060
6	1,984	2,000	2,050
7	1,948	1,870	1,980
8	2,100 (est)	-	2,080

TABLE 61

Well Pumping Rates, Scenarios 1 - 15

Well ID	Scenarios	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Pumping Rate (GPM)														
Navajo #2		500	250	350	400	-	-	400	250	325	300	-	-	-	-	-
Navajo #3		500	350	350	400	300	-	400	350	350	400	300	-	500	500	500
Navajo #4		500	350	350	400	300	-	400	350	350	400	300	-	500	500	500
Navajo #5		500	300	350	400	300	-	400	300	350	300	300	-	500	500	500
Navajo #6		500	350	350	400	300	-	450	350	350	400	300	-	500	500	500
Navajo #7		600	450	350	400	300	-	550	450	350	400	300	-	600	600	600
Navajo #8		500	350	350	400	300	-	400	350	350	400	300	-	500	500	500
New Well #1		-	600	575	400	600	600	-	600	-	400	600	600	-	-	-
New Well #2		-	600	575	400	600	600	-	-	575	-	600	600	-	-	-
New Well #3		-	-	-	-	600	600	-	-	-	-	-	600	-	-	-
New Well #4		-	-	-	-	-	600	-	-	-	-	-	-	-	-	-
New Well #5		-	-	-	-	-	600	-	-	-	-	-	600	-	-	-
New Well #6		-	-	-	-	-	600	-	-	-	-	-	600	-	-	-
New Well #7		-	-	-	-	-	-	-	-	-	-	-	-	500	-	-
New Well #8		-	-	-	-	-	-	-	-	-	-	-	-	-	500	-
New Well #9		-	-	-	-	-	-	-	-	-	-	-	-	-	-	500
TOTAL		3600	3600	3600	3600	3600	3600	3000	3000	3000	3000	3000	3000	3600	3600	3600

drawdown results for each pumpage scenario are presented in Figures 105 through 120. Figures 104 and 117 are included with Figures 105 to 116 and 118 to 120, respectively, to provide well location references for the 15 drawdown scenarios. Varying the pumpage rates at the different wells appears to have no effect on the drawdowns and shape of the cone of depression at a distance of one to two miles out from the leasehold. Within the leasehold, cone of depression changes can be significantly affected by both pumpage rates and well location. Based on these projections, the east tract of the leasehold was found to be a poor location for any new Navajo wells.

Navajo Aquifer Water Quality. The shallow ground water types present in the Black Mesa drainage area have been described in the previous sections of this chapter. Cooley's observations on the relationship between TDS and water type have been referenced in the Wepo aquifer discussion. These observations also hold true for the Navajo water quality. The average TDS value for each well is presented in Table 62.

TABLE 62

Average TDS Concentrations in mg/l for Navajo Wells

Well Number	2	3	4	5	6	7	8	9
Concentration	148	152	157	175	169	167	404	140

Av. 2-9 = 158 mg/l

Figure 121 is a summarization of the Navajo water quality, as gathered by the USGS and Peabody Coal. Individual trilinear plots for each well based on samples collected by the USGS and PCC are found in Figures 122 through 136.

As Figure 121 shows, there are two distinct water types present. The first type represented by Wells 1-7 and 9 is a sodium-bicarbonate water. The average TDS concentration for these wells is 158 mg/l. This relationship of water type to TDS corresponds well to those documented previously. The second water type present is that of Well 8, a sodium sulfate water, with an average TDS concentration of 404 mg/l.

The most obvious explanation for this difference in water types is that Well 8 is not completed in the Wingate Sandstone. The other Peabody N-aquifer wells are. Based on isolated aquifer tests performed in test well Navajo No. 1, the Wingate Sandstone yields

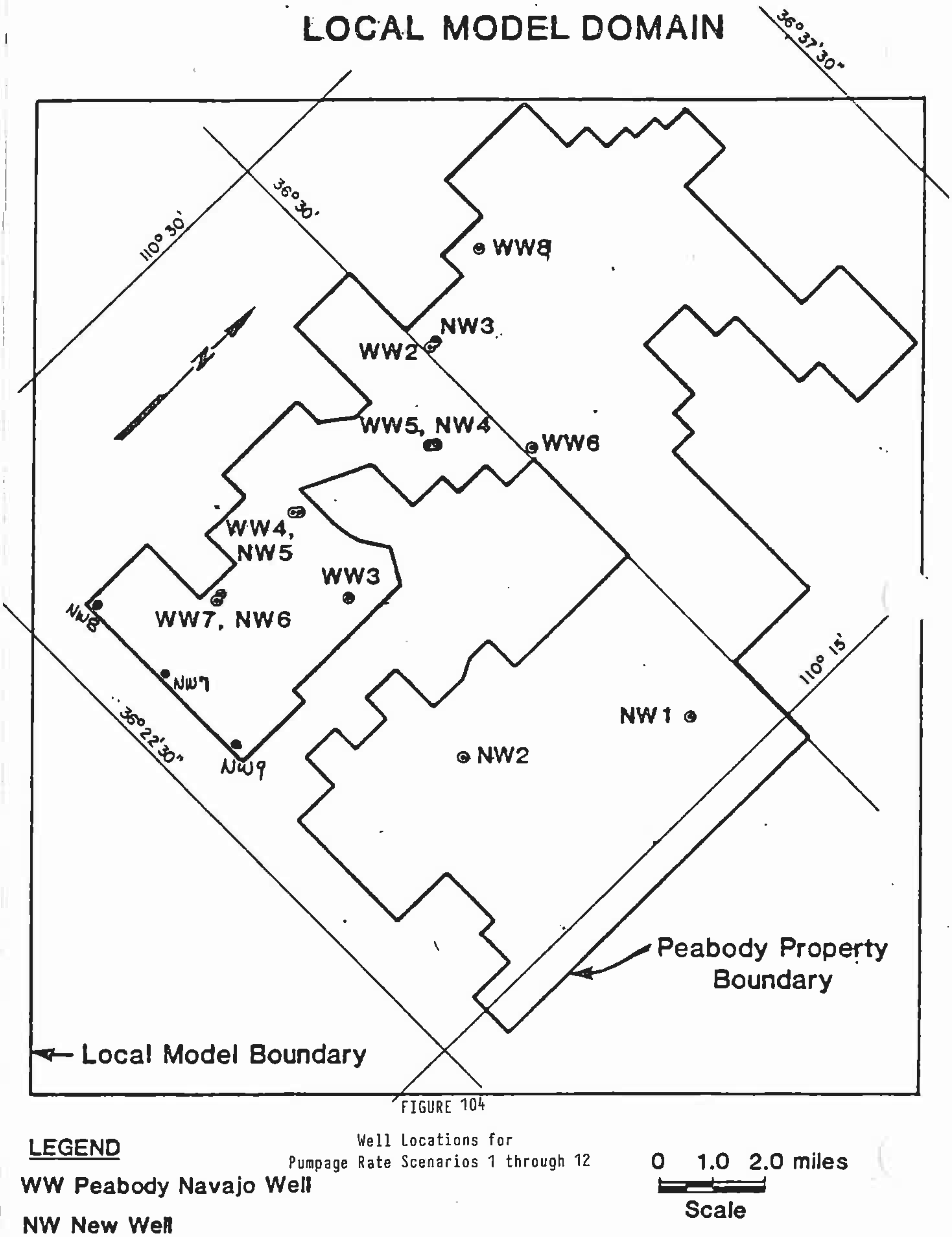


FIGURE 104

Well Locations for
Pumpage Rate Scenarios 1 through 12

LOCAL MODEL SCENARIO 1 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE = 3600 GPM

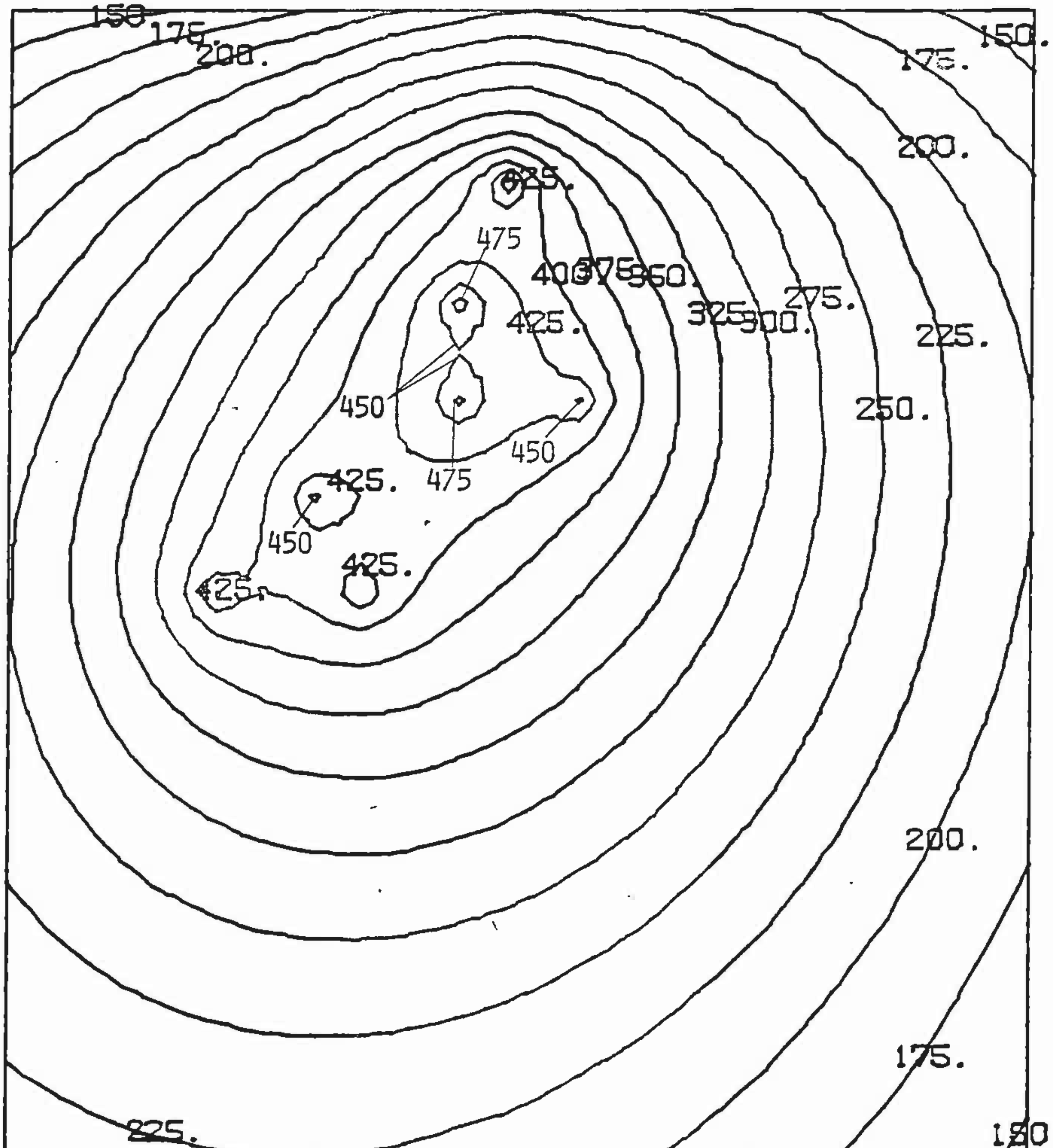


FIGURE 105

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 1

LOCAL MODEL SCENARIO 2 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE = 3600 GPM

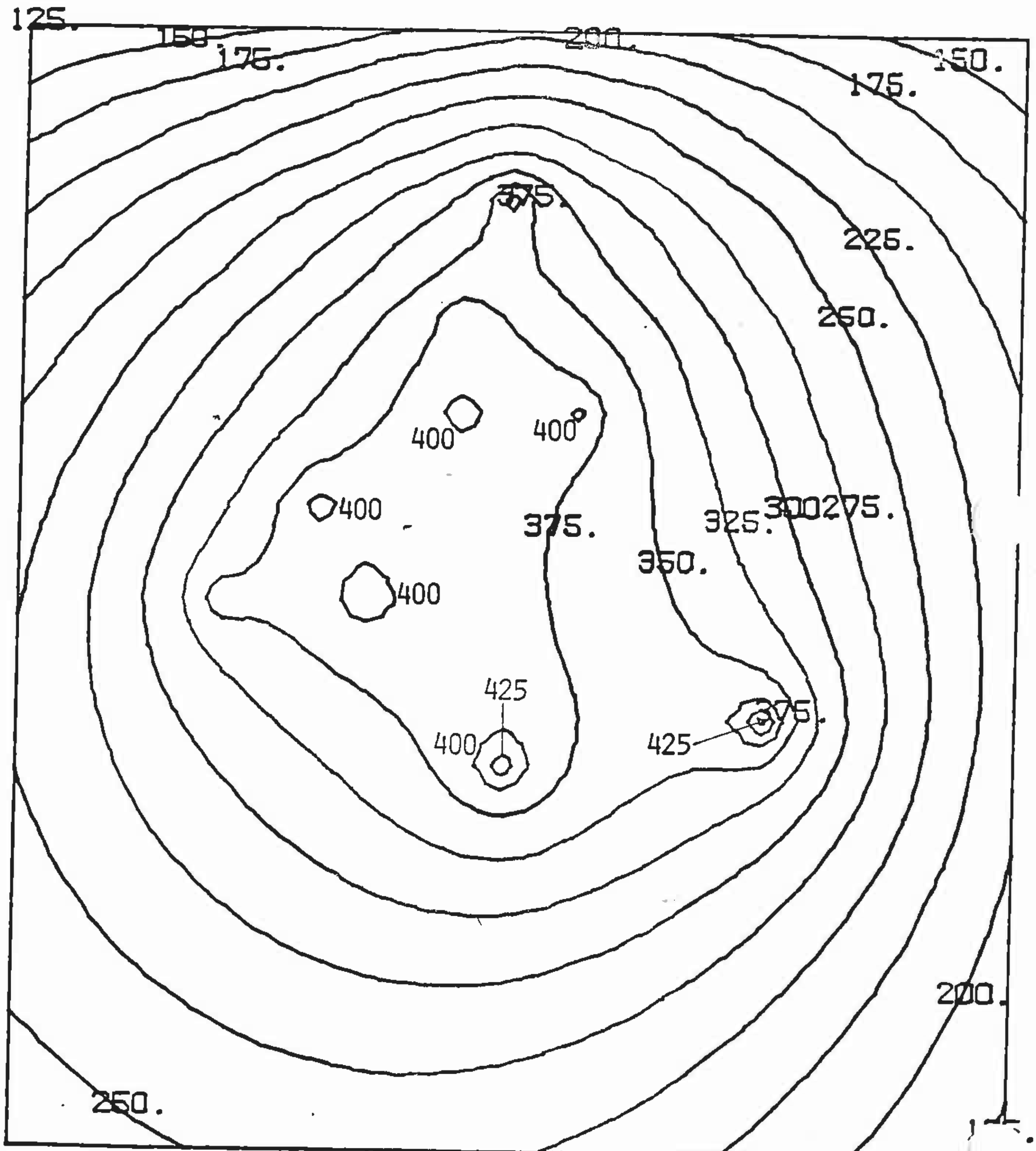


FIGURE 106

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 2

LOCAL MODEL SCENARIO 3 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE = 3600 GPM

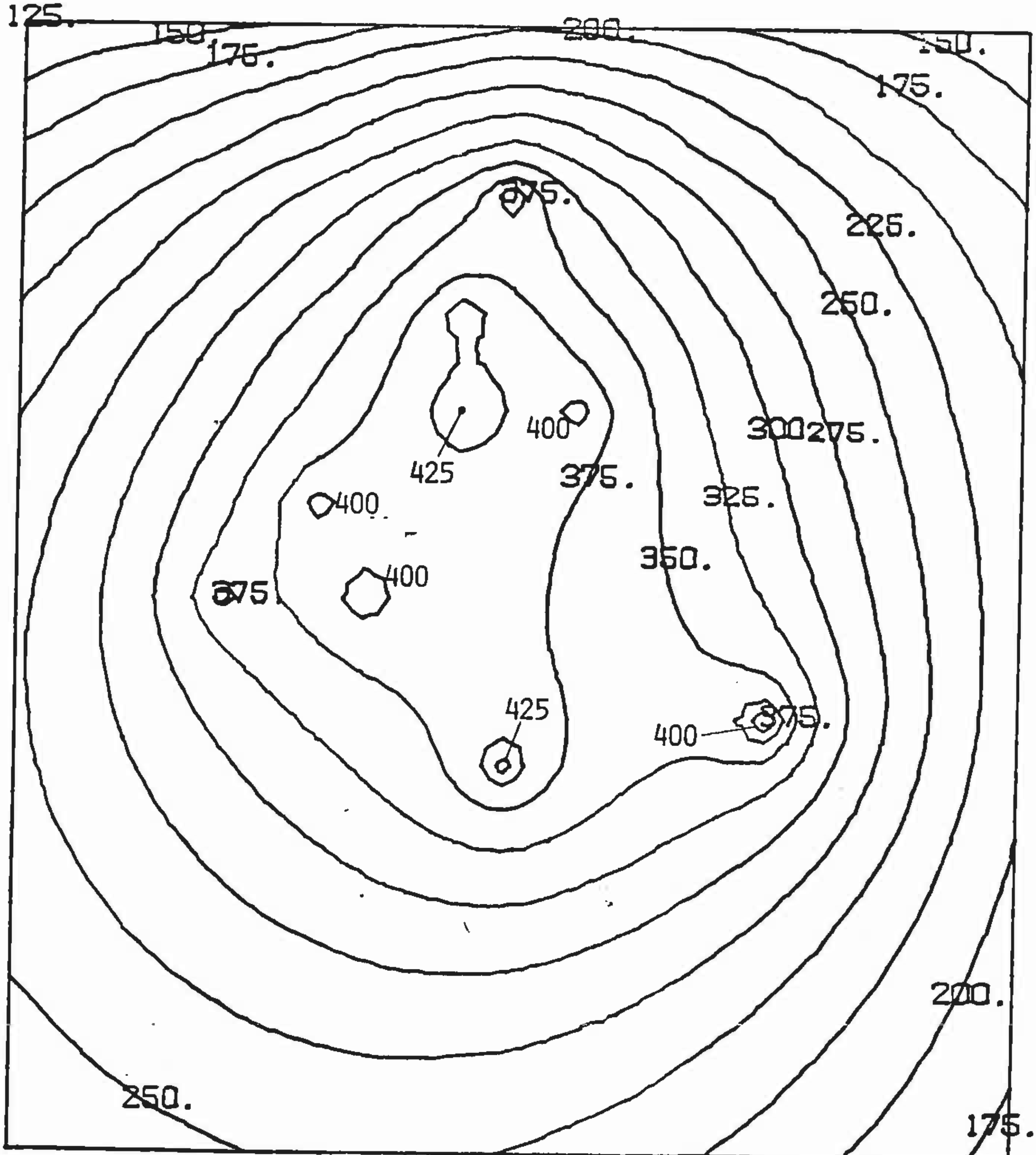


FIGURE 107

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 3

LOCAL MODEL SCENARIO 4 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE = 3600 GPM

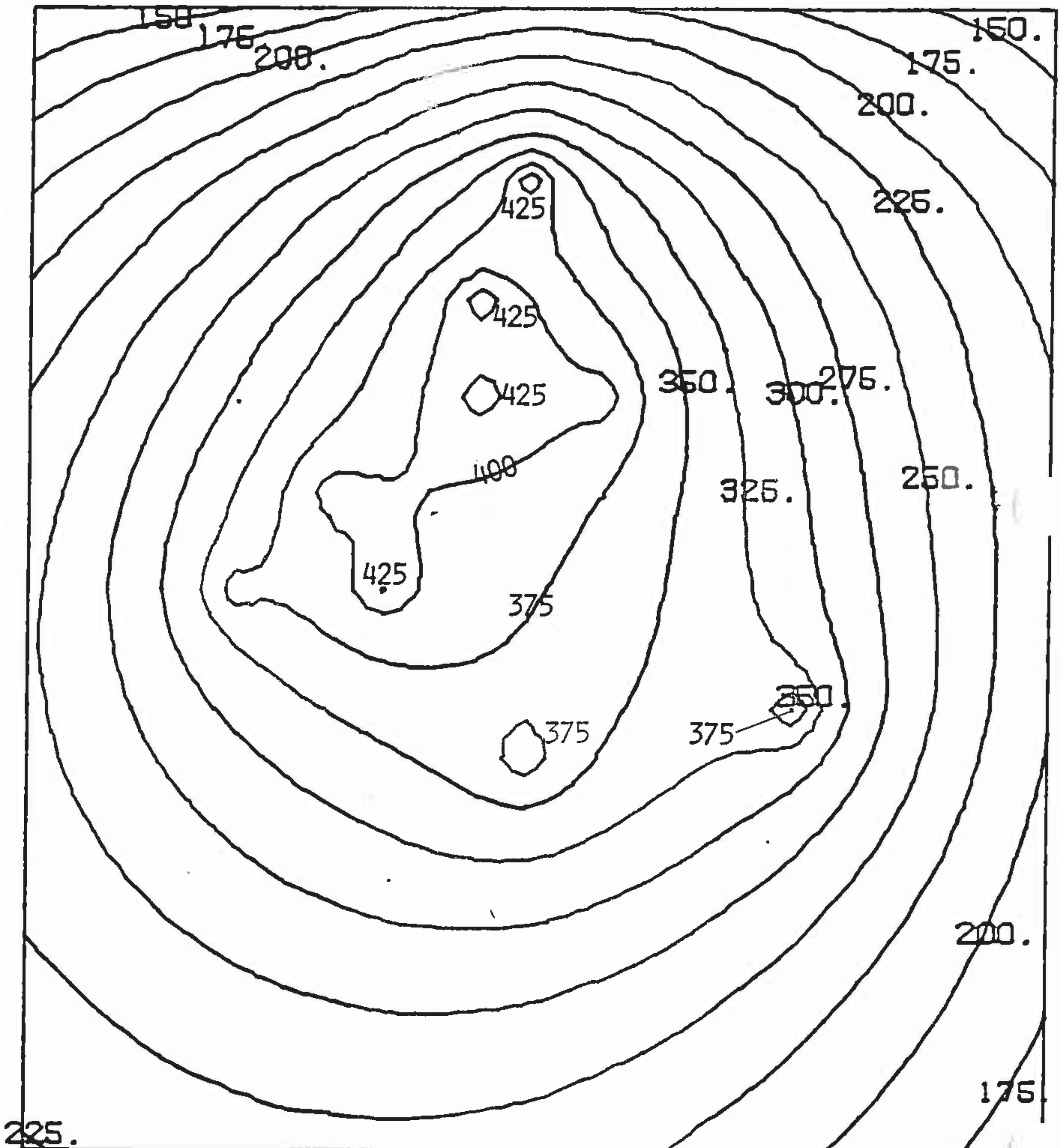


FIGURE 108

Drawdowns for Pumpage Scenario No. 4

CONTOUR INTERVAL = 25.

LOCAL MODEL SCENARIO 5 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE = 3600 GPM

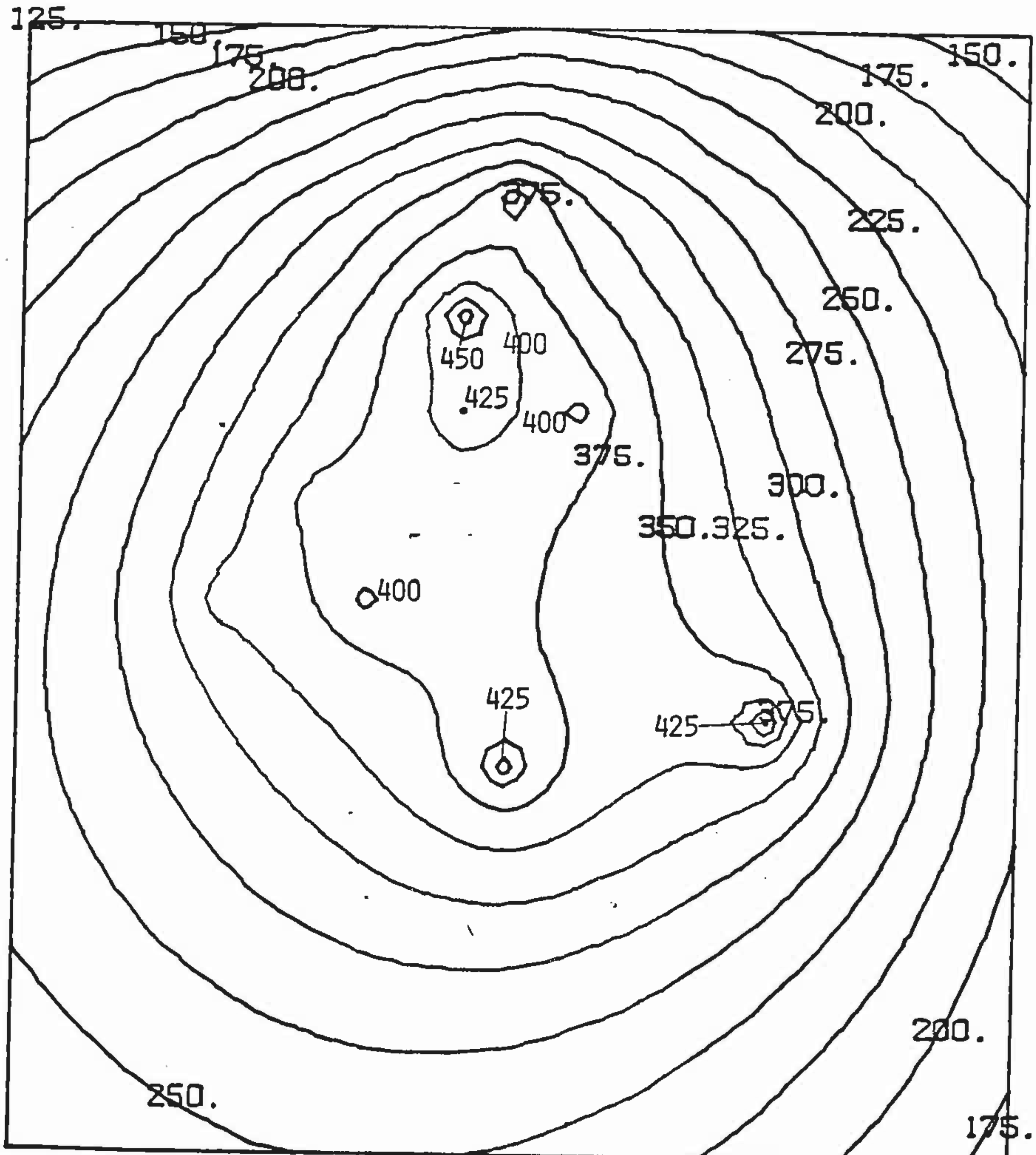


FIGURE 109

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 5

LOCAL MODEL SCENARIO 6 DRAWDOWNS (FT.): YEAR 20.4
PCC TOTAL PUMPAGE = 3600 GPM

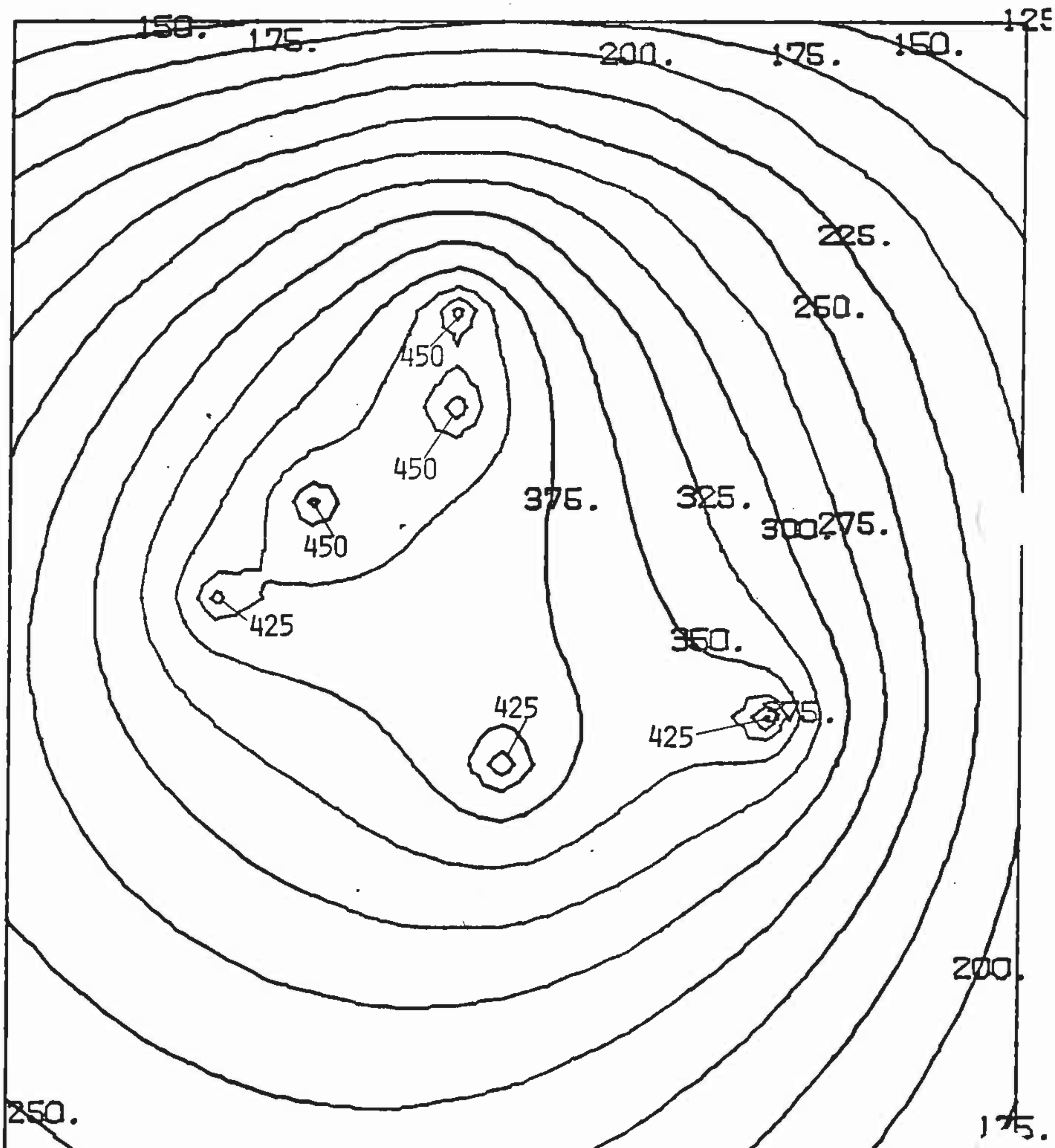


FIGURE 110

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 6

LOCAL MODEL SCENARIO 7 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE: 3000 GPM

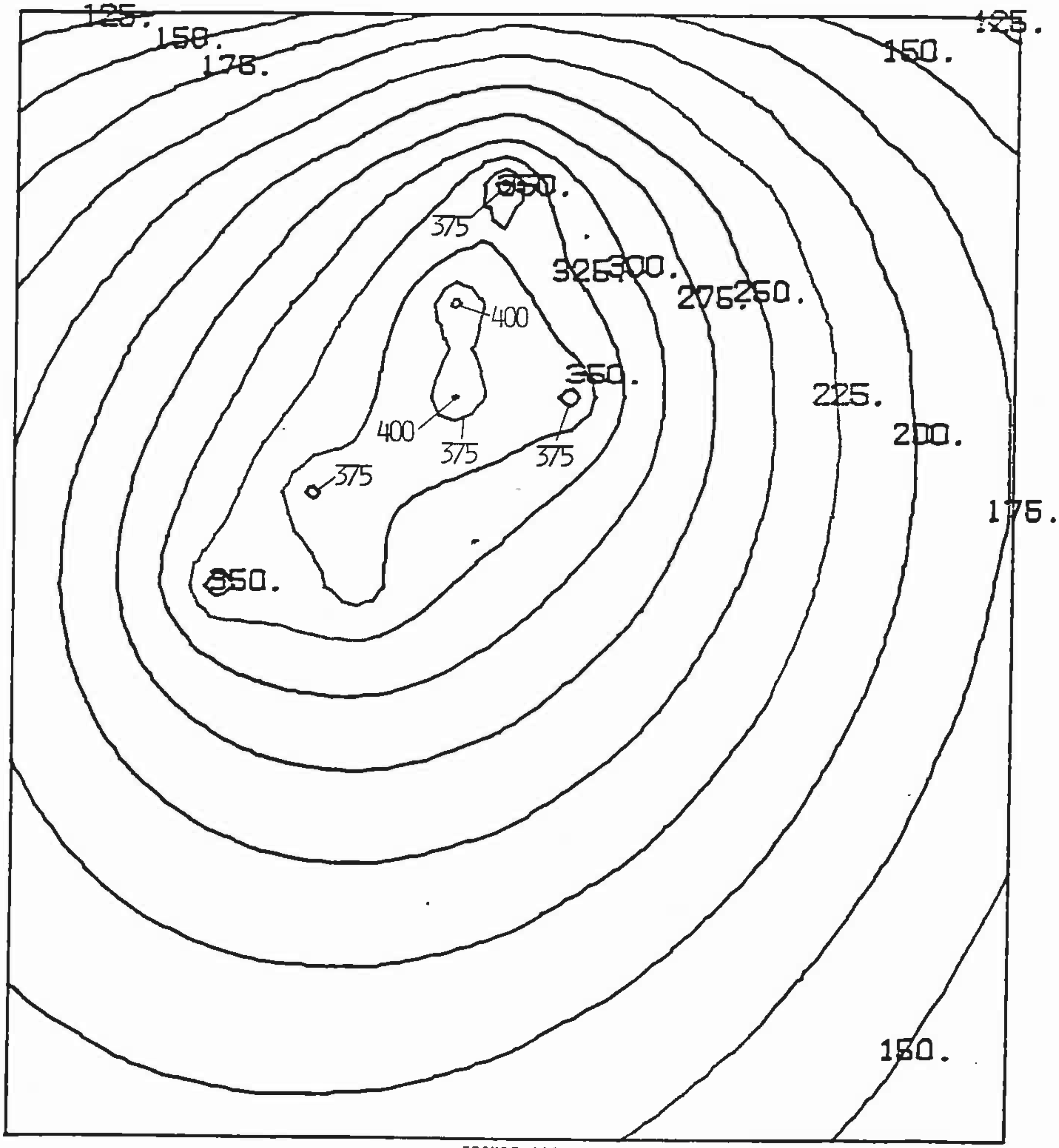


FIGURE 111

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 7

LOCAL MODEL SCENARIO 8 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE: 3000 GPM

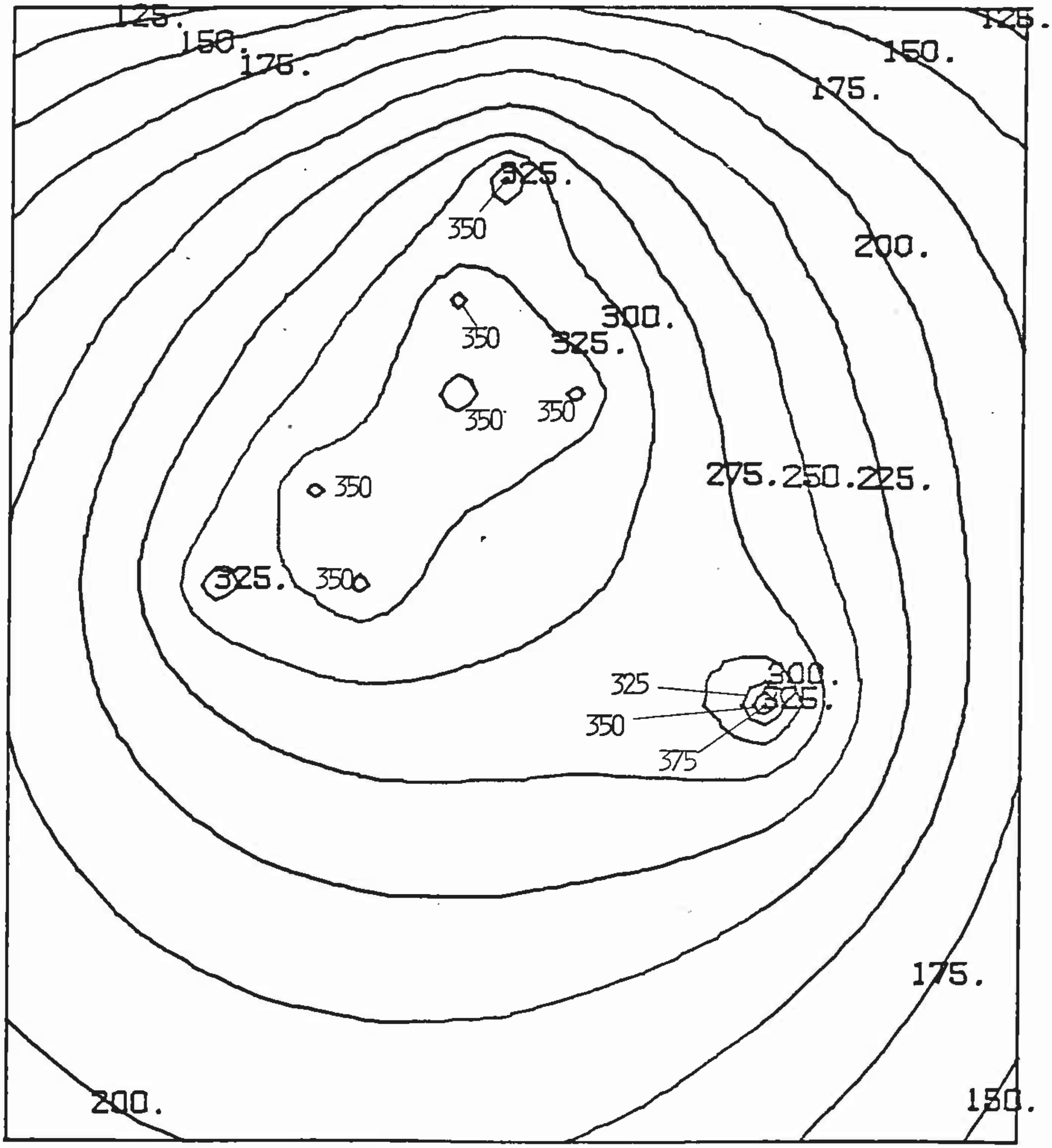


FIGURE 112

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 8

LOCAL MODEL SCENARIO 9 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE: 3000 GPM

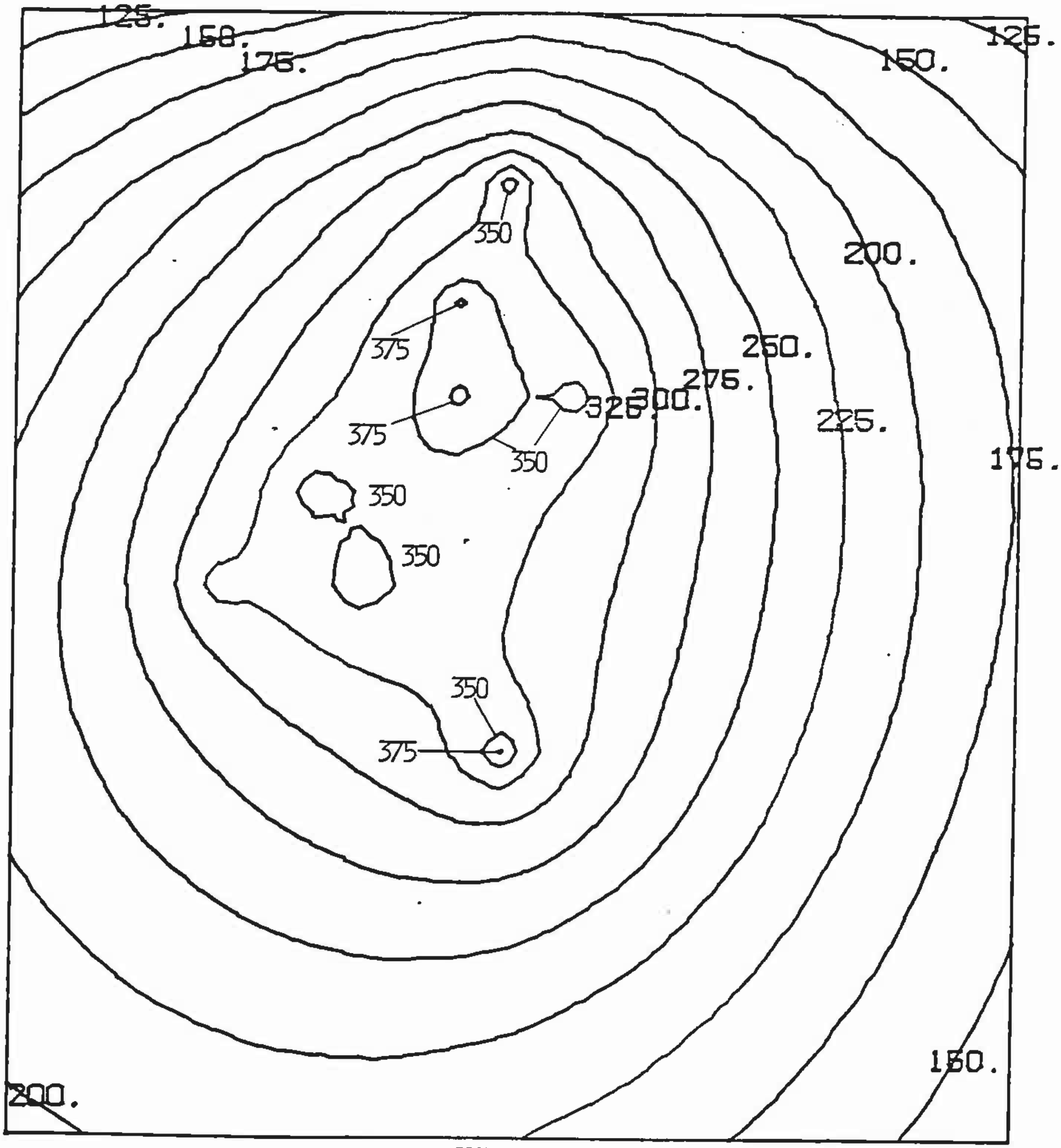


FIGURE 113

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 9

LOCAL MODEL SCENARIO 10 DRAWDOWNS (FT.): YEAR 2[
PCC TOTAL PUMPAGE: 3000 GPM

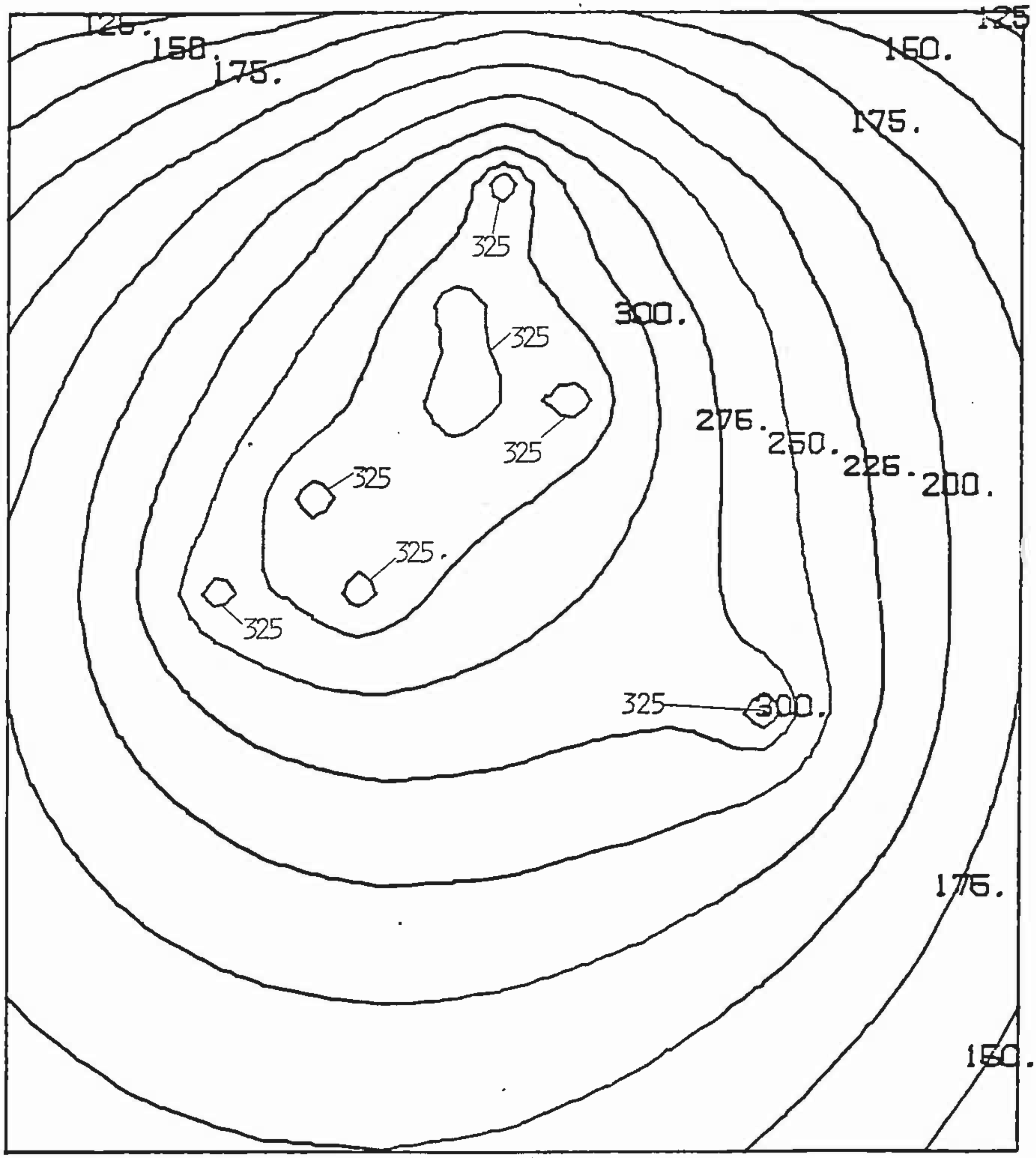


FIGURE 114

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 10

LOCAL MODEL SCENARIO 11 DRAWDOWNS (FT.): YEAR 2014
PCC TOTAL PUMPAGE: 3000 GPM

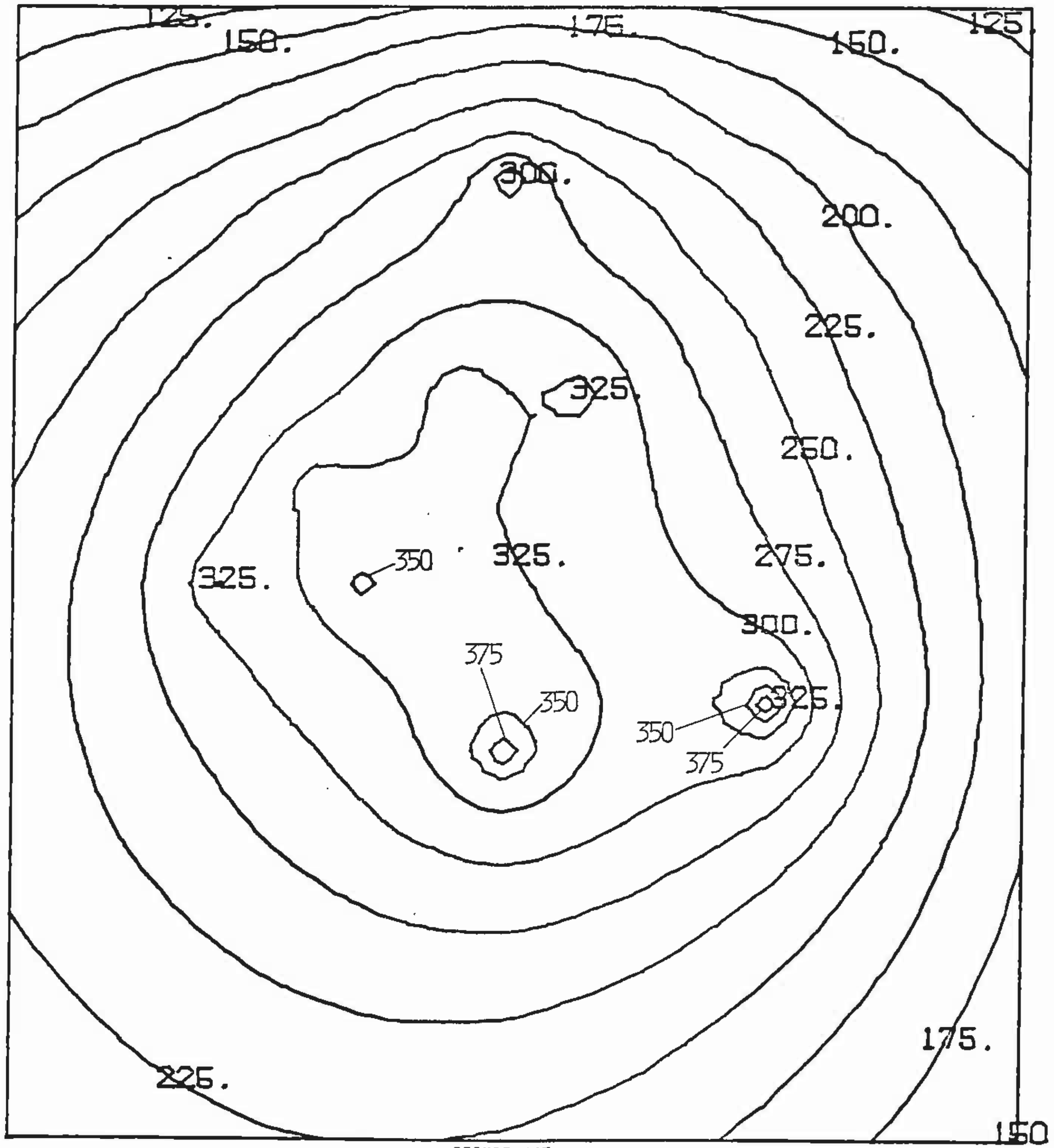


FIGURE 115

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 11

LOCAL MODEL SCENARIO 12 DRAWDOWNS (FT.): YEAR 20[illegible]
PCC TOTAL PUMPAGE: 3000 GPM

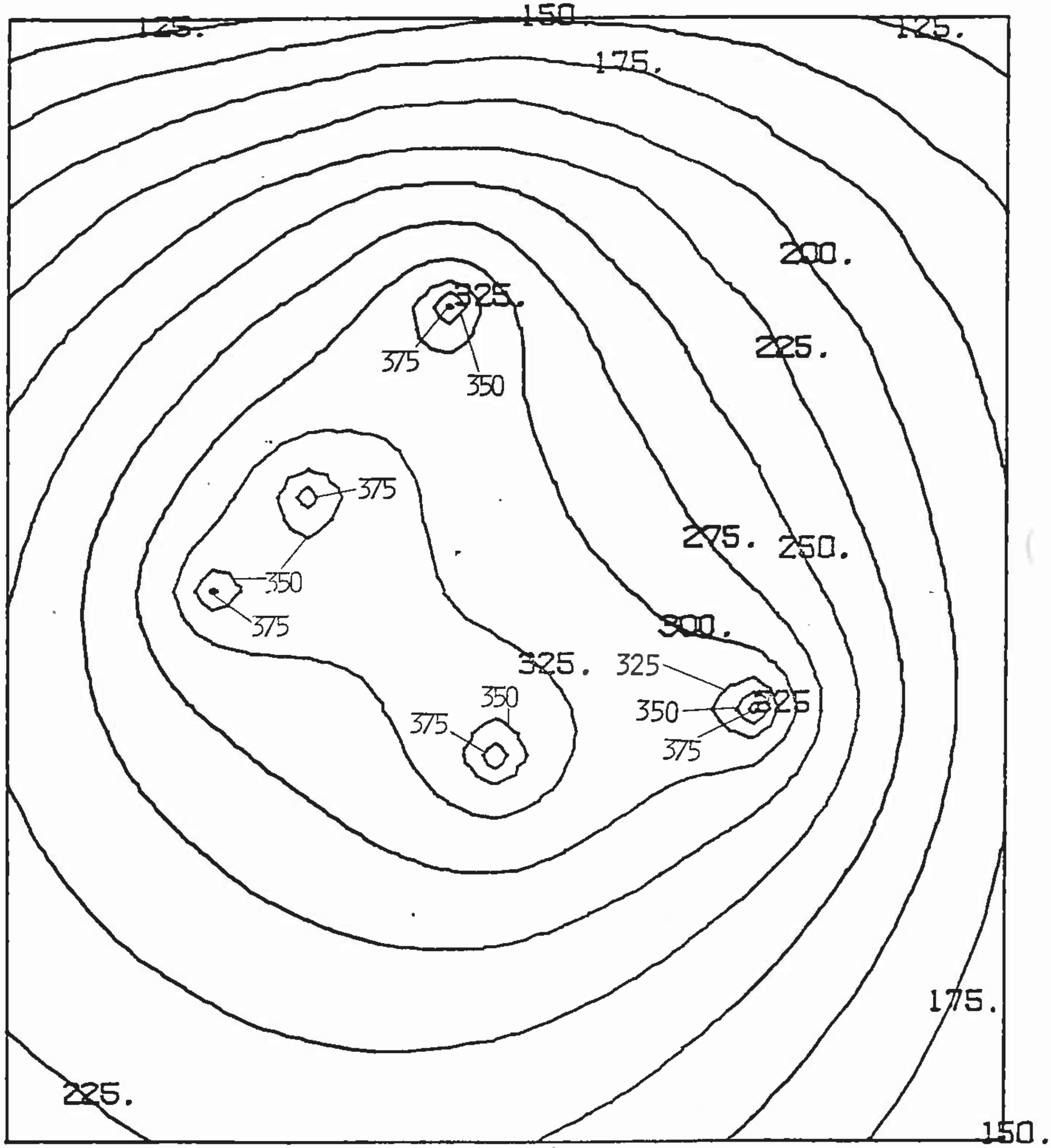


FIGURE 116

CONTOUR INTERVAL = 25.

Drawdowns for Pumpage
Scenario No. 12

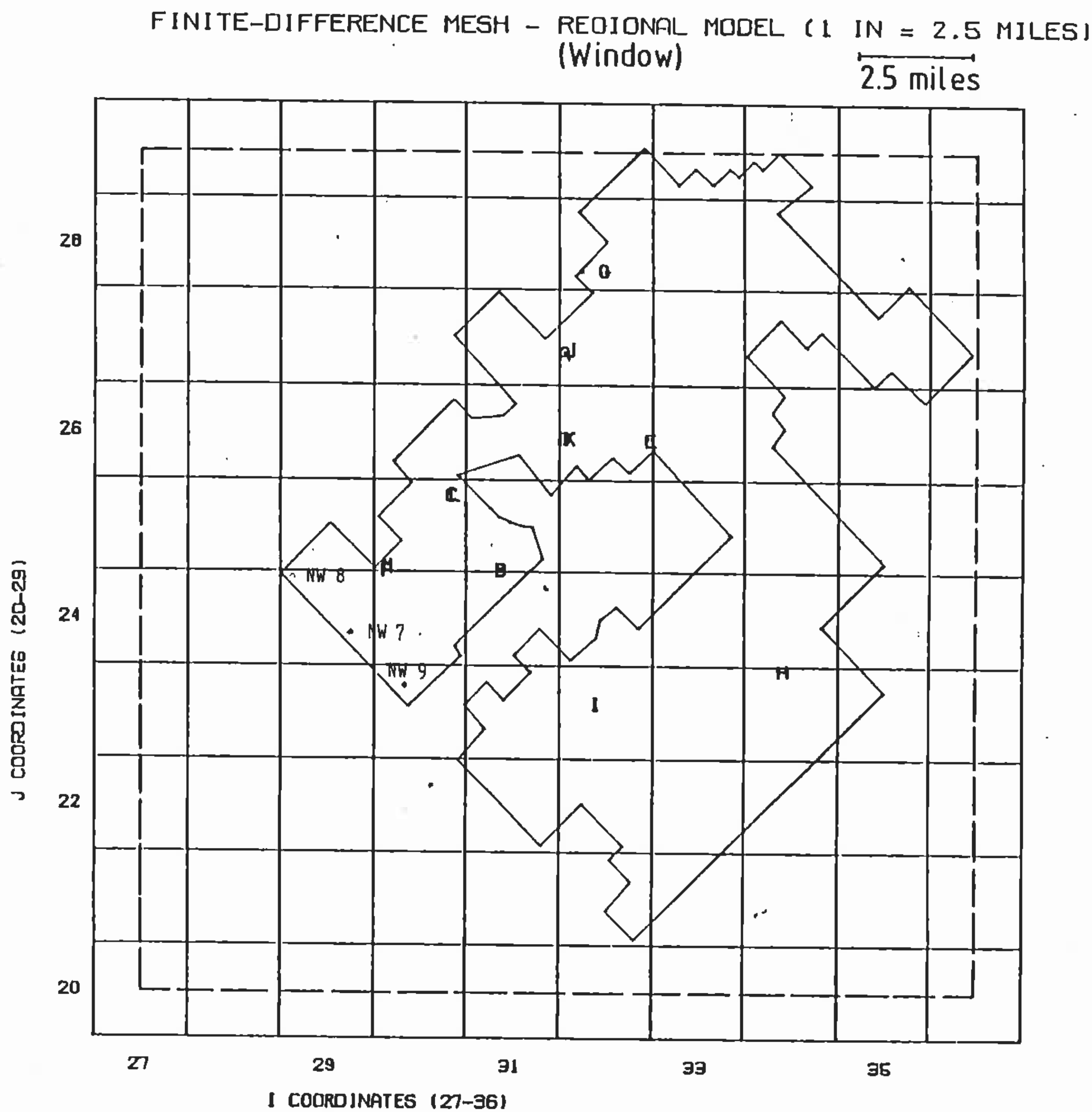
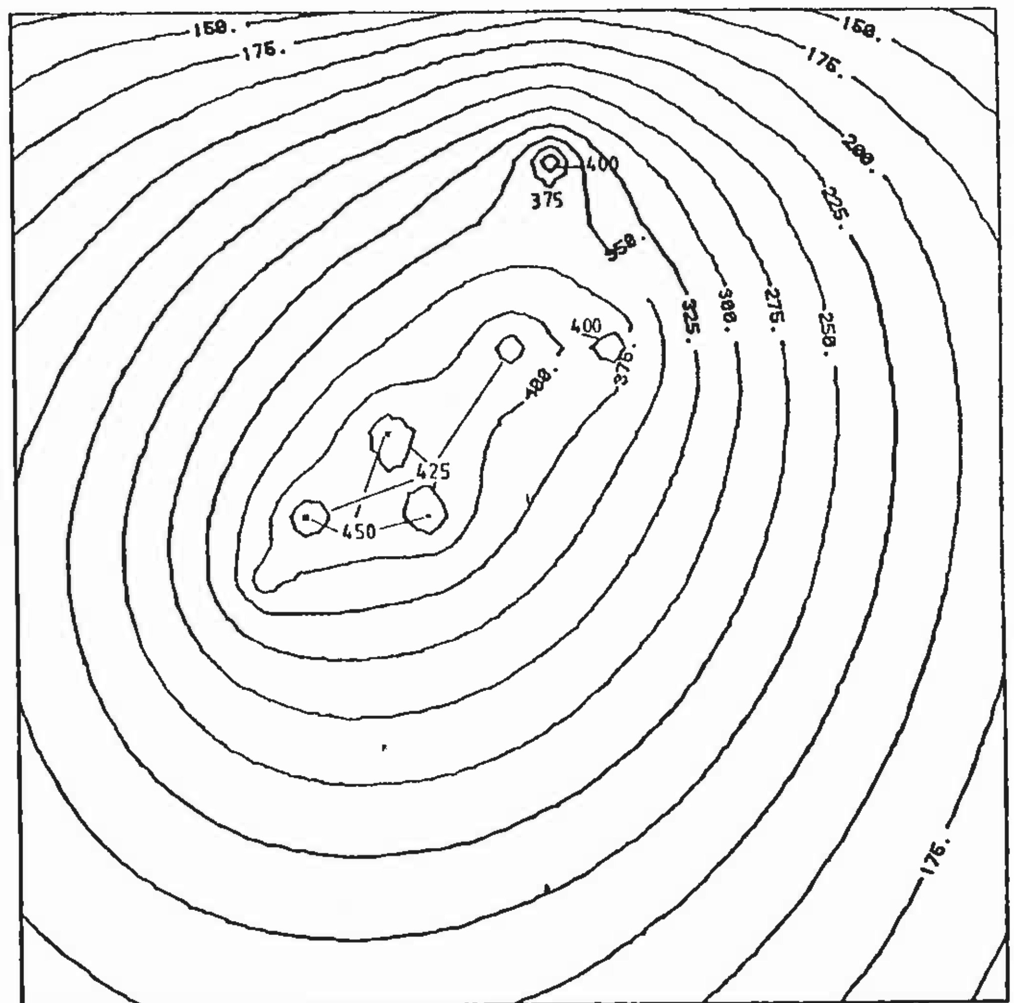


FIGURE 117
Well Locations for Pumpage Rate
Scenarios 13 through 15

LOCAL MODEL SCENARIO 13 DRAWDOWNS (FT) YEAR 2014
PCC TOTAL PUMPAGE: 3600 GPM 13-FEB-83



TIME = 12775.00 STEP = 700

FIGURE 118

Drawdowns for Pumpage
Scenario No. 13

LOCAL MODEL SCENARIO 14 DRAWDOWNS (FT) YEAR 2014
PCC TOTAL PUMPAGE: 3600 GPM 14-FEB-83

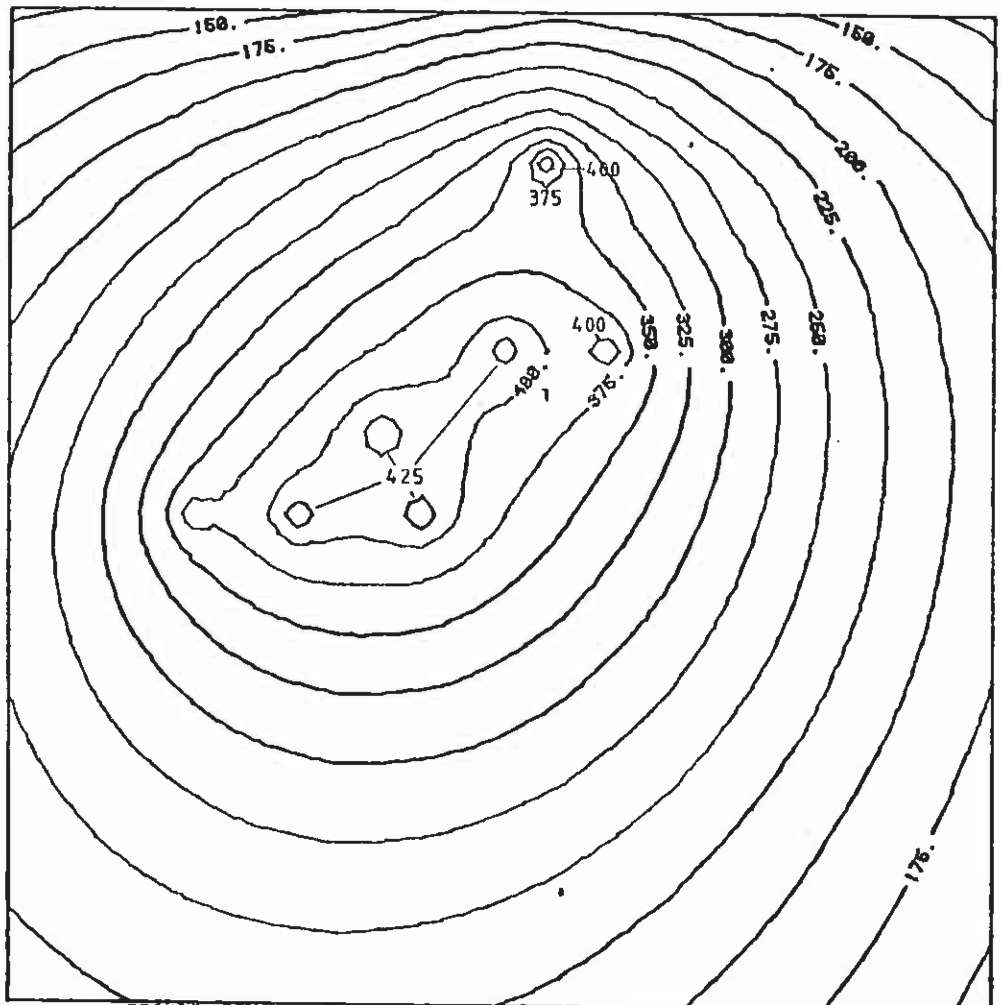


FIGURE 119

Drawdowns for Pumpage
Scenario No. 14

TIME = 12775.00 STEP = 700

LOCAL MODEL SCENARIO 15 DRAWDOWNS (FT) YEAR 2014
PCC TOTAL PUMPAGE: 3600 GPM   14-FEB-83

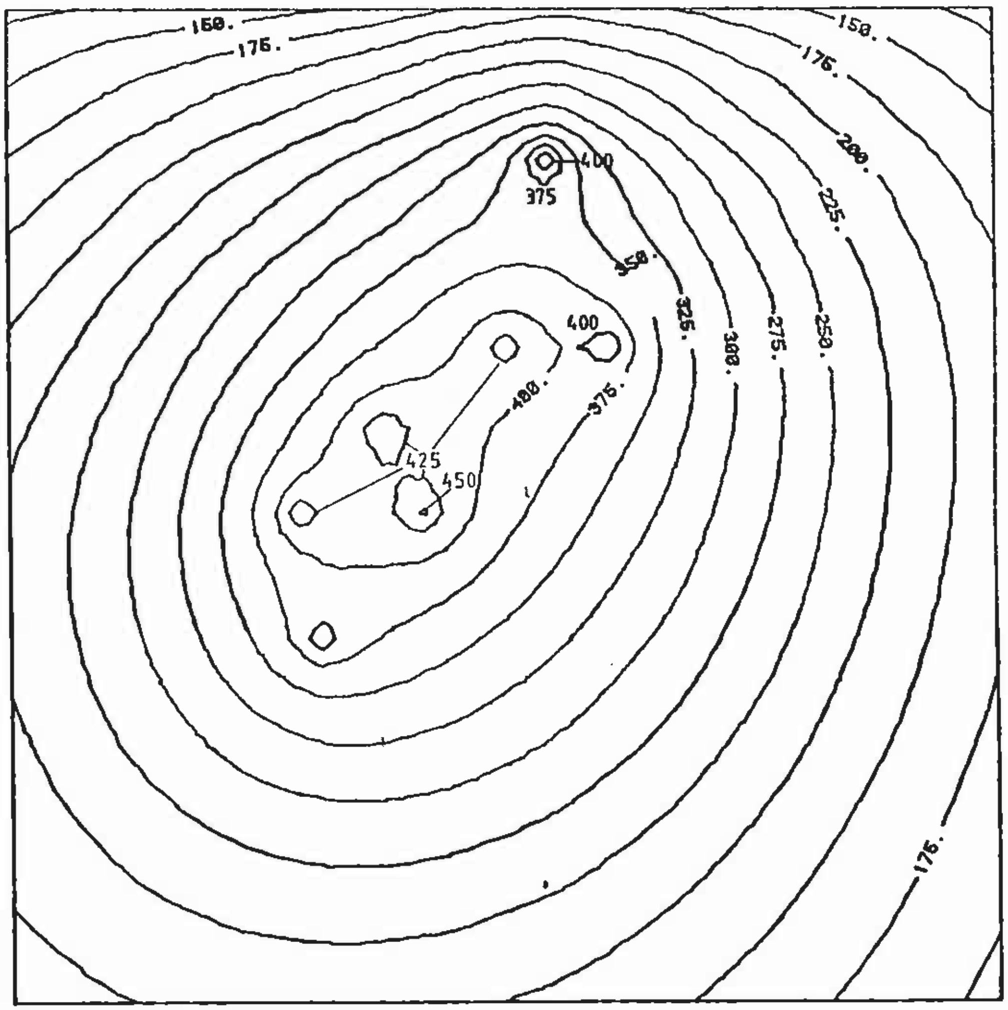


FIGURE 120

Drawdowns for Pumpage
Scenario No. 15

TIME = 12775.00 STEP = 700

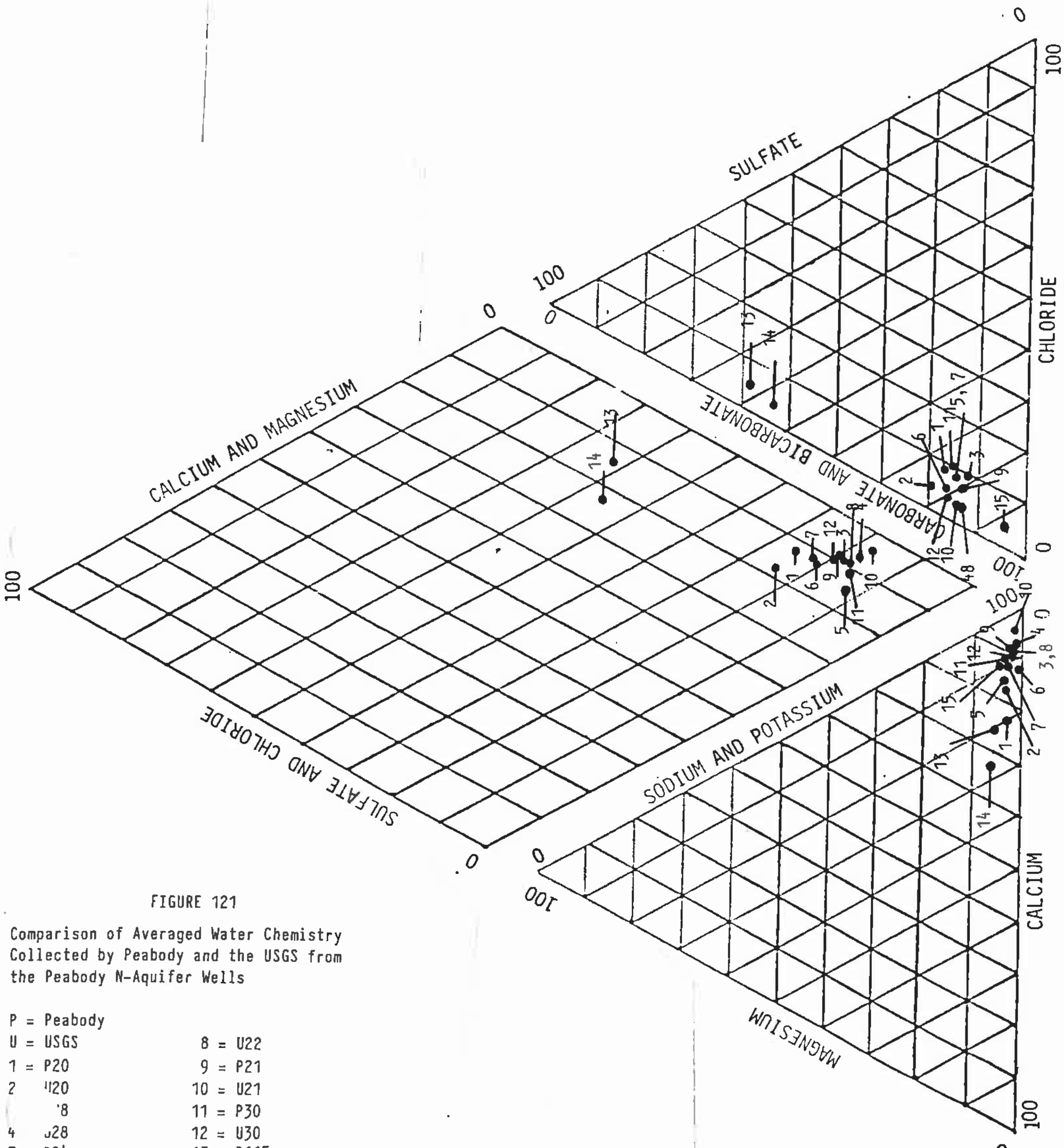


FIGURE 121

Comparison of Averaged Water Chemistry Collected by Peabody and the USGS from the Peabody N-Aquifer Wells

P = Peabody
U = USGS

1 = P20	8 = U22
2 U20	9 = P21
8	10 = U21
4 U28	11 = P30
5 = P24	12 = U30
6 = U24	13 = P115
7 = P22	14 = U115
	15 = P156

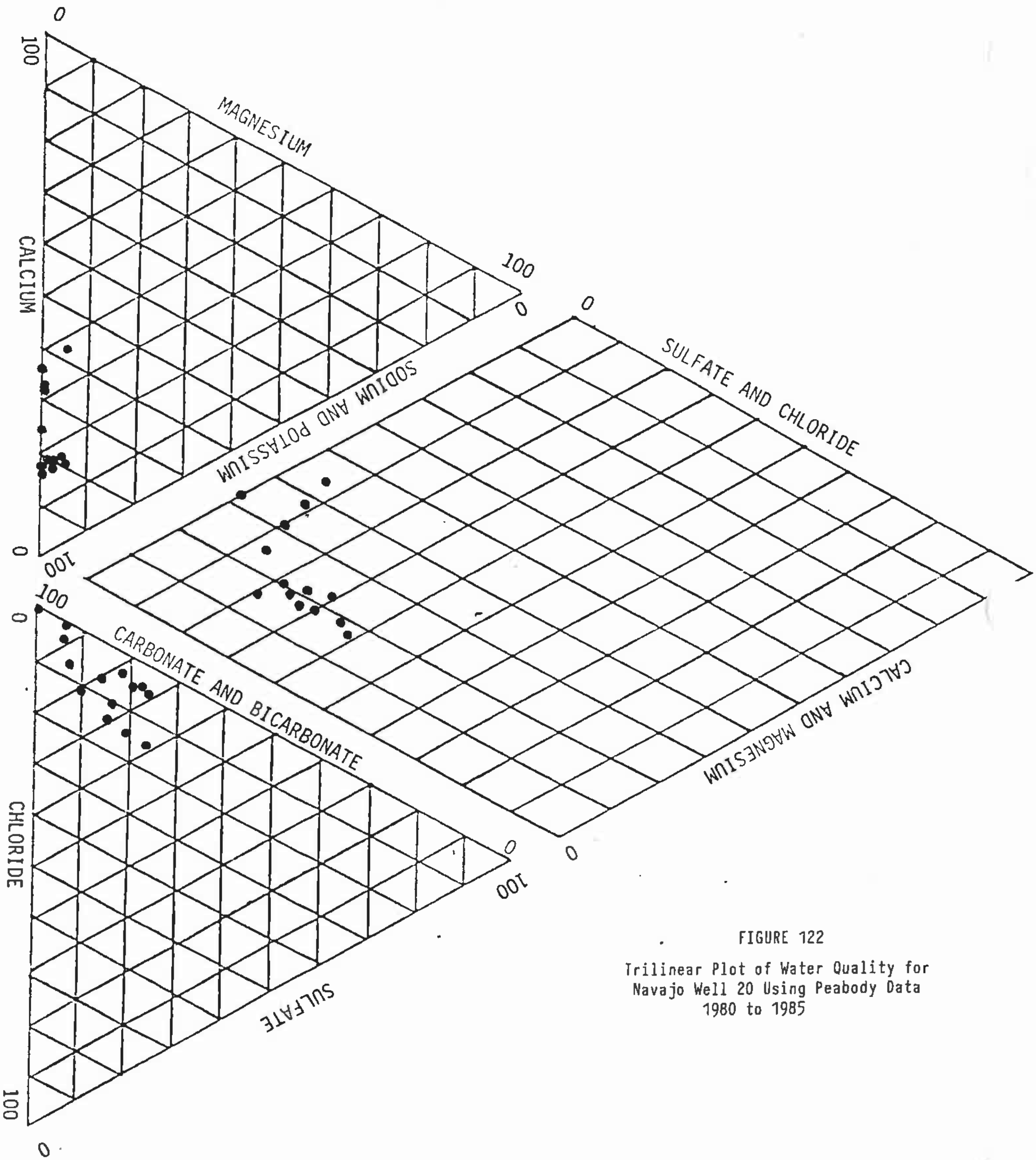


FIGURE 122

Trilinear Plot of Water Quality for
Navajo Well 20 Using Peabody Data
1980 to 1985

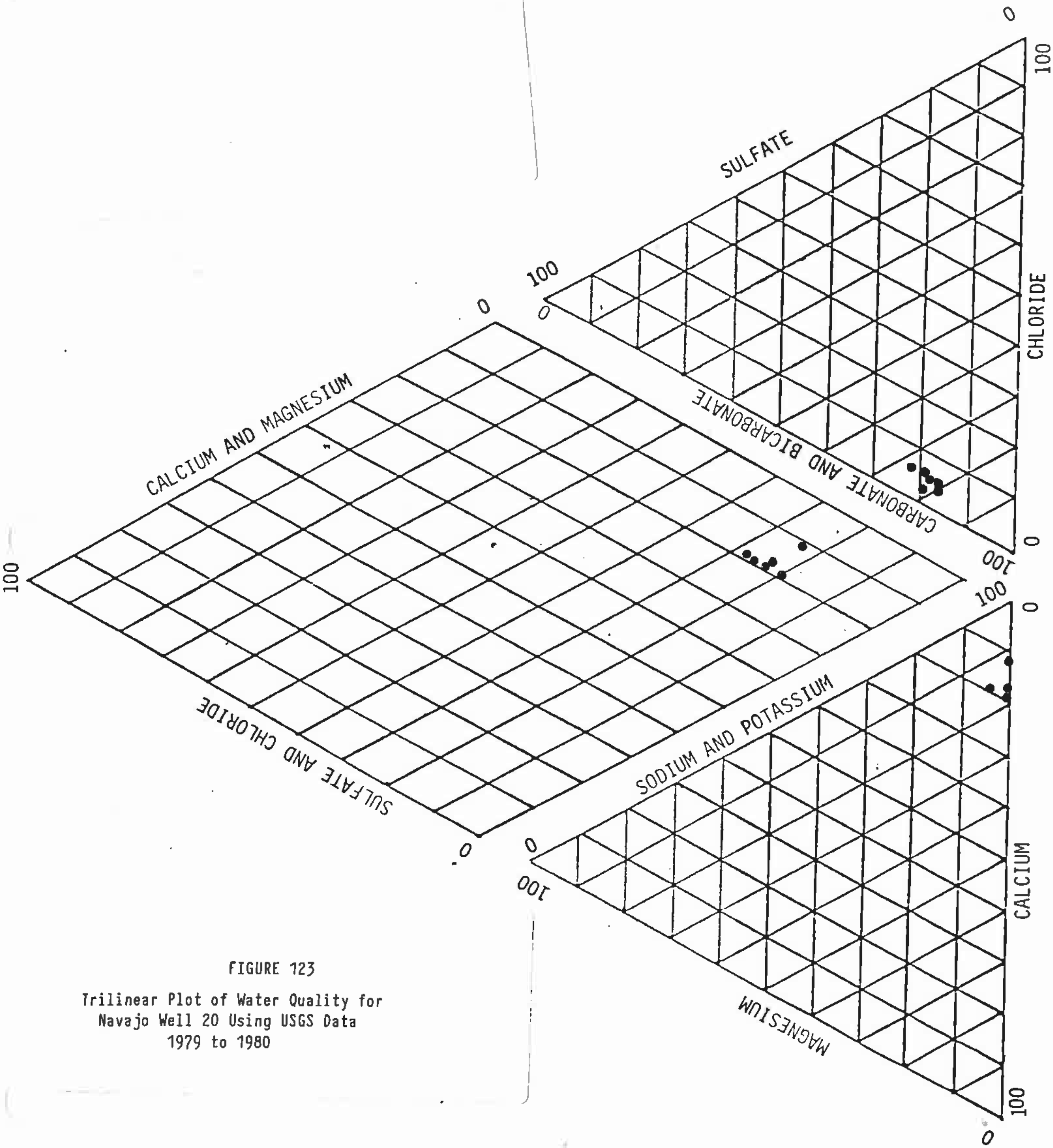


FIGURE 123

Trilinear Plot of Water Quality for
Navajo Well 20 Using USGS Data
1979 to 1980

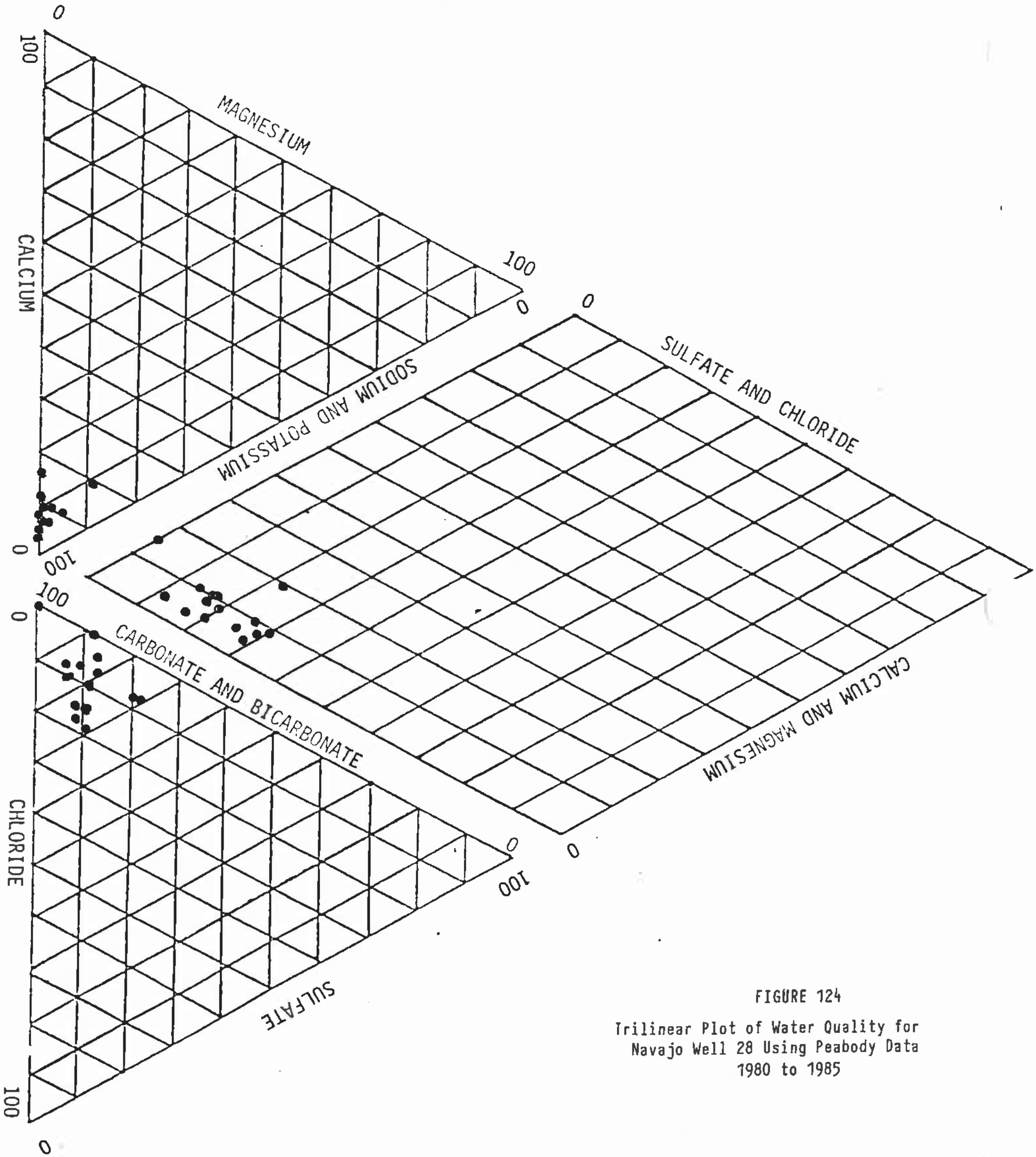


FIGURE 124

Trilinear Plot of Water Quality for
Navajo Well 28 Using Peabody Data
1980 to 1985

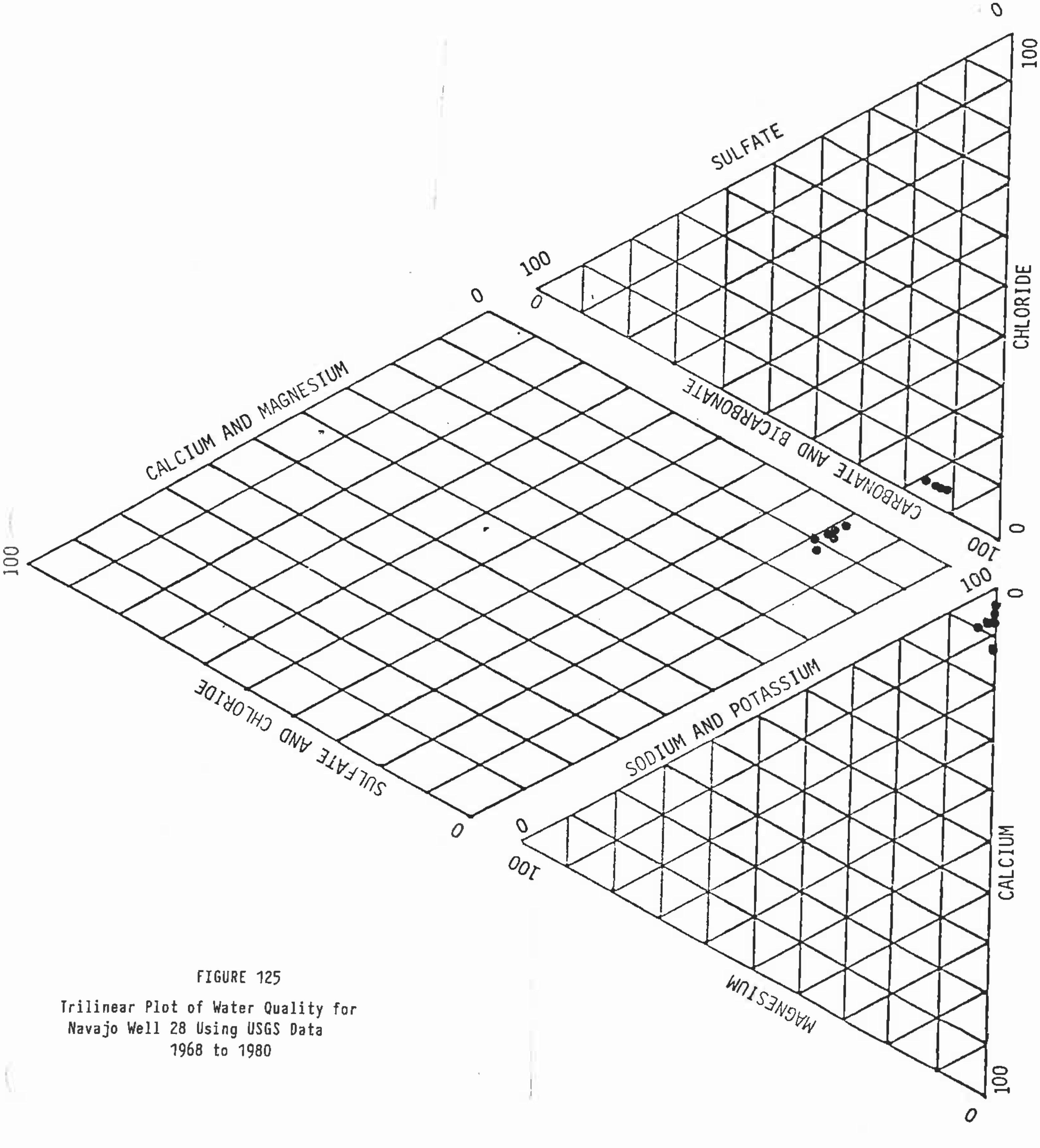


FIGURE 125

Trilinear Plot of Water Quality for Navajo Well 28 Using USGS Data 1968 to 1980

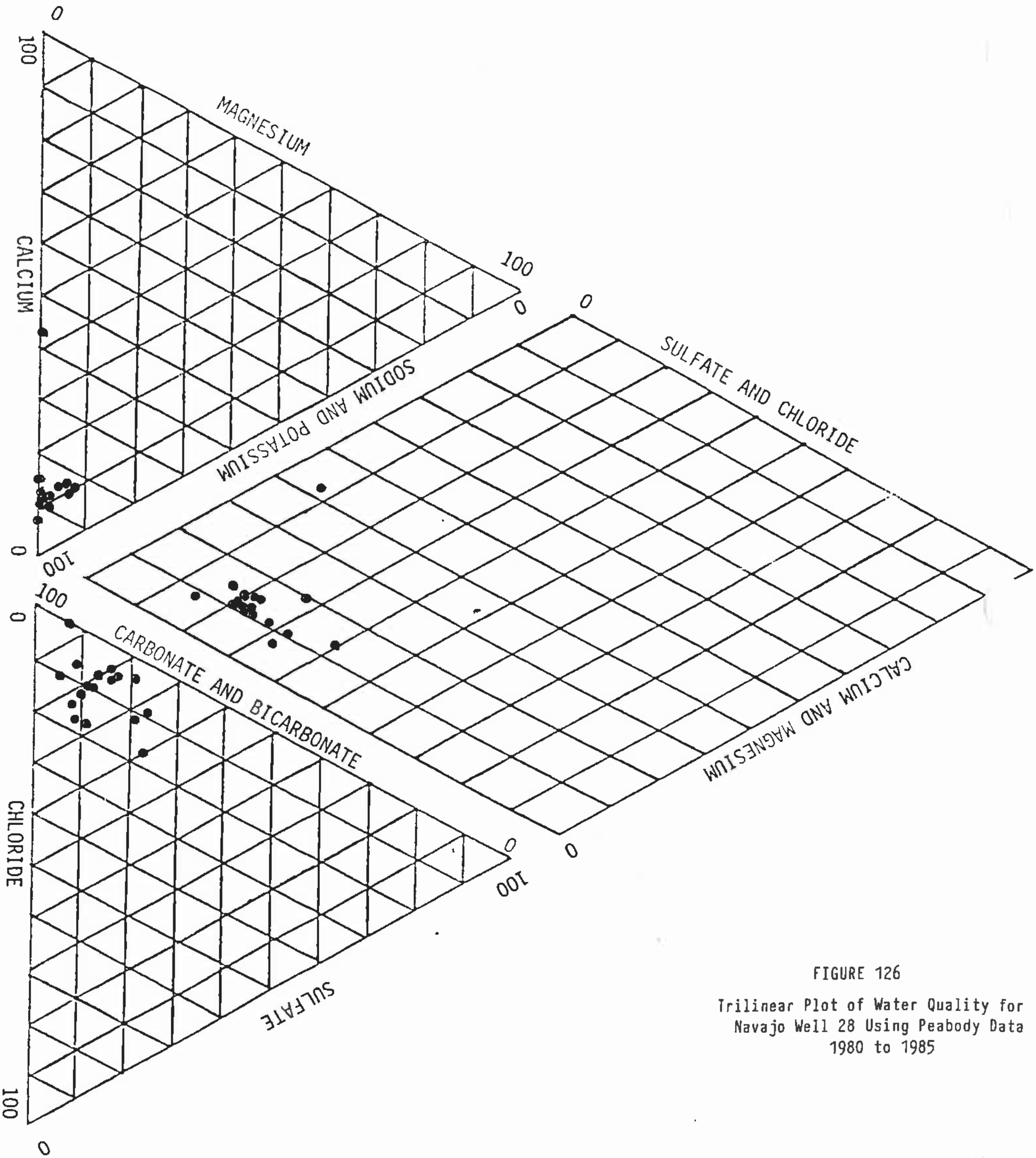


FIGURE 126

Trilinear Plot of Water Quality for Navajo Well 28 Using Peabody Data 1980 to 1985

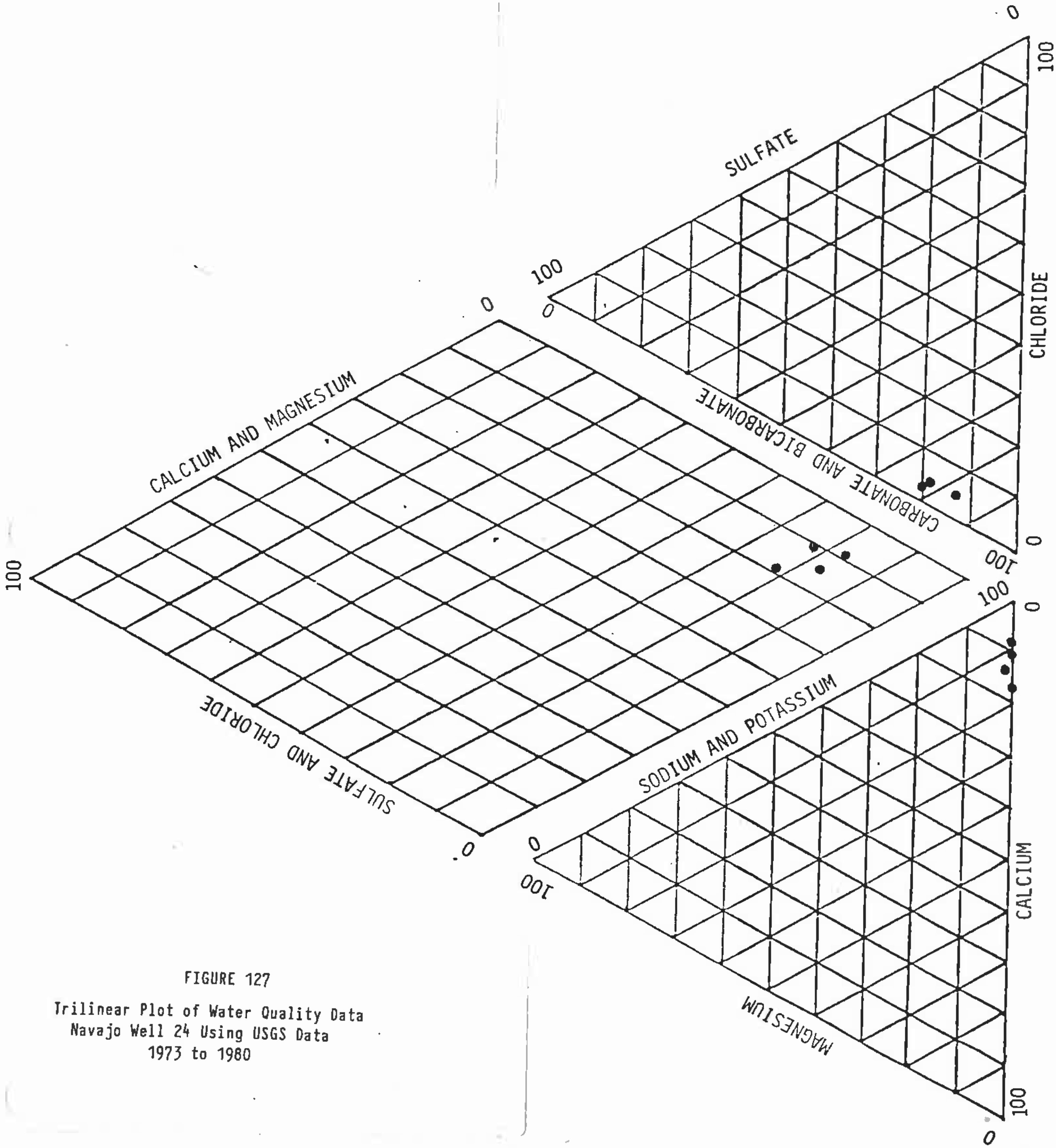


FIGURE 127

Trilinear Plot of Water Quality Data
Navajo Well 24 Using USGS Data
1973 to 1980

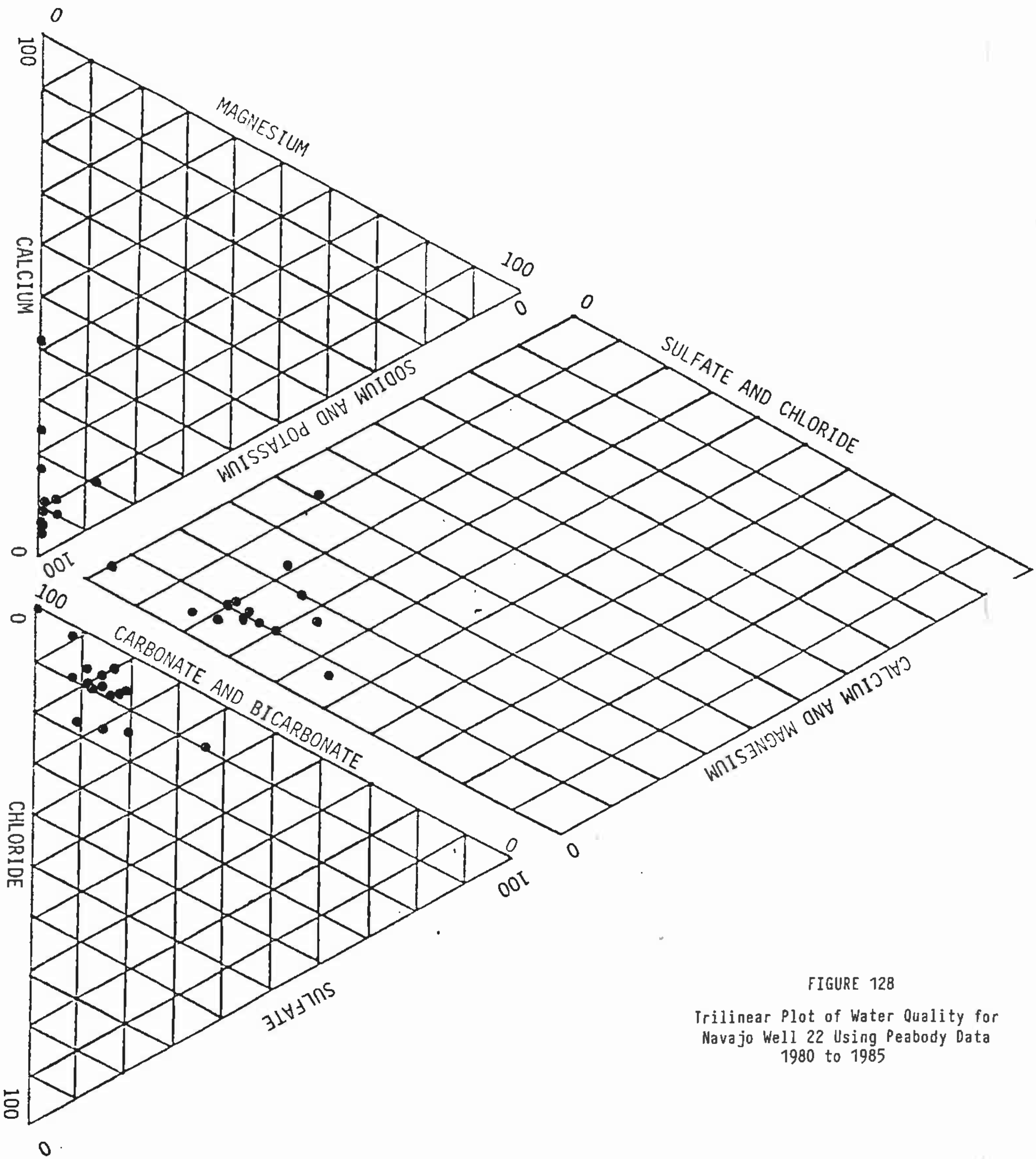


FIGURE 128

Trilinear Plot of Water Quality for
Navajo Well 22 Using Peabody Data
1980 to 1985

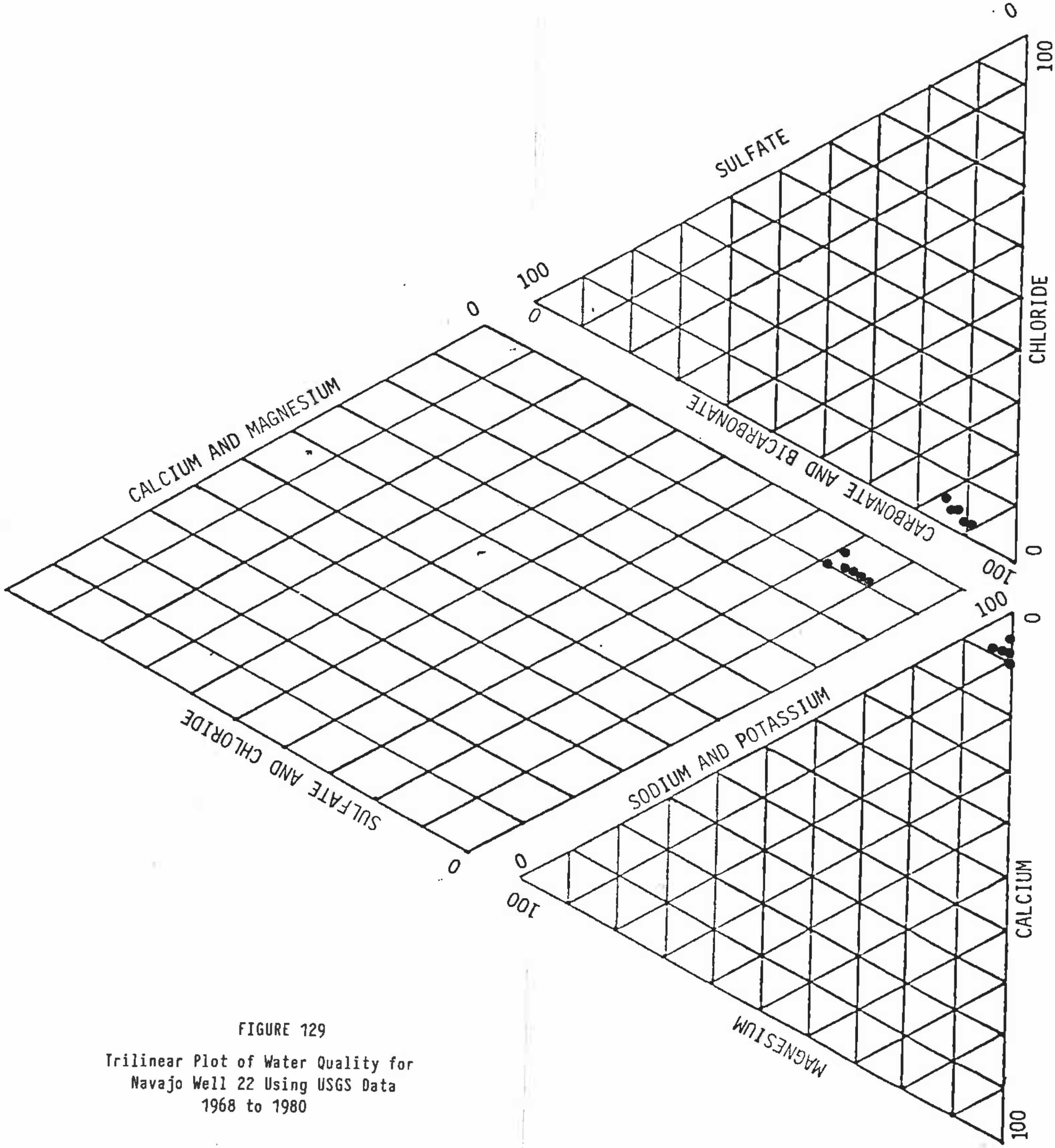


FIGURE 129

Trilinear Plot of Water Quality for Navajo Well 22 Using USGS Data 1968 to 1980

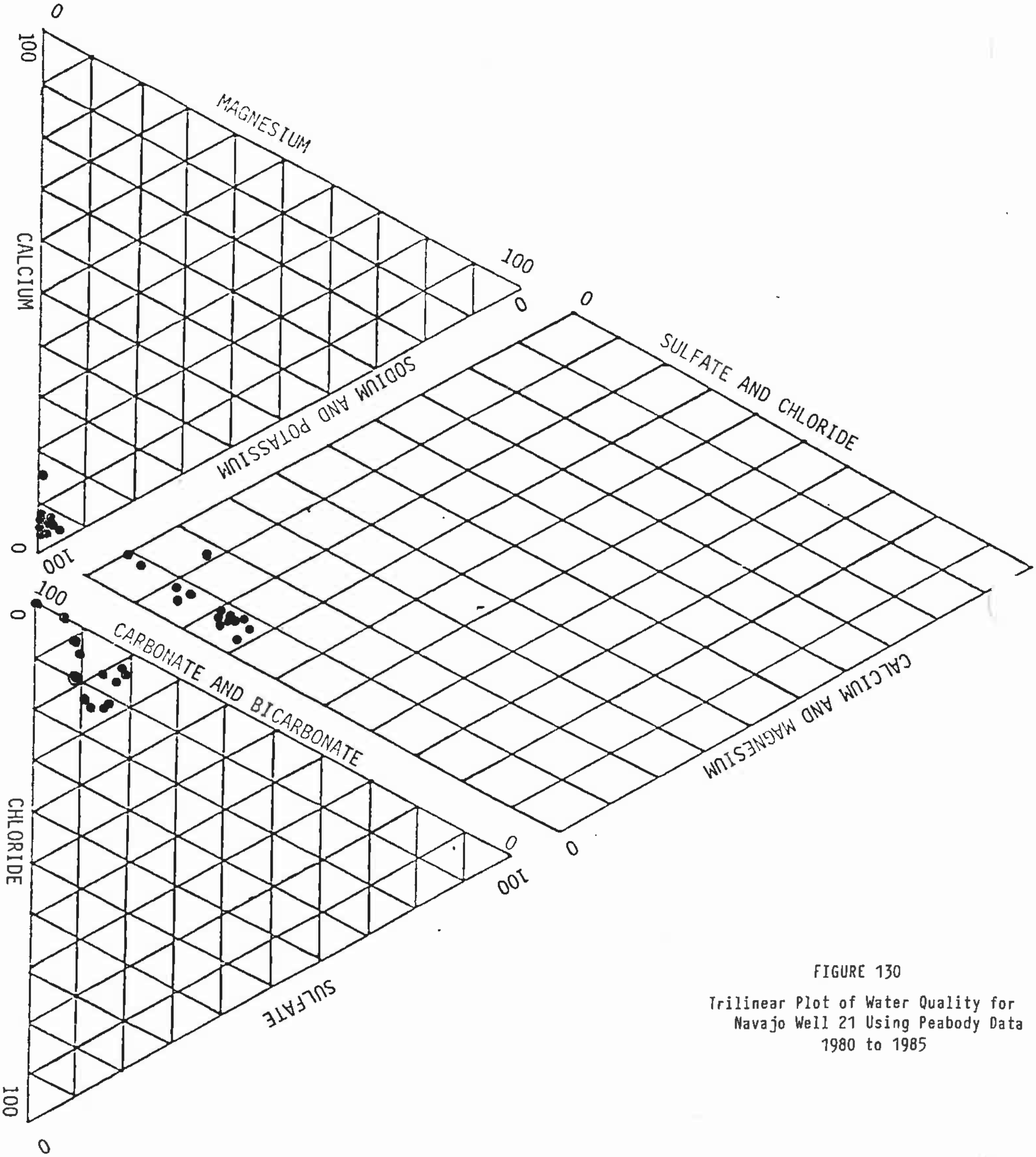


FIGURE 130

Trilinear Plot of Water Quality for Navajo Well 21 Using Peabody Data 1980 to 1985

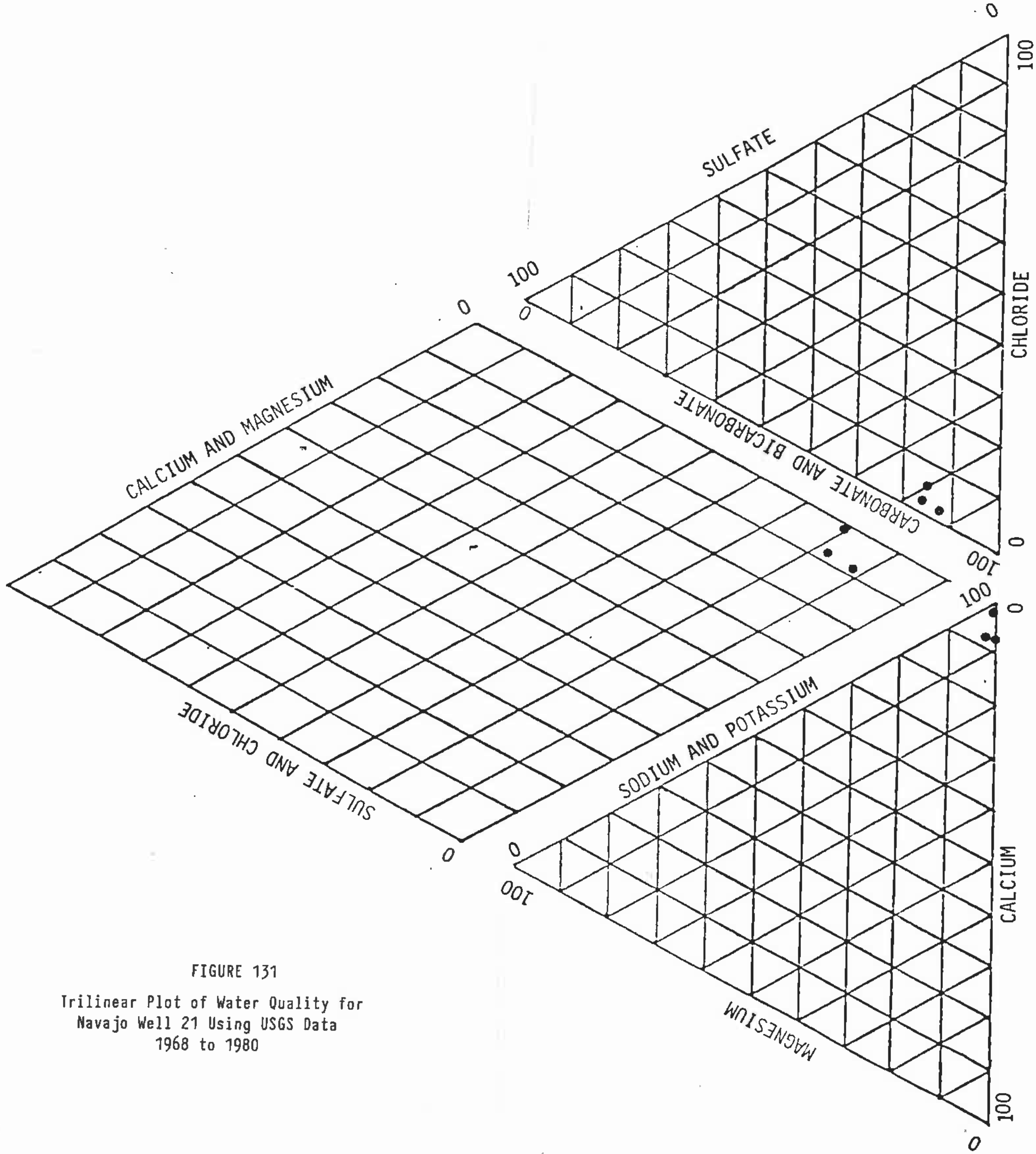


FIGURE 131

Trilinear Plot of Water Quality for Navajo Well 21 Using USGS Data 1968 to 1980

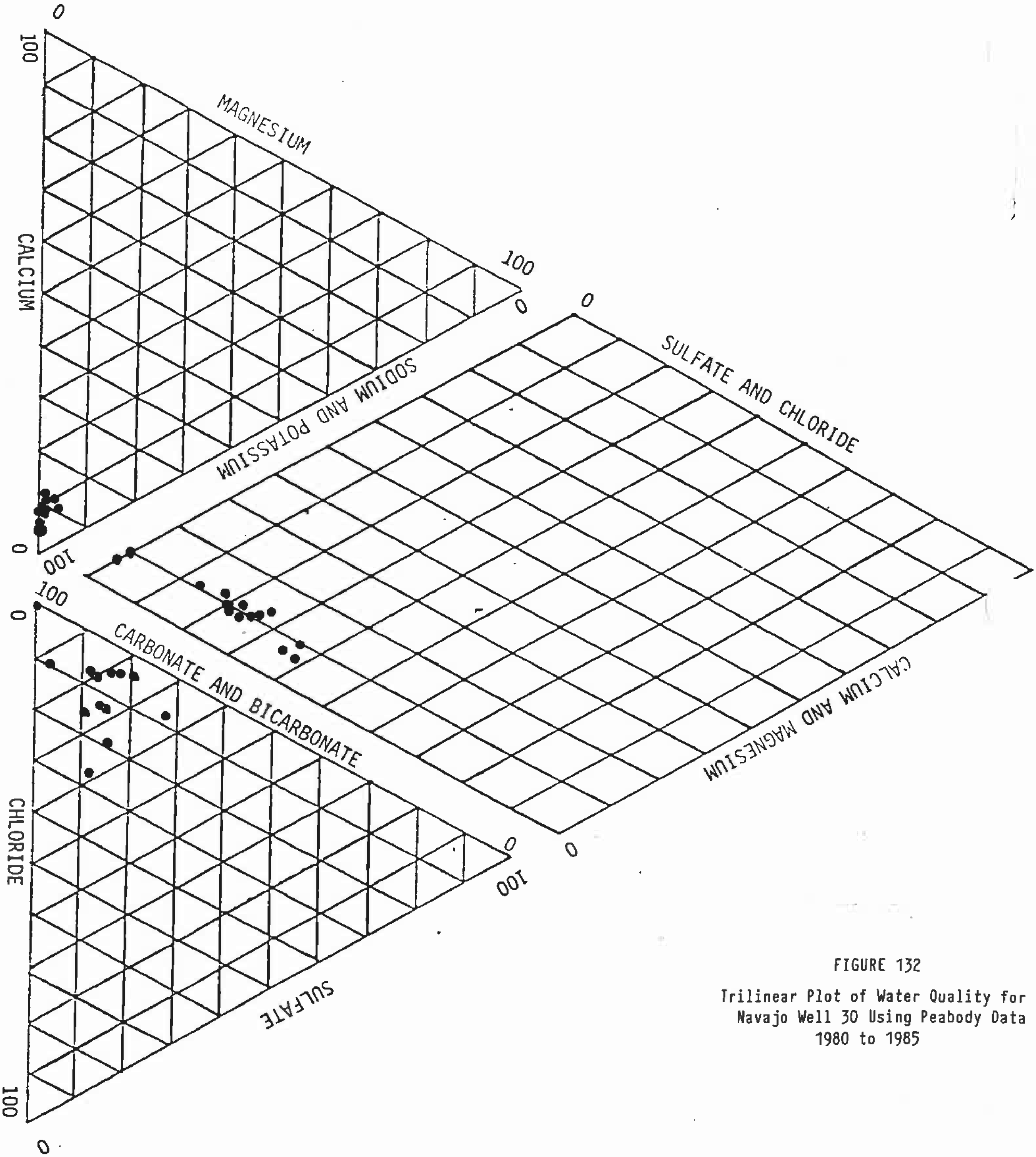


FIGURE 132

Trilinear Plot of Water Quality for Navajo Well 30 Using Peabody Data 1980 to 1985

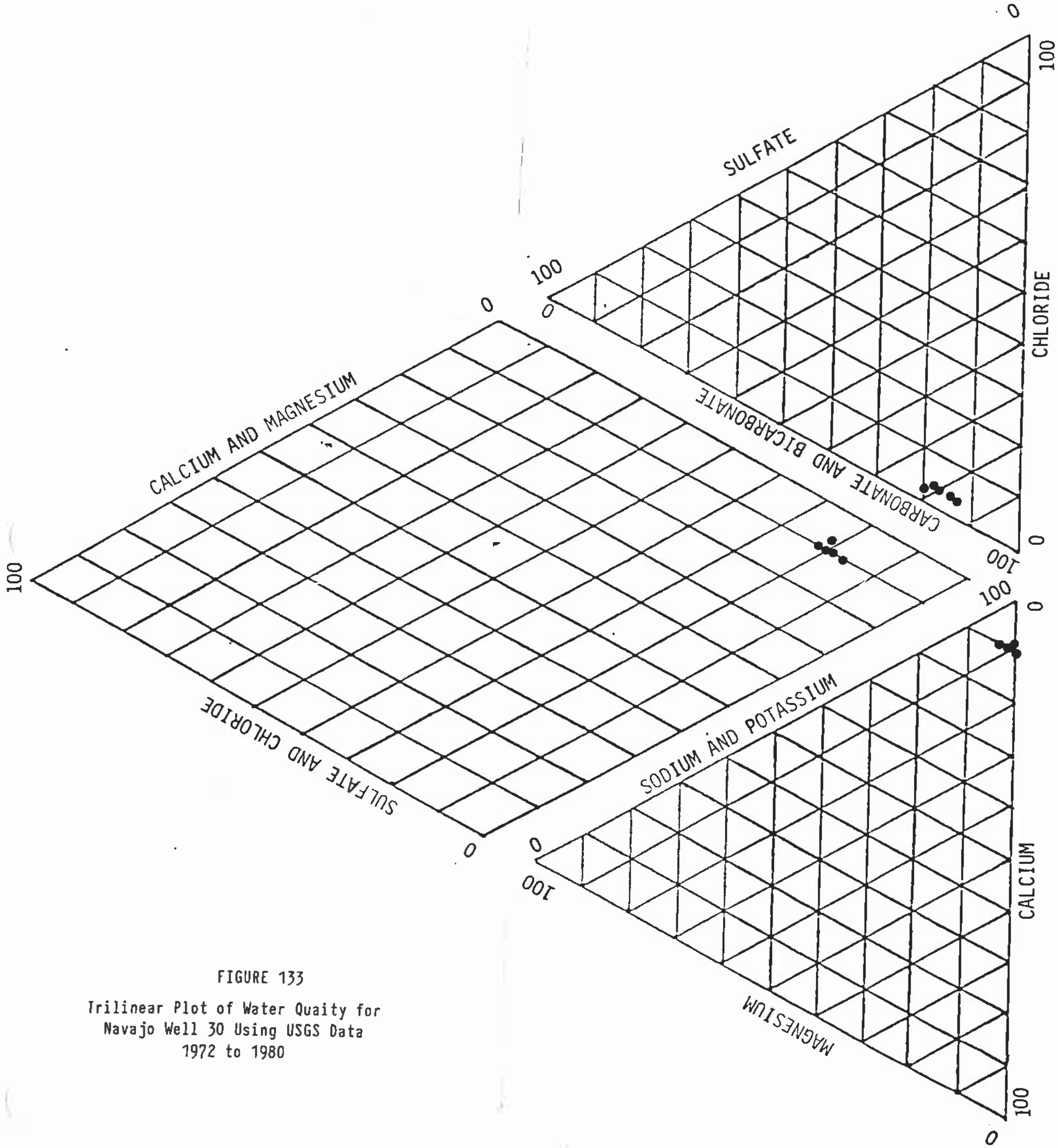


FIGURE 133

Trilinear Plot of Water Quaity for
Navajo Well 30 Using USGS Data
1972 to 1980

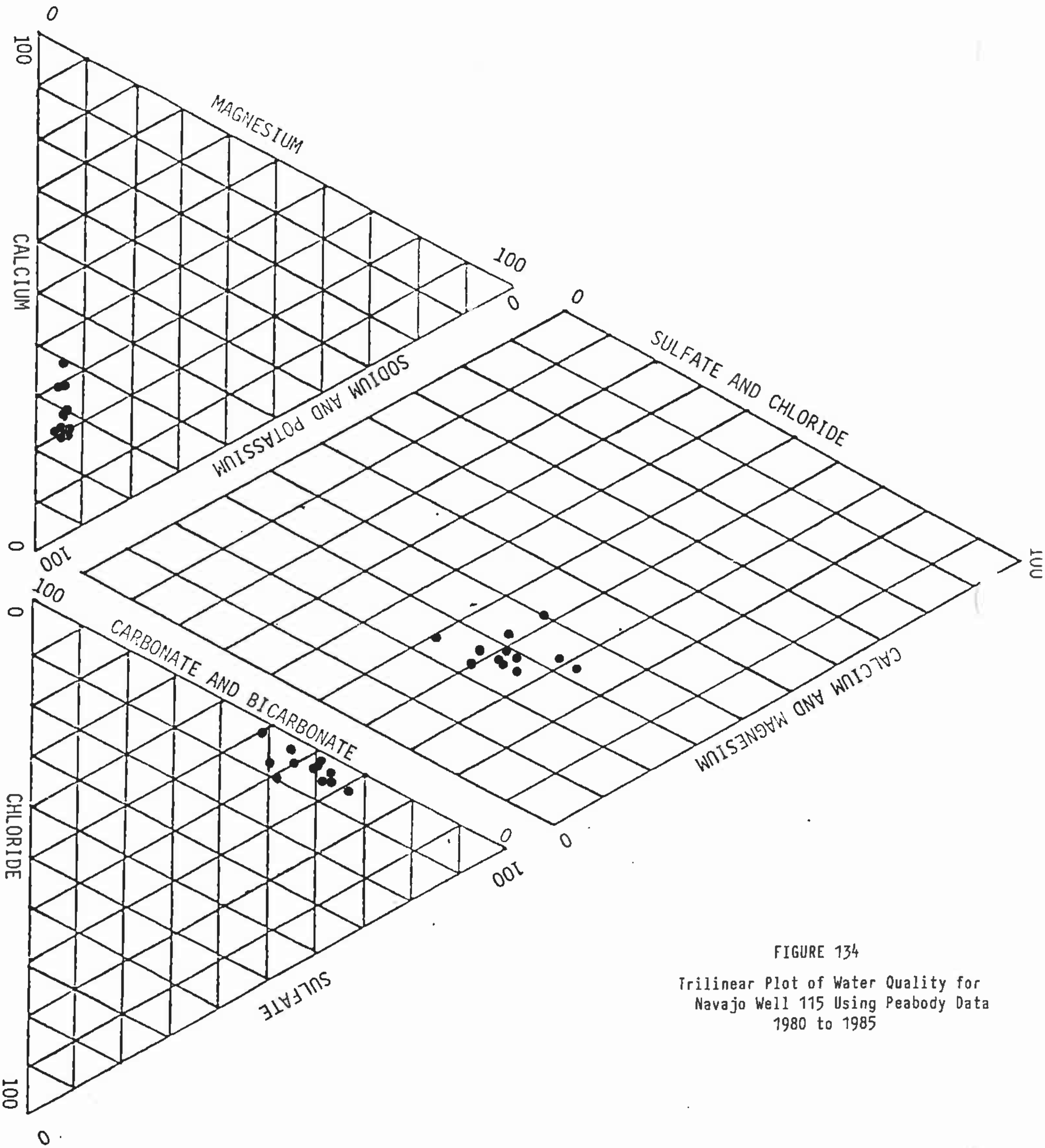


FIGURE 134

Trilinear Plot of Water Quality for Navajo Well 115 Using Peabody Data 1980 to 1985

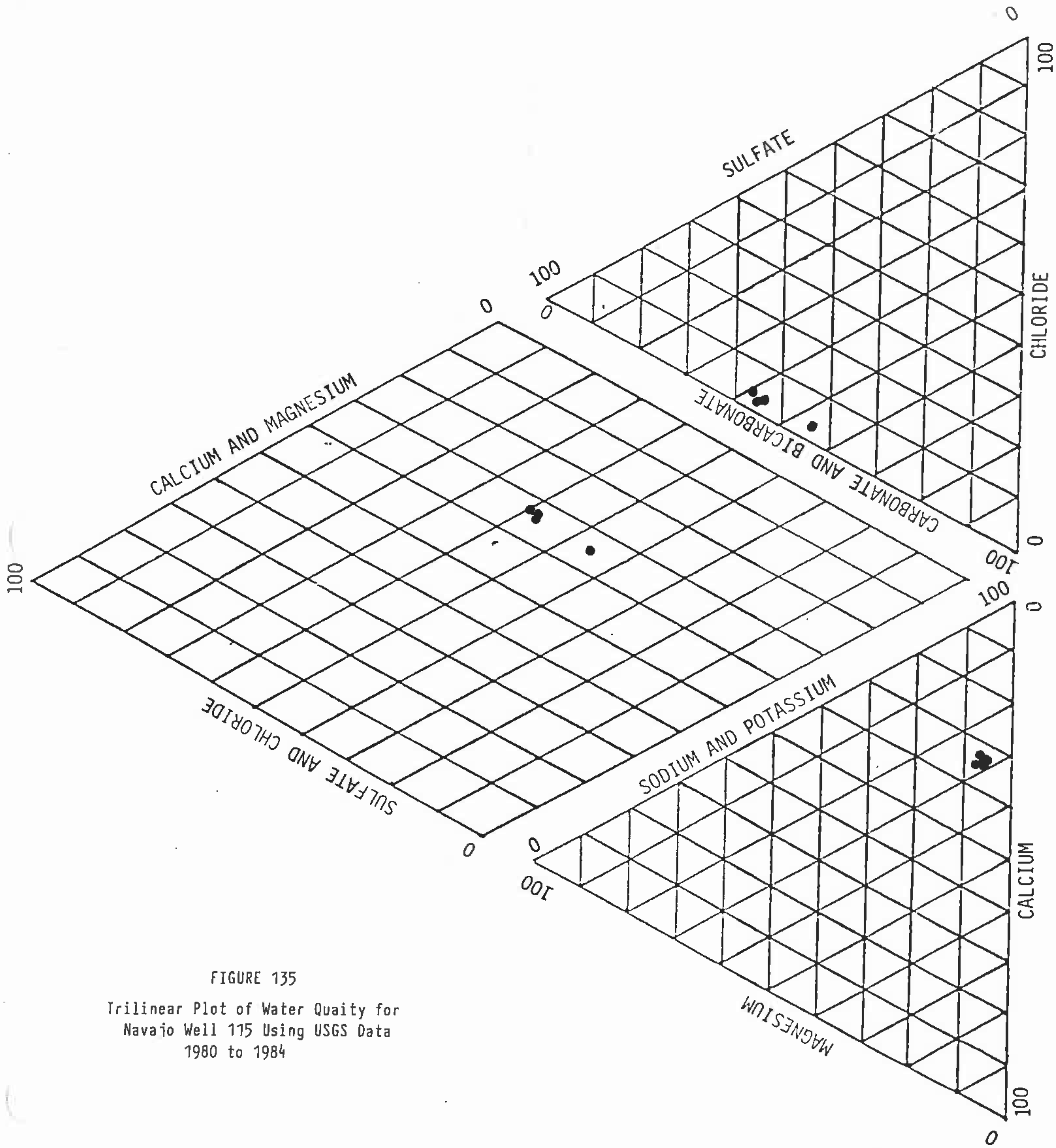


FIGURE 135

Trilinear Plot of Water Quaity for
Navajo Well 115 Using USGS Data
1980 to 1984

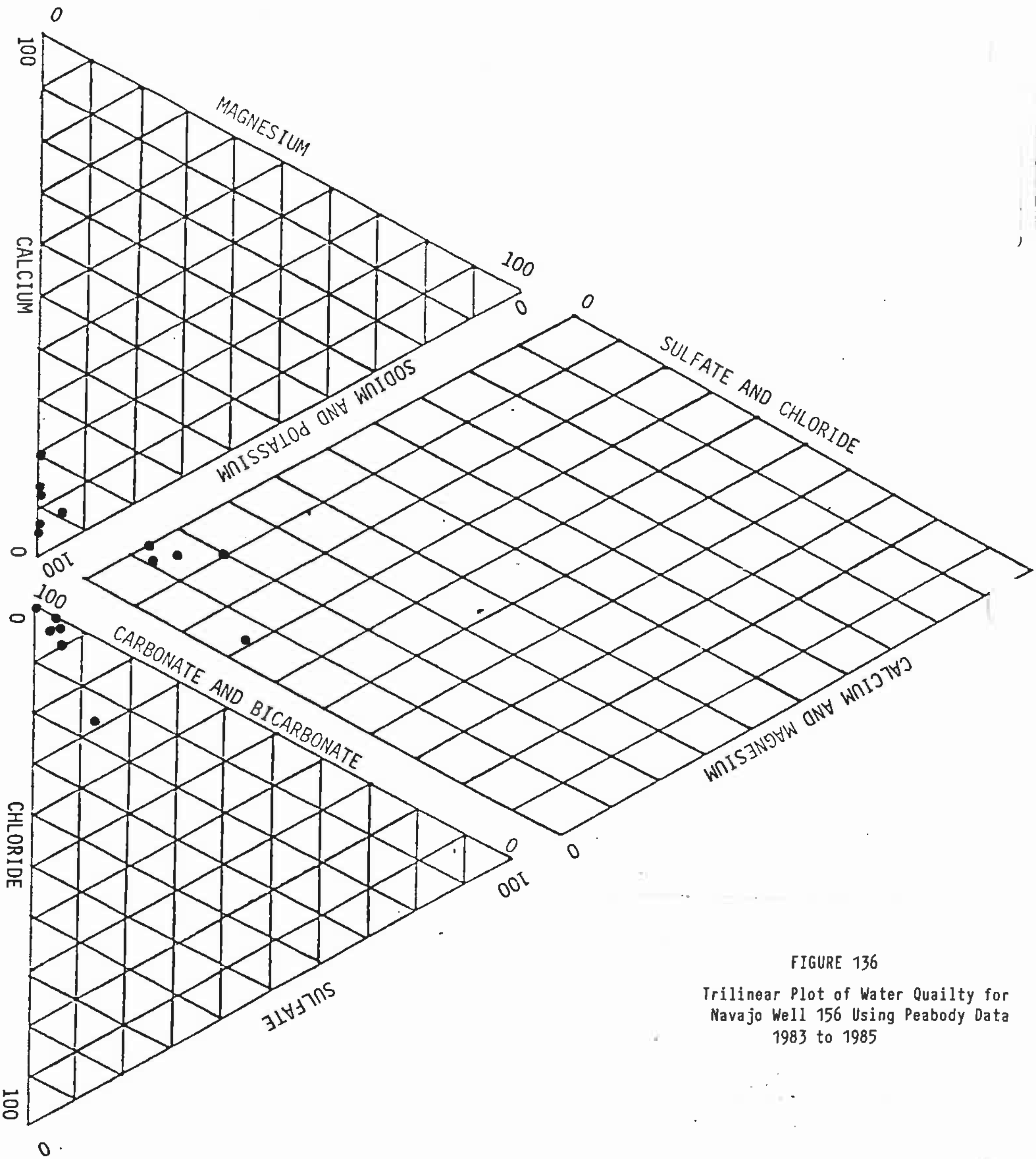


FIGURE 136

Trilinear Plot of Water Quailty for Navajo Well 156 Using Peabody Data 1983 to 1985 significant amounts of good quality water in comparison to the Navajo Sandstone. Well 8 appears to be completed in a tighter zone of the Navajo aquifer (more highly cemented and affected by local impermeable boundaries). These factors most likely account for the TDS difference. Further documentation for this is based on Well 8's poor well performance to date. Well 8 was completed with 22 percent open area in its production zone as compared to 1 percent - 4 percent in the original Wells 2 through 7. Yet Navajo 8's specific capacity (gallons per minute for each foot of drawdown) is one of the poorest in the wellfield. Although the calcium levels observed at Well 8 are higher than those of the other wells, they are believed to be a function of the formation perforated and not related to distance from recharge area.

There is no evidence of any seasonal change in water quality in the Navajo aquifer. This is to be expected because of the depth to the aquifer and its low permeability. Statistical summaries of the principal ions and trace metals in the Peabody N-aquifer wells are presented in Attachment 23.

USGS N-Aquifer Monitoring and Modeling.

Regional Water Quantity and Quality Monitoring. Since 1971, the USGS has been jointly funded by Peabody and the Navajo and Hopi Tribes to perform monitoring of off-lease wells completed in the D-aquifer and the N-aquifer, springs supplied by water from the Mesa Verde Formations, the D-aquifer system and the N-aquifer system, and stream baseflows fed by the N-aquifer. In addition, the USGS periodically monitored the water quality of the Peabody production wells. The thrust of the USGS monitoring program is to monitor the effects of Peabody and Tribal pumpage on the quantity and quality of water in the N-aquifer, any quantity and quality changes in springs fed by the D and N-aquifer systems, and any reductions in N-aquifer fed stream baseflows.

A more detailed description of the USGS monitoring program, modeling and types of monitoring is given in Chapter 16 "Hydrological Monitoring Program". The following discussion will summarize the data presented in the 1977, 1982, 1983 and 1984 Progress Reports submitted by the USGS to the cooperators in this program. Copies of the Progress Reports are included as Attachment 24.

Total Peabody (industrial) and Tribal (nonindustrial) pumpage has been monitored by the USGS since 1965. Table 63 summarizes each of the types of pumpage by year. The highest

TABLE 63

Withdrawls From the N-aquifer, 1965-84

(Measurements are in acre-feet. Data for 1965-79 from Eychaner, 1983)

		Nonindustrial[2] Year	
Year	Industrial[1]	Confined[3]	Unconfined[4]
1965	0	50	20
1966	0	110	30
1967	0	120	50
1968	95	150	100
1969	43	200	100
1970	740	280	150
1971	1,900	340	150
1972	3,680	370	250
1973	3,520	530	300
1974	3,830	580	362
1975	3,550	600	508
1976	4,180	690	645
1977	4,090	750	726
1978	3,000	830	930
1979	3,500	860	930
1980	3,540	910	880
1981	4,010	960	1,000
1982	4,740	870	965
1983	4,460	1,360	1,280
1984	4,170	1,070	1,400

[1] Metered pumpage by Peabody Coal Company at their mine on Black Mesa.

[2] Does not include withdrawals from wells equipped with windmills.

[3] Includes metered pumpage at Kayenta and estimated pumpage at Chilchinbito, Rough Rock, Pinon, Keams Canyon and Oraibi prior to 1980; metered and estimated pumpage furnished by the Navajo Tribal Utility Authority and the U.S. Bureau of Indian Affairs and collected by the U.S. Geological Survey, 1980-84.

[4] Includes estimated pumpage, 1965-73, and metered pumpage, 1974-79, at Tuba City; metered and estimated data furnished by the Navajo Tribal Utility Authority and the U.S. Bureau of Indian Affairs, 1980-84.

Peabody pumpage (4,740 acre-feet) occurred in 1982. Pumpage from 1980 through 1984 has averaged 4,184 acre-feet/year. The highest Tribal pumpage (2,640 acre-feet) occurred in 1983 and Tribal pumpage from 1980 through 1984 has averaged 2,139 acre-feet/year.

The water quality from Peabody and Tribal wells completed in the N-aquifer has been periodically monitored by the USGS since 1967. The thrust of the N-aquifer water quality monitoring effort has been towards assessing if vertical leakage from the overlying D-aquifer system is significant. The concentrations of dissolved solids, chloride and sulfate ions in the D-aquifer is 7 times, 11 times and 30 times greater, respectively, than in the N-aquifer. If N-aquifer water level declines are inducing large amounts of vertical leakage from the D-aquifer system, there should be marked changes with time in these parameter concentrations. Comparisons of these concentration levels over a period of several years are presented for the Peabody wells in Table 64 and the Tribal wells in Table 65. There is no evidence to suggest that significant vertical leakage is occurring from the D-aquifer system into the N-aquifer system.

Springs fed by the D and N-aquifers have been periodically monitored by the USGS since 1948. Monitoring has been oriented towards determining if Peabody and/or Tribal pumpage from the N and D-aquifers has caused significant reductions in flow or deterioration of spring water quality. Table 66 is a summary of the flow and water quality parameters monitored at D and N-aquifer springs by the USGS. For the water quality deterioration analysis, the same criteria and chemical parameters were used as was described previously. Spring flow reductions at Pasture Canyon, Chilchinbito and Shonto are most probably a function of local irrigation and stock water use in addition to Tribal pumpage from wells in the vicinity. Spring flows at Rough Rock, Nasjo Toh and Dinnebito have shown increases since 1954. A review of the spring water chemistry indicates that deterioration of spring water quality is not occurring. The few cases where a chemical constituent has increased has in no way affected the potential use of the water. Springs from the alluvial, Wepo and Toreva aquifers are not discussed here as they can in no way be affected by the D and N-aquifer pumpage. The potential of pit pumpage from the Wepo aquifer as it affects local water uses will be discussed in Chapter 18, "Probable Hydrologic Consequences".

The USGS has monitored baseflows on three washes (Moenkopi Wash, Laguna Creek and Chinle Creek) to determine if Peabody and Tribal pumpage from the N-aquifer is significantly reducing natural discharge from the N-aquifer. Comparisons of past average baseflows with current baseflows are shown in Table 67. Moenkopi Wash and Laguna Creek have shown

TABLE 64

Selected Parameters from Chemical Analysis of Water From Peabody N-Aquifer Wells, Black Mesa Area, 1967-74 and 1980-84

Well Number	Year	Specific Conductance (umhos)	Dissolved Solids Residue at 180°C (mg/L)	Chloride, Dissolved (mg/L as Cl)	Sulfate, Dissolved (mg/L as SO_4)
2	1967	221	144[1]	5.0	21
	1980	225	144	11	20
3	1968	236	154[1]	4.0	17
	1980	230	151	3.5	14
4	1974	200	140	3.8	13
	1980	230	139	4.3	13
5	1968	224	149[1]	3.5	16
	1980	210	134	2.9	9.5
6	1968	201	333[1]	3.0	13
	1980	260	160	3.5	15
7	1972	222	141[1]	2.5	20
	1980	210	136	3.7	11
8	1980	420	283	4.8	100
	1983	440	278	4.8	100
	1984	436	264	4.7	100

[1] Dissolved-solids data from 1974.

TABLE 65

Selected Parameters From Chemical Analysis of Water From Nonindustrial Wells

That Tap the N-aquifer, Black Mesa Area, 1982-84

Site Name	Year	Specific Conductance (umhos)	Dissolved Solids Residue at 180°C (mg/L)	Chloride, Dissolved (mg/L as Cl)	Sulfate, Dissolved (mg/L as SO_4)
Keams	1982	1,010	592	94	35
Canyon 2	1983	1,120	636	120	42
	1984	1,040	578	96	36
Rough Rock	1983	1,090	628	130	110
PM 5	1984	1,090	613	130	99
Rocky Ridge	1982	255	---	1.4	6.0
PM 3					
New Oraibi	1982	385	228	4.0	10
PM 4					
New Oraibi	1983	400	235	4.1	9.8
PM 3	1984	395	216	4.0	9.9
Kayenta	1982	360	228	4.5	58
PM 2	1983	375	230	---	60
	1984	365	209	4.2	51
Forest Lake	1982	470	281	11	67
Kitsillie	1982	580	365	5.4	84
	1983	505	291	4.4	37
	1984	460	258	5.2	20
Pinon	1982	485	---	3.7	5.0
PM 6	1983	505	293	3.6	5.3
	1984	495	273	3.7	5.4

TABLE 66

Flow and Selected Parameters From Chemical Analyses of Water Samples From Springs

In The Black Mesa Area 1948-1984.

(From Hill, 1983 and 1985; and Davis et al. 1963)

Spring Name	BIA No.	Formation	Date Flow Measured	Flow (gpm)	Date Sampled	Specific Conductance (umhos)	Dissolved Chloride (mg/L)	Dissolved Sulfate (mg/L)	Water Use
Pasture Canyon	3A-5	Navajo	10/8/54	174	2/27/48	199	5.0	13	Stock,
			9/18/82	135	9/18/82	240	5.1	18	Irrigation
Chilchinbito	8A-122	Morrison	2/10/55	2.5-3	6/12/54	2,750	30	1,520	Domestic,
			7/20/83	0.68	7/20/83	1,980	31	990	Stock
Near Rough Rock	10R-158A	Dakota	8/4/54	0.1 est.	7/28/49	362	27	39	Domestic,
			7/20/83	0.15	7/20/83	290	6	25	Stock
Near Steamboat	17M-261	Dakota	---	No Measurement	7/10/49	222	3	11	Domestic,
			6/26/84	Seeping	6/26/84	280	4	15	Stock,
				(Could not measure)					Irrigation
Nasjo Toh	8A-109	Dakota	10/13/54	1.0 est.	8/15/84	470	10	100	Domestic,
			8/15/84	1.0 est.					Stock
Shonto	6M-54	Navajo	8/26/53	2-3	7/09/52	1,080	82	281	Domestic,
			6/26/84	0.67	6/26/84	989	64	260	Stock
Near Dinnehotso	8A-224	Navajo	10/6/54	1.0 est.	6/27/84	187	2.8	7.1	Domestic,
			6/27/84	2.0					Stock

TABLE 67

Summary of USGS N-Aquifer Baseflow Monitoring

At Moenkopi Wash, Chinle Wash and Laguna Creek

Monitoring Site	Aquifer Discharge	Pre-1984 Average (cfs)	1984 Average (cfs)
Moenkopi Wash	Navajo	3.2	3.0
Chinle Creek	Navajo	5.5	9.1
Laguna Creek	Navajo	3.9	3.3

average baseflow discharge declines of six and fifteen percent, respectively. Whether these decreases are totally a function of N-aquifer pumpage or are partly affected by climatic variations is not completely clear. The Moenkopi site has been monitored for approximately nine years and the Laguna Creek site for four years. If continued declines in baseflow persist, the N-aquifer pumpage by all users is most likely the principal cause.

Chinle Creek has shown a 65 percent increase in baseflow in 1984. Because Chinle Creek receives baseflow from other sources besides Laguna Creek, it is probably a less reliable indicator of N-aquifer losses.

Regional N-Aquifer Flow Model. The cooperators have also retained the USGS to model the N-aquifer to predict future water level drawdowns for four different Peabody and Tribal pumpage scenarios. The four model scenarios are described in more detail in Chapter 16, "Hydrological Monitoring Program". The N-aquifer modeling effort was completed in 1981 and the results have been published as Open-File Report 81-911 and Water Supply Paper 2201.

Following the completion of the modeling, it was determined that future Peabody pumpage estimates and initial and future Tribal pumpage figures were somewhat low. The cooperators requested that the USGS rerun the model through 1984 with the corrected pumpage figures. This work was performed and the results were distributed to the cooperators in September, 1985.

As a check on the accuracy of the model, simulated versus measured drawdowns at the six principal N-aquifer observation wells (BM1-BM6) are presented in Figures 137 and 138. Circles have been used to allow comparison of the new simulated trends with the former trends. There is good agreement between measured and simulated drawdowns at all observation wells but BM2 and BM3. In both cases, the simulated drawdowns are less than the measured values. The USGS allows that the prediction differences can be attributed to the scale of the model grid blocks (two miles on each side). Multiple pumpage is occurring in one block of the model as a result of the completion of new wells at Kayenta. If pumpage from the new wells were moved to adjacent grid blocks, the model would predict different water levels for both BM2 and BM3.

For assessing the regional N-aquifer water level drawdowns attributable to Peabody, Model

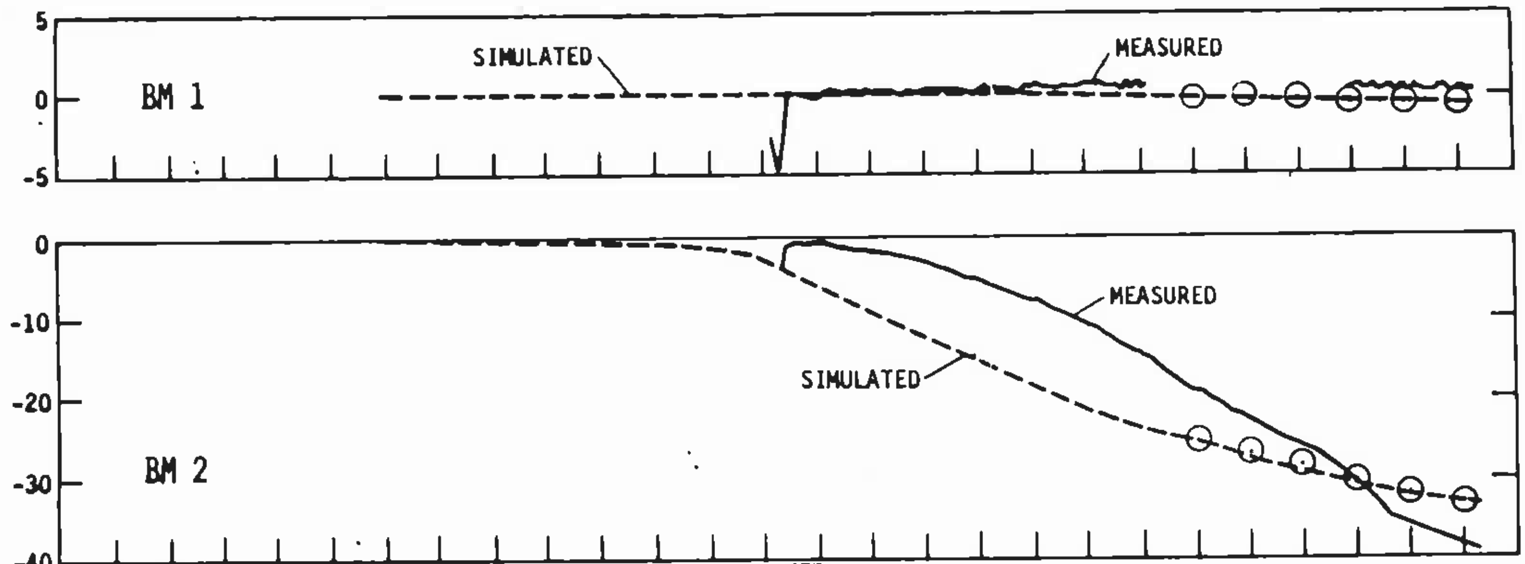
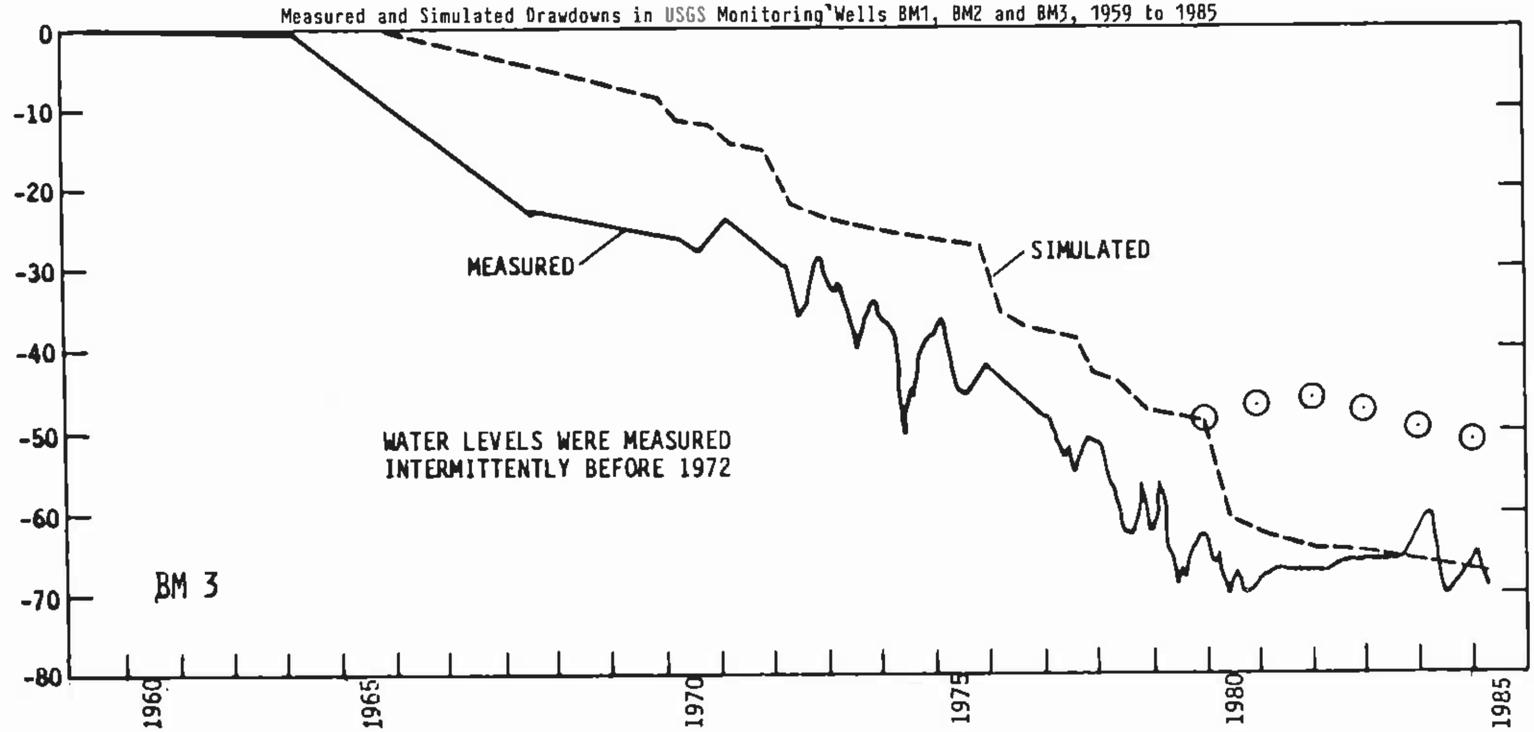


FIGURE 137

Measured and Simulated Drawdowns in USGS Monitoring Wells BM1, BM2 and BM3, 1959 to 1985



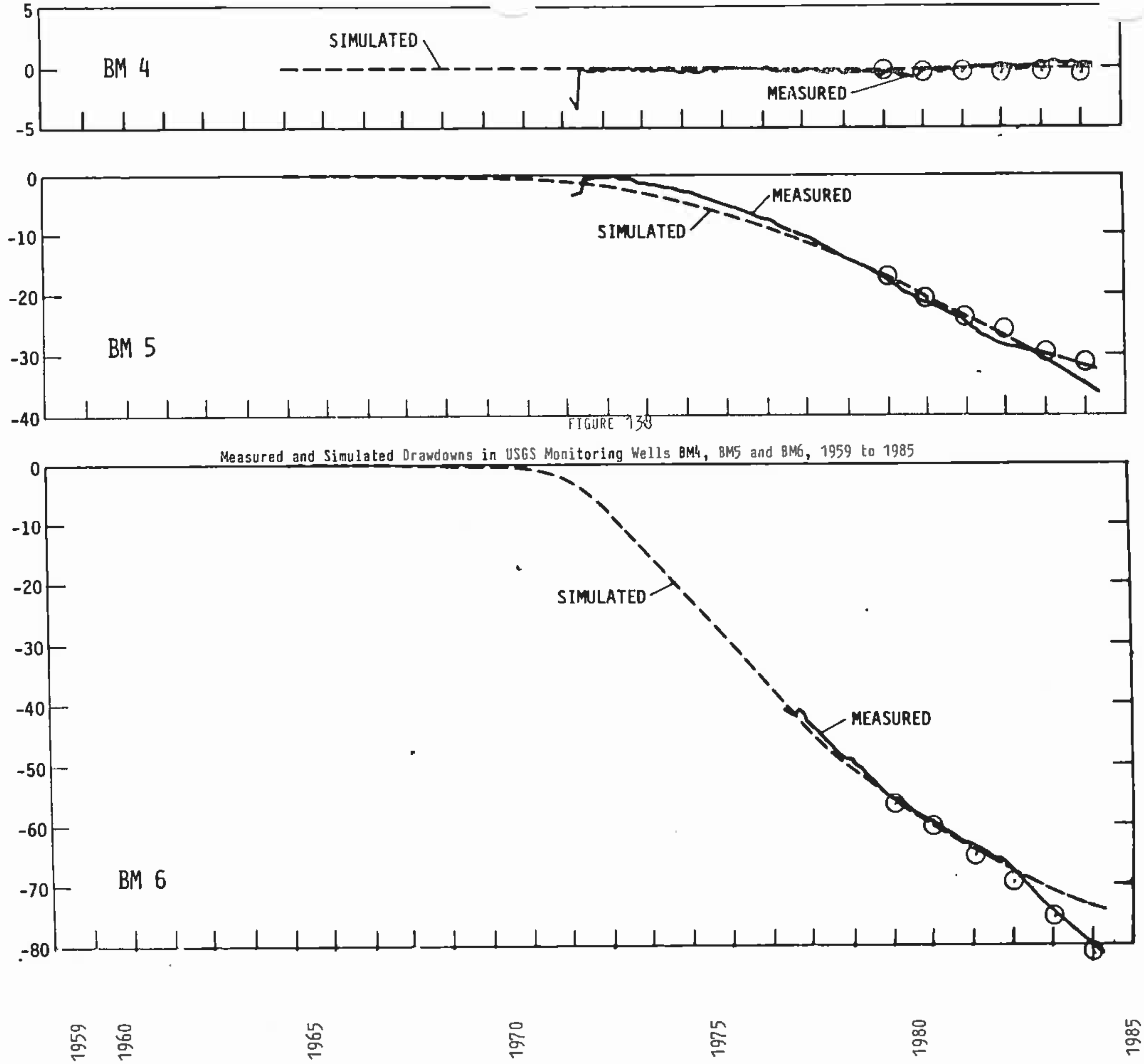


FIGURE 138

Measured and Simulated Drawdowns in USGS Monitoring Wells BM4, BM5 and BM6, 1959 to 1985

Scenarios 1 and 4 have been utilized. The Peabody pumpage projections are assumed to be zero after the year 2001 when in reality the current contractual agreements call for coal to be supplied to the Navajo and Mojave Power Plants until 2011 and 2007, respectively. This discrepancy in the model should be of minor significance, however, since over 80 percent of the total pumpage drawdown has already occurred. Future declines associated with Peabody pumpage will be at a considerably reduced rate.

Scenario 1 assumes Peabody and Tribal pumpage rates based on historic pumpage values. Peabody pumpage continues until 2001, whereas Tribal pumpage continues through 2014. Scenario 4 assumes no Peabody pumpage and Tribal pumpage is at the same rate as that used in Scenario 1. The difference between simulated drawdowns at the various communities for the two scenarios would represent that portion of the total drawdown caused by Peabody pumpage alone. Table 68 presents a summary of the drawdown differences for 19 different Tribal communities. The maximum drawdown attributable to Peabody pumpage is 122 feet at the community of Forest Lake. Other drawdowns attributable to Peabody pumpage range from 2 to 58 feet. Based on prepumpage (1964), Navajo aquifer water levels at each of these communities, the above-referenced drawdowns account for 0.2 to 5.4 percent of the total available feet of water in the N-aquifer wells at these locations (Table 69).

Other conclusions from Model Scenario 1 are as follows. Approximately 94 percent of the 210,000 acre-feet of water pumped would be from aquifer storage. Total aquifer storage would decrease about 0.1 percent to the year 2001. The rest of the aquifer withdrawal would be accounted for in reduction of stream baseflows and discharge to springs, reduction of evapotranspiration from the aquifer and increased leakage from the D-aquifer. Discharge from the N-aquifer to streams and springs would be 5 percent less in 2001 than in 1964. Most of the reduction would occur along Laguna Creek. Evapotranspiration would be 5 percent less and leakage through overlying confining layers would be approximately 260 acre-feet/year. This increased leakage would not cause significant water level declines in the overlying aquifers comprising the D-aquifer system.

In comparison, conclusions from Scenario 4 (Tribal pumpage only) are that two-thirds of the discharge losses to streams, springs and alluvium will be as a result of Tribal pumpage. About one-third of the simulated decrease in evapotranspiration and increase in vertical leakage from overlying aquifers would be caused by Tribal pumpage.

TABLE 68

Drawdowns Projected at Year 2001 From

Tribal and Peabody Wellfield Pumpage

Community	Combined Tribal-Peabody Pumpage Drawdowns (ft)	Drawdown Attributable to Tribal Pumpage (ft)	Drawdown % of Total	Drawdown Attributable to Peabody Pumpage (ft)	Drawdown % of Total
Forest Lake	130.0	8.1	6.2	121.9	93.8
Cottonwood	4.0	1.6	40.0	2.4	60.0
Keams Canyon	100.0	80.6	81.0	19.4	19.0
Polacca	55.0	36.1	66.0	18.9	34.0
Mishongovi	35.0	20.3	58.0	14.7	42.0
Second Mesa	30.0	19.2	64.0	10.8	36.0
Shongopovi	30.0	20.3	68.0	9.7	32.0
Oraibi	50.0	42.0	84.0	8.0	16.0
Hotevilla	30.0	16.1	54.0	13.9	46.0
Tuba City	115.0	115.0	100.0	-	-
Red Lake	2.0	.2	10.0	1.8	90.0
Shonto	.1	-	-	-	-
Kayenta	110.0	110.3	100.0	50.0	45.3
Rough Rock	20.0	9.7	49.0	10.3	51.0
Kitsille	65.0	6.9	11.0	58.1	89.0
Chilchinbito	60.0	12.7	21.0	47.3	79.0
Dennehotso	-	-	-	-	-
Low Mountain	60.0	25.3	42.0	34.7	58.0
Pinon	79.0	22.8	29.0	46.2	71.0

TABLE 69

Percent of Available Water Height in Tribal Wells
Lost Because of Peabody Pumpage Through 2001

Community	Elevation of Top of N-Aquifer	Saturated Thickness of N-Aquifer (ft)	Elevation of Bottom of N-Aquifer	Water Level Elevations in Wells In N-Aquifer, 1964	Total Initial Height of Water In Wells in 1964 (ft)	% of Total Available Water Height Lost to Peabody Pumpage as of 2001
Forest Lake	4,250	800	3,450	5,700	2,250	5.4%
Cottonwood	5,600	300	5,300	5,680	380	0.6%
Keams Canyon	5,000	15	4,985	5,540	555	3.5%
Polacca	4,820	280	4,540	5,460	920	2.1%
Mishongovi	5,000	260	4,740	5,415	675	2.2%
Second Mesa	5,080	240	4,840	5,400	560	1.9%
Shongopovi	5,040	270	4,770	5,404	634	1.5%
Oraibi	4,930	350	4,580	5,409	829	1.0%
Hotevilla	4,950	410	4,540	5,400	860	1.6%
Tuba City	5,000	300	4,700	5,000	300	0%
Red Lake	5,250	930	4,320	5,445	1,125	.2%
Shonto	6,625	580	6,045	6,320	275	0%

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TABLE 69 (Cont.)

Percent of Available Water Height in Tribal Wells
Lost Because of Peabody Pumpage Through 2001

Community	Elevation of Top of N-Aquifer	Saturated Thickness of N-Aquifer (ft)	Elevation of Bottom of N-Aquifer	Water Level Elevations in Wells In N-Aquifer, 1964	Total Initial Height of Water In Wells in 1964 (ft)	% of Total Available Water Height Lost to Peabody Pumpage as of 2001
Kayenta	5,500	850	4,650	5,570	920	5.4%
Rough Rock	5,230	610	4,620	5,525	905	1.1%
Kitsillie	4,740	700	4,040	5,584	1,544	3.8%
Chilchinbito	4,960	800	4,160	5,490	1,330	3.6%
Dennehotso	5,465	700	4,765	5,025	260	0%
Low Mountain	4,960	180	4,780	5,620	840	4.1%
Pinon	4,500	500	4,000	5,653	1,653	2.8%

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ATTACHMENT 1

Channel Cross Sections Near
Stream Monitoring Sites

Table 6.--Chemical analyses of surface waters sampled as a part of the Black Mesa monitoring program

If the name of the site is preceeded by an 8-digit number starting with 09, the site is one where systematic observations are being or have been made. The 8-digit number is called a downstream order number. If the name of the site is preceeded by a 15-digit number of which the first 13 digits are identical to the latitude and longitude of the site, then the site is a miscellaneous site where only random observations are made.

Code for agency analyzing sample: 1028 is U. S. G. S.

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)
09401236 - YELLOW WATER CANYON NR SHONTO (LAT 36 30 33 LONG 110 26 20)												
JUL , 1975												
15...	0800	.50	15	60	39	39	10	159	0	380	13	.9
09401240 - MOENKOPI WASH NR SHONTO (LAT 36 24 51 LONG 110 27 28)												
DEC , 1973												
13...	1100	1.5	15	20	170	220	8.3	295	0	1700	26	.5
MAR , 1974												
13...	1220	1.2	15	170	170	220	11	284	0	1700	26	.5
MAY												
08...	1200	.08	15	80	170	260	14	244	0	1700	26	.6
JUL												
25...	1200	E1.0	20	40	160	220	12	265	0	1700	26	.5
SEP												
18...	1100	.91	11	50	140	170	10	223	--	1400	22	.8
FEB , 1975												
27...	0950	.27	11	40	150	190	7.7	250	--	1500	24	.6
JUN												
11...	1100	.10	16	50	170	240	12	274	0	1700	29	.7
MAR , 1977												
17...	0815	--	13	50	150	240	9.2	345	0	1400	28	.4
09401248 - BEGASHIBITO WASH NEAR TONALEA ARIZ (LAT 36 12 58 LONG 110 58 36)												
JAN , 1975												
21...	1400	--	11	10	34	110	3.2	257	--	450	25	.5
JUN												
09...	1330	.05	10	30	34	120	4.5	158	0	480	31	.8
DEC												
11...	1430	E.10	7.5	20	32	110	4.7	256	0	410	28	.4
DEC , 1976												
10...	0930	.02	9.3	30	31	97	2.7	263	0	390	25	.5

DATE	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (TONS PER AC-FT)	HARDNESS (CA,MG) (MG/L)	NON-CARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	DISSOLVED BORON (B) (UG/L)	CODE FOR AGENCY ANALYZING SAMPLE
09401236 - YELLOW WATER CANYON NR SHONTO (LAT 36 30 33 LONG 110 26 20)												
JUL , 1975												
15...	.96	.00	729	.99	460	330	.8	940	7.8	21.0	120	1028
09401240 - MOENKOPI WASH NR SHONTO (LAT 36 24 51 LONG 110 27 28)												
DEC , 1973												
13...	1.8	.04	2810	3.82	1500	1300	2.5	3032	7.9	.0	130	1028
MAR , 1974												
13...	2.4	.02	2840	3.86	1600	1300	2.4	3090	7.9	17.0	120	1028
MAY												
08...	.05	.01	2820	3.84	1400	1200	3.0	3050	8.1	25.0	160	1028
JUL												
25...	1.3	.01	2840	3.86	1500	1300	2.5	3810	7.9	--	200	1028
SEP												
18...	2.7	.04	2360	3.21	1300	1100	2.1	2500	7.7	28.0	140	1028
FEB , 1975												
27...	3.1	.01	2500	3.40	1400	1200	2.2	2750	8.0	—	120	1028
JUN												
11...	.11	.01	2710	3.69	1400	1200	2.8	3000	8.1	27.5	170	1028
MAR , 1977												
17...	.88	.01	2650	3.60	1300	1000	2.9	2800	8.0	.0	110	1028
09401248 - BEGASHIBITO WASH NEAR TONALEA ARIZ (LAT 36 12 58 LONG 110 58 36)												
JAN , 1975												
21...	.14	.01	907	1.23	460	250	2.2	1120	8.0	1.0	120	1028
JUN												
09...	.08	.00	922	1.25	380	250	2.7	1240	8.4	29.0	190	1028
DEC												
11...	.02	.00	881	1.20	430	220	2.3	1100	8.4	12.0	130	1028
DEC , 1976												
10...	.03	.02	854	1.16	430	210	2.0	1100	7.8	.5	130	1028

Table E.--Chemical analyses of surface waters sampled as a part of the Black Mesa monitoring program--Contir

09401250 - MOENKOPI WASH NR MOENKOPI, ARIZ. (LAT 36 06 36 LONG 111 09 19)

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)
JUN , 1972												
22...	1330	E200	14	70	79	200	15	196	0	1500	25	.7
SEP												
26...	--	E2.5	10	30	23	100	5.5	243	0	320	10	.7
OCT												
26...	1430	E400	6.3	60	32	64	5.4	78	0	650	8.0	.7
JUL , 1973												
20...	1325	E15	8.3	60	170	630	15	248	0	2700	64	1.2
SEP												
12...	1030	3.7	8.9	100	73	160	9.6	137	0	1100	20	.9
OCT												
03...	0930	1.1	7.9	50	24	140	4.7	231	7	380	14	.8
DEC												
12...	1145	1.7	7.9	30	21	110	4.0	230	8	290	12	.5
MAR , 1974												
11...	1400	3.0	8.6	50	32	110	5.7	219	0	440	12	.7
JUL												
19...	1315	270	15	50	150	240	15	248	0	2300	24	.5
22...	1300	47	14	50	72	120	10	168	0	1100	13	.6
23...	1330	5.8	13	30	66	110	9.6	153	0	1000	13	.6
SEP												
03...	1040	.14	8.3	50	46	190	6.9	208	--	680	22	.8
19...	1030	1.2	8.4	50	36	150	7.6	187	--	580	14	.7
OCT												
31...	1300	8.5	6.8	10	34	120	7.7	136	--	660	9.9	.5
NOV												
25...	1330	2.0	8.2	40	19	110	4.1	245	--	290	10	.5
JAN , 1975												
15...	1215	1.2	13	10	24	120	4.3	314	--	310	15	.5
FEB												
28...	1430	2.3	7.0	30	18	100	3.5	218	--	260	11	.5
MAR												
20...	1330	2.1	9.1	20	53	150	6.3	228	0	610	15	.5
MAY												
06...	1305	2.4	6.7	20	26	130	4.7	247	--	350	19	.6
JUN												
09...	1220	.78	4.1	10	22	140	6.2	216	0	310	17	.7

09401250 - MOENKOPI WASH NR MOENKOPI, ARIZ. (LAT 36 06 36 LONG 111 09 19)

DATE	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (TONS PER AC-FT)	HARDNESS (CA,MG) (MG/L)	NON-CARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	DISSOLVED BORON (B) (UG/L)	CODE FOR AGENCY ANALYZING SAMPLE
JUN , 1972												
22...	2.4	.01	--	3.20	1300	1200	2.4	2780	7.9	22.0	--	1028
SEP												
26...	.03	--	--	.92	320	120	2.4	950	8.2	21.0	130	1028
OCT												
26...	1.7	.01	1090	1.48	630	570	1.1	1350	7.4	12.0	70	1028
JUL , 1973												
20...	.24	.02	4300	5.85	1600	1400	6.8	4860	7.7	32.0	460	1028
SEP												
12...	3.4	.07	1910	2.60	930	810	2.3	2130	7.4	19.5	60	1028
OCT												
03...	.03	.02	824	1.12	280	80	3.6	1130	8.4	11.0	120	1028
DEC												
12...	.23	.02	640	.87	270	85	2.9	943	8.3	4.0	90	1028
MAR , 1974												
11...	.38	.01	865	1.18	410	230	2.4	1200	8.2	17.0	80	1028
JUL												
19...	.65	.02	3640	4.95	1900	1700	2.4	2250	7.1	25.5	230	1028
22...	1.7	.02	1850	2.52	1000	910	1.6	1900	7.3	28.8	160	1028
23...	.62	.01	1760	2.39	950	820	1.6	1600	7.4	31.0	160	1028
SEP												
03...	.10	.01	1330	1.63	540	370	3.6	1600	8.1	22.5	200	1028
19...	.15	.00	1080	1.47	450	290	3.1	1400	8.1	19.0	130	1028
OCT												
31...	1.7	.02	1140	1.55	510	400	2.3	1490	7.8	11.0	40	1028
NOV												
25...	.03	.00	667	.91	290	90	2.8	950	8.3	9.0	100	1028
JAN , 1975												
15...	.43	.00	747	1.02	330	76	2.9	1100	8.1	1.0	80	1028
FEB												
28...	.04	.01	614	.84	250	70	2.8	901	8.5	18.0	80	1028
MAR												
20...	.39	.01	1190	1.62	570	380	2.7	1580	8.0	17.0	90	1028
MAY												
06...	.00	.00	749	1.02	280	82	3.4	950	--	17.0	130	1028
JUN												
09...	.03	.01	679	.92	220	38	4.2	908	8.7	31.0	120	1028

Table 6.--Chemical analyses of surface waters sampled as a part of the Black Mesa monitoring program--Continued

09401250 - MOENKOPI WASH NR MOENKOPI, ARIZ. (LAT 36 06 36 LONG 111 09 19)

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)
JUL , 1975												
09...	1330	.86	12	10	58	300	15	183	0	1100	22	.9
11...	1230	86	13	10	59	150	15	222	0	910	22	.7
13...	1215	205	13	10	72	130	12	194	0	1100	14	.6
AUG												
11...	1130	.21	7.8	10	49	190	11	146	0	880	22	.7
12...	1415	4.3	9.3	20	44	190	11	183	0	820	14	.8
22...	1415	1.2	7.8	0	29	170	8.0	195	0	590	15	.7
SEP												
23...	1130	3.9	8.3	30	51	85	9.3	103	0	880	21	.6
OCT												
07...	1030	.86	8.6	40	26	110	8.6	165	0	510	9.7	.5
NOV												
06...	1100	2.4	9.2	10	19	110	4.8	247	0	340	10	.5
DEC												
11...	1300	3.3	8.3	10	19	110	3.9	235	0	320	12	.5
FEB , 1976												
18...	1345	2.5	7.3	10	18	110	3.6	226	5	300	12	.5
MAR												
18...	1650	2.3	7.9	0	19	120	4.6	228	6	300	12	.7
APR												
23...	1250	1.8	6.3	370	21	130	4.9	234	0	300	18	.6
MAY												
28...	1530	.50	4.7	10	18	150	6.8	194	12	310	17	.8

09401250 - MOENKOPI WASH NR MOENKOPI, ARIZ. (LAT 36 06 36 LONG 111 09 19)

DATE	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (TONS PER AC-FT)	HARDNESS (CA+MG) (MG/L)	NON-CARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	DISSOLVED BORON (B) (UG/L)	CODE FOR AGENCY ANALYZING SAMPLE
JUL , 1975												
09...	4.5	.00	1940	2.64	680	550	5.0	2420	8.2	34.0	180	1028
11...	.68	.00	1670	2.27	870	690	2.2	1700	7.3	29.0	190	1028
13...	.42	.00	1900	2.58	1100	910	1.7	2120	7.3	22.5	160	1028
AUG												
11...	.04	.00	1490	2.03	630	510	3.3	1800	7.9	28.0	190	1028
12...	.31	.01	1420	1.93	630	480	3.3	1650	7.9	29.0	150	1028
22...	.05	.00	1090	1.48	390	230	3.7	1400	8.0	33.0	130	1028
SEP												
23...	1.5	.01	1510	2.05	810	720	1.3	1625	7.2	18.0	90	1028
OCT												
07...	.00	.00	861	1.17	410	270	2.4	1200	8.4	15.0	100	1028
NOV												
06...	.27	.00	694	.94	310	110	2.7	1000	8.3	9.0	70	1028
DEC												
11...	.18	.01	677	.92	300	110	2.8	984	8.3	7.0	30	1028
FEB , 1976												
18...	.15	.00	668	.91	270	78	2.9	960	8.4	13.0	70	1028
MAR												
18...	.00	.00	652	.89	260	64	3.2	940	9.0	17.0	160	1028
APR												
23...	.06	.00	669	.91	300	100	3.3	1200	8.4	26.0	100	1028
MAY												
28...	.03	.00	657	.89	200	25	4.6	980	8.7	26.0	130	1028

Table 6.--Chemical analyses of surface waters sampled as a part of the Black Mesa monitoring program--Cont.

DATE	TIME	INSTAN-TANEOUS DIS-CHARGE (CFS)	DIS-SOLVED SILICA (SIO2) (MG/L)	DIS-SOLVED IRON (FE) (UG/L)	DIS-SOLVED MAG-NE-SIUM (MG) (MG/L)	DIS-SOLVED SODIUM (NA) (MG/L)	DIS-SOLVED PO-TAS-SIUM (K) (MG/L)	BICAR-BONATE (HCO3) (MG/L)	CAR-BONATE (CO3) (MG/L)	DIS-SOLVED SULFATE (SO4) (MG/L)	DIS-SOLVED CHLO-RIDE (CL) (MG/L)	DIS-SOLVED FLUO-RIDE (F) (MG/L)
09401260 - MOENKOPI WASH AT MOENKOPI (LAT 36 06 18 LONG 111 12 04)												
JAN , 1976												
24...	1000	E2.0	--	--	--	--	--	--	--	--	--	--
FEB												
10...	1600	E2.0	--	--	--	--	--	--	--	--	--	--
MAY												
21...	1900	E5.0	--	--	--	--	--	--	--	--	--	--
JUL												
27...	1515	139	13	30	160	330	19	234	0	2300	31	.6
30...	1500	2.4	11	30	86	230	19	87	0	1800	12	.7
31...	1000	640	--	--	--	--	--	--	--	--	--	--
AUG												
08...	0800	45	--	--	--	--	--	--	--	--	--	--
20...	1430	26	--	--	--	--	--	--	--	--	--	--
NOV												
11...	1320	2.5	7.8	10	20	110	4.5	217	0	350	12	.5
DEC												
10...	1240	4.6	8.7	30	20	110	3.8	226	0	320	15	.5
JAN , 1977												
19...	1300	3.3	8.8	80	16	99	3.3	217	0	260	16	.4
MAR												
15...	1430	1.5	6.3	20	19	120	4.4	220	2	310	18	.6
360849111015801 - LOWER COAL MINE WASH AT MOENKOPI (LAT 36 08 49 LONG 111 01 58.01)												
DEC , 1973												
12...	1415	.20	11	40	27	380	6.0	516	0	700	19	1.0
JAN , 1975												
21...	1130	.10	13	10	30	500	6.8	588	--	930	24	2.9

DATE	DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L)	DIS-SOLVED ORTHO. PHOS-PHORUS (P) (MG/L)	DIS-SOLVED SOLIDS (RESI-DUE AT 180 C) (MG/L)	DIS-SOLVED SOLIDS (TONS PER AC-FT)	HARD-NESS (CA,MG) (MG/L)	NON-CAR-BONATE HARD-NESS (MG/L)	SODIUM AD-SORP-TION RATIO	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	DIS-SOLVED BORON (B) (UG/L)	CODE FOR AGENCY ANA-LYZING SAMPLE
09401260 - MOENKOPI WASH AT MOENKOPI (LAT 36 06 18 LONG 111 12 04)												
JAN , 1976												
24...	--	--	--	--	--	--	--	--	--	1.0	--	--
FEB												
10...	--	--	--	--	--	--	--	--	--	8.0	--	--
MAY												
21...	--	--	--	--	--	--	--	--	--	18.0	--	--
JUL												
27...	.77	.03	3790	5.15	2000	1600	3.2	3100	7.1	26.0	260	1028
30...	11	.03	2750	3.74	1500	1400	2.6	2700	7.7	33.0	140	1028
31...	--	--	--	--	--	--	--	--	--	20.0	--	--
AUG												
08...	--	--	--	--	--	--	--	--	--	14.0	--	--
20...	--	--	--	--	--	--	--	--	--	26.0	--	--
NOV												
11...	.11	.00	682	.93	320	140	2.7	760	8.0	10.0	80	1028
DEC												
10...	.33	.02	707	.96	300	120	2.8	820	8.1	1.5	70	1028
JAN , 1977												
19...	.53	.02	615	.84	250	75	2.7	720	8.3	--	70	1028
MAR												
15...	.05	.09	668	.91	260	79	3.2	920	8.4	8.5	80	1028
360849111015801 - LOWER COAL MINE WASH AT MOENKOPI (LAT 36 08 49 LONG 111 01 58.01)												
DEC , 1973												
12...	.16	.02	1460	1.99	328	0	9.3	2112	8.1	4.0	180	1028
JAN , 1975												
21...	.12	.01	1880	2.56	340	0	12	2500	8.0	1.0	180	1028

Table 6.--Chemical analyses of surface waters sampled as a part of the Black Mesa monitoring program--Continued

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)
360907110593600 - BEGASHIBITO WASH AT MOUTH NR TONALEA AZ (LAT 36 09 07 LONG 110 59 36)												
DEC , 1973 12...	1515	.50	9.3	80	18	56	3.0	270	0	130	15	.4
JAN , 1975 21...	1300	--	11	40	16	53	3.3	267	--	130	12	.0
362541110233000 - PEABODY RESERVOIR ON BLACK MESA (LAT 36 25 41 LONG 110 23 30)												
JAN , 1975 22...	1530	--	8.9	10	27	53	6.9	217	--	270	13	.6
NOV 06...	0930	--	.0	0	41	85	8.3	115	0	390	18	.6
MAR , 1977 17...	1035	--	.6	30	26	56	6.4	148	0	270	14	.7
362622110233300 - BLACK MESA PUMPING STATION RESERVOIR (LAT 36 26 22 LONG 110 23 33)												
NOV , 1971 10...	--	--	20	--	3.6	87	1.5	182	0	58	7.5	1.2
362728110234200 - MOENKOPI WASH AT HAUL ROAD (LAT 36 27 28 LONG 110 23 42)												
NOV , 1971 10...	--	--	7.8	--	160	180	7.7	144	0	1600	24	1.8
362738110250000 - BLACK MESA MINE, STRIP J-3 (LAT 36 27 38 LONG 110 25 00)												
NOV , 1971 10...	--	--	3.8	—	7.8	160	2.0	218	0	190	16	1.2

DATE	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (TONS PER AC-FT)	HARDNESS (CA,MG) (MG/L)	NON-CARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	DISSOLVED BORON (B) (UG/L)	CODE FOR AGENCY ANALYZING SAMPLE
360907110593600 - BEGASHIBITO WASH AT MOUTH NR TONALEA AZ (LAT 36 09 07 LONG 110 59 36)												
DEC , 1973 12...	.12	.02	432	.59	240	20	1.6	675	8.3	1.5	80	1028
JAN , 1975 21...	.31	.00	431	.59	240	22	1.5	640	8.2	1.0	70	1028
362541110233000 - PEABODY RESERVOIR ON BLACK MESA (LAT 36 25 41 LONG 110 23 30)												
JAN , 1975 22...	.12	.00	622	.85	360	180	1.2	876	8.2	.0	50	1028
NOV 06...	.01	.00	765	1.04	330	220	2.0	1060	8.8	9.0	120	1028
MAR , 1977 17...	.01	.00	546	.74	290	170	1.4	560	8.3	5.0	100	1028
362622110233300 - BLACK MESA PUMPING STATION RESERVOIR (LAT 36 26 22 LONG 110 23 33)												
NOV , 1971 10...	--	--	--	.38	40	0	6.0	445	7.9	--	--	1028
362728110234200 - MOENKOPI WASH AT HAUL ROAD (LAT 36 27 28 LONG 110 23 42)												
NOV , 1971 10...	--	--	--	3.25	1500	1400	2.8	2450	8.1	--	--	1028
362738110250000 - BLACK MESA MINE, STRIP J-3 (LAT 36 27 38 LONG 110 25 00)												
NOV , 1971 10...	--	--	--	—	42	0	8.2	846	8.5	--	--	1028

Table 6.--Chemical analyses of surface waters sampled as a part of the Black Mesa monitoring program--Continued

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)
363040110252501 - SITE 3, COAL MINE WASH ON BLACK MESA (LAT 36 30 40 LONG 110 25 25.01)												
APR , 1973 12...	1145	1.0	12	30	150	130	5.0	236	0	1300	23	.7
363142110243200 - COAL MINE WASH NEAR 09401229 (LAT 36 31 42 LONG 110 24 32)												
JAN , 1975 21...	1700	--	16	10	160	93	2.7	216	--	1400	21	.5
NOV 06...	1100	--	11	0	190	110	4.8	148	0	1800	27	.5
363213110242800 - COAL MINE WASH TRIB NO.2 AB 09401229 (LAT 36 32 13 LONG 110 24 28)												
JAN , 1975 21...	1620	--	9.4	80	660	770	5.7	248	--	4100	300	.5
363223110242700 - COAL MINE WASH TRIB 2, SITE A-4 (LAT 36 32 23 LONG 110 24 27)												
MAY , 1973 17...	1030	<.01	20	40	480	410	4.0	287	0	3100	84	1.5
NOV , 1975 06...	1145	--	15	0	540	630	5.2	256	0	3900	85	1.8
363237110250000 - PROSPECT PIT NO. 1 (LAT 36 32 37 LONG 110 25 00)												
SEP , 1973 25...	1130	--	3.0	80	350	120	22	229	0	2000	120	.8

DATE	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (TONS PER AC-FT)	HARDNESS (CA,MG) (MG/L)	NON-CARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	DISSOLVED BORON (B) (UG/L)	CODE FOR AGENCY ANALYZING SAMPLE
363040110252501 - SITE 3, COAL MINE WASH ON BLACK MESA (LAT 36 30 40 LONG 110 25 25.01)												
APR , 1973 12...	10	.01	2200	2.99	1300	1100	1.6	1900	8.1	11.5	130	1028
363142110243200 - COAL MINE WASH NEAR 09401229 (LAT 36 31 42 LONG 110 24 32)												
JAN , 1975 21...	6.0	.01	2320	3.16	1400	1300	1.1	2520	8.1	--	120	1028
NOV 06...	5.0	.00	2870	3.90	1800	1600	1.1	2690	8.6	10.0	150	1028
363213110242800 - COAL MINE WASH TRIB NO.2 AB 09401229 (LAT 36 32 13 LONG 110 24 28)												
JAN , 1975 21...	270	.01	7990	10.9	3900	3700	5.4	8000	7.0	--	900	1028
363223110242700 - COAL MINE WASH TRIB 2, SITE A-4 (LAT 36 32 23 LONG 110 24 27)												
MAY , 1973 17...	300	.03	6630	9.02	3800	3600	2.9	5500	6.7	11.0	760	1028
NOV , 1975 06...	228	.08	7290	9.91	3800	3600	4.4	6910	8.4	12.0	670	1028
363237110250000 - PROSPECT PIT NO. 1 (LAT 36 32 37 LONG 110 25 00)												
SEP , 1973 25...	1.2	.02	3430	4.66	2200	2100	1.1	3650	7.9	13.0	220	1028

Table 6.--Chemical analyses of surface waters sampled as a part of the Black Mesa monitoring program--Continued

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED SILICA (SIO2) (MG/L)	DISSOLVED IRON (FE) (UG/L)	DISSOLVED MAGNESIUM (MG) (MG/L)	DISSOLVED SODIUM (NA) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO3) (MG/L)	CARBONATE (CO3) (MG/L)	DISSOLVED SULFATE (SO4) (MG/L)	DISSOLVED CHLORIDE (CL) (MG/L)	DISSOLVED FLUORIDE (F) (MG/L)
363243110252200 - YELLOW WATER CANYON AT ROAD CROSSING (LAT 36 32 43 LONG 110 25 22)												
JAN , 1975												
22...	1700	--	2.2	10	45	37	2.6	45	--	570	5.0	.3
JUL												
29...	1730	E30	11	310	12	9.6	7.6	176	0	110	7.6	.6

DATE	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED ORTHO. PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180 C) (MG/L)	DISSOLVED SOLIDS (TONS PER AC-FT)	HARDNESS (CA,MG) (MG/L)	NONCARBONATE HARDNESS (MG/L)	SODIUM ADSORPTION RATIO	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	DISSOLVED BORON (B) (UG/L)	CODE FOR AGENCY ANALYZING SAMPLE
363243110252200 - YELLOW WATER CANYON AT ROAD CROSSING (LAT 36 32 43 LONG 110 25 22)												
JAN , 1975												
22...	1.7	.01	874	1.19	540	500	.7	1120	7.2	--	30	1028
JUL												
29...	.01	.00	379	.52	230	90	.3	400	7.7	17.5	130	1028

09401260. MOENKOPI WASH AT MOENKOPI, ARIZ.

LOCATION.--Lat 36°06'18", long 111°12'04", in NE¼ sec.3, T.31 N., R.11 E. (unsurveyed), Coconino County, in Navajo Indian Reservation, at gaging station 1.3 mi (2.1 km) southeast of Moenkopi, 12.5 mi (20.1 km) downstream from Begashibito Wash, 2.5 mi (4.0 km) downstream from former gaging station 09401250.

DRAINAGE AREA.--1,660 mi^2 (4,300 km^2), approximately.

PERIOD OF RECORD.--Specific conductance: October 1973 to current year.
Water temperature: October 1973 to current year.
Sediment records: October 1973 to current year.

EXTREMES.--Current year:
Specific conductance: Maximum daily, 3,000 micromhos July 30; minimum daily, 700 micromhos Dec. 13.
Water temperatures: Maximum observed, 33.0°C July 30; minimum observed, 1.0°C Nov. 21, Jan 3, 4, 15, 24.
Sediment concentrations: Maximum daily, 262,000 mg/L Sept. 25; minimum daily, no flow on many days.
Sediment discharge: Maximum daily, 1,600,000 tons (1,450,000 tonnes) Sept. 25; minimum daily, 0 ton (0 tonne) on many days.
Period of record:
Specific conductance: Maximum daily, 4,070 micromhos July 14, 1975; minimum daily, 700 micromhos Dec. 13, 1975.
Water temperatures: Maximum observed, 33.0°C July 9, Aug. 22, 1975, July 30, 1976; minimum observed, freezing point on many days during winter months.
Sediment concentrations: Maximum daily, 262,000 mg/L Sept. 25, 1976; minimum daily, no flow on many days.
Sediment discharge: Maximum daily, 1,600,000 tons (1,450,000 tonnes) Sept. 25, 1976; minimum daily, 0 ton (0 tonne) on many days.

REMARKS.--Sediment loads from Oct. 1 to June 30 were computed using discharge at sta 09401250; after July 1 sediment loads were computed from discharge obtained at this site.

SPECIFIC CONDUCTANCE (MICROMHOS/CM AT 25 DEG. C), WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976
ONCE-DAILY

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1390	820	1300	660	870	940	1030	1040	1150	---	2550	---
2	1380	870	1360	1060	---	950	1070	1080	1180	---	2400	---
3	---	850	960	1090	970	1040	955	1040	1200	---	2400	---
4	1300	820	810	990	975	1040	1140	1080	1200	---	2300	1480
5	1220	750	850	1010	980	1000	1140	1040	---	---	2300	1160
6	1210	810	800	890	975	1020	1120	1070	---	---	2400	1460
7	1210	830	800	885	965	940	960	1090	---	---	---	1450
8	1250	800	800	870	990	925	1000	1070	---	---	2000	982
9	1250	800	800	860	1010	940	980	1060	---	---	2600	1740
10	1250	820	780	820	1090	950	965	1030	---	---	2500	1760
11	1210	800	650	640	1070	935	1100	1020	---	---	2400	1500
12	1210	820	600	770	1040	990	1030	1010	---	---	---	1280
13	1210	850	700	820	1010	965	1080	1080	---	---	---	1150
14	1200	920	690	855	1060	1000	1110	1090	---	---	---	1290
15	1200	820	900	875	1040	920	1140	1100	---	---	---	1550
16	1180	820	1050	790	975	935	1360	1070	---	---	---	1550
17	1220	820	1150	780	1060	940	1120	1040	---	---	---	1450
18	1100	820	1150	815	925	980	1100	1060	---	---	---	1410
19	1070	850	770	830	1050	960	970	1040	---	---	---	1370
20	1070	920	860	815	1050	1010	970	1060	---	---	1690	1180
21	1150	900	950	655	1090	975	930	1320	---	---	1600	1160
22	1150	910	750	770	1050	950	915	1100	---	---	1520	1310
23	1120	850	730	790	1030	925	915	1120	---	---	1410	1170
24	1080	920	900	920	990	1030	930	1040	---	2700	885	1320
29	1040	930	880	870	940	950	930	1100	---	2700	---	1210
30	1020	1220	900	850	---	990	965	1160	---	3000	1990	1200
31	1020	---	860	890	---	---	---	1240	---	2600	2400	---
MEAN	1170	878	866	858	1010	964	1020	1080	---	---	---	1430

YEAR	MAX	3000	MIN	700	MEAN	1130

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--October 1973 to current year.

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 1973 to current year.
WATER TEMPERATURES: October 1973 to current year.
SUSPENDED SEDIMENT DISCHARGE: October 1973 to current year.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: Maximum observed, 4,070 micromhos July 14, 1975; minimum observed, 564 micromhos Dec. 28, 1976.
WATER TEMPERATURES: Maximum observed, 33.0°C July 9, Aug. 22, 1975, July 30, 1976; minimum observed, 0.0°C on many days during winter months.
SEDIMENT CONCENTRATIONS: Maximum daily, 262,000 mg/L Sept. 25, 1976; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 1,600,000 tons (1,450,000 tonnes) Sept. 25, 1976; minimum daily, 0 ton (0 tonne) on many days.

EXTREMES FOR CURRENT YEAR.--
SPECIFIC CONDUCTANCE: Maximum observed, 3,110 micromhos July 19; minimum observed, 564 micromhos Dec. 28.
WATER TEMPERATURES: Maximum observed, 30.0°C Aug. 22; minimum observed, 1.0°C Dec. 11, 18, Jan. 7, 15, 16, 19, 31, Feb. 2.
SEDIMENT CONCENTRATIONS: Maximum daily, 207,000 mg/L July 21; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 840,000 tons (762,000 tonnes) July 23; minimum daily, 0 ton (0 tonne) on many days.

SPECIFIC CONDUCTANCE (MICROMHOS/CM AT 25 DEG. C), WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977
ONCE-DAILY

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1440	978	1210	729	868	985	920	1000	1060	---	2070	---
2	1480	962	1150	752	870	965	866	1040	1090	---	---	---
3	1470	952	1140	726	872	966	865	1050	1090	---	---	2120
4	1440	955	1030	786	872	936	872	1010	1100	---	---	2040
5	1410	944	1020	842	881	946	894	1010	1120	---	---	2050
6	1380	935	962	848	868	939	906	1050	1110	---	---	1410
7	1370	935	953	909	893	970	900	1150	1120	---	---	1790
8	1340	934	935	914	880	962	922	1150	1120	---	---	1870
9	1300	1030	855	909	891	970	931	1150	1120	---	---	1870
10	1290	989	935	1010	891	954	964	1180	1140	---	---	1900
11	1280	995	827	1040	866	1020	979	1130	---	---	---	1780
12	1240	913	---	1010	864	1000	975	1180	---	1910	1700	1770
13	1230	912	848	1020	869	1000	1000	1120	---	1730	2100	2260
14	1200	955	861	1010	871	1000	995	1160	---	2000	2000	1880
15	1180	927	873	999	860	930	976	1160	---	2150	1720	1970
16	1160	1030	---	951	886	886	962	1110	---	2140	1450	2140
17	1140	911	---	904	898	884	970	1100	---	1570	1910	2190
18	1120	915	857	880	886	895	971	1090	---	2080	1900	2130
19	1120	912	899	820	883	865	991	1030	---	3110	1900	1970
20	1110	894	869	796	902	870	954	1040	---	1510	1800	1880
21	1090	900	915	758	905	861	955	1040	---	1720	1790	1790
22	1060	906	886	784	936	857	929	989	---	1280	1820	1660
23	1050	894	907	803	959	859	946	977	---	1230	1900	1420
24	1030	901	915	739	922	954	927	993	---	1310	1900	1400
25	1010	912	910	776	938	885	936	988	---	1540	1980	1410
26	1020	900	884	883	961	902	958	986	---	1800	1930	1330
27	1020	917	923	907	973	881	969	959	---	1820	1560	1360
28	1020	962	564	884	983	875	971	968	---	1880	1570	1320
29	976	988	883	883	---	894	991	1040	---	1890	---	1250
30	971	1020	728	880	---	900	1000	1030	---	1910	---	1260
31	975	---	731	879	---	917	---	1050	---	---	---	---
MEAN	1190	943	910	872	898	927	947	1060	1110	1820	1830	1760

WTR YR 1977 MEAN 1150 MAX 3110 MIN 564

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--October 1973 to current year.

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 1973 to current year.
WATER TEMPERATURES: October 1973 to current year.
SUSPENDED SEDIMENT DISCHARGE: October 1973 to current year.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: Maximum observed, 4,070 micromhos July 14, 1975; minimum observed, 564 micromhos Dec. 28, 1976.
WATER TEMPERATURES: Maximum observed, 33.0°C July 9, Aug. 22, 1975, July 30, 1976; minimum observed, 0.0°C on many days during winter months.
SEDIMENT CONCENTRATIONS: Maximum daily, 262,000 mg/L Sept. 25, 1976; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 1,600,000 tons (1,450,000 tonnes) Sept. 25, 1976; minimum daily, 0 ton (0 tonne) on many days.

EXTREMES FOR CURRENT YEAR.--
SPECIFIC CONDUCTANCE: Maximum observed, 3,080 micromhos Oct. 29; minimum observed, 702 micromhos Feb. 20.
WATER TEMPERATURES: Maximum observed, 29.0°C May 19; minimum observed, 1.0°C Nov. 9.
SEDIMENT CONCENTRATIONS: Maximum daily, 114,000 mg/L Sept. 25; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 34,700 tons (31,500 tonnes) Sept. 25; minimum daily, 0 ton (0 tonne) on many days.

WATER QUALITY DATA, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)
NOV 21...	1615	2.4	1000	8.2	8.0	290	85	83
JAN 04...	1715	2.7	920	8.4	7.5	240	55	65
FEB 17...	1340	3.5	900	8.1	4.0	250	77	70
JUL 19...	1215	2.8	1400	8.5	27.0	230	15	47
SEP 25...	1630	75	2100	7.2	19.0	1300	1100	380

DATE	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)	CARBONATE (MG/L AS CO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)
NOV 21...	20	120	3.1	5.8	250	0	310	15	.5
JAN 04...	19	110	3.1	4.2	210	8	290	15	.6
FEB 17...	18	100	2.8	3.6	210	0	260	13	.5
JUL 19...	27	260	7.5	7.7	260	0	510	20	.6
SEP 25...	97	220	2.6	14	360	0	1500	22	.5

DATE	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	SOLIDS, DISSOLVED (TONS PER AC-FT)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	PHOSPHORUS, ORTHO, DISSOLVED (MG/L AS P)	BORON, DISSOLVED (UG/L AS B)	IRON, DISSOLVED (UG/L AS FE)
NOV 21...	10	678	689	.92	.30	.00	0	60
JAN 04...	7.8	652	624	.89	.16	.00	80	10
FEB 17...	7.2	573	577	.78	.15	.00	80	20
JUL 19...	11	984	1020	1.34	2.1	.01	150	680
SEP 25...	11	2630	2430	3.58	1.7	.06	190	40

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

SPECIFIC CONDUCTANCE (MICROMHOS/CM AT 25 DEG. C), WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
ONCE-DAILY

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1260	856	834	912	854	1030	959	1210	1050	---		---
2	1200	873	837	925	859	---	916	966	1060	---		---
3	1070	862	791	926	851	1490	933	964	1110	---		---
4	1130	832	788	901	836	1510	932	938	1200	---		---
5	1060	846	812	873	821	1520	916	961	1200	---		---
6	1130	1150	815	869	818	1170	870	878	1200	---		---
7	1110	1160	829	856	826	1280	903	868	1280	---		---
8	1130	1160	825	867	848	1540	909	862	1500	---		---
9	1170	1380	840	853	826	1230	919	862	1380	---		---
10	1140	1400	868	864	854	1220	898	865	1380	---		---
11	1130	1220	862	876	847	1090	902	883	---	---		---
12	1020	894	833	897	859	911	860	863	---	---		---
13	955	870	822	847	963	883	901	903	---	---		---
14	2970	860	815	861	832	858	890	908	---	---		---
15	1000	838	896	856	847	1400	887	879	---	---		---
16	926	834	891	888	841	1410	919	930	---	---		---
17	900	880	971	888	836	883	929	1030	---	---		---
18	918	875	931	909	853	861	840	1020	---	---		---
19	896	908	937	873	868	857	847	999	---	1600		---
20	893	916	951	943	702	841	840	935	---	1450		---
21	887	925	809	933	782	---	938	926	---	---		---
22	900	853	809	910	771	856	951	920	---	---		---
23	889	842	809	922	775	845	895	923	---	---		---
24	881	859	803	897	781	916	850	1090	---	---		---
25	872	834	798	892	804	917	876	1240	---	---		1820
26	869	835	780	872	786	871	862	1250	---	2090		2500
27	848	816	781	894	843	830	899	1150	---	1800		2200
28	839	815	785	797	847	847	903	1150	---	1810		2060
29	3080	824	909	789	---	840	889	1040	---	1740		1930
30	1000	822	925	805	---	837	865	1050	---	1800		1750
31	883	---	955	840	---	973	---	1040	---	---		---
MAX	3080	1400	971	943	963	1540	959	1250	1500	2090		2500
MIN	839	815	780	789	702	830	840	862	1050	1450		1750

WTR YR 1978 MAX 3080 MIN 702

WATER-QUALITY RECORDS

PERIOD OF RECORD.--October 1973 to current year.

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 1973 to September 1978.
WATER TEMPERATURES: October 1973 to September 1978.
SUSPENDED-SEDIMENT DISCHARGE: October 1973 to current year.

EXTREMES FOR PERIOD OF DAILY RECORD.--
SEDIMENT CONCENTRATIONS: Maximum daily, 262,000 mg/L Sept. 25, 1976; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 1,600,000 tons (1,450,000 tonnes) Sept. 25, 1976; minimum daily, 0 ton (0 tonne) on many days.

EXTREMES FOR CURRENT YEAR.--
SEDIMENT CONCENTRATIONS: Maximum daily, 108,000 mg/L Feb. 14; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 47,200 tons (42,800 tonnes) Nov. 12; minimum daily, 0 ton (0 tonne) on many days.

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DATE	TIME	STREAM-FLOW, INSTANTANEOUS (CFS)	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE, WATER (DEG C)	OXYGEN, DISSOLVED (MG/L)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	SODIUM ADSORPTION RATIO
NOV 16...	1430	2.8	1050	8.8	--	--	--	--	110	--	80	--
DEC 14...	1400	E10	825	8.0	--	--	240	140	68	17	98	2.8
JAN 03...	1530	2.5	1080	8.1	1.0	--	310	95	84	24	120	3.0
MAR 08...	1200	9.4	2900	7.7	15.5	--	1100	930	300	82	190	2.5
APR 06...	1600	E2.0	1000	8.5	16.5	7.0	220	57	59	18	99	2.9

DATE	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	SOLIDS, DISSOLVED (TONS PER AC-FT)	BORON, DISSOLVED (UG/L AS B)	IRON, DISSOLVED (UG/L AS FE)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)
NOV 16...	6.3	110	450	9.6	.5	6.6	791	--	1.08	80	--	.86
DEC 14...	4.2	98	260	13	.4	8.6	579	530	.79	80	0	.43
JAN 03...	5.3	210	350	7.0	.6	12	752	734	1.02	80	0	.65
MAR 08...	11	160	1400	21	.7	14	2140	2120	2.91	120	30	2.2
APR 06...	4.0	160	260	13	.6	6.7	559	559	.76	80	0	.04

E Estimated.

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--October 1975 to current year.

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 1975 to September 1978.
WATER TEMPERATURES: October 1975 to September 1978.
SUSPENDED-SEDIMENT DISCHARGE: October 1975 to December 1979 (discontinued).

EXTREMES FOR PERIOD OF DAILY RECORD.--
SEDIMENT CONCENTRATIONS: Maximum daily, 262,000 mg/L Sept. 25, 1976; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 1,600,000 tons (1,450,000 tonnes) Sept. 25, 1976; minimum daily, 0 ton (0 tonne) on many days.

EXTREMES FOR PERIOD OCTOBER - DECEMBER 1979.--
SEDIMENT CONCENTRATIONS: Maximum daily, 70,000 mg/L Oct. 21; minimum daily, no flow on many days.
SEDIMENT LOADS: Maximum daily, 15,700 tons (14,200 tonnes) Oct. 21; minimum daily, 0 ton (0 tonne) on many days.

WATER QUALITY DATA, WATER YEAR OCTOBER 1979 TO SEPTEMBER 1980

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS)	PH (UNITS)	TEMPER-ATURE, WATER (DEG C)	OXYGEN, DIS-SOLVED (MG/L)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)
NOV 14...	1600	.60	790	8.3	7.0	9.6	200	21	59
DEC 12...	1030	3.7	650	8.4	1.5	--	200	20	57
JAN 15...	1400	3.0	850	8.7	8.0	--	190	0	50
AUG 18...	1400	.42	2875	8.2	27.0	--	1400	1400	450

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)
NOV 14...	13	95	2.9	4.8	180	220	12	.4	10
DEC 12...	14	89	2.7	3.8	180	170	12	.4	11
JAN 15...	13	120	3.8	4.5	190	220	12	.5	9.4
AUG 18...	74	110	1.3	12	67	1600	11	.6	6.8

DATE	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	BORON, DIS-SOLVED (UG/L AS B)	IRON, DIS-SOLVED (UG/L AS FE)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	PHOS-PHORUS, ORTHOPH OSPHATE DISSOL. (MG/L AS P)	PHOS-PHORUS, ORTHOPH OSPHATE DISSOL. (MG/L AS PO4)
NOV 14...	527	526	.72	80	90	.72	.00	.00
DEC 12...	470	468	.64	60	40	.63	.00	.00
JAN 15...	541	549	.74	70	50	.28	.00	.00
AUG 18...	2390	2310	3.25	120	40	1.2	.00	.00

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--October 1973 to April 1981 (discontinued).

PERIOD OF DAILY RECORD.--
SPECIFIC CONDUCTANCE: October 1973 to September 1978.
WATER TEMPERATURES: October 1973 to September 1978.
SUSPENDED-SEDIMENT DISCHARGE: October 1973 to December 1979.

WATER QUALITY DATA, WATER YEAR OCTOBER 1980 TO SEPTEMBER 1981

DATE	TIME	STREAMFLOW, INSTANTANEOUS (CFS)	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	HARDNESS (MG/L AS CACO3)	HARDNESS NONCARBONATE (MG/L AS CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)
JAN									
08...	1615	5.0	840	8.8	3.0	220	25	62	17
FEB									
05...	1400	2.5	815	--	5.0	220	41	62	16
APR									
02...	1400	1.8	860	8.5	18.0	210	20	56	17

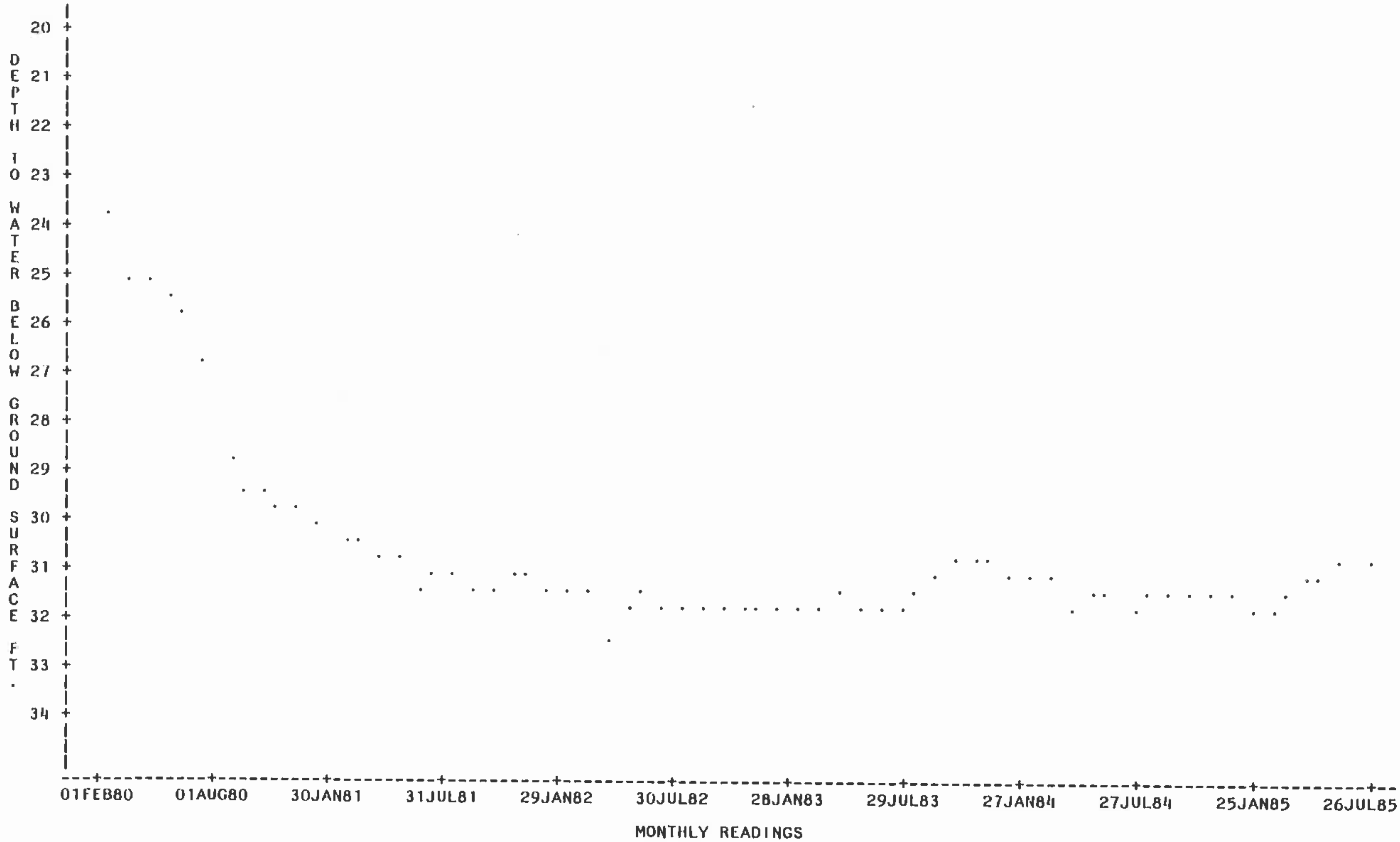
DATE	SODIUM, DISSOLVED (MG/L AS NA)	SODIUM ADSORPTION RATIO	POTASSIUM, DISSOLVED (MG/L AS K)	ALKALINITY LAB (MG/L AS CACO3)	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)
JAN									
08...	97	2.8	3.1	200	230	11	.5	7.6	539
FEB									
05...	92	2.7	2.9	180	220	11	.4	8.2	521
APR									
02...	110	3.3	3.6	190	240	13	.5	6.4	564

DATE	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	SOLIDS, DISSOLVED (TONS PER AC-FT)	BORON, DISSOLVED (UG/L AS B)	IRON, DISSOLVED (UG/L AS FE)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	PHOSPHORUS, ORTHO, DISSOLVED (MG/L AS P)	PHOSPHATE, ORTHO, DISSOLVED (MG/L AS PO4)	POTASSIUM 40 DISSOLVED (PCI/L AS K40)
JAN								
08...	549	.73	50	20	.11	.010	.03	--
FEB								
05...	521	.71	50	230	.02	--	--	2.2
APR								
02...	562	.77	60	30	.24	--	--	2.7

ATTACHMENT 7

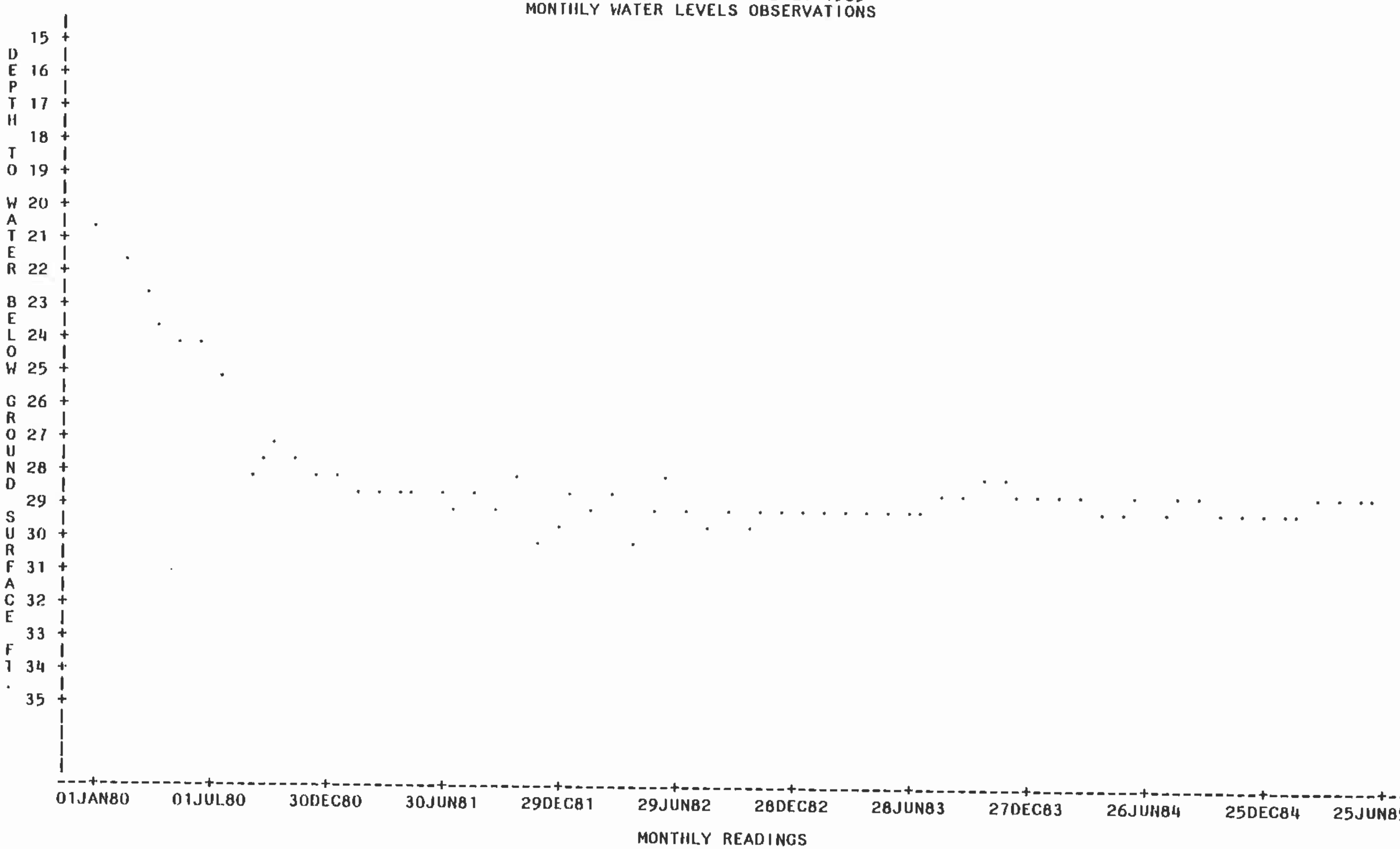
Wepo Well Hydrograph Analyses

WEPO WELL # 38
FEBRUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



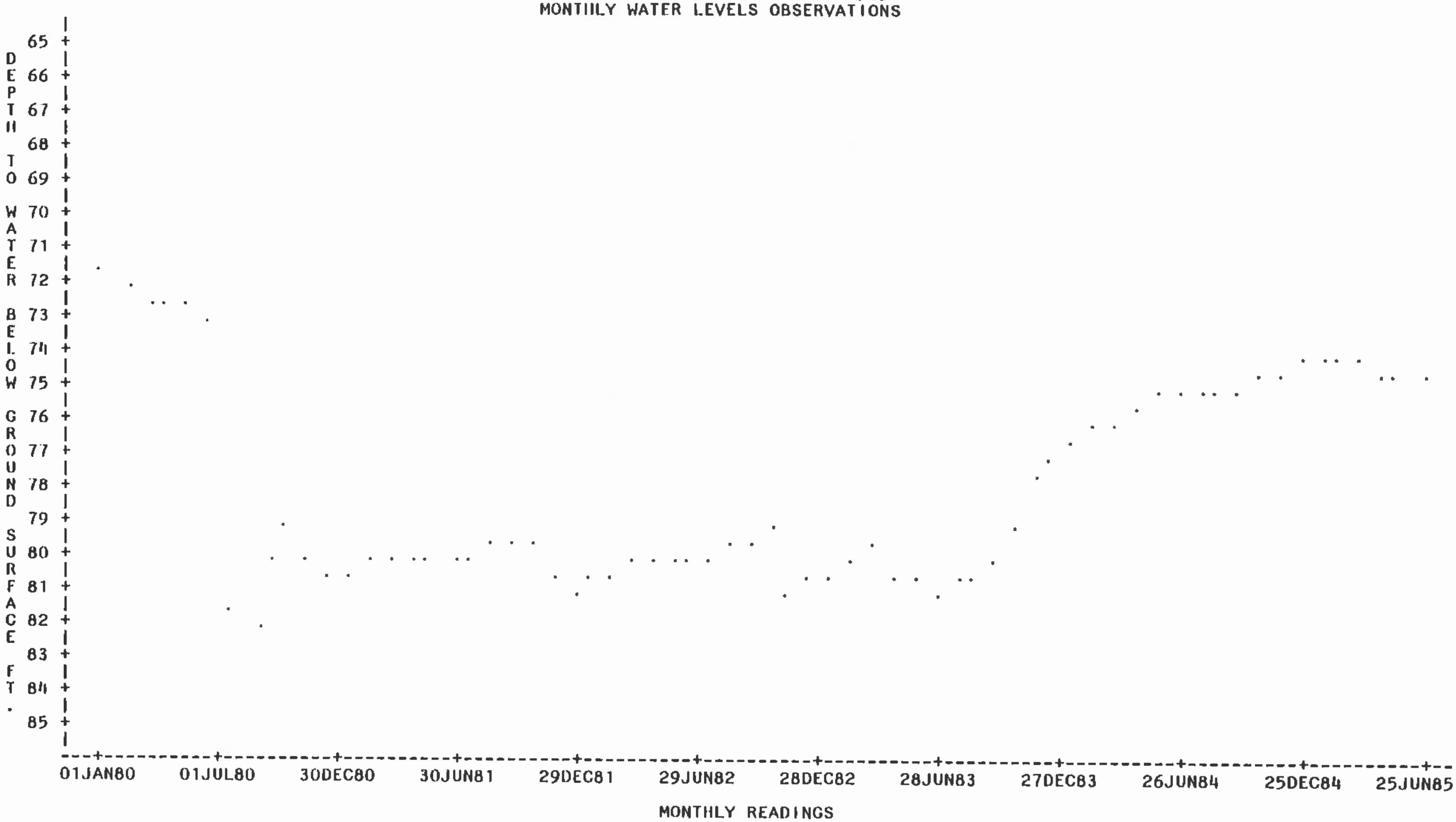
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	66	30.55500000	1.86625685	23.52000000	32.37000000	8.85000000

WEPO WELL # 39
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



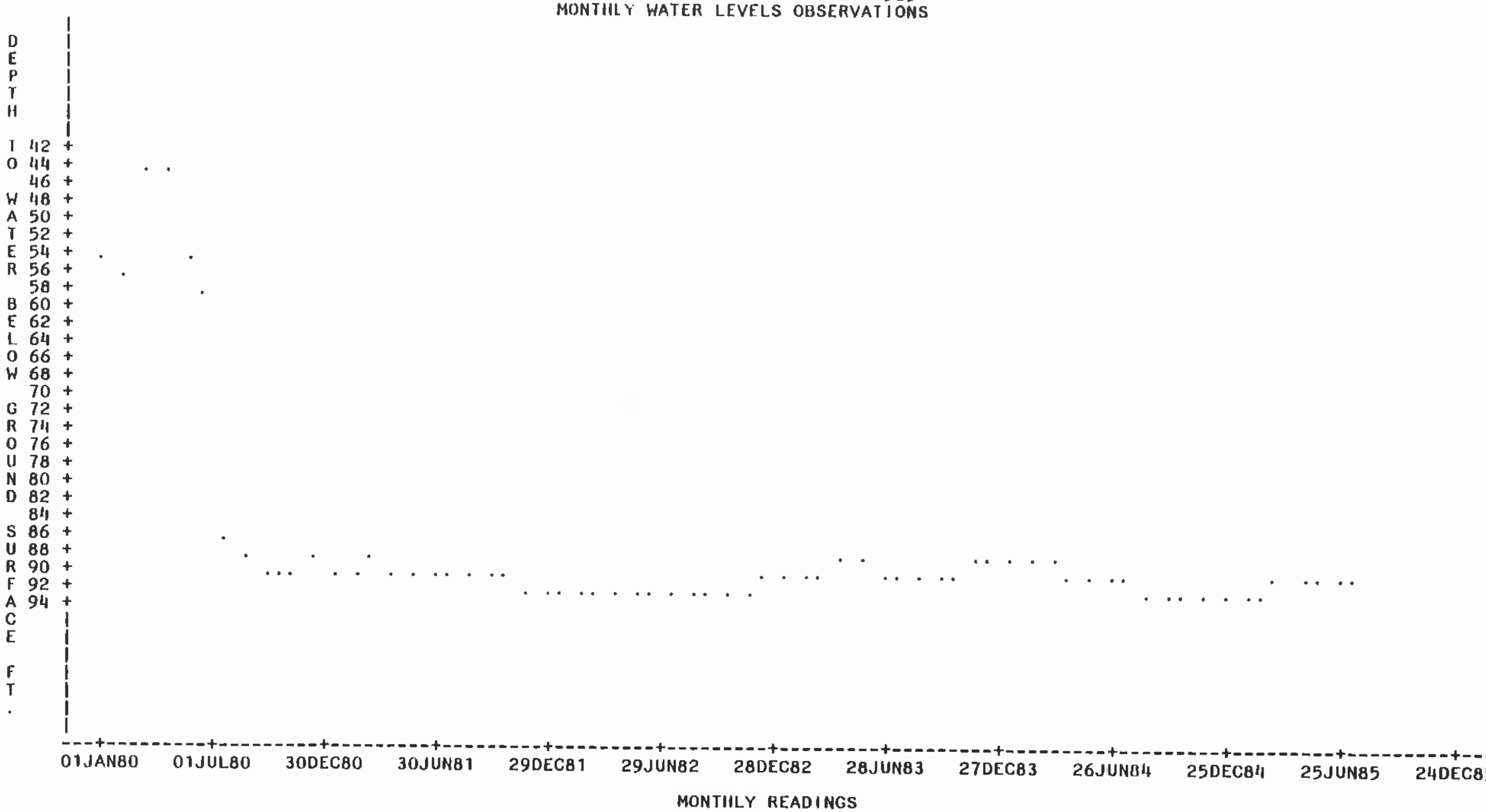
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	67	28.09194030	1.87256123	20.75000000	30.25000000	9.50000000

WEPO WELL # 40
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



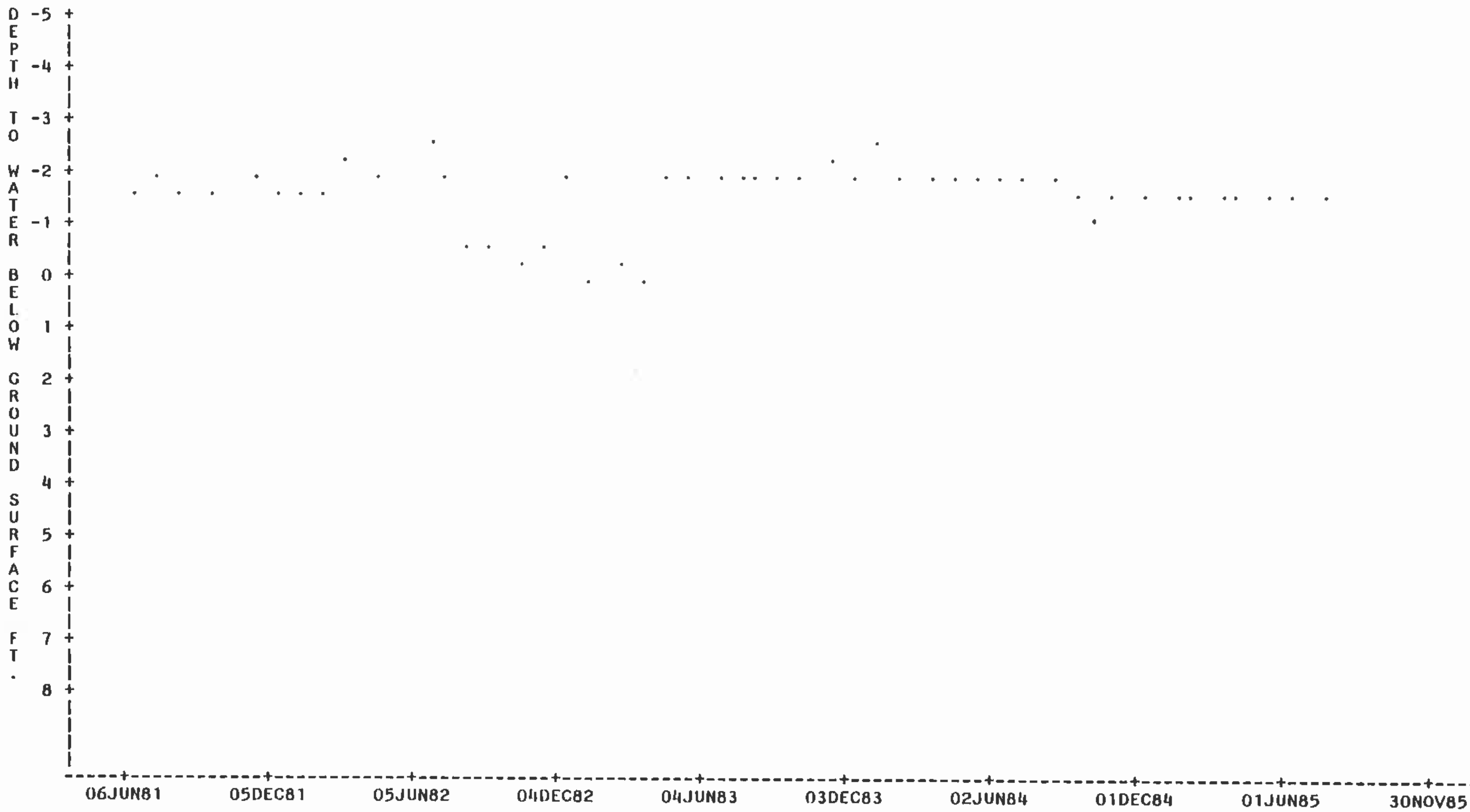
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	67	77.89835821	3.02767267	71.54000000	82.23000000	10.69000000

WEPO WELL # 41
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	67	86.72447761	11.27321716	43.80000000	92.44000000	48.64000000

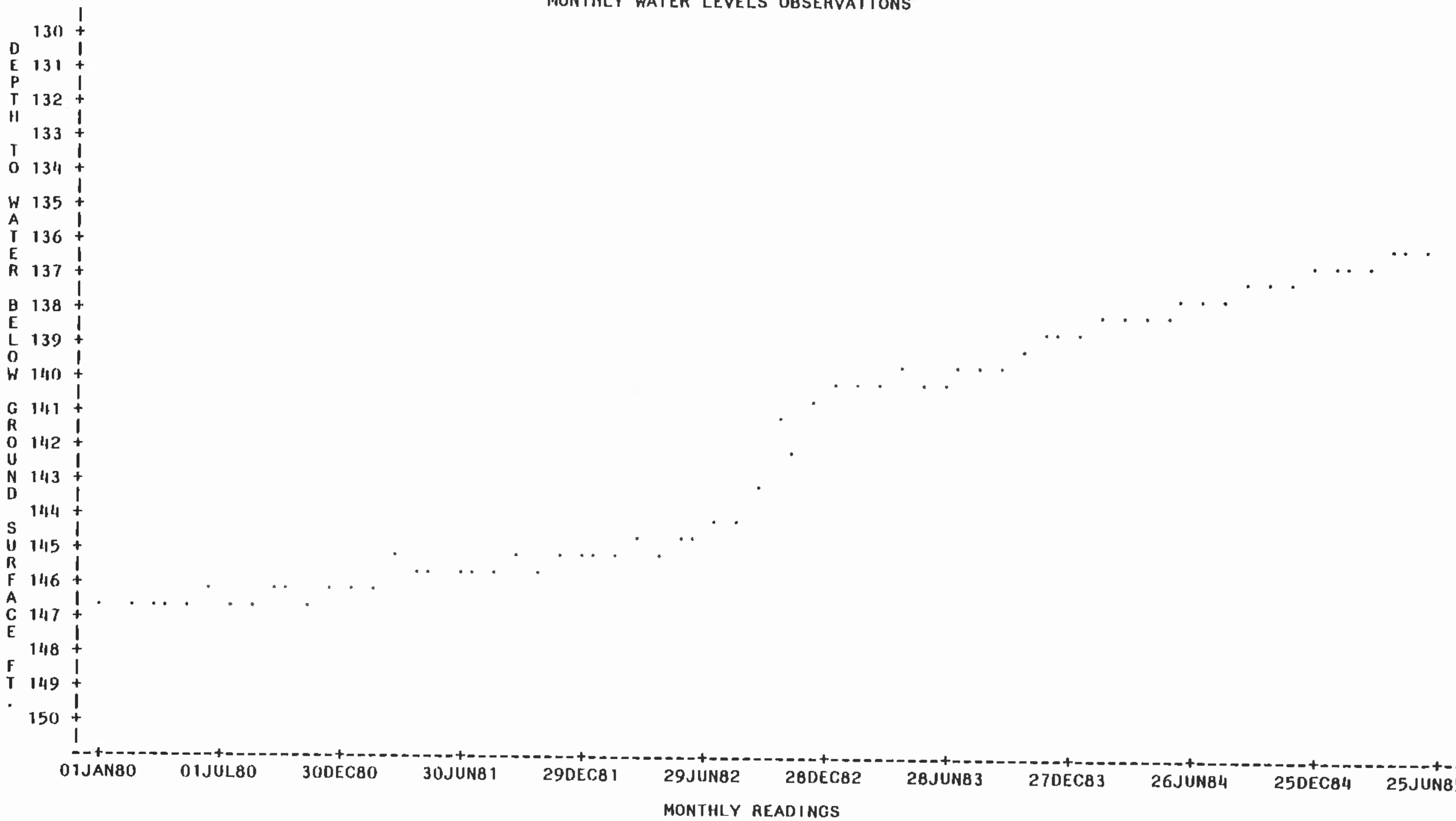
WEPO WELL # 42
JUNE 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	48	-1.70875000	0.59359570	-2.55000000	-0.08000000	2.47000000

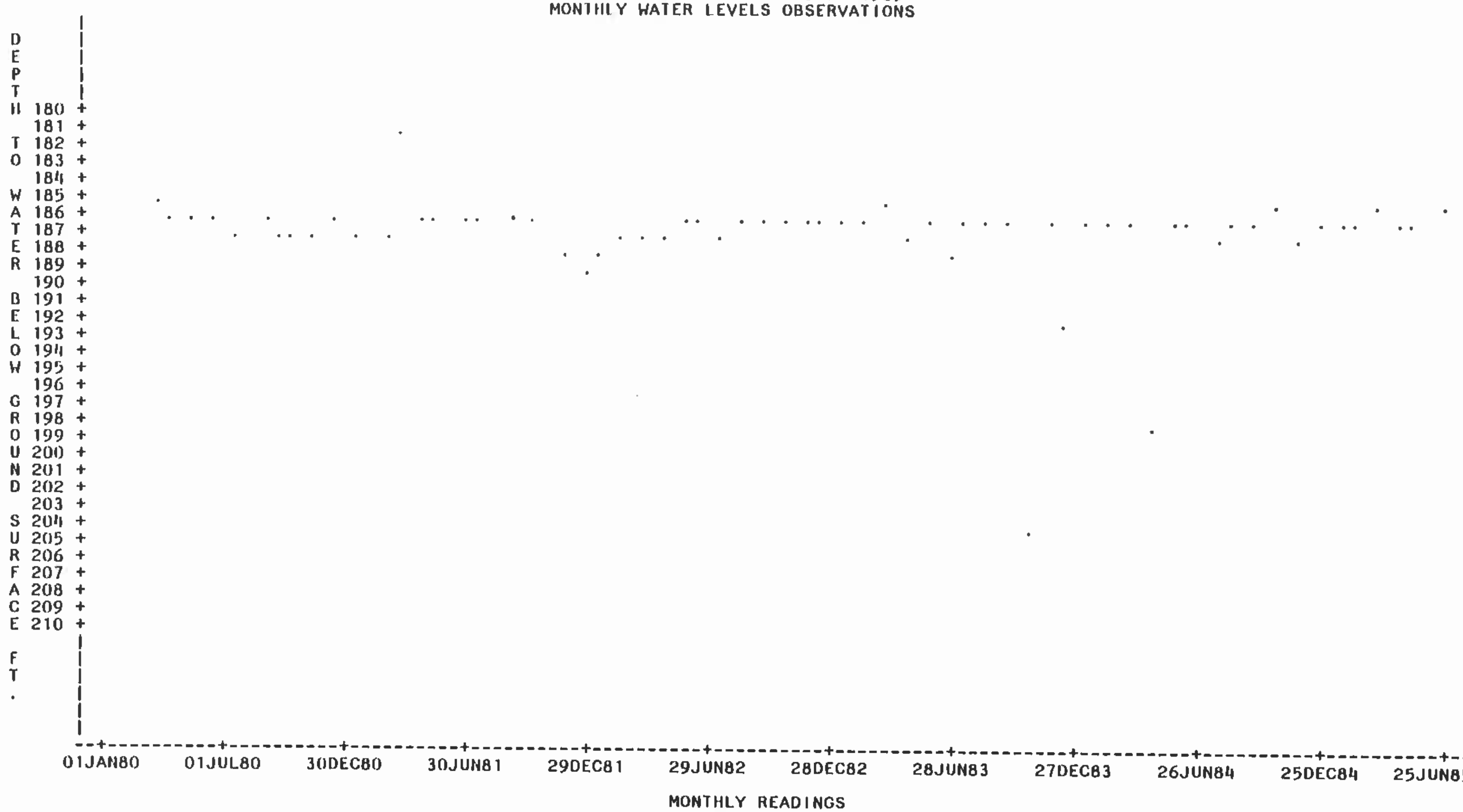
NOTE: NEGATIVE VALUES IMPLY MEASUREMENT OF PIEZOMETERIC HEAD ABOVE GROUND SURFACE.

WEPO WELL # 43
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



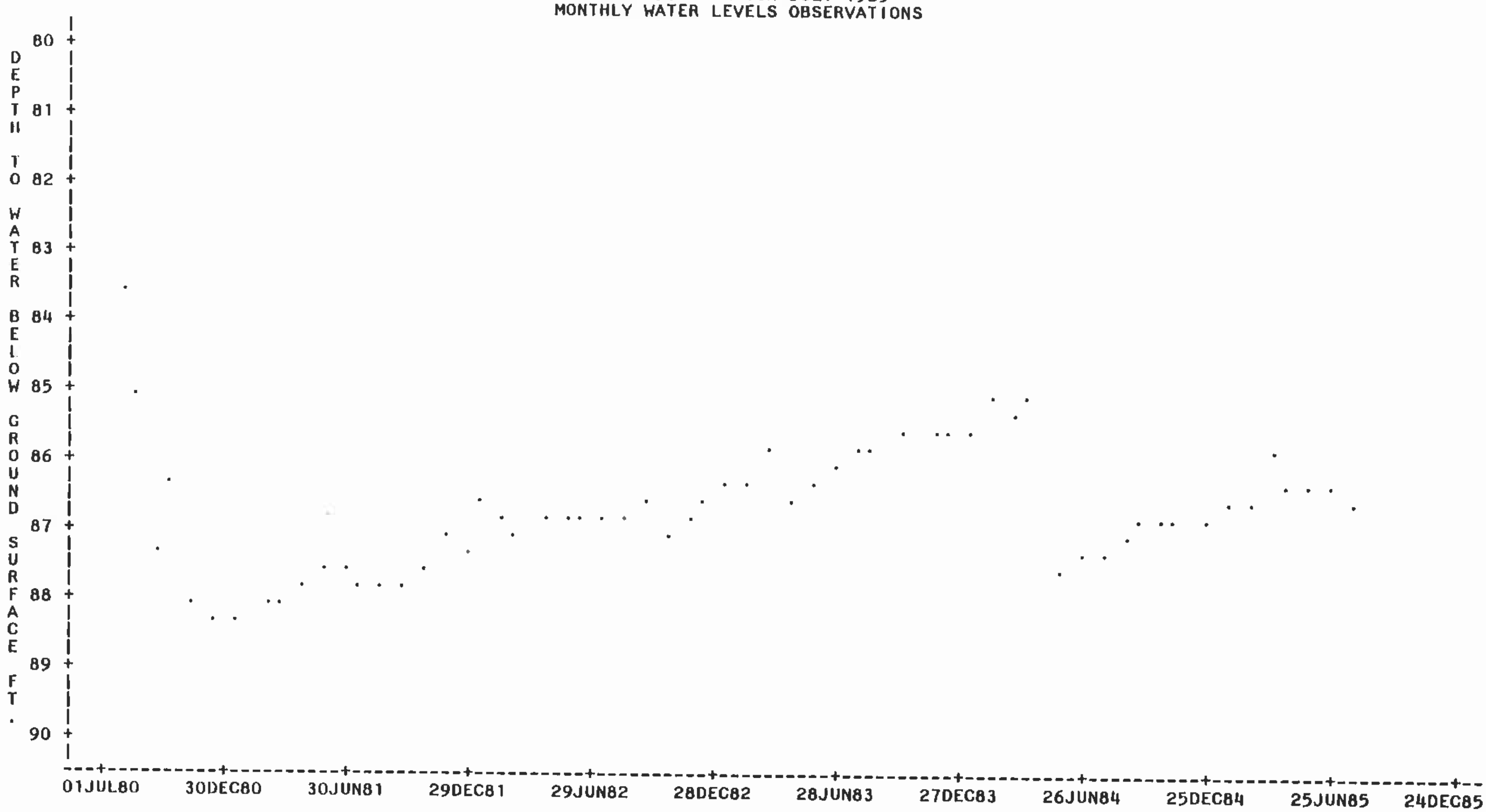
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	67	141.81641791	3.83925486	135.80000000	146.60000000	10.80000000

WEPO WELL # 44
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



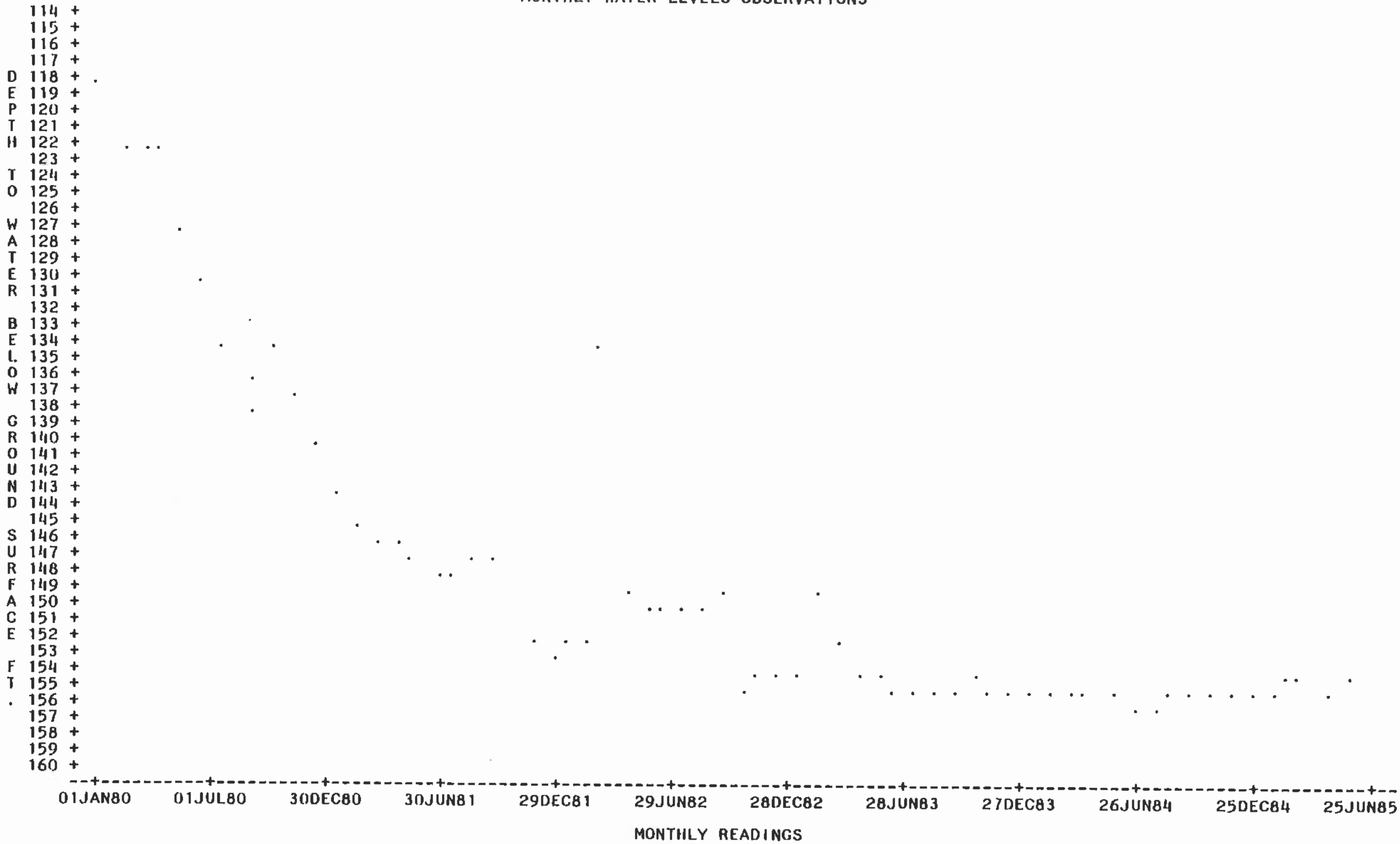
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	65	186.77846154	2.82452940	180.90000000	203.80000000	22.90000000

WEPO WELL # 45
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



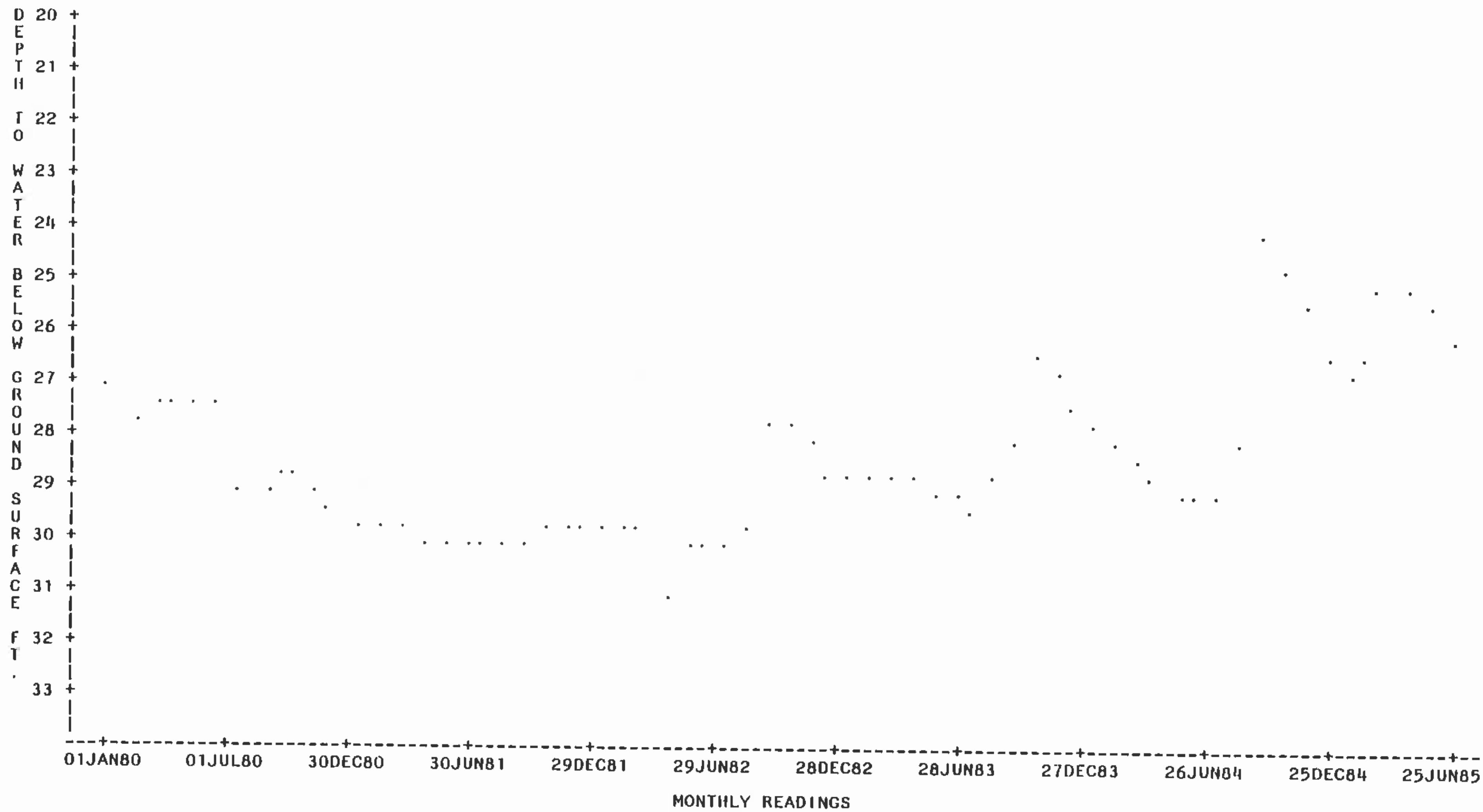
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	61	86.56737705	0.91325407	83.44000000	88.15000000	4.71000000

WEPO WELL # 46
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



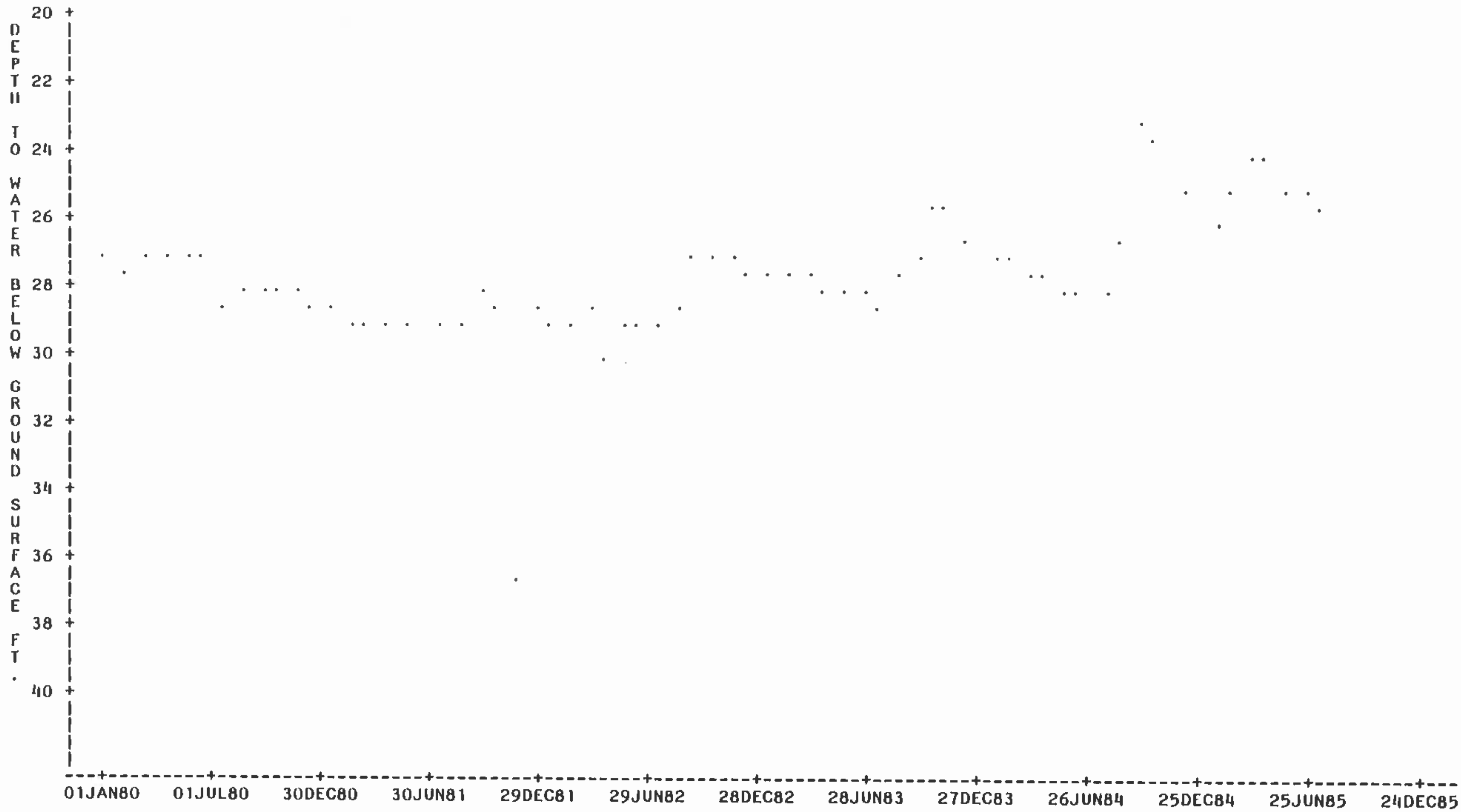
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	66	148.19242424	9.88472498	117.90000000	155.90000000	38.00000000

WEPO WELL # 47
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



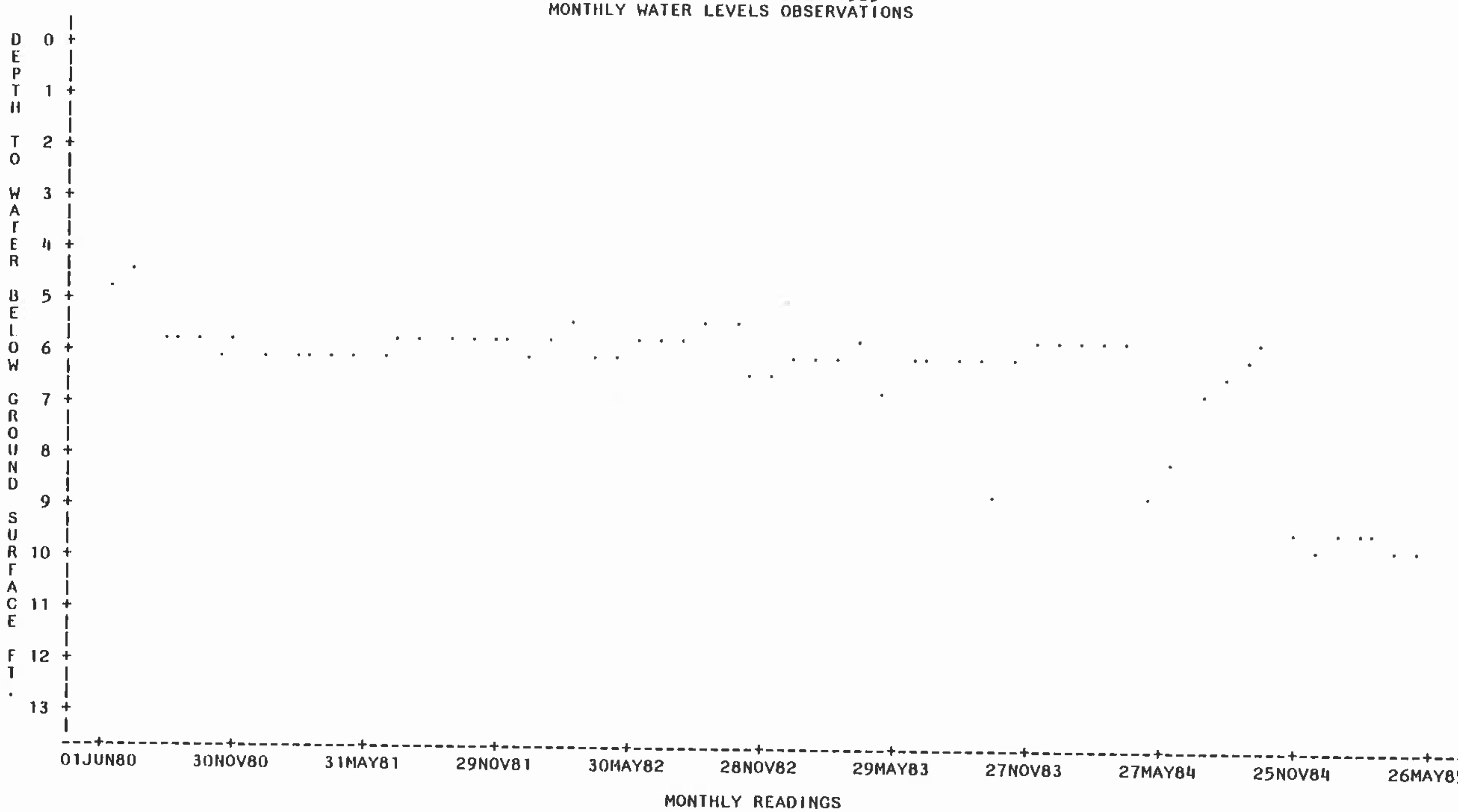
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	67	28.29104478	1.55663987	24.02000000	30.92000000	6.90000000

WEPO WELL # 48
JANUARY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



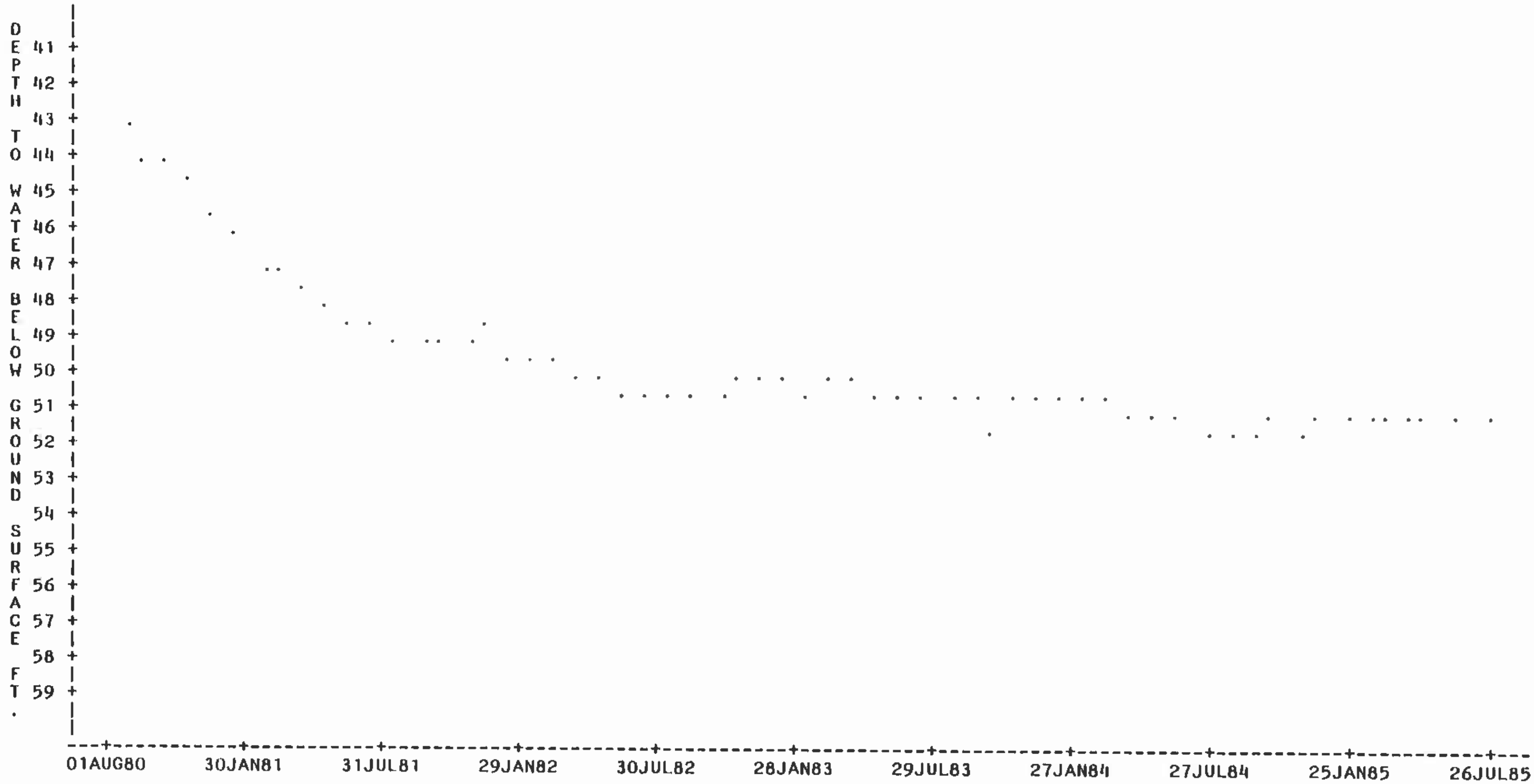
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	66	27.49848485	1.90616348	22.81000000	36.60000000	13.79000000

WEPO WELL # 49
JUNE 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



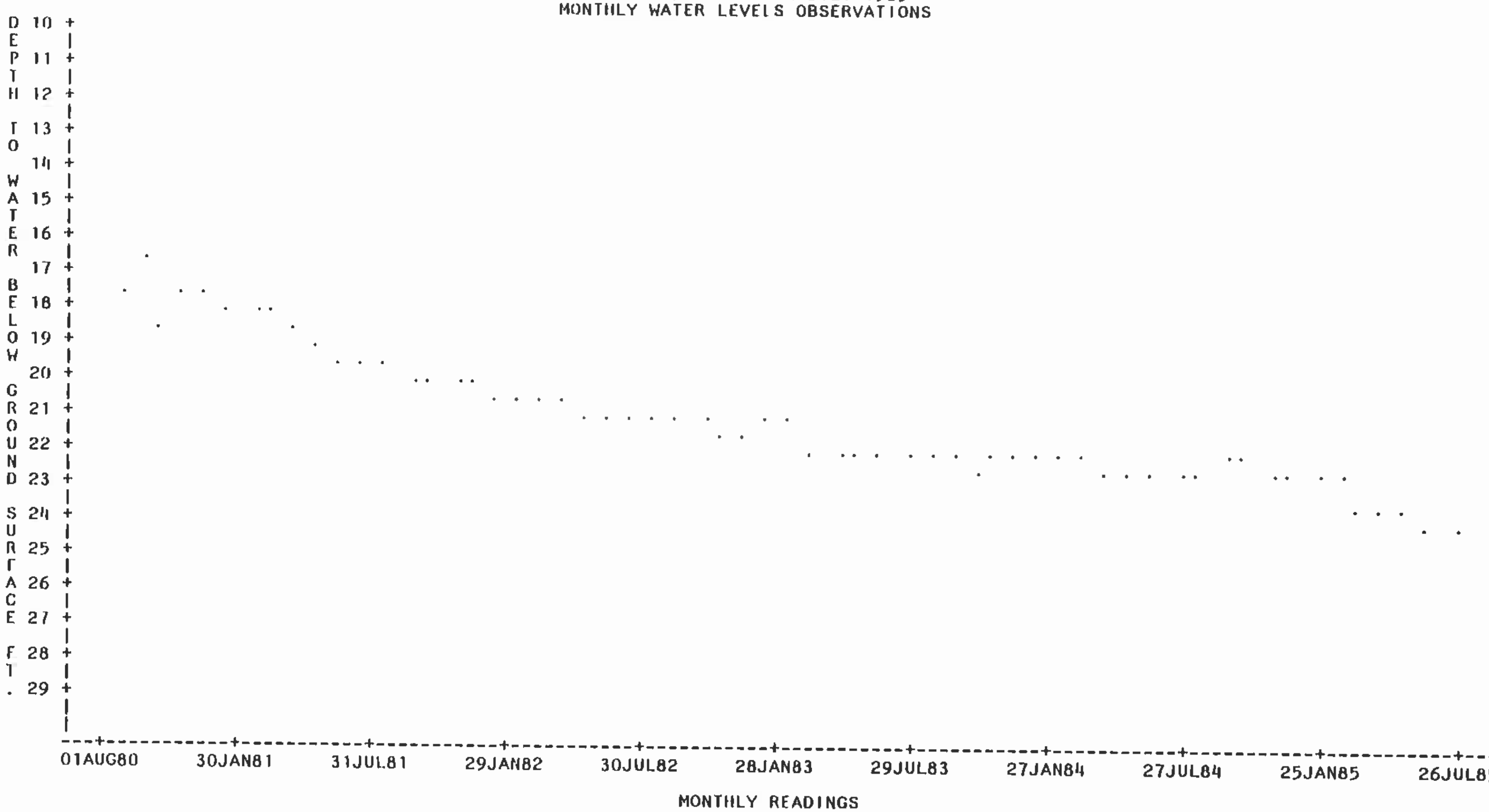
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	62	6.45306452	1.40309680	4.27000000	9.73000000	5.46000000

WEPO WELL # 51
AUGUST 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



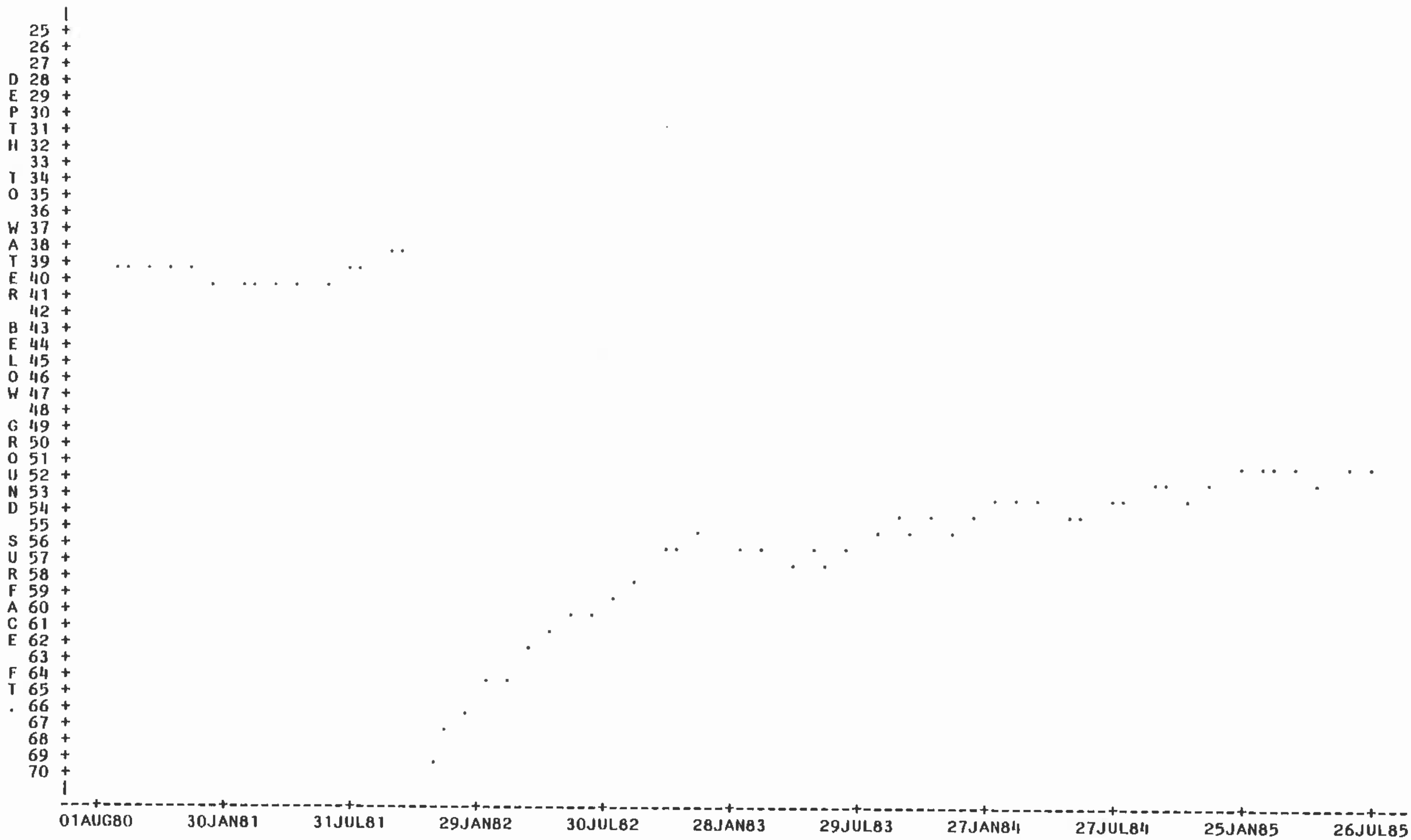
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	60	49.58483333	2.05875517	43.00000000	51.54000000	8.54000000

WEPO WELL # 52
AUGUST 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



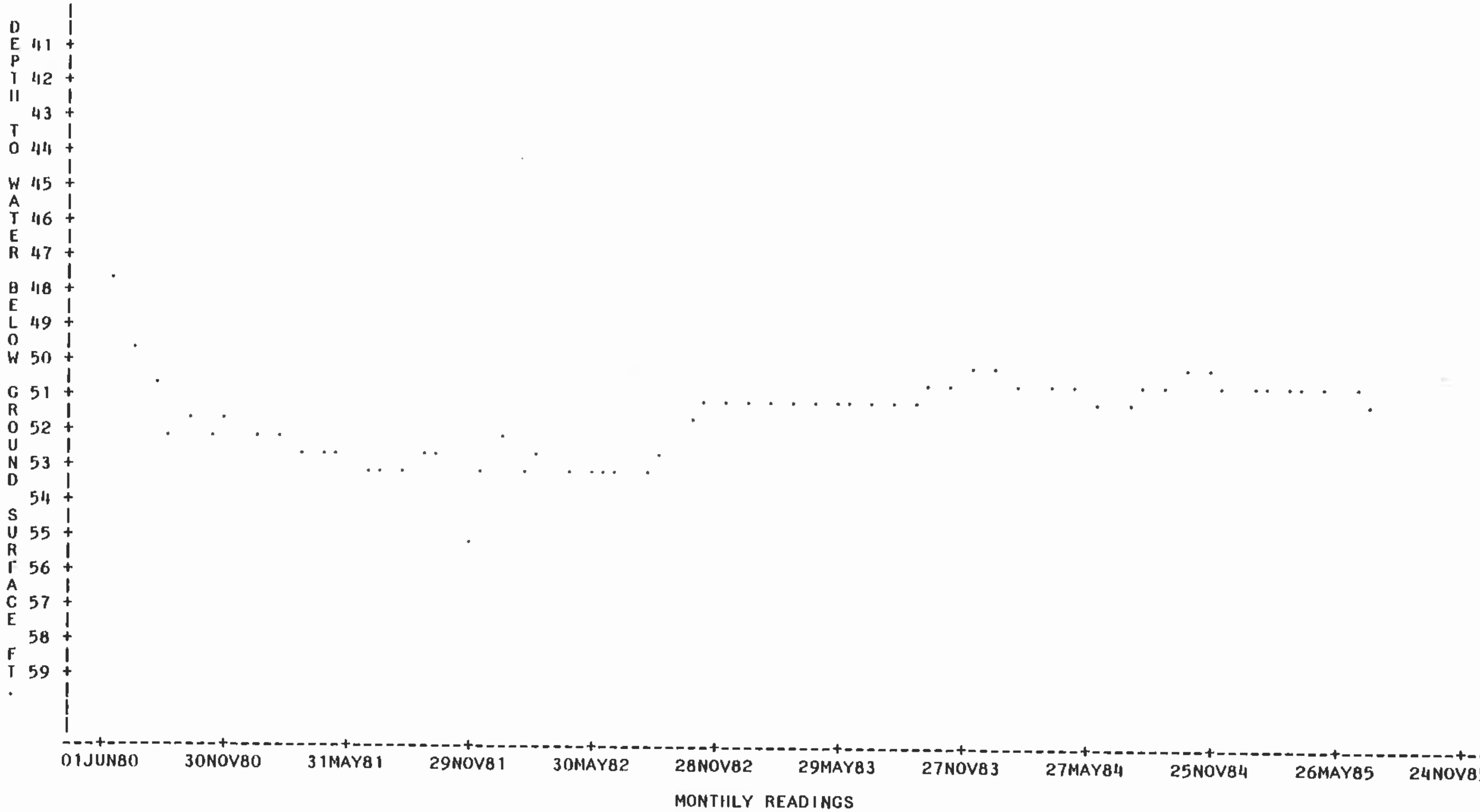
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	60	21.06050000	1.78364265	16.33000000	23.95000000	7.62000000

WEPO WELL # 53
AUGUST 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



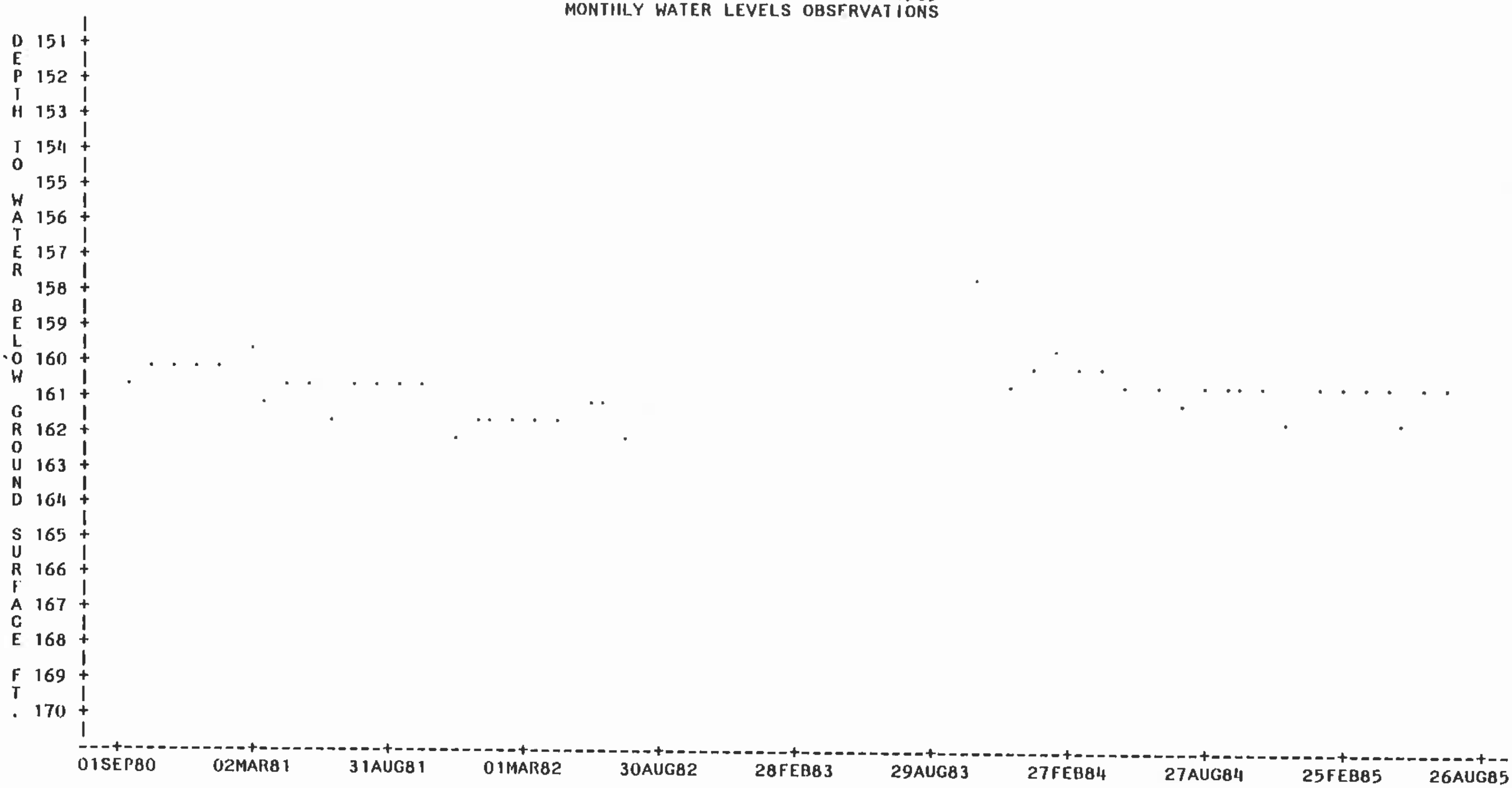
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	60	51.74900000	8.32636892	37.77000000	68.70000000	30.93000000

WEPO WELL # 54
JUNE 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



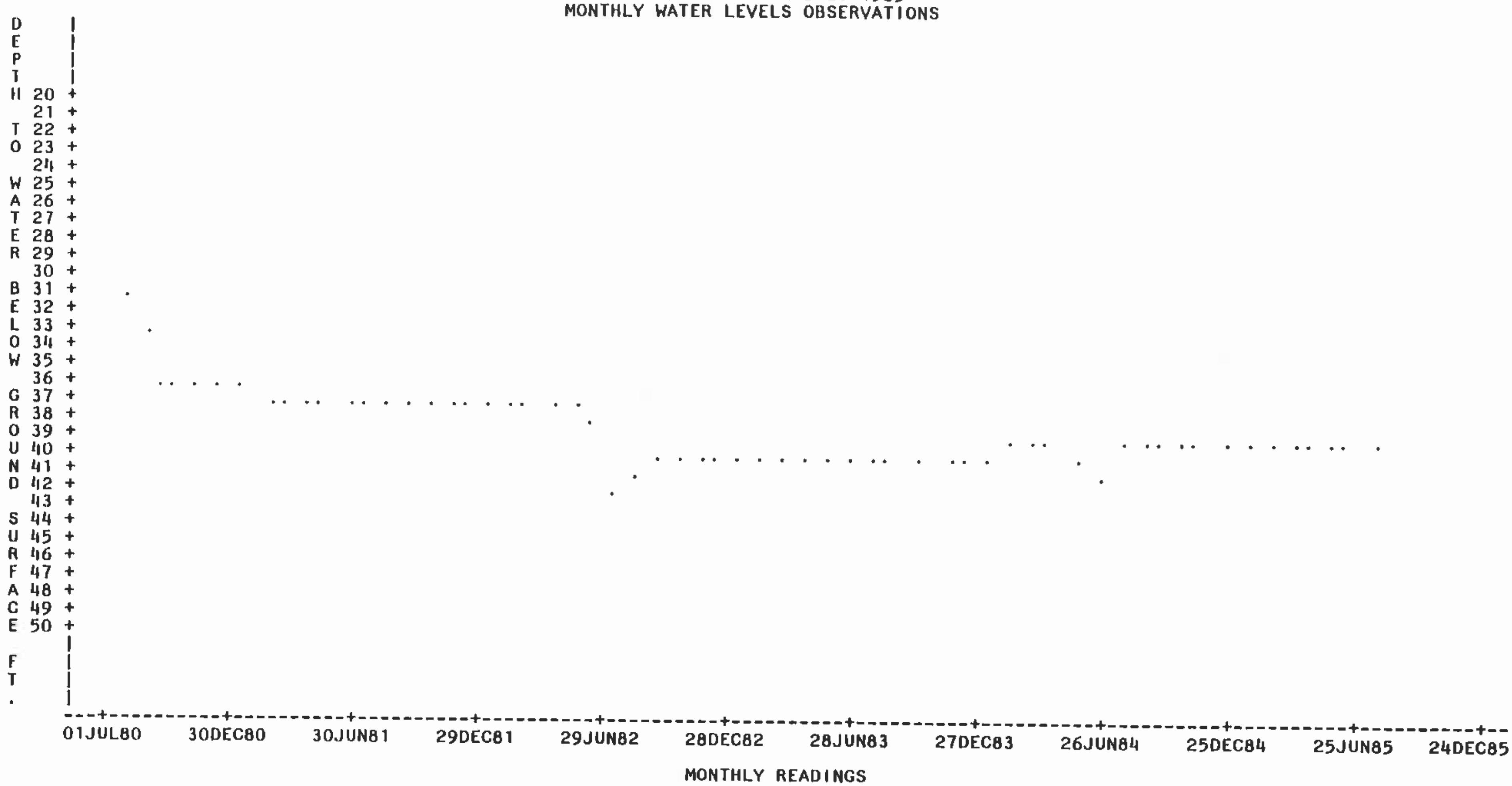
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	62	51.38548387	1.23921138	47.36000000	55.15000000	7.79000000

WEPO WELL # 55
SEPTEMBER 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSFRVATIONS



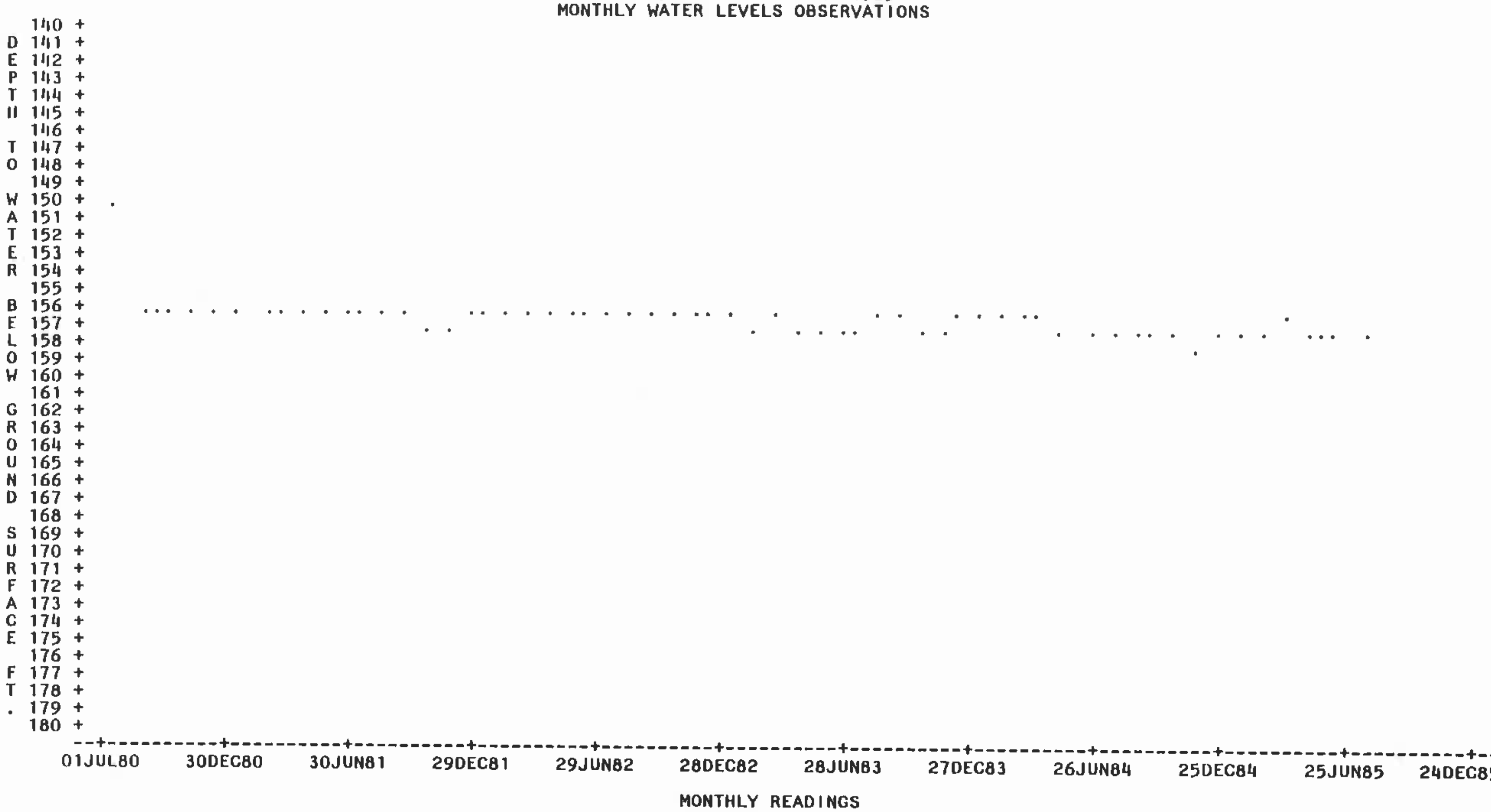
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	44	160.64090909	0.77499233	157.60000000	162.20000000	4.60000000

WEPO WELL # 56
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



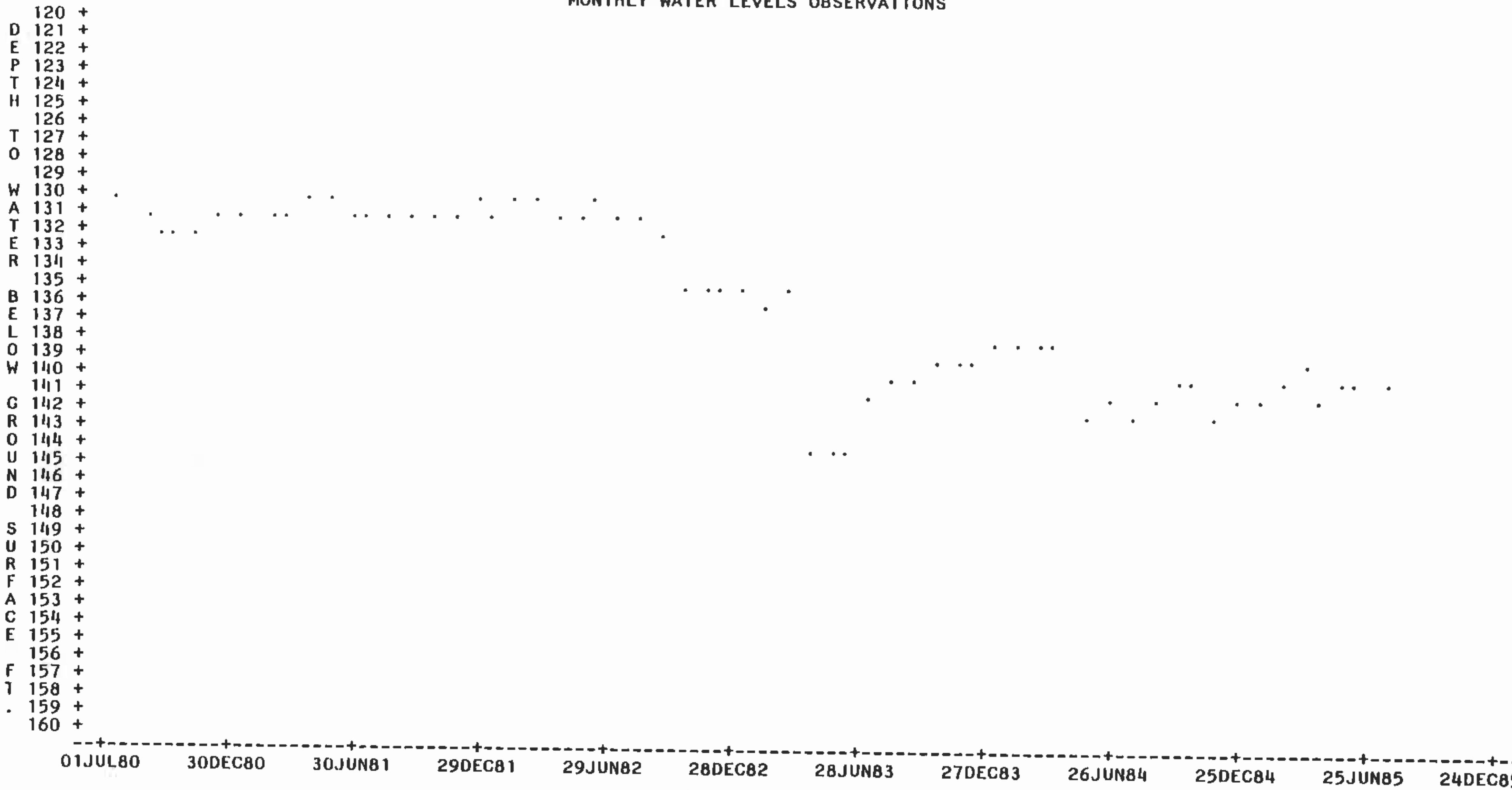
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	61	38.39754098	1.97646963	30.93000000	41.73000000	10.80000000

WEPO WELL # 57
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	61	156.36065574	0.97095806	150.10000000	157.60000000	7.50000000

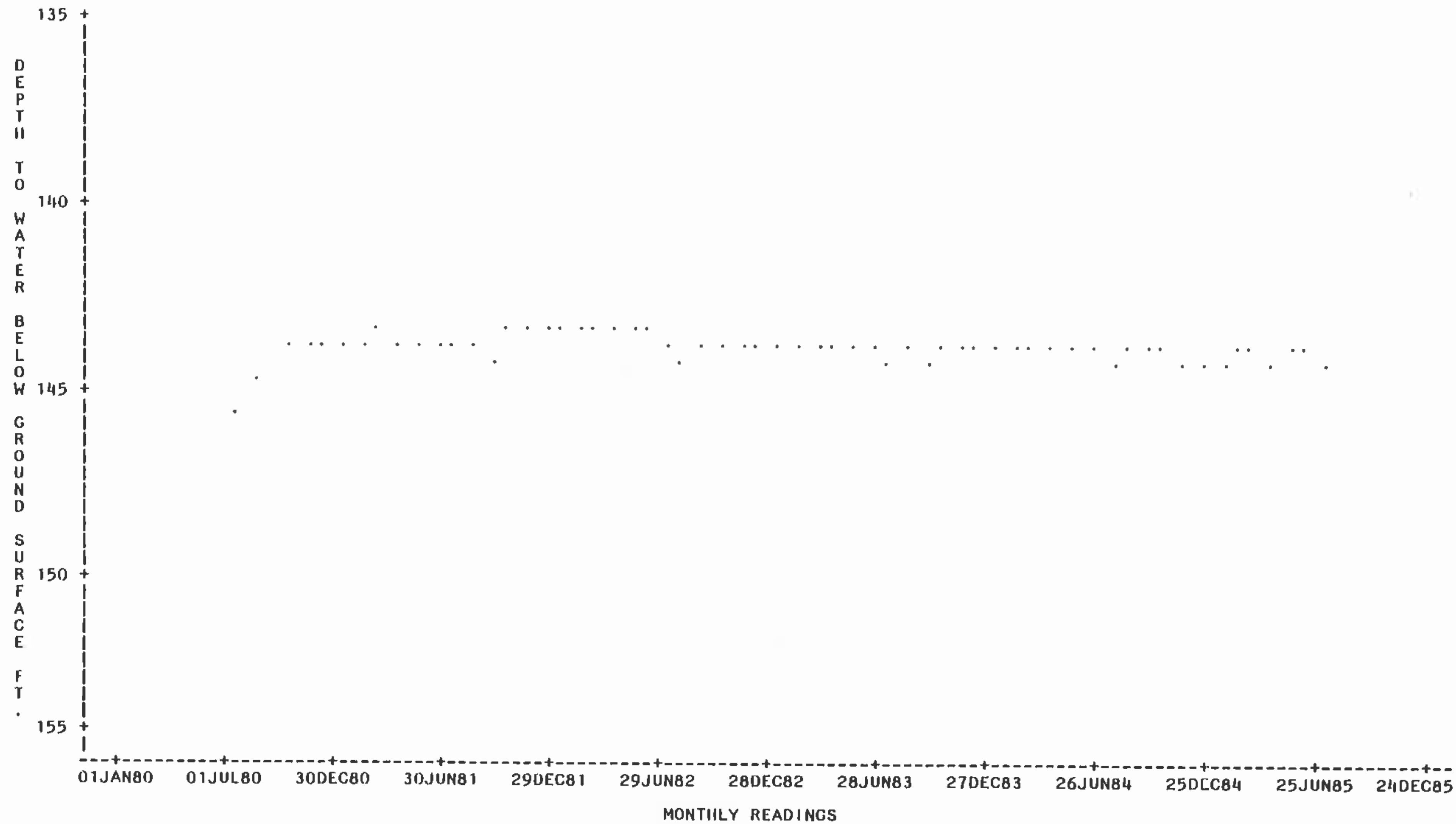
WEPO WELL # 58
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



MONTHLY READINGS

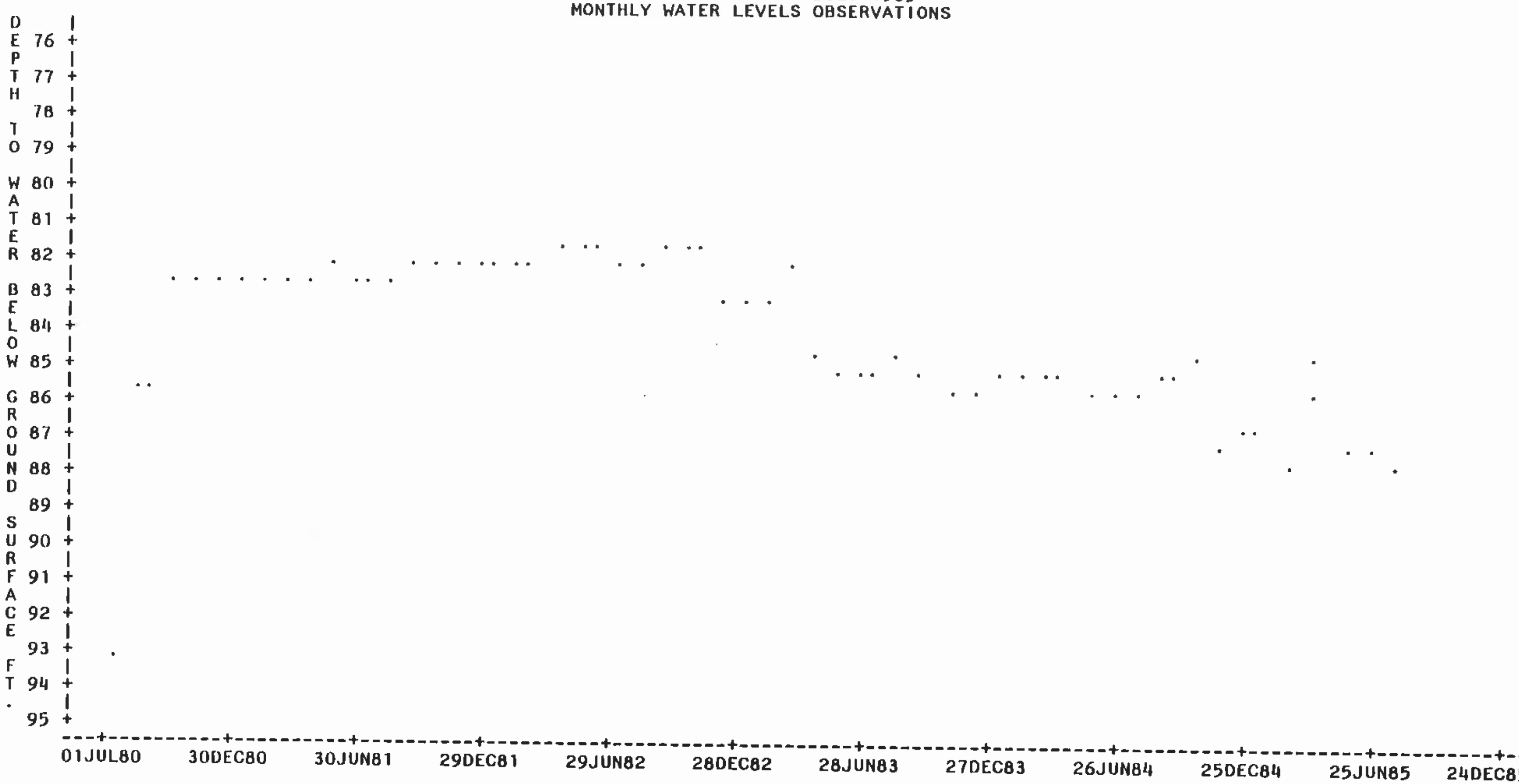
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	61	135.70655738	4.77465073	130.30000000	144.50000000	14.20000000

WEPO WELL # 59
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



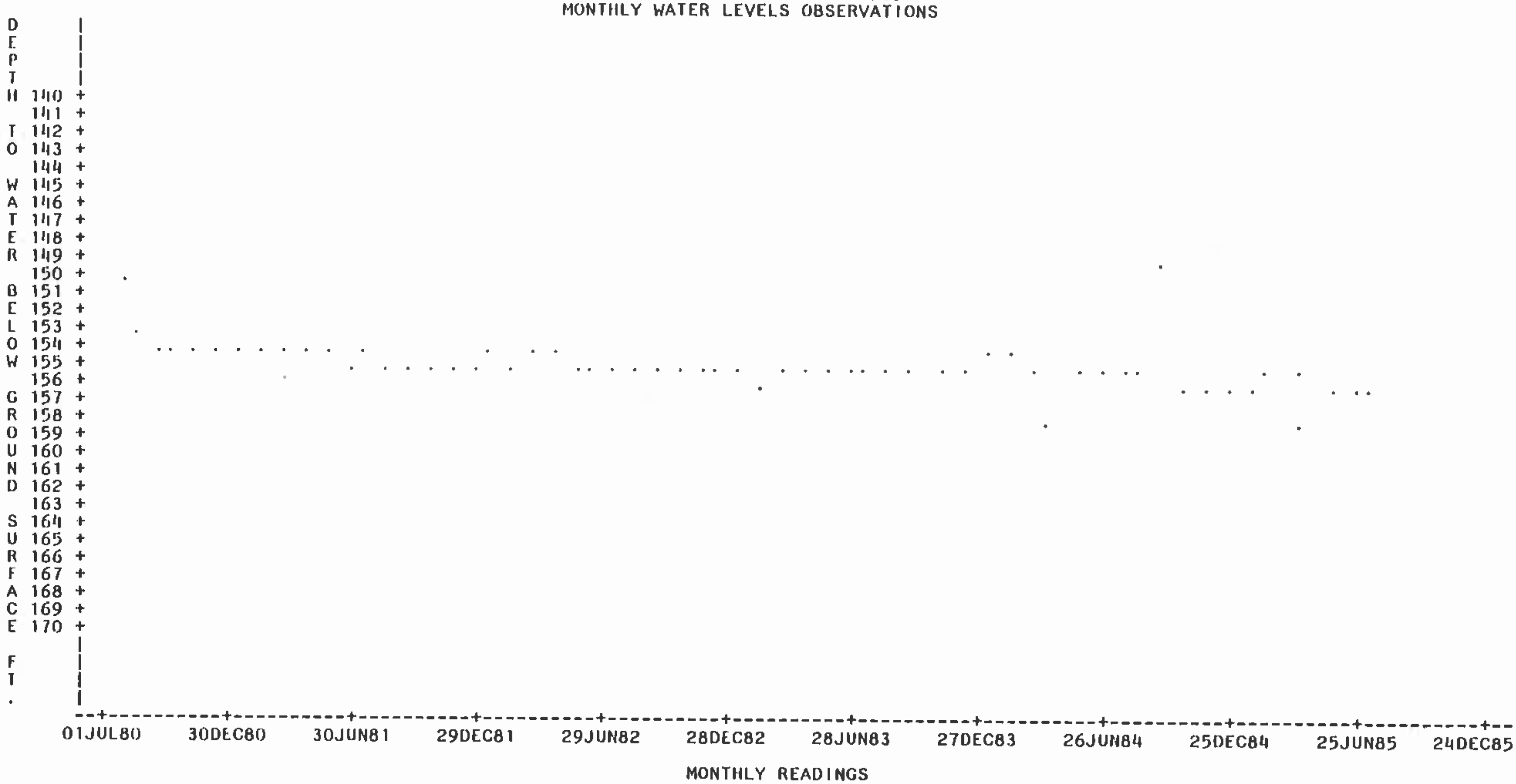
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	60	143.66333333	0.37595829	143.00000000	145.60000000	2.60000000

WEPO WELL # 60
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



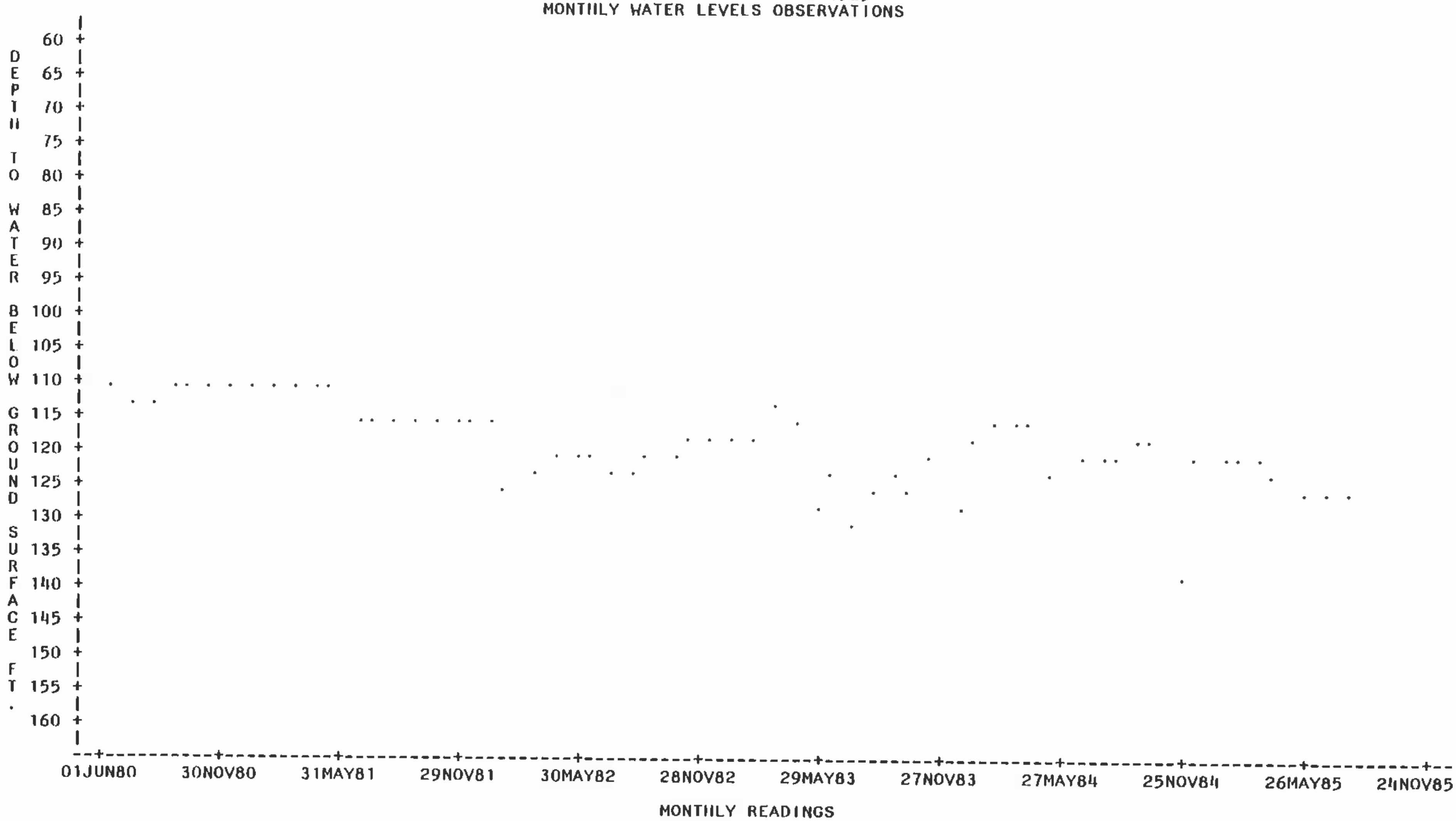
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	61	84.00655738	2.17378770	81.36000000	93.00000000	11.64000000

WEPO WELL # 61
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



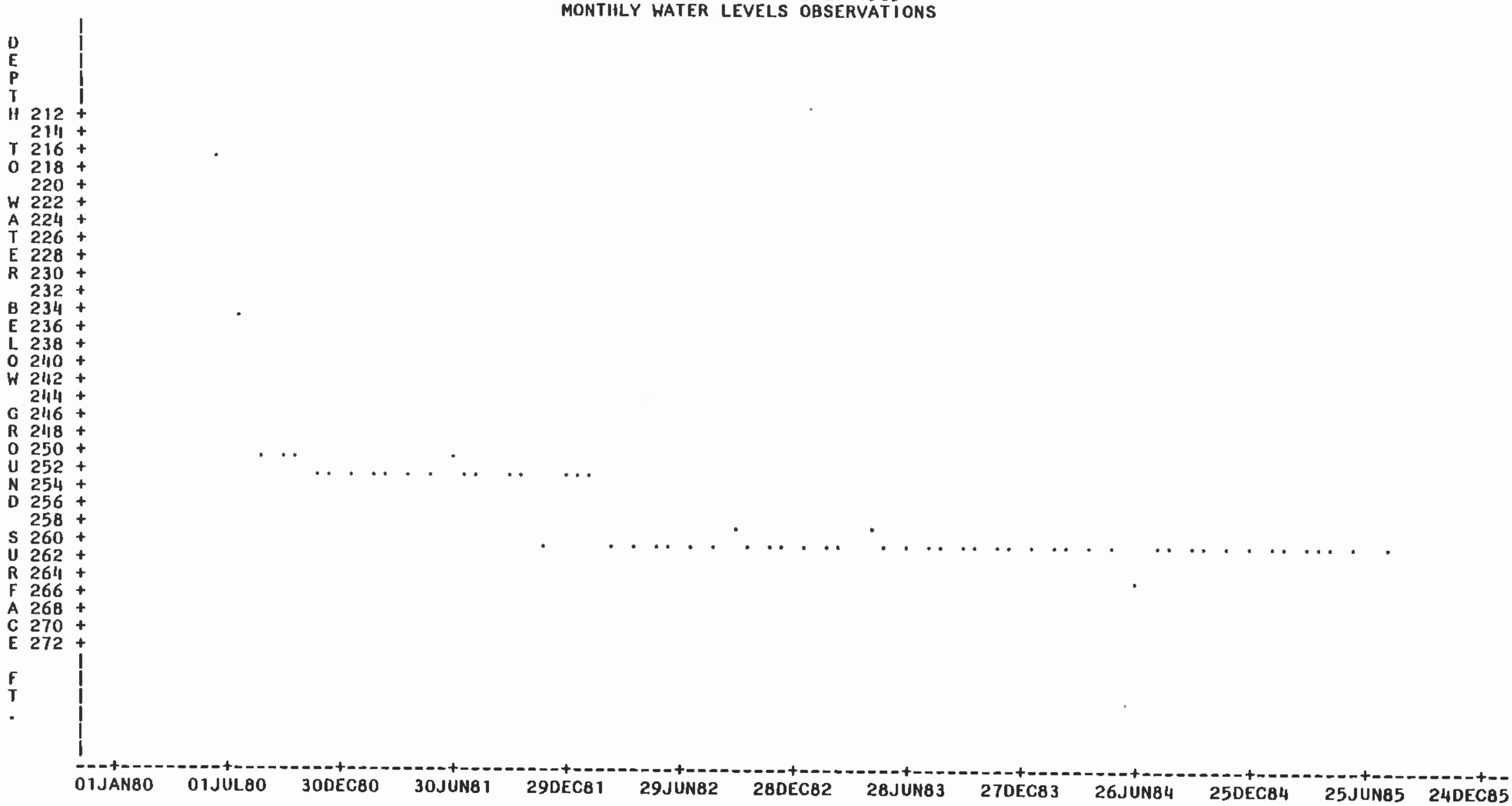
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	61	154.81311475	1.21469824	149.40000000	157.80000000	8.40000000

WEPO WELL # 62
JUNE 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



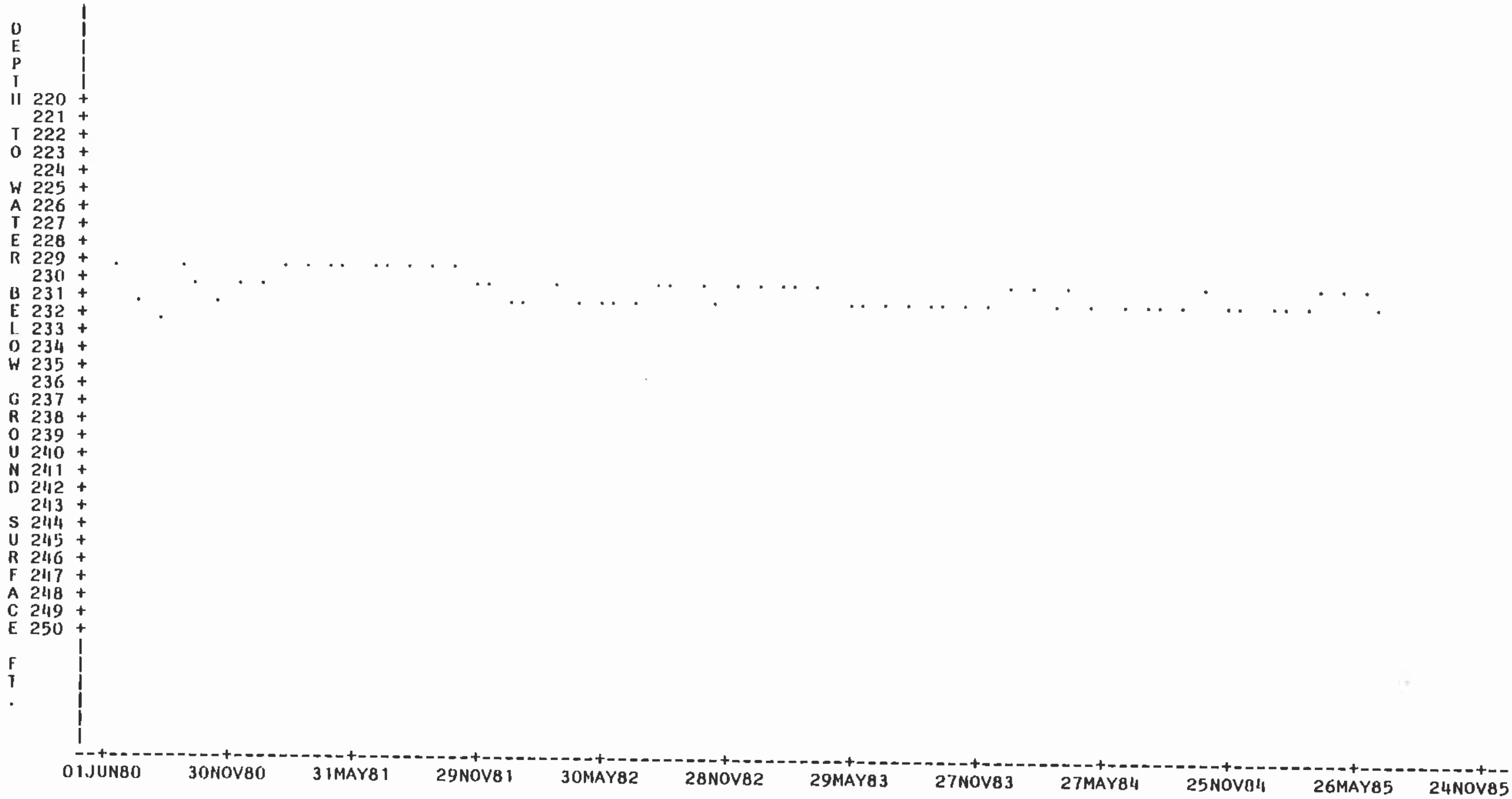
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	62	118.16451613	5.77527508	109.00000000	137.50000000	28.50000000

WEPO WELL # 63
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



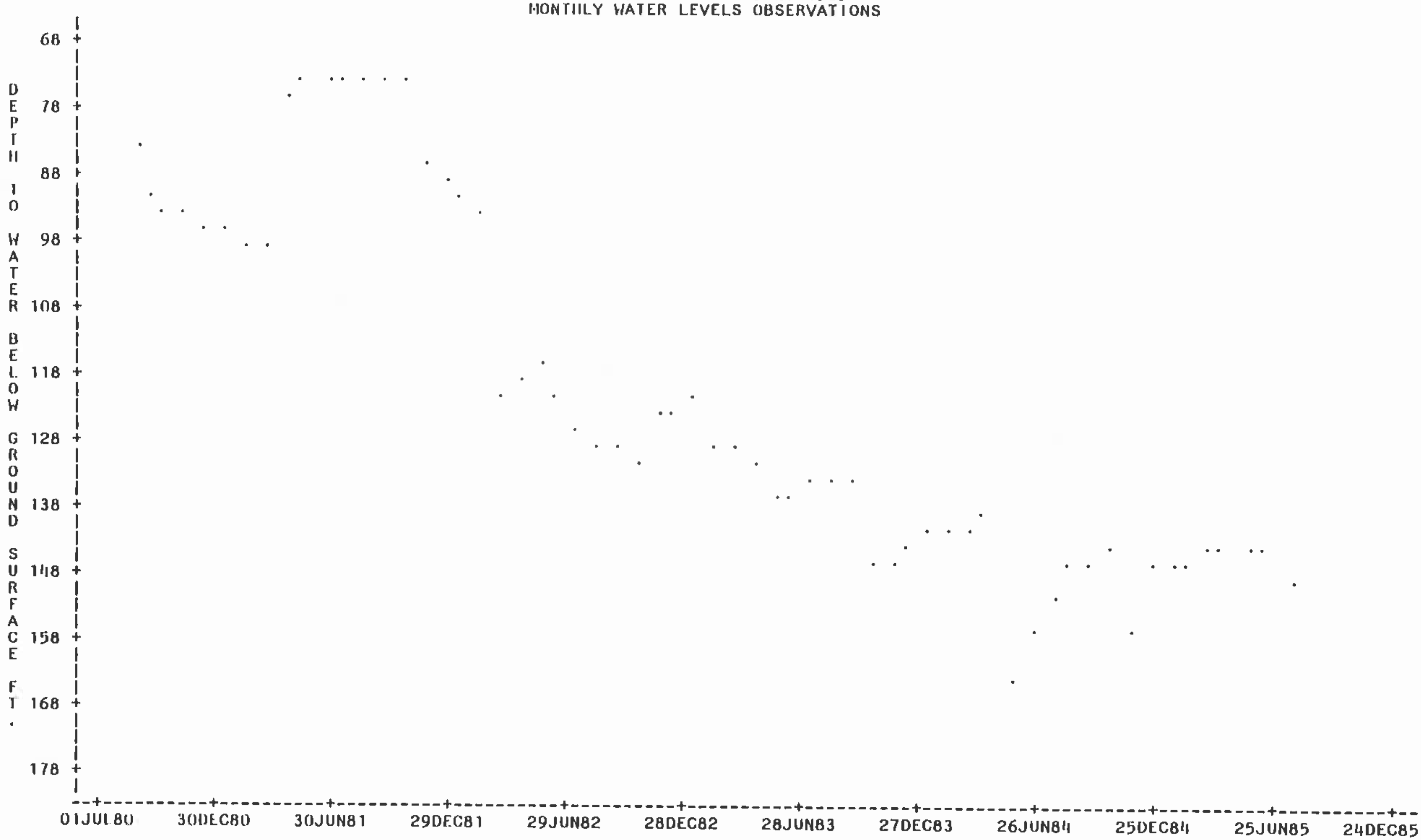
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	62	256.26290323	7.18863479	215.50000000	263.60000000	48.10000000

WEPO WELL # 64
JUNE 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



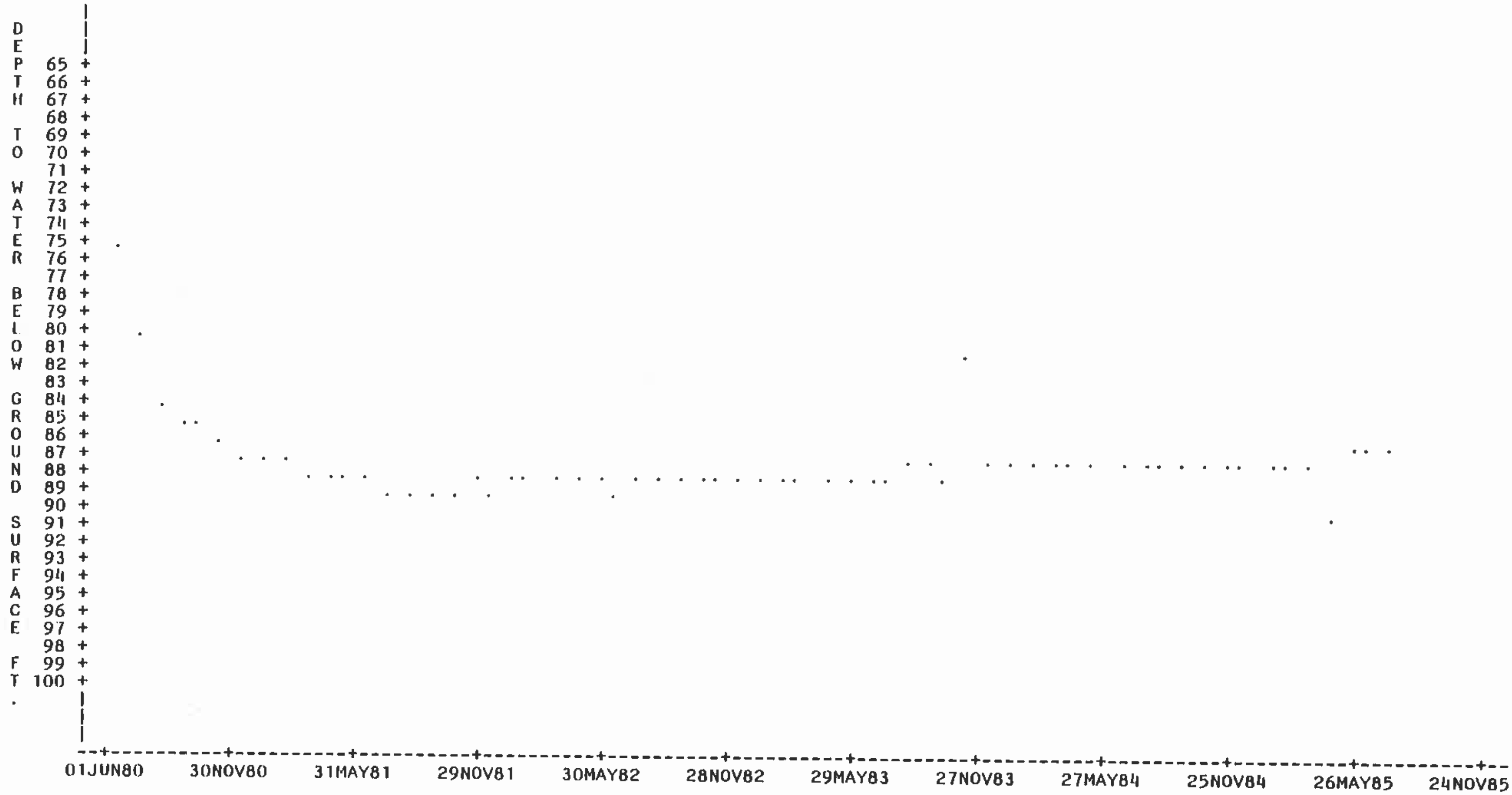
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	62	230.36774194	0.63161884	228.80000000	231.90000000	3.10000000

WEPO WELL # 65
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



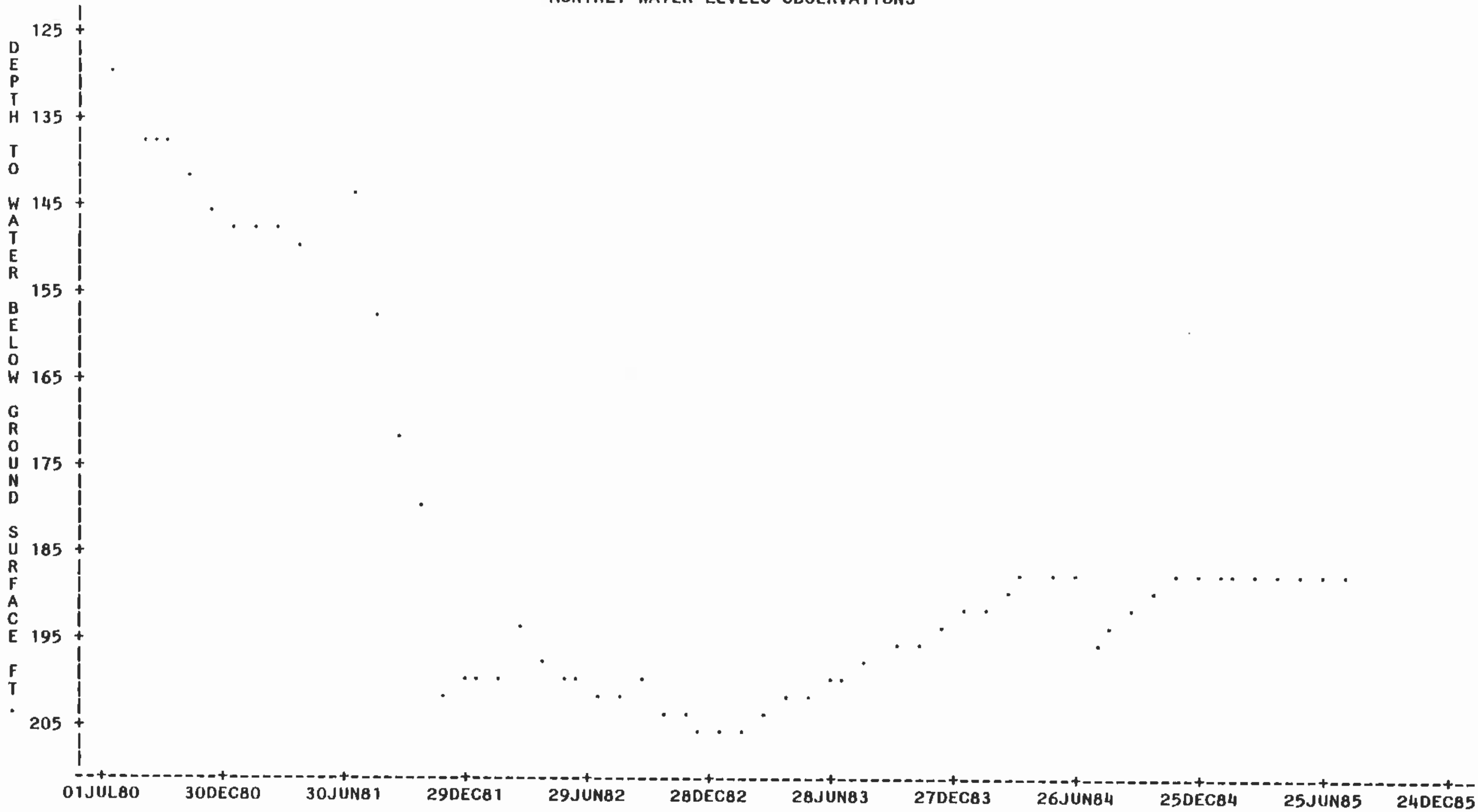
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	61	119.70180328	27.09380597	71.91000000	161.90000000	89.99000000

WEPO WELL # 66
JUNE 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



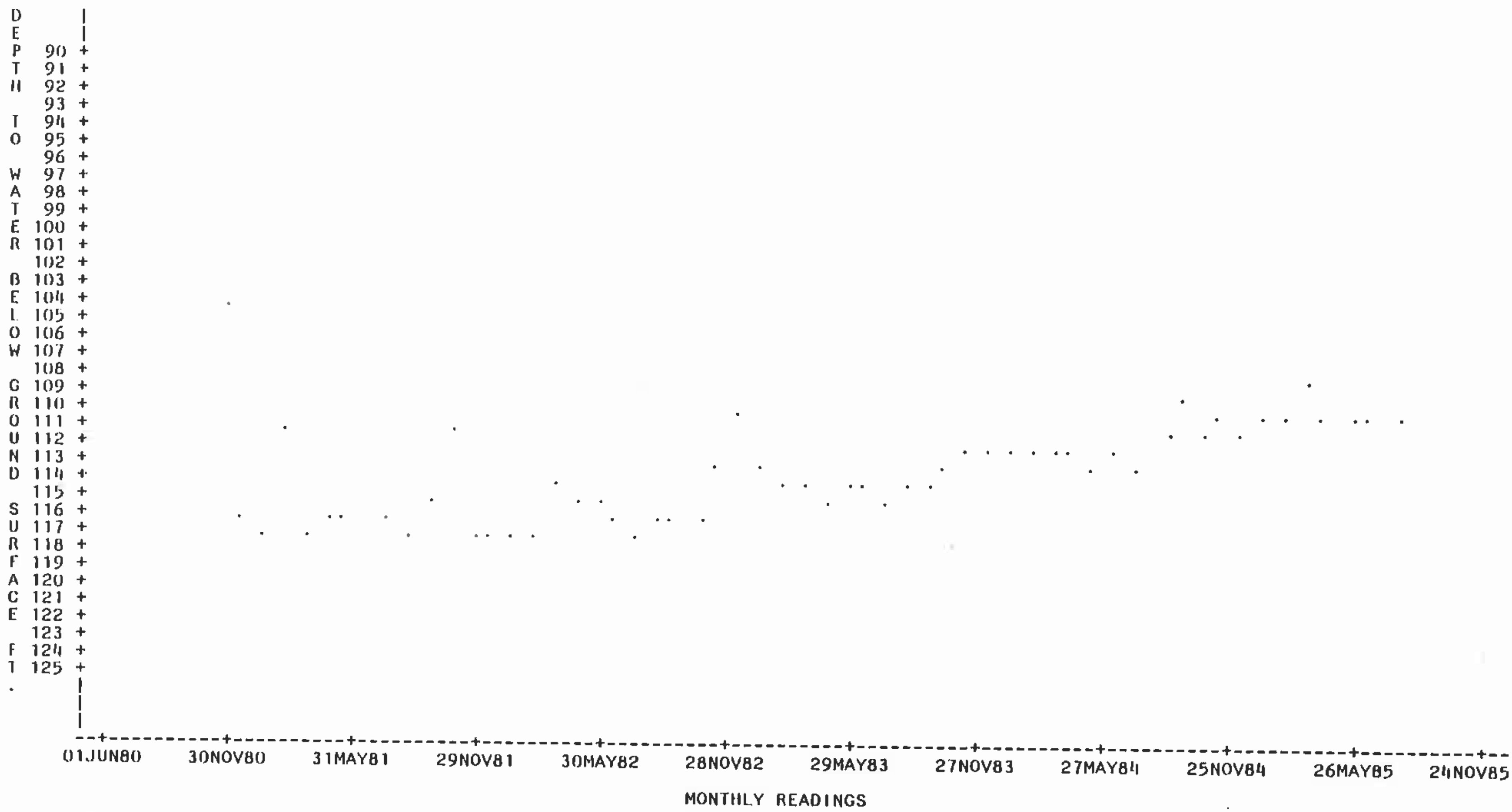
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	62	87.07467742	2.23298427	75.38000000	89.52000000	14.14000000

WEPO WELL # 67
JULY 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



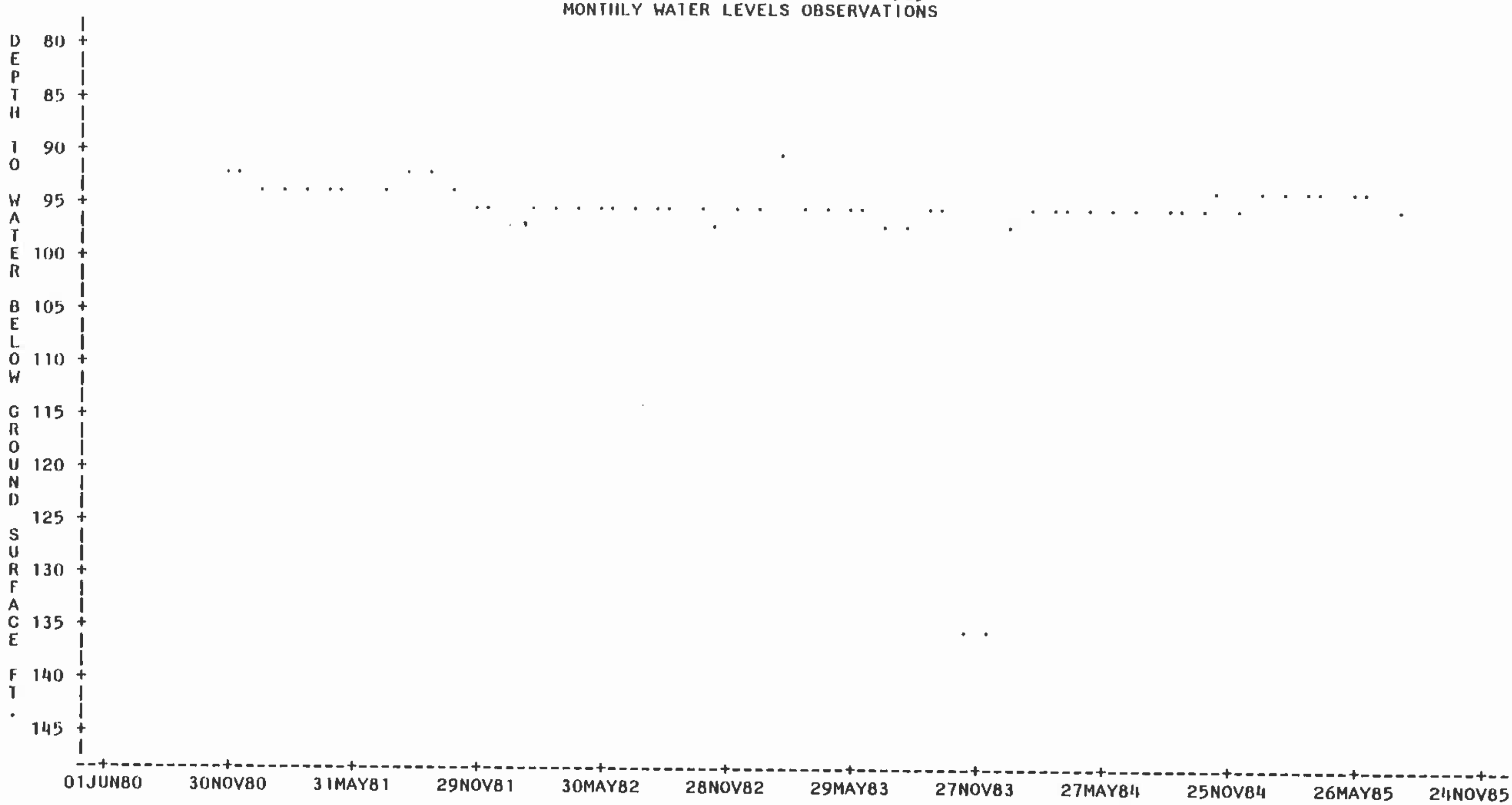
VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	59	183.63389831	21.92247005	129.40000000	204.40000000	75.00000000

WEPO WELL # 86
NOVEMBER 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	56	113.25178571	2.83163865	103.90000000	117.40000000	13.50000000

WEPO WELL # 90
NOVEMBER 1980 THROUGH JULY 1985
MONTHLY WATER LEVELS OBSERVATIONS



MONTHLY READINGS

VARIABLE	LABEL	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	RANGE
FEET	DEPTH TO WATER BELOW GROUND SURFACE FT.	56	95.88357143	7.79736865	90.32000000	135.60000000	45.28000000

TABLE A

Summary of Seasonal Water Level Fluctuations
In the Wepo Aquifer

WEPO WELL

NO. 38

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.15 - .60	.05 - .65	.05 - .35	.05 - .35
-) Recharge Deficit	---	.05 - .25	.05 - .50	---
+) Rainfall	---	---	.05 - 1.00	---
+) Snowmelt	.20 - .45	---	---	--
+) Rain/Snow	---	.10 - .30	---	.50 - 1.00

WEPO WELL

NO. 40

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.25 - 2.55	.60 - .85	.10 - 3.95	.10 - .15
-) Recharge Deficit	---	.05 - .15	.05 - .45	---
+) Rainfall	---	---	.10 - .50	---
+) Snowmelt	.05 - .35	---	---	---
+) Rain/Snow	---	.10 - .35	---	.20 - 1.85

WEPO WELL

NO. 41

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.60 - 2.15	.15 - .70	.50 - 2.50	---
-) Recharge Deficit	.50 - 3.25	1.0 - 2.25	.30 - 2.40	.25 - 1.55
+) Rainfall	---	---	.60 - 2.70	---
+) Snowmelt	.80 - 3.50	---	---	---
+) Rain/Snow	---	.50 - 1.40	---	.60 - 1.25

WEPO WELL

NO. 43

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.15 - 1.20	.10 - .62	.10 - 11.35	.25 - 1.0
-) Recharge Deficit	.11 - 4.15	1.00 - 2.00	.10 - 2.70	.90 - 1.85
+) Rainfall	---	---	.15 - 3.05	---
+) Snowmelt	1.55 - 2.55	---	---	---
+) Rain/Snow	---	1.15 - 2.10	---	1.00 - 1.80

WEPO WELL

NO. 44

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.20 - 17.60	3.60 - 28.30	3.75-22.60	15.80 - 18.45
-) Recharge Deficit	.25 - 1.15	.85 - 1.40	.15 - 1.05	.30 - .90
+) Rainfall	---	---	.20 - 1.75	---
+) Snowmelt	.85 - 3.00	---	---	---
+) Rain/Snow	---	.65 - 1.45	---	.45 - 1.75

WEPO WELL

NO. 45

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.10 - .80	.10 - 3.20	.50 - 1.0	---
-) Recharge Deficit	.30 - 3.55	1.40 - 3.20	1.40 - 2.00	.10 - 1.80
+) Rainfall	---	---	.45 - 2.50	---
+) Snowmelt	.45 - 3.25	---	---	---
+) Rain/Snow	---	.25 - 3.15	---	2.20 - 2.55

WEPO WELL

NO. 46

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	2.00 - 2.40	6.80 - 7.60	1.60 - 3.20
-) Recharge Deficit	9.40 - 21.20	3.00 - 9.40	2.00- 11.48	1.40 - 5.60
+) Rainfall	---	---	2.40- 12.60	---
+) Snowmelt	3.60 - 20.60	---	---	---
+) Rain/Snow	---	2.40 - 7.00	---	1.40 - 6.80

WEPO WELL

NO. 47

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.15 - .10	.10 - 1.70	.55 - 2.25	.10 - 1.00
-) Recharge Deficit	1.25 - 1.50	.35 - 1.20	.40 - 1.15	.60 - 1.40
+) Rainfall	---	---	1.20 - 5.65	---
+) Snowmelt	.75 - 1.60	---	---	---
+) Rain/Snow	---	.60 - .85	---	.25 - .65

WEPO WELL

NO. 49

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.20 - .25	.10 - 3.15	.10 - 2.95	.95 - 3.80
-) Recharge Deficit	.95 - 1.75	.40 - 1.05	.75 - 1.55	.75 - 1.05
+) Rainfall	---	---	.80 - 1.65	---
+) Snowmelt	1.05 - 1.80	---	---	---
+) Rain/Snow	---	.85 - 1.75	---	.65 - 1.25

WEPO WELL

NO. 51

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	.10 - .75	1.00 - 2.75	.10 - .60
-) Recharge Deficit	.90 - 2.10	.75 - 1.40	.50 - 1.25	.50 - 2.05
+) Rainfall	---	---	.60 - 1.15	---
+) Snowmelt	.75 - 1.25	---	---	---
+) Rain/Snow	---	.20 - .80	---	.20 - 1.10

WEPO WELL

NO. 52

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.15 - 1.00	.15 - 1.00	.90 - 1.00	.15 - .60
-) Recharge Deficit	1.50 - 1.95	1.00 - 1.65	.65 - 1.40	.25 - 1.25
+) Rainfall	---	---	.95 - 1.30	---
+) Snowmelt	1.00 - 1.50	---	---	---
+) Rain/Snow	---	.45 - 1.45	---	.10 - 1.45

WEPO WELL

NO. 53

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.80 - 6.60	2.00 - 3.30	.30- 34.60	1.90 - 7.10
-) Recharge Deficit	.80 - 1.40	.30 - .40	.20 - .90	.60 - 1.00
+) Rainfall	---	---	2.40 - 3.50	---
+) Snowmelt	1.00 - 3.90	---	---	---
+) Rain/Snow	---	.80 - 2.40	---	1.70 - 2.10

WEPO WELL

NO. 54

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.25 - .60	.25 - .40	.25 - 10.20	.35 - 2.95
-) Recharge Deficit	1.65 - 3.00	1.10 - 1.70	.80 - 2.60	.90 - 1.60
+) Rainfall	---	---	.70 - 2.45	---
+) Snowmelt	1.35 - 2.15	---	---	---
+) Rain/Snow	---	1.20 - 1.30	---	.75 - 1.65

WEPO WELL

NO. 55

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	1.60	---	.90 - 1.25	.40
-) Recharge Deficit	.60	.10 - .75	.25 - .30	.75
+) Rainfall	---	---	.35 - .50	---
+) Snowmelt	.30 - .60	---	---	---
+) Rain/Snow	---	.15 - .50	---	.15 - .20

WEPO WELL

NO. 56

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.30 - 1.00	.20 - 4.50	.35 - .65	---
-) Recharge Deficit	.25 - 2.40	.55 - 1.65	.30 - 2.10	.15 - 1.45
+) Rainfall	---	---	.15 - 1.70	---
+) Snowmelt	.40 - 1.90	---	---	---
+) Rain/Snow	---	.30 - 1.15	---	.15 - 1.55

WEPO WELL

NO. 57

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	.50 - 1.35	.50 - 1.85	---
-) Recharge Deficit	.15 - 1.00	.30 - .75	.20 - .50	.35 - .60
+) Rainfall	---	---	.10 - .55	---
+) Snowmelt	.20 - 1.35	---	---	---
+) Rain/Snow	---	.20 - .50	---	.05 - 1.15

WEPO WELL

NO. 58

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	.20 - 4.50	.65 - 3.65	---
-) Recharge Deficit	.15 - 1.00	.25 - 3.65	.15 - 1.05	.10 - 2.70
+) Rainfall	---	---	.10 - 1.80	---
+) Snowmelt	.10 - .85	---	---	---
+) Rain/Snow	---	.25 - 1.05	---	.25 - 1.15

WEPO WELL

NO. 59

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.15 - .40	.20 - .40	.35 - .75	.25 - .55
-) Recharge Deficit	1.35 - 2.15	1.05 - 1.70	.15 - 1.75	.65 - 1.70
+) Rainfall	---	---	.35 - 1.75	---
+) Snowmelt	1.45 - 3.70	---	---	---
+) Rain/Snow	---	.90 - 1.60	---	.75 - 1.55

WEPO WELL

NO. 60

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.35 - 4.15	.95	.65 - .70	2.05 - 2.10
-) Recharge Deficit	.10 - 1.75	.60 - 1.40	.10 - 1.60	.20 - 2.15
+) Rainfall	---	---	.50 - 1.80	---
+) Snowmelt	.20 - 2.00	---	---	---
+) Rain/Snow	---	.20 - 1.15	---	.30 - 1.60

WEPO WELL

NO. 61

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.25 - .35	.20	.20 - .85	.25
-) Recharge Deficit	.10 - .50	.25 - .90	.15 - 3.20	.25 - .40
+) Rainfall	---	---	.15 - .65	---
+) Snowmelt	.25 - .60	---	---	---
+) Rain/Snow	---	.15	---	.10 - .45

WEPO WELL

NO. 62

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	2.30- 11.15	4.90 - 16.85	.65 - 9.20	.55 - 4.65
-) Recharge Deficit	.40 - 2.00	.10 - 4.20	1.00 - 3.65	1.20 - 4.90
+) Rainfall	---	---	1.40 - 4.30	---
+) Snowmelt	.75 - 2.35	---	---	---
+) Rain/Snow	---	.20 - 1.40	---	1.00 - 9.20

WEPO WELL

NO. 63

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.10 - 7.50	1.20 - 1.25	1.60	.50 - .90
-) Recharge Deficit	.10 - 2.25	.25 - 3.75	.75 - 2.05	.40 - 2.45
+) Rainfall	---	---	.60 - 2.20	---
+) Snowmelt	.35 - 2.50	---	---	---
+) Rain/Snow	---	.25 - 3.85	---	.20 - 2.75

WEPO WELL

NO. 64

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.40	.45 - 1.30	.35 - 1.30	.45 - .95
-) Recharge Deficit	.50 - 2.20	.20 - 1.30	1.30 - 3.30	.45 - 1.65
+) Rainfall	---	---	.50 - 2.55	---
+) Snowmelt	.55 - 2.35	---	---	---
+) Rain/Snow	---	.20 - 1.40	---	.25 - 1.95

WEPO WELL

NO. 65

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	.25 - 31.40	2.50- 28.00	4.20- 14.40	.35 - 18.40
-) Recharge Deficit	1.80 - 7.20	7.50- 11.00	.60 - 5.60	1.80 - 3.20
+) Rainfall	---	---	.80 - 9.50	---
+) Snowmelt	1.00- 10.40	---	---	---
+) Rain/Snow	---	1.00- 12.00	---	3.50 - 5.60

WEPO WELL

NO. 66

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	.40 - .60	.40 - 4.00	.50 - .75
-) Recharge Deficit	.40 - 2.35	.20 - 2.05	.40 - 2.00	.30 - 1.65
+) Rainfall	---	---	.30 - 3.70	---
+) Snowmelt	.50 - 2.15	---	---	---
+) Rain/Snow	---	.50 - 1.30	---	.20 - 1.60

WEPO WELL

NO. 67

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	---	6.70- 10.00	2.20 - 4.20
-) Recharge Deficit	1.50 - 2.50	.70 - 4.30	3.60- 15.00	1.10 - 2.05
+) Rainfall	---	---	1.20 - 4.40	---
+) Snowmelt	2.50 - 6.40	---	---	---
+) Rain/Snow	---	.60 - 8.70	---	.60 - 2.90

WEPO WELL

NO. 86

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	1.05	.45 - 1.85	5.50 - 12.30
-) Recharge Deficit	.65 - 3.10	1.15 - 1.60	.45 - 3.20	1.80
+) Rainfall	---	---	1.65 - 5.75	---
+) Snowmelt	.25 - 3.15	---	---	---
+) Rain/Snow	---	.30 - 1.25	---	.50 - 2.00

WEPO WELL

NO. 90

	JAN-MAR.	APR-JUN	JUL-OCT	NOV-DEC
-) Aquifer Testing & Water Quality Sampling	---	---	.70 - 2.60	1.60
-) Recharge Deficit	.15 - 5.00	.25 - 1.20	.15 - .45	.35 - 1.20
+) Rainfall	---	---	.55 - 1.55	---
+) Snowmelt	1.05 - 5.20	---	---	---
+) Rain/Snow	---	.10 - .45	---	.15 - 1.90

ATTACHMENT 8

Wepo Monitoring Well Lithologic Logs

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 9/30/79

AREA N-7 PAGE No. 1 of HOLE No. 38

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	3	0	3	0	Brown Sandy Clay
3	0	13	0	10	0	Sand and Gravel
13	0	13	7	0	7	Hard Rock Boulder
13	7	23	0	9	3	Damp Brown Sandy Clay and Mud
23	0	31	3	8	3	Gray Shale
31	3	40	3	9	0	Hard Gray Sandstone - Water
40	3	42	7	2	4	Very Hard Rock
42	7	43	0	0	3	"A lot of water"
43	0	45	4	2	4	Brown - Yellow Sand Rock
45	4	55	4	10	0	Hard Gray Sandstone
55	4	60	4	5	0	Coal
60	4	61	4	1	0	Dark Shale
61	4	62	2	0	8	Coal
62	2	73	5	11	3	Gray Shale
73	5	78	5	5	0	Gray Shale - Dark Shale
78	5	80	5	2	0	Coal
80	5	84	6	4	1	Dark Shale
84	6	85	6	1	0	Coal
85	6	102	0	16	4	Hard Gray Shale and Sandstone
102	0	117	0	15	0	Gray Shale
117	0	120	7	3	7	Gray Shale and Sandstone
120	7	122	0	1	3	Hard Sandstone Rock
122	0	127	2	5	2	Hard Dark Gray Shale
127	2	129	2	2	0	Coal

PEABODY COAL COMPANY

Environmental Quality

Well Logs

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AREA N-7

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FORMATION RECORD

DEPTH From— Feet	From— Tenths	To— Feet	To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
129	2	131	0	1	8	Gray Shale
131	0	134	3	3	3	Gray Sandstone and Shale
134	3	135	3	1	0	Hard Gray Sandstone
135	3	137	3	2	0	Coal
137	3	141	2	3	9	Gray Shale
141	2	146	2	5	0	Coal
146	2	160	2	14	0	Hard Gray Shale
160	2	160	8	0	6	Hard Sandstone
160	8	164	5	3	7	Hard Gray Shale and Sandstone
164	5	167	5	3	0	Dark Shale and Coal
167	5	171	0	3	5	Gray Shale and Sandstone
171	0	196	1	25	1	Hard Gray Sandy Shale
196	1	202	2	5	9	Dark Gray Shale
202	2	205	7	3	7	Gray Shale
205	7	211	2	5	5	Hard Gray Sandstone
211	2	212	2	1	0	Coal
212	2	217	2	5	0	Gray Shale
217	2	219	2	2	0	Dark Shale
219	2	220	2	1	0	Coal
220	2	228	0	7	8	Gray Shale
228	0	235	0	7	0	Gray Sandstone
235	0	245	0	10	0	Dark Gray Shale and Dark Shale
245	0	275	5	30	5	Gray Shale with Hard Streaks
275	5	278	5	3	0	Coal

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 9/30/79

AREA N-7 PAGE No. 3 of HOLE No. 38

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
278	5	288	6	10	1	Gray Shale and Sandstone
288	6	297	6	9	0	Gray Shale
297	6	300	1	2	5	Coal
300	1	303	0	2	9	Gray Shale
303	0	305	7	2	7	Dark Shale
305	7	307	2	1	5	Coal
307	2	325	0	17	8	Gray Shale
325	0	350	0	25	0	Light Gray Sandstone with Shale Bands
350	0					T.D.
						Monitoring Water Well.
						220' deep; 6" ID pvc casing; gravel packed; cemented;
						perforated 13'-95', 107'-130', 137'-147'; 155'-197',
						207'-220'.
						* The 4" pilot hole went to 350'. The hole was then
						reamed out to 9" to a depth of 220'. The well was
						cased and completed to a depth of 220'.

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 9/19/79

AREA N-7 PAGE No. 1 of HOLE No. 39

FORMATION RECORD

DEPTH				Thickness of stratum		Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
From—		To—				
Feet	Tenths	Feet	Tenths	Feet	Tenths	
0	0	1	0	1	0	Surface Sand
1	0	10	0	9	0	Sand and Gravel
10	0	23	4	13	4	Boulders and Gravel
23	4	23	8	0	4	Boulder
23	8	24	6	0	8	Gray-brown Clay - Shale
24	6	24	9	0	3	Boulder
24	9	25	4	0	5	Gray Shale
25	4	27	0	1	6	Brown Rock
27	0	29	6	2	6	Gray Shale and Sandstone
29	6	30	6	1	0	Hard Rock
30	6	37	6	7	0	Gray Shale and Sandstone Streaks
37	6	42	0	4	4	Hard Rock
42	0	51	7	9	7	Gray Shale
51	7	56	7	5	0	Coal
56	7	57	9	1	2	Dark Gray Shale
57	9	59	9	2	0	Coal
59	9	63	0	3	1	Gray Shale and Sandstone
63	0	69	6	6	6	Gray Sandstone and Hard Sandstone
69	6	78	8	9	2	Gray Shale and Dark Gray Shale
78	8	80	8	2	0	Coal
80	8	87	2	6	4	Gray Shale
87	2	96	3	9	1	Hard Gray Sandstone and Shale
96	3	102	0	5	7	Hard Sandstone Rock
102	0	120	0	18	0	Hard Gray Sandstone and Shale

THE MILLS COMPANY, SHERIDAN 139308

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 9/19/79

AREA N-7 PAGE No. 2 of HOLE No. 39

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
120	0	122	0	2	0	Hard Rock
122	0	123	0	1	0	Hard Black Shale
123	0	126	1	3	1	Hard Dark Gray Shale
126	1	128	1	2	0	Coal
128	1	130	3	2	2	Gray Shale with Hard Streaks
130	3	132	4	2	1	Light Gray Sandstone
132	4	133	4	1	0	Hard Rock
133	4	135	7	2	3	Gray Shale
135	7	138	0	2	3	Coal
138	0	139	4	1	4	Gray Shale
139	4	143	3	3	9	Coal
143	3	153	5	10	2	Gray Shale with Hard Streaks
153	5	154	0	0	5	Coal
154	0	158	0	4	0	Gray Shale and Sandstone
158	0	160	2	2	2	Hard Brown Rock
160	2	160	9	0	7	Gray Shale and Sandstone
160	9	162	5	1	6	Coal
162	5	166	0	3	5	Gray Shale and Sandstone
166	0	177	0	11	0	Gray Shale
177	0	188	0	11	0	Gray Shale and Sandstone
188	0	195	0	7	0	Coal
195	0	218	5	23	5	Gray Shale and Sandstone
218	5	219	5	1	0	Coal
219	5	220		0	5	Hard Rock
220						T.D.

Monitoring Water Well. 4" pvc casing; set 220' casing; perforated from 13'-96', 107'-130', 137'-147', 155'-197', & 207'-220'; gravel packed; well sealed with cement

PEABODY COAL COMPANY

Environmental Quality
Well Logs

DATE 10/13/79

AREA N-1 PAGE No. 1 of HOLE No. 40

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	2	0	2	0	Topsoil
2	0	21	0	19	0	Burnt Shale and Sandstone
21	0	25	0	4	0	Sandstone and Shale
25	0	52	0	27	0	Burnt, red-gray Shale and Sandstone
52	0	57	0	5	0	Sand
57	0	75	0	18	0	Baked Dark Gray Shale
75	0	77	9	2	9	Dark Shale - Smut
77	9	81	9	4	0	Coal
81	9	90	0	8	1	Gray Shale with Hard Streaks
90	0	106	5	16	5	Gray Shale
106	5	107	5	1	0	Coal
107	5	108	5	1	0	Dark Shale
108	5	109	5	1	0	Coal
109	5	111	5	2	0	Dark Shale
111	5	124	0	12	5	Gray Shale
124	0	140	0	16	0	Sandy Shale - Damp
140	0	148	0	8	0	Hard Gray Sand
148	0	153	2	5	2	Gray Shale and Dark Shale
153	2	155	2	2	0	Coal
155	2	156	0	0	8	Gray Shale and Sandstone
156	0	158	0	2	0	Hard Sandstone
158	0	160	0	2	0	Gray Shale and Sandstone
160	0	169	0	9	0	Gray Shale
169	0	171	5	2	5	Coal

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 10/13/79

AREA N-1

PAGE No. 2 of HOLE No. 40

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
171	5	175	0	3	5	Dark Shale
175	0	183	0	8	0	Dark Gray Shale
183	0	194	0	11	0	Gray Shale with Hard Streaks
194	0	206	0	12	0	Hard Gray Sandstone
206	0	208	5	2	5	Gray Shale
208	5	211	5	3	0	Coal
211	5	213	0	1	5	Dark Shale
213	0	226	6	13	6	Gray Shale and Sandstone
226	6	228	6	2	0	Coal
228	6	229	9	1	3	Dark Gray Shale
229	9	235	6	5	7	Gray Shale and Sandstone
235	6	239	6	4	0	Hard Gray Sandstone
239	6	240	6	1	0	Coal
240	6	244	7	4	1	Hard Gray Shale
244	7	251	7	7	0	Coal
251	7	258	7	7	0	Gray Shale and Sandstone
258	7	262	0	3	3	Hard Gray Sandstone
262	0	265	0	3	0	Gray Shale and Sandstone
265	0	276	8	11	8	Gray Sandstone
276	8	277	9	1	1	Hard Sandstone
277	9	283	0	5	1	Gray Shale
283	0	326	0	43	0	Gray Sandstone
326	0	332	1	6	1	Gray Shale and Coal Steaks
332	1	342	1	10	0	Gray Shale

THE HILLS COMPANY, SHERIDAN 138506

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 10/13/7?

AREA N-1

PAGE No. 3 of HOLE No. 40

FORMATION RECORD

DEPTH From— Feet	From— Tenths	To— Feet	To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
342	1	344	1	2	0	Coal
344	1	350	0	5	9	Gray Shale and Sandstone
350	0	360	0	10	0	Gray Sandstone and Shale
360	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 360' casing; perforated from 168'-183',
						192'-252', 257'-327', 333'-336', and 342'-360'; gravel
						packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DAT. 11/4/79

AREA N-2 PAGE No. 1 of HOLE No. 41

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	3	2	3	2	Brown Sandy Clay
3	2	20	5	17	3	Hard Brown Sand Rock
20	5	25	3	4	8	Gray-brown Shale
25	3	35	3	10	0	Brown Sand Rock
35	3	43	0	7	7	Sandy Shale
43	0	44	7	1	7	Gray Shale
44	7	45	7	1	0	Gray Shale - Damp
45	7	47	0	1	3	Dark Shale
47	0	50	7	3	7	Gray Shale
50	7	53	7	3	0	Coal - Bottom Red
53	7	60	7	7	0	Gray Shale
60	7	62	3	1	6	Coal
62	3	67	3	5	0	Gray Shale with Hard Streaks
67	3	68	3	1	0	Coal
68	3	81	0	12	7	Gray Shale
81	0	82	0	1	0	Coal
82	0	89	6	7	6	Gray Shale
89	6	90	6	1	0	Sandstone - Damp
90	6	91	6	1	0	Sandstone - Wet
91	6	95	6	4	0	Gray Shale
95	6	98	1	2	5	Coal, Damp - Yellow 0
98	1	100	0	1	9	Dark Shale
100	0	104	7	4	7	Gray Sandstone and Shale
104	7	105	7	1	0	Coal

PEABODY COAL COMPANY
Environmental Quality
Well Log:

DATE: 11/4/79

AREA: N-2

PAGE No. 2 of HOLE No. 41

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
105	7	360	0	254	3	Shale
*360	0					T.D.
						Monitoring Water Well.
						350 ft. deep; 6" ID pvc casing; gravel packed; cemented
						perforated intervals 220-238
						244-257
						262-266
						272-279
						292-350
						*Well was cased and completed to a depth of 350'.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 10/18/79

AREA N-10

PAGE No. 1 of HOLE No. 42

FORMATION RECORD

DEPTH From— feet	From— tenths	To— feet	To— tenths	Thickness of stratum feet	Thickness of stratum tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	13	0	13	0	Brown Clay Shale and Sandstone
13	0	14	5	1	5	Hard Gray Sandstone - Very Hard
14	5	18	0	3	5	Brown and Gray Shale
18	0	20	0	2	0	Hard Sandstone and Shale
20	0	28	3	8	3	Gray Shale
28	3	29	6	1	3	Hard Gray Rock
29	6	31	0	1	4	Gray Shale
31	0	34	6	3	6	Brown Sand Rock
34	6	36	8	2	2	Dark Shale and Smut - Damp
36	8	40	9	4	1	Gray Shale - Wet
40	9	42	2	1	3	Hard Rock
42	2	43	0	0	8	Gray Shale - Damp
43	0	45	0	2	0	Dark Shale and Smut - Coal
45	0	60	0	15	0	Gray Shale
60	0	65	0	5	0	Dark Shale
65	0	84	0	19	0	Gray Shale
84	0	87	0	3	0	Dark Shale and Coal
87	0	92	0	5	0	Gray Shale
92	0	97	0	5	0	Gray Sandstone and Shale
97	0	104	0	7	0	Hard Gray Sandy Shale
104	0	115	0	11	0	Hard Gray Sandstone
115	0	126	0	11	0	Gray Sandstone and Sandy Shale
126	0	132	0	6	0	Gray Shale
132	0	134	0	2	0	Dark Shale and Coal

THE MILLS COMPANY, [illegible] 139388

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 10/18/79

AREA N-10

PAGE No. 2 of HOLE No. 42

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
134	0	140	0	6	0	Hard Gray Shale and Dark Shale
140	0	157	0	17	0	Gray Shale and Sandstone
157	0	170	0	13	0	Hard Gray Sandstone and Shale
170	0	203	0	33	0	Sand and Water
203	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 200' casing; perforated from 32'-52',
						60'-68', 80'-87', 100'-135', and 157'-200'; gravel
						packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 12/4/79

AREA N-5 PAGE No. 1 of HOLE No. 43

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	10	1	10	1	Burnt Formation
10	1	15	0	4	9	Sand
15	0	25	0	10	0	Red Dust
25	0	40	0	15	0	Brown Sand Dust
40	0	63	0	23	0	Red-brown Dust
63	0	68	4	5	4	Baked Red Shale and Sandstone
68	4	82	0	13	6	Shale and Sandstone
82	0	104	6	22	6	Red Shale and Sandstone with Blind Spots
104	6	107	6	3	0	Hard Red Rock - Burnt
107	6	120	0	12	4	Burnt Hard Rock
120	0	123	0	3	0	Hard Burnt Black Rock
123	0	134	7	11	7	Hard Burnt Gray Shale and Sandstone
134	7	140	0	5	3	Smut and Dark Shale
140	0	143	0	3	0	Dark Shale
143	0	151	8	8	8	Gray Shale
151	8	155	0	3	2	Gray Sandy Shale
155	0	160	0	5	0	Sandy Shale - Damp
160	0	176	6	16	6	Sand and Sandy Shale - Damp
176	6	179	0	2	4	Very Hard Rock
179	0	197	0	18	0	Soft Formation
197	0	200	0	3	0	Coal
200	0	203	0	3	0	Hard Formation
203	0	214	1	11	1	Soft Formation
214	1	225	7	11	6	Coal

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 12/4/79

AREA N-5 PAGE No. 2 of HOLE No. 43

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
225	7	231	7	6	0	Soft Formation
231	7	235	0	3	3	Hard Formation
235	0	244	0	9	0	Soft Formation
244	0	263	8	19	8	Gray Shale - Dry
263	8	269	3	5	5	Coal
269	3	275	4	6	1	Gray Shale and Sandstone
275	4	278	4	3	0	Coal
278	4	280	0	1	6	Gray Shale
280	0	285	0	5	0	Sand - Silty
285	0	288	0	3	0	Coal
288	0	310	0	22	0	Sandstone and Shale
310	0	337	0	27	0	Sand - Silty sandstone
337	0	360	0	23	0	Shale
360	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 360' casing; perforated from 195'-204',
						210'-230', 237'-257', and 260'-360'; gravel packed; well
						sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 2/3/80

AREA J-1 PAGE No. 1 of HOLE No. 44

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	2	0	2	0	Red Surface Sand
2	0	7	2	5	2	Burnt Sandrock
7	2	10	0	2	8	Burnt Clay and Rock
10	0	25	0	15	0	Burnt Sandrock
25	0	30	3	5	3	Red-Gray-Brown Clay - Damp
30	3	42	0	11	7	Baked - Burnt Sandstone
42	0	50	1	8	1	Brown Shale and Sandstone
50	1	71	5	21	4	Sandstone
71	5	75	0	3	5	Smut and Dark Shale
75	0	78	5	3	5	Baked Dark Shale
78	5	83	0	4	5	Hard Gray Shale and Sandstone - Burnt
83	0	94	1	11	1	Dark Gray Shale
94	1	95	7	1	6	Smut - Soft Coal
95	7	97	0	1	3	Dark Shale
97	0	100	9	3	9	Baked Gray Shale
100	9	104	0	3	1	Gray Shale and Sandstone
104	0	119	7	15	7	Hard Gray Sandstone
119	7	123	0	3	3	Hard Gray Sandstone
123	0	129	2	6	2	Gray Shale
129	2	130	0	0	8	Gray Sandstone
130	0	130	2	0	2	Gray Shale
130	2	131	7	1	5	Coal
131	7	136	8	5	1	Gray Shale
136	8	138	0	1	2	Dark Shale with Coal Bands

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 2/3/80

AREA J-1

PAGE No. 2 of HOLE No. 44

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
138	0	140	0	2	0	Gray Shale
140	0	144	0	4	0	Baked Shale
144	0	146	9	2	9	Gray Sandstone and Shale
146	9	152	0	5	1	Hard Gray Sandstone
152	0	161	4	9	4	Gray Shale
161	4	165	0	3	6	Coal
165	0	165	8	0	8	Dark Shale
165	8	168	4	2	6	Coal
168	4	182	0	13	6	Gray Shale with Hard Streaks
182	0	183	0	1	0	Dark Shale
183	0	188	0	5	0	Gray Shale
188	0	191	8	3	8	Light Gray Sandstone
191	8	192	3	0	5	Hard Rock
192	3	202	0	9	7	Hard Gray Shale and Sandstone
202	0	203	0	1	0	Very Hard Rock
203	0	220	0	17	0	Hard Gray Shale and Sandstone
220	0	244	0	24	0	Gray Sandy Shale and Sandstone - Damp
244	0	250	8	6	8	Gray Shale
250	8	261	9	11	1	Hard Gray Sandstone and Shale
261	9	265	6	3	7	Coal
265	6	267	0	1	4	Gray Shale and Sandstone
267	0	275	2	8	2	Gray Shale
275	2	278	0	2	8	Hard Light Gray Sandstone and Shale
278	0	282	5	4	5	Hard Sandy Shale - Damp

PEABODY COAL COMPANY

Environmental Quality

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DATE 2/3/80

AREA J-1 PAGE No. 3 of HOLE No. 44

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
282	5	283	0	0	5	Dark Shale and Coal
283	0	290	6	7	6	Coal
290	6	291	6	1	0	Dark Shale
291	6	297	2	5	6	Gray Shale and Sandstone
297	2	301	6	4	4	Very Hard Sandstone
301	6	304	7	3	1	Coal
304	7	309	7	5	0	Gray Shale
309	7	311	7	2	0	Dark Shale
311	7	316	7	5	0	Gray Shale and Sandy Shale
316	7	317	7	1	0	Coal
317	7	320	7	3	0	Dark Shale
320	7	321	2	0	5	Coal
321	2	323	7	2	5	Gray Shale
323	7	324	7	1	0	Coal
324	7	335	8	11	1	Gray Shale and Sandy Shale
335	8	350	0	14	2	Gray Sandy Shale - Damp
350	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 350' casing; perforated from
						282'-350'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 7/22/80

AREA J-3 PAGE No. 1 of HOLE No. 45

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	17	2	17	2	Sand
17	2	18	0	0	8	Sandstone - Hard
18	0	19	2	1	2	Sand
19	2	35	6	16	4	Sand, Sandstone
35	6	39	6	4	0	Sand
39	6	46	0	6	4	Sandstone - Hard
46	0	56	6	10	6	Shale - Gray
56	6	59	0	2	4	Shale - Gray
59	0	70	5	11	5	Shale - Gray
70	5	76	5	6	0	Coal
76	5	79	0	2	5	Shale - Gray
79	0	91	6	12	6	Shale - Sandy
91	6	93	0	1	4	Sandstone - Hard
93	0	110	0	17	0	Shale - Sandy
110	0	112	7	2	7	Sandstone - Hard
112	7	116	0	3	3	Shale - Sandy
116	0	121	0	5	0	Shale - Sandy
121	0	132	0	11	0	Shale
132	0	135	0	3	0	Shale
135	0	147	2	12	2	Shale - Sandy
147	2	149	9	2	5	Coal
149	9	157	9	8	0	Shale - Sandy
157	9	159	9	2	0	Coal
159	9	162	0	2	1	Shale - Sandy

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 7/22/80

AREA J-3 PAGE No. 2 of HOLE No. 45

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
162	0	173	0	11	0	Shale
173	0	178	0	5	0	Sandstone - Hard
178	0	182	6	4	6	Shale
182	6	183	0	0	4	Shale
183	0	193	1	10	1	Shale - Sandy
193	1	202	6	9	5	Coal
202	6	203	6	1	0	Shale - Gray
203	6	205	6	2	0	Coal
205	6	210	0	4	4	Shale - Sandy
210	0	215	0	5	0	Shale - Sandy
215	0	223	0	8	0	Sandstone
223	0	260	0	37	0	Shale - Sandy
260	0	280	0	20	0	Shale
280	0	281	0	1	0	Sandstone - Hard
281	0	285	1	4	1	Sandstone
285	1	293	0	7	9	Shale
293	0	300	0	7	0	Shale
300	0	309	0	9	0	Sandy Shale
309	0	341	0	32	0	Shale
						T.D.
						Monitoring Water Well.
						6" pvc casing; set 330' casing' perforated from 130'-170'
						and 190'-330'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality
Well Logs

DATE 12/12/79

AREA J-27

PAGE No. 1 of HOLE No. 46

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	8	9	8	9	Loose Surface Sand
8	9	10	5	1	6	Gray Shale
10	5	11	0	0	5	Shale
11	0	14	2	3	2	Gray Shale
14	2	16	2	2	0	Dark Shale
16	2	23	8	7	6	Gray Shale
23	8	26	3	2	5	Hard Brown Sand Rock
26	3	27	0	0	7	Gray Shale
27	0	27	6	0	6	Coal, Damp
27	6	34	3	6	7	Gray Shale and Sandstone
34	3	35	0	0	7	Hard Sandstone
35	0	38	0	3	0	Gray Shale and Sandstone
38	0	45	0	7	0	Hard Gray Sandstone
45	0	47	4	2	4	Gray Shale
47	4	53	4	6	0	Coal, Baked, Damp - Orange 1 & 2 Combined
53	4	71	5	18	1	Gray Shale
71	5	72	5	1	0	Coal - Orange 3
72	5	74	0	1	5	Dark Shale
74	0	74	5	0	5	Dark Gray Shale
74	5	76	0	1	5	Coal - Orange 3
76	0	85	0	9	0	Gray Shale
85	0	92	0	7	0	Gray Shale and Sandstone
92	0	101	0	9	0	Gray Sandstone
101	0	110	0	9	0	Hard Sandstone

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 12/12/79

AREA J-27 PAGE No. 2 of HOLE No. 46

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
110	0	120	8	10	8	Gray Sandy Shale - Damp
120	8	124	0	3	2	Dark Shale
124	0	126	0	2	0	Dark Gray Shale
126	0	141	0	15	0	Gray Shale
141	0	143	5	2	5	Hard Gray Sandstone
143	5	157	9	14	4	Gray Shale
157	9	160	0	2	1	Hard Sandstone and Sandy Shale - Damp
160	0	173	0	13	0	Sandy Shale - Damp
173	0	180	0	7	0	Gray Shale
180	0	184	0	4	0	Dark Shale
184	0	203	0	19	0	Gray Shale with Hard Streaks
203	0	216	2	13	2	Sandy Shale - Damp
216	2	255	4	39	2	Light Gray Sand - Sandstone - Wet
255	4	280	0	24	6	Gray Shale and Sandy Shale
280	0	287	0	7	0	Gray Sandstone and Sand
287	0	303	0	16	0	Gray Shale and Sandy Shale
303	0	308	7	5	7	Dark Gray Shale
308	7	310	2	1	5	Coal
310	2	317	0	6	8	Dark Gray Shale
317	0	324	0	7	0	Gray Sandy Shale and Sandstone
324	0	336	8	12	8	Gray Shale
336	8	338	8	2	0	Coal
338	8	340	0	1	2	Gray Shale and Sandstone
340	0	344	0	4	0	Dark Sandy Shale

PEABODY COAL COMPANY

Environmental Quality
Well Logs

DATE 12/12/79

AREA J-27 PAGE No. 3 of HOLE No. 46

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
344	0	360	0	16	0	Gray Shale
*360	0					T.D.
						Monitoring Water Well
						260' deep; 6" ID pvc; gravel packed; cemented;
						perforated from 155'-160', 165'-177', 180'-187',
						190'-195', 197'-260'.
						* A 4" pilot hole drilled to 360'. The hole was then
						reamed out to 9" to a depth of 260'. The well was
						cased and completed to 260'.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 11/16/79

AREA J-7 PAGE No. 1 of HOLE No. 47

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	20	0	20	0	Sand and Gravel
20	0	24	0	4	0	Brown Shale
24	0	31	8	7	8	Gray Shale - Damp
31	8	33	3	1	5	Coal
33	3	35	0	1	7	Dark Shale
35	0	36	8	1	8	Gray Shale
36	8	38	3	1	5	Coal - Wet
38	3	43	5	5	2	Gray Shale - Wet
43	5	54	4	10	9	Hard Gray Sandstone and Shale
54	4	56	4	2	0	Dark Shale - Wet
56	4	68	5	12	1	Gray Shale
68	5	71	5	3	0	Coal
71	5	91	8	20	3	Gray Shale
91	8	92	4	0	6	Hard Rock
92	4	94	6	2	2	Gray Shale
94	6	96	6	2	0	Coal
96	6	97	6	1	0	Gray - Dark Shale
97	6	99	6	2	0	Coal
99	6	104	7	5	1	Gray Shale with Hard Streaks
104	7	106	2	1	5	Hard Rock
106	2	126	3	20	1	Gray Shale
126	3	127	0	0	7	Coal
127	0	132	0	5	0	Gray Shale - Dark Shale
132	0	140	0	8	0	Gray Shale and Sandstone

THE HALL COMPANY, ... 139586

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 11/16/79

AREA J-7 PAGE No. 2 of HOLE No. 47

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
140	0	144	0	4	0	Light Gray Sandstone
144	0	170	9	26	9	Gray Shale
170	9	177	9	7	0	Gray Sandstone
177	9	178	6	0	7	Hard Dark Rock
178	6	181	0	2	4	Soft Light Gray Sandstone
181	0	190	0	9	0	Gray Shale
190	0	196	0	6	0	Gray Shale and Sandstone
196	0	230	0	34	0	Light Gray Sandstone - Shale
230	0	235	8	5	8	Gray Shale
235	8	237	3	1	5	Very Hard Rock
237	3	244	0	6	7	Gray Shale and Sandy Shale
244	0	253	0	9	0	Dark Shale with Coal Streaks
253	0	261	9	8	9	Gray Sandy Shale
261	9	271	9	10	0	Coal
271	9	283	0	11	1	Gray Shale and Sandstone
283	0	323	0	40	0	Gray Sandstone
*323	0					T.D.
						Monitoring Water Well
						220' deep; 6" ID pvc casing; gravel packed; cemented;
						perforated 35'-73', 83'-108', 117'-147', 172'-220'.
						* A 4" pilot hole was drilled to 323'. The hole was reamed
						out to 9" to a depth of 220'. The well was cased and
						completed to 220'.

THE HILLS COMPANY, SHERIDAN 139308

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 11/11/79

AREA J-7 PAGE No. 1 of HOLE No. 48

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	20	0	20	0	Sand and Gravel
20	0	24	0	4	0	Brown Shale
24	0	31	8	7	8	Gray Shale - Damp
31	8	33	3	1	5	Coal
33	3	35	0	1	7	Dark Shale
35	0	36	8	1	8	Gray Shale
36	8	38	3	1	5	Coal - Wet
38	3	43	5	5	2	Gray Shale - Wet
43	5	54	4	10	9	Hard Gray Sandstone and Shale
54	4	56	4	2	0	Dark Shale - Wet
56	4	68	5	12	1	Gray Shale
68	5	71	5	3	0	Coal
71	5	91	8	20	3	Gray Shale
91	8	92	4	0	6	Hard Rock
92	4	94	6	2	2	Gray Shale
94	6	96	6	2	0	Coal
96	6	97	6	1	0	Gray - Dark Shale
97	6	99	6	2	0	Coal
99	6	104	7	5	1	Gray Shale with Hard Streaks
104	7	106	2	1	5	Hard Rock
106	2	126	3	20	1	Gray Shale
126	3	127	0	0	7	Coal
127	0	132	0	5	0	Gray Shale - Dark Shale
132	0	140	0	8	0	Gray Shale and Sandstone

PEABODY COAL COMPANY
Environmental Quality
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DATE 11/11/79

AREA J-7 PAGE No. 2 of HOLE No. 48

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
140	0	144	0	4	0	Light Gray Sandstone
144	0	170	9	26	9	Gray Shale
170	9	177	9	7	0	Gray Sandstone
177	9	178	6	0	7	Hard Dark Rock
178	6	181	0	2	4	Soft Light Gray Sandstone
181	0	190	0	9	0	Gray Shale
190	0	196	0	6	0	Gray Shale and Sandstone
196	0	230	0	34	0	Gray Sandstone and Sandstone
230	0	235	8	5	8	Gray Shale
235	8	237	3	1	5	Very Hard Rock
237	3	244	0	6	7	Gray Shale and Sandy Shale
244	0	253	0	9	0	Dark Shale with Coal Streaks
253	0	261	9	8	9	Gray Sandy Shale
261	9	271	9	10	0	Coal
271	9	283	0	11	1	Gray Shale and Sandstone
283	0	323	0	40	0	Gray Sandstone
*323	0					T.D.
						Monitoring Water Well
						220' deep; 4" ID pvc casing; gravel packed; cemented;
						perforated 40'-75, 85'-120', 125'-145', 172'-220'.
						* A 4" pilot hole was drilled to 323'. The hole was
						reamed out to 9" to a depth of 220'. The well was
						cased and completed to 220'.

THE MILLS COMPANY, BEETHOVEN 138508

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 5/23/80

AREA N-14

PAGE No. 1 of HOLE No. 49

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	16	7	16	7	Sand
16	7	18	7	2	0	Gravel
18	7	19	9	1	2	Shale
19	9	21	7	1	8	Gray Shale and Coal
21	7	23	0	1	3	Soft Coal
23	0	24	0	1	0	Coal
24	0	26	9	2	9	Shale
26	9	29	9	3	0	Coal
29	9	36	9	7	0	Shale
36	9	37	7	0	8	Hard Rock
37	7	38	9	1	2	Shale
38	9	39	9	1	0	Coal
39	9	41	0	1	1	Shale
41	0	48	0	7	0	Sandy Shale
48	0	51	0	3	0	Sandstone - Hard
51	0	52	0	1	0	Gray Shale
52	0	54	3	2	3	Shale - Hard
54	3	63	0	8	7	Shale
63	0	65	0	2	0	Gray Shale
65	0	75	6	10	6	Shale
75	6	78	8	3	2	Sandstone and Sandy Shale
78	8	80	0	1	2	Hard Rock
80	0	83	5	3	5	Sandstone
83	5	109	3	25	8	Shale and Sandstone

PEABODY COAL COMPANY

Environmental Quality

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AREA N-14

PAGE No. 2 of HOLE No. 49

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
109	3	113	0	3	7	Sandstone and Sandy Shale
113	0	113	8	0	8	Hard Rock
113	8	125	0	11	2	Sandstone and Sandy Shale
125	0	126	5	1	5	Gray Shale
126	5	128	5	2	0	Coal
128	5	131	4	2	9	Sandy Shale and Sandstone
131	4	132	4	1	0	Gray Shale and Coal
132	4	136	4	4	0	Sandstone - Hard
136	4	137	4	1	0	Coal and Gray Shale
137	4	138	9	1	5	Coal
138	9	140	0	1	1	Gray Shale
140	0	147	0	7	0	Sandy Shale
147	0	149	0	2	0	Coal
149	0	160	0	11	0	Shale and Sandstone
160	0	168	0	8	0	Shale with Hard Streaks
168	0	186	0	18	0	Sandy Sandstone and Shale
186	0	192	7	6	7	Sandy Shale with Hard Streaks
192	7	194	0	1	3	Gray Shale and Coal
194	0	196	0	2	0	Gray Shale
196	0	202	7	6	7	Shale and Sandstone
202	7	204	7	2	0	Coal
204	7	205	0	0	3	Shale and Sandstone
205	0	211	8	6	8	Shale with Hard Streaks
211	8	212	8	1	0	Gray Shale and Coal

PEABODY COAL COMPANY

Environmental Quality

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AREA N-14

PAGE No. 3 of HOLE No. 49

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances	
212	8	214	8	2	0	Coal	
214	8	218	0	3	2	Shale with Hard Streaks	
218	0	230	9	12	9	Sandy Shale	
230	9	233	9	3	0	Coal	
233	9	235	0	1	1	Gray Shale	
235	0	236	4	1	4	Shale and Sandstone	
236	4	240	0	3	6	Shale with Hard Streaks	
240	0	247	0	7	0	Brown Shale with Hard Streaks	
247	0	260	0	13	0	Sandy Shale and Sand	
260	0	263	0	3	0	Gray Shale	
263	0	268	0	5	0	Sandy Shale and Sandstone	
268	0	276	1	8	1	Sandstone and Shale	
276	1	284	0	7	9	Sandy Shale	
284	0	292	2	8	2	Shale	
292	2	296	0	3	8	Shale with Hard Streaks	Monitoring Water Well.
296	0	304	0	8	0	Sandy Sandstone	6' pvc casing; set 350'
304	0	314	3	10	3	Sandy Shale and Sandstone	casing; perforated from
314	3	318	3	4	0	Coal	8'-18', 18'-23', 42'-52',
318	3	320	3	2	0	Gray Shale	81'-91', 98'-113', 140'-
320	3	322	0	1	7	Shale with Hard Streaks	155', 160'-175', 179'-189',
322	0	350	0	28	0	Sandy Shale	237'-247', & 252'-350';
350	0					T.D.	Gravel packed; well sealed
							with cement.

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 8/5/80

AREA N-8 PAGE No. 1 of HOLE No. 51

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	3	5	3	5	Clay and Sand
3	5	23	0	19	5	Sand and Gravel
23	0	24	0	1	0	Shale - Soft
24	0	39	5	15	5	Sandstone
39	5	40	0	0	5	Shale - Soft
40	0	41	0	1	0	Coal
41	0	41	5	0	5	Clay
41	5	45	0	3	5	Sandstone - Hard
45	0	47	2	2	2	Shale - Soft
47	2	51	2	4	0	Coal
51	2	52	5	1	3	Gray Shale - Soft
52	5	53	0	0	5	Shale
53	0	58	0	5	0	Sandstone
58	0	61	0	3	0	Sandy Shale
61	0	61	5	0	5	Gray Shale - Soft
61	5	62	5	1	0	Coal
62	5	69	5	7	0	Shale and Sandstone - Soft
69	5	70	5	1	0	Sandstone - Hard
70	5	76	5	6	0	Sandy Shale - Soft
76	5	77	5	1	0	Coal
77	5	78	0	0	5	Shale - Soft
78	0	85	0	7	0	Sandstone and Sandy Shale - Hard
85	0	85	5	0	5	Shale - Hard
85	5	91	8	6	3	Coal

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 8-5-85

AREA N-8

PAGE No. 2 of HOLE No. 51

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
91	8	94	8	3	0	Shale - Soft
94	8	95	5	0	7	Coal
95	5	101	0	5	5	Shale and Sandy Shale - Hard
101	0	120	5	19	5	Sandstone - Hard
120	5	122	0	1	5	Coal
122	0	126	5	4	5	Shale - Hard
126	5	127	5	1	0	Gray Shale
127	5	128	5	1	0	Sandstone - Hard
128	5	129	5	1	0	Sandy Shale
129	5	131	5	2	0	Gray Shale - Hard
131	5	137	0	5	5	Shale - Hard
137	0	139	5	2	5	Coal
139	5	148	0	8	5	Sandstone
148	0	149	0	1	0	Shale - Soft
149	0	151	2	2	2	Coal
151	2	155	0	3	8	Gray Shale - Hard
155	0	210	5	55	5	Sandstone - Hard
210	5	212	0	1	5	Coal
212	0	242	5	30	5	Sandstone - Hard
242	5	244	5	2	0	Coal
244	5	285	0	40	5	Sandstone
285	0	289	0	4	0	Coarse Sandstone
289	0	320	0	31	0	Sandstone - Hard
320	0	321	5	1	5	Coal

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 8-5-80

AREA N-8

PAGE No. 3 of HOLE No. 51

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
321	5	347	0	25	5	Sandstone - Hard
347	0	350	0	3	0	Sandstone - Coarse - Hard
350	0					T.D.
						Monitoring Water Well.
						6' pvc casing; set 350' casing; perforated from 250'-350';
						gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 8/3/80

AREA N-9 **PAGE No.** 1 **of HOLE No.** 52

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	7	4	7	4	Sand, Sandy Clay
7	4	8	9	1	5	Gravel
8	9	12	0	3	1	Clay, Sandstone
12	0	17	0	5	0	Sandstone
17	0	21	5	4	5	Sandstone - Hard
21	5	30	6	9	1	Sandstone
30	6	32	6	2	0	Shale
32	6	34	6	2	0	Coal
34	6	38	6	4	0	Shaly Sandstone
38	6	40	1	1	5	Coal
40	1	41	0	0	9	Gray Shale, Coal
41	0	43	0	2	0	Shale
43	0	46	0	3	0	Coal
46	0	48	1	2	1	Shale - Gray
48	1	53	0	4	9	Shaly Sandstone
53	0	57	6	4	6	Hard Sandstone, Shale
57	6	60	0	2	4	Hard Sandstone
60	0	63	7	3	7	Shale
63	7	67	7	4	0	Coal
67	7	68	1	0	4	Shale - Gray
68	1	71	7	3	6	Coal
71	7	72	7	1	0	Gray Shale, Coal
72	7	74	7	2	0	Coal
74	7	80	0	5	3	Shale - Gray

THE HILLS COMPANY, SHERMAN 139508

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 8-3-80

AREA N-9

PAGE No. 2 of HOLE No. 52

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
80	0	82	0	2	0	Coal
82	0	83	0	1	0	Shaly Sandstone
83	0	89	2	6	2	Sandstone and Sandy Shale
89	2	105	0	15	8	Hard Sandstone
105	0	108	9	3	9	Sandy Shale and Shale
108	9	112	9	4	0	Coal
112	9	116	6	3	7	Shale
116	6	117	8	1	2	Hard Sandstone
117	8	122	0	4	2	Shaly Sandstone
122	0	128	0	6	0	Shale with Hard Streaks
128	0	129	0	1	0	Coal
129	0	140	5	11	5	Shale
140	5	143	5	3	0	Coal
143	5	161	0	17	5	Shaly Sandstone
161	0	163	0	2	0	Coal
163	0	165	0	2	0	Shaly Sandstone
165	0	168	0	3	0	Hard Sandstone
168	0	170	2	2	2	Shale with Hard Streaks
170	2	176	2	6	0	Coal
176	2	180	0	3	8	Shale with Hard Streaks
180	0	182	3	2	3	Sandy Shale
182	3	182	8	0	5	Coal
182	8	185	0	2	2	Gray Shale, Coal
185	0	190	6	5	6	Shale

PEABODY COAL COMPANY

Environmental Quality
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DATE 8-3-80

AREA N-9 PAGE No. 3 of HOLE No. 52

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
190	6	192	0	1	4	Hard Sandstone
192	0	193	3	1	3	Shale
193	3	195	0	1	7	Coal
195	0	251	5	56	5	Sandy Shale
251	5	255	6	4	1	Gray Shale, Coal
255	6	260	0	4	4	Shale
260	0	323	0	63	0	Sandy Shale
323	0	326	0	3	0	Gray Shale
326	0	330	0	4	0	Gray Shale, Coal
330	0	333	0	3	0	Shale with Hard Streaks
333	0	334	5	1	5	Coal
334	5	338	0	3	5	Shaly Sandstone
338	0	345	0	7	0	Shale
345	0	350	0	5	0	Sandy Shale and Sandstone
350	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 350' casing; perforated from 70'-90',
						150'-250', and 270'-350'; gravel packed; well sealed
						with cement.

THE MILLS COMPANY, OWENSBORO 138308

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 7/23/80

AREA N-3 PAGE No. 1 of HOLE No. 53

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	11	6	11	6	Sandy Clay
11	6	13	0	1	4	Smut and Coal
13	0	15	6	2	6	Coal
15	6	17	0	1	4	Shale
17	0	21	0	4	0	Rock - Hard
21	0	25	3	4	3	Shale and Rock - Hard
25	3	30	9	5	6	Shale
30	9	34	5	3	6	Hard Rock
34	5	40	0	5	5	Shale and Sandstone
40	0	45	0	5	0	Shale - Soft
45	0	49	3	4	3	Coal
49	3	58	0	8	7	Shale
58	0	61	0	3	0	Sandstone
61	0	63	4	2	4	Shale and Sandstone Streaks
63	4	70	0	6	6	Hard Sandstone
70	0	72	4	2	4	Shale
72	4	74	4	2	0	Coal
74	4	79	5	5	1	Shale
79	5	82	0	2	5	Hard Sandstone
82	0	92	5	10	5	Shale and Sandstone - Hard
92	5	95	5	3	0	Coal
95	5	98	0	2	5	Shale and Sandstone
98	0	101	1	3	1	Hard Sandstone
101	1	101	7	0	6	Shale - Soft

THE MILLS COMPANY, SHERIDAN 138308

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 7-23-80

AREA N-3 PAGE No. 2 of HOLE No. 53

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
101	7	102	5	0	8	Sandstone - Hard
102	5	111	6	9	1	Shale - Hard
111	6	115	0	3	4	Sandstone - Hard
115	0	125	0	10	0	Sandstone
125	0	132	3	7	3	Shale and Sandstone
132	3	136	0	3	7	Sandstone - Hard
136	0	139	7	3	7	Shale
139	7	146	8	7	1	Sandstone and Shale
146	8	148	8	2	0	Hard Rock
148	8	152	8	4	0	Shale with Hard Streaks
152	8	157	3	4	5	Coal
157	3	160	0	2	7	Shale
160	0	166	9	6	9	Coal
166	9	171	4	4	5	Shale and Sandstone
171	4	175	0	3	6	Very Hard Sandstone
175	0	177	5	2	5	Shale
177	5	178	5	1	0	Coal
178	5	179	0	0	5	Shale
179	0	191	3	12	3	Shale and Sandstone
191	3	193	3	2	0	Hard Sandstone
193	3	197	0	3	7	Shale
197	0	199	0	2	0	Coal
199	0	208	1	9	1	Shale
208	1	216	1	8	0	Coal

PEABODY COAL COMPANY

Environmental Quality

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AREA N-3

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FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances	
216	1	220	7	4	6	Shale	
220	7	222	2	1	5	Hard Sandstone and Rock	
222	2	225	0	2	8	Shale and Sandstone	
225	0	240	0	15	0	Shale	
240	0	245	5	5	5	Sandy Shale	
245	5	247	5	2	0	Hard Sandstone	
247	5	256	0	8	5	Sandstone and Shale Streaks	
256	0	258	6	2	6	Hard Sandstone	
258	6	282	5	23	9	Shale with Hard Streaks	
282	5	285	5	3	0	Coal	
285	5	295	5	10	0	Shale	
295	5	296	0	0	5	Hard Rock	
296	0	315	0	19	0	Sandy Shale	
315	0	322	1	7	1	Shale	
322	1	322	7	0	6	Hard Rock	
322	7	325	0	2	3	Shale and Sandstone Streaks	
325	0	332	0	7	0	Shale - Soft	
332	0	336	3	4	3	Shale and Sandstone	
336	3	337	1	0	8	Very Hard Rock	Monitoring Water Well.
337	1	340	0	2	9	Shale	6" pvc casing; set 350' casing;
340	0	350	0	10	0	Sandy Shale	perforated from 190'-350';
350	0					T.D.	gravel packed; well sealed with
							cement.

PEABODY COAL COMPANY

Environmental Quality

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AREA N-14 PAGE No. 1 of HOLE No. 54

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	8	0	8	0	Clay, Gravel
8	0	16	0	8	0	Sandstone - Soft
16	0	33	5	17	5	Sandstone - Hard
33	5	36	7	3	2	Coal
36	7	38	9	2	2	Black Shale
38	9	39	6	0	7	Coal
39	6	43	5	3	9	Black Shale - Soft
43	5	47	0	3	5	Sandy Shale - Hard
47	0	54	0	7	-0	Gray Shale - Soft
54	0	55	0	1	0	Coal
55	0	58	2	3	2	Gray Shale - Soft
58	2	59	0	0	8	Coal
59	0	68	0	9	0	Gray Shale - Soft
68	0	69	5	1	5	Sandstone - Hard
69	5	71	0	1	5	Shale - Soft
71	0	73	0	2	0	Coal
73	0	78	0	5	0	Shale - Soft
78	0	82	0	4	0	Shale - Hard
82	0	96	0	14	0	Sandstone - Medium
96	0	98	0	2	0	Shale - Soft
98	0	106	7	8	7	Sandstone - Hard
106	7	109	9	3	2	Coal
109	9	111	0	1	1	Shale - Soft
111	0	115	0	4	0	Sandy Shale - Hard

PEABODY COAL COMPANY

Environmental Quality

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AREA N-14

PAGE No. 2 of HOLE No. 54

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
115	0	135	5	20	5	Sandstone - Medium
135	5	137	4	1	9	Coal
137	4	139	0	1	6	Gray Shale - Soft
139	0	170	0	31	0	Sandstone - Medium
170	0	171	0	1	0	Coal
171	0	173	0	2	0	Shale - Soft
173	0	174	0	1	0	Coal
174	0	178	7	4	7	Sandstone - Hard
178	7	181	0	2	3	Coal
181	0	184	0	3	0	Gray Shale - Soft
184	0	187	0	3	0	Shale - Soft
187	0	190	0	3	0	Coal
190	0	191	0	1	0	Shale - Soft
191	0	192	0	1	0	Coal
192	0	196	0	4	0	Shale - Soft
196	0	197	0	1	0	Coal
197	0	200	0	3	0	Shale - Soft
200	0	202	8	2	8	Coal
212	8	206	7	3	9	Shale - Soft
206	7	207	7	1	0	Coal
207	7	210	5	2	8	Shale - Soft
210	5	211	5	1	0	Coal
211	5	215	0	3	5	Shale - Soft
215	0	215	8	0	8	Coal

PEABODY COAL COMPANY

Environmental Quality

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DATE 5/24/80

AREA N-14 PAGE No. 3 of HOLE No. 54

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
215	8	220	5	4	7	Sandstone - Hard
220	5	221	2	0	7	Coal
221	2	230	4	9	2	Sandstone
230	4	231	0	0	6	Coal
231	0	234	0	3	0	Sandstone
234	0	239	0	5	0	Sandstone - Hard and Coal Blinds
239	0	240	0	1	0	Coarse Sandstone
240	0	242	0	2	0	Sandstone - Hard
242	0	244	0	2	0	Shale - Soft
244	0	246	5	2	5	Sandstone - Hard
246	5	260	0	13	5	Sandstone - Soft
260	0	285	5	25	5	Sandstone - Hard
285	5	287	0	1	5	Coal
287	0	303	0	16	0	Sandstone - Hard
303	0	304	0	1	0	Coal
304	0	305	0	1	0	Shale - Soft
305	0	350	0	45	0	Sandstone - Hard
350	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 350' casing; perforated from 120'-135',
						135'-143', 160'-170', 179'-189', 199'-209', 218'-228',
						238'-248', 257'-267', and 272'-350'; gravel packed; well
						sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 7/30/80

AREA J-15 PAGE No. 1 of HOLE No. 55

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	3	0	3	0	Sandy Clay
3	0	4	0	1	0	Gravel
4	0	6	0	2	0	Sandstone - Soft
6	0	38	0	32	0	Sandstone - Hard
38	0	39	0	1	0	Red Sandstone - Soft
39	0	42	5	3	5	Sandstone - Hard
42	5	43	7	1	2	Sandy Shale - Soft
43	7	44	5	0	8	Shale - Soft
44	5	47	5	3	0	Sandstone - Hard
47	5	52	0	4	5	Shale - Soft
52	0	53	9	1	9	Coal
53	9	54	5	0	6	Shale - Soft
54	5	59	0	4	5	Sandstone - Hard
59	0	61	4	2	4	Dark Shale - Hard
61	4	62	0	0	6	Coal
62	0	67	0	5	0	Shale - Soft
67	0	68	0	1	0	Coal
68	0	70	0	2	0	Shale - Soft
70	0	70	5	0	5	Sandstone - Hard
70	5	72	3	1	8	Shale - Soft
72	3	72	4	0	1	Sandstone - Hard
72	4	75	0	2	6	Coal
75	0	77	5	2	5	Shale - Soft
77	5	81	5	4	0	Coal

PEABODY COAL COMPANY

Environmental Quality

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DATE 7-30-80

AREA J-15 PAGE No. 2 of HOLE No. 55

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
81	5	83	0	1	5	Sandstone
83	0	83	5	0	5	Coal
83	5	84	5	1	0	Sandstone - Hard
84	5	85	5	1	0	Shale - Soft
85	5	86	8	1	3	Coal
86	8	88	0	1	2	Sandstone - Hard
88	0	89	0	1	0	Coal
89	0	90	5	1	5	Shale - Soft
90	5	92	0	1	5	Coal
92	0	97	0	5	0	Sandstone - Hard
97	0	100	5	3	5	Coal
100	5	104	0	3	5	Shale - Soft
104	0	106	5	2	5	Coal
106	5	107	0	0	5	Shale - Soft
107	0	112	5	5	5	Coal
112	5	115	5	3	0	Sandstone - Hard
115	5	125	8	10	3	Sandy Shale - Hard
125	8	145	0	19	2	Sandstone - Hard
145	0	147	0	2	0	Coal
147	0	149	3	2	3	Sandstone - Hard
149	3	151	0	1	7	Coal
151	0	160	0	9	0	Sandstone - Hard
160	0	161	0	1	0	Shale - Soft
161	0	168	3	7	3	Sandy Shale - Hard

PEABODY COAL COMPANY
Environmental Quality
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AREA J-15 PAGE No. 3 of HOLE No. 55

FORMATION RECORD

DEPTH From—		DEPTH To—		Thickness of stratum		Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
Feet	Tenths	Feet	Tenths	Feet	Tenths	
168	3	170	0	1	7	Coal
170	0	195	0	25	0	Sandstone - Hard
195	0	196	0	1	0	Dark Shale - Hard
196	0	202	3	6	3	Sandstone - Hard
202	3	204	0	1	7	Dark Shale - Hard
204	0	204	6	0	6	Coal
204	6	207	6	3	0	Shale - Soft
207	6	212	0	4	4	Shale - Hard
212	0	219	0	7	0	Sandstone - Hard
219	0	220	0	1	0	Shale - Hard
220	0	221	0	1	0	Coal
221	0	225	0	4	0	Shale - Hard
225	0	239	0	14	0	Sandstone - Hard
239	0	246	0	7	0	Dark Shale - Medium Hard
246	0	284	0	38	0	Sandstone - Hard
284	0	285	0	1	0	Dark Shale - Hard
285	0	291	0	6	0	Coal
291	0	293	0	2	0	Dark Shale - Hard
293	0	315	5	22	5	Sandstone - Hard
315	5	317	5	2	0	Coal
317	5	323	5	6	0	Dark Shale - Hard
323	5	334	0	10	5	Sandstone - Hard
334	0	337	0	3	0	Coal
337	0	338	0	1	0	Dark Shale - Hard

PEABODY COAL COMPANY
Environmental Quality
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AREA J-15 PAGE No. 4 of HOLE No. 55

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
338	0	343	0	5	0	Coal
343	0	345	0	2	0	Sandstone - Hard
345	0	346	5	1	5	Shale - Soft
346	5	350	0	3	5	Sandstone - Hard
350	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 350' casing; perforated from
						190'-350'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality
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AREA J-2

PAGE No. 1 of HOLE No. 56

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	5	0	5	0	Surface Sand and Gravel
5	0	8	4	3	4	Gray-Brown Clay; Sand and Gravel
8	4	12	5	4	1	Gray-Brown Clay-Shale
12	5	15	8	3	3	Gray-Brown Sand, Clay
15	8	21	0	5	2	Gray Clay-shale
21	0	35	8	14	8	Gray Sandstone
35	8	42	9	7	1	Sandy Shale, Siltstone
42	9	44	7	1	8	Coal
44	7	56	9	12	2	Siltstone
56	9	58	2	1	3	Carbonaceous Shale
58	2	64	0	5	8	Siltstone
64	0	65	8	1	8	Silty Sandstone
65	8	75	2	9	4	Siltstone
75	2	78	9	3	7	Coal
78	9	84	0	5	1	Siltstone
84	0	90	5	6	5	Coal
90	5	95	7	5	2	Siltstone
95	7	98	4	2	7	Sandstone, Siltstone
98	4	120	7	22	3	Siltstone
120	7	124	8	4	1	Shale
124	8	127	0	2	2	Siltstone
127	0	128	1	1	1	Coal
128	1	135	2	7	1	Shale
135	2	139	0	3	8	Siltstone

PEABODY COAL COMPANY

Environmental Quality

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AREA J-2 PAGE No. 2 of HOLE No. 56

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
139	0	141	2	2	2	Concretion (High Density, Siliceous)
141	2	145	9	4	7	Silty Shale
145	9	148	4	2	5	Coal
148	4	150	7	2	3	Shale
150	7	151	6	0	9	Carbonaceous Shale
151	6	170	4	18	8	Siltstone, Shale
170	4	177	2	6	8	Sandstone, Siltstone
177	2	188	0	10	8	Siltstone, Shale
188	0	199	8	11	8	Shale
199	8	206	7	6	9	Sandstone
206	7	228	4	21	7	Siltstone, Shale
228	4	230	7	2	3	Shale
230	7	233	5	2	8	Siltstone
233	5	235	4	1	9	Shale
235	4	242	0	6	6	Sandstone, Siltstone
242	0	248	6	6	6	Shale
248	6	258	9	10	3	Siltstone
258	9	261	7	2	8	Shale
261	7	279	0	17	3	Sandy Siltstone, Shale
279	0	281	2	2	2	Coal
281	2	284	3	3	1	Silty Shale
284	3	287	3	3	0	Carbonaceous Shale
287	3	293	4	6	1	Siltstone, Shale
293	4	296	0	2	6	Shale

PEABODY COAL COMPANY
Environmental Quality
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DATE 7/17/80

AREA J-2 PAGE No. 3 of HOLE No. 56

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
296	0	297	5	1	5	Siltstone
297	5	302	5	5	0	Siltstone, Shale
302	5	303	8	1	3	Coal
303	8	315	2	11	4	Silty Shale
315	2	325	3	10	1	Sandy Siltstone
325	3	332	6	7	3	Silty Shale
332	6	337	2	4	6	Carbonaceous Shale
337	2	347	0	9	8	Silty Shale
*347	0					T.D.
						Monitoring Water Well.
						350' deep; 6" pvc casing; gravel packed; cemented;
						perforated interval from 130'-350'.
						*A 4" pilot hole was drilled to 347'. The hole was then
						reamed out to 9" to a depth of 350'. The well was then
						cased and completed to 350'.

PEABODY COAL COMPANY

Environmental Quality

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AREA J-4 PAGE No. 1 of HOLE No. 57

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	19	0	19	0	Brown Sandy Clay
19	0	36	0	17	0	Gray Sandy Clay
36	0	49	0	13	0	Siltstone
49	0	57	0	8	0	Coal
57	0	62	0	5	0	Gray Sandy Shale
62	0	65	0	3	0	Coal
65	0	70	0	5	0	Gray Sandy Shale
70	0	75	0	5	0	Mudstone
75	0	80	0	5	0	Gray Shale
80	0	95	0	5	0	Sandy Siltstone
95	0	122	5	27	5	Mudstone, Damp
122	5	127	5	5	0	Gray Shale
127	5	130	0	2	5	Gray, Fine-Grained Sandstone
130	0	135	0	5	0	Gray Siltstone
135	0	147	0	12	0	Dark Shale, Shale
147	0	152	0	5	0	Gray Sandstone, Coarse Grained
152	0	153	0	1	0	Hard Gray Sandstone
153	0	162	0	9	0	Coal
162	0	169	0	7	0	Gray Shale - Sandstone
169	0	172	0	3	0	Coal
172	0	175	5	3	5	Gray Silty Sandstone
175	5	177	5	2	0	Coal
177	5	182	0	4	5	Gray Sandstone, Coarse Grained
182	0	185	0	3	0	Hard Gray Shale

PEABODY COAL COMPANY
Environmental Quality
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DATE 7/19/80

AREA J-4 PAGE No. 2 of HOLE No. 57

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
190	0	190	0	5	0	Hard Gray Sandstone
195	0	196	5	1	5	Hard Gray Shale
196	5	200	5	4	0	Coal, Shaley
200	5	215	0	14	5	Hard Gray Sandstone
215	0	242	0	27	0	Hard Dark Shale, Wet
242	0	246	0	4	0	Gray Sandstone
246	0	252	0	6	0	Gray Shale
252	0	285	5	33	5	Hard Gray Sandstone
285	5	311	0	25	5	Hard Gray Silty Shale
*311	0					T.D.
						Monitoring Water Well
						315' deep; 6" pvc casing; gravel packed, cemented;
						perforated 115-315'.
						*A 4" pilot hole was drilled to 311'. The hole was then
						reamed out to 9" to a depth of 315'. The well was cased
						and completed to 315'.

PEABODY COAL COMPANY

Environmental Quality

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DATE 7/6/80

AREA J-13 PAGE No. 1 of HOLE No. 58

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	7	1	7	1	Surface Sand, Gravel
7	1	21	6	14	5	Brown Clay, Siltstone
21	6	24	2	2	6	Carbonaceous Shale
24	2	27	5	3	3	Siltstone
27	5	31	3	3	8	Silty Shale
31	3	33	4	2	1	Sandy Siltstone
33	4	38	1	4	7	Siltstone
38	1	42	3	4	2	Carbonaceous Shale
42	3	44	6	2	3	Siltstone
44	6	46	9	2	3	Silty Shale
46	9	55	8	8	9	Siltstone
55	8	61	7	5	9	Silty Shale
61	7	63	8	2	1	Siltstone
63	8	65	7	1	9	Carbonaceous Shale
65	7	71	8	6	1	Silty Shale
71	8	74	8	3	0	Siltstone
74	8	99	2	24	4	Silty Sandstone
99	2	100	5	1	3	Carbonaceous Shale
100	5	103	0	2	5	Shale
103	0	114	3	11	3	Silty Shale
114	3	116	3	2	0	Coal
116	3	120	7	4	4	Siltstone
120	7	137	8	17	1	Sandstone
137	8	143	0	5	2	Silty Shale

PEABODY COAL COMPANY

Environmental Quality

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AREA J-13

PAGE No. 2 of HOLE No. 58

FORMATION RECORD

DEPTH From— Feet	From— Tenths	To— Feet	To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
143	0	144	4	1	4	Carbonaceous Shale
144	4	150	7	6	3	Silty Shale
150	7	156	2	5	5	Shale
156	2	158	0	1	8	Silty Shale
158	0	166	4	8	4	Shale
166	4	167	6	1	2	Coal
167	6	176	2	8	6	Siltstone
176	2	190	8	14	6	Sandstone
190	8	199	1	8	3	Siltstone
199	1	206	0	6	9	Silty Sandstone
206	0	210	1	4	1	Sandy Siltstone
210	1	212	9	2	8	Silty Sandstone
212	9	217	8	4	9	Sandy Siltstone
217	8	222	6	4	8	Silty Sandstone
222	6	226	0	3	4	Siltstone
226	0	228	2	2	2	Shale
228	2	232	0	3	8	Coal
232	0	234	1	2	1	Siltstone
234	1	238	5	4	4	Sandstone
238	5	247	4	8	9	Siltstone
247	4	252	0	4	6	Sandstone
252	0	260	1	8	1	Siltstone
260	1	265	6	5	5	Sandy Siltstone
265	6	272	0	6	4	Sandstone

PEABODY COAL COMPANY
Environmental Quality
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DATE 7/6/80

AREA J-13

PAGE No. 3 of HOLE No. 58

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
272	0	276	4	4	4	Siltstone
276	4	281	8	5	4	Shale
281	8	295	6	13	8	Siltstone, Shale
295	6	297	0	1	4	Carbonaceous Shale
297	0	301	2	4	2	Shale
301	2	303	4	2	2	Coal
303	4	306	2	2	8	Shale
306	2	307	1	0	9	Carbonaceous Shale
307	1	312	9	5	8	Shale
312	9	315	7	2	8	Shaley Siltstone
315	7	316	8	1	1	Shale
316	8	322	2	5	4	Siltstone
322	2	327	3	5	1	Sandy Siltstone
327	3	329	0	1	7	Shaley Siltstone
329	0	337	4	8	4	Siltstone
337	4	338	6	1	2	Sandstone
338	6	349	0	10	4	Siltstone
349	0					T.D.
						Monitoring Water Well.
						350 ft deep; 6" pvc casing; gravel packed; cemented;
						perforated 150-350.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/25/80

AREA J-12 PAGE No. 1 of HOLE No. 59

FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	5	0	5	0	Brown Shale
5	0	6	0	1	0	Gray Sandstone - Soft
6	0	10	0	4	0	Brown Sandstone - Soft
10	0	13	0	3	0	Gray Sandstone - Medium Hard
13	0	22	0	9	0	Brown Sandy Shale - Soft
22	0	25	5	3	5	Black Shale - Soft
25	5	43	4	17	9	Brown Sandstone - Medium Hard
43	4	45	0	1	6	Gray Sandstone - Soft
45	0	49	0	4	0	Gray Sandy Shale - Soft
49	0	53	5	4	5	Gray Sandstone - Medium Hard
53	5	55	0	1	5	Gray Sandy Shale - Soft
55	0	59	0	4	0	Gray Shale - Soft
59	0	65	3	6	3	Gray Sandstone - Medium Hard
65	3	66	5	1	2	Coal
66	5	68	5	2	0	Gray Shale - Soft
68	5	70	0	1	5	Gray Sandy Shale - Medium Hard
70	0	79	0	9	0	Gray Sandstone - Medium Hard
79	0	84	5	5	5	Gray Sandstone - Hard
84	5	87	8	3	3	Gray Sandstone - Medium Hard
87	8	91	5	3	7	Black Shale - Soft
91	5	92	5	1	0	Coal
92	5	94	5	2	0	Black Shale - Soft
94	5	96	0	1	5	Brown Shale - Soft
96	0	102	0	6	0	Gray Shale - Soft

PEABODY COAL COMPANY

Environmental Quality

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AREA J-12 PAGE No. 2 of HOLE No. 59

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations: character of rock; oil, gas and water horizons; coal and other mineral occurances
102	0	113	0	11	0	Gray Sandstone - Medium Hard
113	0	115	0	2	0	Gray Sandy Shale - Hard
115	0	131	0	16	0	Gray Sandstone - Medium Hard
131	0	132	0	1	0	Gray Sandy Shale - Hard
132	0	133	0	1	0	Gray Shale - Soft
133	0	134	0	1	0	Brown Shale - Soft
134	0	134	5	0	5	Coal
134	5	137	0	2	5	Black Shale - Soft
137	0	143	0	6	0	Gray Shale - Soft
143	0	145	0	2	0	Gray Sandy Shale
145	0	148	0	3	0	Gray Sandstone - Medium Hard
148	0	150	9	2	9	Gray Shale - Soft
150	9	153	0	2	1	Gray Sandy Shale - Hard
153	0	154	5	1	5	Black Shale - Soft
154	5	161	0	6	5	Gray Shale - Soft
161	0	163	4	2	4	Gray Sandy Shale - Medium Hard
163	4	165	0	1	6	Gray Sandstone - Medium Hard
165	0	166	3	1	3	Gray Shale - Soft
166	3	167	5	1	2	Black Shale - Soft
167	5	169	0	1	5	Coal
169	0	173	7	4	7	Gray Shale - Soft
173	7	175	0	1	3	Gray Sandstone - Medium Hard
175	0	178	0	3	0	Gray Shale - Medium Hard
178	0	210	0	32	0	Gray Sandstone - Medium Hard

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AREA J-12

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FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
210	0	212	5	2	5	Gray Shale - Soft
212	5	218	0	5	5	Coal
218	0	230	0	12	0	Gray Shale - Soft
230	0	234	3	4	3	Coal
234	3	240	5	6	2	Gray Shale - Soft
240	5	244	5	4	0	Gray Sandstone - Hard
244	5	246	5	2	0	Gray Shale - Soft
246	5	311	5	65	0	Gray Sandstone - Hard
311	5	314	7	3	2	Gray Shale - Soft
314	7	350	0	35	3	Gray Sandstone - Medium Hard
350	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 350' casing; perforated from
						115'-350'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

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AREA J-10

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FORMATION RECORD

DEPTH From— Feet	From— Tenths	To— Feet	To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	6	3	6	3	Yellow Clay and Rock
6	3	8	0	1	7	Gray Shale
8	0	14	3	6	3	Brown-Yellow Sandstone and Clay
14	3	20	0	5	7	Sand and Rock
20	0	20	5	0	5	Hard Rock
20	5	23	0	2	5	Yellow Sandstone
23	0	25	0	2	0	Hard Rock
25	0	26	0	1	0	Gray Shale
26	0	27	5	1	5	Dark Shale
27	5	30	5	3	0	Gray Shale
30	5	34	5	4	0	Smut - Soft Coal
34	5	36	5	2	0	Dark Shale
36	5	38	0	1	5	Shale
38	0	48	5	10	5	Gray Shale
48	5	51	5	3	0	Coal - Soft
51	5	53	0	1	5	Red and Gray Shale
53	0	55	0	2	0	Gray Shale
55	0	59	0	4	0	Red Clay - Soft
59	0	61	1	2	1	Gray Shale and Sandstone
61	1	61	6	0	5	Hard Rock
61	6	62	6	1	0	Gray Shale
62	6	66	1	3	5	Coal
66	1	66	5	0	4	Hard
66	5	73	1	6	6	Coal

PEABODY COAL COMPANY

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AREA J-10

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FORMATION RECORD

DEPTH From— Feet	DEPTH From— Tenths	DEPTH To— Feet	DEPTH To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
73	1	76	6	3	5	Gray Shale
76	6	78	0	1	4	Hard Gray Sandstone
78	0	79	0	1	0	Very Hard Rock
79	0	90	9	11	9	Gray Shale
90	9	91	9	1	0	Hard Rock
91	9	94	2	2	3	Gray Shale with Hard Streaks
94	2	100	0	5	8	Gray Shale
100	0	104	0	4	0	Gray Shale and Sandstone
104	0	106	0	2	0	Gray Shale and Dark Shale
106	0	120	0	14	0	Gray Shale with Hard Ledge
120	0	142	0	22	0	Light Gray Sandy Sandstone and Shale
142	0	144	0	2	0	Gray Shale and Sandstone
144	0	145	5	1	5	Coal
145	5	146	8	1	3	Gray Shale
146	8	147	5	0	7	Hard Gray Sandstone
147	5	149	0	1	5	Dark Gray Shale
149	0	149	8	0	8	Coal
149	8	155	0	5	2	Gray Shale
155	0	158	0	3	0	Gray Shale with Hard Ledge
158	0	160	0	2	0	Coal
160	0	170	0	10	0	Gray Shale
170	0	175	0	5	0	Light Gray Sandstone
175	0	184	7	9	7	Gray Shale and Sandstone
184	7	187	7	3	0	Coal

THE MILLS COMPANY, SHEBOYGAN 139308

PEABODY COAL COMPANY

Environmental Quality

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AREA J-10

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FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
187	7	193	2	5	5	Gray Shale with Hard Ledge
193	2	195	2	2	0	Coal
195	2	200	5	5	3	Gray Shale and Sandstone
200	5	201	7	1	2	Hard Rock
201	7	212	3	10	6	Gray Shale and Dark Gray Shale
212	3	214	0	1	7	Coal
214	0	218	0	4	0	Gray Shale with Hard Ledge
218	0	224	0	6	0	Light Gray Sandy Shale
224	0	235	0	11	0	Gray Shale
235	0	237	0	2	0	Hard Rock
237	0	240	0	3	0	Light Gray Hard Sandstone
240	0	249	5	9	5	Light Shale
249	5	252	5	3	0	Light Gray Sandy Sandstone
252	5	261	1	8	6	Gray Shale
261	1	261	5	0	4	Hard Rock
261	5	263	0	1	5	Gray Shale
263	0	267	6	4	6	Gray Shale with Hard Ledge
267	6	270	0	2	4	Light Gray Sandy Sandstone
270	0	292	7	22	7	Light Gray Sandy Shale and Sandstone
292	7	308	2	15	5	Gray Shale
308	2	312	8	4	6	Light Gray Sand and Shale
312	8	320	0	7	2	Gray Shale
320	0	348	5	28	5	Light Gray Sandy Shale
348	5	349	0	0	5	Hard Rock

Monitoring Water Well.
6' pvc casing; set 349' casing; perforated from 175'-349'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

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AREA J-8 PAGE No. 1 of HOLE No. 61

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	9	2	9	2	Surface Sand, Gravel
9	2	20	7	11	5	Clay, Shale
20	7	24	8	4	1	Carbonaceous Shale, Clinker
24	8	29	3	4	5	Clay, Shale
29	3	31	4	2	1	Carbonaceous Shale, Clinker
31	4	35	3	3	9	Silty Shale
35	3	38	4	3	1	Coal
38	4	51	0	12	6	Sandstone, Siltstone
51	0	52	8	1	8	Concretion (Dense, Siliceous)
52	8	62	3	9	5	Silty Shale
62	3	67	0	4	7	Coal
67	0	69	1	2	1	Silty Shale
69	1	74	4	5	3	Coal
74	4	75	3	0	9	Silty Shale
75	3	78	4	3	1	Coal
78	4	80	3	1	9	Silty Shale
80	3	81	8	1	6	Carbonaceous Shale
81	8	89	1	7	2	Shale
89	1	91	0	1	9	Silty Shale
91	0	98	2	7	2	Shale
98	2	100	8	2	6	Concretion
100	8	113	7	12	9	Silty Shale
113	7	116	3	2	6	Sandy Siltstone
116	3	118	1	1	8	Silty Shale

THE MILLS COMPANY, SHEFFIELD 139386

PEABODY COAL COMPANY

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AREA J-8

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FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
118	1	119	3	1	2	Shale
119	3	125	3	6	0	Silty Shale
125	3	128	1	2	8	Coal
128	1	130	0	1	9	Silty Shale
130	0	131	5	1	5	Coal
131	5	134	0	2	5	Shale
134	0	138	8	4	8	Coal
138	8	140	7	1	9	Silty Shale
140	7	141	1	0	4	Coal
141	1	143	2	2	1	Silty Shale
143	2	145	2	2	0	Carbonaceous Shale
145	2	148	3	3	1	Siltstone
148	3	150	9	2	6	Silty Sandstone
150	9	155	4	4	5	Siltstone
155	4	156	4	1	0	Carbonaceous Shale
156	4	158	6	2	2	Sandy Siltstone
158	6	160	8	2	2	Coal
160	8	170	0	9	2	Siltstone
170	0	204	8	34	8	Sandstone
204	8	206	2	1	4	Siltstone
206	2	217	8	11	6	Shale
217	8	221	0	3	2	Carbonaceous Shale
221	0	230	0	9	0	Shale
230	0	232	5	2	5	Silty Shale

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AREA J-8

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FORMATION RECORD

DEPTH From— feet	tenths	To— feet	tenths	Thickness of stratum feet	tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
232	5	233	3	0	8	Carbonaceous Shale
233	3	240	0	6	7	Silty Shale
240	0	241	6	1	6	Coal
241	6	249	4	7	8	Siltstone
249	4	277	0	27	6	Silty Shale
277	0	278	5	1	5	Siltstone
278	5	297	8	19	3	Sandstone
297	8	303	4	5	6	Siltstone
303	4	305	8	2	4	Sandstone
305	8	318	5	12	7	Sandy Siltstone
318	5	326	0	7	5	Silty Sandstone
326	0	345	0	19	0	Sandy Siltstone
*345	0					T.D.
						Monitoring Water Well.
						350 ft. deep; 6" pvc casing; gravel packed; cemented;
						perforated interval from 170-350.
						*A 4" pilot hole was drilled to 345'. The hole was
						then reamed out to 9" to 350'. The hole was cased
						and completed to 350'.

PEABODY COAL COMPANY

Environmental Quality

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AREA J-16 PAGE No. 1 of HOLE No. 62

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	10	0	10	0	Sandy Clay
10	0	11	0	1	0	Shale - Soft
11	0	12	0	1	0	Coal - Soft
12	0	13	0	1	0	Sandy Shale - Soft
13	0	15	0	2	0	Shale and Coal
15	0	20	0	5	0	Gray Shale - Soft
20	0	31	0	11	0	Shale - Soft
31	0	36	0	5	0	Sandstone - Soft
36	0	38	3	2	3	Coal
38	3	40	0	1	7	Shale - Soft
40	0	56	0	16	0	Sandstone - Hard
56	0	58	0	2	0	Gray Shale - Soft
58	0	60	0	2	0	Sandstone - Hard
60	0	62	0	2	0	Gray Shale - Soft
62	0	64	7	2	7	Coal
64	7	65	5	0	8	Gray Shale - Soft
65	5	68	0	2	5	Sandy Shale - Hard
68	0	74	0	6	0	Gray Shale - Soft
74	0	83	0	9	0	Sandstone - Hard
83	0	87	5	4	5	Shale - Hard
87	5	92	5	5	0	Coal
92	5	96	6	4	1	Shale - Hard
96	6	98	2	1	6	Coal
98	2	100	5	2	3	Shale

PEABODY COAL COMPANY
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AREA J-16

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FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
100	5	101	0	0	5	Coal
101	0	102	0	1	0	Shale - Soft
102	0	110	4	8	4	Sandstone - Hard
110	4	112	6	2	2	Coal
112	6	123	0	10	4	Sandy Shale - Hard
123	0	127	0	4	0	Gray Sandy Shale - Hard
127	0	132	0	5	0	Sandy Shale - Hard
132	0	134	0	2	0	Coal
134	0	135	0	1	0	Shale - Soft
135	0	136	3	1	3	Coal
136	3	136	7	0	4	Shale - Soft
136	7	138	0	1	3	Coal
138	0	140	0	2	0	Shale - Soft
140	0	142	8	2	8	Coal
142	8	147	3	4	5	Shale - Soft
147	3	147	7	0	4	Coal
147	7	152	0	4	3	Shale - Hard
152	0	165	0	13	0	Sandstone - Hard
165	0	169	0	4	0	Shale - Soft
169	0	170	8	1	8	Coal
170	8	172	2	1	4	Shale - Soft
172	2	175	0	2	8	Sandy Shale - Hard
175	0	182	0	7	0	Sandstone - Hard
182	0	197	0	15	0	Sandstone - Hard

PEABODY COAL COMPANY

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AREA J-16

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FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances	
197	0	198	2	1	2	Shale - Soft	
198	2	199	5	1	3	Coal	
199	5	201	0	1	5	Shale - Soft	
201	0	217	2	16	2	Sandstone - Hard	
217	2	217	5	0	3	Shale - Soft	
217	5	224	4	6	9	Coal	
224	4	234	0	9	6	Sandstone - Hard	
234	0	241	0	7	0	Shale - Soft	
241	0	243	0	2	0	Sandstone - Hard	
243	0	246	5	3	5	Sandy Shale - Hard	
246	5	262	8	16	3	Gray Shale	
262	8	272	4	9	6	Coal	
272	4	282	0	9	6	Shale - Soft	
282	0	285	0	3	0	Shale with Coal	
285	0	289	0	4	0	Shale - Soft	
289	0	293	0	4	0	Shale with Coal	
293	0	295	5	2	5	Sandstone - Hard	
295	5	310	0	14	5	Shale - Soft	
310	0	311	5	1	5	Sandy Shale - Hard	Monitoring Water Well.
311	5	322	0	10	5	Shale - Soft	6" pvc casing; set 350' casing;
322	0	323	0	1	0	Coal	perforated from 150'-170',
323	0	326	5	3	5	Shale - Soft	190'-220', and 230'-350';
326	5	327	3	0	8	Coal	gravel packed; well sealed
327	3	350	0	22	7	Shale with Sandstone	with cement.

350 0 T D

PEABODY COAL COMPANY

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AREA J-28 PAGE No. 1 of HOLE No. 63

FORMATION RECORD

DEPTH From— Feet	DEPTH From— Tenths	DEPTH To— Feet	DEPTH To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	15	2	15	2	Sandy Clay
15	2	15	8	0	6	Coal - Soft
15	8	17	7	1	9	Shale
17	7	22	0	4	3	Sandstone
22	0	22	5	0	5	Coal
22	5	23	9	1	4	Shale
23	9	24	4	0	5	Boulder - Hard
24	4	28	1	3	7	Shale
28	1	29	5	1	4	Boulder
29	5	31	0	1	5	Rock - Hard
31	0	33	1	2	1	Shale
33	1	34	6	1	5	Coal
34	6	35	9	1	3	Shale
35	9	38	0	2	1	Rock - Hard
38	0	51	5	13	5	Shale
51	5	53	5	2	0	Sandstone Rock - Hard
53	5	56	0	2	5	Shale
56	0	60	2	4	2	Coal
60	2	63	0	2	8	Shale and Gray Shale
63	0	66	0	3	0	Sandy Shale
66	0	68	6	2	6	Shale
68	6	70	1	1	5	Gray Shale with Coal
70	1	72	0	1	9	Gray Shale
72	0	78	1	6	1	Sandy Shale

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AREA J-28 PAGE No. 2 of HOLE No. 63

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
78	1	80	5	2	4	Sandstone
80	5	90	0	9	5	Shale with Hard Streaks
90	0	101	3	11	3	Shale and Sandstone
101	3	104	0	2	7	Sandstone - Hard
104	0	107	3	3	3	Shale with Hard Streaks
107	3	110	0	2	7	Sandstone - Hard
110	0	112	0	2	0	Shale and Sandstone
112	0	112	6	0	6	Sandstone - Hard
112	6	121	8	9	2	Shale with Hard Streaks
121	8	125	0	3	2	Sandstone - Hard Rock
125	0	135	4	10	4	Shale and Sandstone
135	4	146	9	11	5	Coal
146	9	150	5	3	6	Gray Shale
150	5	151	5	1	0	Gray Shale and Coal
151	5	153	0	1	5	Shale
153	0	162	0	9	0	Sandstone and Shale
162	0	163	8	1	8	Sandstone - Hard
163	8	165	8	2	0	Shale with Hard Streaks
165	8	169	4	3	6	Sandy Shale
169	4	171	6	2	2	Coal
171	6	172	6	1	0	Shale - Hard
172	6	175	1	2	5	Coal
175	1	177	0	1	9	Shale - Hard
177	0	180	0	3	0	Shale and Sandstone - Hard

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AREA J-28

PAGE No. 3 of HOLE No. 63

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
180	0	182	0	2	0	Sandstone - Hard
182	0	183	7	1	7	Shale
183	7	184	7	1	0	Coal
184	7	187	0	2	3	Shale and Gray Shale
187	0	191	7	4	7	Coal
191	7	193	7	2	0	Gray Shale and Coal
193	7	195	0	1	3	Shale - Hard
195	0	201	0	6	0	Sandy Shale
201	0	209	8	8	8	Shale and Sandstone
209	8	213	0	3	2	Coal
213	0	213	6	0	6	Gray Shale
213	6	214	8	1	2	Shale with Hard Streaks
214	8	222	8	8	0	Sandy Shale and Sand
222	8	228	0	5	2	Shale with Hard Streaks
228	0	229	7	1	7	Shale
229	7	231	5	1	8	Sandstone - Coarse Hard
231	5	239	9	8	4	Shale with Hard Streaks
239	9	247	0	7	1	Sandy Shale and Sand
247	0	252	6	5	6	Sandstone - Hard
252	6	254	3	1	7	Shale
254	3	255	3	1	0	Gray Shale and Coal
255	3	257	0	1	7	Gray Shale
257	0	265	4	8	4	Shale and Sandy Shale
265	4	267	6	2	2	Sandstone - Hard

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AREA J-28 PAGE No. 4 of HOLE No. 63

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
267	6	279	6	12	0	Shale and Sandy Shale
279	6	280	0	0	4	Rock - Hard
280	0	281	4	1	4	Sandy Shale and Sandstone
281	4	281	9	0	5	Boulder - Hard
281	9	285	0	3	1	Shale with Hard Streaks
285	0	288	0	3	0	Sandy Shale and Sand
288	0	295	0	7	0	Sandy Shale and Sandstone with Hard Streaks
295	0	315	0	20	0	Sandy Shale and Sandstone
315	0	328	0	13	0	Sandstone
328	0	342	0	14	0	Shale
342	0	345	0	3	0	Coal
345	0	350	0	5	0	Shale
350	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 350' casing; perforated from 195'-
						350'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

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FORMATION RECORD

DEPTH				Thickness of stratum		Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurences
From—		To—				
Feet	Tenths	Feet	Tenths	Feet	Tenths	
0	0	6	0	6	0	Clay
6	0	11	0	5	0	Shale - Soft
11	0	12	0	1	0	Sandstone - Hard
12	0	22	8	10	8	Shale - Soft
22	8	24	0	1	2	Coal
24	0	30	0	6	0	Sandy Shale - Soft
30	0	30	3	0	3	Coal
30	3	31	7	1	4	Gray Shale - Soft
31	7	35	0	3	3	Coal
35	0	36	7	1	7	Shale
36	7	38	0	1	3	Sandy Shale - Hard
38	0	40	0	2	0	Coal
40	0	47	0	7	0	Sandstone - Hard
47	0	54	0	7	0	Sandy Shale - Hard
54	0	55	0	1	0	Gray Shale - Soft
55	0	57	0	2	0	Coal
57	0	61	0	4	0	Shale - Soft
61	0	62	0	1	0	Sandstone - Hard
62	0	66	0	4	0	Sandy Shale - Hard
66	0	70	0	4	0	Gray Shale - Soft
70	0	71	0	1	0	Sandy Shale - Hard
71	0	75	0	4	0	Sandstone - Hard
75	0	79	0	4	0	Shale - Soft
79	0	84	0	5	0	Coal

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/5/80

AREA J-18

PAGE No. 2 of HOLE No. 64

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
84	0	88	7	4	7	Shale - Soft
88	7	92	0	3	3	Sandstone - Hard
92	0	94	5	2	5	Shale - Soft
94	5	95	3	0	8	Coal
95	3	96	5	1	2	Gray Shale - Soft
96	5	107	0	10	5	Sandstone - Hard
107	0	107	5	0	5	Gray Shale - Soft
107	5	108	4	0	9	Coal
108	4	109	0	0	6	Gray Shale - Soft
109	0	110	5	1	5	Shale - Soft
110	5	112	0	1	5	Gray Shale - Soft
112	0	113	0	1	0	Coal
113	0	114	0	1	0	Gray Shale - Soft
114	0	128	5	14	5	Shale and Sandstone - Hard
128	5	132	0	3	5	Sandy Shale - Hard
132	0	138	5	6	5	Coal
138	5	139	0	0	5	Shale - Soft
139	0	139	6	0	6	Coal
139	6	143	5	3	9	Shale - Soft
143	5	145	0	1	5	Sandy Shale - Hard
145	0	148	0	3	0	Sandstone - Hard
148	0	149	0	1	0	Shale - Soft
149	0	150	0	1	0	Gray Shale - Soft
150	0	154	0	4	0	Sandy Shale - Hard

PEABODY COAL COMPANY

Environmental Quality
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AREA J-18

PAGE No. 3 of HOLE No. 64

FORMATION RECORD

DEPTH From— Feet	From— Tenths	To— Feet	To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
154	0	156	5	2	5	Shale - Soft
156	5	165	5	9	0	Sandy Shale - Hard
165	5	166	5	1	0	Sandstone - Hard
166	5	168	2	1	7	Sandy Shale - Hard
168	2	173	5	5	3	Sandstone - Hard
173	5	176	0	2	5	Coal
176	0	180	0	4	0	Sandy Shale - Hard
180	0	183	4	3	4	Shale - Soft
183	4	184	7	1	3	Coal
184	7	187	0	2	3	Gray Shale - Soft
187	0	189	0	2	0	Shale - Soft
189	0	194	8	5	8	Coal
194	8	198	5	3	7	Sandstone - Hard
198	5	199	5	1	0	Gray Shale - Soft
199	5	203	0	3	5	Shale - Hard
203	0	204	0	1	0	Coal
204	0	211	5	7	5	Sandy Shale - Hard
211	5	212	8	1	3	Coal
212	8	216	5	3	7	Sandy Shale - Hard
216	5	219	0	2	5	Coal and Gray Shale
219	0	225	0	6	0	Sandy Shale - Hard
225	0	229	0	4	0	Sandstone - Hard
229	0	244	0	15	0	Sandstone - Coarse Hard
244	0	246	0	2	0	Coal

PEABODY COAL COMPANY

Environmental Quality
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AREA J-18 PAGE No. 4 of HOLE No. 64

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
246	0	252	5	6	5	Sandy Shale - Hard
252	5	254	0	1	5	Coal
254	0	260	7	6	7	Shale - Hard
260	7	262	0	1	3	Gray Shale - Soft
262	0	272	0	10	0	Shale - Hard
272	0	274	5	2	5	Coal
274	5	275	0	0	5	Shale - Soft
275	0	277	5	2	5	Sandstone - Hard
277	5	278	5	1	0	Sandy Shale - Hard
278	5	285	0	6	5	Sandstone - Hard
285	0	288	5	3	5	Shale - Hard
288	5	290	0	1	5	Coal
290	0	295	5	5	5	Sandy Shale - Hard
295	5	350	0	54	5	Sandstone - Hard
350	0					T.D.

Monitoring Water Well.

6' pvc casing; set 350' casing; perforated from
120'-132', 155'-177', 195'-205', 219'-245', and
250'-350'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/17/80

AREA J-20 PAGE No. 1 of HOLE No. 65

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	7	4	7	4	Sandy Clay
7	4	8	4	1	0	Smut
8	4	14	0	5	6	Shale and Sandstone
14	0	21	0	7	0	Sandstone
21	0	30	6	9	6	Shale
30	6	31	6	1	0	Hard Rock
31	6	37	6	6	0	Shale
37	6	39	4	1	8	Coal
39	4	46	0	6	6	Shale
46	0	49	1	3	1	Sandstone - Hard
49	1	53	0	3	9	Sandy Shale
53	0	56	5	3	5	Coal
56	5	60	3	3	8	Shale
60	3	61	0	0	7	Sandstone - Hard
61	0	64	1	0	8	Hard Rock
64	9	66	7	1	8	Shale
66	7	68	0	1	3	Coal
68	0	73	7	5	7	Shale with Hard Streaks
73	7	77	7	4	0	Shale - Gray
77	7	78	7	1	0	Coal
78	7	80	0	1	3	Shale - Gray
80	0	84	0	4	0	Shale
84	0	92	5	8	5	Sandy Shale
92	5	93	1	0	6	Hard Rock

THE MILLS COMPANY, SHERMAN 138508

PEABODY COAL COMPANY

Environmental Quality
Well Logs

DATE 6/17/80

AREA J-20 PAGE No. 2 of HOLE No. 65

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
93	1	93	6	0	5	Shale
93	6	100	0	6	4	Sandstone and Hard Rock
100	0	109	0	9	9	Sandy Shale
109	0	111	9	2	0	Coal
111	9	122	0	10	1	Sandy Shale with Hard Streaks
112	0	124	0	2	0	Coal
124	0	136	6	2	6	Sandy Shale
136	6	138	0	1	4	Hard Rock
138	0	141	2	3	2	Shale
141	2	143	2	2	0	Coal
143	2	143	6	0	4	Shale - Gray
143	6	145	6	2	0	Coal
145	6	150	4	4	8	Shale
150	4	150	9	0	5	Hard Rock
150	9	159	1	8	2	Sandy Shale
159	1	162	1	3	0	Coal
162	1	168	1	6	0	Shale
168	1	171	0	2	9	Shaly Sandstone
171	0	181	0	10	0	Sandy Shale and Sandstone
181	0	184	0	3	0	Sandy Shale and Sand
184	0	191	7	7	7	Sandy Sandstone
191	7	199	0	7	3	Sandstone - Hard
199	0	222	9	23	9	Shale and Sandy Shale
222	9	223	3	0	4	Hard Rock

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/17/80

AREA J-2Q

PAGE No. 3 of HOLE No. 65

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
223	3	225	8	2	5	Sandy Shale
225	8	226	0	0	2	Sandstone and Hard Rock
226	0	228	0	2	0	Sandy Shale with Hard Streaks
228	0	250	0	22	0	Sandy Shale and Sand
250	0	265	0	15	0	Shale with Hard Streaks
265	0	275	0	10	0	Sandy Shale
275	0	279	4	4	4	Shale
279	4	280	4	1	0	Coal
280	4	286	1	5	7	Shale
286	1	286	6	0	5	Hard Rock
286	6	300	0	13	4	Shale and Sandy Shale
300	0	301	2	1	2	Hard Rock
301	2	318	8	17	6	Sandy Shale
318	8	321	8	3	0	Coal
321	8	325	0	3	2	Gray Shale - Coal
325	0	327	1	2	1	Shale - Gray
327	1	332	9	5	8	Sandy Shale
332	9	337	5	4	6	Sandy Shale and Sandstone
337	5	340	0	2	5	Coal
340	0	340	5	0	5	Shale - gray and Coal
340	5	345	0	4	5	Coal
345	0	350	0	5	0	Shale - Gray
350	0					T.D. Monitoring Water Well. 6" pvc casing; set 350' casing; perforated from 190'-350'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/7/80

AREA J-21 PAGE No. 1 of HOLE No. 66

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	3	1	3	1	Hard Shale
3	1	4	5	1	4	Sandy Rock
4	5	6	0	1	5	Shale and Sandy Rock
6	0	6	8	0	8	Shale
6	8	14	6	7	8	Sandy Rock
14	6	17	6	3	0	Shale
17	6	18	6	1	0	Gray Shale and Coal
18	6	20	6	2	0	Coal
20	6	31	0	10	4	Shale
31	0	31	8	0	8	Coal
31	8	37	8	6	0	Shale and Sandy Shale
37	8	38	9	1	1	Coal
38	9	42	5	3	6	Shale
42	5	43	7	1	2	Hard Rock
43	7	53	8	10	1	Shale
53	8	56	8	3	0	Coal
56	8	61	0	4	2	Shale
61	0	72	9	11	9	Shale and Sandstone
72	9	75	9	3	0	Coal
75	9	82	5	6	6	Shale
82	5	84	5	2	0	Coal
84	5	86	0	1	5	Shale
86	0	87	0	1	0	Coal
87	0	90	4	3	4	Shale and Sandstone

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/7/80

AREA J-21

PAGE No. 2 of HOLE No. 66

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
90	4	92	0	1	6	Hard Sandstone and Rock
92	0	97	8	5	8	Shale and Sandstone - Hard
97	8	99	0	1	2	Sandstone - Hard
99	0	100	8	1	8	Shale
100	8	103	1	2	3	Coal
103	1	105	5	2	4	Shale
105	5	106	4	0	9	Sandstone and Rock - Hard
106	4	118	0	11	6	Shale and Sandstone
118	0	120	0	2	0	Sandstone - Hard
120	0	125	0	5	0	Shale and Sandstone
125	0	137	2	12	2	Sandy Sandstone and Sand
137	2	139	1	1	9	Very Hard Rock
139	1	148	0	8	9	Sandstone
148	0	160	0	12	0	Sandy Shale and Sand
160	0	168	4	8	4	Hard Sandstone
168	4	175	0	6	6	Sandy Shale
175	0	177	0	2	0	Shale and Sandstone
177	0	178	0	1	0	Sandstone - Hard
178	0	190	0	12	0	Shale with Hard Streaks
190	0	204	8	14	8	Sandy Sandstone and Sand
204	8	223	0	18	2	Shale with Hard Streaks
223	0	233	7	10	7	Sandy Shale and Sand
233	7	235	7	2	0	Shale and Coal
235	7	238	7	3	0	Shale

THE MILLS COMPANY, SHERIDAN 139508

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/7/85

AREA J-21

PAGE No. 3 of HOLE No. 66

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances	
238	7	241	0	2	3	Hard Rock	
241	0	248	0	7	0	Shale and Sandstone	
248	0	255	0	7	0	Sandstone and Shale Streaks	
255	0	261	0	6	0	Sandy Sandstone and Sand	
261	0	263	4	2	4	Shale with Hard Streaks	
263	4	263	8	0	4	Coal	
263	8	267	9	4	1	Sandy Shale and Sand	
267	9	268	5	0	6	Hard Rock	
268	5	278	9	10	4	Sandy Shale and Shale	
278	9	282	5	3	6	Coal	
282	5	283	3	0	8	Gray Shale	
283	3	292	3	9	0	Coal	
292	3	294	5	2	2	Gray Shale	
294	5	295	5	1	0	Coal	
295	5	295	8	0	3	Gray Shale	
295	8	297	0	1	2	Hard Sandstone	
297	0	298	0	1	0	Shale	
298	0	322	0	24	0	Gray Shale and Coal	
322	0	330	0	8	0	Sandy Shale and Sandstone	
330	0	347	0	17	0	Sandstone	Monitoring Water Well.
247	0	350	0	3	0	Hard Sandstone	6' pvc casing; set 350' casing;
350	0					T.D.	perforated from 115'-150', 175-'225',
							240'-350'; gravel packed; well sealed
							with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Log:

DATE: /20/82

AREA: J-23/J-24

PAGE No. 1 of HOLE No. 67

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	22	2	22	2	Surface Sand, Gravel
22	2	24	6	2	4	Clay, Silt
24	6	27	6	3	0	Carbonaceous Shale, Clinker
27	6	39	4	11	8	Shale
39	4	42	5	3	1	Carbonaceous Shale
42	5	48	7	6	2	Silty Shale
48	7	52	4	3	7	Carbonaceous Shale
52	4	53	1	0	7	Silty Shale
53	1	59	8	6	7	Shale
59	8	66	6	6	8	Siltstone
66	6	70	8	4	2	Silty Shale
70	8	78	5	7	7	Shale
78	5	79	4	0	9	Carbonaceous Shale
79	4	80	4	1	0	Shale
80	4	82	6	2	2	Carbonaceous Shale
82	6	87	7	5	1	Silty Shale
87	7	93	4	5	7	Coal
93	4	107	4	14	0	Silty Shale
107	4	120	4	13	0	Coal
120	4	121	6	1	2	Shale
121	6	124	6	3	0	Coal
124	6	126	8	2	2	Shale
126	3	129	1	2	3	Carbonaceous Shale
129	1	134	6	5	5	Silty Shale

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 6/20/80

AREA J-23/J-24 PAGE No. 2 of HOLE No. 67

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
134	6	138	3	3	7	Coal
138	3	142	4	4	1	Shale
142	4	144	5	2	1	Coal
144	5	145	3	0	8	Shale
145	3	147	1	1	8	Coal
147	1	150	2	3	1	Shale
150	2	163	2	13	0	Siltstone
163	2	165	8	2	6	Coal
165	8	174	0	8	2	Shale
174	0	176	0	2	0	Sandy Shale
176	0	185	0	9	0	Shale
185	0	191	0	6	0	Sandstone
191	0	207	0	16	0	Shale
207	0	210	0	3	0	Shaly Sandstone
210	0					T.D.
						Monitoring Water Well
						210 ft. deep; 6' pvc casing; gravel packed; cemented;
						perforated from 64'-204'.

PEABODY COAL COMPANY

Environmental Quality
Well Logs

DATE 10/29/80

AREA J-3 PAGE No. 1 of HOLE No. 86

FORMATION RECORD

DEPTH From— Feet	DEPTH From— Tenths	DEPTH To— Feet	DEPTH To— Tenths	Thickness of stratum Feet	Thickness of stratum Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	3	0	3	0	Fill
3	0	34	5	31	4	Shale and Sandstone
34	5	36	0	1	5	Dark Shale
36	0	38	0	2	0	Coal
38	0	90	7	52	7	Shale and Sandstone
90	7	91	9	1	2	Coal
91	9	95	9	4	0	Shale
95	9	96	4	0	5	Hard Dark Shale
96	4	101	8	5	4	Shale with Hard Streaks
101	8	105	0	3	2	Coal
105	0	167	1	62	1	Shale and Sandstone
167	1	177	1	10	0	Coal
177	1	179	0	1	9	Dark Shale
179	0	194	2	15	2	Coal
194	2	196	0	1	8	Dark Shale and Shale
196	0	198	0	2	0	Shale
198	0	199	6	1	6	Coal
199	6	201	5	1	9	Shale
201	5	202	5	1	0	Dark Shale and Coal
202	5	207	5	5	0	Shale and Sandy Shale
207	5	208	5	1	0	Coal
208	5	224	4	15	9	Shale and Hard Sandstone Streaks
224	4	230	4	6	0	Coal
230	4	236	0	5	6	Sandstone

PEABODY COAL COMPANY
Environmental Quality
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DATE 10/29/80

AREA J-3 PAGE No. 2 of HOLE No. 86

FORMATION RECORD

DEPTH From— Feet	Tenths	DEPTH To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock: oil, gas and water horizons; coal and other mineral occurances
236	0	245	0	9	0	Shale and Sandy Shale
245	0	252	0	7	0	Shale with Hard Streaks
252	0					T.D.
						Monitoring Water Well.
						6" pvc casing; set 250' casing; perforated from
						90'-250'; gravel packed; well sealed with cement.

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 10/25/80

AREA J-3 PAGE No. 1 of HOLE No. 90

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	3	0	3	0	Fill
3	0	5	0	2	0	Clay, Shale
5	0	9	1	4	1	Sandstone
9	1	9	5	0	4	Coal
9	5	12	1	2	6	Sandy Shale and Soft Sandstone
12	1	20	0	7	9	Sandstone and Claystone
20	0	36	0	16	0	Soft Sandstone and Shale
36	0	37	0	1	0	Dark Shale and Coal
37	0	39	3	2	3	Dark Shale
39	3	40	3	1	0	Coal
40	3	46	3	6	0	Shale
46	3	47	8	1	5	Hard Dark Shale
47	8	55	3	7	5	Shale and Sandstone
55	3	56	3	1	0	Dark Shale and Coal
56	3	100	5	44	2	Shale and Sandstone
100	5	103	5	3	0	Coal
103	5	105	6	2	1	Shale
105	6	107	6	2	0	Coal
107	6	119	0	11	4	Shale and Hard Sandstone Streaks
119	0	123	0	4	0	Shale and Sandstone
123	0	128	7	5	7	Sandstone
128	7	129	7	1	0	Coal
129	7	146	0	16	3	Shale and Sandstone
146	0	161	0	15	0	Hard Shale

PEABODY COAL COMPANY

Environmental Quality

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AREA J-3 PAGE No. 2 of HOLE No. 90

FORMATION RECORD

DEPTH From— Feet	Tenths	To— Feet	Tenths	Thickness of stratum Feet	Tenths	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
161	0	177	0	16	0	Shale and Sandstone
177	0	179	0	2	0	Hard Sandstone
179	0	180	0	1	0	Shale and Sandstone
180	0	191	0	11	0	Hard Sandstone
191	0	192	5	1	5	Dark Shale
192	5	197	0	4	5	Sandstone and Shale
197	0	205	1	8	1	Hard Sandstone
205	1	213	9	8	8	Soft Sandstone
213	9	215	1	1	2	Coal
215	1	238	0	22	9	Shale and Hard Sandstone Streaks
238	0	241	0	3	0	Coal
241	0	260	0	19	0	Coal with Shale Partings
260	0	262	4	2	4	Shale
262	4	265	4	1	0	Coal
265	4	270	0	4	6	Dark Shale
270	0					T.D.
						Monitoring Water Well
						4" pvc casing; set 270' casing; perforated from 90'-270';
						gravel packed; well sealed with cement.

PEABODY COAL COMPANY

Environmental Quality

Well Logs

DATE 10-6-85

AREA J-21 PAGE No. 1 of HOLE No. 63R

FORMATION RECORD

DEPTH From— Feet	Inches	To— Feet	Inches	Thickness of stratum Feet	Inches	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	4	0	4	0	Sand
4	0	7	4	3	4	Clay, shale
7	4	8	4	1	0	Coal
8	4	9	0	0	6	Dark Shale
9	0	11	0	2	0	Shale
11	0	25	2	14	2	Shale and sandy shale
25	2	25	7	0	5	Hard sandy shale
25	7	30	0	4	3	Sandstone and sandy shale - hard
30	0	30	7	0	7	Shale and coal streak
30	7	31	7	1	0	Shale
31	7	33	4	1	7	Hard sandstone
33	4	34	6	1	2	Hard shale
34	6	35	0	0	4	Hard sandstone
35	0	35	4	0	4	Shale
35	4	36	3	0	9	Hard sandstone
36	3	36	6	0	3	Shale with hard streak
36	6	37	5	0	9	Soft shale
37	5	41	0	3	5	Shale
41	0	41	6	0	6	Hard sandstone
41	6	43	4	1	8	Shale
43	4	44	2	0	8	Hard sandstone
44	2	40	5	5	3	Shale
49	5	56	3	6	8	Coal
56	3	56	8	0	5	Shale

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 10-6-85

AREA J-21 PAGE No. 2 of HOLE No. 63R

FORMATION RECORD

DEPTH From— Feet	DEPTH From— Inches	DEPTH To— Feet	DEPTH To— Inches	Thickness of stratum Feet	Thickness of stratum Inches	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
56	8	58	0	1	2	Hard sandstone
58	0	59	5	1	5	Shale
59	5	61	0	1	5	Shale with coal streak
61	0	64	7	3	7	Shale
64	7	65	9	1	2	Very hard sandstone
65	9	67	0	1	1	Shale with sandstone streak
67	0	70	9	3	9	Sandy shale and sandstone
70	9	72	1	1	2	Very hard sandstone
72	1	75	0	2	9	Sandstone and sandy shale
75	0	77	1	2	1	Shale
77	1	78	1	1	0	Dark shale and coal
78	1	81	0	2	9	Shale and sandy shale
81	0	82	0	1	0	Very hard shale
82	0	88	9	6	9	Sandy shale
88	9	90	7	1	8	Coal
90	7	92	7	2	0	Shale
92	7	101	7	9	0	Coal
101	7	103	7	2	0	Shale and sandstone
103	7	106	8	3	1	Shale with dark shale streak
106	8	108	5	1	7	Dark shale and coal streak
108	5	109	3	0	8	Hard sandstone
109	3	110	3	1	0	Very hard sandstone
110	3	111	4	1	1	Sandstone and sandy shale streak
111	4	112	0	0	6	Dark shale with coal streak

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 10-6-85

AREA J-21

PAGE No. 3 of HOLE No. 63R

FORMATION RECORD

DEPTH From— Feet	From— Inches	To— Feet	To— Inches	Thickness of stratum Feet	Thickness of stratum Inches	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
112	0	112	3	0	3	Sandstone and shale streak
112	3	113	0	0	7	Shale and coal streak
113	0	114	5	1	5	Hard sandstone
114	5	115	4	0	9	Very hard sandstone
115	4	117	0	1	6	Sandstone
117	0	117	3	0	3	Shale and sandstone
117	3	119	8	2	5	Coal
119	8	121	8	2	0	Shale and sandstone
121	8	124	2	2	4	Coal
124	2	124	7	0	5	Shale and dark shale
124	7	125	2	0	5	Coal
125	2	127	9	2	7	Shale and sandstone
127	9	131	9	4	0	Shale
131	9	132	4	0	5	Dark shale with coal streak
132	4	134	0	1	6	Shale
134	0	0				Total Depth
						Monitoring Water Well:
						6" PVC casing; set 129' casing; perforated from
						29' - 129'; gravel packed; well sealed with cement

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 10-14-85

AREA J-19 PAGE No. 1 of HOLE No. 64R

FORMATION RECORD

DEPTH From— Feet	Inches	To— Feet	Inches	Thickness of stratum Feet	Inches	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
0	0	2	0	2	0	Sandy clay
2	0	3	0	1	0	Clay and sandstone
3	0	18	7	15	7	Clay
18	7	19	7	1	0	Dark shale and coal
19	7	20	0	0	3	Shale with sandstone streak
20	0	21	3	1	3	Sandstone
21	3	26	5	5	2	Shale
26	5	29	5	3	0	Hard sandstone
29	5	30	4	0	9	Shale with hard streak
30	4	33	5	3	1	Shale
33	5	34	0	0	5	Sandstone
34	0	35	0	1	0	Sandstone with shale streak
35	0	38	9	3	9	Shale
38	9	39	6	0	7	Hard sandstone
39	6	40	0	0	4	Shale
40	0	40	7	0	7	Hard sandstone
40	7	41	5	0	8	Shale
41	5	42	7	1	2	Sandstone and shale
42	7	43	2	0	5	Dark shale
43	2	43	9	0	7	Hard sandstone
43	9	44	3	0	4	Shale
44	3	47	8	3	5	Coal
47	8	48	3	0	5	Dark shale
48	3	50	6	2	3	Sandstone and sandy shale

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 10-14-85

AREA J-19 PAGE No. 2 of HOLE No. 64R

FORMATION RECORD

DEPTH From— Feet	Inches	To— Feet	Inches	Thickness of stratum Feet	Inches	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
50	6	51	1	0	5	Hard and very hard sandstone
51	1	52	6	1	5	Hard shale and sandstone
52	6	55	8	3	2	Shale
55	8	58	1	2	3	Coal
58	1	59	9	1	8	Shale
59	9	60	6	0	7	Hard dark shale
60	6	71	7	11	1	Coal
71	7	72	4	0	7	Shale
72	4	74	2	1	8	Shale and dark shale
74	2	75	2	1	0	Coal
75	2	76	2	1	0	Shale and dark shale
76	2	78	2	2	0	Dark shale and coal
78	2	78	7	0	5	Dark shale
78	7	80	1	1	4	Very hard sandstone
80	1	81	0	0	9	Hard sandstone
81	0	82	7	1	7	Hard shale and sandstone
82	7	84	2	1	5	Dark shale
84	2	85	0	0	8	Coal
85	0	85	3	0	3	Dark shale
85	3	86	0	0	7	Coal
86	0	87	0	1	0	Shale and hard sandstone
87	0	91	0	4	0	Hard shale
91	0	92	8	1	8	Dark shale and coal
92	8	94	8	2	0	Coal

PEABODY COAL COMPANY
Environmental Quality
Well Logs

DATE 10-14-85

AREA J-19 PAGE No. 3 of HOLE No. 64R

FORMATION RECORD

DEPTH From— Feet	Inches	To— Feet	Inches	Thickness of stratum Feet	Inches	Geologic formations; character of rock; oil, gas and water horizons; coal and other mineral occurances
94	8	96	0	1	2	Shale and dark shale
96	0	98	1	2	1	Hard sandstone
98	1	101	8	3	7	Shale and sandstone
101	8	103	0	1	2	Shale with hard streak
103	0	113	9	10	9	Hard sandstone
113	9	115	0	1	1	Shale and sandstone
115	0	116	4	1	4	Shale
116	4	117	9	1	5	Coal
117	9	122	3	4	4	Sandy shale and sandstone
122	3	126	4	4	1	Coal
126	4	128	4	2	0	Shale
128	4	132	0	3	6	Dark shale and coal
132	0	133	0	1	0	Shale
133	0	134	2	1	2	Coal
134	2	149	1	14	9	Sandy shale and sandstone with hard streak
149	1	151	1	2	0	Coal
151	1	156	4	5	3	Shale and sandstone with hard streak
156	4	158	7	2	3	Coal.
158	7	164	0	5	3	Shale and sandstone with hard streak
164	0	0				Total Depth
						Monitoring Water Well:
						6" PVC casing; set 161.5" casing; perforated from 81' to 16
						gravel packed; well sealed with cement

Wepo Well Lithologic Logs
And Completions

Revised 5/22/00

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	SWEPO175
Geologic Unit Monitored:	Underburden
Ground surface Elevation:	6576.62 (ft-amsi)

Location: Mine Coordinates	N	-581.73				E	17714.26	
	S					W		
		¼		¼	S		T	R

Drilling Date:	Start	06/16/92
	Finish	06/16/92
Drilled by:		Winnek Drilling Co.
Logged by:		T. Smith
Geophysically Logged by:		None
Total Depth Drilled:		90.0 ft

FORMATION RECORD

DEPTH (ft) FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	11.0	Black brown fine to medium grained, very sandy, gravelly clay
11.0	15.0	Black brown silt, very clayey sand (fine to coarse grained) with gravel and pieces of coal
15.0	20.0	Black brown slightly silty fine to coarse sand and gravel, piece of coal
20.0	32.0	Black brown clayey silty sandy gravel with pieces of siltstone, mudstone, and coal
32.0	40.0	Boulders
40.0	50.0	Same as above with silty, very clayey sandy gravel and boulders, more mudstone and coal
50.0	56.5	Same as above with siltstone
56.5	69.0	Gray siltstone
69.0	75.0	Gray mudstone
75.0	76.5	Coal
76.5	90.0	gray mudstone
	90.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

..ne:	Black Mesa / Kayenta	Monitor Well Name:	SWEPO175

Type of Drilling: Air Rotary
Drilling Fluid: Foam
Total Depth: 86.1 ft
Note: Lost 3.9 ft with hole fill-in

Lithologic Unit Monitored: Shallow Wepo beneath spoil
Completion Date: 06/16/92

Borehole Diameter:

Surface:	6 ¾ inch	**From:** 0.0	**To:** 51.0
Intermediate:		**From:**	**To:**
Production Zone:	6 ¾ inch	**From:** 51.0	**To:** 86.1

Casing Specifications: Blank

1. **Surface:** 4-inch schedule 40 PVC
2. **Intermediate:**
3. **Production Zone:**

sing Specifications: Perforated

1. **Type:** 4-inch schedule 40 PVC screen, 0.020 inch horizontal mill slots, 3 columns
2. **Type:**

Blank Intervals:

From	0.0	To	51.0	From		To		From		To		From		To	
From		To		From		To		From		To		From		To	

Perforated Intervals:

From	51.0	To	86.1	From		To		From		To		From		To	
From		To		From		To		From		To		From		To	

Length Per Casing Section That is Not Perforated:

Cement Seal:

From	0.0	To	10.0	From		To		From		To		From		To	
e	Portland Type 2			Type				Type				Type			

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

...ne:	Black Mesa / Kayenta	Monitor Well Name:	SWEPO175

Sand Pack:

From 47.0 To 86.1 From ___ To ___ From ___ To ___ From ___ To ___

Type CO silica 8-12 Type ___ Type ___ Type ___

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ntonite Seal: **pellets**

From 10.0 To 47.0 From ___ To ___ From ___ To ___ From ___ To ___

Type ___ Type ___ Type ___ Type ___

Casing Height Above
Ground Surface

Protective Casing Housing: Type ___ Dimensions ___

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	SWEPO175

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	4		4	+3.0	1.0
2	10		14	1.0	11.0
3	10		24	11.0	21.0
4	10		34	21.0	31.0
5	10		44	31.0	41.0
6	10		54	41.0	51.0
7		5	59	51.0	56.0
8		10	69	56.0	66.0
9		10	79	66.0	76.0
10		10	89	76.0	86.0

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	**SWEPO179**
Geologic Unit Monitored:	Underburden
Ground surface Elevation:	6568.12 (ft-amsi)

Location: Mine Coordinates	N	-2435.28				E	18428.08			
	S					W				
		¼		¼	S		T		R	

Drilling Date:	Start	06/17/92
	Finish	06/17/92
Drilled by:		PCC / Winnek Drilling Co.
Logged by:		J. Ohlman
Geophysically Logged by:		None
Total Depth Drilled:		80.0 ft

FORMATION RECORD

DEPTH (ft) FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	36.0	Spoil, brown tan, loose with sand (fine to coarse grained) and coal fragments *Note:* started foam at 10 ft, lost circulation 22-34 ft, no cuttings 22-36 ft
36.0	55.0	Very hard at 50-55 ft, no cuttings, possible coal at 55 ft
55.0	64.0	Continuing with possible coal seam, few cuttings
64.0	80.0	Soft with hard layers, few cuttings
	80.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

ine:	Black Mesa / Kayenta	Monitor Well Name:	SWEPO179

Type of Drilling: 6 ¾ inch Air Rotary **Lithologic Unit Monitored:** Underburden
Drilling Fluid: Foam **Completion Date:** 06/17/92
Total Depth: 80.0 ft

Borehole Diameter:

Surface:	6 ¾ inch	**From:** 0.0	**To:** 34.5
Intermediate:		**From:**	**To:**
Production Zone:	6 ¾ inch	**From:** 34.5	**To:** 79.5

Casing Specifications: Blank

1. **Surface:** 4-inch schedule 40 PVC
2. **Intermediate:**
3. **Production Zone:**

asing Specifications: Perforated

1. **Type:** 4-inch schedule 40 PVC screen, 0.020 horizontal mill slots spaced ¼ inch vertically 3 columns
2. **Type:**

Blank Intervals:

From 0.0	To 34.5	From	To	From	To	From	To
From	To	From	To	From	To	From	To

Perforated Intervals:

From 34.5	To 79.5	From	To	From	To	From	To
From	To	From	To	From	To	From	To

Length Per Casing Section That is Not Perforated:

ement Seal:

m 0.00	To 6.0	From	To	From	To	From	To
Type Portland Type 2		Type		Type		Type	

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

.ine:	Black Mesa / Kayenta	Monitor Well Name:	SWEPO179

Sand Pack:

From 30.0 To 79.5 From 79.5 To 80.0 From ____ To ____ From ____ To ____

Type CO silica 8-12 Type Natural Fill Type ____ Type ____

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ıntonite Seal: Pellets

rrom 6.0 To 30.0 From ____ To ____ From ____ To ____ From ____ To ____

Type volclay Type ____ Type ____ Type ____

Casing Height Above Ground Surface: 2.5 ft

Protective Casing Housing: Type BK-6 Dimensions ____

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	SWEPO179

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	7		7	-2.5	4.5
2	10		17	4.5	14.5
3	10		27	14.5	24.5
4	10		37	24.5	34.5
5		10	47	34.5	44.5
6		10	57	44.5	54.5
7		10	67	54.5	64.5
8		10	77	64.5	74.5
9		5	82	74.5	79.5

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	WEPO43R
Geologic Unit Monitored:	Wepo formation
Ground surface Elevation:	6601.69 (ft-amsi)

Location: Mine Coordinates	N	-14053.73		E	23846.46		
	S			W			
		¼	¼	S	T		R

Drilling Date:	Start	7/14/97
	Finish	7/15/97
Drilled by:		Mo-Te Drilling
Logged by:		T. Smith
Geophysically Logged by:		Southwest Geophysical
Total Depth Drilled:		316.0 ft

FORMATION RECORD

DEPTH (ft)		Lithographic description of unconsolidated and consolidated units and water horizons.
FROM	TO	
0.0	140.0	Varicolored burn
140.0	145.0	Black shale and gray siltstone
145.0	160.0	Gray siltstone and brown sandstone (water at 153 feet)
160.0	171.0	Black shale with some gray siltstone
171.0	180.0	Brown fine grained sandstone (soft)
180.0	206.0	Gray fine grained sandstone (making some water)
206.0	216.0	Black shale and dark brown mudstone
216.0	219.0	Coal
219.0	232.0	Gray black mudstone and shale
232.0	244.0	Coal (making more water)
244.0	257.0	Dark brown mudstone
257.0	260.0	Coal
260.0	268.0	Gray sandy siltstone
268.0	274.0	Dark brown mudstone and carbonaceous shale
274.0	282.0	Gray brown sandy siltstone
282.0	287.0	Coal
287.0	291.0	Black shale
291.0	306.5	Carbonaceous shale and coal
306.5	316.0	Black shale with some gray siltstone
	316.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

,ine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO43R

Type of Drilling: Rotary
Drilling Fluid: Air and foam
Total Depth: 316.0 ft
Lithologic Unit Monitored: Wepo formation
Completion Date: 7/15/97

Borehole Diameter:

Surface:	9.0-inch	**From:** 0.0	**To:** 6.0
Intermediate:	7-7/8 inch	**From:** 6.0	**To:** 246.0
Production Zone:	7-7/8 inch	**From:** 246.0	**To:** 316.0

Casing Specifications: Blank

1. **Surface:** 4-inch schedule 40 PVC
2. **Intermediate:** 4 -nch schedule 40 PVC
3. **Production Zone:**

asing Specifications: Perforated

1. **Type:** 4-inch schedule 40 PVC screen, 0.020 horizontal mill slots
2. **Type:**

Blank Intervals:

From 00.0 To 156.0 From 246.0 To 256.0 From 306.0 To 316.0 From ____ To ____
From ____ To ____ From ____ To ____ From ____ To ____ From ____ To ____

Perforated Intervals:

From 156.0 To 246.0 From 256.0 To 306.0 From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____ From ____ To ____ From ____ To ____

Length Per Casing Section That is Not Perforated: ____

ement Seal:

m 0.0 To 10.0 From ____ To ____ From ____ To ____ From ____ To ____
Type Portland Type 2 Type ____ Type ____ Type ____

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

.ine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO43R

Sand Pack:

From 154.0 To 316.0 From ____ To ____ From ____ To ____ From ____ To ____

Type CO silica 8-12 Type ____ Type ____ Type ____

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ntonite Seal: pellets and slurry

From 10.0 To 120.0 From 120.0 To 150.0 From 150.0 To 154.0 From ____ To ____

Type hole plug Type slurry Type pellets Type ____

Casing Height Above Ground Surface

Protective Casing Housing: Type ____ Dimensions ____

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO43R

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	6		6	0.0	6.0
2	10		16	6.0	16.0
3	10		26	16.0	26.0
4	10		36	26.0	36.0
5	10		46	36.0	46.0
6	10		56	46.0	56.0
7	10		66	56.0	66.0
8	10		76	66.0	76.0
9	10		86	76.0	86.0
10	10		96	86.0	96.0
11	10		106	96.0	106.0
12	10		116	106.0	116.0
13	10		126	116.0	126.0
14	10		136	126.0	136.0
15	10		146	136.0	146.0
16	10		156	146.0	156.0
17		10	166	156.0	166.0
18		10	176	166.0	176.0
19		10	186	176.0	186.0
20		10	196	186.0	196.0
21		10	206	196.0	206.0
22		10	216	206.0	216.0
23		10	226	216.0	226.0
24		10	236	226.0	236.0
25		10	246	236.0	246.0
26	10		256	246.0	256.0
27		10	266	256.0	266.0
28		10	276	266.0	276.0
29		10	286	276.0	286.0
30		10	296	286.0	296.0
31		10	306	296.0	306.0
32	10		316	306.0	316.0

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	WEPO47R
Geologic Unit Monitored:	Wepo Formation
Ground surface Elevation:	6277.78 (ft-amsi)

Location: Mine Coordinates	N	-51855.04			E	24768.56		
	S				W			
		¼		¼	S		T	R

Drilling Date:	Start	04/01/98
	Finish	04/03/98
Drilled by:		Stewart Brothers Drilling Co.
Logged by:		J. Ohlman
Geophysically Logged by:		Southwest Geophysical
Total Depth Drilled:		302.0 ft

FORMATION RECORD

DEPTH (ft)		Lithographic description of unconsolidated and consolidated units and water horizons.
FROM	TO	
0.0	15.0	Tan brown sand, alluvium
15.0	25.0	Tan gravelly sand
25.0	34.0	Varicolored shale, damp
34.0	35.0	Coal
35.0	38.0	Medium dark brown shale
38.0	39.0	Yellow brown to gray shale
39.0	44.0	Dark brown shale with coal
44.0	55.0	Light medium gray shale
55.0	56.0	Yellow brown sandstone, water at 56 feet
56.0	59.0	Dark brown gray shale
59.0	60.0	White gray (fine to medium grained) sandstone
60.0	75.0	Medium gray siltstone and sandstone and light medium gray shale
75.0	80.0	Medium dark gray shale with coal stringers and lenses of hard siltstone and some sandstone
80.0	100.0	Medium light gray siltstone and sandstone
100.0	110.0	Gray shale with coal stringers
110.0	120.0	Dark gray shale
120.0	130.0	Light gray shale with some burn near 130 feet
130.0	140.0	Varicolored burn
140.0	160.0	Same as above with some light gray sandstone
160.0	170.0	Same as above with medium to coarse grained arkosic sandstone, water at 160-165 feet
170.0	180.0	Red dark gray siltstone and mudstone, hard
180.0	190.0	Light gray sandstone with some burn and minor coal streaks
190.0	200.0	Varicolored burn

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG (continued)

..ine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO47R

FORMATION RECORD

DEPTH (ft)		
FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
200.0	220.0	Same as above with dark siltstone and red brown (fine to medium grained) sandstone
220.0	230.0	Medium gray sandstone and dark shale with coal at 230 feet
230.0	250.0	Dark gray hard siltstone and sandstone with minor coal stringers
250.0	270.0	Black shale with coal streaks, softer 260-270 feet
270.0	280.0	Medium gray sandy shale with dark shale and minor coal streaks
280.0	290.0	Same as above with some light gray sandstone near 290 feet
290.0	302.0	White gray sandstone
	302.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

Mine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO47R

Type of Drilling: Rotary
Drilling Fluid: Air and Foam
Total Depth: 302.0 ft
Lithologic Unit Monitored: Wepo formation
Completion Date: 04/03/98

Borehole Diameter:

Surface:	10.0-inch	**From:** 0.0	**To:** 18.0
Intermediate:	7.875-inch	**From:** 18.0	**To:** 52.0
Production Zone:	7.875-inch	**From:** 52.0	**To:** 222.0

Casing Specifications: Blank

1. **Surface:** 4-inch schedule 40 PVC inside 8-inch
2. **Intermediate:** 4-inch schedule 40 PVC
3. **Production Zone:** ______

Casing Specifications: Perforated

1. **Type:** 4-inch schedule 40 PVC screen, 0.020-inch horizontal mill slots
2. **Type:** ______

Blank Intervals:

From	0.0	To	52.0	From	62.0	To	82.0	From	112.0	To	122.0	From	222.0	To	302.0
From		To		From		To		From		To		From		To	

Perforated Intervals:

From	52.0	To	62.0	From	82.0	To	112.0	From	122.0	To	222.0	From		To	
From		To		From		To		From		To		From		To	

Length Per Casing Section That is Not Perforated: ______

Cement Seal:

From	0.0	To	5.0	From		To		From		To		From		To	
Type	Portland Type 2			Type				Type				Type			

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

..ne:	Black Mesa / Kayenta	Monitor Well Name:	WEPO47R

Sand Pack:

From 50.0	**To** 114.0	**From** 120.0	**To** 272.0	**From**	**To**	**From**	**To**
Type CO silica 8-12		**Type**		**Type**		**Type**	

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

..ntonite Seal:

From 5.0	**To** 14.0	**From** 14.0	**To** 29.0	**From** 29.0	**To** 50.0	**From** 114.0	**To** 120.0
Type High solids bentonite		**Type** Hole plug		**Type** Bentonite pellets		**Type** Bentonite pellets	

From 272 to 302 bentonite pellets

Casing Height Above Ground Surface: 1.35 ft

Protective Casing Housing: Type Steel Dimensions

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO47R

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	5		3.35	+1.35	2.0
2	10		13.35	2.0	12.0
3	10		23.35	12.0	22.0
4	10		33.35	22.0	32.0
5	10		43.35	32.0	42.0
6	10		53.35	42.0	52.0
7		10	63.35	52.0	62.0
8	10		73.35	62.0	72.0
9	10		83.35	72.0	82.0
10		10	93.35	82.0	92.0
11		10	103.35	92.0	102.0
12		10	113.35	102.0	112.0
13	10		123.35	112.0	122.0
14		10	133.35	122.0	132.0
15		10	143.35	132.0	142.0
16		10	153.35	142.0	152.0
17		10	163.35	152.0	162.0
18		10	173.35	162.0	172.0
19		10	183.35	172.0	182.0
20		10	193.35	182.0	192.0
21		10	203.35	192.0	202.0
22		10	213.35	202.0	212.0
23		10	223.35	212.0	222.0
24	10		233.35	222.0	232.0
25	10		243.35	232.0	242.0
26	10		253.35	242.0	252.0
27	10		263.35	252.0	262.0
28	10		273.35	262.0	272.0
29	10		283.35	272.0	282.0
30	10		293.35	282.0	292.0
31	10		303.35	292.0	302.0

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	**WEPO62R**
Geologic Unit Monitored:	Wepo formation
Ground surface Elevation:	6831.42 (ft-amsi)

Location: Mine Coordinates	N	-22347.95				E	56967.7		
	S					W			
		¼		¼	S		T		R

Drilling Date:	Start	7/15/97
	Finish	7/17/97
Drilled by:		Mo-Te Drilling
Logged by:		J. Ohlman
Geophysically Logged by:		Southwest Geophysical
Total Depth Drilled:		324.0 ft

FORMATION RECORD

DEPTH (ft) FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	10.0	Tan orange siltstone and sandstone
10.0	18.0	Black shale
18.0	20.0	Coal
20.0	34.0	Light medium gray shale
34.0	36.0	Coal
36.0	62.0	Gray sandstone and shale, hard in places
62.0	64.0	Coal
64.0	69.0	Light medium gray siltstone and sandstone
69.0	75.0	Gray black shale
75.0	80.0	Gray sandstone with hard shale and coal lenses
80.0	89.0	Medium dark black shale with coal stringers
89.0	93.0	Coal
93.0	102.0	Black and dark brown shale with hard coal at 96-97 feet
102.0	118.0	Gray white (fine to medium grained) sandstone with hard coal at 109-111 feet
118.0	121.0	Medium dark black mudstone
121.0	129.0	Black shale with coal stringers
129.0	134.0	Coal
134.0	154.0	Black shale with coal stringers, coat at 136-138 feet
154.0	165.0	Light medium gray fine grained sandstone with coal stringers
165.0	167.0	Coal
167.0	196.0	Medium gray black sandstone and siltstone
196.0	200.0	Coal
200.0	209.0	Medium gray black shale and mudstone
209.0	214.0	Light medium gray fine to medium grained sandstone
214.0	224.0	Coal with shale partings

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG (continued)

Mine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO62R

FORMATION RECORD

DEPTH (ft)		
FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
224.0	245.0	Black shale and medium dark gray mudstone with coal at 232-233 feet and 240-242 ft
245.0	251.0	Coal
251.0	257.0	Gray fine to medium grained sandstone
257.0	258.0	Coal
258.0	262.0	Gray fine to medium grained sandstone with minor amounts of black shale
262.0	267.0	Coal with shale at 264-265 feet
267.0	270.0	Black shale with coal and sandy shale stringers
270.0	286.0	Light medium gray fine to medium grained sandstone and siltstone
286.0	320.0	Same as above with mudstone and shale, boring making some water
320.00	324.0	Light pink gray fine grained arkosic sandstone
	324.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

Mine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO62R

Type of Drilling: Rotary **Lithologic Unit Monitored:** Wepo formation
Drilling Fluid: Air and foam **Completion Date:** 07/17/97
Total Depth: 324.0 ft

Borehole Diameter:

Surface:	9.0-inch	**From:** 0.0	**To:** 6.0
Intermediate:	7-7/8 inch	**From:** 6.0	**To:** 194.0
Production Zone:	7-7/8 inch	**From:** 194.0	**To:** 324.0

Casing Specifications: Blank

1. **Surface:** 4-inch schedule 40 PVC
2. **Intermediate:** 4-inch schedule 40 PVC
3. **Production Zone:** ______

asing Specifications: Perforated

1. **Type:** 4-inch schedule 40 PVC screen, 0.020 horizontal mill slots
2. **Type:** ______

Blank Intervals:

From	0.0	To	194.0	From		To		From		To		From		To	
From		To		From		To		From		To		From		To	

Perforated Intervals:

From	194.0	To	324.0	From		To		From		To		From		To	
From		To		From		To		From		To		From		To	

Length Per Casing Section That is Not Perforated: 0.5 feet at each end

Cement Seal:

m	0.0	To	10.0	From		To		From		To		From		To	
Type	Portland Type 2			Type				Type				Type			

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

..ine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO62R

Sand Pack:

From	To	From	To	From	To	From	To
161.0	324.0						
Type: CO silica 8-12		Type:		Type:		Type:	

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ntonite Seal:

From	To	From	To	From	To	From	To
10.0	154.0	154.0	159.0	159.0	161.0		
Type: High solids slurry		Type: Hole plug		Type: ¼" pellets		Type:	

Casing Height Above Ground Surface

Protective Casing Housing: Type ______ Dimensions ______

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO62R

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	6		6	+2.0	4.0
2	10		16	4.0	14.0
3	10		26	14.0	24.0
4	10		36	24.0	34.0
5	10		46	34.0	44.0
6	10		56	44.0	54.0
7	10		66	54.0	64.0
8	10		76	64.0	74.0
9	10		86	74.0	84.0
10	10		96	84.0	94.0
11	10		106	94.0	104.0
12	10		116	104.0	114.0
13	10		126	114.0	124.0
14	10		136	124.0	134.0
15	10		146	134.0	144.0
16	10		156	144.0	154.0
17	10		166	154.0	164.0
18	10		176	164.0	174.0
19	10		186	174.0	184.0
20	10		196	184.0	194.0
21		10	206	194.0	204.0
22		10	216	204.0	214.0
23		10	226	214.0	224.0
24		10	236	224.0	234.0
25		10	246	234.0	244.0
26		10	256	244.0	254.0
27		10	266	254.0	264.0
28		10	276	264.0	274.0
29		10	286	274.0	284.0
30		10	296	284.0	294.0
31		10	306	294.0	304.0
32		10	316	304.0	314.0
33		10	326	314.0	324.0

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	**WEPO68**
Geologic Unit Monitored:	WEPO formation
Ground surface Elevation:	7063.11 (ft-amsi)

Location: Mine Coordinates	N	-37627.94			E	72384.28		
	S				W			
		¼		¼	S		T	R

Drilling Date:	Start	7/17/97
	Finish	7/21/98
Drilled by:		Mo-Te Drilling
Logged by:		J. Ohlman
Geophysically Logged by:		Southwest Geophysical
Total Depth Drilled:		280.0 ft

FORMATION RECORD

DEPTH (ft)		Lithographic description of unconsolidated and consolidated units and water horizons.
FROM	TO	
0.0	7.0	Varicolored, burnt shale and sandstone, smut at 4-7 feet
7.0	64.0	Same as above, hard at 48-52 feet
64.0	66.0	Coal
66.0	68.0	Brown black shale
68.0	72.0	Coal
72.0	75.0	Black shale
75.0	78.0	Coal, poor quality
78.0	87.0	Gray shale
87.0	94.0	Medium dark gray shale and mudstone, hard at 90 feet
94.0	98.0	Coal
98.0	102.0	Gray shale and shaley mudstone
102.0	106.0	Coal, poor quality
106.0	109.0	Medium dark black mudstone
109.0	121.5	Gray shale and mudstone with lenses of hard sandstone and siltstone at 109, 114 and 117-119 feet
121.5	137.0	Gray shale and mudstone with black laminae and sandstone and siltstone lenses
137.0	138.0	Coal
138.0	139.0	Gray fine grained sandstone
139.0	141.0	Coal
141.0	147.0	Black shale with coal seams, wet
147.0	149.0	Coal, water
149.0	154.0	Black shale with coal seams
154.0	158.0	Gray sandstone and siltstone
158.0	160.0	Coal
160.0	167.0	Black shale

PEABODY COAL COMPANY – WESTERN DIVISION
MONITOR WELL LITHOLOGIC LOG (continued)

..ine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO68

FORMATION RECORD

DEPTH (ft)		
FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
167.0	169.0	Coal
169.0	172.0	Gray sandstone and siltstone
172.0	174.0	Coal
174.0	195.0	Gray sandstone and siltstone
195.0	205.0	Coal with gray shale interbeds, red 2 seam
205.0	226.0	Medium dark gray mudstone, shale and coal with shale lenses; sandstone and siltstone beds from 211-214 feet
226.0	228.0	Coal, orange seam
228.0	238.0	Light gray fine-grained sandstone and silty sandstone with mudstone and hard shale beds
238.0	240.0	Coal
240.0	258.0	Light gray fine grained sandstone and silty sandstone with mudstone and hard shale beds
258.0	260.0	Coal, orange 1 seam
260.0	262.0	Dark gray shale parting
262.0	270.0	Coal, orange 1 seam
270.0	279.0	Gray shale
279.0	280.0	Light medium gray fine grained sandstone
	280.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

..ine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO68

Type of Drilling: Rotary
Drilling Fluid: Air and Foam
Total Depth: 280.0 ft

Lithologic Unit Monitored: Wepo Formation
Completion Date: 07/21/97

Borehole Diameter:

Surface:	9.0-inch	**From:**	0.0	**To:**	6.0
Intermediate:	7-7/8 inch	**From:**	6.0	**To:**	144.0
Production Zone:	7-7/8 inch	**From:**	144.0	**To:**	280.0

Casing Specifications: Blank

1. **Surface:** 4-inch schedule 40 PVC
2. **Intermediate:** 4-inch schedule 40 PVC
3. **Production Zone:** ____________

..sing Specifications: Perforated

1. **Type:** 4-inch schedule 40 PVC screen, 0.020 horizontal mill slots
2. **Type:** ____________

Blank Intervals:

From -2.6 To 137.0 From ______ To ______ From ______ To ______ From ______ To ______

From ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______

Perforated Intervals:

From 137.0 To 277.0 From ______ To ______ From ______ To ______ From ______ To ______

From ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______

Length Per Casing Section That is Not Perforated: ____________

..ement Seal:

..m 0.0 To 10.0 From ______ To ______ From ______ To ______ From ______ To ______

Type Portland Type 2 Type ______ Type ______ Type ______

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

..ne:	Black Mesa / Kayenta	Monitor Well Name:	WEPO68

Sand Pack:

From	121.0	To	277.0	From		To	
Type	CO silica 8-12			Type			

From		To		From		To	
Type				Type			

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

..ntonite Seal: pellets. slurry and hole plug

From	111.0	To	121.0	From	20.0	To	111.0
Type	Pellets and hole plug			Type	Slurry		

From	10.0	To	20.0	From		To	
Type	Hole plug			Type			

Casing Height Above Ground Surface: 2.6 ft

Protective Casing Housing: Type ______ Dimensions ______

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	WEPO68

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	9.6		9.6	-2.6	7.0
2	10		19.6	7.0	17.0
3	10		29.6	17.0	27.0
4	10		39.6	27.0	37.0
5	10		49.6	37.0	47.0
6	10		59.6	47.0	57.0
7	10		69.6	57.0	67.0
8	10		79.6	67.0	77.0
9	10		89.6	77.0	87.0
10	10		99.6	87.0	97.0
11	10		109.6	97.0	107.0
12	10		119.6	107.0	117.0
13	10		129.6	117.0	127.0
14	10		139.6	127.0	137.0
15		10	149.6	137.0	147.0
16		10	159.6	147.0	157.0
17		10	169.6	157.0	167.0
18		10	179.6	167.0	177.0
19		10	189.6	177.0	187.0
20		10	199.6	187.0	197.0
21		10	209.6	197.0	207.0
22		10	219.6	207.0	217.0
23		10	229.6	217.0	227.0
24		10	239.6	227.0	237.0
25		10	249.6	237.0	247.0
26		10	259.6	247.0	257.0
27		10	269.6	257.0	267.0
28		10	279.6	267.0	277.0

Spoil Well Lithologic Logs
And Completions

Revised 05/22/00

PEABODY COAL COMPANY – WESTERN DIVISION
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	SPL161
Geologic Unit Monitored:	J16 Spoil
Ground surface Elevation:	6336.29 (ft-amsi)

Location: Mine Coordinates	N	-18477			E	56911			
	S				W				
		¼		¼	S		T		R

Drilling Date:	Start	8/23/95
	Finish	8/23/95
Drilled by:		Winnek Drilling Company
Logged by:		J. Cochran
Geophysically Logged by:		none
Total Depth Drilled:		113.0 ft

FORMATION RECORD

DEPTH (ft) FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	108.0	Spoil
108.0	111.0	Mudstone and shale
111.0	113.0	Sandstone (hard)
	113.0	T.D.

PEABODY COAL COMPANY – WESTERN DIVISION
MONITOR WELL LITHOLOGIC LOG (continued)

Page /

ne:	Black Mesa / Kayenta	Monitor Well Name:	

FORMATION RECORD

DEPTH (ft)		
FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL161

Type of Drilling: Rotary **Lithologic Unit Monitored:** Spoil
Drilling Fluid: Air and foam **Completion Date:** 8/23/95
Total Depth: 113.0 ft.
Backfilled to 111.0 ft. with pellets

Borehole Diameter:

Surface:	6.75 in	**From:** 0.0	**To:** 91.0
Intermediate:		**From:**	**To:**
Production Zone:	6.75 in	**From:** 91.0	**To:** 111.0

Casing Specifications: Blank

1. **Surface:** 2" schedule 40 pvc
2. **Intermediate:**
3. **Production Zone:**

ısing Specifications: Perforated

1. **Type:** 2" schedule 40 pvc screen, 3 columns of .020 inch horizontal mill slots spaced 0.25" apart
2. **Type:**

Blank Intervals:

From 0.0 To 91.0 From ___ To ___ From ___ To ___ From ___ To ___
From ___ To ___ From ___ To ___ From ___ To ___ From ___ To ___

Perforated Intervals:

From 91.0 To 111.0 From ___ To ___ From ___ To ___ From ___ To ___
From ___ To ___ From ___ To ___ From ___ To ___ From ___ To ___

Length Per Casing Section That is Not Perforated: ___

˜ement Seal:

m 0.0 To 5.0 From ___ To ___ From ___ To ___ From ___ To ___
Type Portland Type 2 Type ___ Type ___ Type ___

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL161

Sand Pack:

From	69.5	To	75.0	From	81.0	To	111.0
From		To		From		To	

Type Colo. Silica 8-16 Type ____ Type ____ Type ____

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ntonite Seal:

rom	5.0	To	69.5	From	75.0	To	81.0
From	111.0	To	113.0	From		To	

Type High solids bentonite Type Pellets Type Pellets Type ____

Casing Height Above
Ground Surface 1.98 ft.

Protective Casing Housing: Type ____ Dimensions ____

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY COAL COMPANY – WESTERN DIVISION
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	SPL161

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	2.98		2.98	+1.98	1.0
2	10		12.98	1.0	11.0
3	10		22.98	11.0	21.0
4	10		32.98	21.0	31.0
5	10		42.98	31.0	41.0
6	10		52.98	41.0	51.0
7	10		62.98	51.0	61.0
8	10		72.98	61.0	71.0
9	10		82.98	71.0	81.0
10	10		92.98	81.0	91.0
11		10	102.98	91.0	101.0
12		10	112.98	101.0	111.0
13					
14					
15					
16					
17					
18					
19					
20					
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22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	**SPL174**
Geologic Unit Monitored:	N8 Spoil
Ground surface Elevation:	(ft-amsi)

Location: Mine Coordinates	N			E					
	S			W					
		¼	¼	S		T		R	

Drilling Date:	Start	04/25/92
	Finish	04/25/92
Drilled by:		Winneck Drilling Co.
Logged by:		T. Smith
Geophysically Logged by:		None
Total Depth Drilled:		32.0 ft

FORMATION RECORD

DEPTH (ft) FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	1.5	Brown sandy silt with angular rock fragments
1.5	3.0	Brown black silty sandy (fine to coarse grained) clay with considerable angular rock fragments
3.0	10.0	Brown black sandy (fine to coarse grained) silt with considerable pieces of sandstone and siltstone (boulder)
10.0	18.0	Brown black silty sandy (medium to coarse grained) clay with considerable rock fragments (clinker, sandstone and mudstone)
18.0	21.0	Same as above with smaller rock fragments
21.0	24.0	Sandstone boulders and clinker (all broken rock fragments)
24.0	27.0	Dark brown silty sandy clay with small rock fragments
27.0	29.5	Boulders (sandstone, clinker and siltstone)
29.5	32.0	Brown black silty sandy clay with considerable small rock fragments
	32.0	T.D. (Bedrock)
		Dry hole did not case

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

..ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL174

Type of Drilling: ______ Lithologic Unit Monitored: ______
Drilling Fluid: ______ Completion Date: ______
Total Depth: ______

Borehole Diameter:

Surface: ______ From: ______ To: ______
Intermediate: ______ From: ______ To: ______
Production Zone: ______ From: ______ To: ______

Casing Specifications: Blank

1. Surface: ______
2. Intermediate: ______
3. Production Zone: ______

ısing Specifications: Perforated

1. Type: ______
2. Type: ______

Blank Intervals:

From ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______
From ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______

Perforated Intervals:

From ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______
From ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______

Length Per Casing Section That is Not Perforated: ______

ement Seal:

m ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______
Type ______ Type ______ Type ______ Type ______

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

.ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL174

Sand Pack:

From ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______

Type ______ Type ______ Type ______ Type ______

Packers:

Locations: ______

Type: ______

Centralizers:

Locations: ______

Type: ______

ɜntonite Seal: pellets and slurry

ı rom ______ To ______ From ______ To ______ From ______ To ______ From ______ To ______

Type ______ Type ______ Type ______ Type ______

Casing Height Above
Ground Surface

Protective Casing Housing: Type ______ Dimensions ______

Additional Details: ______

Development Summary: ______

Type: ______

Duration: ______

Dates of Development: ______

Development Comments: ______

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	SPL174

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	SPL176
Geologic Unit Monitored:	N7 Spoil
Ground surface Elevation:	6568.47 (ft-amsi)

Location: Mine Coordinates	N	-630.22			E	18202.82		
	S				W			
		¼		¼	S		T	R

Drilling Date:	Start	04/22/92
	Finish	04/22/92
Drilled by:		Winnek Drilling Co.
Logged by:		T. Smith
Geophysically Logged by:		
Total Depth Drilled:		59.0 ft

FORMATION RECORD

DEPTH (ft) FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	1.5	Brown sandy silt with gravel
1.5	3.5	Gray to black silty, very sandy (fine to coarse grained) clay with pieces of mudstone, coal and sandstone
3.5	9.0	Gray, same as above with no coal
9.0	11.0	Gray brown very sandy (fine to coarse grained) clayey silt with rock fragments
11.0	16.0	Gray same as above
16.0	20.0	Gray brown same as above, very clayey silt
20.0	27.0	Brown same as above with pieces of rock and coal, considerable rock fragments starting at 23 feet
27.0	32.0	Less rock fragments but considerable pieces of trees
32.0	36.5	Dark brown sandy, very clayey silt with coal and rock fragments (clayey silt balling up indicating an increase in moisture)
36.5	44.0	Gray and tan gray very sandy clayey silt with considerable sandstone, rock fragments and some carbonaceous shale (wet at 36.5 feet)
44.0	45.0	Tan gravelly silty sand with rock fragments
45.0	51.0	Gray brown sandy, clayey, silt with numerous pieces of sandstone, coal, and mudstone
51.0	54.0	Gray brown sandy clayey silt and silty clay with numerous rock fragments (sandstone, mudstone, and coal)
`54.0	56.5	Gray brown clayey, sandy silt with large sandstone chunks
56.5	59.0	Boulders and weathered sandstone with some carbonaceous lenses
	59.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

,ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL176

Type of Drilling: Auger **Lithologic Unit Monitored:** Spoil
Drilling Fluid: None **Completion Date:** 04/22/92
Total Depth: 59.0 ft

Borehole Diameter:

Surface:	8.0-inch	**From:**	0.0	**To:**	39.0
Intermediate:		**From:**		**To:**	
Production Zone:	8.0-inch	**From:**	39.0	**To:**	59.0

Casing Specifications: Blank

1. **Surface:** 2-inch schedule 40 PVC
2. **Intermediate:**
3. **Production Zone:**

ısing Specifications: Perforated

1. **Type:** 2-inch schedule 40 PVC screen, 3 columns of 0.020-inch horizontal mill slots space ¼ inch apart vertically
2. **Type:**

Blank Intervals:

From	0.0	To	39.0	From		To		From		To		From		To	
From		To		From		To		From		To		From		To	

Perforated Intervals:

From	39.0	To	59.0	From		To		From		To		From		To	
From		To		From		To		From		To		From		To	

Length Per Casing Section That is Not Perforated: 10 ft

ᐨement Seal:

m	0.0	To	5.0	From		To		From		To		From		To	

Type	Portland Type 2	Type		Type		Type	

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

.ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL176

Sand Pack:

From 5.0 To 37.3 From 37.3 To 59.0 From ___ To ___ From ___ To ___

Type Cuttings Type CO silica 8-16 Type ___ Type ___

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ntonite Seal:

. rom None To ___ From ___ To ___ From ___ To ___ From ___ To ___

Type ___ Type ___ Type ___ Type ___

Casing Height Above Ground Surface: 3.0 ft

Protective Casing Housing: Type ___ Dimensions ___

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	SPL176

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	2		2	+3.0	+1.0
2	10		12	+1.0	9.0
3	10		22	9.0	19.0
4	10		32	19.0	29.0
5	10		42	29.0	39.0
6		10	52	39.0	49.0
7		10	62	49.0	59.0

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	**SPL177**
Geologic Unit Monitored:	N7 Spoil
Ground surface Elevation:	6566.93 (ft-amsi)

Location: Mine Coordinates	N	-1023.95		E	18143.2				
	S			W					
		¼		¼	S		T		R

Drilling Date:	Start	04/22/92
	Finish	04/22/92
Drilled by:		Winnek Drilling Co.
Logged by:		T. Smith
Geophysically Logged by:		None
Total Depth Drilled:		59.0 ft

FORMATION RECORD

DEPTH (ft)		
FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	1.0	Brown sandy (fine to coarse grained) clayey silt with some pieces of gravel
1.0	4.0	Gray same as above with some pieces of coal and sandstone
4.0	9.0	Gray tan same as above with more rock fragments
9.0	13.0	Gray same as above
13.0	37.0	Gray tan same as above with lots of rock fragments
37.0	38.0	Gray same as above
38.0	40.0	Dark gray same as above, moisture balling soil
40.0	44.0	Dark gray and gray clayey sandy silt and sandstone and carbonaceous siltstone, boulders, (wet)
44.0	47.0	Black and gray same as above
47.0	50.0	Black gray sandy (fine to coarse grained) silty clay
50.0	52.0	Black and gray clayey very sandy (coarse grained) silt with rock fragments
52.0	55.0	Black and gray sandstone and mudstone, boulders
55.0	59.0	Boulders and sandstone, carbonaceous shale and siltstone
	59.0	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL177

Type of Drilling: Auger
Drilling Fluid: None
Total Depth: 59.0 ft

Lithologic Unit Monitored: Spoil
Completion Date: 04/22/92

Borehole Diameter:

Surface:	8.0-inch	**From:** 0.0	**To:** 34.0
Intermediate:		**From:**	**To:**
Production Zone:	8.0-inch	**From:** 34.0	**To:** 59.0

Casing Specifications: Blank

1. **Surface:** 2-inch schedule 40 PVC blank casing
2. **Intermediate:**
3. **Production Zone:**

sing Specifications: Perforated

1. **Type:** Type 2-inch schedule 40 PVC screen, 3 columns of 0.020-inch horizontal mill slots spaced ¼ inch apart vertically
2. **Type:**

Blank Intervals:

From 0.0 To 34.0 From ___ To ___ From ___ To ___ From ___ To ___
From ___ To ___ From ___ To ___ From ___ To ___ From ___ To ___

Perforated Intervals:

From 34.0 To 59.0 From ___ To ___ From ___ To ___ From ___ To ___
From ___ To ___ From ___ To ___ From ___ To ___ From ___ To ___

Length Per Casing Section That is Not Perforated: 2 inches

Cement Seal:

m 0.0 To 6.0 From ___ To ___ From ___ To ___ From ___ To ___
Type Portland Type 2 Type ___ Type ___ Type ___

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL177

Sand Pack:

From 6.0 To 32.0 From 32.0 To 59.0 From ____ To ____ From ____ To ____

Type Cuttings Type CO silica 8-16 Type ____ Type ____

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ntonite Seal:

: ,om None To ____ From ____ To ____ From ____ To ____ From ____ To ____

Type ____ Type ____ Type ____ Type ____

Casing Height Above
Ground Surface

Protective Casing Housing: Type ____ Dimensions ____

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	SPL177

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	8		8	+4.0	4.0
2	10		18	4.0	14.0
3	10		28	14.0	24.0
4	10		38	24.0	34.0
5		10	48	34.0	44.0
6		10	58	44.0	54.0
7		5	63	54.0	59.0

PEABODY WESTERN COAL COMPANY
MONITOR WELL LITHOLOGIC LOG

Mine:	Black Mesa / Kayenta
Monitor Well Name:	SPL188 (Replaces SPL205)
Geologic Unit Monitored:	N2 Spoil
Ground surface Elevation:	6665 (ft-amsl)

Location: Mine Coordinates	N	2471					E	29313			
	S						W				
		¼		¼	S		T		R		

Drilling Date:	Start	04/30/92
	Finish	04/30/92
Drilled by:		Winnek Drilling Co.
Logged by:		J. Ohlman
Geophysically Logged by:		None
Total Depth Drilled:		49.5 ft

FORMATION RECORD

DEPTH (ft) FROM	TO	Lithographic description of unconsolidated and consolidated units and water horizons.
0.0	12.0	Medium dark gray brown sandy silty gravel, minor clay, coal fragments and pieces of white to gray sandstone (fine to coarse grained) and sandy siltstone, dry. *Note*: rocks at 5.0 – 5.5 feet, coal fragments start at 10 feet
12.0	20.0	Same as above, coal fragments to 1 ½", rock at 20 feet
20.0	33.0	Light tan gray, sand (fine to coarse grained), minor siltstone, little coal, rock at 33 feet, dry
33.0	37.0	Same as above, considerable rounded rock fragments, gravel increases downward, dry
37.0	43.0	Dark gray carbonaceous siltstone and sandstone (fine to medium grained) dry *Note*: pushed auger at approximately 600 psi
43.0	49.5	Same as above, coal stringers, water at 47-48 feet
	49.5	T.D.

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

.ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL188

Type of Drilling: Auger **Lithologic Unit Monitored:** Spoil
Drilling Fluid: None **Completion Date:** 04/30/92
Total Depth: 49.5 ft

NOTE: Borehole backfilled from 49.5 to 37.0 ft with dry cuttings as bedrock was encountered at 37 ft and was mistaken for a boulder.

Borehole Diameter:

Surface: 8.0-inch	**From:** 0.0	**To:** 27.0
Intermediate: ______	**From:** ______	**To:** ______
Production Zone: 8.0-inch	**From:** 27.0	**To:** 37.0

Casing Specifications: Blank

1. **Surface:** 2-inch schedule 40 PVC
2. **Intermediate:** ______
3. **Production Zone:** ______

.sing Specifications: Perforated

1. **Type:** 2-inch schedule 40 PVC screen, 3 columns of 0.020 inch horizontal mill slots spaced ¼ inch apart vertically
2. **Type:** ______

Blank Intervals:

From 0.0 To 27.0 From ____ To ____ From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____ From ____ To ____ From ____ To ____

Perforated Intervals:

From 27.0 To 37.0 From ____ To ____ From ____ To ____ From ____ To ____
From ____ To ____ From ____ To ____ From ____ To ____ From ____ To ____

Length Per Casing Section That is Not Perforated: ______

Cement Seal:

From 0.0 To 5.0 From ____ To ____ From ____ To ____ From ____ To ____
e Portland Type 2 Type ______ Type ______ Type ______

PEABODY WESTERN COAL COMPANY
MONITOR WELL COMPLETION AND DEVELOPMENT DETAILS

ne:	Black Mesa / Kayenta	Monitor Well Name:	SPL188

Sand Pack:

From	5.0	To	6.0	From	6.0	To	37.0
Type	Spoil Fill			Type	CO silica 8-16		
From	37.0	To	49.5	From		To	
Type	Spoil Fill			Type			

Packers:

Locations: None

Type:

Centralizers:

Locations: None

Type:

ntonite Seal:

rom	None	To		From		To	
Type				Type			
From		To		From		To	
Type				Type			

Casing Height Above Ground Surface

Protective Casing Housing: Type ______ Dimensions ______

Additional Details:

Development Summary:

Type:

Duration:

Dates of Development:

Development Comments:

PEABODY WESTERN COAL COMPANY
MONITOR WELL CASING AND SCREEN RECORD

Mine:	Black Mesa / Kayenta	Monitor Well Name:	SPL188

Casing Joint Number	Blank Casing Length (ft)	Screen Length (ft)	Cumulative Length (ft)	Depth Interval (feet below ground surface)	
				From	To
1	10		10	+3.0	7.0
2	10		20	7.0	17.0
3	10		30	17.0	27.0
4		10	40	27.0	37.0

ATTACHMENT 9

Wepo Aquifer Test Data and Results

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N) S., R. 18 (E) W., Sec. 8 WELL NO. 39

Personnel Smith, Cochran, Dee Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery (3.) Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

al well depth 220 ft. Well diameter 9 in. Casing diameter 6 in.

ing type pvc Type of screen or perforation saw slots

interval of screen or perforation 13-95, 107-130, 137-147, 155-197, 207-220 Pump hp. & type 1/3 hp. Fairbanks Mor

Pump depth 200 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6612.2 How determined surveyed

MP Above/Below LSD .58' Altitude MP 6612.78

SWL from MP 28.89' How measured Stevens Digital Recorder

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
5/19/82	11:13	28.89	0	pump on		
	11:32	30.31	19			1.42
	11:37	30.36	24			1.47
	11:42	30.49	29			1.60
	11:47	30.62	34			1.73
	11:52	30.74	39			1.85
	11:57	30.91	44			2.02
	12:02	30.98	49			2.09
	12:07	31.04	54			2.15
	12:12	31.10	59			2.21
	12:17	31.16	64			2.27
	12:22	31.21	69			2.32
	12:27	31.26	74			2.37
	12:32	31.31	79			2.42
	12:37	31.35	84			2.46
	12.42	31.40	89			2.51
	12.47	31.44	94			2.55
	12.52	31.47	99			2.58
	12:57	31.50	104			2.61
	1:02	31.53	109			2.64
	1:07	31.56	114			2.67
	1:12	31.59	119			2.70
	1:17	31.61	124			2.72
	1:22	31.64	129			2.75
	1:27	31.66	134			2.77
	1:32	31.68	139			2.79
	1:37	31.70	144			2.81
	1:42	31.72	149			2.83

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 8 WELL NO. 39

Personnel Smith, Cochran, Dee Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery (3.) Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

..al well depth 220 ft. Well diameter 9 in. Casing diameter 6 in.

..ng type pvc Type of screen or perforation saw slots

..nterval of screen or perforation 13-95,107-130,137-147, 155-197,207-220 Pump hp. & type 1/3 hp. Fairbanks Mor..

Pump depth 200 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6612.2 How determined surveyed

MP Above/Below LSD .58' Altitude MP 6612.78

SWL from MP 28.89' How measured Stevens Digital Recorder

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
5/19/82	1:47	31.74	154			2.85
	1:52	31.76	159			2.87
	2:02	31.81	169			2.92
	2:12	31.84	179			2.95
	2:22	31.87	189			2.98
	2:32	31.89	199			3.00
	2:52	31.93	219			3.04
	3:22	32.01	249			3.12
	3:47	32.08	274			3.19
	4:12	32.12	299			3.23
	4:37	32.15	324			3.26
	5:02	32.20	349			3.31
	5:27	32.23	374			3.34
	5:52	32.27	399			3.38
	6:42	32.36	449			3.47
	7:32	32.44	499			3.55
	8:22	32.52	549			3 .63
	9:12	32.62	599			3.73
	10:02	32.63	649			3.74
	10:52	32.67	699			3.78
	11:42	32.72	749			3.83
5/20/82	12:32	32.75	799			3.86
	1:22	32.78	849			3.89
	2:12	32.82	899			3.93
	3:02	32.86	949			3.97
	3:52	32.89	999			4.00
	4:42	32.91	1049			4.02
	5:32	32.95	1099			4.06

PEABODY HYDROLOGIC TESTING — AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 8 WELL NO. 39

Personnel Smith, Cochran, Dee Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery (3.) Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

l well depth 220 ft. Well diameter 9 in. Casing diameter 6 in.

ng type pvc Type of screen or perforation saw slots

Interval of screen or perforation 13-95, 107-130, 137-147, 155-197, 207-220 Pump hp. & type 1/3 hp. Fairbanks Mors

Pump depth 200 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6612.2 How determined surveyed

MP Above / Below LSD .58' Altitude MP 6612.78

SWL from MP 28.89' How measured Stevens Digital Recorder

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
5/20/82	6:22	32.97	1149			4.08
	7:12	33.00	1199			4.11
	9:17	33.08	1324			4.19
	9:42	33.10	1349			4.21
	10:32	33.11	1399			4.22
	11:24	pump off	1451			

WATER WELL 38

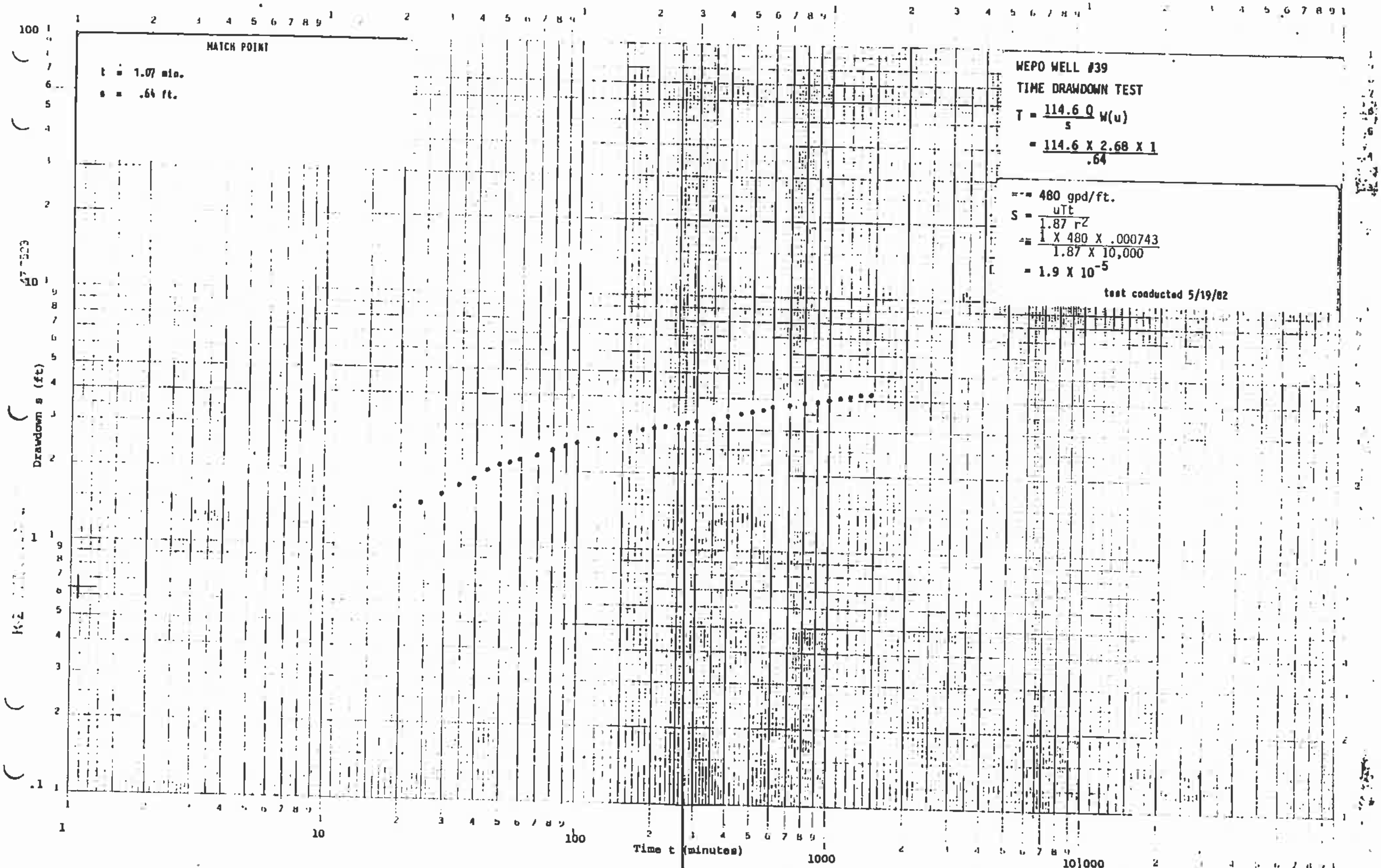
PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
5/19/82	11:17	102.8	.584	3.5	.0031	.0063
	11.18	55.0	1.091	3.5	.0010	.0038
	11:20	57.0	1.053	3.5	.0027	.0100
	11:26	62.0	.968	3.5	.0027	.0091
	11:28	50.0	1.200	3.5	.0017	.0071
	11:31	65.0	.923	3.5	.0020	.0064
	11:34	58.0	1.034	3.5	.0024	.0087
	11:38	55.0	1.091	3.5	.0027	.0103
	11:42	58.0	1.034	3.5	.0027	.0098
	11:46	57.5	1.043	3.5	.0027	.0098
	11:50	58.0	1.034	3.5	.0027	.0098
	11:54	57.5	1.043	3.5	.0027	.0098
	11:58	58.0	1.034	3.5	.0027	.0098
	12:02	58.0	1.034	3.5	.0027	.0098
	12:08	58.0	1.034	3.5	.0048	.0173
	12:28	58.0	1.034	3.5	.0138	.0499
	12:48	59.0	1.017	3.5	.0138	.0491
	1:18	59.0	1.017	3.5	.0138	.0491
	1:48	59.0	1.017	3.5	.0138	.0491
	2:18	59.0	1.017	3.5	.0138	.0491
	2:48	60.0	1.000	3.5	.0138	.0483
	3:18	60.0	1.000	3.5	.0138	.0483
	3:48	60.0	1.000	3.5	.0138	.0483
	4:18	59.0	1.017	3.5	.0138	.0491
	4:48	59.0	1.017	3.5	.0138	.0491
	5:18	60.0	1.000	3.5	.0138	.0483
	5:48	60.0	1.000	3.5	.0138	.0483
	6:18	60.0	1.000	3.5	.0138	.0483
	6:48	60.0	1.000	3.5	.0138	.0483
	7:18	60.0	1.000	3.5	.0138	.0483
	7:48	60.0	1.000	3.5	.0138	.0483
	8:18	60.0	1.000	3.5	.0138	.0483

WATER WELL 38

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
5/19/82	8:48	61.0	.984	3.5	.0138	.0475
	9:18	61.0	.984	3.5	.0138	.0475
	9:48	60.5	.992	3.5	.0138	.0479
	10:18	60.5	.992	3.5	.0138	.0479
	10:48	60.0	1.000	3.5	.0275	.0962
	11:48	60.3	.995	3.5	.0413	.1438
5/20/82	12:48	60.5	.992	3.5	.0275	.0955
	1:18	60.4	.993	3.5	.0138	.0480
	1:48	60.5	.992	3.5	.0138	.0479
	2:18	60.3	.995	3.5	.0138	.0480
	2:48	60.3	.995	3.5	.0138	.0480
	3:18	59.5	1.008	3.5	.0138	.0487
	3:48	59.7	1.005	3.5	.0138	.0485
	4:18	60.2	.997	3.5	.0138	.0481
	4:48	61.0	.984	3.5	.0138	.0475
	5:18	60.0	1.000	3.5	.0138	.0483
	5:48	60.5	.992	3.5	.0138	.0479
	6:18	60.0	1.000	3.5	.0138	.0483
	6:48	60.0	1.000	3.5	.0138	.0483
	7:18	60.0	1.000	3.5	.0138	.0483
	7:48	61.0	.984	3.5	.0138	.0475
	8:18	61.0	.984	3.5	.0138	.0475
	8:48	61.0	.984	3.5	.0138	.0475
	9:18	60.0	1.000	3.5	.0138	.0483
	9:48	60.0	1.000	3.5	.0138	.0483
	10:18	60.0	1.000	3.5	.0138	.0483
	10:48	60.5	.992	3.5	.0138	.0479
	11:18	60.0	1.000	3.5	.0089	.0311
	11:24	pump off				
				Weighted Average Discharge	=	2.68 gpm


MATCH POINT
t = 1.07 min.
s = .64 ft.
WEPO WELL #39
TIME DRAWDOWN TEST
T = 114.6 Q / s W(u)
= 114.6 X 2.68 X 1 / .64
= 480 gpd/ft.
S = uTt / 1.87 r2
= 1 X 480 X .000743 / 1.87 X 10,000
= 1.9 X 10-5
test conducted 5/19/82
Drawdown s (ft)
Time t (minutes)

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.)/S., R. 18 (E)/W., Sec. 16 WELL NO. 40

Personnel Cochran, Smith, Dee Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) Modified Slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type PVC Type of screen or perforation Saw slots

Interval of screen or perforation 168-182; 192-232; 257-327; 333-336; 342-360 Pump hp. & type 1/3 hp. Fairbanks Morse

Pump depth 250 ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy shale

Altitude of land surface 6590 How determined surveyed

MP Above/Below LSD N/A Altitude MP N/A

SWL from MP 67.28 How measured Pressure transducer

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
11/30/81	11:00	11:15				
			.25	110.22	108.87	.987
			.50	110.22	108.43	.983
			1.0	110.22	107.60	.976
			1.5	110.22	106.75	.968
			2.0	110.22	105.90	.960
			3.0	110.22	104.41	.947
			5.0	110.22	101.59	.921
			7.0	110.22	99.18	.900
			10.0	110.22	95.80	.869
			15.0	110.22	90.17	.818
			20.0	110.22	85.23	.773
			30.0	110.22	73.60	.668
			45.0	110.22	59.75	.542
			75.0	110.22	40.37	.366
			95.0	110.22	31.50	.286
			125.0	110.22	22.0	.199
			155.0	110.22	15.48	.140
			185.0	110.22	10.42	.094

WEPO WELL #40
MODIFIED SLUG TEST

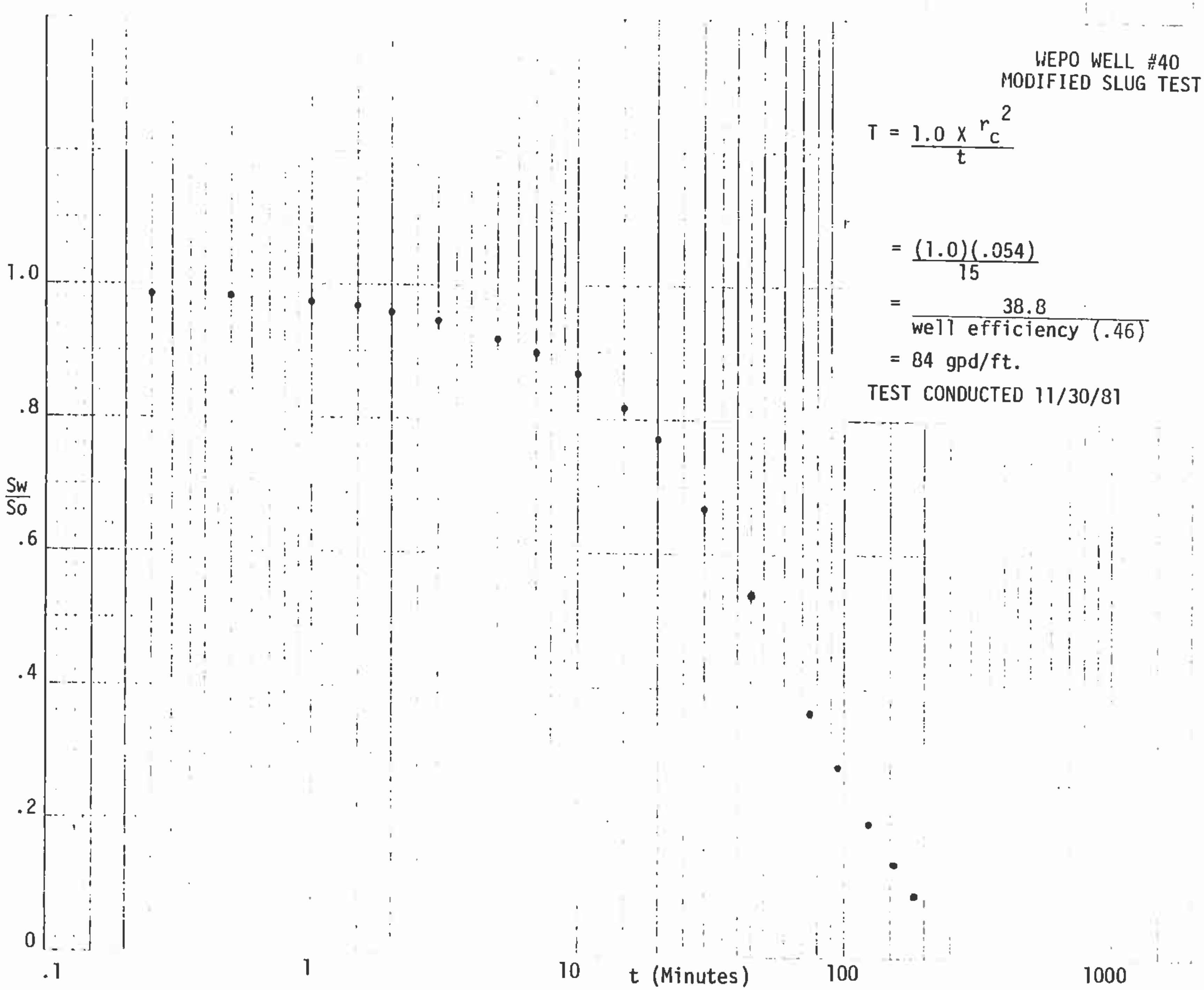
$$T = \frac{1.0 \times r_c^{2}}{t}$$

$$= \frac{(1.0)(.054)}{15}$$

$$= \frac{38.8}{\text{well efficiency } (.46)}$$

= 84 gpd/ft.

TEST CONDUCTED 11/30/81



PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 34 WELL NO. 41

Personnel Cochran, Hamilton, Dee Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) Modified Slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

asing type pvc Type of screen or perforation saw slots

Interval of screen or perforation 220-238, 244-257, 262-266, 272-279, 292-350 Pump hp. & type 1/3 hp Fairbanks Morse

Pump depth 275 ft. Aquifer wepo Aquifer lithology sandstone and sandy shale

Altitude of land surface 6780 How determined surveyed

MP Above / Below LSD Altitude MP

SWL from MP 66.46 How measured pressure transducer

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
12/4/81	11:00	11:09:30				
			.12	99.4	99.29	.998
			.25	99.4	98.98	.995
			.75	99.4	98.25	.988
			1.25	99.4	97.45	.980
			2.0	99.4	96.69	.973
			3.45	99.4	94.68	.952
			5.30	99.4	91.59	.921
			10.30	99.4	87.20	.877
			16.30	99.4	81.18	.817
			26.30	99.4	71.74	.721
			36.30	99.4	63.68	.640
			46.30	99.4	56.70	.570
			79.30	99.4	40.72	.410
			94.30	99.4	35.88	.361
			124.30	99.4	29.27	.294
			184.30	99.4	22.04	.222
			230.0	99.4	19.14	.193

WEPO WELL #41
MODIFIED SLUG TEST

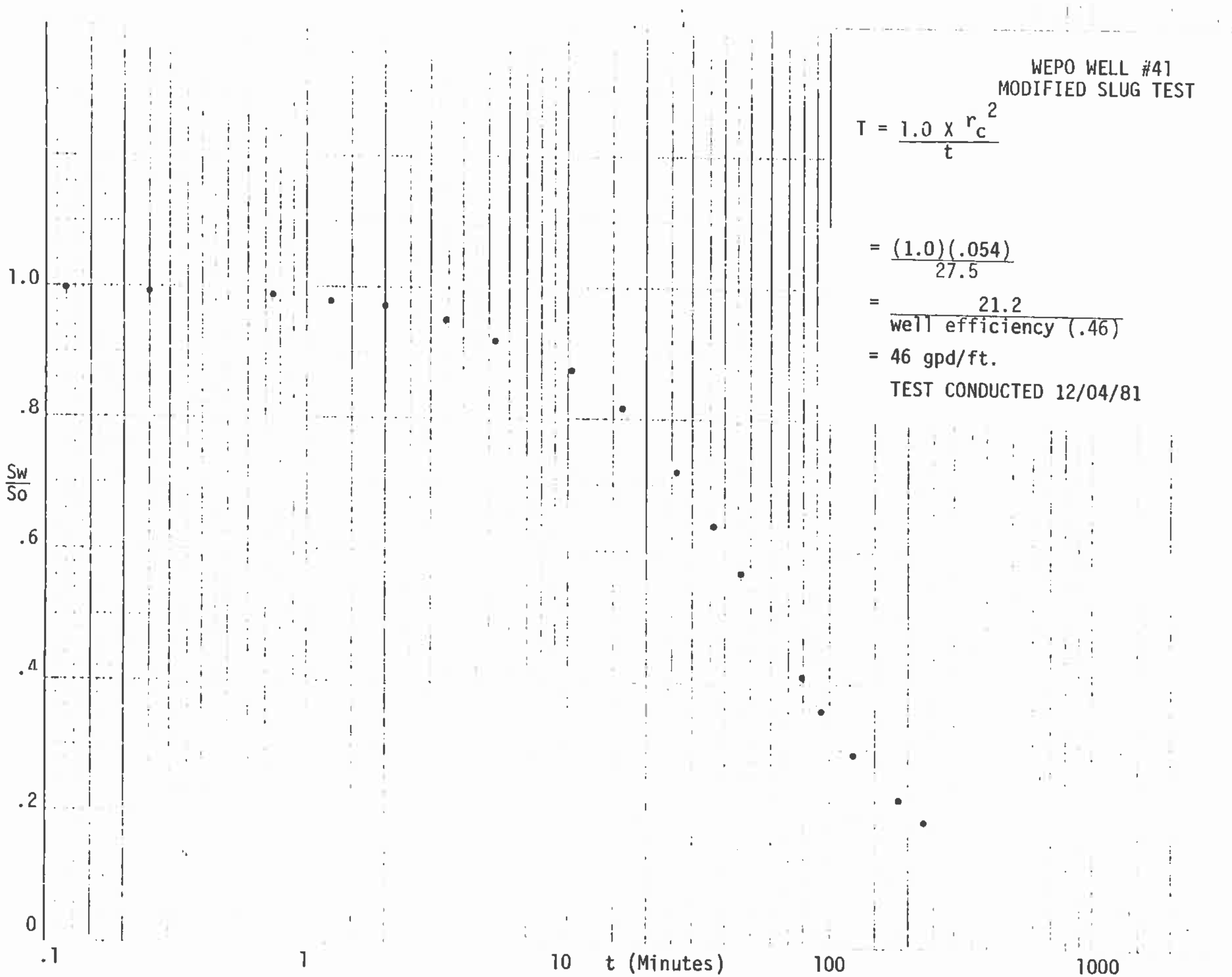
$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{27.5}$$

$$= \frac{21.2}{\text{well efficiency } (.46)}$$

$= 46$ gpd/ft.

TEST CONDUCTED 12/04/81



PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N) S., R. 18 (E) W., Sec. 11 WELL NO. 42

Personnel Cochran, Andrew Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

l well depth 203 ft. Well diameter 9 in. Casing diameter 6 in.

ng type pvc Type of screen or perforation slotted

Interval of screen or perforation 32'-52';60'-68';80'-87'; 100'-135';157'-200' Pump hp. & type 2 hp. Red Jacket

Pump depth 175 ft. Aquifer Wepo, Toreva Aquifer lithology sandstone, sandy shale

Altitude of land surface 6620.7 How determined surveyed

MP Above/Below LSD 2.65 Altitude MP 6623.35

SWL from MP 4.51 How measured (SINCO) water level indicator

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
8/5/82	7:35	4.51	pump on			
	7:35:30	11.87	.5			7.36
	7:36	17.43	1			12.92
	7:37	24.15	2			19.64
	7:38	29.18	3			24.67
	7:39	33.23	4			28.72
	7:40	36.41	5			31.90
	7:42	41.22	7			36.71
	7:45	44.76	10			40.25
	7:47	46.64	12			42.13
	7:50	48.69	15			44.18
	7:53	50.21	18			45.70
	7:55	51.02	20			46.51
	8:00	52.77	25			48.26
	8:06	54.42	31			49.91
	8:10	55.70	35			51.19
	8:15	56.56	40			52.05
	8:25	58.30	50			53.79
	8:35	59.78	60			55.27
	8:45	61.01	70			56.50
	8:55	62.19	80			57.68
	9:05	63.07	90			58.56
	9:15	64.10	100			59.59
	9:35	65.56	120			61.05
	9:55	66.84	140			62.33
	10:15	68.00	160			63.49
	10:35	69.08	180			64.57
	10:55	70.02	200			65.51

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 11 WELL NO. 42

Personnel Cochran, Andrew Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

…al well depth 203 ft. Well diameter 9 in. Casing diameter 6 in.

…ng type pvc Type of screen or perforation slotted

Interval of screen or perforation 32'-52';60'-68';80'-87'; 100'-135';157'-200' Pump hp. & type 2 hp. Red Jacket

Pump depth 175 ft. Aquifer Wepo, Toreva Aquifer lithology sandstone, sandy shale

Altitude of land surface 6620.7 How determined surveyed

MP Above/Below LSD 2.65 Altitude MP 6623.35

SWL from MP 4.51 How measured (SINCO) water level indicator

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	s, FT. RESIDUAL DRAWDOWN
8/5/82	11:15	70.99	220			66.48
	11:35	71.76	240			67.25
	11:55	72.40	260			67.89
	12:15	73.12	280			68.61
	12:35	73.71	300			69.20
	12:55	74.32	320			69.81
	1:15	74.85	340			70.34
	1:35	75.32	360			70.81
	1:55	76.55	380			72.04
	2:15	77.95	400			73.44
	2:35	79.20	420	pump off		74.69

WATER WELL 42

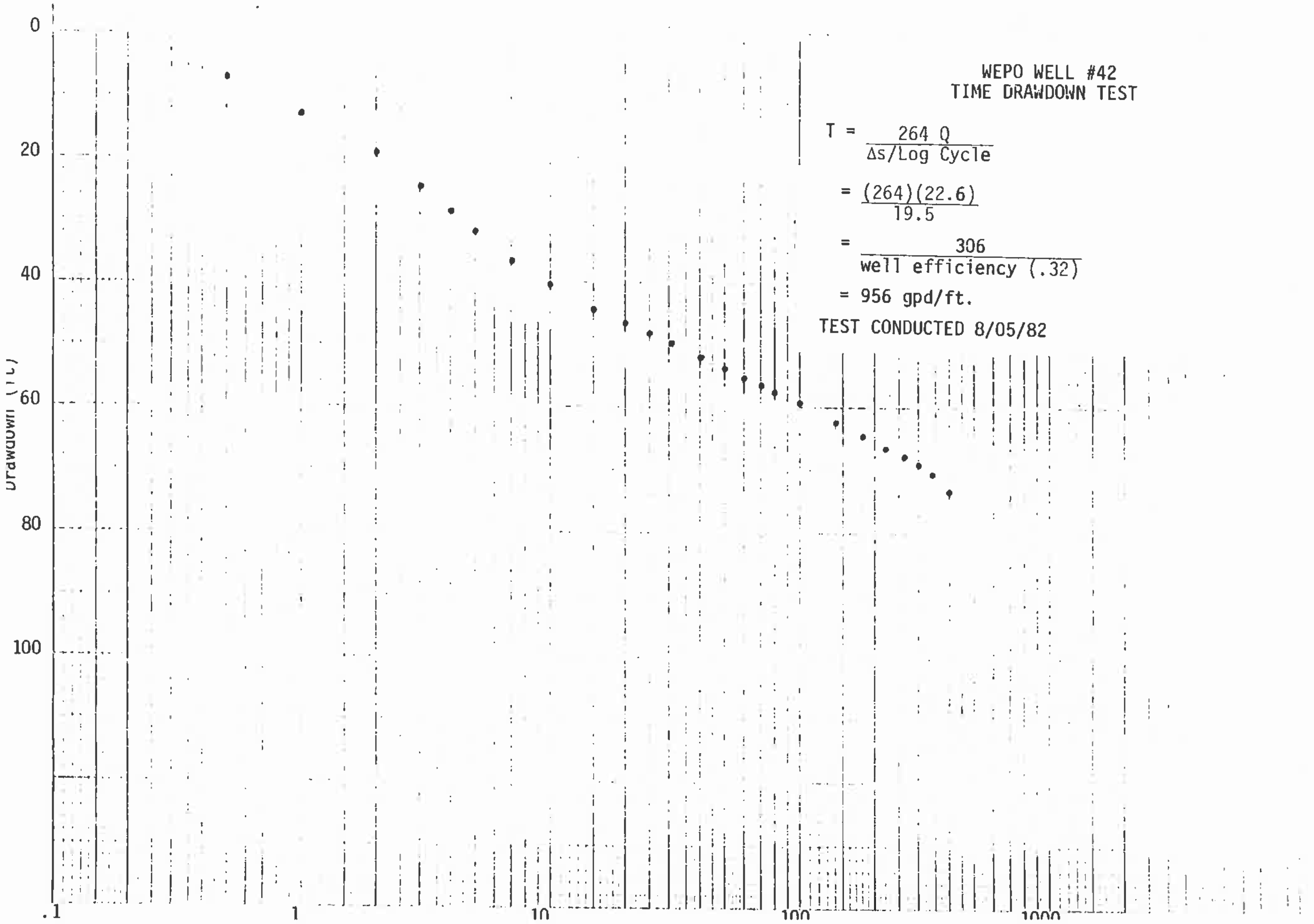
PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
8/5/82	7:35	pump on				
	7:35:30	9.47	6.336	3.0	.0036	.0684
	7:37:30	8.78	6.834	3.0	.0048	.0984
	7:39:30	9.91	6.054	3.0	.0048	.0872
	7:41:30	8.50	7.059	3.0	.0048	.1016
	7:43:30	6.95	8.633	3.0	.0042	.1088
	7:45	7.06	8.498	3.0	.0077	.1963
	7:50	6.78	8.849	3.0	.0119	.3159
	7:55	9.39	6.390	3.0	.0119	.2281
	8:00	8.00	7.500	3.0	.0178	.4005
	8:10	8.41	7.134	3.0	.0202	.4323
	8:17	9.18	6.536	3.0	.0202	.3961
	8:27	9.13	6.572	3.0	.0238	.4692
	8:37	9.80	6.122	3.0	.0238	.4371
	8:47	8.9	6.742	3.0	.0238	.4814
	8:57	7.8	7.692	3.0	.0238	.5492
	9:07	9.0	6.667	3.0	.0238	.4760
	9:17	7.9	7.594	3.0	.0357	.8133
	9:37	7.2	8.333	3.0	.0476	1.1900
	9:57	7.7	7.792	3.0	.0476	1.1127
	10:17	7.0	8.571	3.0	.0476	1.2240
	10:37	7.5	8.000	3.0	.0476	1.1424
	10:57	8.2	7.317	3.0	.0476	1.0449
	11:17	8.35	7.186	3.0	.0476	1.0262
	11:37	9.04	6.637	3.0	.0476	.9478
	11:57	8.6	6.977	3.0	.0476	.9963
	12:17	7.2	8.333	3.0	.0476	1.1900
	12:37	7.3	8.219	3.0	.0476	1.1737
	12:57	7.3	8.219	3.0	.0476	1.1737
	1:17	7.2	8.333	3.0	.0476	1.1900
	1:37	7.4	8.108	3.0	.0476	1.1578
	1:57	7.6	7.895	3.0	.0476	1.1274

WATER WELL 42

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
8/5/82	2:27	7.7	7.792	3.0	.0476	1.1127
	2:35	pump off				
		TOTAL PUMPING TIME = 420 minutes				
		WEIGHTED AVERAGE DISCHARGE				22.6 gpm



WEPO WELL #42
TIME DRAWDOWN TEST
T = 264 Q / Δs/Log Cycle
= (264)(22.6) / 19.5
= 306 / well efficiency (.32)
= 956 gpd/ft.
TEST CONDUCTED 8/05/82
Drawdown (ft)
0
20
40
60
80
100
.1
1
10
100
1000

PEABODY HYDROLOGIC TESTING — AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 21 WELL NO. 43

Personnel Cochran, Dee, Andrew Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well Recovery with obs. well (5.) Other (specify) modified slug

..l well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation horizontal saw slots

Interval of screen or perforation 195'-204', 210'-230', 237'-257', 260'-335' Pump hp. & type 2 hp., Red Jacket

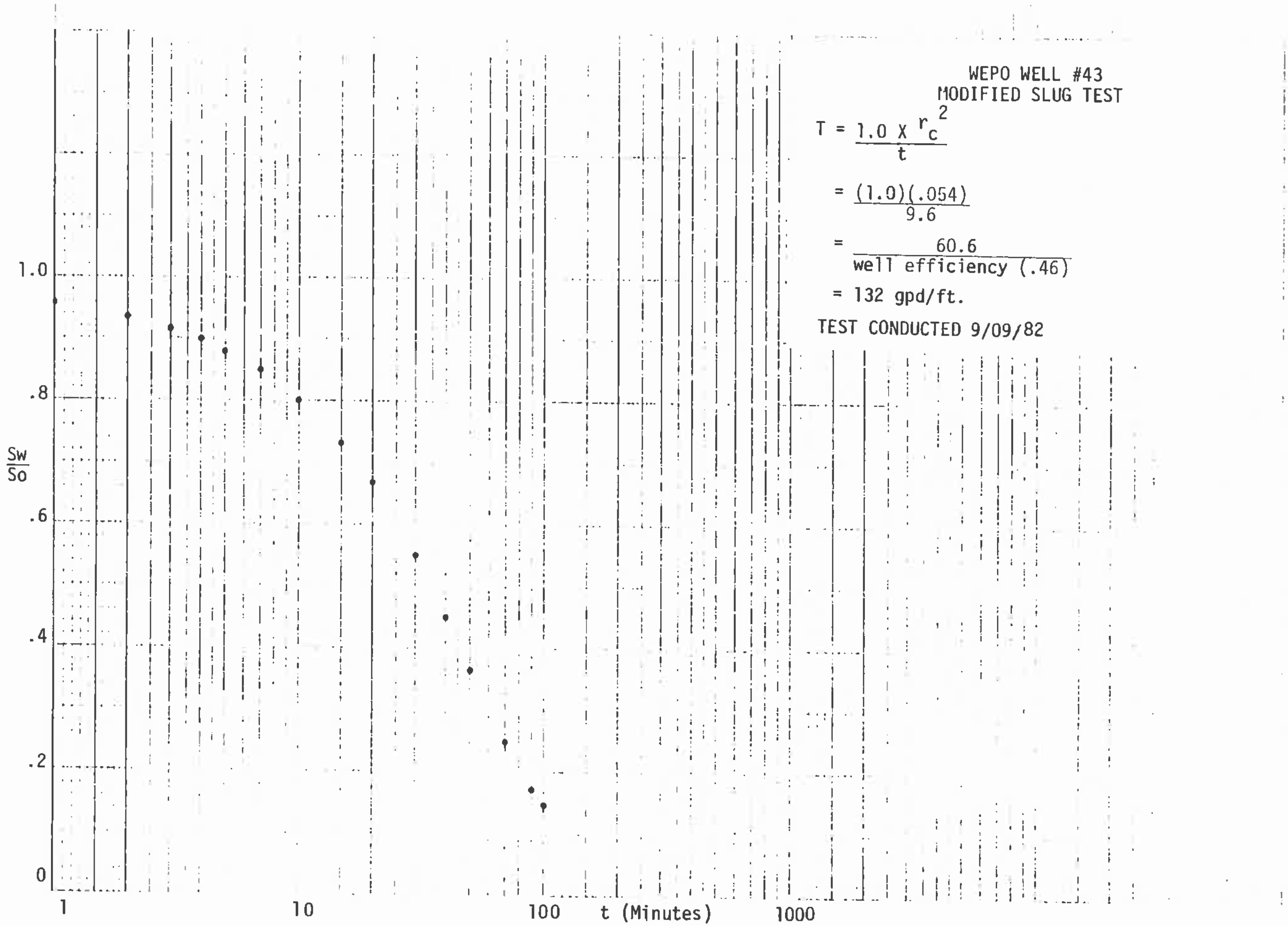
Pump depth 215 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6594.6 How determined surveyed

MP Above/Below LSD 2.70 Altitude MP 6597.30

SWL from MP 143.93 How measured water well indicator (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
9/9/82	8:00					
	8:01				13.32	
	8:02				23.07	
	8:03				32.17	
	8:04				40.47	
		8:05		48.09	48.09	1.000
		8:06	1	48.09	46.11	.959
		8:07	2	48.09	45.08	.937
		8:08	3	48.09	44.11	.917
		8:09	4	48.09	43.25	.899
		8:10	5	48.09	42.39	.881
		8:12	7	48.09	40.84	.849
		8:15	10	48.09	38.58	.802
		8:17	12	48.09	37.21	.774
		8:20	15	48.09	35.24	.733
		8:23	18	48.09	33.31	.693
		8:25	20	48.09	32.13	.668
		8:30	25	48.09	29.20	.607
		8:35	30	48.09	26.50	.551
		8:40	35	48.09	23.94	.498
		8:45	40	48.09	21.67	.451
		8:55	50	48.09	17.65	.367
		9:05	60	48.09	14.32	.298
		9:15	70	48.09	11.96	.249
		9:25	80	48.09	10.00	.208
		9:35	90	48.09	8.40	.175
		9:45	100	48.09	7.07	.147

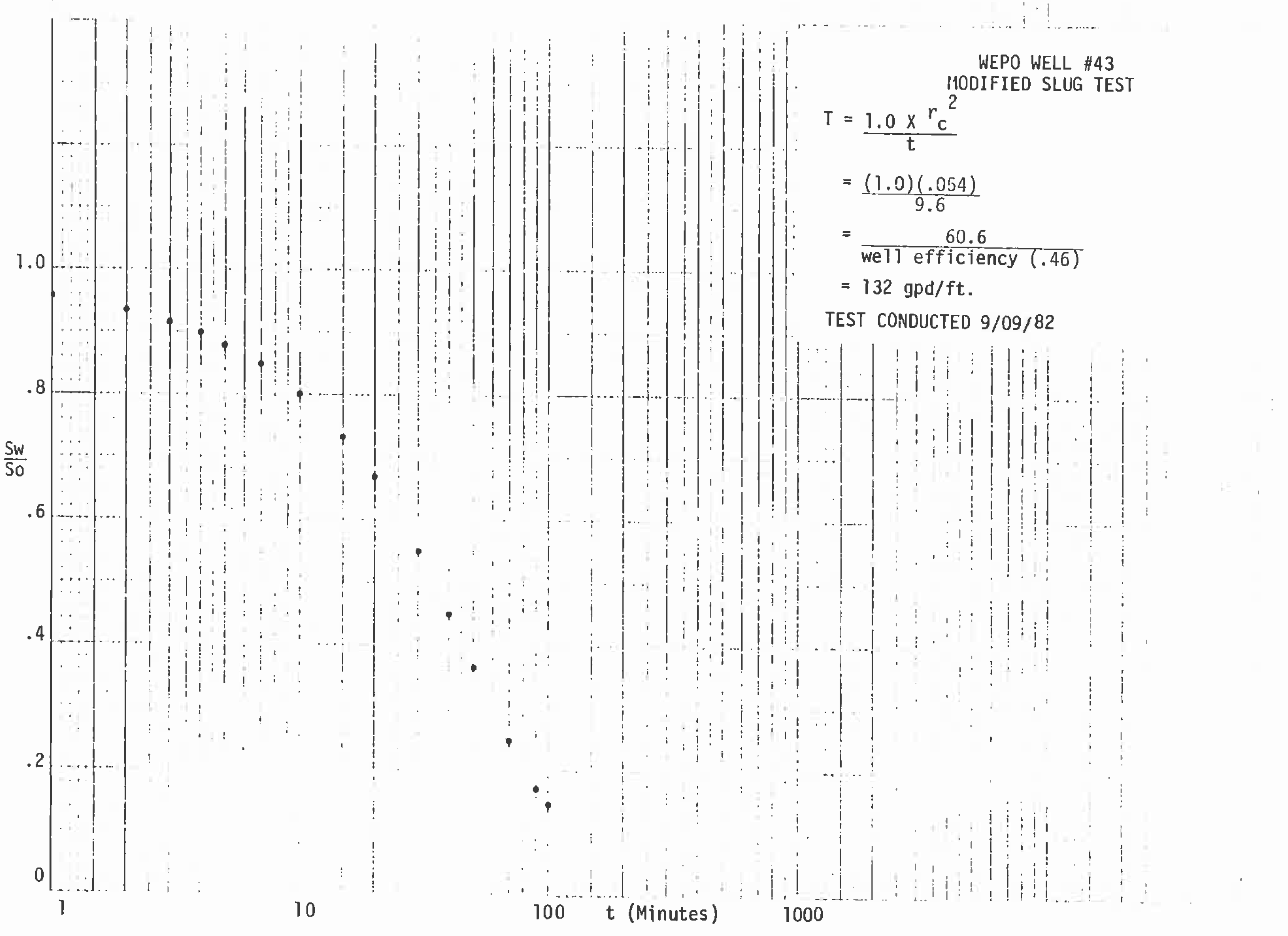


WEPO WELL #43
MODIFIED SLUG TEST
T = 1.0 X r_c^2 / t
= (1.0)(.054) / 9.6
= 60.6 / well efficiency (.46)
= 132 gpd/ft.
TEST CONDUCTED 9/09/82
Sw/So
1.0
.8
.6
.4
.2
0
1
10
100
1000
t (Minutes)

WATER WELL 43

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
9/9/82						
	8:00	10.24	5.859	3.0	.100	1.758
	8:01	11.47	5.231	3.0	.200	3.139
	8:02	10.89	5.509	3.0	.200	3.305
	8:03	10.96	5.474	3.0	.200	3.284
	8:04	10.89	5.509	3.0	.300	4.958
	8:05	pump off				
				TOTAL	=	16.444
			WEIGHTED AVERAGE DISCHARGE		=	16.4 gpm



WEPO WELL #43
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{9.6}$$

$$= \frac{60.6}{\text{well efficiency } (.46)}$$

$$= 132 \text{ gpd/ft.}$$

TEST CONDUCTED 9/09/82

PEABODY HYDROLOGIC TESTING — AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 27 WELL NO. 44

Personnel Cochran, Smith Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well 5. Other (specify) slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation saw slots

Interval of screen or perforation 282-350 Pump hp. & type 1/3 hp Fairbanks Morse

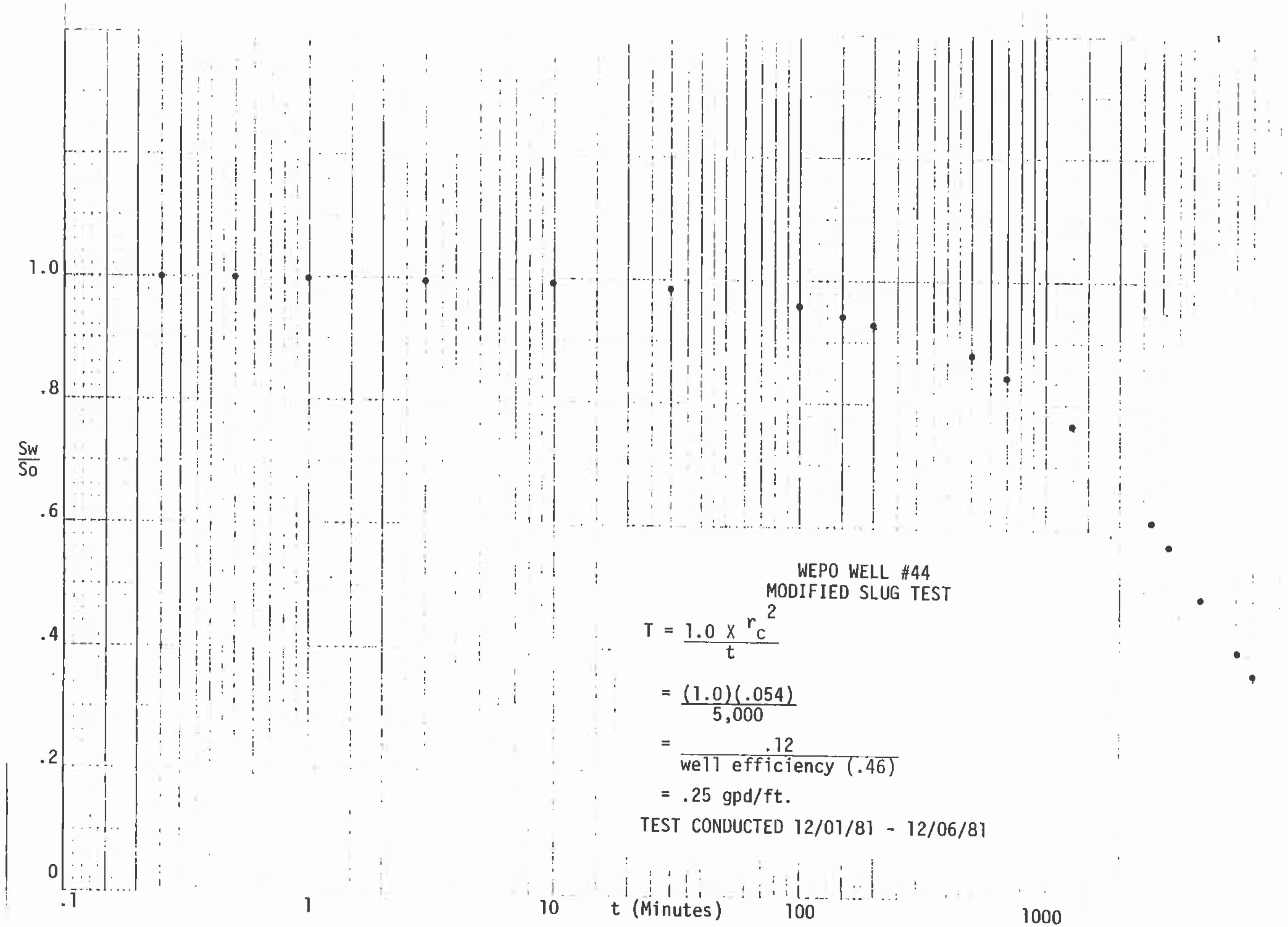
Pump depth 275 ft. Aquifer Wepo Aquifer lithology sandstone and sandy shale

Altitude of land surface 6550 How determined surveyed

MP Above/Below LSD Altitude MP

SWL from MP 161.73 How measured pressure transducer

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
12/1/81	10:17	11:04				
			.25	60.15	60.13	.999
			.50	60.15	60.10	.999
			1.00	60.15	60.06	.998
			3.00	60.15	59.97	.997
			10.00	60.15	59.74	.993
			30.00	60.15	59.32	.986
			100.00	60.15	57.62	.958
			150.00	60.15	56.70	.942
			200.00	60.15	55.85	.928
			500.00	60.15	52.90	.879
			695.00	60.15	50.73	.843
12/2/81			1280.00	60.15	45.93	.764
			1455.00	60.15	45.51	.756
12/3/81			2720.00	60.15	36.62	.609
			3140.00	60.15	34.52	.574
12/4/81			4300.00	60.15	29.54	.491
12/5/81			6070.00	60.15	24.32	.404
12/6/81			7025.00	60.15	22.11	.367



WEPO WELL #44
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{5{,}000}$$

$$= \frac{.12}{\text{well efficiency } (.46)}$$

$$= .25 \text{ gpd/ft.}$$

TEST CONDUCTED 12/01/81 - 12/06/81

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 33 WELL NO. 45

Personnel Cochran,Hamilton Driller Elliott

t type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well Recovery with obs. well (5.) Other (specify) Modified Slug

Total well depth 341 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation Vertical Slotted

Interval of screen or perforation 130'-170'; 190'-330' Pump hp. & type 2hp., Red Jacket

Pump depth 208.65ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy Shale

Altitude of land surface 6519.00 How determined Surveyed

MP Above/Below LSD n/a Altitude MP n/a

SWL from MP 92.38 How measured Pressure transducer (SINCO)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
10/5/82	8:40					
		8:43		42.02	42.02	1.000
		8:44	1	42.02	40.68	.968
		8:45	2	42.02	39.98	.951
		8:46	3	42.02	39.61	.943
		8:47	4	42.02	39.34	.936
		8:48	5	42.02	39.11	.931
		8:50	7	42.02	38.76	.922
		8:53	10	42.02	38.07	.906
		8:55	12	42.02	37.81	.900
		8:58	15	42.02	37.63	.895
		9:01	18	42.02	37.12	.883
		9:03	20	42.02	36.93	.879
		9:08	25	42.02	36.42	.867
		9:13	30	42.02	35.94	.855
		9:18	35	42.02	35.52	.845
		9:28	45	42.02	34.65	.825
		9:33	50	42.02	34.21	.814
		9:43	60	42.02	33.35	.794
		9:53	70	42.02	32.56	.775
		9:58	75	42.02	32.15	.765
		10:08	85	42.02	31.39	.747
		10:13	90	42.02	31.02	.738
		10:23	100	42.02	30.28	.721
		10:43	120	42.02	28.87	.687
		11:13	150	42.02	26.91	.640
		11:43	180	42.02	25.04	.596
		12:03	200	42.02	23.86	.568

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 33 WELL NO. 45

Personnel Cochran, Hamilton Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well (5.) Other (specify) Modified Slug

Total well depth 341 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation Vertical Slotted

Interval of screen or perforation 130'-170', 190'-330' Pump hp. & type 2hp..Red Jacket

Pump depth 208.65ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy Shale

Altitude of land surface 6519.00 How determined Surveyed

MP Above/Below LSD n/a Altitude MP n/a

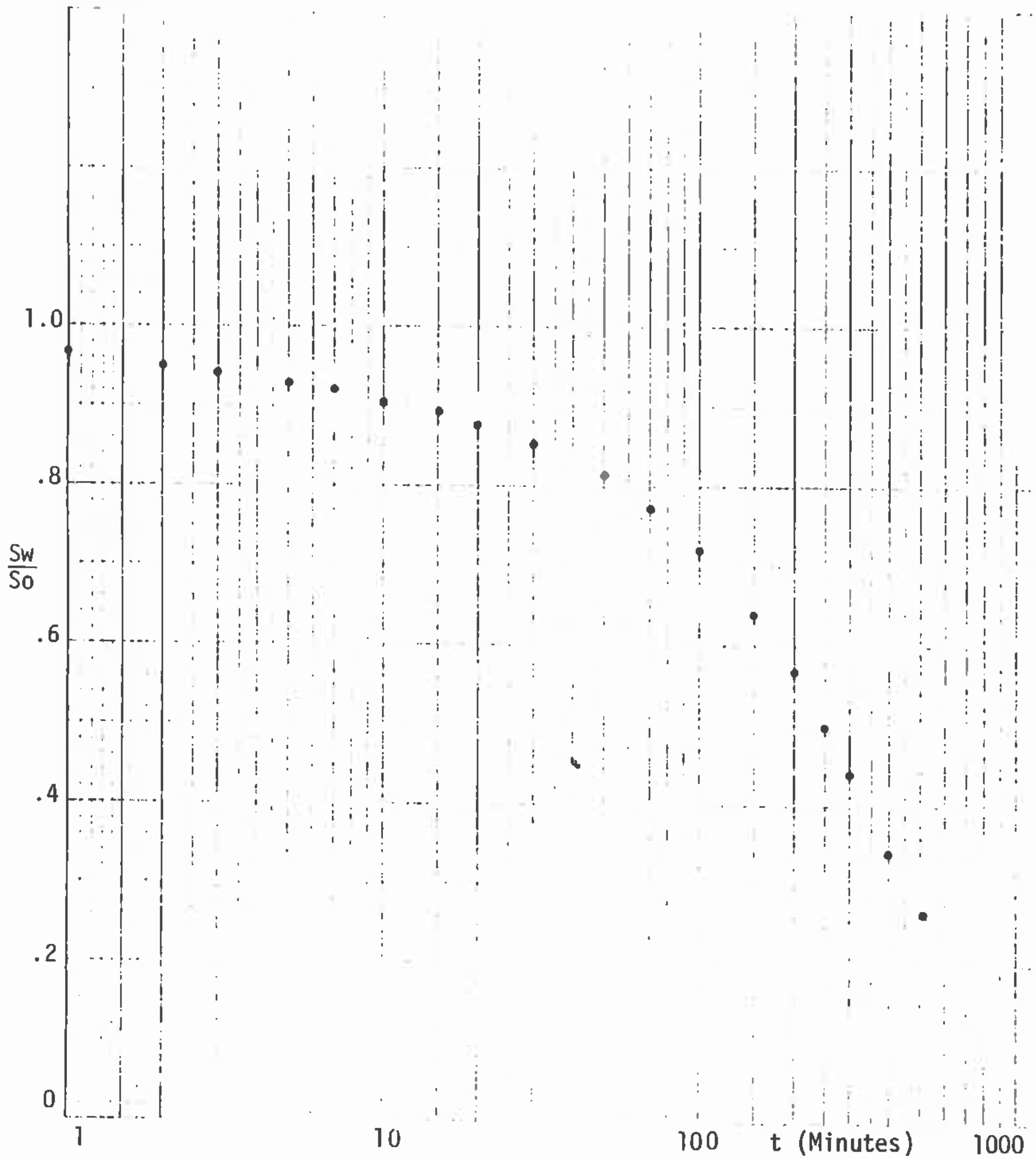
SWL from MP 92.38 How measured Pressure Transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
10/5/82		12:53	250	42.02	21.02	.500
		1:43	300	42.02	18.48	.440
		2:33	350	42.02	16.26	.387
		3:23	400	42.02	14.39	.342
		4:13	450	42.02	12.79	.304
		5:13	510	42.02	11.15	.265

WATER WELL 45

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
10/5/82	8:40	pump on				
	8:40	9.6	6.25	3.0	.1666	3.1237
	8:41	9.6	6.25	3.0	.3333	6.2494
	8:42	9.6	6.25	3.0	.5000	9.3750
	8:43	pump off				
			TOTAL PUMPING TIME = 3 minutes			
					TOTAL =	18.7481
			WEIGHTED AVERAGE DISCHARGE		=	18.75 gpm



WEPO WELL #45
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)\ (.054)}{110}$$

$$= \frac{5.3}{\text{well efficiency } (.46)}$$

= 11.5 gpd/ft.

TEST CONDUCTED 10/05/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 10 WELL NO. 46

Personnel Hamilton, Cochran Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

Total well depth 360 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slots

Interval of screen or perforation 155-160, 185-177, 180-187, 190-195, 197, 260 Pump hp. & type 2 hp., Red Jacket

Pump depth 215.24 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6444.4 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

SWL from MP 156.17 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
10/11/81	8:45:01					
		8:48:00		13.73	13.73	1.000
		8:48:30	.5	13.73	13.45	.979
		8:49:00	1	13.73	13.25	.965
		8:50:00	2	13.73	12.97	.945
		8:51:01	3	13.73	12.66	.922
		8:52:01	4	13.73	12.43	.905
		8:53:01	5	13.73	12.23	.891
		8:54:01	6	13.73	12.04	.877
		8:55:01	7	13.73	11.86	.864
		8:56:01	8	13.73	11.72	.854
		8:57:01	9	13.73	11.56	.842
		8:58:01	10	13.73	11.42	.832
		9:03:01	15	13.73	10.75	.783
		9:08:01	20	13.73	10.15	.740
		9:13:01	25	13.73	9.62	.701
		9:18:01	30	13.73	9.11	.663
		9:23:01	35	13.73	8.65	.630
		9:28:01	40	13.73	8.23	.599
		9:33:01	45	13.73	7.84	.571
		9:38:01	50	13.73	7.47	.544
		9:48:01	60	13.73	6.82	.497
		9:58:01	70	13.73	6.22	.453
		10:08:01	80	13.73	5.69	.414
		10:18:01	90	13.73	5.20	.379
		10:28:01	100	13.73	4.77	.347
		10:48:01	120	13.73	4.00	.291
		11:18:01	150	13.73	3.14	.229

PEABODY HYDROLOGIC TESTING — AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 10 WELL NO. 46

Personnel Hamilton, Cochran Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well (5.) Other (specify) modified slug

Total well depth 360 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slots

Interval of screen or perforation 155-160, 165-177, 180-187, 190-195, 197-260 Pump hp. & type 2 hp., Red Jacket

Pump depth 215.24 ft. Aquifer Wepo Aquifer lithology Sandstone, sandy shale

Altitude of land surface 6444.4 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

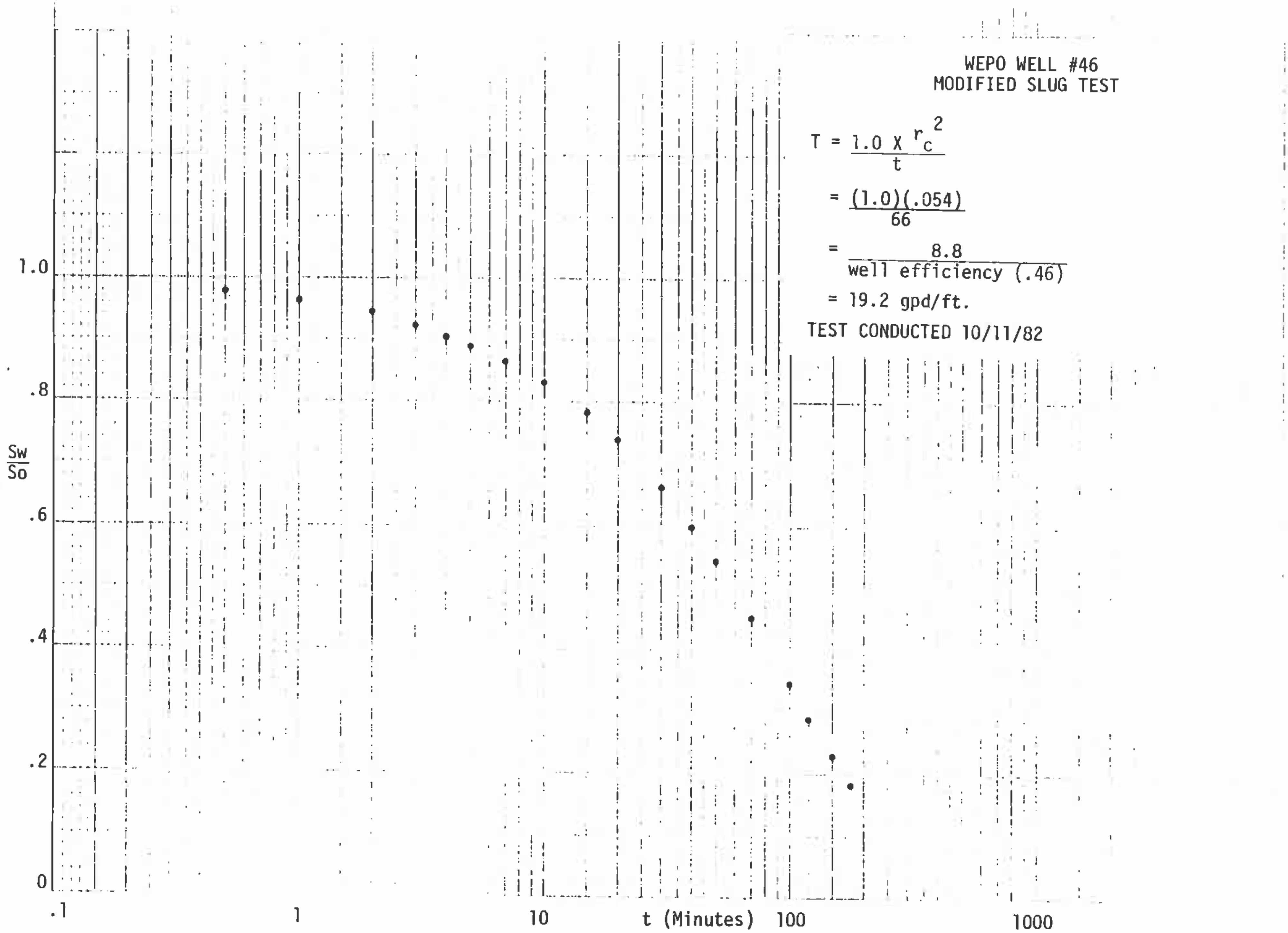
SWL from MP 156.17 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
10/11/82		11:48:01	180	13.73	2.50	.182

WATER WELL 46

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
10/11/82	8:45	11	5:45	3.0	.1666	2.724
	8:46	11	5.45	3.0	.3333	5.449
	8:47	11	5.45	3.0	.5000	8.175
	8:48	pump off			TOTAL=	16.348
			WEIGHTED AVERAGE DISCHARGE		=	16.3


WEPO WELL #46
MODIFIED SLUG TEST
T = 1.0 X r_c^2 / t
= (1.0)(.054) / 66
= 8.8 / well efficiency (.46)
= 19.2 gpd/ft.
TEST CONDUCTED 10/11/82
Sw/So
1.0
.8
.6
.4
.2
0
.1
1
10
t (Minutes)
100
1000

WATER WELL 47

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
3/23/82	9:55	22.1	2.71	3.7	.0034	.0341
	10:00	21.8	2.75	3.7	.0024	.0244
	10:05	22.5	2.67	3.7	.0024	.0237
	10:10	22.2	2.70	3.7	.0048	.0479
	10:25	21.9	2.74	3.7	.0053	.0537
	10:32	22.3	2.69	3.7	.0043	.0428
	10:42	22.8	2.63	3.7	.0048	.0467
	10:52	22.4	2.68	3.7	.0048	.0476
	11:02	22.3	2.69	3.7	.0048	.0478
	11:12	22.4	2.68	3.7	.0048	.0476
	11:22	22.4	2.68	3.7	.0048	.0476
	11:32	22.5	2.67	3.7	.0048	.0474
	11:42	22.3	2.69	3.7	.0048	.0473
	11:52	22.2	2.70	3.7	.0048	.0479
	12:02	22.3	2.69	3.7	.0048	.0478
	12:12	22.5	2.67	3.7	.0048	.0474
	12:22	22.5	2.67	3.7	.0048	.0474
	12:32	22.6	2.65	3.7	.0048	.0470
	12:42	22.5	2.67	3.7	.0048	.0474
	12:52	22.6	2.65	3.7	.0048	.0470
	1:02	22.8	2.63	3.7	.0048	.0467
	1:12	22.7	2.64	3.7	.0048	.0469
	1:22	22.7	2.64	3.7	.0048	.0469
	1:32	26.0	2.31	3.7	.0096	.0821
	1:52	26.0	2.31	3.7	.0096	.0821
	2:12	26.0	2.31	3.7	.0096	.0821
	2:32	26.0	2.31	3.7	.0096	.0821
	2:52	26.0	2.31	3.7	.0096	.0821
	3:12	26.0	2.31	3.7	.0096	.0821
	3:32	26.0	2.31	3.7	.0096	.0821
	3:52	26.0	2.31	3.7	.0096	.0821
	4:12	26.0	2.31	3.7	.0096	.0821

WATER WELL 47

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
3/23/82	4:32	26.0	2.31	3.7	.0096	.0821
	4:52	26.0	2.31	3.7	.0096	.0821
	5:12	26.0	2.31	3.7	.0096	.0821
	5:32	26.0	2.31	3.7	.0096	.0821
	5:52	26.0	2.31	3.7	.0096	.0821
	6:12	26.0	2.31	3.7	.0096	.0821
	6:32	23.0	2.61	3.7	.0096	.0927
	6:52	23.2	2.59	3.7	.0144	.1380
	7:22	23.3	2.57	3.7	.0144	.1369
	7:52	23.3	2.58	3.7	.0144	.1375
	8:22	23.4	2.56	3.7	.0144	.1364
	8:52	23.5	2.55	3.7	.0144	.1359
	9:22	22.8	2.63	3.7	.0144	.1401
	9:52	22.9	2.62	3.7	.0144	.1396
	10:22	23.2	2.59	3.7	.0144	.1379
	10:52	23.0	2.61	3.7	.0144	.1391
	11:22	23.0	2.61	3.7	.0144	.1391
	11:52	23.1	2.59	3.7	.0144	.1379
3/24/82	12:22	23.3	2.58	3.7	.0144	.1375
	12:52	23.4	2.56	3.7	.0144	.1364
	1:22	23.7	2.53	3.7	.0144	.1348
	1:52	23.6	2.54	3.7	.0144	.1353
	2:22	23.9	2.51	3.7	.0144	.1337
	2:52	23.8	2.52	3.7	.0144	.1343
	3:27	23.8	2.52	3.7	.0144	.1343
	3:52	23.9	2.51	3.7	.0144	.1337
	4:27	24.0	2.50	3.7	.0144	.1332
	4:52	23.7	2.53	3.7	.0144	.1348
	5:27	23.6	2.54	3.7	.0144	.1353
	5:52	23.5	2.55	3.7	.0144	.1359
	6:27	23.6	2.54	3.7	.0144	.1353
	6:52	23.7	2.53	3.7	.0144	.1348

WATER WELL 47

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
3/24/82	7:27	23.8	2.52	3.7	.0144	.1343
	7:52	23.7	2.53	3.7	.0144	.1348
	8:27	23.9	2.51	3.7	.0144	.1337
	8:52	23.7	2.53	3.7	.0144	.1348
	9:22	23.6	2.54	3.7	.0144	.1353
	9:52	23.6	2.54	3.7	.0193	.1814
	10:42	25.0	2.40	3.7	.0241	.2140
	11:32	24.7	2.43	3.7	.0241	.2167
	12:22	25.5	2.35	3.7	.0217	.1887
	1:02	24.5	2.45	3.7	.0169	.1532
	1:32	24.7	2.43	3.7	.0217	.1951
	2:32	24.9	2.41	3.7	.0217	.1935
	3:02	24.8	2.42	3.7	.0144	.1289
	3:32	24.8	2.42	3.7	.0144	.1289
	4:02	25.0	2.40	3.7	.0217	.1927
	5:02	25.2	2.38	3.7	.0289	.2545
	6:02	25.7	2.33	3.7	.0289	.2491
	7:02	26.1	2.30	3.7	.0217	.1847
	7:32	25.8	2.33	3.7	.0144	.1241
	8:02	25.9	2.32	3.7	.0144	.1236
	8:30	26.1	2.30	3.7	.0077	.0655
	8:31	pump,off				
					TOTAL	
					WEIGHTED	
					AVERAGE	
					DISCHARGE	9.23 G.P.M.

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) ~~S.~~, R. 18 (E.) ~~W.~~, Sec. 33 WELL NO. 48

Personnel Cochran, Dee, Hamilton Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery (3) Drawdown with obs. well
4. Recovery with obs. well 5. Other (specify)

-l well depth 220 ft. Well diameter 9 in. Casing diameter 6 in.

-ng type pvc Type of screen or perforation saw slotted

Interval of screen or perforation 40-75, 85-120, 125-145, 172-220 Pump hp. & type 1/3 hp. Fairbanks Mor

Pump depth 125 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6309.4 How determined surveyed

MP Above/Below LSD .23 Altitude MP 6309.63

SWL from MP 28.17 How measured water level indicator

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
3/23/82	9:50	28.17	0			
	9:53	28.19	3			.01
	9:58	28.24	8			.07
	10:03	28.30	13			.13
	10:08	28.52	18			.35
	10:13	28.80	23			.63
	10:18	29.07	28			.90
	10:23	29.29	33			1.12
	10:28	29.51	38			1.34
	10:33	29.72	43			1.55
	10:38	29.92	48			1.75
	10:43	30.11	53			1.94
	10:48	30.29	58			2.12
	10:53	30.47	63			2.30
	10:58	30.65	68			2.48
	11:03	30.82	73			2.65
	11:08	30.99	78			2.82
	11:13	31.15	83			2.98
	11:18	31.33	88			3.16
	11:23	31.48	93			3.31
	11:28	31.64	98			3.47
	11:33	31.80	103			3.63
	11:38	31.96	108			3.79
	11:43	32.10	113			3.93
	11:48	32.25	118			4.08
	11:58	32.55	128			4.38
	12:08	32.83	138			4.66
	12:18	33.10	148			4.93

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 33 WELL NO. 48

Personnel Cochran, Dee, Hamilton Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery (3) Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

ıl well depth 220 ft. Well diameter 9 in. Casing diameter 6 in.

ıng type pvc Type of screen or perforation saw slotted

Interval of screen or perforation 40-75,85-120,125-145, 172-220 Pump hp. & type 1/3 hp. Fairbanks Mors

Pump depth 125 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6309.4 How determined surveyed

MP Above/Below LSD .23 Altitude MP 6309.63

SWL from MP 28.17 How measured water level indicator

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
3/23/82	12:28	33.38	158			5.21
	12:38	33.64	168			5.47
	12:48	33.90	178			5.73
	12:58	34.16	188			5.99
	1:08	34.41	198			6.24
	1:18	34.66	208			6.49
	1:28	34.90	218			6.73
	1:38	35.13	228			6.96
	1:48	35.35	238			7.18
	1:58	35.59	248			7.42
	2:08	35.83	258			7.66
	2:18	36.03	268			7.86
	2:28	36.24	278			8.07
	2:38	36.46	288			8.29
	2:48	36.67	298			8.50
	3:38	37.64	348			9.47
	4:28	38.56	398			10.39
	5:18	39.44	448			11.27
	6:08	40.25	498			12.08
	6:58	40.93	548			12.76
	7:48	41.79	598			13.62
	8:38	42.44	648			14.27
	9:28	43.11	698			14.94
	10:20	43.53	750			15.36
	11:10	44.08	800			15.91
'24/82	1:10	45.18	920			17.01
	3:30	46.29	1,060			18.12
	5:15	46.99	1,165			18.82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 33 WELL NO. 48

Personnel Cochran, Dee, Hamilton Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery (3.) Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

well depth 220 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation saw slots

Interval of screen or perforation 40-75,85-120,125-145, 172-220 Pump hp. & type 1/3 hp. Fairbanks Mor

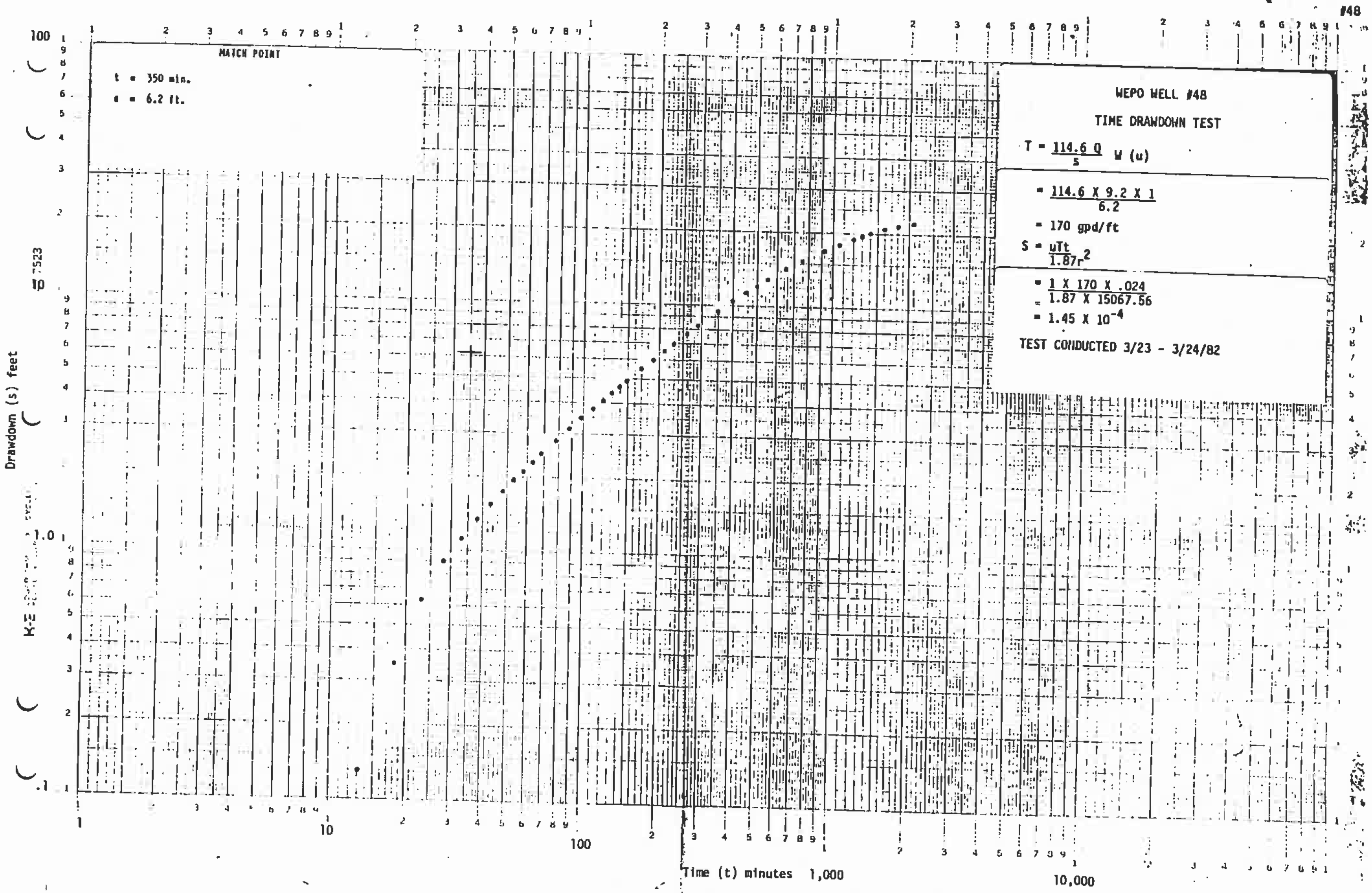
Pump depth 125 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6309.4 How determined surveyed

MP Above/Below LSD .23 Altitude MP 6309.63

SWL from MP 28.17 How measured water level indicator

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t^1, MIN.	t/t^1	S, FT. RESIDUAL DRAWDOWN
3/24/82	5:50	47.20	1,200			19.03
	7:30	47.76	1,300			19.59
	9:10	48.33	1,400			20.16
	10:00	49.05	1,450			20.88
	12:30	49.20	1,600			21.03
	3:50	49.81	1,800			21.64
	7:50	50.26	2,040			22.09
	8:31	50.35	2,081			22.18
mp off	8:31		2,081			



#48
MATCH POINT
t = 350 min.
s = 6.2 ft.
WEPO WELL #48
TIME DRAWDOWN TEST
T = 114.6 Q / s W (u)
= 114.6 X 9.2 X 1 / 6.2
= 170 gpd/ft
S = uTt / 1.87r2
= 1 X 170 X .024 / 1.87 X 15067.56
= 1.45 X 10-4
TEST CONDUCTED 3/23 - 3/24/82
Drawdown (s) feet
Time (t) minutes
1
10
100
1,000
10,000
.1
1.0
10
100

PEABODY HYDROLOGIC TESTING — AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 19 (E.) W., Sec. 21 WELL NO. 49

Personnel Burke Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4 Recovery with obs. well 5. Other (specify)

ıl well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

ing type P.V.C. Type of screen or perforation Horizontal saw slots

Interval of screen or perforation Zones from 8' - 350' Pump hp. & type 3/4 hp Jacuzzi

Pump depth 150 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface How determined

MP (Above) Below LSD .84 Altitude MP

SWL from MP 5.93' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
08/28/80	09:39:00	5.93	OFF			
	10:26:00	8.31	After pump setting			
	10:30:00	8.31	ON			2.38
	10:31:30	10.97	1.5			5.04
	10:32:00	13.73	2.0			7.80
	10:32:30	14.90	2.5			8.97
	10:33:00	16.01	3.0			10.08
	10:33:30	16.77	3.5			10.84
	10:34:00	18.01	4.0			12.08
	10:34:30	18.85	4.5			12.92
	10:35:00	19.20	5.0			13.27
	10:35:30	19.90	5.5			13.97
	10:36:00	20.55	6.0			14.62
	10:37:30	22.30	7.5			16.37
	10:38:00	22.91	8.0			16.98
	10:38:30	23.15	8.5			17.22
	10:39:00	23.85	9.0			17.92
	10:40:00	24.60	10.0			18.67
	10:41:30	25.55	11.5			19.62
	10:42:00	25.86	12.0			19.93
	10:43:00	26.56	13.0			20.63
	10:44:00	26.90	14.0			20.97
	10:45:30	27.67	15.5			21.74
	10:47:00	27.92	17.0			21.99
	10:51:00	29.00	21.0			23.07
	10:52:00	29.22	22.0			23.29
	10:55:00	29.88	25.0			23.95
	10:58:00	29.98	28.0			24.05

PEABODY HYDROLOGIC TESTING   AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 19 (E.) W., Sec. 21 WELL NO. 49

Personnel Burke Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
' Recovery with obs. well 5. Other (specify)

al well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

.sing type P.V.C. Type of screen or perforation Horizontal saw slots

Interval of screen or perforation Zones from 8' - 350' Pump hp. & type 3/4 hp Jacuzzi

Pump depth 150 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface How determined

MP (Above) Below LSD .84 Altitude MP

SWL from MP 5.93' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t^1, MIN.	t/t^1	S_1 FT. RESIDUAL DRAWDOWN
08/28/80	11:00:00	30.00	30.0			24.07
	11:05:00	30.80	35.0			24.87
	11:10:00	30.92	40.0			24.99
	11:15:00	31.15	45.0			25.22
	11:20:00	31.41	50.0			25.48
	11:32:00	31.92	62.0			25.99
	11:36:00	Test shut down -- Galvanometer Broken				

WATER WELL 49

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
8/28/80	10:36:30	26.5	2.26	3.7	.136	1.137
	10:41	26.5	2.26	3.7	.053	.443
	10:44:30	26.0	2.31	3.7	.091	.778
	10:52:30	26.5	2.26	3.7	.083	.694
	10:57	26.5	2.26	3.7	.061	.510
	11:01	26.0	2.31	3.7	.091	.778
	11:09	26.0	2.31	3.7	.121	1.034
	11:16	26.0	2.31	3.7	.364	3.111
	TEST ENDED AT 66 MINUTES					
				WEIGHTED AVERAGE DISCHARGE 8.49gpm		

WEPO WELL #49
TIME DRAWDOWN TEST

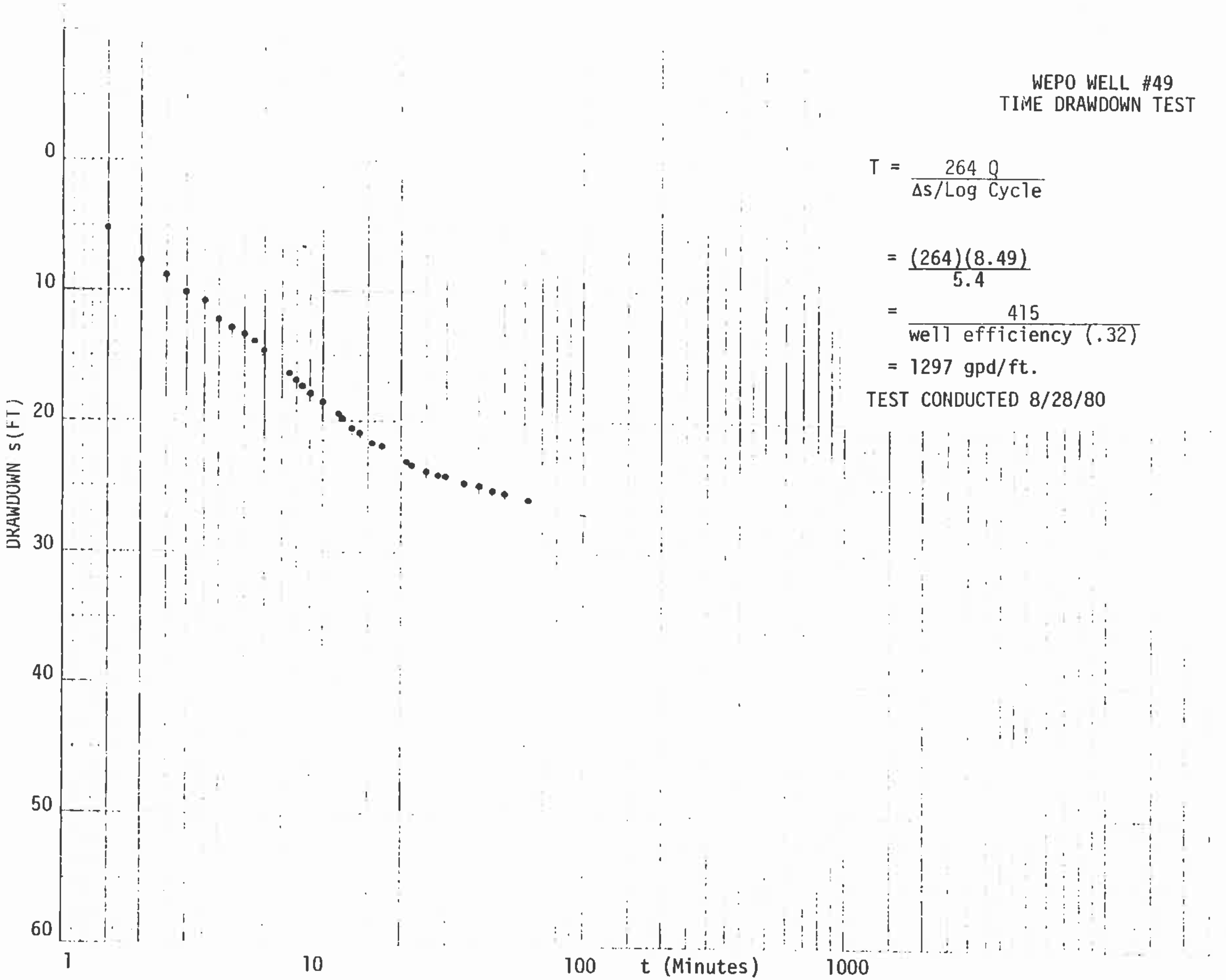
$$T = \frac{264\ Q}{\Delta s/\text{Log Cycle}}$$

$$= \frac{(264)(8.49)}{5.4}$$

$$= \frac{415}{\text{well efficiency } (.32)}$$

$$= 1297 \text{ gpd/ft.}$$

TEST CONDUCTED 8/28/80



PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 5 WELL NO. 51

Personnel Burke Driller Been

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well 5. Other (specify)

al well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

Casing type P.V.C. Type of screen or perforation Horizontal saw slots

Interval of screen or perforation 250' - 350' Pump hp. & type 3/4 hp Fairbanks/Moor

Pump depth 140 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface 6701.0 How determined Surveyed

MP (Above) Below LSD 0.66' Altitude MP 6701.7'

SWL from MP 43.65' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
09/27/80	09:00:00	43.65	ON	ON		
	09:00:30	47.87	30 Sec.			4.22
	09:02:00	55.75	2.0 Min			12.10
	09:03:00	58.68	3.0			15.03
	09:03:30	60.55	3.5			16.90
	09:04:00	61.93	4.0			18.28
	09:04:30	63.41	4.5			19.76
	09:05:00	64.90	5.0			21.25
	09:05:30	66.06	5.5			22.41
	09:06:00	67.24	6.0			23.59
	09:06:30	68.33	6.5			24.68
	09:07:00	69.40	7.0			25.75
	09:07:30	70.29	7.5			26.64
	09:08:00	71.24	8.0			27.59
	09:08:30	72.05	8.5			28.40
	09:09:00	72.86	9.0			29.21
	09:09:30	73.70	9.5			30.05
	09:10:00	74.42	10.0			30.77
	09:11:00	75.78	11.0			32.13
	09:12:00	76.88	12.0			33.23
	09:13:00	77.94	13.0			34.29
	09:14:00	78.98	14.0			35.33
	09:15:00	79.85	15.0			36.20
	09:17:00	81.48	17.0			37.83
	09:19:00	82.85	19.0			39.20
	09:21:00	84.03	21.0			40.38
	09:23:00	84.95	23.0			41.30
	09:25:00	85.82	25.0			42.17

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 5 WELL NO. 51

Personnel Burke Driller Been

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well 5. Other (specify)

al well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

Casing type P.V.C. Type of screen or perforation Horizontal saw slots

Interval of screen or perforation 250' - 350' Pump hp. & type 3/4 hp Fairbanks/Moor

Pump depth 140 ft. Aquifer Wepo Form Aquifer lithology Sandstone, Sandy Shale

Altitude of land surface 6701.0 How determined Surveyed

MP (Above) Below LSD 0.66' Altitude MP 6701.7'

SWL from MP 43.65' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
09/27/80	09:28:00	86.98	28.0			43.33
	09:31:00	87.95	31.0			44.30
	09:33:00	88.46	33.0			44.81
	09:36:00	89.13	36.0			45.48
	09:39:00	89.75	39.0			46.10
	09:41:00	90.25	41.0			46.60
	09:45:00	90.80	45.0			47.15
	09:50:00	91.52	50.0			47.87
	09:55:00	92.10	55.0			48.45
	10:00:00	92.60	60.0			48.95
	10:10:00	93.55	70.0			49.90
	10:20:00	94.22	80.0			50.57
	10:30:00	94.75	90.0			51.10
	10:40:00	95.45	100.0			51.80
	10:50:00	95.95	110.0			52.30
	11:00:00	96.26	120.0			52.61
	11:10:00	96.64	130.0			52.99
	11:20:00	97.00	140.0			53.35
	11:30:00	97.28	150.0			53.63
	11:40:00	97.68	160.0			54.03
	11:50:00	97.88	170.0			54.23
	12:00:00	98.24	180.0			54.59
	12:10:00	98.55	190.0			54.90
	12:20:00	98.80	200.0			55.15
	12:40:00	99.35	220.0			55.70
	13:00:00	99.95	240.0			56.30
	13:20:00	100.25	260.0			56.60
	13:40:00	100.65	280.0			57.00

PEABODY HYDROLOGIC TESTING　　AQUIFER TEST DATA

State AZ　County Navajo　T. 36 (N.) S., R. 18 (E.) W., Sec. 5　WELL NO. 51

Personnel Burke　Driller Been

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well 5. Other (specify)

:al well depth 350 ft.　Well diameter 9.0 in.　Casing diameter 6.0 in.

casing type P.V.C.　Type of screen or perforation Horizontal saw slots

Interval of screen or perforation 250' - 350'　Pump hp. & type 3/4hp Fairbanks/Moorse

Pump depth 140 ft.　Aquifer Wepo Form　Aquifer lithology Sandstone, Sandy Shale

Altitude of land surface 6701.0　How determined Surveyed

MP (Above) Below LSD 0.66'　Altitude MP 6701.7'

SWL from MP 43.65'　How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t¹, MIN.	t/t¹	S, FT. RESIDUAL DRAWDOWN
09/27/80	13:59:00	100.97	299.0			57.32
	14:00:00	Pump Off	300.0			

WATER WELL 51

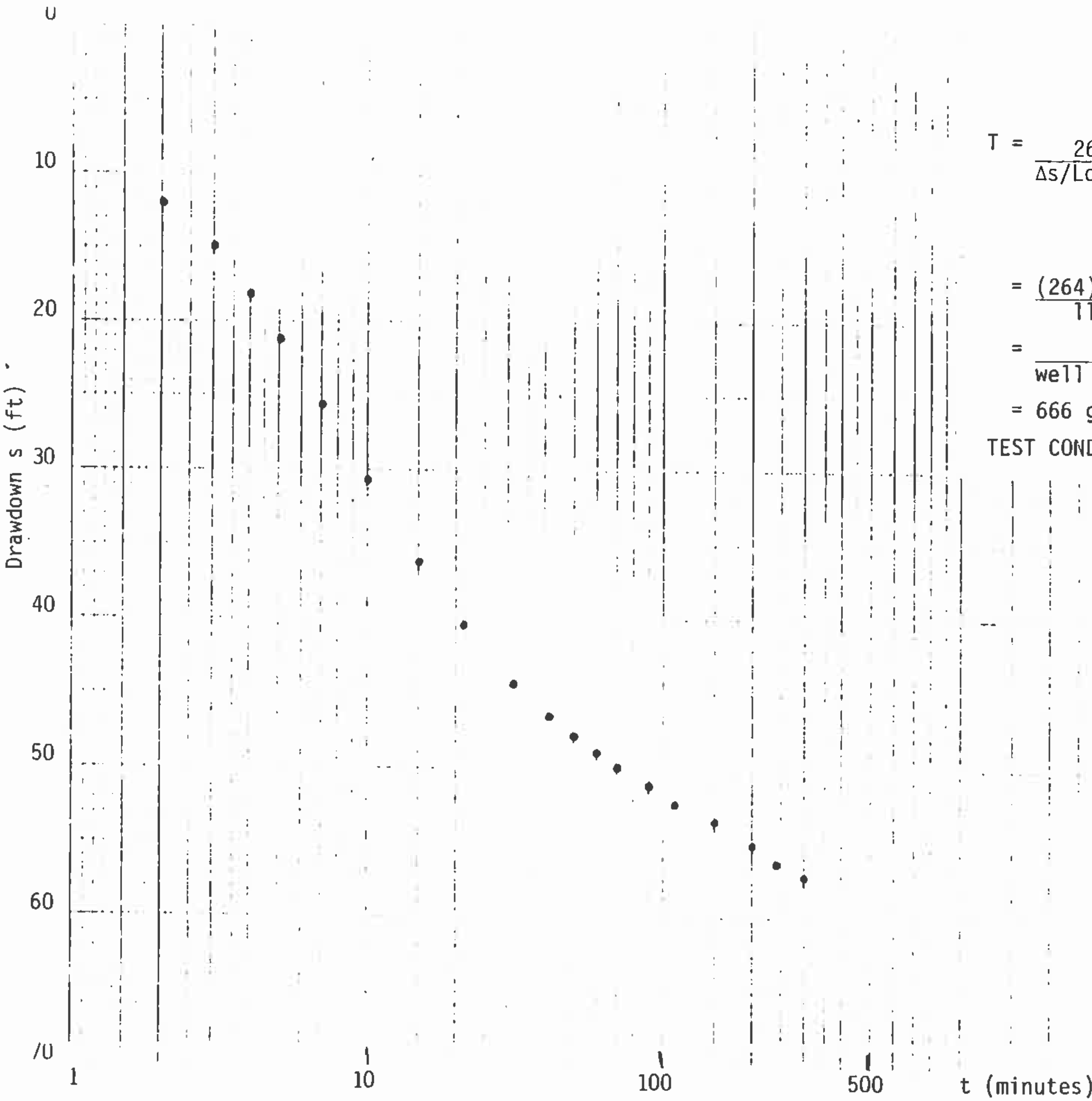
PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
09/27/80	9:02	25.0	2.40	3.7	0.010	0.089
	9:04	22.8	2.63	3.7	0.007	0.068
	9:06	23.1	2.60	3.7	0.007	0.067
	9:08	23.4	2.56	3.7	0.007	0.066
	9:10	22.9	2.62	3.7	0.007	0.068
	9:12	23.2	2.57	3.7	0.007	0.066
	9:14	23.5	2.55	3.7	0.007	0.066
	9:16	23.5	2.55	3.7	0.007	0.066
	9:18	23.6	2.54	3.7	0.007	0.066
	9:20	23.6	2.54	3.7	0.007	0.066
	9:22	23.6	2.54	3.7	0.007	0.066
	9:24	23.9	2.51	3.7	0.013	0.121
	9:30	24.0	2.50	3.7	0.020	0.185
	9:35	24.1	2.48	3.7	0.017	0.156
	9:40	23.9	2.51	3.7	0.017	0.158
	9:45	24.0	2.50	3.7	0.017	0.157
	9:50	24.3	2.47	3.7	0.017	0.155
	9:55	24.5	2.45	3.7	0.017	0.154
	10:00	24.5	2.45	3.7	0.023	0.208
	10:10	24.3	2.47	3.7	0.033	0.301
	10:20	23.7	2.53	3.7	0.033	0.309
	10:30	24.0	2.50	3.7	0.033	0.305
	10:40	23.2	2.57	3.7	0.033	0.314
	10:50	23.2	2.57	3.7	0.033	0.314
	11:00	23.5	2.55	3.7	0.033	0.311
	11:10	23.5	2.55	3.7	0.033	0.311
	11:20	24.0	2.50	3.7	0.033	0.305
	11:30	23.8	2.52	3.7	0.050	0.466
	11:50	23.6	2.54	3.7	0.050	0.470
	12:00	23.5	2.55	3.7	0.050	0.472
	12:20	23.3	2.57	3.7	0.067	0.637
	12:40	24.0	2.50	3.7	0.067	0.620

WATER WELL 51

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
09/27/80	13:00	23.7	2.53	3.7	0.067	0.627
	13:20	23.8	2.52	3.7	0.067	0.625
	13:40	23.8	2.52	3.7	0.100	0.932
	14:00	PUMP OFF				
					TOTAL	9.370
					Weighted	
					Average	
					Discharge	9.37 GPM



WEPO WELL #51
TIME DRAWDOWN TEST

$$T = \frac{264\ Q}{\Delta s/\text{Log Cycle}}$$

$$= \frac{(264)(9.37)}{11.6}$$

$$= \frac{213.25}{\text{well efficiency } (.32)}$$

= 666 gpd/ft.

TEST CONDUCTED 9/27/80

PEABODY HYDROLOGIC TESTING

AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 4 WELL NO. 52

Personnel Burke Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

ıl well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

ıng type P.V.C. Type of screen or perforation Horizontal saw slots

Interval of screen or perforation 70'-90' 150'-350' Pump hp. & type 3/4 hp Fairbanks Mo[illegible]

Pump depth 185 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface 6652.8' How determined Surveyed

MP (Above) Below LSD .80' Altitude MP 6653.6'

SWL from MP 13.35 How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
10/9/80	08:59:30	13.35				
	09:00:00	On				
	09:00:30	16.91	0.5 Min.			3.56
	09:01:00	19.70	1.0			6.35
	09:01:30	22.12	1.5			8.77
	09:02:00	24.25	2.0			10.90
	09:02:30	26.44	2.5			13.09
	09:03:00	28.80	3.0			15.45
	09:03:30	30.86	3.5			17.51
	09:04:00	32.83	4.0			19.48
	09:04:30	35.00	4.5			21.65
	09:05:00	36.98	5.0			23.63
	09:05:30	39.05	5.5			25.70
	09:06:00	41.10	6.0			27.75
	09:06:30	43.15	6.5			29.80
	09:07:00	44.80	7.0			31.45
	09:07:30	46.62	7.5			33.27
	09:08:00	48.50	8.0			35.15
	09:08:30	50.29	8.5			36.94
	09:09:00	51.95	9.0			38.60
	09:09:30	53.61	9.5			40.26
	09:10:00	55.22	10.0			41.87
	09:11:00	58.25	11.0			44.90
	09:12:00	60.35	12.0			47.00
	09:13:00	64.35	13.0			51.00
	09:14:00	67.32	14.0			53.97
	09:15:00	70.22	15.0			56.87
	09:16:00	73.00	16.0			59.65
	09:17:00	75.75	17.0			62.40

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 4 WELL NO. 52

Personnel Burke Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

Total well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

Casing type P.V.C. Type of screen or perforation Horizontal saw slots

Interval of screen or perforation 70'-80' 150'-350' Pump hp. & type 3/4 hp Fairbanks M

Pump depth 185 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface 6652.8' How determined Surveyed

MP (Above) Below LSD .80' Altitude MP 6653.6'

SWL from MP 13.35 Ft. How measured Galvanometer (Slope Indicator)

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
10/9/80	11:50:00	164.50	170.0			151.15
	12:00:00	165.35	180.0			152.00
	12:10:00	166.30	190.0			152.95
	12:20:00	167.21	200.0			153.86
	12:30:00	168.22	210.0			154.87
	12:40:00	169.03	220.0			155.68
	12:50:00	169.64	230.0			156.29
	13:00:00	170.25	240.0			156.90
	13:10:00	171.07	250.0			157.72
	13:20:00	171.65	260.0			158.30
	13:30:00	172.15	270.0			158.80
	13:40:00	172.85	280.0			159.50
	13:50:00	173.43	290.0			160.08
	14:00:00	173.90	300.0			160.55
	14:20:00	174.67	320.0			161.32
	14:40:00	175.78	340.0			162.43
	15:00:00	176.75	360.0			163.40
	15:20:00	177.45	380.0			164.10
	15:40:00	177.95	400.0			164.60
	16:00:00	178.70	420.0			165.35
	16:29:30	179.67	449.5			166.32
	16:30:00		Off			

Pump Tested 10/9/80 - 10/10/80
Discharge measured by bucket and stop watch done by B. Lomayaktewa

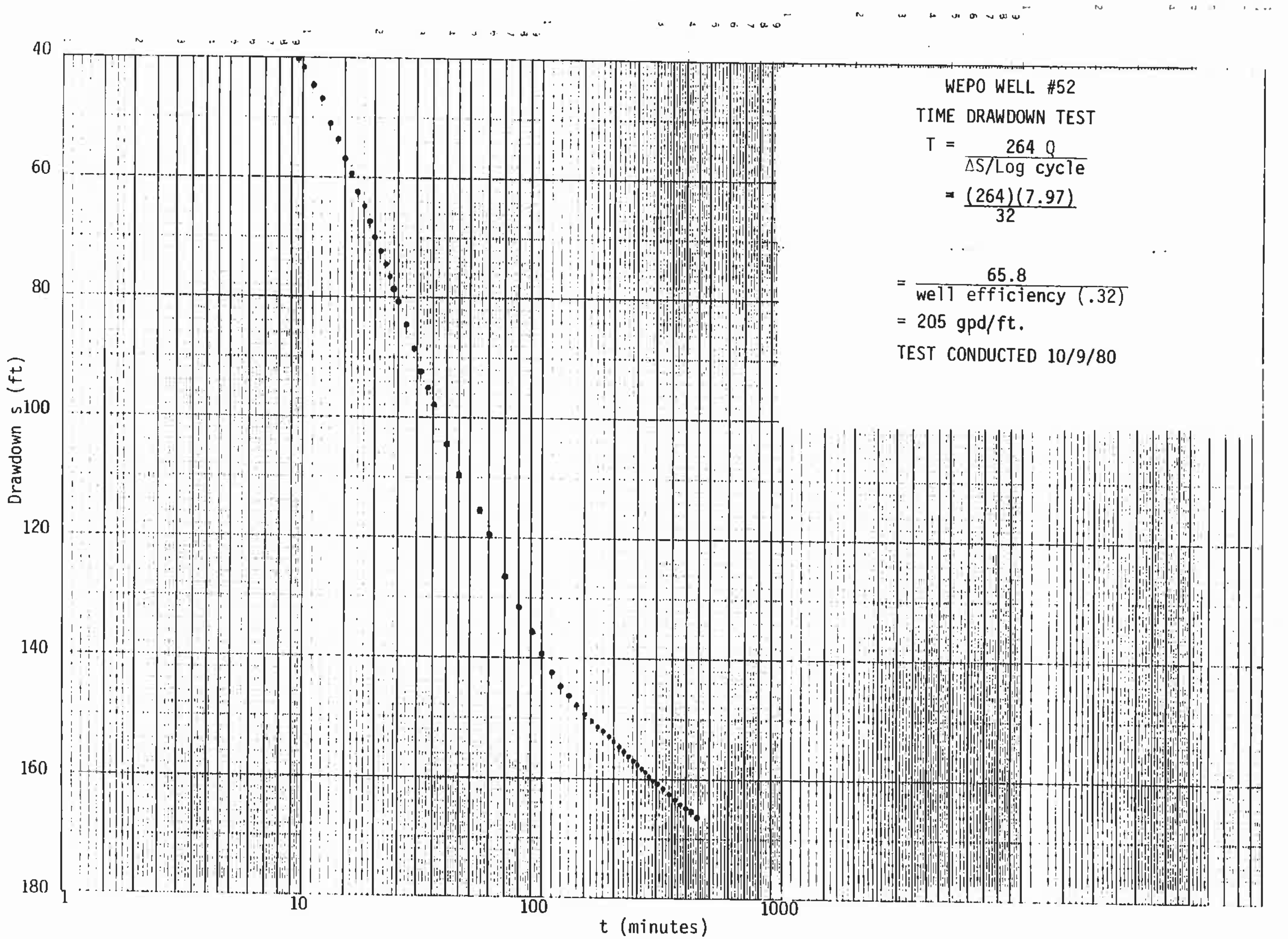
WATER WELL #52

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
10/09/80	09:00	Pump On				
	09:02	21.30	2.82	3.7	0.007	0.073
	09:04	23.20	2.59	3.7	0.004	0.038
	09:06	21.85	2.74	3.7	0.004	0.040
	09:08	22.95	2.61	3.7	0.004	0.039
	09:10	22.50	2.67	3.7	0.009	0.089
	09:15	23.55	2.55	3.7	0.011	0.104
	09:20	23.65	2.54	3.7	0.011	0.103
	09:25	23.45	2.56	3.7	0.011	0.104
	09:30	25.15	2.40	3.7	0.011	0.099
	09:35	24.90	2.41	3.7	0.011	0.098
	09:40	25.70	2.34	3.7	0.011	0.095
	04:45	25.60	2.34	3.7	0.011	0.095
	09:50	25.75	2.33	3.7	0.011	0.095
	09:55	24.85	2.41	3.7	0.011	0.098
	10:00	25.35	2.37	3.7	0.011	0.096
	10:05	26.30	2.28	3.7	0.011	0.093
	10:10	25.60	2.34	3.7	0.016	0.095
	10:20	27.05	2.22	3.7	0.022	0.183
	10:30	26.80	2.24	3.7	0.022	0.184
	10:40	26.70	2.25	3.7	0.022	0.185
	10:50	26.50	2.26	3.7	0.022	0.186
	11:00	26.40	2.27	3.7	0.022	0.187
	11:10	26.85	2.23	3.7	0.022	0.183
	11:20	27.50	2.18	3.7	0.022	0.179
	11:30	26.50	2.26	3.7	0.022	0.186
	11:40	27.80	2.16	3.7	0.022	0.178
	11:50	27.50	2.18	3.7	0.022	0.179
	12:00	27.20	2.21	3.7	0.022	0.182
	12:10	27.70	2.17	3.7	0.022	0.178
	12:20	27.85	2.15	3.7	0.022	0.177
	12:30	27.55	2.18	3.7	0.022	0.179

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
10/09/80	12:40	27.80	2.15	3.7	0.022	0.177
	12:50	28.55	2.10	3.7	0.022	0.173
	13:00	27.80	2.16	3.7	0.022	0.178
	13:10	27.70	2.17	3.7	0.022	0.178
	13:20	29.20	2.05	3.7	0.022	0.168
	13:30	29.00	2.07	3.7	0.022	0.170
	13:40	27.70	2.17	3.7	0.022	0.178
	13:50	29.20	2.05	3.7	0.022	0.168
	14:00	28.70	2.09	3.7	0.022	0.172
	14:10	28.30	2.12	3.7	0.022	0.174
	14:20	29.60	2.03	3.7	0.033	0.248
	14:40	29.50	2.05	3.7	0.044	0.334
	15:00	29.50	2.03	3.7	0.044	0.331
	15:20	29.50	2.03	3.7	0.044	0.331
	15:40	29.50	2.03	3.7	0.044	0.331
	16:00	30.00	2.00	3.7	0.055	0.327
	16:20	29.50	2.03	3.7	0.033	0.331
	16:30	Pump Off				
					TOTAL	7.97 GPM
					Weighted	
					Average	
					Discharge	



WEPO WELL #52
TIME DRAWDOWN TEST
T = 264 Q / ΔS/Log cycle
= (264)(7.97) / 32
= 65.8 / well efficiency (.32)
= 205 gpd/ft.
TEST CONDUCTED 10/9/80
Drawdown s (ft)
40
60
80
100
120
140
160
180
1
10
100
1000
t (minutes)

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 15 WELL NO. 53

Personnel Cochran Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 190'-350' Pump hp. & type 1/3 hp., Berkeley

Pump depth 215 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6681.2 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

SWL from MP 69.38 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
12/20/82	1:36:29					
	1:37:00					
		2:25:00		110.32	110.32	1.000
		2:26	1	110.32	109.17	.989
		2:27	2	110.32	108.22	.981
		2:28	3	110.32	107.28	.972
		2:29	4	110.32	106.35	.964
		2:30	5	110.32	105.43	.955
		2:32	7	110.32	103.69	.940
		2:35	10	110.32	101.27	.918
		2:37	12	110.32	99.70	.904
		2:39	14	110.32	98.17	.890
		2:43	18	110.32	95.36	.864
		2:45	20	110.32	93.99	.852
		2:50	25	110.32	90.64	.822
		2:55	30	110.32	87.53	.793
		3:00	35	110.32	84.78	.768
		3:05	40	110.32	82.49	.748
		3:15	50	110.32	78.70	.713
		3:25	60	110.32	75.35	.683
		3:35	70	110.32	72.23	.655
		3:45	80	110.32	69.39	.629
		3:55	90	110.32	66.87	.606
		4:05	100	110.32	64.45	.584
		4:25	120	110.32	59.99	.544
		4:45	140	110.32	56.02	.508
		5:05	160	110.32	52.46	.475
		5:25	180	110.32	49.20	.446

PEABODY HYDROLOGIC TESTING   AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 15 WELL NO. 53

Personnel Cochran Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

-al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation modified slug

Interval of screen or perforation 190'-350' Pump hp. & type 1/3 hp., Berkeley

Pump depth 215 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6681.2 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

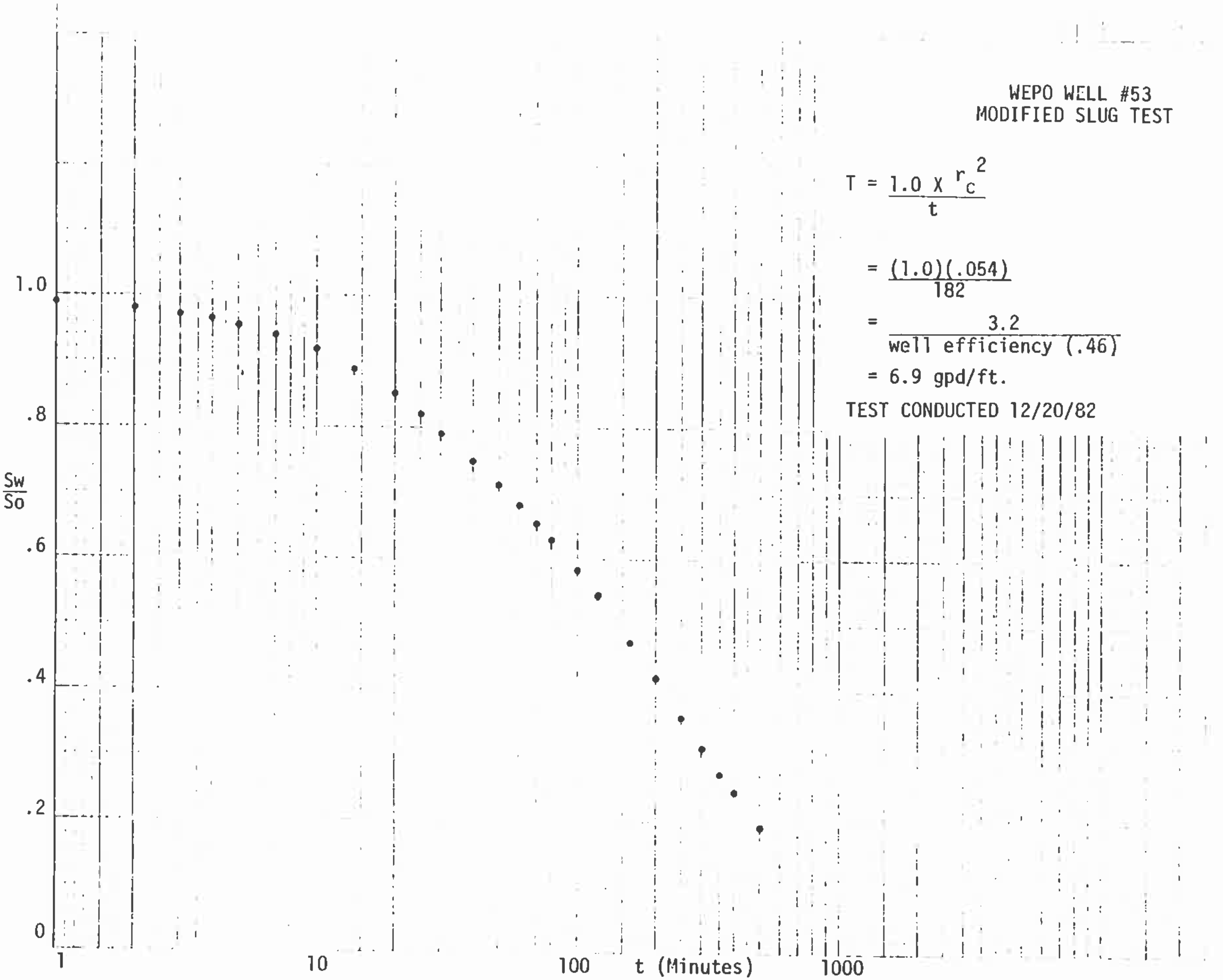
SWL from MP 69.38 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
12/20/82		5:45	200	110.32	46.25	.419
		6:35	250	110.32	39.87	.361
		7:25	300	110.32	34.60	.313
		8:15	350	110.32	30.35	.275
		9:05	400	110.32	26.91	.244
		9:55	450	110.32	24.05	.218
		10:45	500	110.32	21.62	.196

WATER WELL 53

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
12/20/81	13:37	PUMP ON		3.0		
	13:40	30.4	1.973	3.0	.0937	.5546
	13:43	28.3	2.120	3.0	.0625	.3975
	13:46	27.2	2.206	3.0	.0729	.4824
	13:50	29.0	2.069	3.0	.0937	.5816
	13:55	31.8	1.887	3.0	.1042	.5899
	14:00	32.4	1.852	3.0	.1042	.5789
	14:05	36.4	1.648	3.0	.1042	.5152
	14:10	39.4	1.523	3.0	.1042	.4761
	14:15	39.6	1.515	3.0	.1042	.4736
	14:20	43.6	1.376	3.0	.1042	.4301
	14:25	PUMP OFF			TOTAL =	5.0799
			Weighted Average Discharge =			5 .08gpm



WEPO WELL #53
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{182}$$

$$= \frac{3.2}{\text{well efficiency } (.46)}$$

$= 6.9$ gpd/ft.

TEST CONDUCTED 12/20/82

PEABODY HYDROLOGIC TESTING

AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 19 (E.) W., Sec. 19 WELL NO. 54

Personnel Burke Driller Bean

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

al well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

sing type P.V.C. Type of screen or perforation Vertical saw slots

Interval of screen or perforation zones from 120' - 350' Pump hp. & type 3/4 hp Fairbanks Mor

Pump depth 160 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface How determined Surveyed

MP (Above) Below LSD .65' Altitude MP

SWL from MP 44.00' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t[1], MIN.	t/t[1]	S, FT. RESIDUAL DRAWDOWN
08/31/80	11:00:00	44.00	ON			
	11:00:30	47.27	0.5			3.27
	11:01:00	49.65	1.0			5.65
	11:02:00	55.15	2.0			11.15
	11:03:00	57.50	3.0			13.50
	11:03:30	59.80	3.5			15.80
	11:04:00	61.30	4.0			17.30
	11:04:30	63.01	4.5			19.01
	11:05:00	64.75	5.0			20.75
	11:05:30	66.20	5.5			22.20
	11:06:00	67.85	6.0			23.85
	11:06:30	69.42	6.5			25.42
	11:07:00	70.73	7.0			26.73
	11:07:30	72.21	7.5			28.21
	11:08:00	73.61	8.0			29.61
	11:08:30	74.97	8.5			30.97
	11:09:30	77.55	9.5			33.55
	11:10:00	79.05	10.0			35.05
	11:12:00	83.47	12.0			39.47
	11:13:00	86.75	13.0			42.75
	11:14:00	88.07	14.0			44.07
	11:15:00	89.95	15.0			45.95
	11:16:30	93.10	16.5			49.10
	11:18:00	95.83	18.0			51.83
	11:19:00	97.30	19.0			53.30
	11:20:00	99.37	20.0			55.37
	11:22:00	102.57	22.0			58.57
	11:24:00	105.00	24.0			61.00

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State AZ County Navajo T. 36 (N.) S., R. 19 (E.) W., Sec. 19 WELL NO. 54

Personnel Burke Driller Bean

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
4. Recovery with obs. well 5. Other (specify)

al well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

ing type P.V.C. Type of screen or perforation Vertical saw slots

Interval of screen or perforation Zones from 120' - 350' Pump hp. & type 3/4 hp Fairbanks Mors

Pump depth 160 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface How determined Surveyed

MP (Above) Below LSD .65' Altitude MP

SWL from MP 44.00' How measured Galvanometer

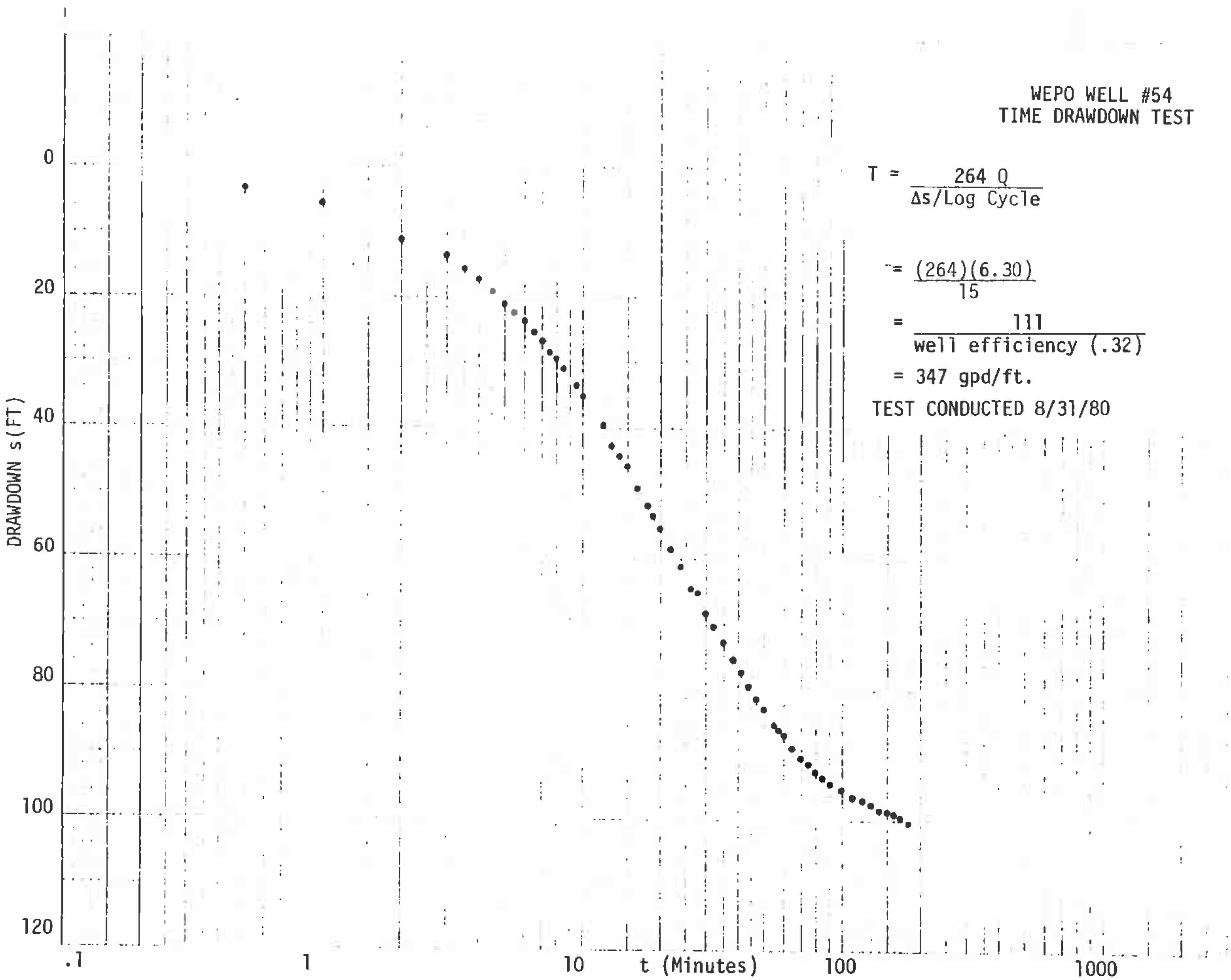
DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t[1], MIN.	t/t[1]	S, FT. RESIDUAL DRAWDOWN
08/31/80	11:26:30	108.46	26.5			64.46
	11:28:00	109.00	28.0			65.00
	11:30:00	112.12	30.0			68.12
	11:32:00	114.13	32.0			70.13
	11:35:00	116.92	35.0			72.92
	11:38:00	119.38	38.0			75.38
	11:41:00	121.33	41.0			77.33
	11:44:00	123.57	44.0			79.57
	11:47:00	125.18	47.0			81.18
	11:50:00	126.55	50.0			82.55
	11:55:00	129.38	55.0			85.38
	11:58:00	130.00	58.0			86.00
	12:00:00	130.98	60.0			86.98
	12:05:00	132.92	65.0			88.92
	12:10:00	134.20	70.0			90.20
	12:15:00	135.37	75.0			91.37
	12:20:00	136.42	80.0			92.42
	12:25:00	137.32	85.0			93.32
	12:30:00	138.04	90.0			94.04
	12:40:00	139.33	100.0			95.33
	12:50:00	140.10	110.0			96.10
	13:00:00	140.95	120.0			96.95
	13:10:00	141.82	130.0			97.82
	13:20:00	142.20	140.0			98.20
	13:30:00	142.78	150.0			98.78
	13:40:00	143.20	160.0			99.20
	13:50:00	143.64	170.0			99.64
	14:00:00	144.04	180.0			100.04

Pump Off

WATER WELL 54

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
08/31/80	11:10:30	31.0	1.94	3.7	.067	.479
	11:15:30	31.5	1.90	3.7	.033	.235
	11:21	31.5	1.90	3.7	.017	.117
	11:25	31.8	1.89	3.7	.028	.194
	11:31	32.5	1.85	3.7	.033	.228
	11:36	33.0	1.82	3.7	.028	.189
	11:41	34.0	1.76	3.7	.028	.181
	11:45	34.5	1.74	3.7	.028	.179
	11:51	34.0	1.76	3.7	.028	.181
	11:56	34.5	1.74	3.7	.028	.179
	12:01	35.0	1.71	3.7	.044	.282
	12:11	34.5	1.74	3.7	.050	.322
	12:21	35.0	1.71	3.7	.056	.352
	12:31	35.5	1.69	3.7	.061	.382
	12:41	35.0	1.71	3.7	.055	.352
	12:51	35.0	1.71	3.7	.053	.335
	13:00	35.0	1.71	3.7	.053	.335
	13:11	35.5	1.69	3.7	.056	.347
	13:21	35.8	1.68	3.7	.061	.379
	13:31	35.0	1.71	3.7	.056	.352
	13:41	35.0	1.71	3.7	.056	.352
	13:51	35.0	1.71	3.7	.056	.352
	14:00	PUMP OFF				
				Weighted Average	Discharge =	6.30 GPM



$$T = \frac{264\ Q}{\Delta s/\text{Log Cycle}}$$

$$= \frac{(264)(6.30)}{15}$$

$$= \frac{111}{\text{well efficiency } (.32)}$$

= 347 gpd/ft.

TEST CONDUCTED 8/31/80

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.), S., R. 18 (E.), W., Sec. 31 WELL NO. 55

Personnel Cochran, Dee Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

Total well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 190'-350' Pump hp. & type 2 hp., Red Jacket

Pump depth 271 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6481.5 How determined surveyed

MP Above/Below LSD 3.74' Altitude MP 6458.24

SWL from MP 161.86' How measured water level indicator (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
6/21/82	12:45			17.32		
		12:47		17.32	17.32	1.000
		12:48	1	17.32	16.07	.928
		12:49	2	17.32	15.66	.904
		12:50	3	17.32	14.89	.860
		12:52	5	17.32	14.04	.811
		12:53	6	17.32	13.46	.777
		12:54	7	17.32	13.21	.762
		12:55	8	17.32	12.85	.742
		12:56	9	17.32	12.55	.724
		12:57	10	17.32	12.29	.709
		12:59	12	17.32	11.76	.679
		1:02	15	17.32	11.05	.638
		1:05	18	17.32	10.43	.602
		1:07	20	17.32	10.04	.580
		1:12	25	17.32	9.20	.531
		1:17	30	17.32	8.48	.490
		1:22	35	17.32	7.86	.454
		1:27	40	17.32	7.22	.417
		1:37	50	17.32	6.12	.353
		1:47	60	17.32	5.31	.307
		1:57	70	17.32	4.66	.269
		2:07	80	17.32	4.22	.244
		2:17	90	17.32	3.60	.208
		2:27	100	17.32	3.17	.183
		2:37	110	17.32	2.78	.160
		2:47	120	17.32	2.42	.140
		2:57	130	17.32	2.18	.126

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 31 WELL NO. 55

Personnel Cochran, Dee Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well

Recovery with obs. well (5.) Other (specify) modified slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 190'-350' Pump hp. & type 2 hp., Red Jacket

Pump depth 271 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6481.5 How determined surveyed

MP Above/Below LSD 3.74' Altitude MP 6458.24

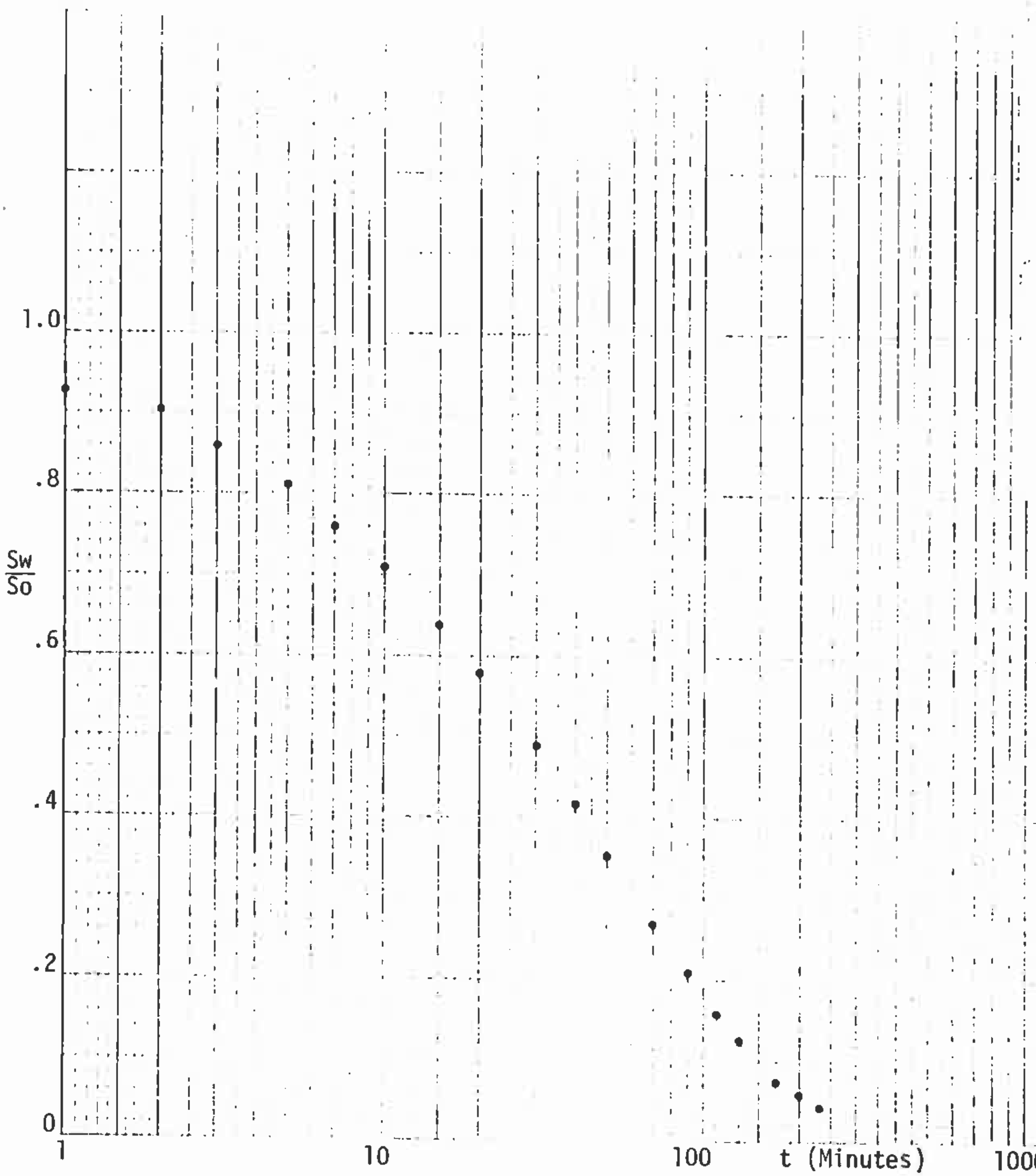
SWL from MP 161.86' How measured water level indicator (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
6/21/82		3:17	150	17.32	1.74	.100
		3:37	170	17.32	1.32	.076
		4:07	200	17.32	1.03	.059
		4:37	230	17.32	.75	.043

WATER WELL 55

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
6/21/82	12:45:15	9.5	6.316	3.0	.25	4.737
	12:45:45	9.9	6.185	3.0	.25	4.639
	12:46:15	9.7	6.185	3.0	.25	4.639
	12:46:45	9.8	6.122	3.0	.25	4.592
					TOTAL =	18.607
				Weighted Average Discharge =		18.6 gpm



WEPO WELL #55
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{32}$$

$$= \frac{18.2}{\text{well efficiency } (.46)}$$

$$= 40 \text{ gpd/ft.}$$

TEST CONDUCTED 6/21/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 32 WELL NO. 56

Personnel Dee, Cochran Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) Modified slug test

al well depth 347 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type PVC Type of screen or perforation Vertical slotted

Interval of screen or perforation 130' - 350' Pump hp. & type 2 hp. Red Jacket

Pump depth 271 ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy shale

Altitude of land surface 6417.7 How determined Surveyed

MP Above/Below LSD 2.58 Altitude MP 6420.28

SWL from MP 39.13 How measured (SINCO) water level indicator

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
6/22/82	14:11			104.26		
		14:22		104.26	143.39	1.000
		14:22:30	.5	104.26	143.02	.996
		14:23	1	104.26	141.82	.985
		14:24	2	104.26	140.37	.971
		14:25	3	104.26	139.05	.958
		14:27	5	104.26	136.53	.934
		14:32	10	104.26	132.45	.895
		14:37	15	104.26	127.95	.852
		14:42	20	104.26	122.80	.803
		14:47	25	104.26	120.10	.776
		14:54	32	104.26	114.78	.725
		15:02	40	104.26	109.30	.673
		15:12	50	104.26	103.94	.621
		15:22	60	104.26	99.22	.576
		15:35	73	104.26	93.72	.523
		15:42	80	104.26	90.98	.497
		15:52	90	104.26	87.05	.460
		16:02	100	104.26	83.34	.424
		16:12	110	104.26	80.33	.395
		16:22	120	104.26	77.90	.372
		16:32	130	104.26	75.49	.349
		16:42	140	104.26	73.31	.328
		16:52	150	104.26	71.30	.309
		17:02	160	104.26	69.61	.292
		17:12	170	104.26	68.04	.277
		17:22	180	104.26	66.61	.264
		17:32	190	104.26	65.12	.249

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 18 (E.) W., Sec. 32 WELL NO. 56

Personnel Dee, Cochran Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well

Recovery with obs. well (5) Other (specify) Modified slug test

al well depth 347 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type PVC Type of screen or perforation Vertical slotted

Interval of screen or perforation 130' - 350' Pump hp. & type 2 hp.Red Jacket

Pump depth 271 ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy shale

Altitude of land surface 6417.7 How determined Surveyed

MP Above/Below LSD 2.58 Altitude MP 6420.28

SWL from MP 39.13' How measured (Sinco) water level indicator

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
6/22/82		17:42	200	104.26	63.67	.235
		18:02	220	104.26	61.21	.212
		18:22	240	104.26	59.47	.195
		18:42	260	104.26	57.61	.177
		19:02	280	104.26	55.96	.161
		19:22	300	104.26	54.47	.147
		19:42	320	104.26	53.29	.136
		20:02	340	104.26	52.23	.126
		21:02	400	104.26	49.73	.102

WATER WELL 56

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
6/22/82	14:11	PUMP ON				
	14:12	7.5	8.00	3.0	.136	3.26
	14:13	8.0	7.50	3.0	.091	2.05
	14:14	8.8	6.82	3.0	.091	1.86
	14:15	9.2	6.52	3.0	.091	1.78
	14:16	9.2	6.52	3.0	.091	1.78
	14:17	9.0	6.67	3.0	.091	1.82
	14:18	9.3	6.45	3.0	.091	1.76
	14:19	9.7	6.18	3.0	.091	1.69
	14:20	10.1	5.94	3.0	.091	1.62
	14:21	10.15	5.91	3.0	.136	2.41
	14:22	PUMP OFF			TOTAL =	20.03

WEPO WELL #56
MODIFIED SLUG TEST

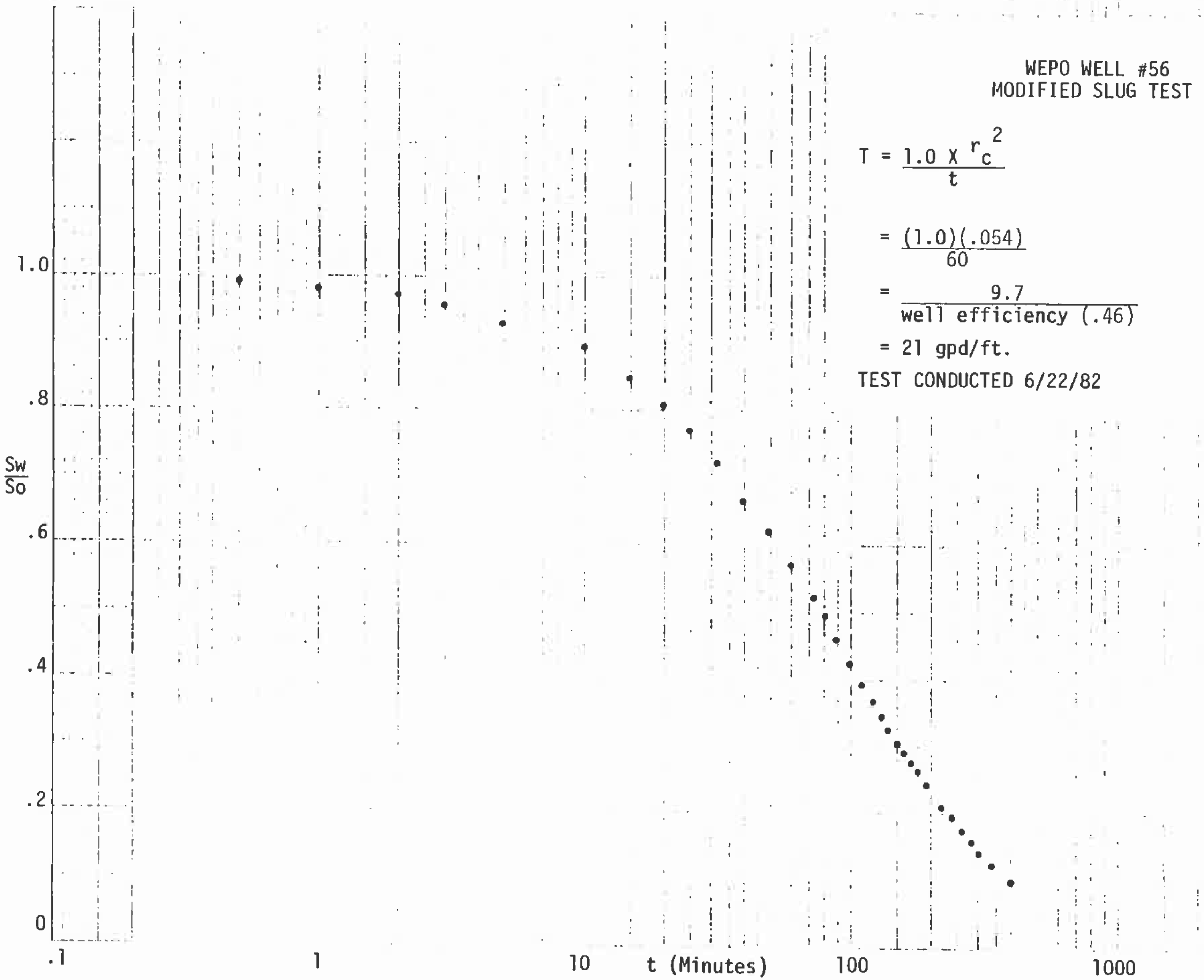
$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{60}$$

$$= \frac{9.7}{\text{well efficiency } (.46)}$$

= 21 gpd/ft.

TEST CONDUCTED 6/22/82



PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 3 WELL NO. 57

Personnel Cochran, Hamilton Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

al well depth 315 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 115'-315' Pump hp. & type 2 hp., Red Jacket

Pump depth 220 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6458.9 How determined surveyed

MP Above/Below LSD 2.48 Altitude MP 6461.38

SWL from MP 155.63 How measured water level indicator (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
9/30/82	6:30					
	6:40					
	6:41				12.09	
		6:42		20.13	20.13	1.000
		6:43	1	20.13	19.18	.953
		6:44	2	20.13	18.39	.913
		6:45	3	20.13	17.69	.879
		6:45:30	3.5	20.13	17.49	.869
		6:46	4	20.13	17.28	.858
		6:46:30	4.5	20.13	16.97	.843
		6:47	5	20.13	16.79	.834
		6:47:30	5.5	20.13	16.51	.820
		6:48	6	20.13	15.88	.789
		6:49	7	20.13	15.44	.767
		6:50	8	20.13	15.05	.747
		6:51	9	20.13	14.50	.720
		6:52	10	20.13	14.24	.707
		6:54	12	20.13	13.64	.677
		6:57	15	20.13	12.72	.632
		7:00	18	20.13	11.89	.590
		7:02	20	20.13	11.44	.568
		7:07	25	20.13	10.49	.521
		7:13	31	20.13	9.34	.464
		7:17	35	20.13	8.63	.429
		7:22	40	20.13	7.97	.396
		7:27	45	20.13	7.36	.365
		7:32	50	20.13	6.82	.339
		7:37	55	20.13	6.21	.308

PEABODY HYDROLOGIC TESTING　　　　AQUIFER TEST DATA

State Arizona　County Navajo　T. 35 (N.) S., R. 18 (E.) W., Sec. 3　WELL NO. 57

Personnel Cochran, Hamilton　Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

-al well depth 315 ft.　Well diameter 9 in.　Casing diameter 6 in.

Casing type pvc　Type of screen or perforation vertical slotted

Interval of screen or perforation 115'-315'　Pump hp. & type 2 hp., Red Jacket

Pump depth 220 ft.　Aquifer Wepo　Aquifer lithology sandstone, sandy shale

Altitude of land surface 6458.9　How determined surveyed

MP Above/Below LSD 2.48　Altitude MP 6461.38

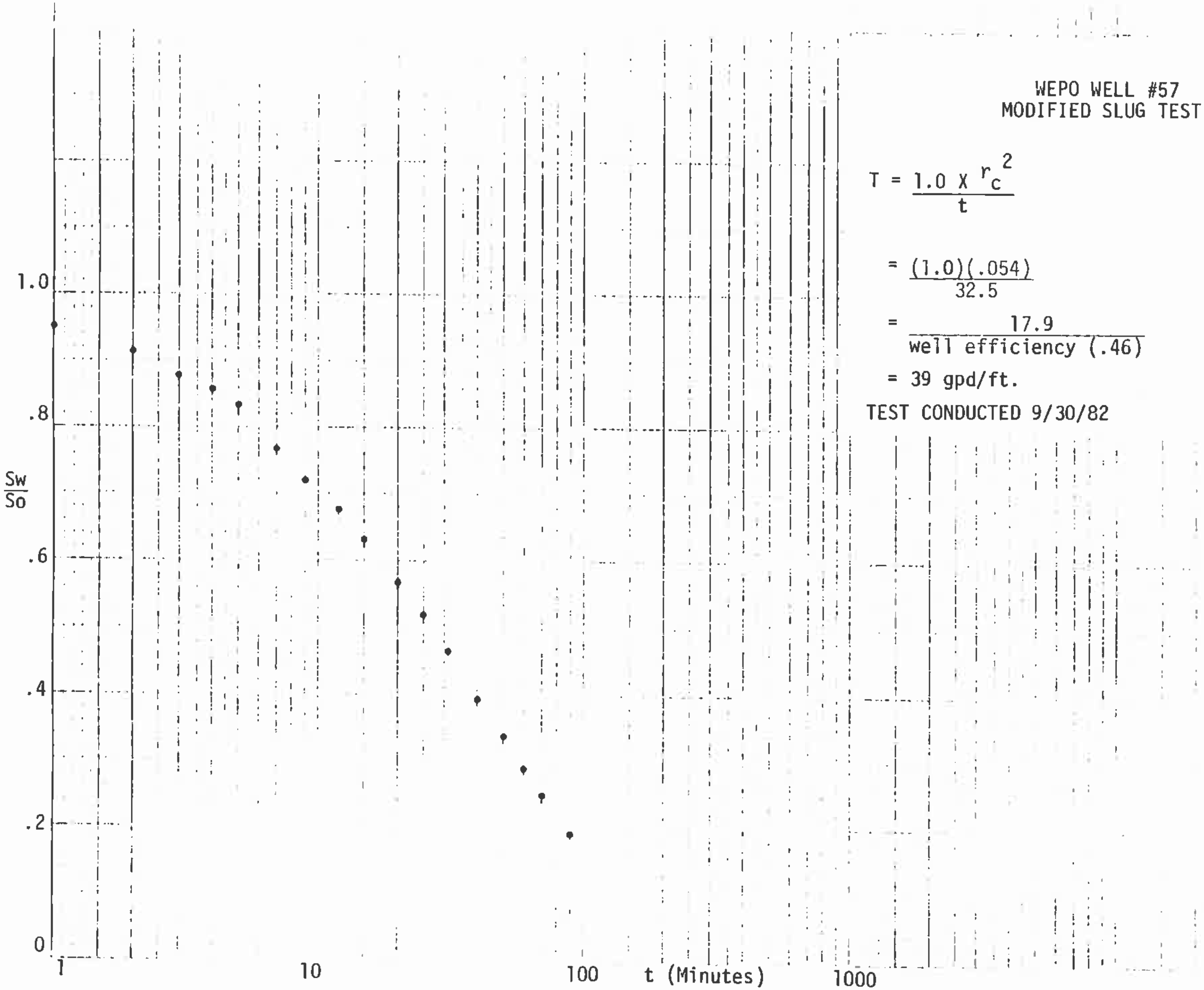
SWL from MP 155.63　How measured water level indicator (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
9/30/82		7:42	60	20.13	5.86	.291
		7:47	65	20.13	5.26	.261
		7:52	70	20.13	5.01	.248
		8:02	80	20.13	4.41	.219
		8:12	90	20.13	3.91	.194

WATER WELL 57

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
9/30/82	6:40	PUMP ON				
	6:41	11:0	5.454	3.0	1.000	16.382
	6:42	PUMP OFF				
TOTAL PUMPING TIME = 2 MIN.					TOTAL=	16.36
				AVERAGE WEIGHTED DISCHARGE= 16.4 g.p.m.		



WEPO WELL #57
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{32.5}$$

$$= \frac{17.9}{\text{well efficiency } (.46)}$$

$= 39$ gpd/ft.

TEST CONDUCTED 9/30/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 17 WELL NO. 58

Personnel Hamilton Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

Total well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.
Casing type pvc Type of screen or perforation vertical slotted
Interval of screen or perforation 150' - 350' Pump hp. & type 2 hp. Red Jacket
Pump depth 260 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale
Altitude of land surface 6334.7 How determined surveyed
MP Above/Below LSD n/a Altitude MP n/a
SWL from MP 134.73 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
10/08/82	8:05					
		8:09				
		8:09:30	.5	25.37	25.37	1.000
		8:10:00	1	25.37	25.27	.996
		8:10:30	1.50	25.37	25.18	.992
		8:11:30	2.50	25.37	24.98	.985
		8:11:59	3	25.37	24.88	.981
		8:13:00	4	25.37	24.70	.973
		8:13:59	5	25.37	24.51	.966
		8:15:00	6	25.37	24.33	.959
		8:17:00	8	25.37	23.96	.944
		8:19:00	10	25.37	23.61	.931
		8:24:01	15	25.37	22.90	.902
		8:29:01	20	25.37	22.14	.873
		8:39:01	30	25.37	20.80	.820
		8:49:01	40	25.37	19.62	.773
		8:59:01	50	25.37	18.57	.732
		9:09:01	60	25.37	17.54	.691
		9:19:01	70	25.37	16.62	.655
		9:29:01	80	25.37	15.90	.627
		9:39:01	90	25.37	15.11	.595
		9:49:01	100	25.37	14.40	.567
		9:59:01	110	25.37	13.73	.541
		10:09:01	120	25.37	13.13	.512
		10:39:01	150	25.37	11.60	.457
		11:09:01	180	25.37	10.37	.409
		11:39:01	210	25.37	9.40	.370
		12.09:01	240	25.37	8.62	.340

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 17 WELL NO. 58

Personnel Hamilton Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

Total well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 150' - 350' Pump hp. & type 2 hp. Red Jacket

Pump depth 260 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6334.7 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

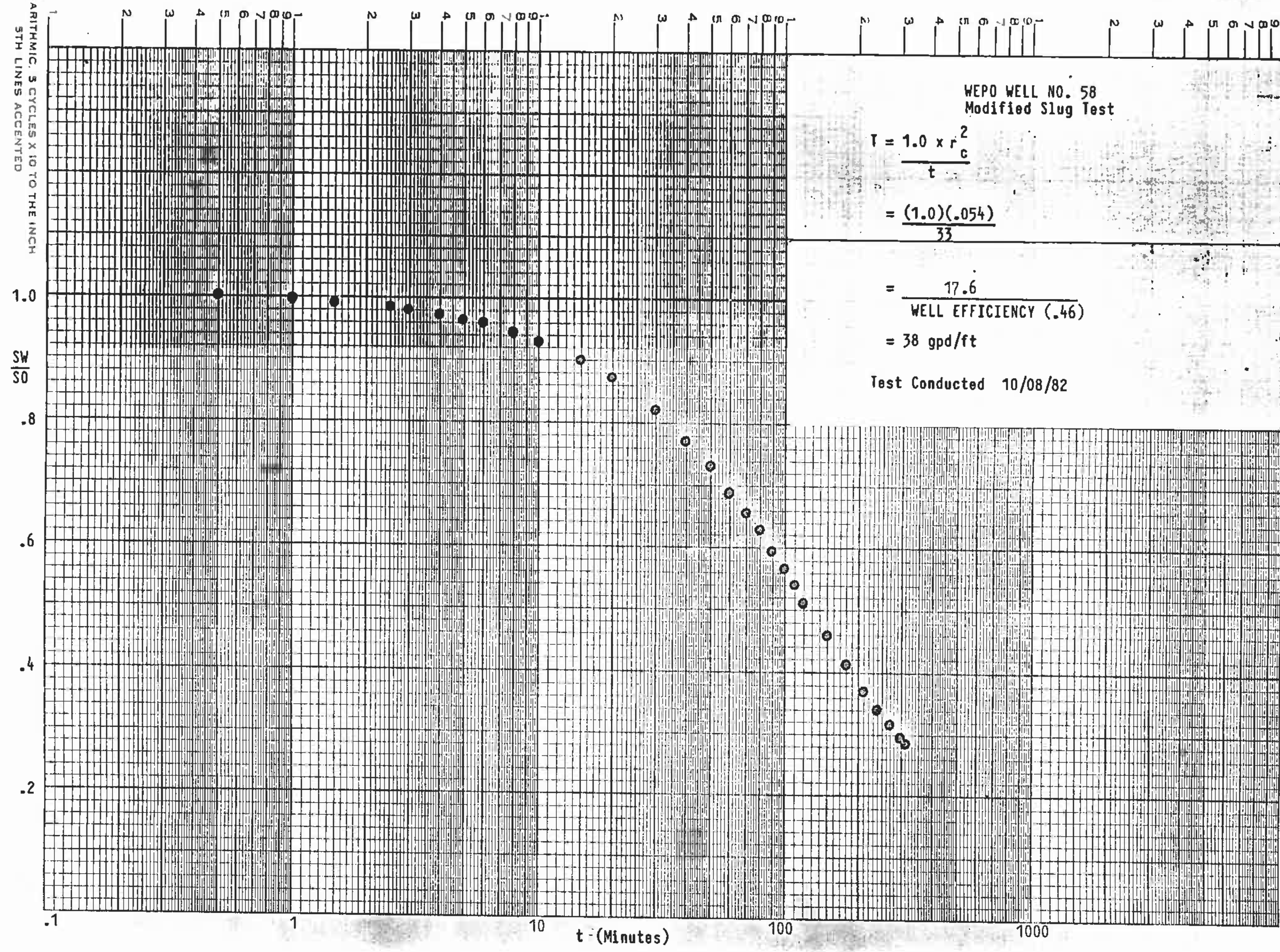
SWL from MP 134.73 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
10/08/82		12:39:01	270	25.37	7.99	.315
		1:09:01	300	25.37	7.49	.295
		1:19:01	310	25.37	7.32	.288

WATER WELL 58

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
10/08/82	0805	~~10.2~~ PUMP ON	5.88	3.0	125	2.20
	0806	9.9	6.06	3.0	.25	4.545
	0807	9.7	6.18	3.0	.25	4.635
	0808	9.8	6.12	3.0	.375	6.885
	0809	PUMP OFF			TOTAL	18.265
TOTAL PUMP TIME = 4 MINUTES				WEIGHTED AVERAGE DISCHARGE = 18.3		



WEPO WELL NO. 58
Modified Slug Test

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{33}$$

$$= \frac{17.6}{\text{WELL EFFICIENCY (.46)}}$$

= 38 gpd/ft

Test Conducted 10/08/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N) S., R. 18 (E) W., Sec. 20 WELL NO. 59

Personnel Cochran Driller Bean

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

[Tota]l well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

[Cas]ing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 115-350 Pump hp. & type 1/3 hp., Berkeley

Pump depth 215 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6296.6 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

SWL from MP 147.35 How measured transducer (pressure)

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
11/10/82	10:15	147.35	0			0
	10:16	152.54	1			5.19
	10:17	154.36	2			7.01
	10:19	157.04	4			9.69
	10:20	158.13	5			10.78
	10:22	159.77	7			12.42
	10:25	161.27	10			13.92
	10:27	161.96	12			14.61
	10:30	162.24	15			14.89
	10:33	162.56	18			15.21
	10:35	162.75	20			15.40
	10:40	163.18	25			15.83
	10:45	163.32	30			15.97
	10:50	163.49	35			16.14
	10:55	163.67	40			16.32
	11:00	163.76	45			16.41
	11:05	163.86	50			16.51
	11:15	163.88	60			16.53
	11:25	163.88	70			16.53
	11:35	163.95	80			16.60
	11:45	164.04	90			16.69
	11:55	164.23	100			16.88
	12:15	164.34	120			16.99
	12:35	164.41	140			17.06
	12:55	164.43	160			17.08
	1:15	164.59	180			17.24
	1:35	164.71	200			17.36
	1:55	164.73	220			17.38

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 20 WELL NO. 59

Personnel Cochran Driller Bean

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4 Recovery with obs. well 5. Other (specify)

ıl well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

ing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 115-350 Pump hp. & type 1/3 hp., Berkeley

Pump depth 215 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6296.6 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

SWL from MP 147.35 How measured transducer (pressure)

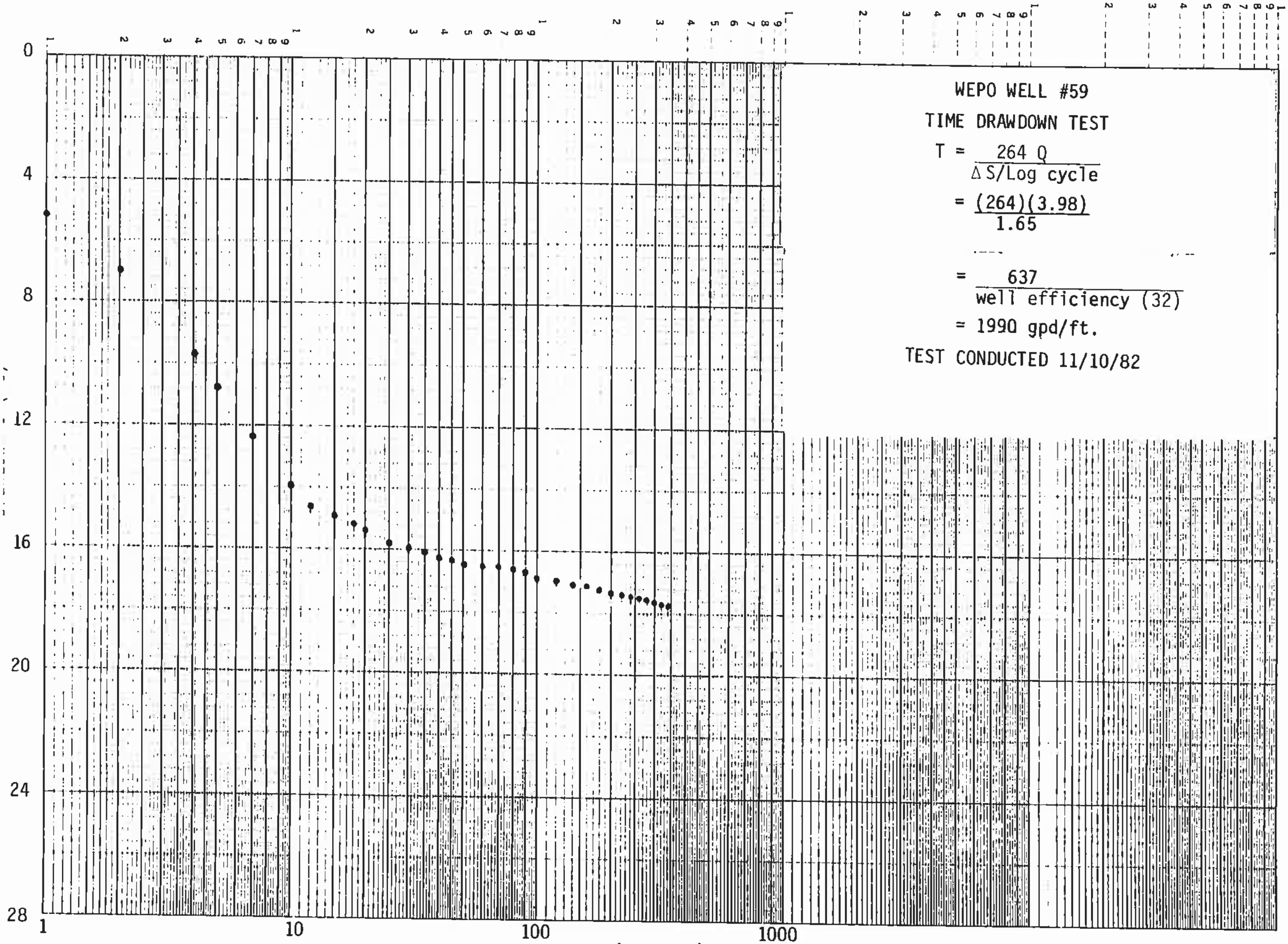
DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t[1], MIN.	$t/_{t^1}$	S, FT. RESIDUAL DRAWDOWN
11/10/82	2:15	164.76	240			17.41
	2:35	164.87	260			17.52
	2:55	164.94	280			17.59
	3:15	164.99	300			17.64
	3:35	165.03	320			17.68
	3:55	165.10	340			17.75
		NOTE: 3:55 last reading valid; readings from 3:55 to 5:00				
		suspect ... transducer slipped down inside casing				
		approximately 4:00.				
	5:00	end pumping - test completed				

WATER WELL 59

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
11/10/82	10:15	pump on		3.0		
	10:20	41.4	1.4493	3.0	.0148	.0643
	10:22	41.1	1.4598	3.0	.0049	.0214
	10:24	40.5	1.4815	3.0	.0062	.0275
	10:25	40.4	1.4851	3.0	.0074	.0330
	10:30	41.6	1.4423	3.0	,0123	.0532
	10:35	41.6	1.4423	3.0	.0123	.0532
	10:40	41.2	1.4563	3.0	.0185	.0808
	10:50	42.2	1.4218	3.0	.0247	.1053
	11:00	42.2	1.4218	3.0	.0309	.1318
	11:15	42.2	1.4218	3.0	.0370	.1578
	11:30	42.3	1.4184	3.0	.0370	.1574
	11:45	42.3	1.4184	3.0	.0370	.1574
	12:00	42.2	1.4218	3.0	.0370	.1578
	12:15	42.2	1.4218	3.0	.0370	.1578
	12:30	42.2	1.4218	3.0	.0370	.1578
	12:45	42.4	1.4151	3.0	.0370	.1571
	1:00	42.5	1.4117	3.0	.0370	.1567
	1:15	42.5	1.4117	3.0	.0370	.1567
	1:30	42.4	1.4151	3.0	.0370	.1571
	1:45	42.4	1.4151	3.0	.0370	.1571
	2:00	42.5	1.4117	3.0	.0370	.1567
	2:15	42.7	1.405	3.0	.0370	.1559
	2:30	42.4	1.4151	3.0	.0370	.1571
	2:45	42.2	1.4218	3.0	.0370	.1578
	3:00	42.2	1.4218	3.0	.0555	.2367
	3:30	42.4	1.4151	3.0	.0741	.3146
	4:00	42.3	1.4184	3.0	.0741	.3153
	4:30	42.4	1.4151	3.0	.1111	.4716
	5:00	pump off				3.9769
			WEIGHTED AVERAGE DISCHARGE			3.98 gpm

K•E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS KEUFFEL & ESSER CO MADE IN U.S.A. 46 6210



WEPO WELL #59

TIME DRAWDOWN TEST

$T = \frac{264\ Q}{\Delta S/\text{Log cycle}}$

$= \frac{(264)(3.98)}{1.65}$

$= \frac{637}{\text{well efficiency }(32)}$

= 1990 gpd/ft.

TEST CONDUCTED 11/10/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 18 (E.) W., Sec. 34 WELL NO. 60

Personnel Hamilton, Cochran Driller Elliott

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

.al well depth 349 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 175' - 349' Pump hp. & type 1/3 hp., Berkeley

Pump depth 215 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6461.2 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

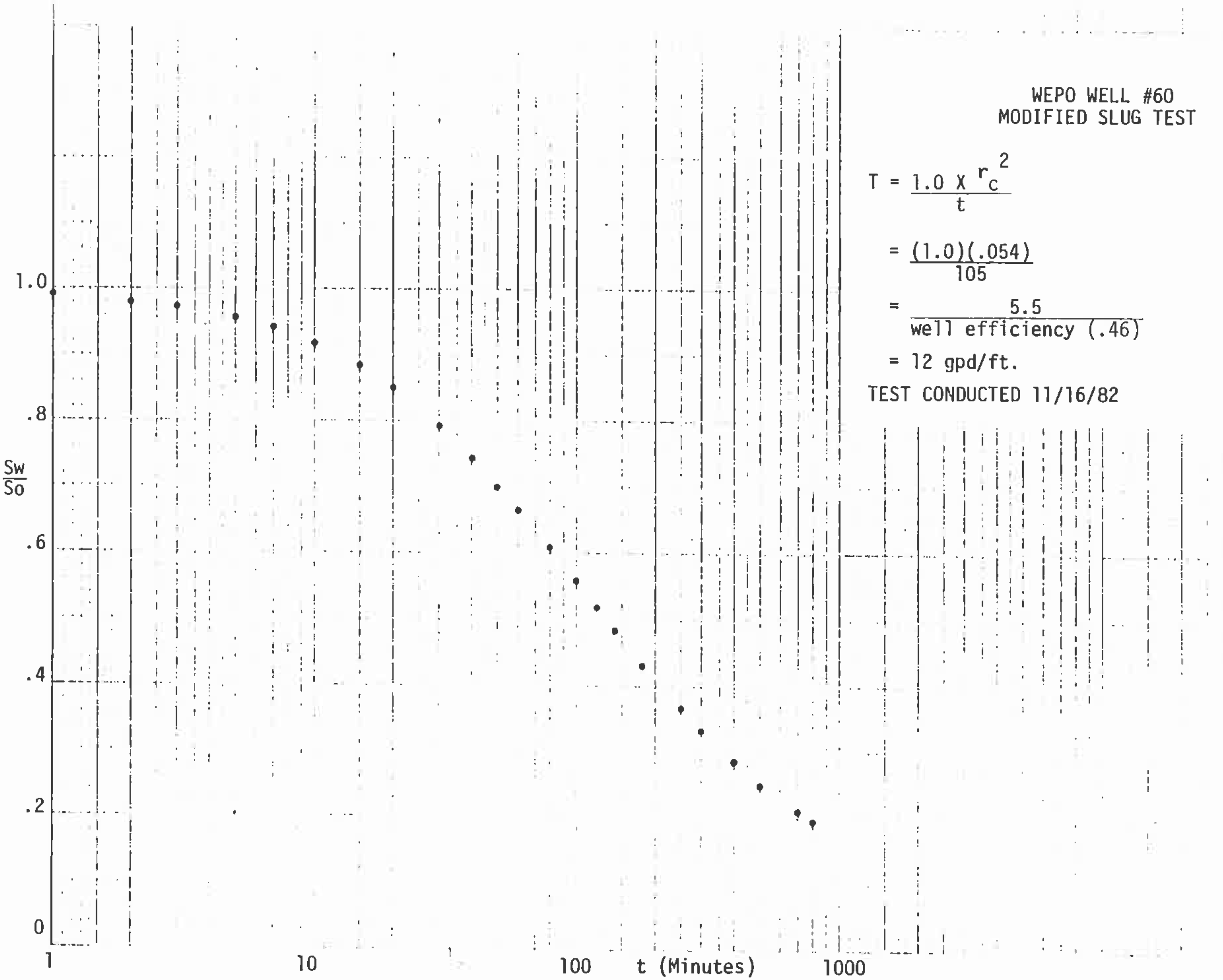
SWL from MP 81.30 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	τ (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
11/16/82		1:36	140	101.03	49.58	.485
		1:56	160	101.03	46.27	.458
		2:16	180	101.03	43.67	.432
		2:36	200	101.03	41.55	.411
		3:26	250	101.03	37.25	.368
		4:16	300	101.03	33.86	.335
		5:56	400	101.03	29.03	.287
		7:36	500	101.03	25.41	.251
		9:06	600	101.03	22.98	.227
		10:46	700	101.03	21.31	.211
11/17/82		12:06	800	101.03	20.05	.198

WATER WELL 60

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
11/16/82	10:06					
	10:19	193	.3109	3.0	.2143	.1999
	10:23	188	.3191	3.0	.0500	.0479
	10:27	174	.3448	3.0	.0428	.0443
	10:31	119	.5042	3.0	.0428	.0647
	10:34	95	.6316	3.0	.0286	.0542
	10:36	78	.7692	3.0	.0286	.0660
	10:40	28	2.1428	3.0	.0214	.1376
	10:41	29	2.0690	3.0	.0143	.0887
	10:42	29	2.0690	3.0	.0143	.0887
	10:43	29	2.0690	3.0	.0143	.0887
	10:44	29	2.0690	3.0	.0143	.0887
	10:45	30	2.0000	3.0	.0214	.1284
	10:47	31	1.9355	3.0	.0286	.1661
	10:49	32	1.8750	3.0	.0286	.1609
	10:51	34	1.7647	3.0	.0286	.1514
	10:53	36	1.6667	3.0	.0286	.1430
	10:55	37	1.6216	3.0	.0286	.1391
	10:57	37	1.6216	3.0	.0286	.1391
	10:59	38	1.5789	3.0	.0286	.1355
	11:01	39	1.5385	3.0	.0286	.1320
	11:03	40	1.5000	3.0	.0286	.1287
	11:05	41	1.4634	3.0	.0286	.1255
	11:07	43	1.3953	3.0	.0286	.1197
	11:09	45	1.3333	3.0	.0286	.1144
	11:11	47	1.2766	3.0	.8571	.3282
	11:16	PUMP OFF				
		TOTAL PUMPING TIME = 70 MINUTES			TOTAL =	3.0814
			AVERAGE WEIGHTED DISCHARGE		=	3.08 g.p.m.



WEPO WELL #60
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{105}$$

$$= \frac{5.5}{\text{well efficiency } (.46)}$$

$= 12$ gpd/ft.

TEST CONDUCTED 11/16/82

PEABODY HYDROLOGIC TESTING   AQUIFER TEST DATA

State Arizona County Navajo T. 34 (N.) S., R. 18 (E.) W., Sec. 6/S WELL NO. 61

Personnel Cochran Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 170'-350' Pump hp. & type 1/3 hp., Berkeley

Pump depth 271 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6506.2 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

SWL from MP 158.87 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
12/22/82	9:09:27					
	9:10					
		9:42		61.21	61.21	1.000
		9:43	1	61.21	60.44	.987
		9:44	2	61.21	59.90	.978
		9:45	3	61.21	59.37	.970
		9:46	4	61.21	58.86	.961
		9:47	5	61.21	58.38	.954
		9:49	7	61.21	57.48	.939
		9:52	10	61.21	56.32	.920
		9:54	12	61.21	55.63	.909
		9:56	14	61.21	54.98	.898
		10:00	18	61.21	53.80	.879
		10:02	20	61.21	53.27	.870
		10:07	25	61.21	52.03	.850
		10:12	30	61.21	50.96	.832
		10:17	35	61.21	50.09	.818
		10:22	40	61.21	49.25	.804
		10:32	50	61.21	46.01	.784
		10:42	60	61.21	46.90	.766
		10:52	70	61.21	45.86	.749
		11:02	80	61.21	44.91	.734
		11:12	90	61.21	44.01	.719
		11:22	100	61.21	43.11	.704
		11:42	120	61.21	41.29	.674
		12:02	140	61.21	39.41	.644
		12:22	160	61.21	37.54	.613
		12:42	180	61.21	35.62	.582

PEABODY HYDROLOGIC TESTING — AQUIFER TEST DATA

State Arizona County Navajo T. 34 (N.) S., R. 18 (E.) W., Sec. 6/S WELL NO. 61

Personnel Cochran Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) modified slug

ʀal well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 170' - 350' Pump hp. & type 1/3 hp., Berkely

Pump depth 271 ft. Aquifer Wepo Aquifer lithology sandstone, sandy shale

Altitude of land surface 6506.2 How determined surveyed

MP Above/Below LSD n/a Altitude MP n/a

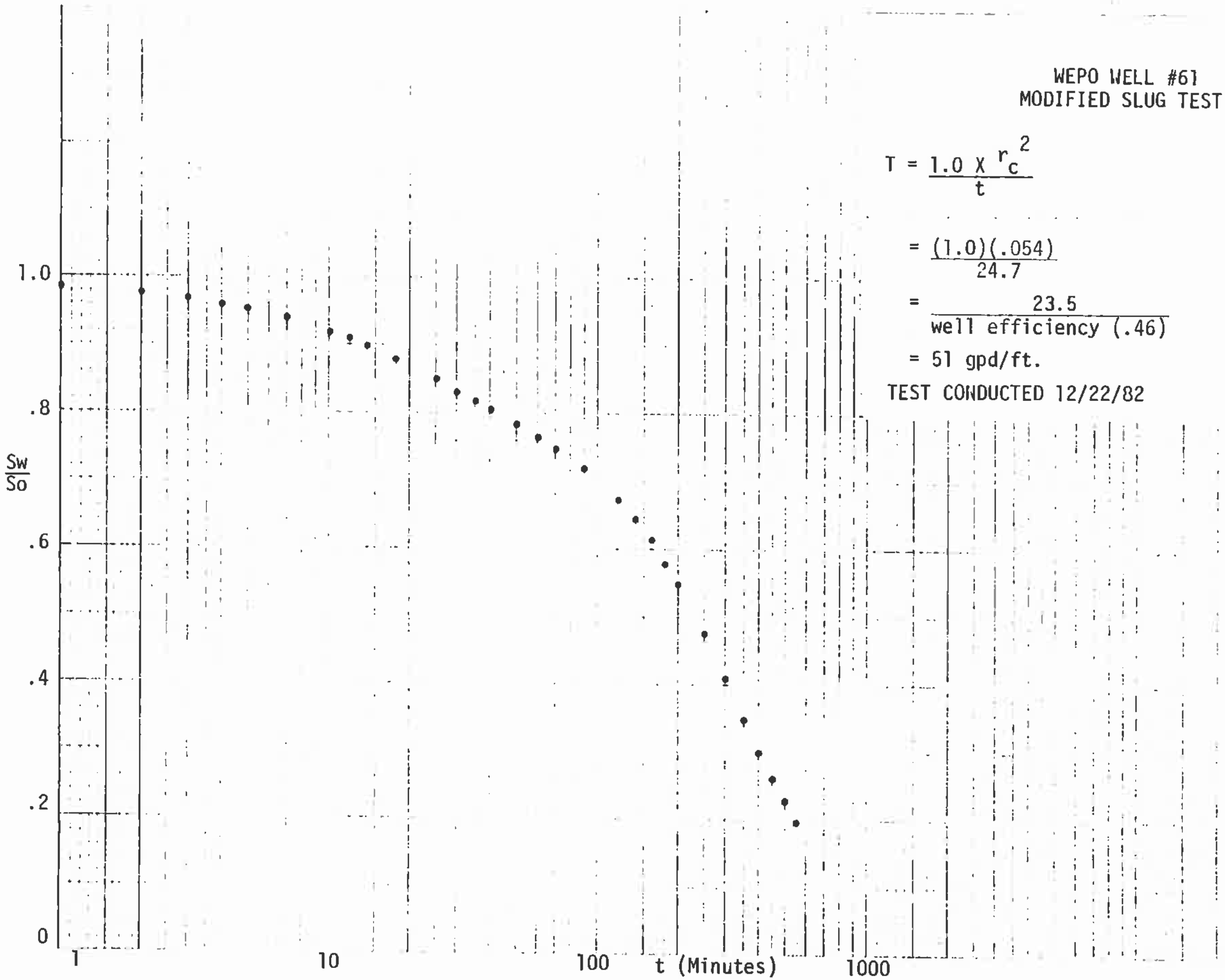
SWL from MP 158.87 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
12/22/82		1:02	200	61.21	33.71	.551
		1:52	250	61.21	29.20	.477
		2:42	300	61.21	25.07	.409
		3:32	350	61.21	21.49	.351
		4:22	400	61.21	18.48	.302
		5:12	450	61.21	15.99	.261
		6:02	500	61.21	13.89	.227
		6:52	550	61.21	12.11	.198

WATER WELL 61

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
12/22/82	9:10	PUMP ON		3.0		
	9:12	53.9	1.113	3.0	.1094	.3653
	9:15	52.0	1.154	3.0	.0937	.3244
	9:18	52.3	1.147	3.0	.1250	.4301
	9:23	53.0	1.132	3.0	.1094	.3715
	9:25	55.0	1.091	3.0	.1094	.3581
	9:30	60.2	.9967	3.0	.1563	.4673
	9:35	63.3	.9478	3.0	.1563	.4444
	9:40	70.1	.8559	3.0	.1406	.3610
	9:42	PUMP OFF			Total	3.1221
	TOTAL PUMPING TIME = 32 MINUTES					
				WEIGHTED AVERAGE	DISCHARGE =	3.1 g.p.m.



WEPO WELL #61
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{24.7}$$

$$= \frac{23.5}{\text{well efficiency } (.46)}$$

$$= 51 \text{ gpd/ft.}$$

TEST CONDUCTED 12/22/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N) S., R. 19 (E) W., Sec. 33 WELL NO. 62

Personnel Dee, Hamilton, Cochran, LaRue Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well Recovery with obs. well (5.) Other (specify) Modified Slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical saw slots

Interval of screen or perforation 150-170 190-220 230-350 Pump hp. & type 3/4 hp. Fairbanks Morse

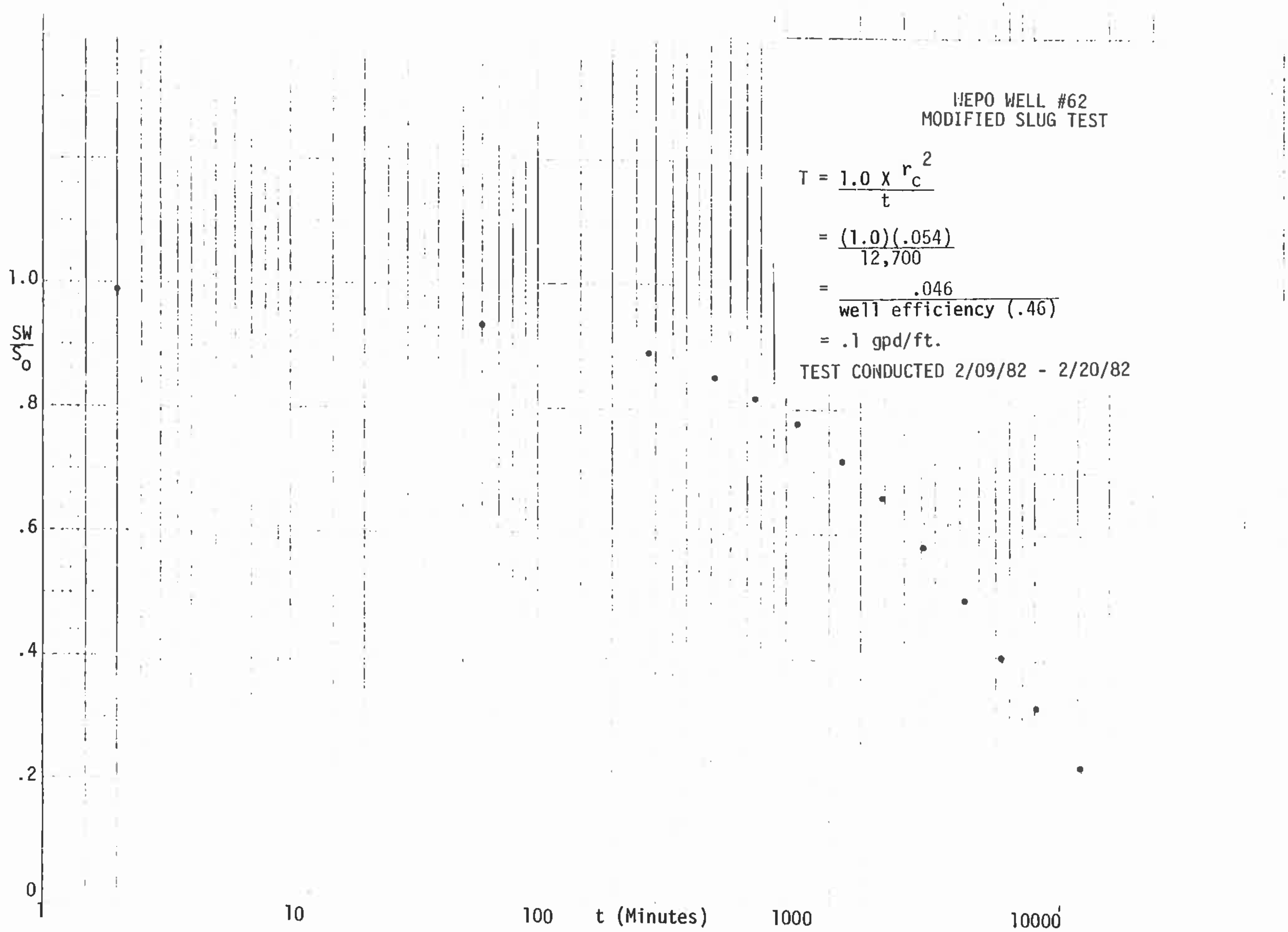
Pump depth 225 ft. Aquifer Wepo Aquifer lithology Sandstone & Sandy Shale

Altitude of land surface 6824 How determined Surveyed

MP Above/Below LSD N/A Altitude MP 6824

SWL from MP 103.86 How measured transducer (SINCO)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
2/09/82	11:55	12:17				
			2	103.14	102.11	.990
			60	103.14	97.04	.934
			283	103.14	91.91	.891
			523	103.14	87.76	.851
2/10/82			763	103.14	84.20	.816
			1123	103.14	80.23	.778
			1363	103.14	77.84	.775
			1723	103.14	74.01	.718
			2083	103.14	70.86	.687
2/11/82			2443	103.14	68.06	.659
			2863	103.14	64.36	.624
			3223	103.14	61.56	.597
			3583	103.14	59.89	.581
2/12/82			3943	103.14	57.75	.560
2/13/82			5263	103.14	51.14	.496
2/14/82			6703	103.14	45.76	.443
			7423	103.14	41.72	.404
2/15/82			8743	103.14	36.90	.357
2/16/82			10,063	103.14	33.36	.323
2/17/82			10,903	103.14	31.25	.301
2/18/82			12,343	103.14	28.20	.272
			13,543	103.14	25.82	.249
2/20/82			15,583	103.14	23.35	.225



HEPO WELL #62
MODIFIED SLUG TEST
$T = \frac{1.0 \times r_c^2}{t}$
$= \frac{(1.0)(.054)}{12,700}$
$= \frac{.046}{\text{well efficiency } (.46)}$
= .1 gpd/ft.
TEST CONDUCTED 2/09/82 - 2/20/82
1.0
.8
.6
.4
.2
0
$\frac{SW}{S_o}$
1
10
100
1000
10000
t (Minutes)

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 36 (N.) S., R. 19 (E.) W., Sec. 35 WELL NO. 63

Personnel Cochran , Smith Driller Elliott

·t type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) Modified Slug

ıotal well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation vertical slotted

Interval of screen or perforation 195-350' Pump hp. & type 3/4 hp., Fairbank Morse

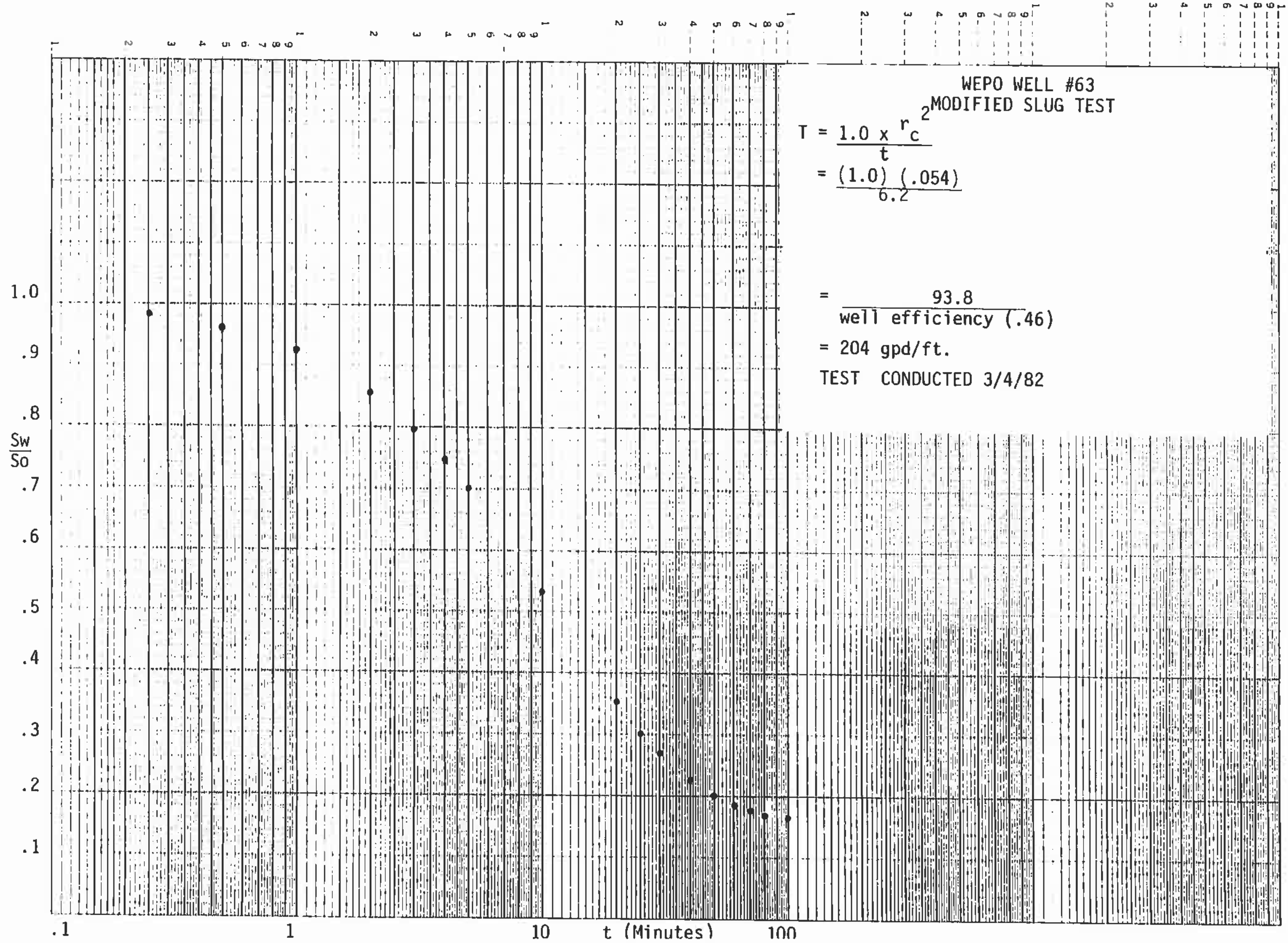
Pump depth 300 ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy Shale

Altitude of land surface 6901.9 How determined Surveyed

MP Above/Below LSD n/a Altitude MP n/a

SWL from MP 226.62 How measured pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
3/4/82	1:56:01					
		1:59:30		9.92	9.92	1.000
		1:59:45	.25	9.92	9.75	.983
		2:00:00	.50	9.92	9.55	.962
		2:00:30	1	9.92	9.18	.925
		2:01:30	2	9.92	8.49	.856
		2:02:30	3	9.92	7.90	.796
		2:03:30	4	9.92	7.39	.745
		2:04:30	5	9.92	6.95	.701
		2:09:30	10	9.92	5.25	.529
		2:19:30	20	9.92	3.49	.352
		2:24:30	25	9.93	2.98	.300
		2:29:30	30	9.92	2.66	.268
		2:39:30	40	9.92	2.22	.224
		2:49:30	50	9.92	1.99	.201
		2:59:30	60	9.92	1.83	.184
		3:09:30	70	9.92	1.76	.177
		3:19:30	80	9.92	1.67	.168
		3:39:30	100	9.92	1.63	.164



WEPO WELL #63
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)\ (.054)}{6.2}$$

$$= \frac{93.8}{\text{well efficiency } (.46)}$$

= 204 gpd/ft.

TEST CONDUCTED 3/4/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N) S., R. 19 (E) W., Sec. 3 WELL NO. 64

Personnel Cochran, Smith, Hamilton Driller Bean

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) Modified Slug

al well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation saw slots

Interval of screen or perforation 120-132, 153-177, 193-205, 219-245, 250-330 Pump hp. & type 3/4 hp. Fairbanks Morse

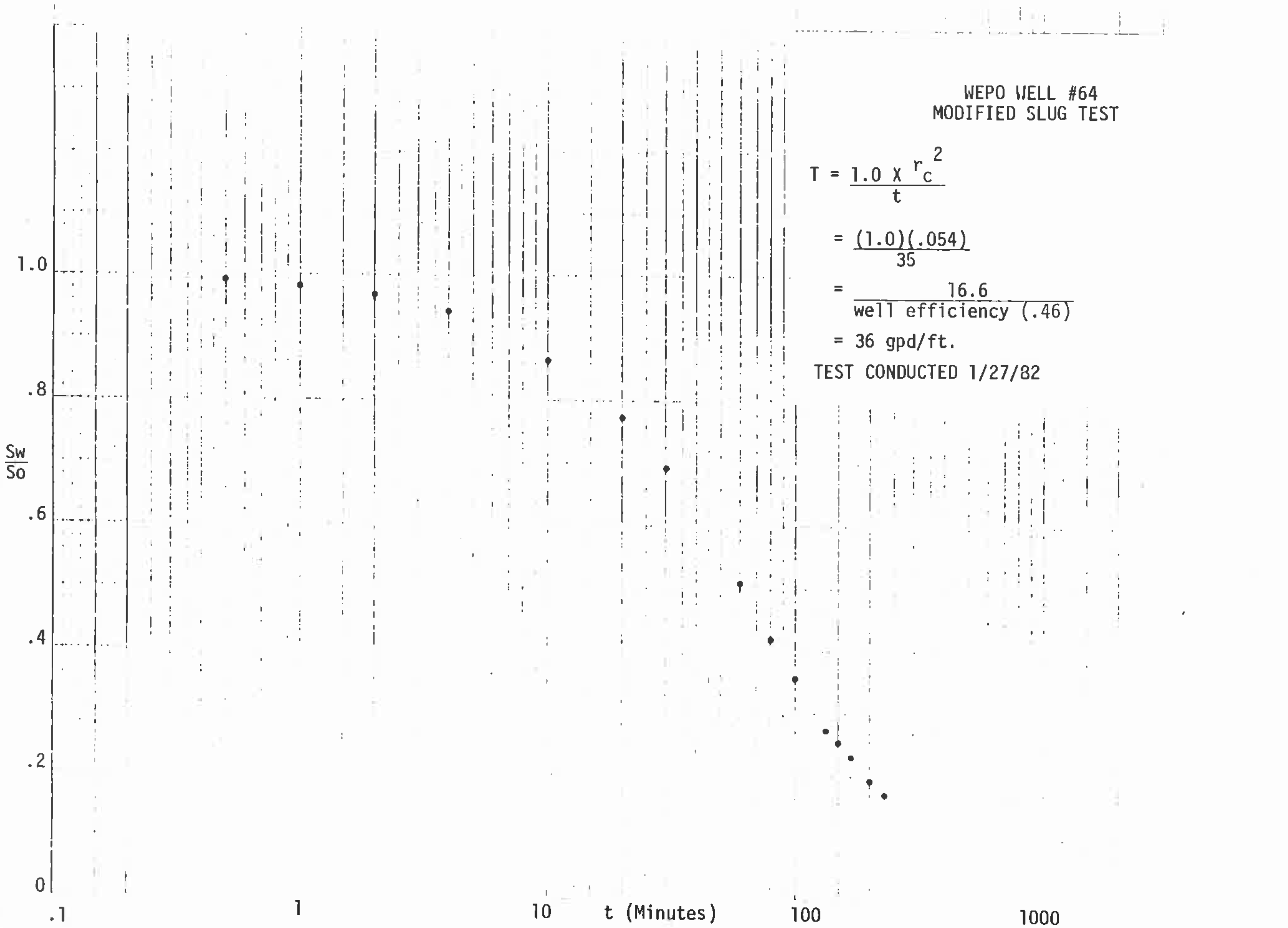
Pump depth 275 ft. Aquifer Wepo Aquifer lithology Sandstone & Sandy Shale

Altitude of land surface 6842 How determined surveyed

MP Above/Below LSD .61 Altitude MP 6842.6

SWL from MP 231.54 How measured Pressure Transducer

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
1/27/82	11:00	11:10				
			.5	36.30	36.04	.993
			1	36.30	35.74	.984
			2	36.30	35.21	.970
			4	36.30	34.22	.943
			10	36.30	31.39	.865
			20	36.30	28.10	.774
			30	36.30	25.15	.693
			60	36.30	18.47	.509
			70	36.30	16.89	.465
			80	36.30	15.32	.422
			100	36.30	12.99	.358
			135	36.30	10.00	.275
			150	36.30	9.26	.255
			170	36.30	8.38	.231
			200	36.30	7.14	.197
			230	36.30	6.29	.173



WEPO WELL #64
MODIFIED SLUG TEST

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{(1.0)(.054)}{35}$$

$$= \frac{16.6}{\text{well efficiency } (.46)}$$

= 36 gpd/ft.

TEST CONDUCTED 1/27/82

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 19 (E.) W., Sec. 14 WELL NO. 64R

Personnel Roznovak, Andrew Driller Circle G Drilling Co.

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
. Recovery with obs. well (5.) Other (specify) Modified Slug

Total Well Depth 129 ft. Well diameter 9 3/4 in. Casing diameter 6 in.
Casing type PVC Type of screen or perforation saw slot
Interval of screen or perforation ______ Pump hp. & type 1/3 submersible
Pump depth 100 ft. Aquifer Wepo Aquifer lithology Sandstone, shale, coal, etc.
Altitude of land surface ______ How determined surveyed
MP Above / Below LSD ______ Altitude MP ______
SWL from MP ______ How measured ______

DATE	TIME (MINS)	WATER LEVEL INDICATOR READING	Ho (ft)	H/Ho
10-22-85	0	54.03	22.80	1.0
	1	53.52		.98
	2	53.07		.96
	3	52.69		.94
	4	52.35		.93
	5	52.07		.91
	6	51.78		.90
	7	51.54		.89
	8	51.34		.88
	9	51.12		.87
	10	50.96		.87
	15	50.06		.83
	20	49.32		.79
	25	48.70		.77
	30	48.14		.74
	35	47.60		.72
	40	47.18		.70
	45	46.82		.68
	50	46.44		.67
	55	45.81		.64
	60	45.24		.61
	70	44.74		.59
	80	44.32		.57
	90	43.93		.56
	100	43.57		.54
	110	43.57		.54
	120	43.25		.53
	130	42.97		.51
	140	42.73		.50

PEABODY HYDROLOGIC TESTING — AQUIFER TEST DATA

State Arizona — County Navajo — T. 35 (N.) S., R. 19 (E.) W., Sec. 14 — WELL NO. 64R

Personnel Roznovak, Andrew — Driller Circle G Drilling Co.

Test type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
. Recovery with obs. well (5.) Other (specify) Modified Slug

otal Well Depth 129 ft. Well diameter 9 3/4 in. Casing diameter 6 in.

Casing type PVC — Type of screen or perforation saw slot

Interval of screen or perforation ______ — Pump hp. & type 1/3 submersible

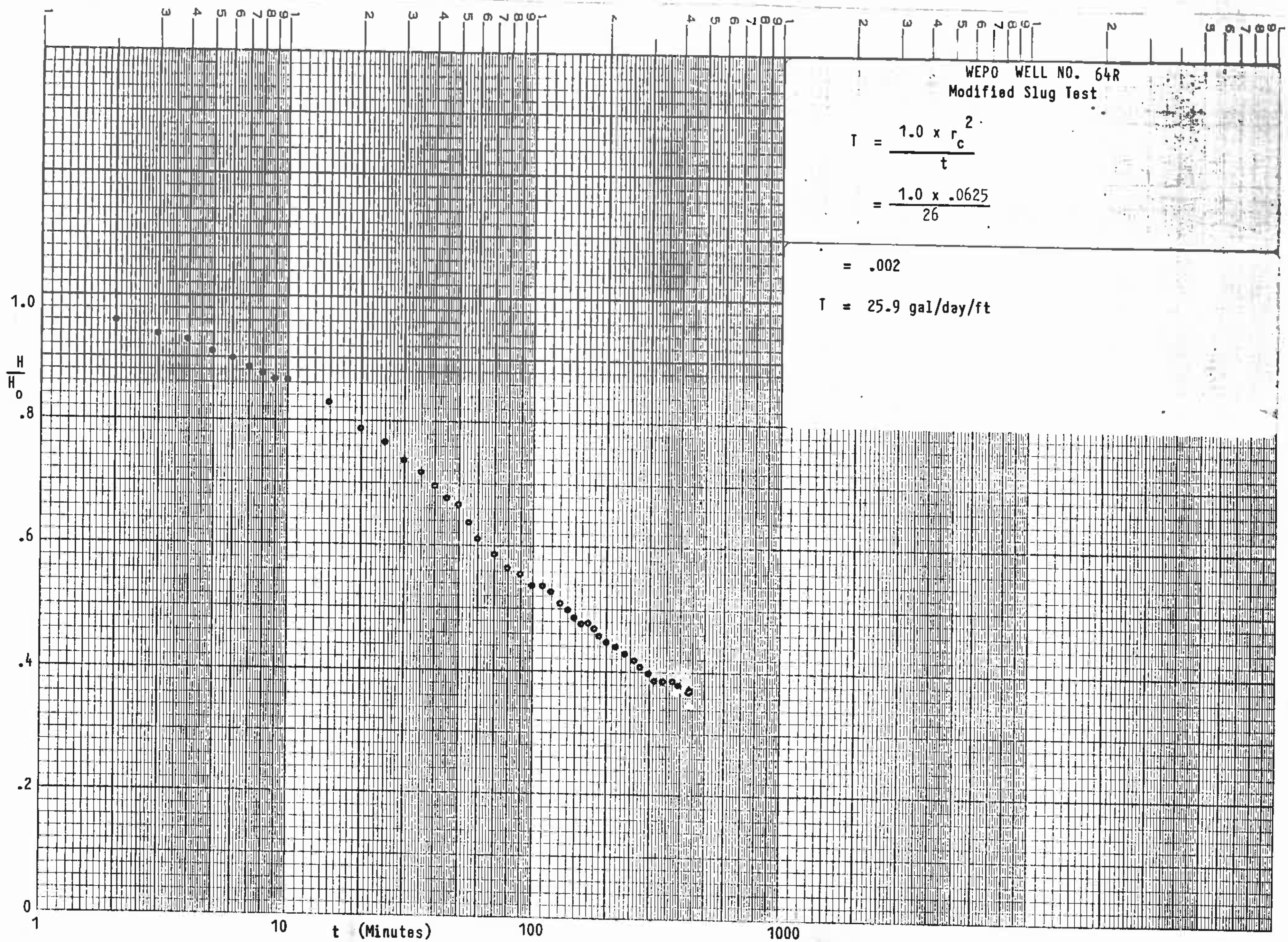
Pump depth 100ft. Aquifer Wepo — Aquifer lithology Sandstone, shale, coal, etc.

Altitude of land surface ______ — How determined surveyed

MP Above / Below LSD ______ — Altitude MP ______

SWL from MP ______ — How measured ______

DATE	TIME (MINS)	WATER LEVEL INDICATOR READING	Ho (ft)	$H/_{Ho}$
10-22-85	150	42.47	22.80	.49
	160	42.26		.48
	170	42.05		.48
	180	41.86		.47
	190	41.70		.46
	200	41.53		.45
	220	41.25		.44
	240	40.97		.43
	260	40.74		.42
	280	40.58		.41
	300	40.40		.40
	320	40.20		.39
	340	40.11		.39
	360	40.00		.39
	380	39.89		.38
	400	39.77		.38
	440	39.61		.37



WEPO WELL NO. 64R
Modified Slug Test

$$T = \frac{1.0 \times r_c^2}{t}$$

$$= \frac{1.0 \times .0625}{26}$$

$$= .002$$

T = 25.9 gal/day/ft

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.)/S., R. 19 (E.)/W., Sec. 17 WELL NO. 65

Personnel Cochran, Dee Driller Elliott

st type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
Recovery with obs. well (5.) Other (specify) Modified Slug

Total well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation Slotted

Interval of screen or perforation 190'-350' Pump hp. & type 2hp., Red Jacket

Pump depth 157 ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy Shale

Altitude of land surface 6814.0 How determined Surveyed

MP Above/Below LSD 1.30 Altitude MP n/a

SWL from MP 112.32 How measured Pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
4/28/82	12:40				(140.46)	
		12:42:06				
		12:42:11	.05	28.14	28.14	1.000
		12:42:41	.57	28.14	26.06	.926
		12:43:11	1.05	28.14	25.12	.893
		12:44:11	2.05	28.14	24.04	.854
		12:45:11	3:05	28.14	23.10	.821
		12:52:01	9.90	28.14	18.67	.663
		12:54:01	11.90	28.14	16.33	.580
		12:57:01	14.90	28.14	14.58	.518
		12:59:01	16.90	28.14	13.55	.481
		1:02:01	19.90	28.14	12.17	.432
		1:07:01	24.90	28.14	10.35	.368
		1:12:01	29.90	28.14	9.07	.322
		1:17:01	34.90	28.14	8.08	.287
		1:22:01	39.90	28.14	7.28	.259
		1:27:01	44.90	28.14	6.64	.236
		1:32:01	49.90	28.14	6.08	.216
		1:37:01	54.90	28.14	5.63	.200
		1:42:01	59.90	28.14	5.26	.187
		1:47:01	64.90	28.14	4.94	.175
		1:52:01	69.90	28.14	4.68	.166
		1:57:01	74.90	28.14	4.48	.159
		2:02:01	79.90	28.14	4.27	.152
		2:07:01	84.90	28.14	4.11	.146
		2:12:01	89.90	28.14	3.95	.140
		2:17:01	94.90	28.14	3.83	.136
		2:22:01	99.90	28.14	3.70	.131

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State Arizona County Navajo T. 35 (N.) S., R. 19 (E.) W., Sec. 17 WELL NO. 65

Personnel Cochran, Dee Driller Elliott

-st type: 1. Single well drawdown 2. Single well recovery 3. Drawdown with obs. well Recovery with obs. well (5.) Other (specify) Modified Slug

-cal well depth 350 ft. Well diameter 9 in. Casing diameter 6 in.

Casing type pvc Type of screen or perforation Slotted

Interval of screen or perforation 190',-350', Pump hp. & type 2hp., Red Jacket

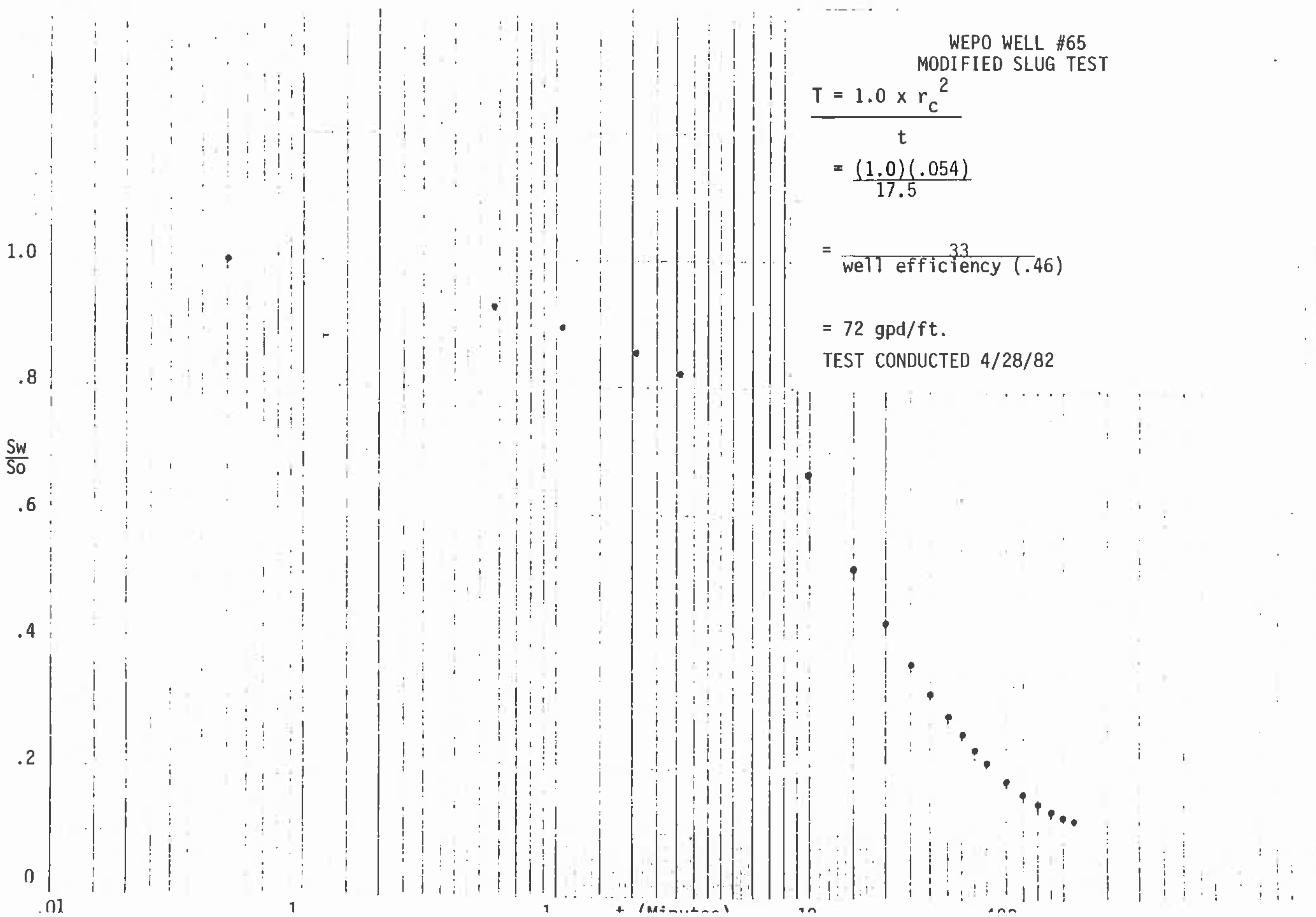
Pump depth 157 ft. Aquifer Wepo Aquifer lithology Sandstone, Sandy Shale

Altitude of land surface 6814.0 How determined Surveyed

MP Above/Below LSD 1.30 Altitude MP n/a

SWL from MP 112.32 How measured Pressure transducer (Sinco)

DATE	PUMP ON	PUMP OFF	t (time since pump off, min.)	So (ft.)	Sw (ft.)	Sw/So
4/28/82		2:27:01	104.9	28.14	3.58	.127
		2:32:01	109.9	28.14	3.51	.125


WEPO WELL #65
MODIFIED SLUG TEST
T = 1.0 x rc2 / t
= (1.0)(.054) / 17.5
= 33 / well efficiency (.46)
= 72 gpd/ft.
TEST CONDUCTED 4/28/82
1.0
.8
Sw/So
.6
.4
.2
0

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State AZ County Navajo T. 35 (N.) S., R. 19 (E.) W., Sec. 23 WELL NO. 66

Personnel Burke Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well
' Recovery with obs. well 5. Other (specify)

.l well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

Casing type P.V.C. Type of screen or perforation Vertical saw slots

Interval of screen or perforation Zones from 115' - 350' Pump hp. & type 3/4 hp Fairbanks/Moors

Pump depth 185 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface 6901.6' How determined Surveyed

MP (Above) Below LSD 1.57' Altitude MP 6903.2'

SWL from MP 83.18' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t¹, MIN.	t/t¹	S, FT. RESIDUAL DRAWDOWN
10/12/80	08:59:30	83.18	Pump Off			
	09:00:00		Pump On			
	09:06:30	105.00	6.5			21.82
	09:07:00	106.10	7.0			22.92
	09:07:30	106.95	7.5			23.77
	09:08:00	107.82	8.0			24.64
	09:08:30	108.80	8.5			25.62
	09:09:00	109.90	9.0			26.72
	09:09:30	110.85	9.5			27.67
	09:10:00	111.57	10.0			28.39
	09:11:00	113.35	11.0			30.17
	09:12:00	114.80	12.0			31.62
	09:13:00	116.40	13.0			33.22
	09:14:00	117.90	14.0			34.72
	09:15:00	119.40	15.0			36.22
	09:16:00	121.04	16.0			37.86
	09:17:00	122.43	17.0			39.25
	09:18:00	123.82	18.0			40.64
	09:19:00	125.20	19.0			42.02
	09:20:00	126.50	20.0			43.32
	09:22:00	129.00	22.0			45.82
	09:24:00	131.32	24.0			48.14
	09:26:00	133.70	26.0			50.52
	09:28:00	135.76	28.0			52.58
	09:30:00	137.72	30.0			54.54
	09:33:00	140.60	33.0			57.42
	09:36:00	143.12	36.0			59.94
	09:39:00	145.40	39.0			62.22

PEABODY HYDROLOGIC TESTING AQUIFER TEST DATA

State AZ County Navajo T. 35 (N.) S., R. 19 (E.) W., Sec. 23 WELL NO. 66

Personnel Burke Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well 4. Recovery with obs. well 5. Other (specify)

al well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

sing type P.V.C. Type of screen or perforation Vertical saw slots

Interval of screen or perforation Zones from 115' - 350' Pump hp. & type 3/4 hp Fairbanks/Moo

Pump depth 185 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface 6901.6' How determined Surveyed

MP (Above) Below LSD 1.57' Altitude MP 6903.2'

SWL from MP 83.18' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t', MIN.	t/t'	S, FT. RESIDUAL DRAWDOWN
10/12/80	09:42:00	147.43	42.0			64.25
	09:45:00	150.15	45.0			66.97
	09:51:30	153.72	51.5			70.54
	09:55:00	155.21	55.0			72.03
	10:00:00	157.42	60.0			74.24
	10:05:00	159.25	65.0			76.07
	10:10:00	160.85	70.0			77.67
	10:15:00	162.25	75.0			79.07
	10:20:00	163.45	80.0			80.27
	10:25:00	164.70	85.0			81.52
	10:30:00	165.64	90.0			82.46
	10:35:00	166.57	95.0			83.39
	10:40:00	167.45	100.0			84.27
	10:50:00	168.85	110.0			85.67
	11:00:00	170.14	120.0			86.96
	11:10:00	171.15	130.0			87.97
	11:20:00	172.15	140.0			88.97
	11:30:00	172.90	150.0			89.72
	11:40:00	173.62	160.0			90.44
	11:50:00	174.14	170.0			90.96
	12:00:00	174.65	180.0			91.47
	12:10:00	175.10	190.0			91.92
	12:20:00	175.49	200.0			92.31
	12:30:00	175.95	210.0			92.77
	12:40:00	176.25	220.0			93.07
	12:50:00	176.57	230.0			93.39
	13:00:00	176.95	240.0			93.77
	13:10:00	177.38	250.0			94.20

PEABODY HYDROLOGIC TESTING

AQUIFER TEST DATA

State AZ County Navajo T. 35 (N.) S., R. 19 (E.) W., Sec. 23 WELL NO. 66

Personnel Burke Driller Elliott

Test type: (1.) Single well drawdown 2. Single well recovery 3. Drawdown with obs. well

4 Recovery with obs. well 5. Other (specify)

al well depth 350 ft. Well diameter 9.0 in. Casing diameter 6.0 in.

sing type P.V.C. Type of screen or perforation Vertical saw slots

Interval of screen or perforation Zones from 115' - 350' Pump hp. & type 3/4 hp Fairbanks/Moo

Pump depth 185 ft. Aquifer Wepo Form Aquifer lithology Sandstone, sandy shale

Altitude of land surface 6901.6' How determined Surveyed

MP (Above) Below LSD 1.57' Altitude MP 6903.2'

SWL from MP 83.18' How measured Galvanometer

DATE	TIME	DEPTH TO WATER LEVEL	TIME SINCE PUMP ON t, MIN.	TIME SINCE PUMP OFF t¹, MIN.	t/t¹	S, FT. RESIDUAL DRAWDOWN
10/12/80	13:30:00	178.25	270.0			95.07
	13:50:00	178.80	290.0			95.62
	14:10:00	179.25	310.0			96.07
	14:30:00	179.60	330.0			96.42
	14:50:00	180.40	350.0			97.22
	15:10:00	180.98	370.0			97.80
	15:30:00	181.65	390.0			98.47
	15:50:00	182.15	410.0			98.97

WATER WELL 66

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
10/12/80	09:02	24.5	2.45	3.7	0.007	0.063
	09:04	23.7	2.53	3.7	0.005	0.049
	09:06	24.2	2.48	3.7	0.005	0.046
	09:08	24.0	2.50	3.7	0.005	0.046
	09:10	24.0	2.50	3.7	0.010	0.093
	09:15	24.6	2.44	3.7	0.012	0.108
	09:20	24.6	2.44	3.7	0.012	0.108
	09:25	26.0	2.31	3.7	0.012	0.103
	09:30	25.0	2.40	3.7	0.012	0.107
	09:35	26.0	2.31	3.7	0.012	0.103
	09:40	26.2	2.29	3.7	0.012	0.102
	09:45	26.1	2.30	3.7	0.012	0.102
	09:50	26.9	2.23	3.7	0.017	0.140
	10:00	26.8	2.24	3.7	0.024	0.199
	10:10	26.5	2.26	3.7	0.024	0.201
	10:20	26.7	2.25	3.7	0.024	0.200
	10:30	27.2	2.21	3.7	0.024	0.196
	10:40	27.5	2.18	3.7	0.024	0.193
	10:50	28.2	2.13	3.7	0.024	0.189
	11:00	27.5	2.18	3.7	0.024	0.194
	11:10	27.6	2.17	3.7	0.037	0.297
	11:30	28.0	2.14	3.7	0.049	0.388
	11:50	28.8	2.08	3.7	0.049	0.377
	12:10	28.1	2.13	3.7	0.049	0.386
	12:30	28.0	2.14	3.7	0.049	0.388
	12:50	29.1	2.06	3.7	0.049	0.373
	13:10	28.5	2.10	3.7	0.049	0.381
	13:30	28.0	2.14	3.7	0.049	0.388
	13:50	28.8	2.08	3.7	0.049	0.377
	14:10	28.5	2.10	3.7	0.049	0.381
	14:30	28.5	2.10	3.7	0.049	0.381
	14:50	28.3	2.12	3.7	0.049	0.384

WATER WELL 66

PUMPING RATE DATA

DATE	TIME TEST TAKEN	TEST DURATION SEC.	TEST DURATIONS PER MIN.	VOLUME OF DISCHARGE, GALS.	TIME WEIGHTED DURATION	WEIGHTED AVERAGE DISCHARGE Q
10/12/80	15:10	28.0	2.14	3.7	0.049	0.388
	15:30	29.1	2.06	3.7	0.049	0.373
	15:48	29.1	2.06	3.7	0.024	0.183
	15:50	Pump Off				
					TOTAL	7.99
					Weighted	
					Discharge	
					G.P.M.	

WEPO WELL #66
TIME DRAWDOWN TEST

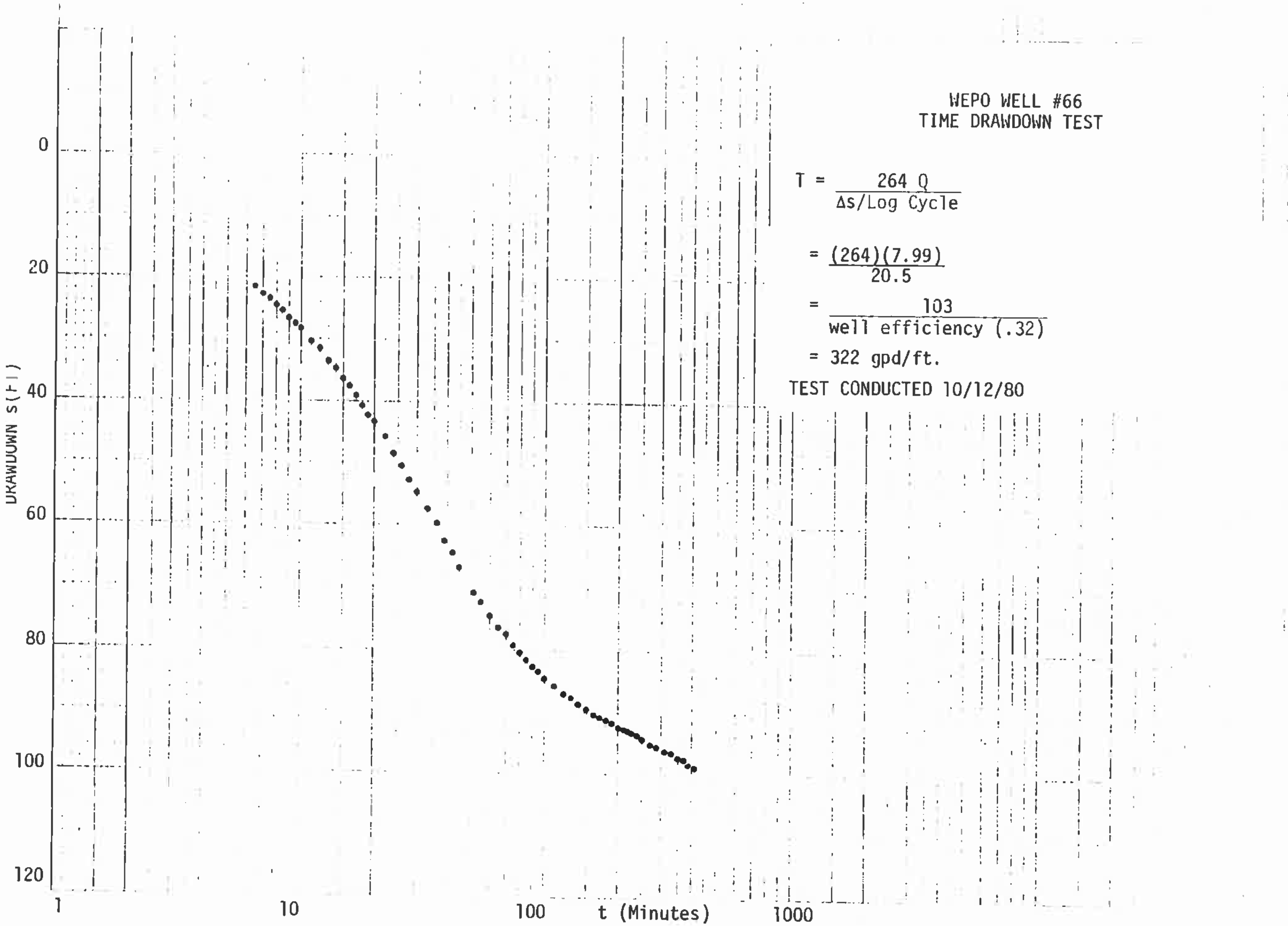
$$T = \frac{264\ Q}{\Delta s/\text{Log Cycle}}$$

$$= \frac{(264)(7.99)}{20.5}$$

$$= \frac{103}{\text{well efficiency } (.32)}$$

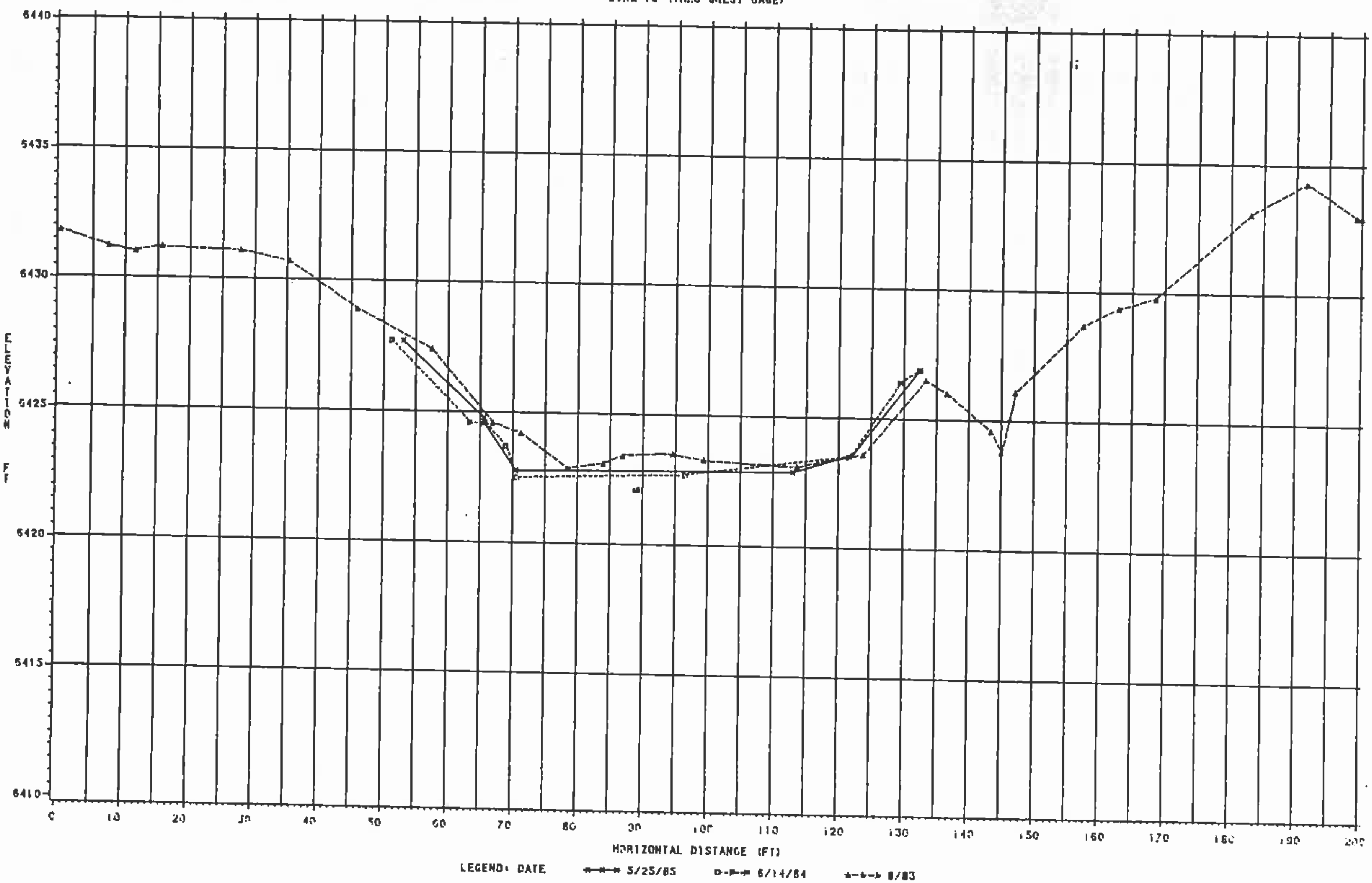
= 322 gpd/ft.

TEST CONDUCTED 10/12/80



CROSS SECTI. . AT SITE 14

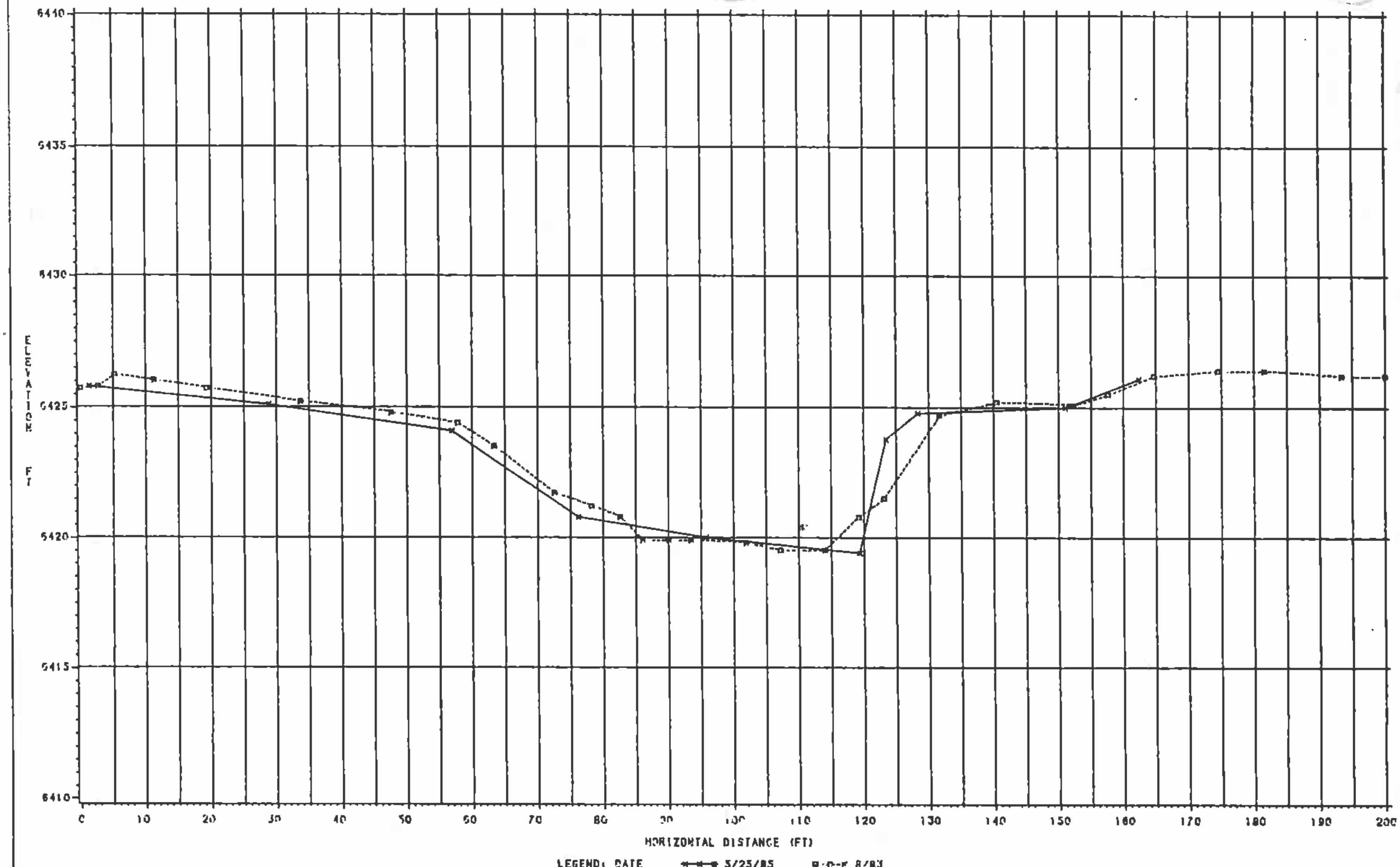
LINE 10 (THRU CREST GAGE)



VIEW LOOKING UPSTREAM

NOTE: 8/83 LINE IS ON A DIFFERENT BEARING THAN THE OTHERS. IT CROSSES THE OTHER LINES AT 65 FT AND IS 11 FT OFF AT 132 FT

CROSS SECTI[illegible] T SITE 14

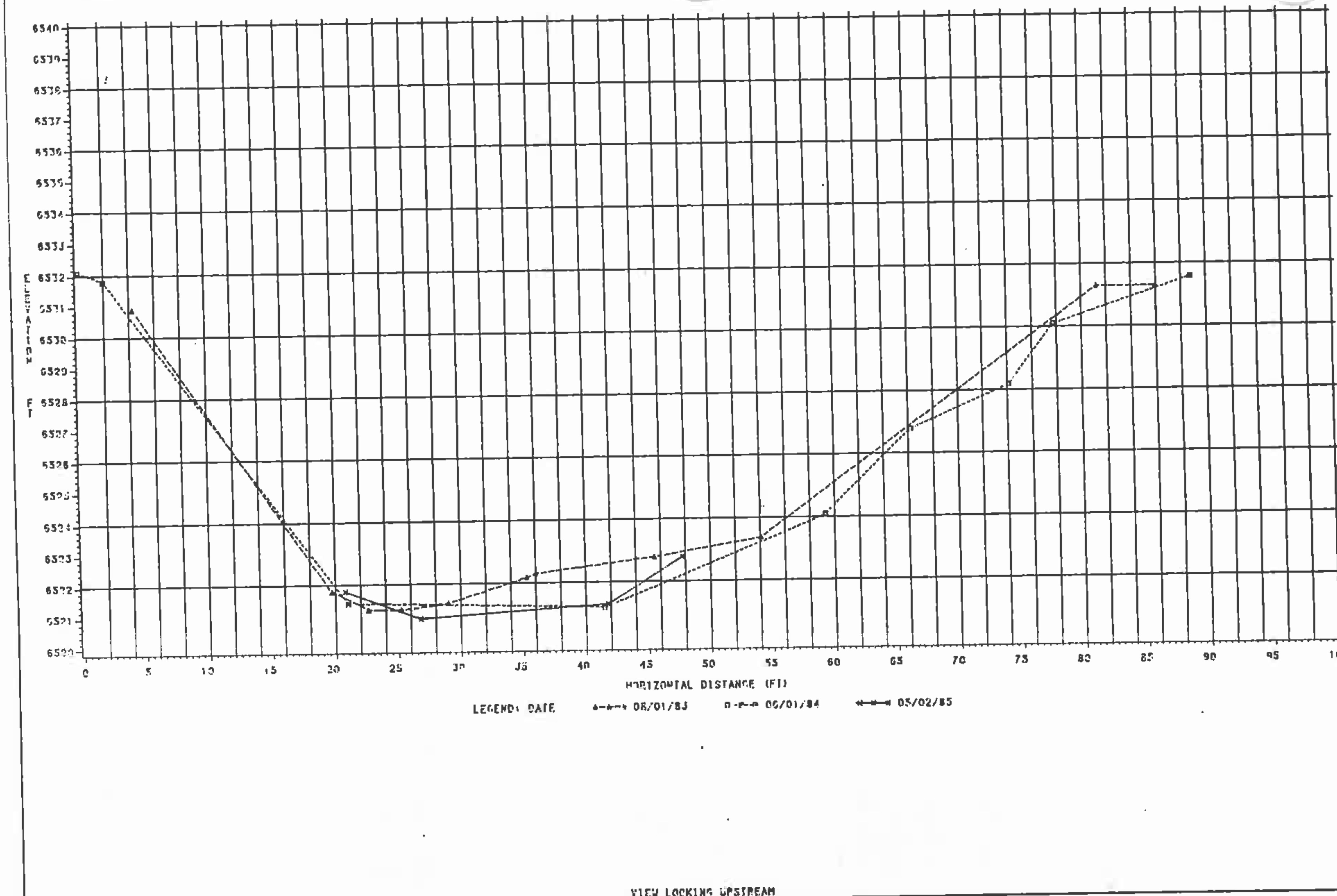


VIEW LOOKING UPSTREAM

NOTE:

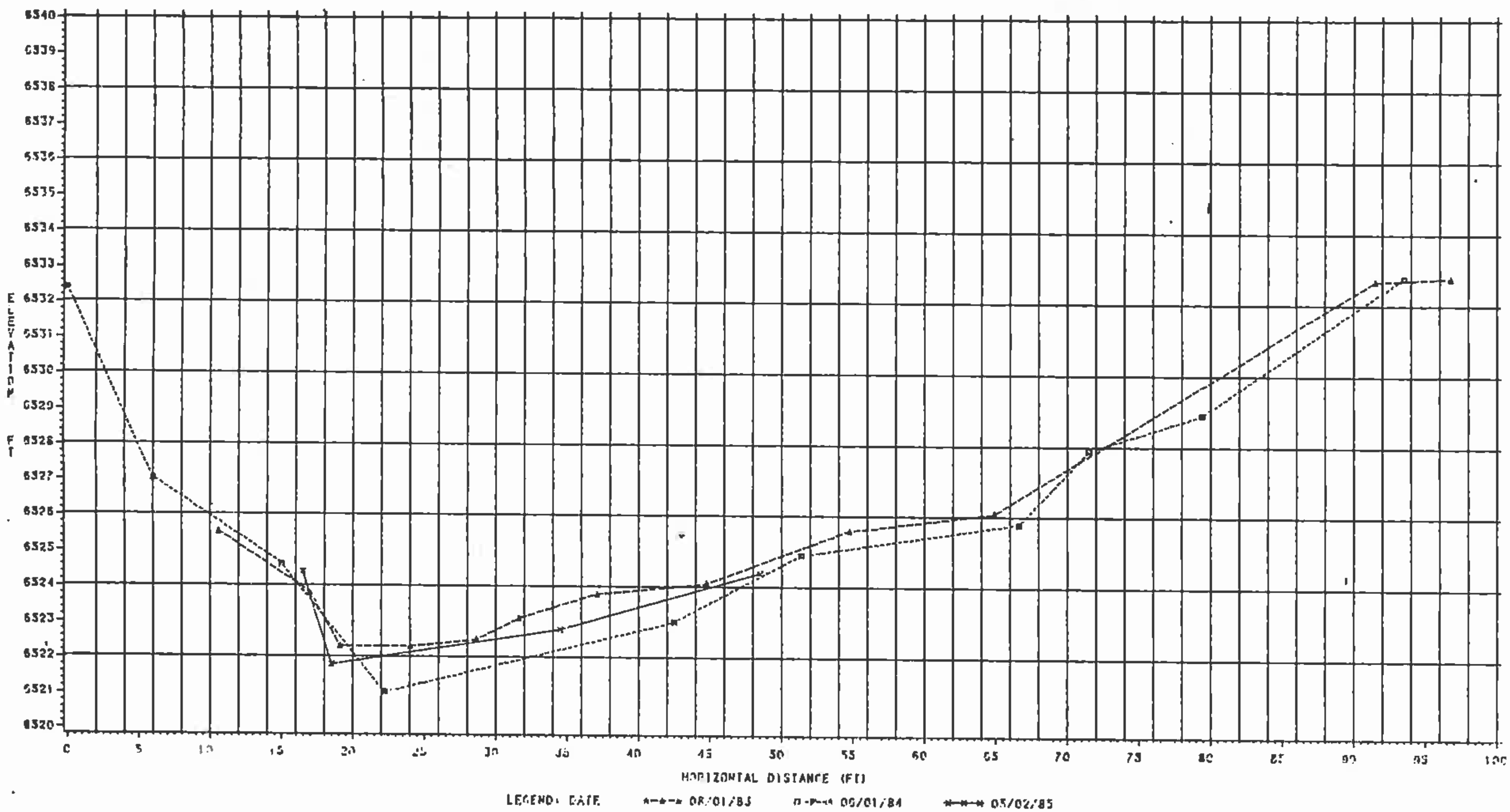
VIEW LOOKING UPSTREAM
NOTE: 8/83 LINE IS ABOUT 1 FT UPSTREAM OF THE 5/85 LINE IN THE CHANNEL BOTTOM

CROSS SECT[illegible] T SITE 15



CROSS SEC[illegible]N AT SITE 15

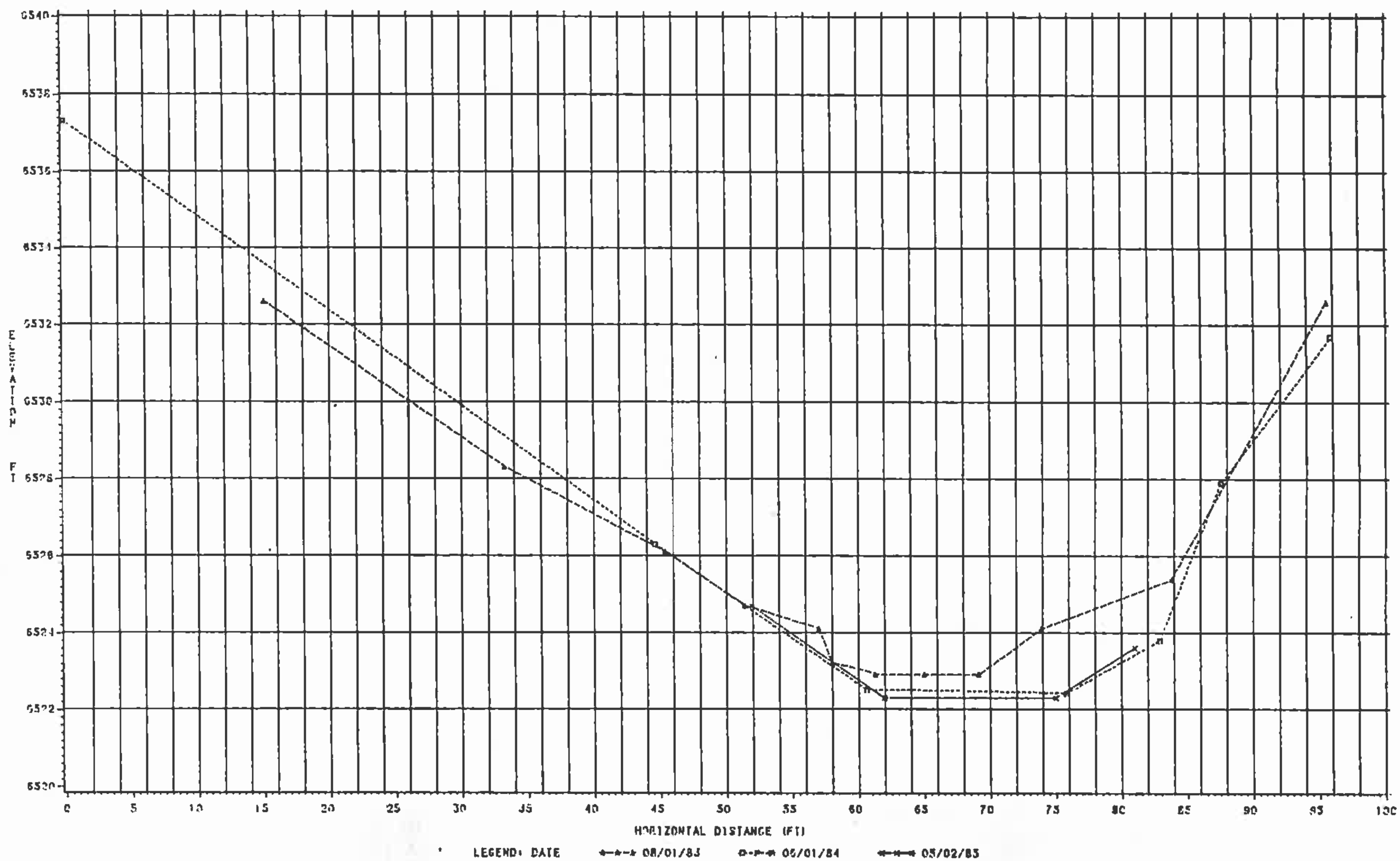
LINE 8



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 15

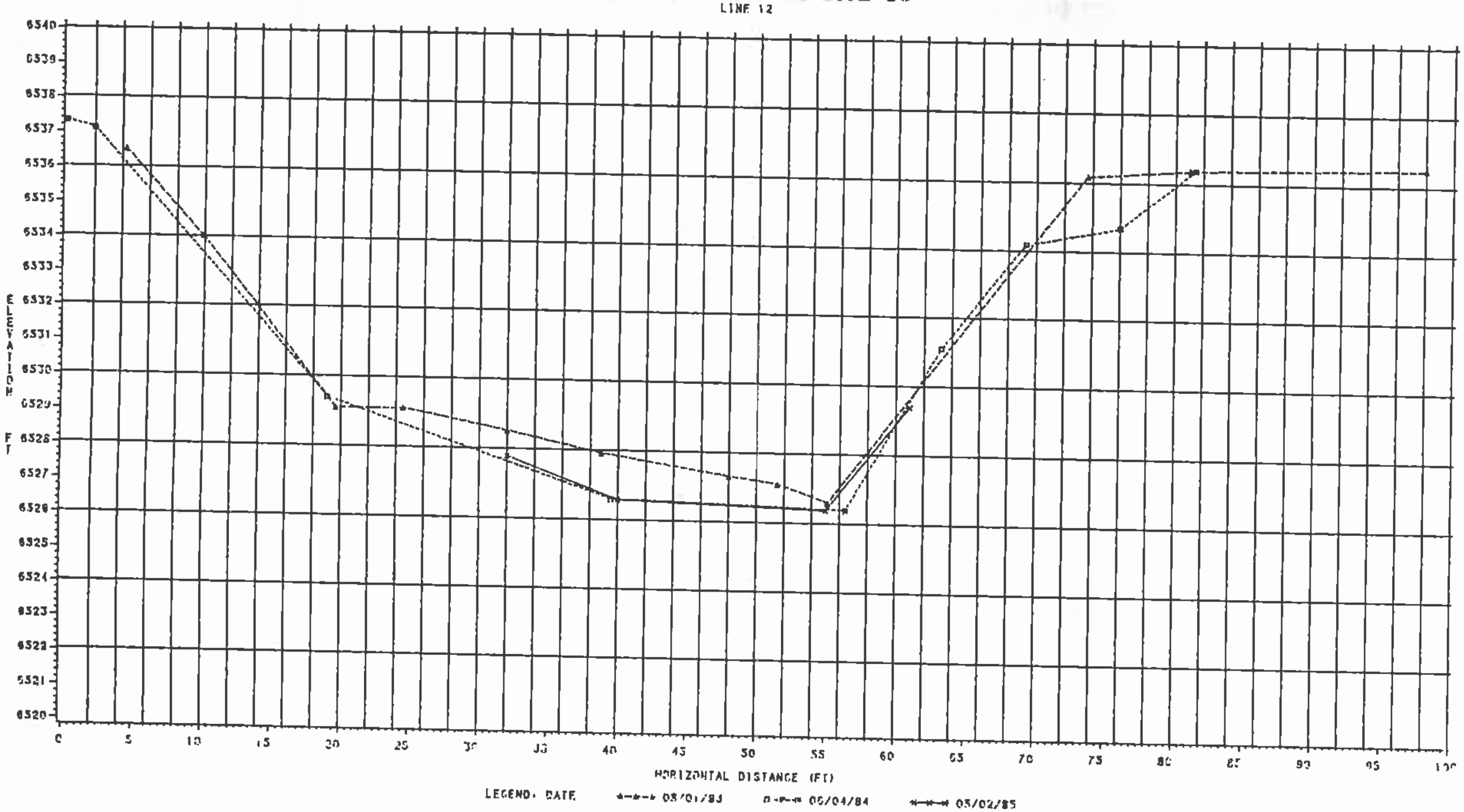
LINE 9



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 15

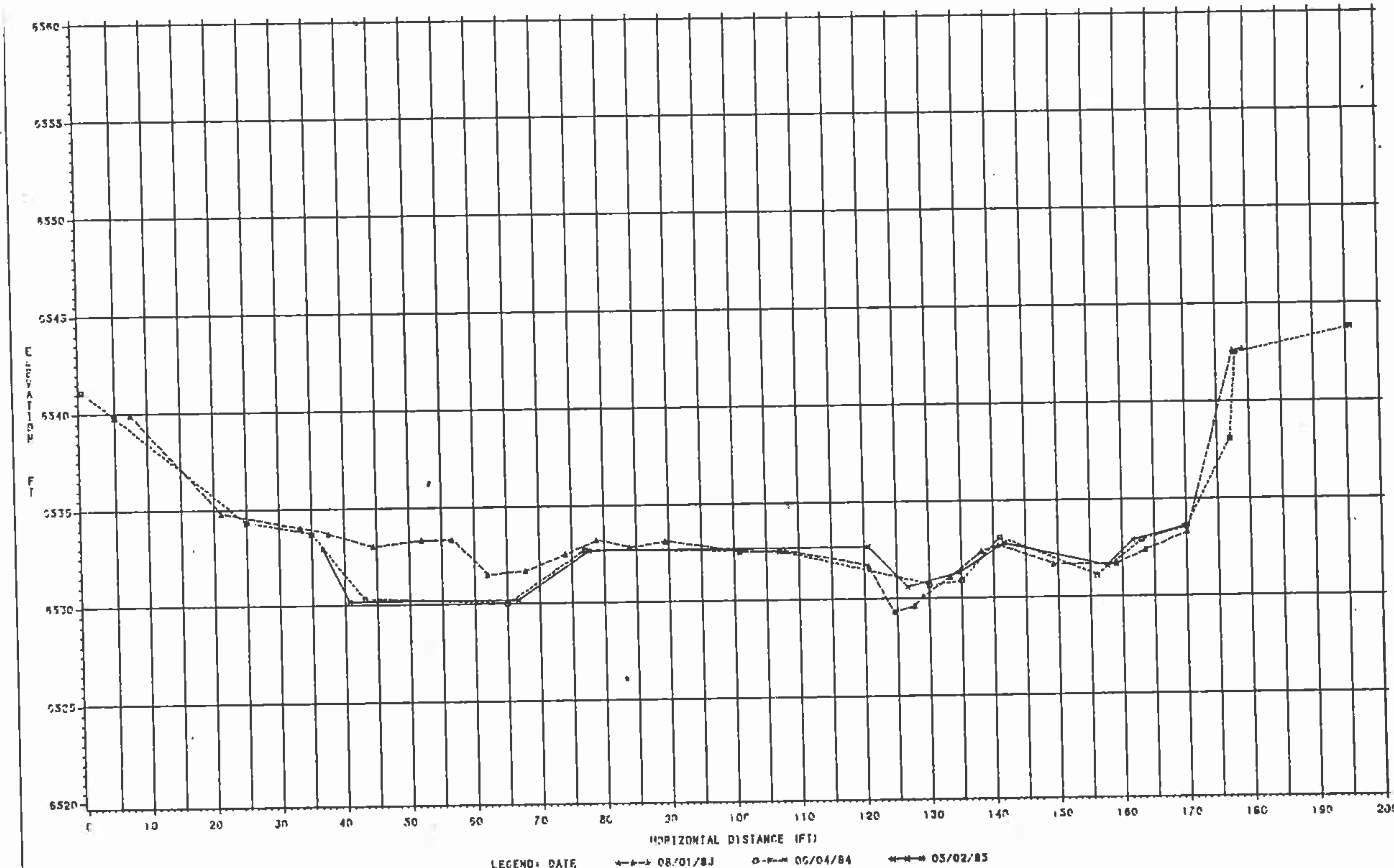
LINE 12



VIEW LOOKING UPSTREAM

CROSS SECTI[illegible] AT SITE 15

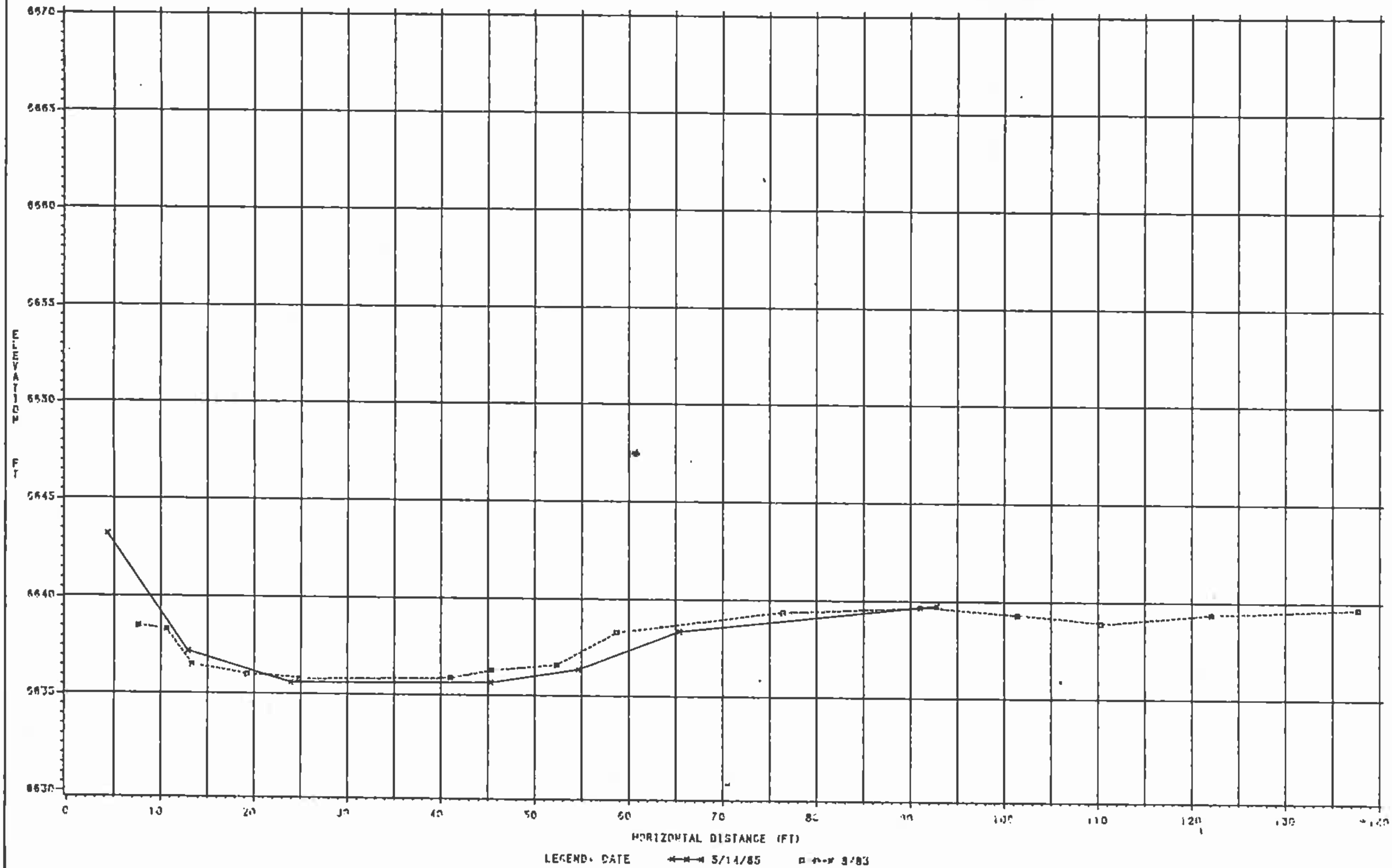
LINE 16



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 16

LINE 8

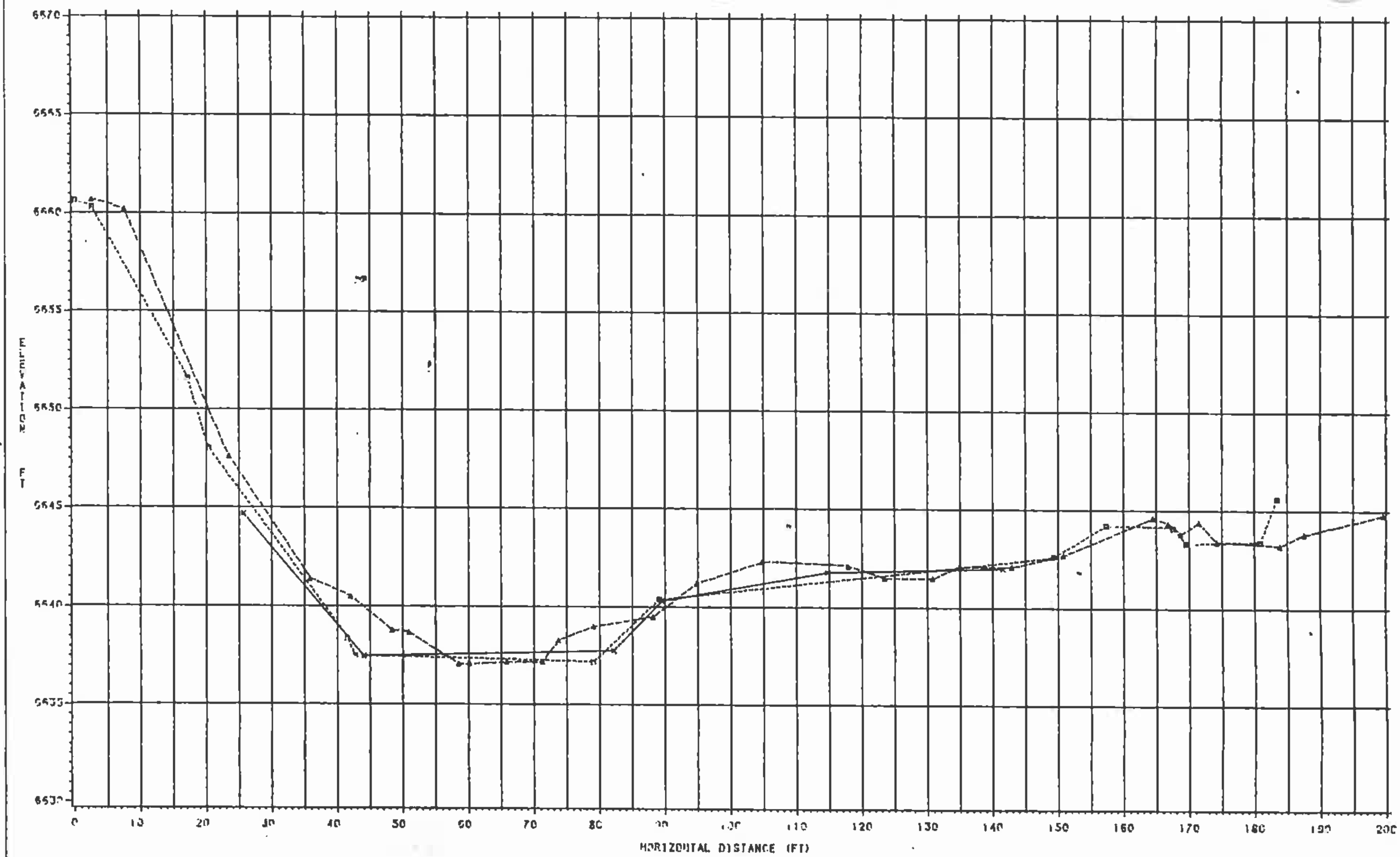


VIEW LOOKING UPSTREAM

NOTE: 8/83 LINE IS APPROX 2 FT DOWNSTREAM OF THE OTHERS

CROSS SECT[illegible] AT SITE 16

LINE 1? (IN FRONT [illegible] STREAM STATION)



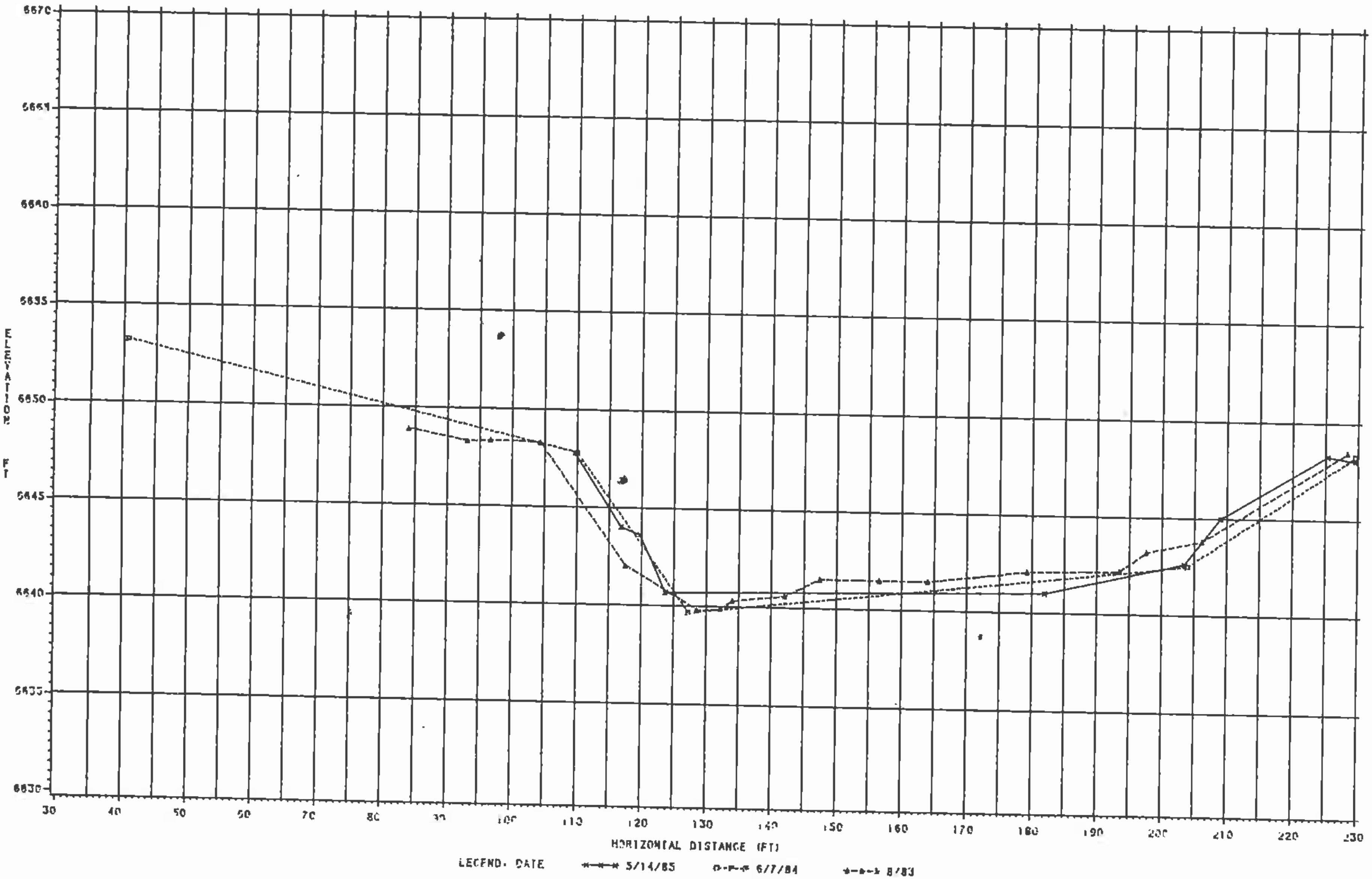
LEGEND: DATE — 5/14/85 — 6/7/84 — 8/83

VIEW LOOKING UPSTREAM

NOTE: 8/83 LINE IS APPROX 3 FT DOWNSTREAM OF THE OTHERS IN THE CHANNEL BOTTOM, AND IS 20 FT OFF AT 200 FT

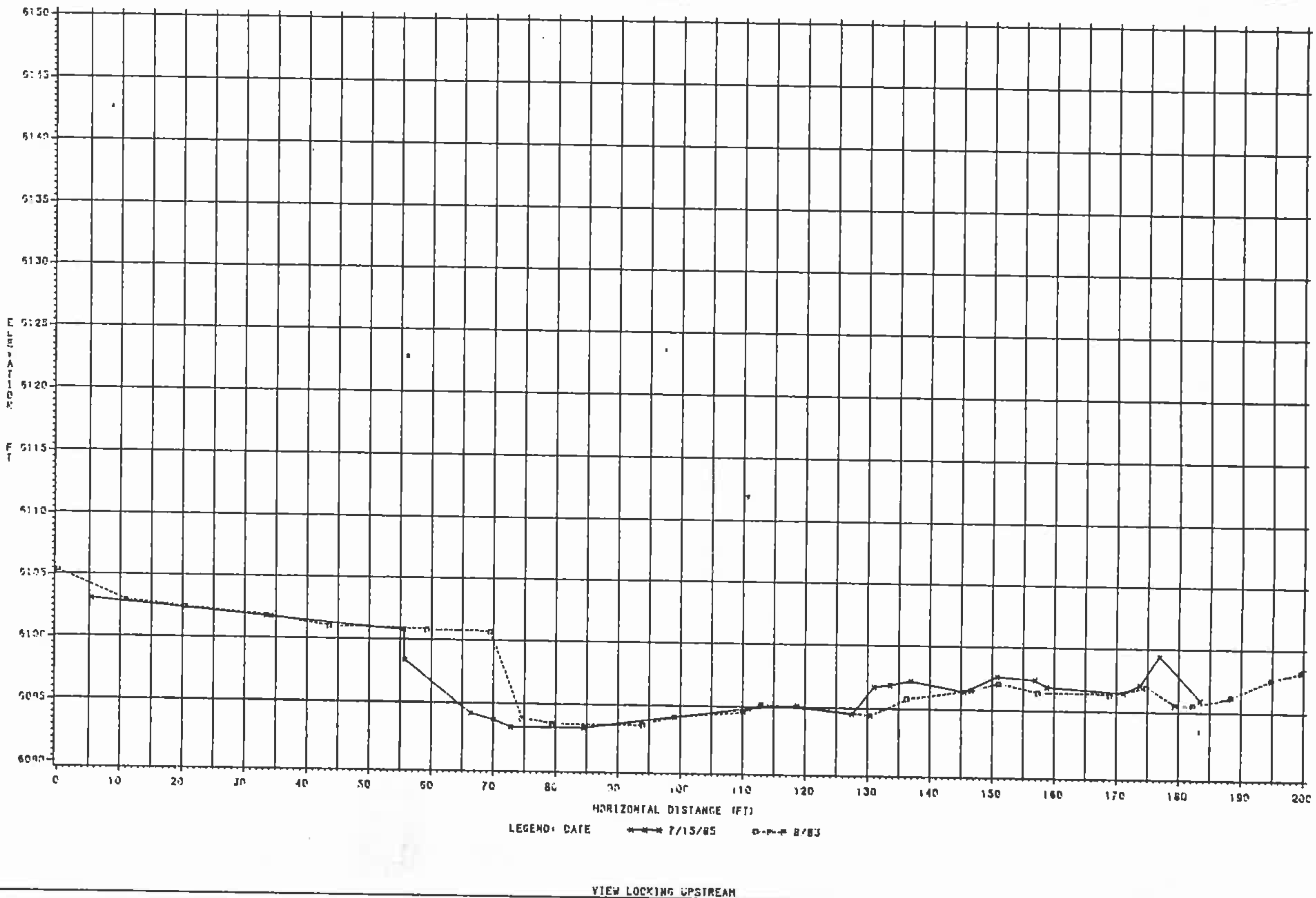
CROSS SECTION AT SITE 16

LINE 14



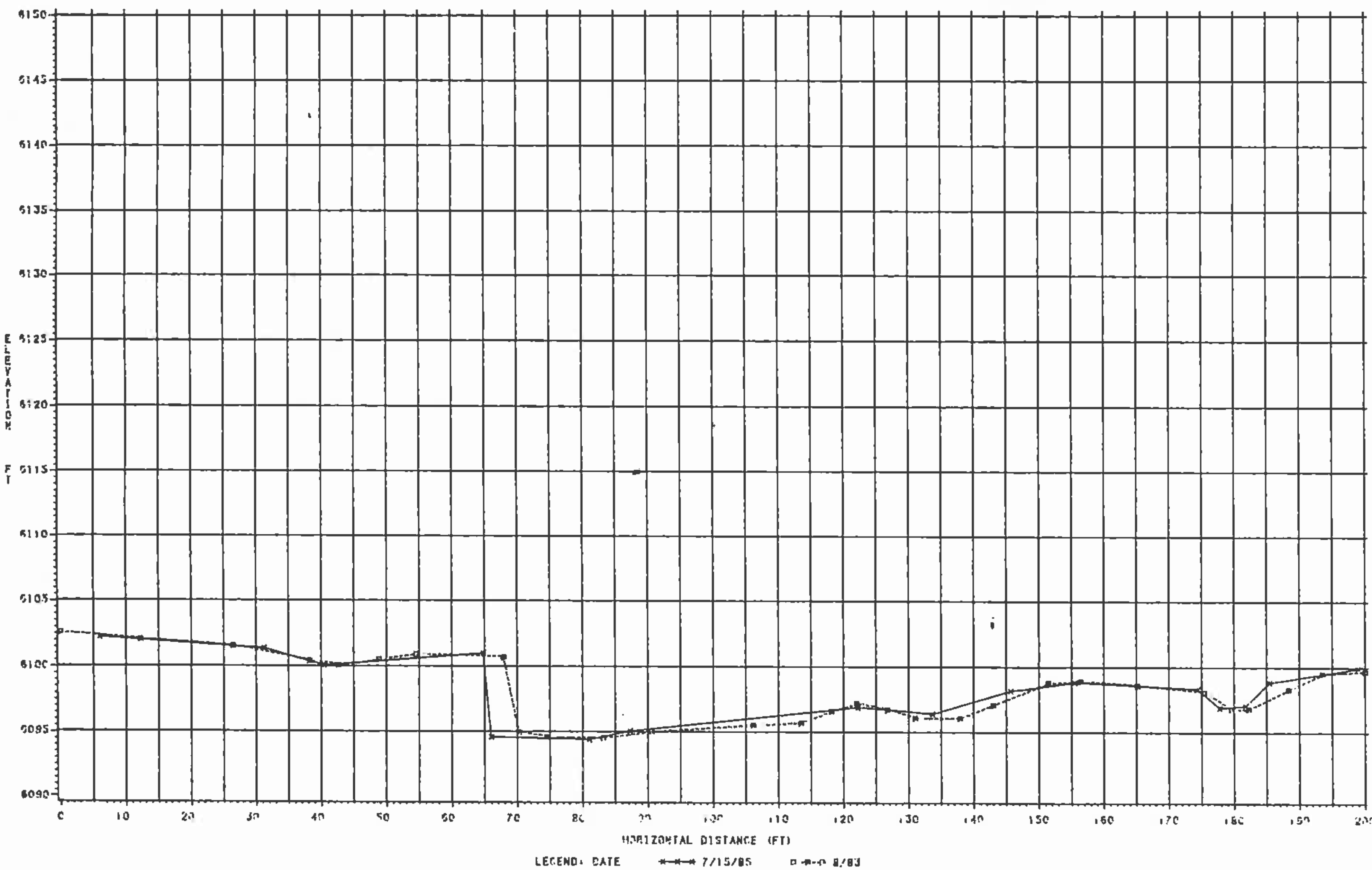
VIEW LOOKING UPSTREAM

CROSS SECTI[illegible] AT SITE 25



CROSS SECTION AT SITE 25

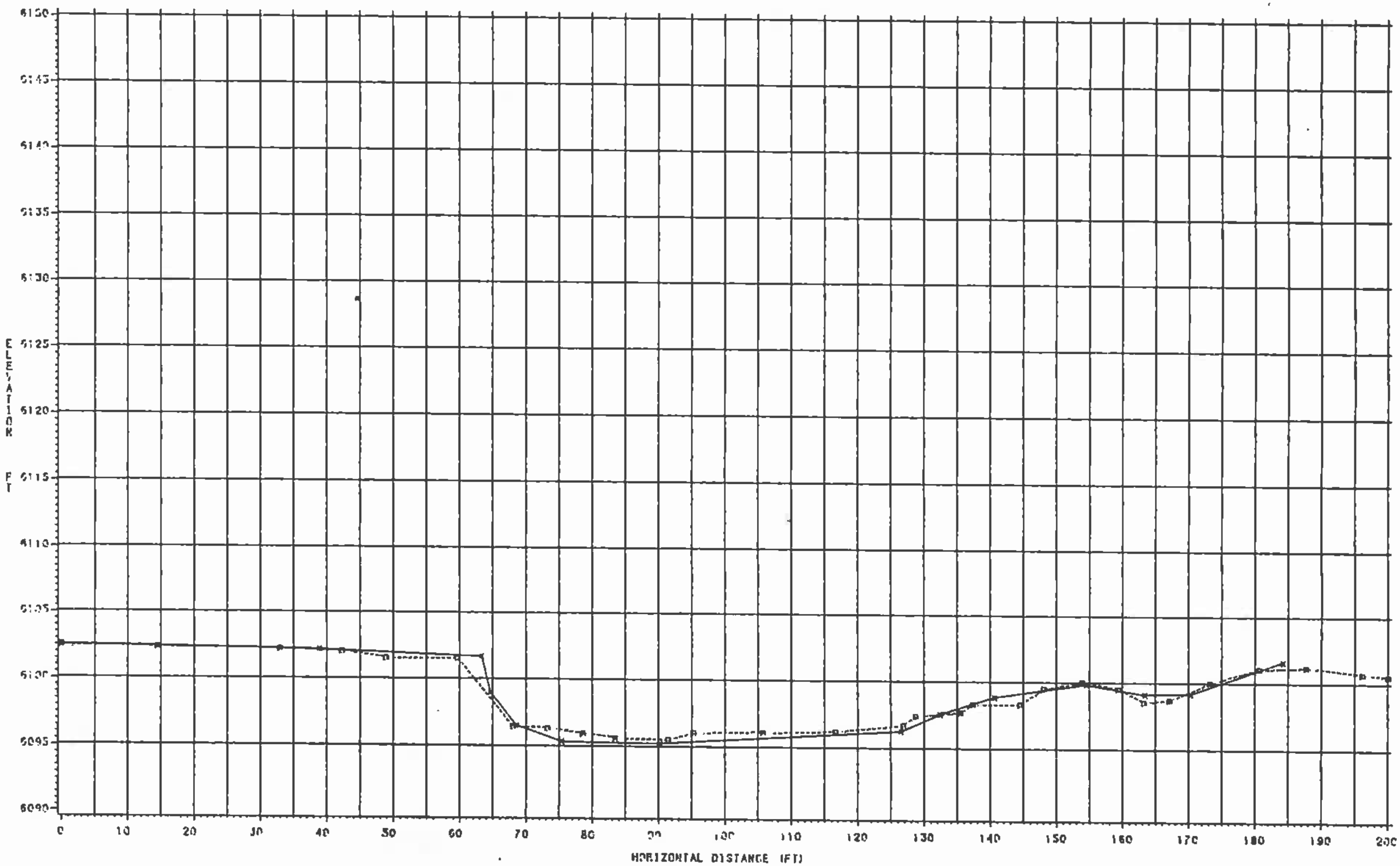
LINE 4



VIEW LOOKING UPSTREAM

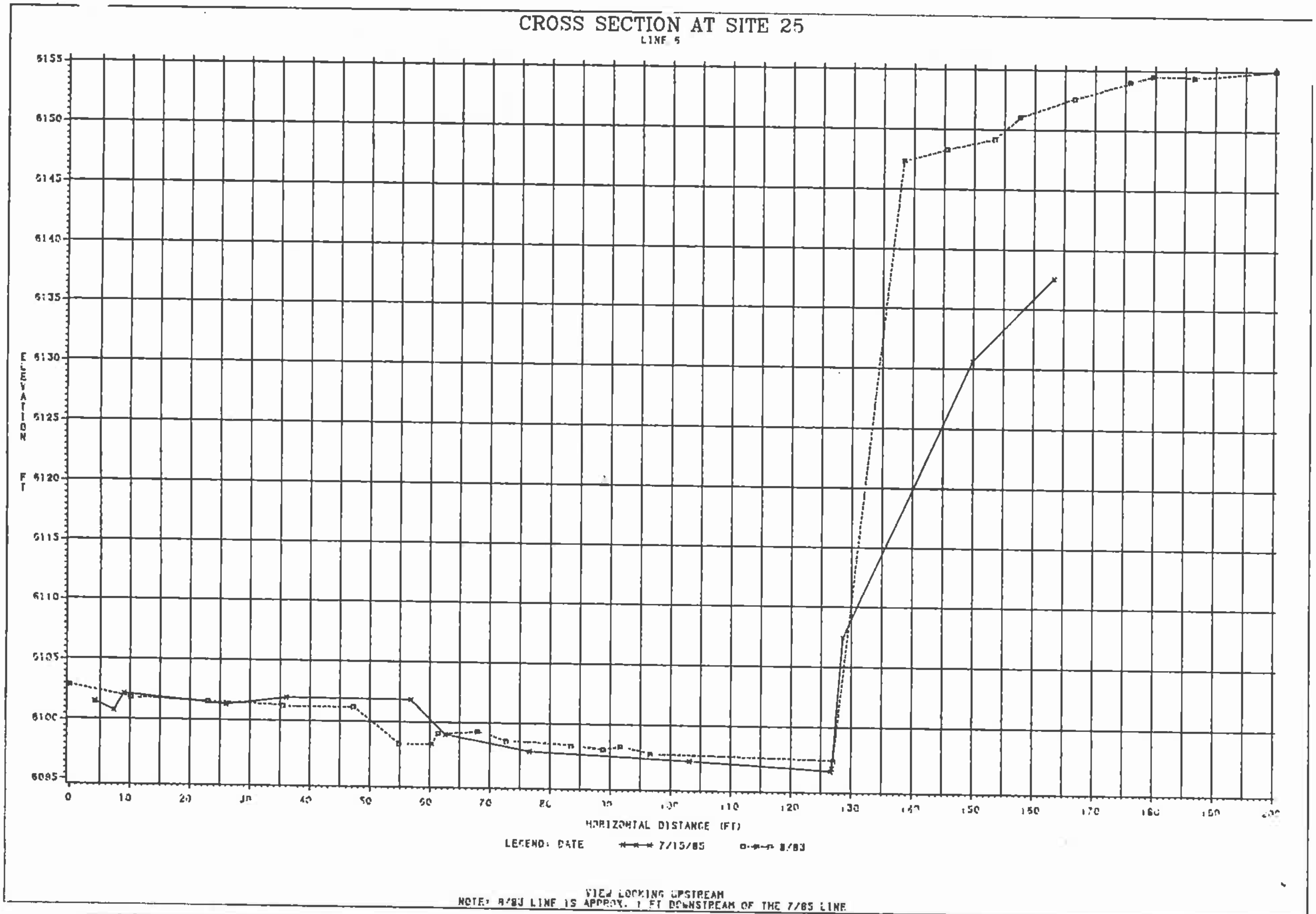
CROSS SECTION AT SITE 25

LINE 5



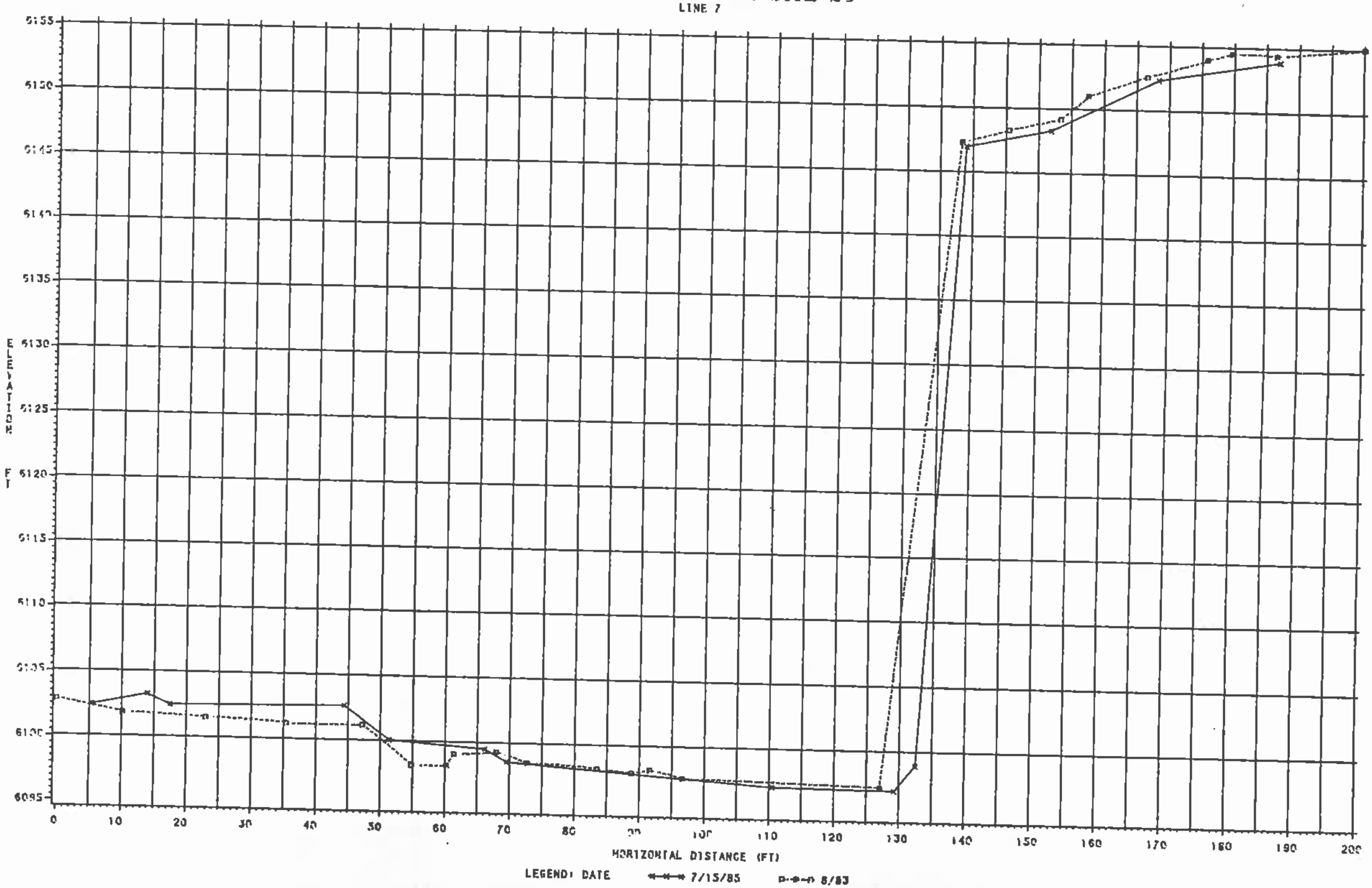
VIEW LOOKING UPSTREAM

NOTE: 8/83 LINE IS APPROX. 1 FT DOWNSTREAM OF THE 7/85 LINE


CROSS SECTION AT SITE 25
LINE 5
ELEVATION FT
6155
6150
6145
6140
6135
6130
6125
6120
6115
6110
6105
6100
6095
0
10
20
40
50
60
70
110
120
130
150
160
170
HORIZONTAL DISTANCE (FT)
LEGEND: DATE
7/15/85
8/83
VIEW LOOKING UPSTREAM
NOTE: 8/83 LINE IS APPROX. 1 FT DOWNSTREAM OF THE 7/85 LINE

CROSS SECTION AT SITE 25

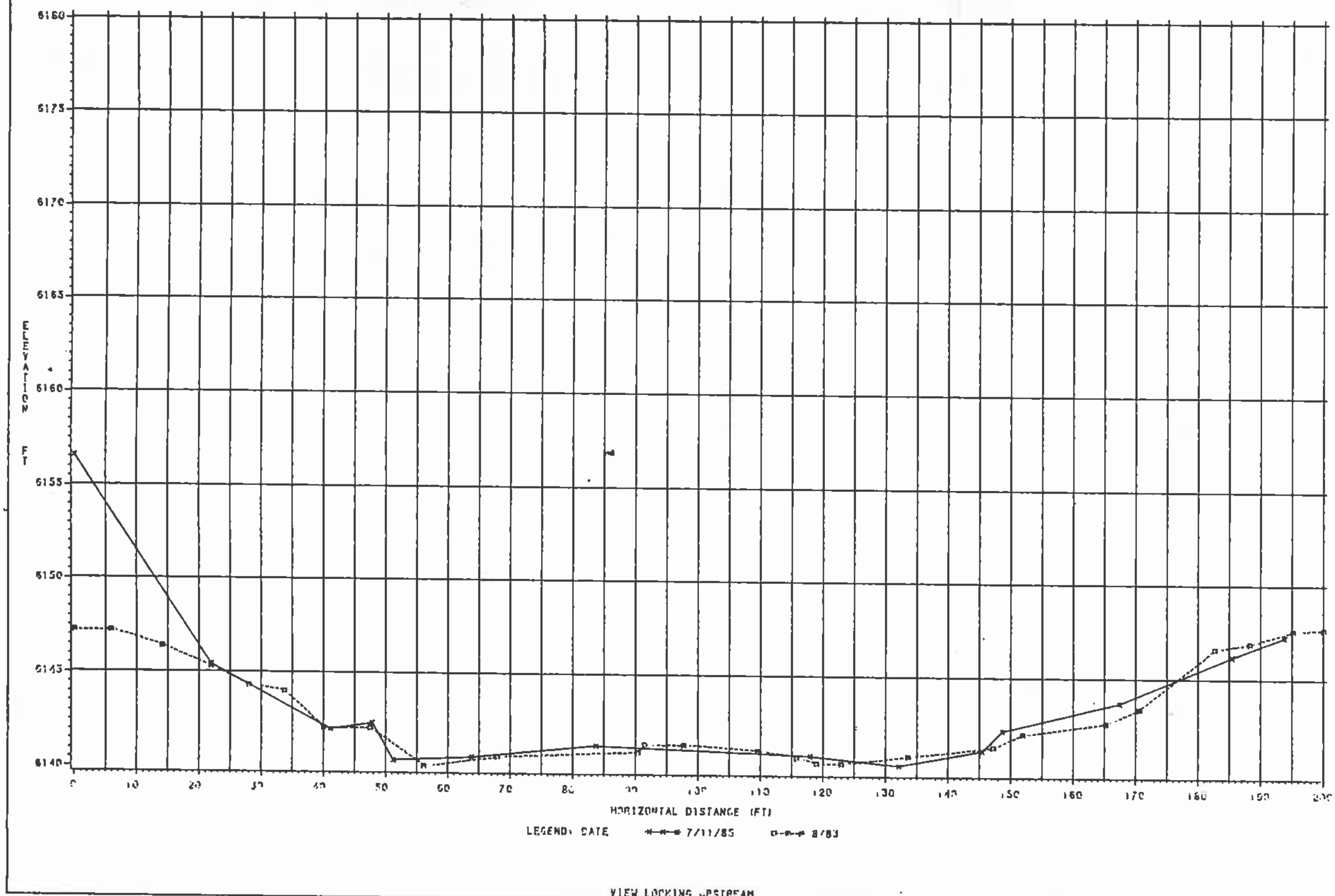
LINE 7



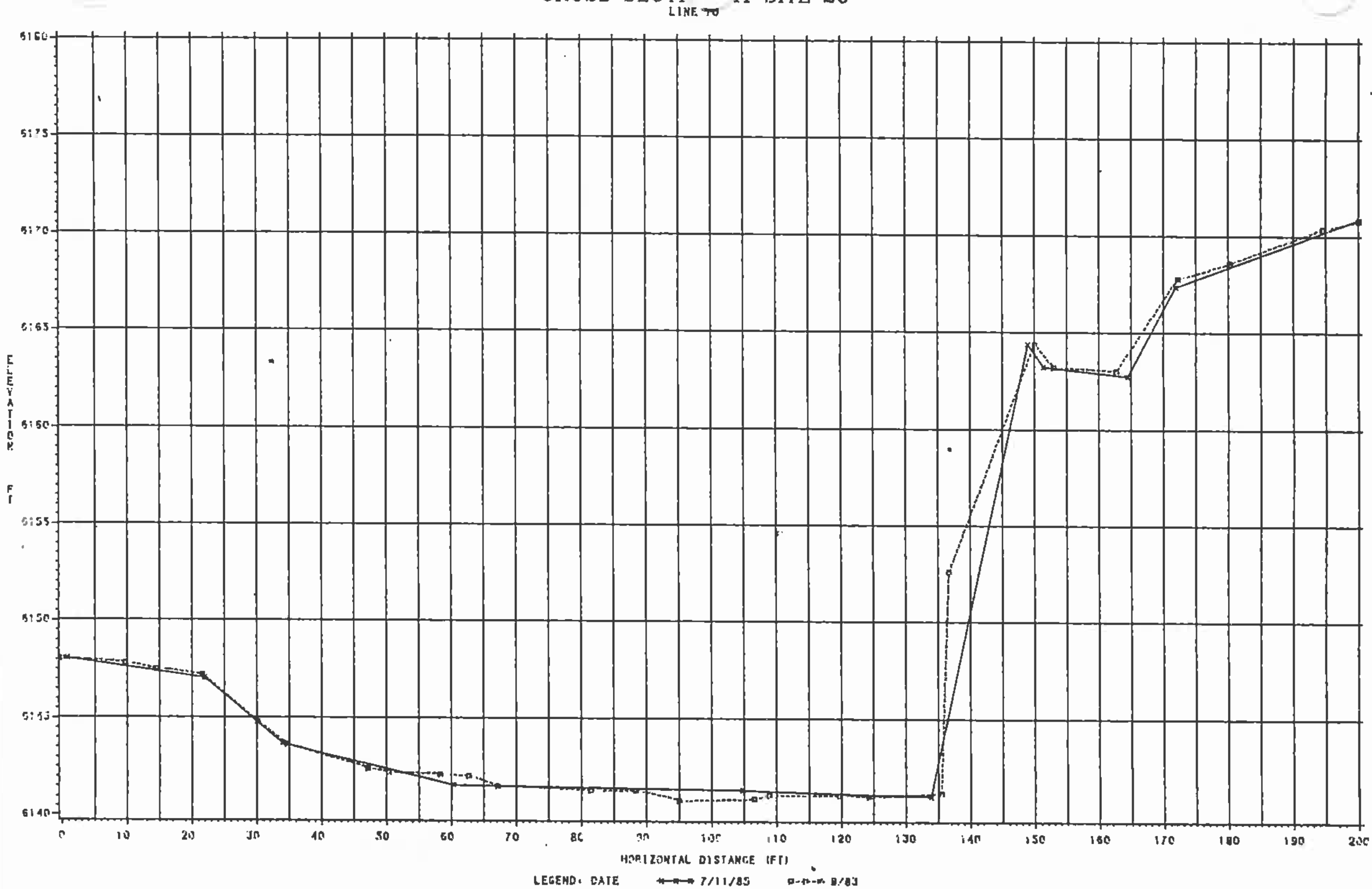
VIEW LOOKING UPSTREAM

NOTE: 8/83 LINE IS APPROX. 4 FT UPSTREAM OF THE 7/85 LINE

CROSS SECTION AT SITE 26
LINE 9



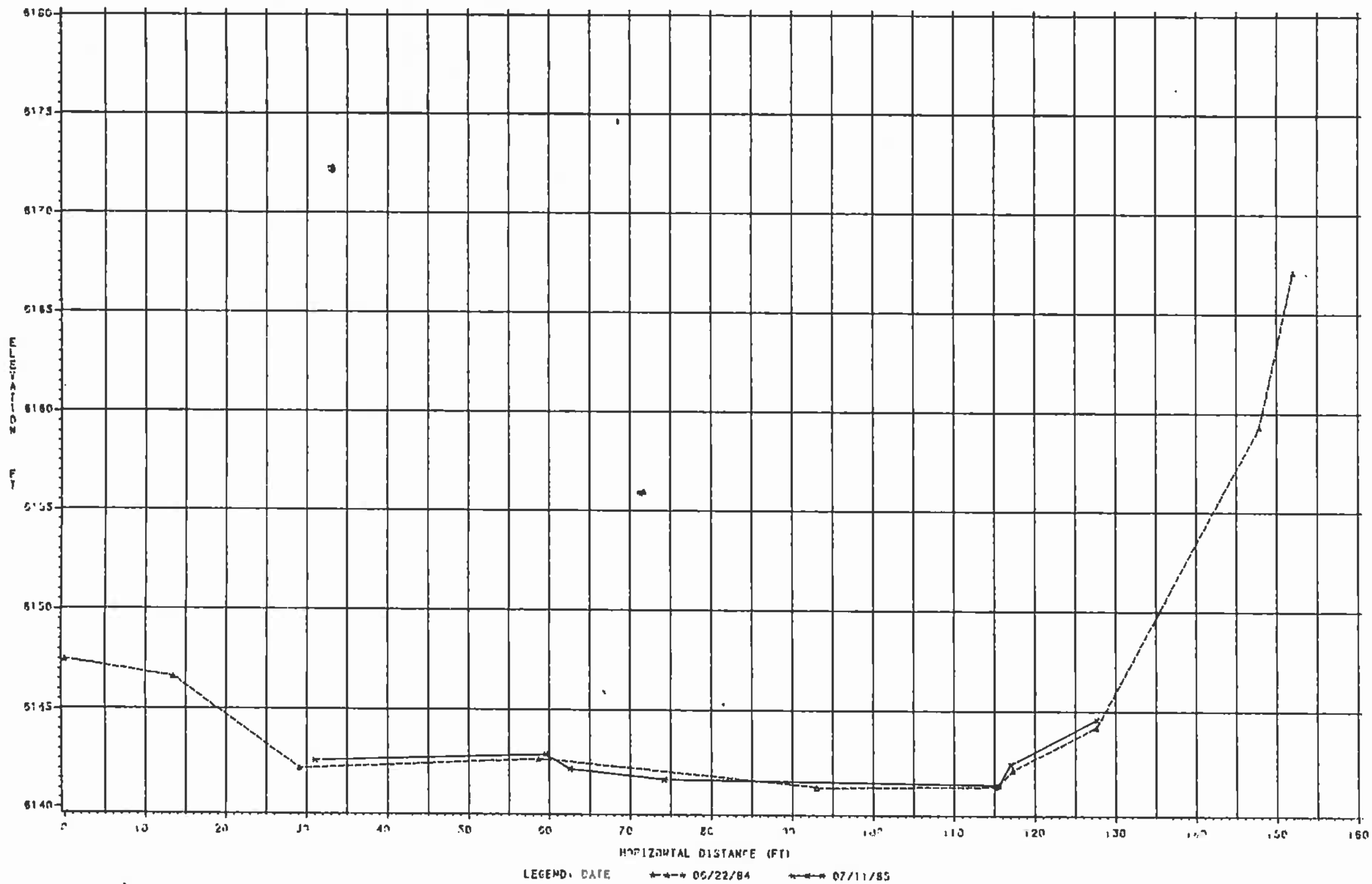
CROSS SECTI[illegible]T SITE 26



VIEW LOOKING UPSTREAM

CROSS SECTI[...]AT SITE 26

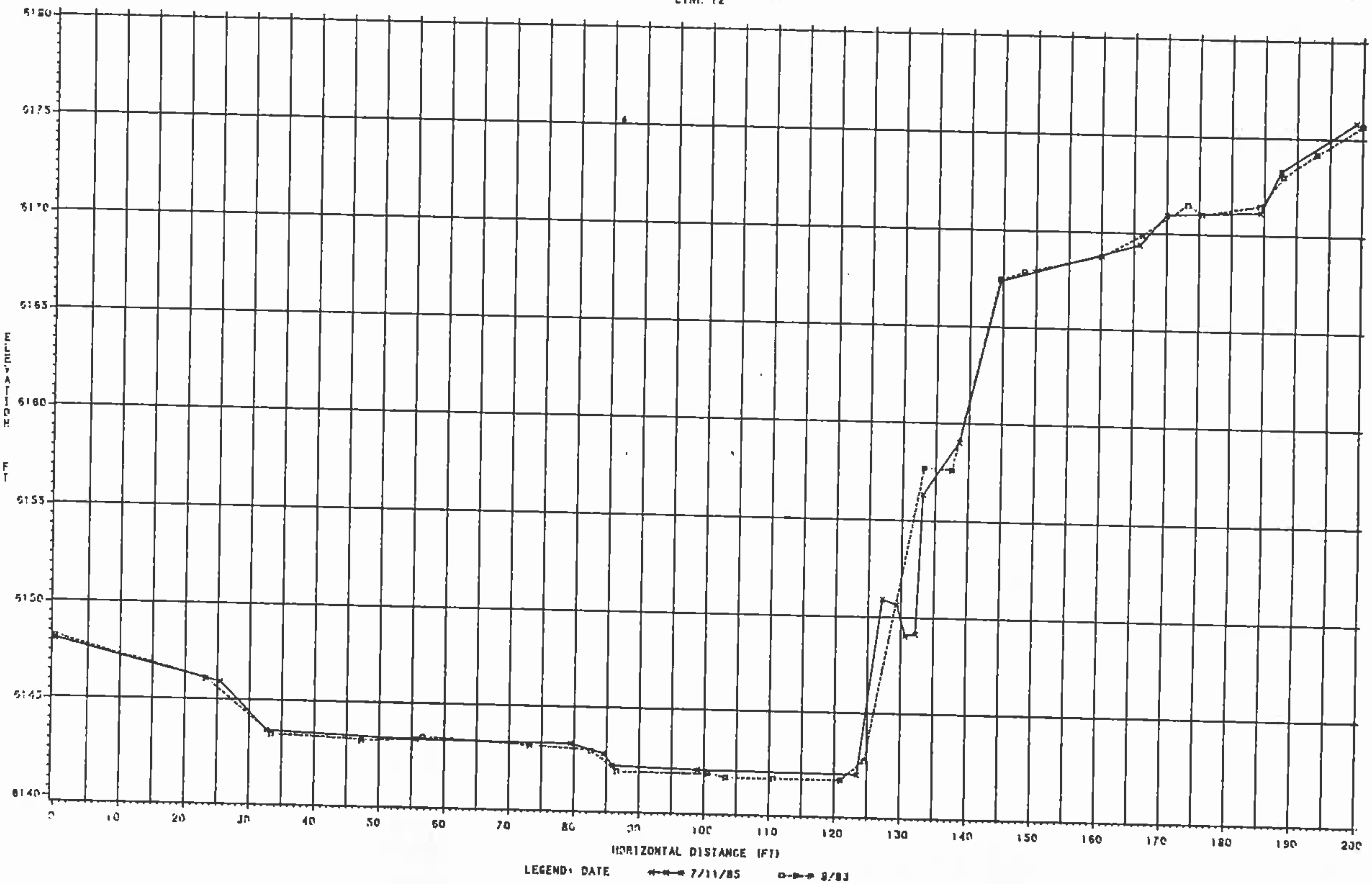
THRU CREST GAGE



VIEW LOOKING UPSTREAM

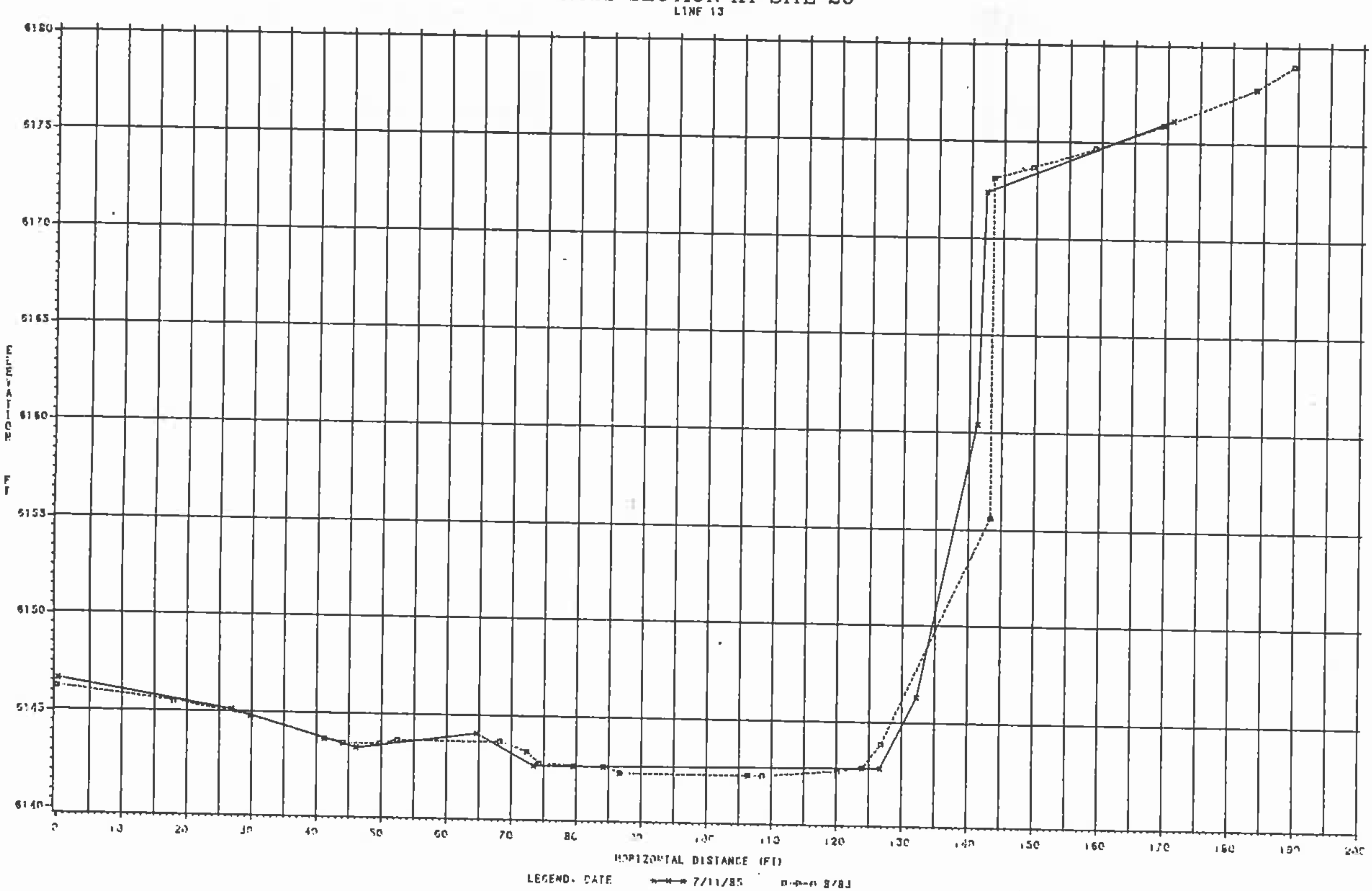
CROSS SECTION AT SITE 26

LINE 12



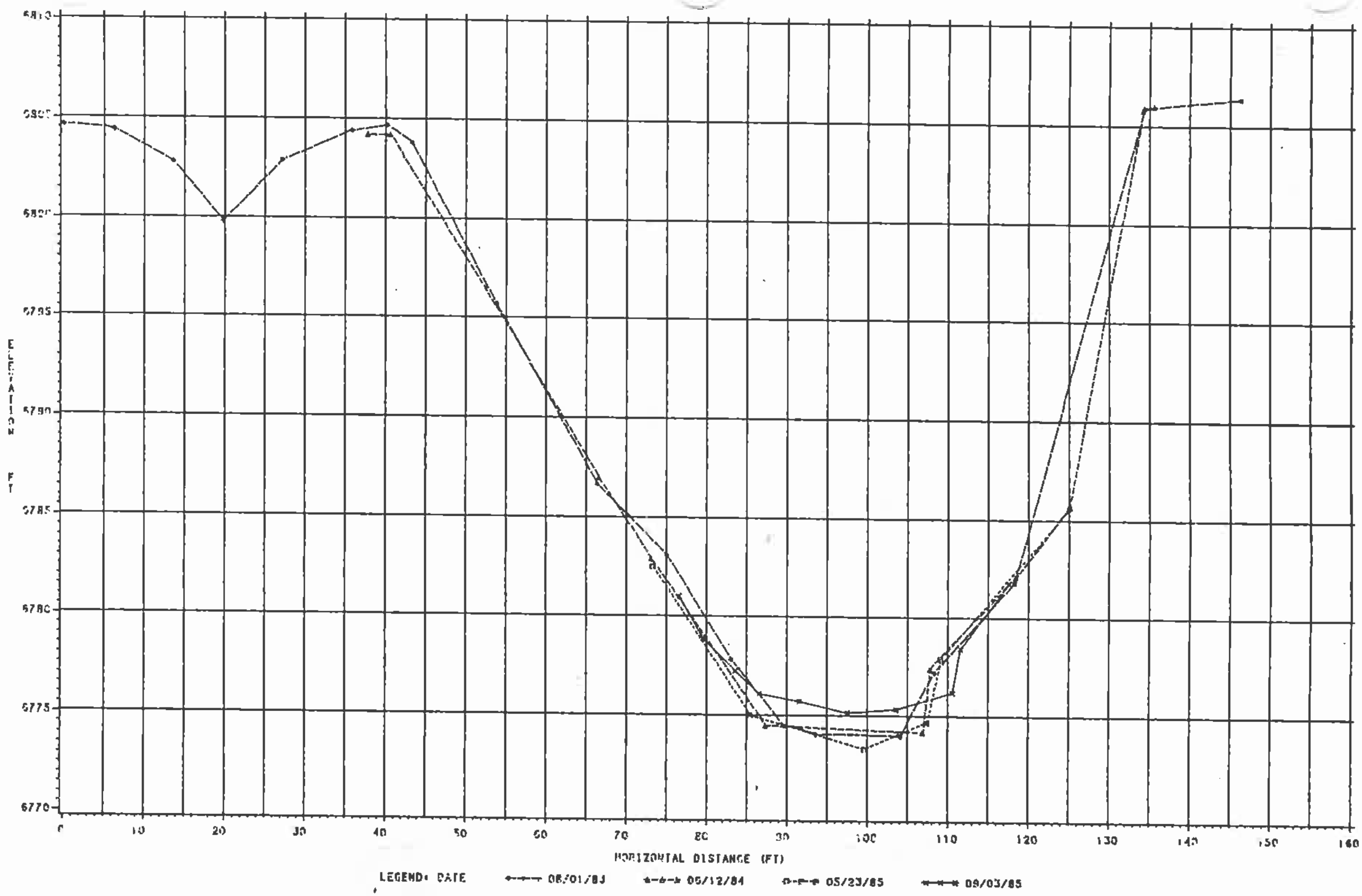
VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 26



VIEW LOOKING UPSTREAM

CROSS SECT[hole punch] AT SITE 34

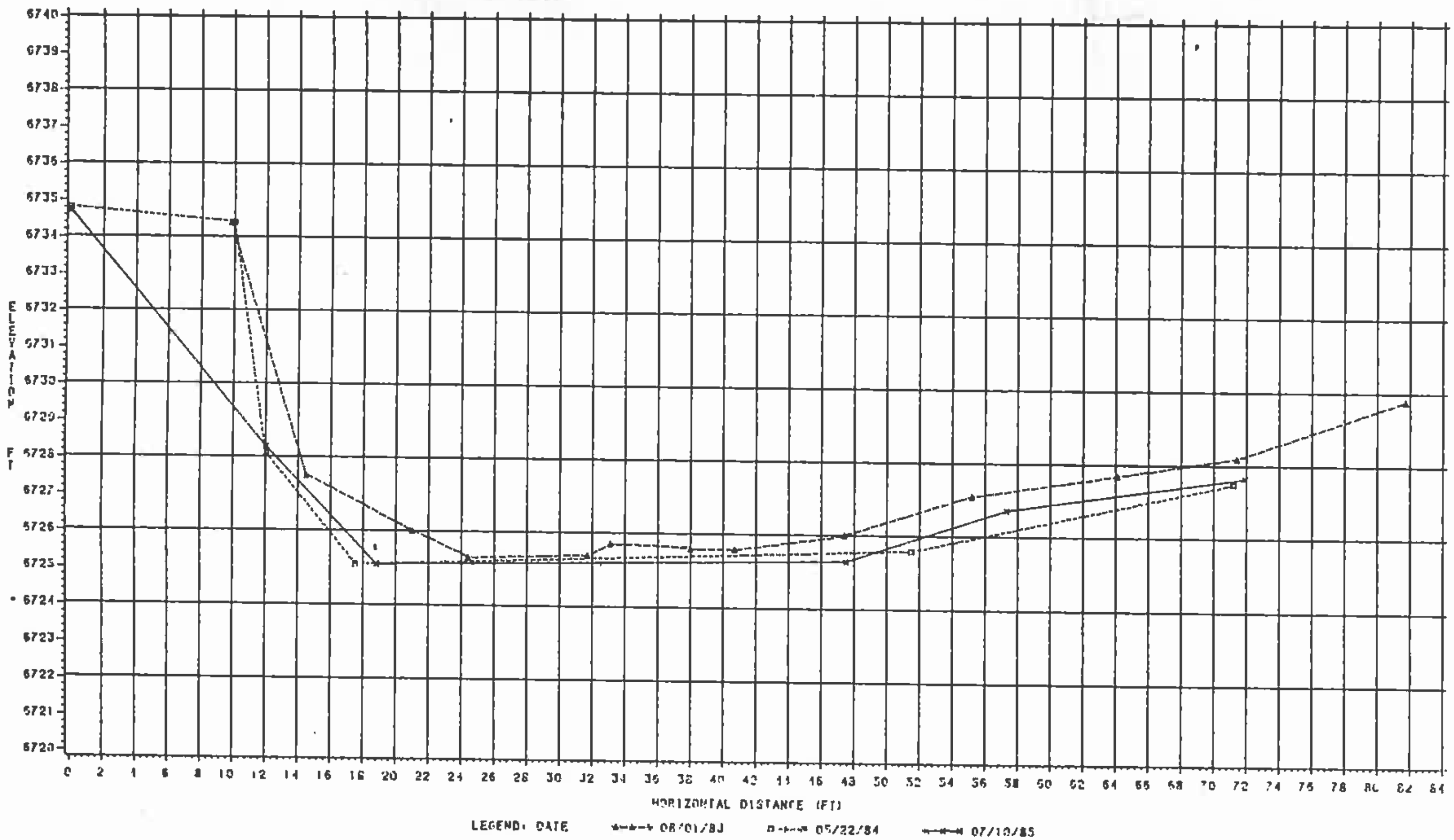


VIEW LOOKING UPSTREAM

NOTE: 8/83 SURVEY LINE IS ABOUT 4 FT UPSTREAM OF THE OTHERS

CROSS SECTION AT SITE 35

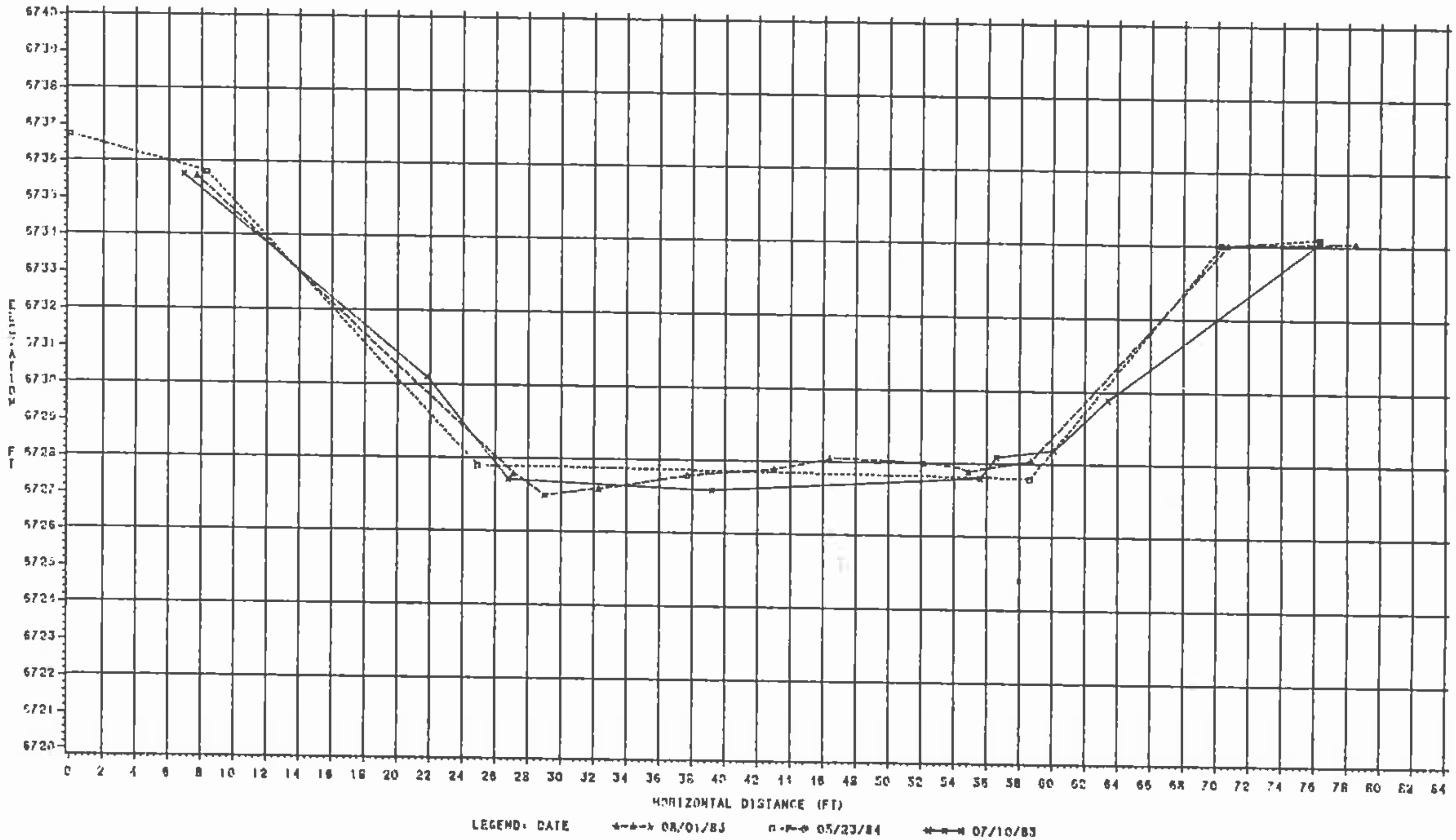
LINE 7



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 35

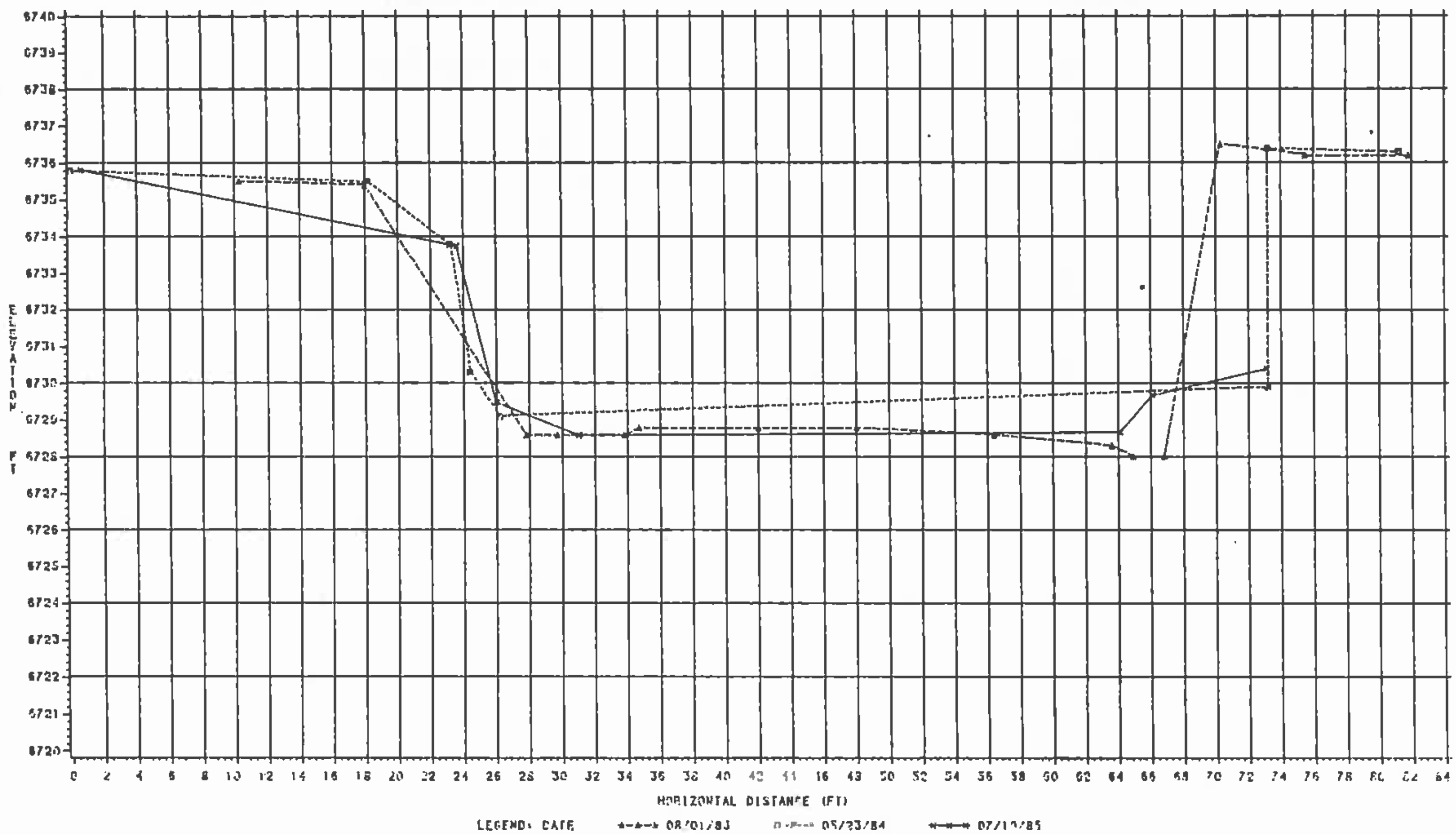
LINE 9



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 35

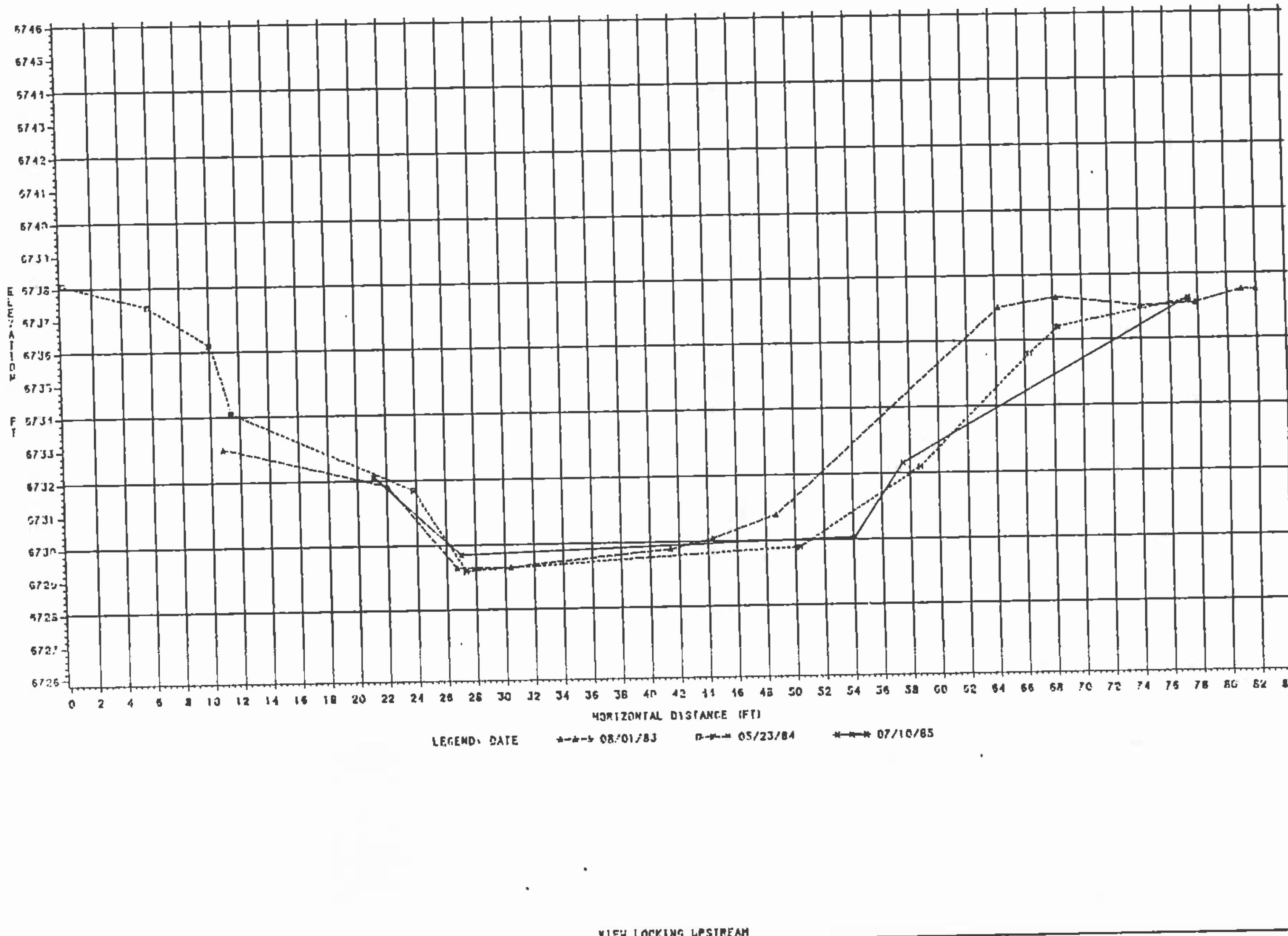
LINE 10 (THRU STREAM STATION)



VIEW LOOKING UPSTREAM

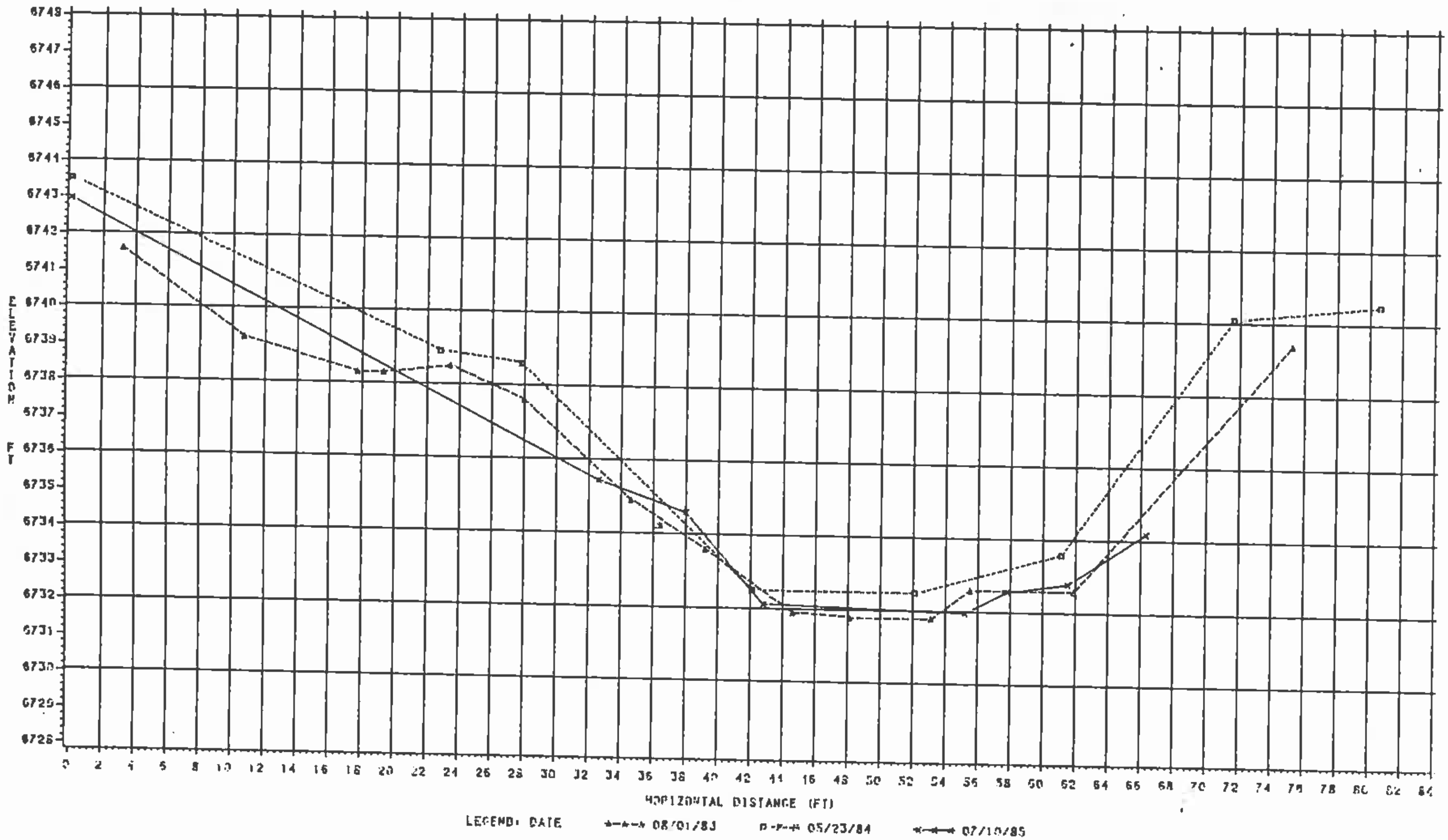
NOTE: STREAM STATION 10 NOT SHOWN

CROSS SECTIO[illegible] SITE 35



CROSS SECTION AT SITE 35

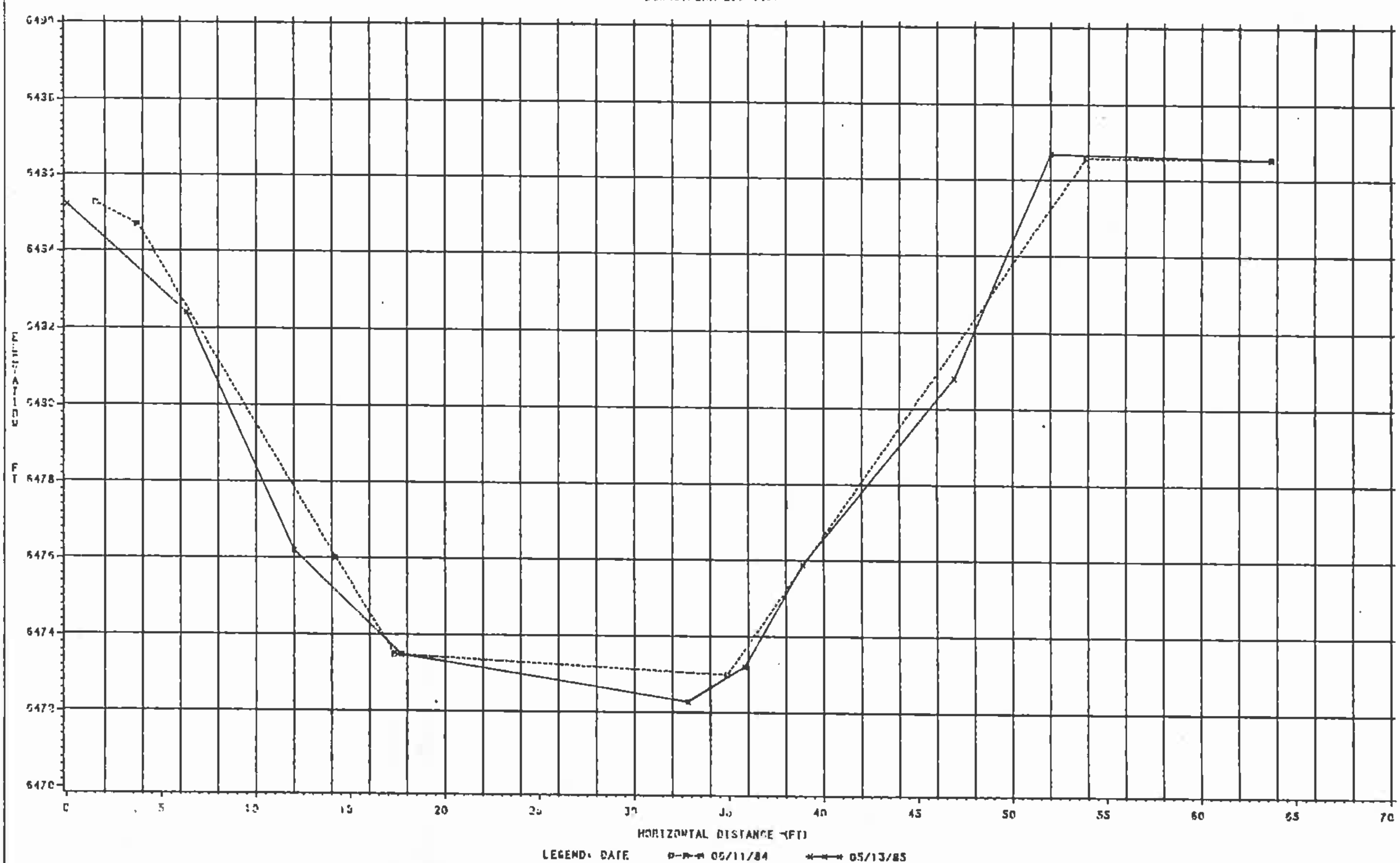
LINE 14



VIEW LOOKING UPSTREAM'

CROSS SECTION AT SITE 37

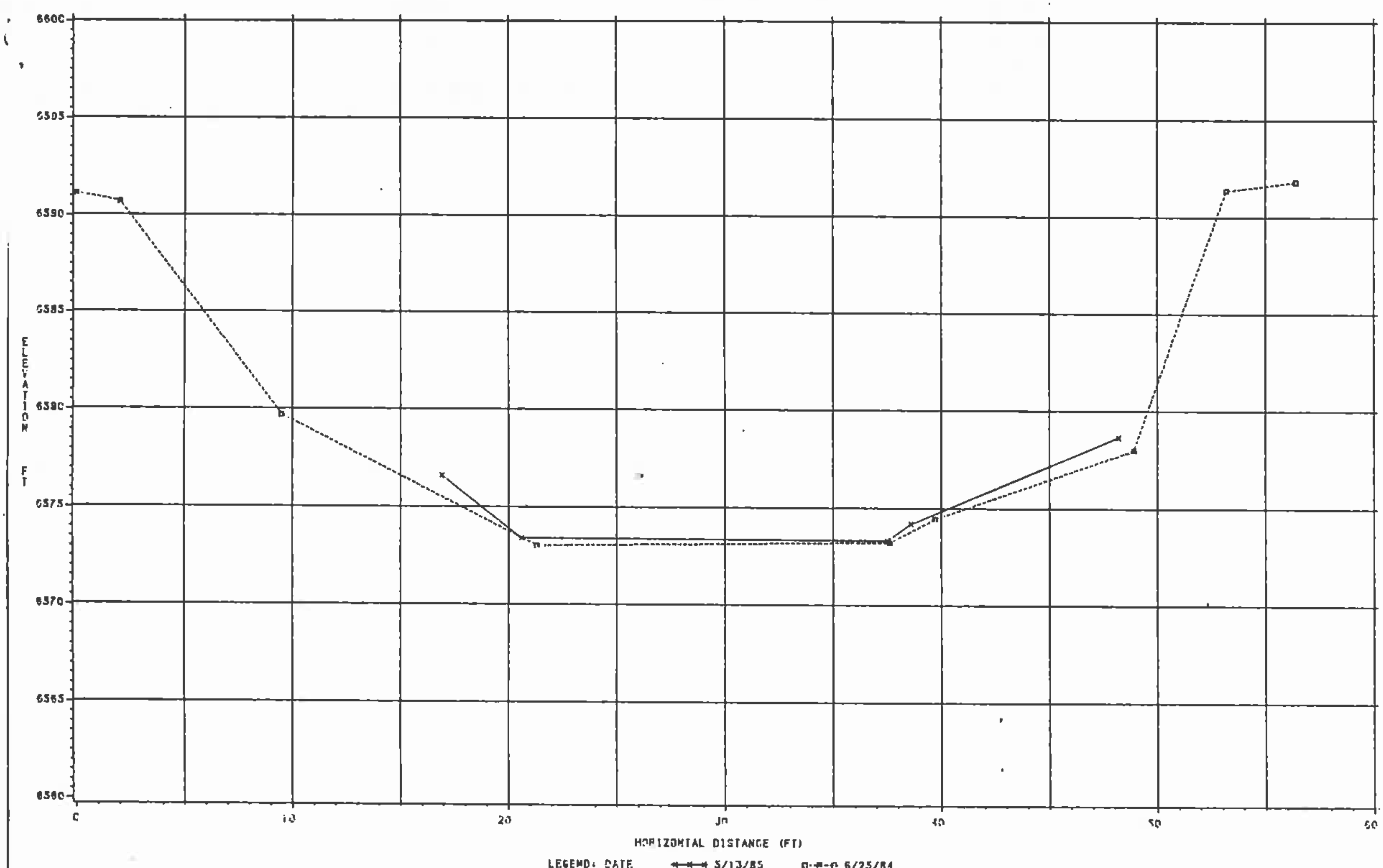
DOWNSTREAM LOCATION



, VIEW LOOKING UPSTREAM

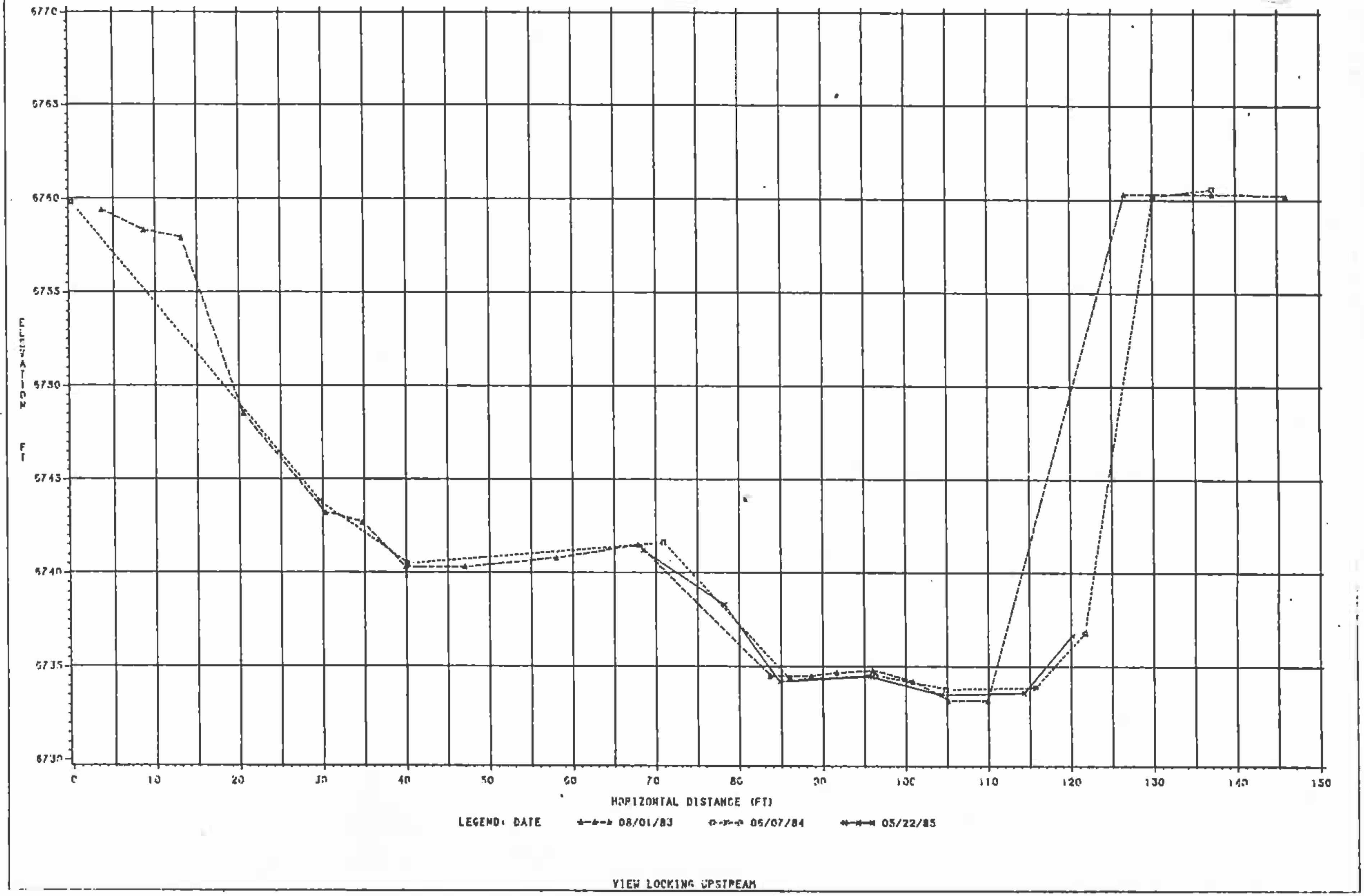
CROSS SECTION AT SITE 37

THRU CREST GAGE (UPSTREAM LOCATION)



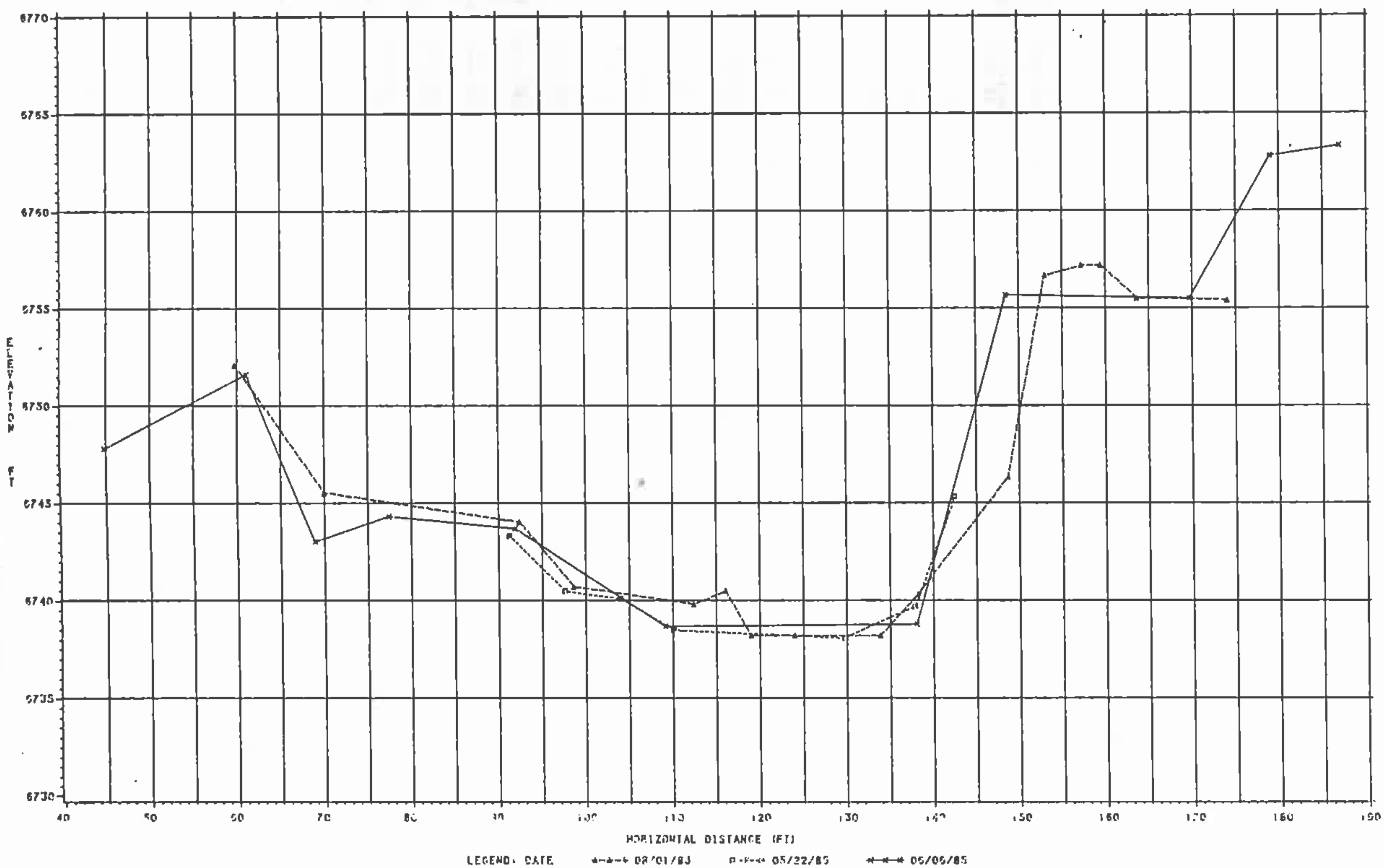
VIEW LOOKING UPSTREAM

CROSS SEC' AT SITE 50



CROSS SECTIC AT SITE 50

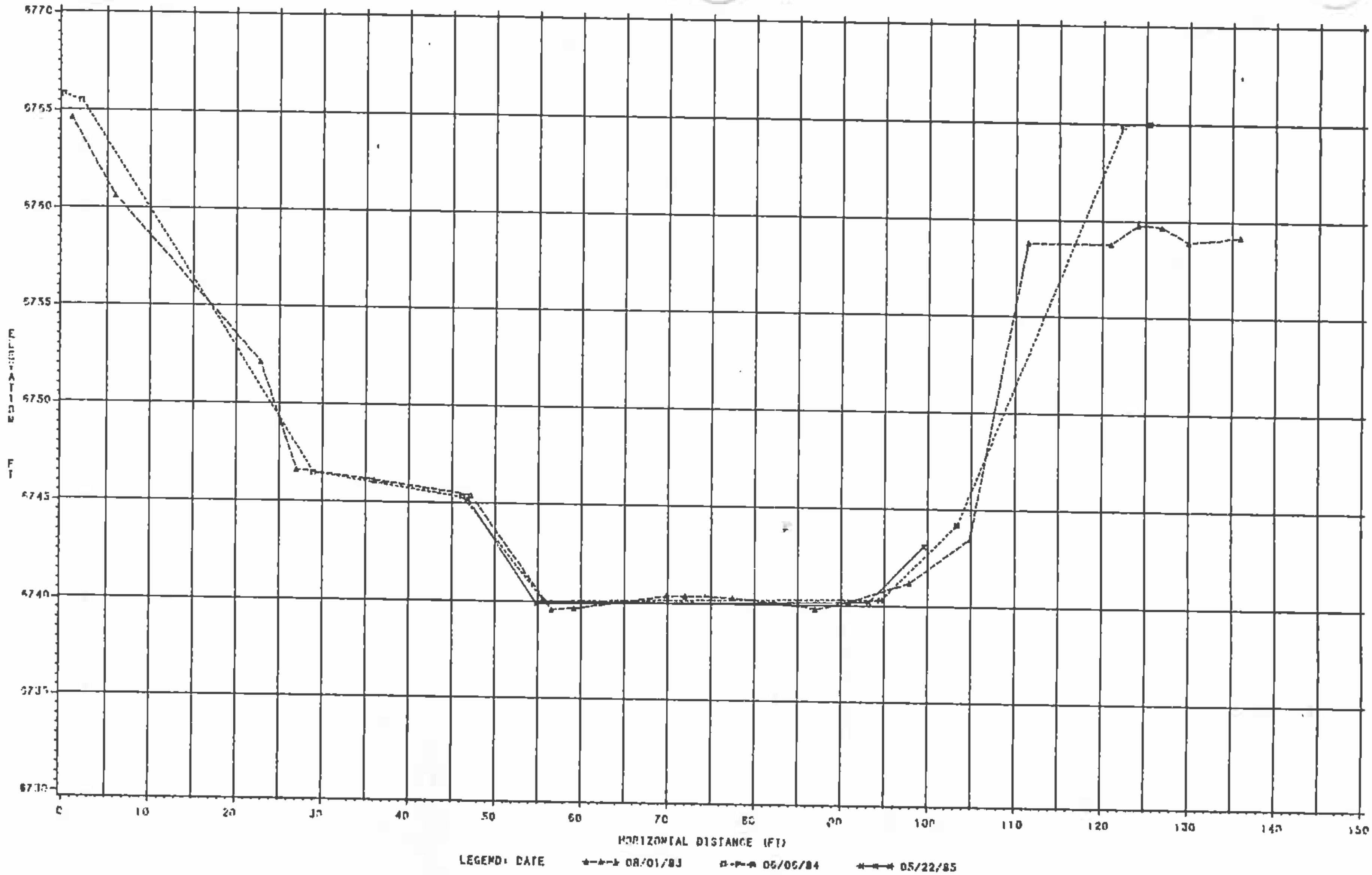
LINE 7



VIEW LOOKING UPSTREAM

CROSS SECTI T SITE 50

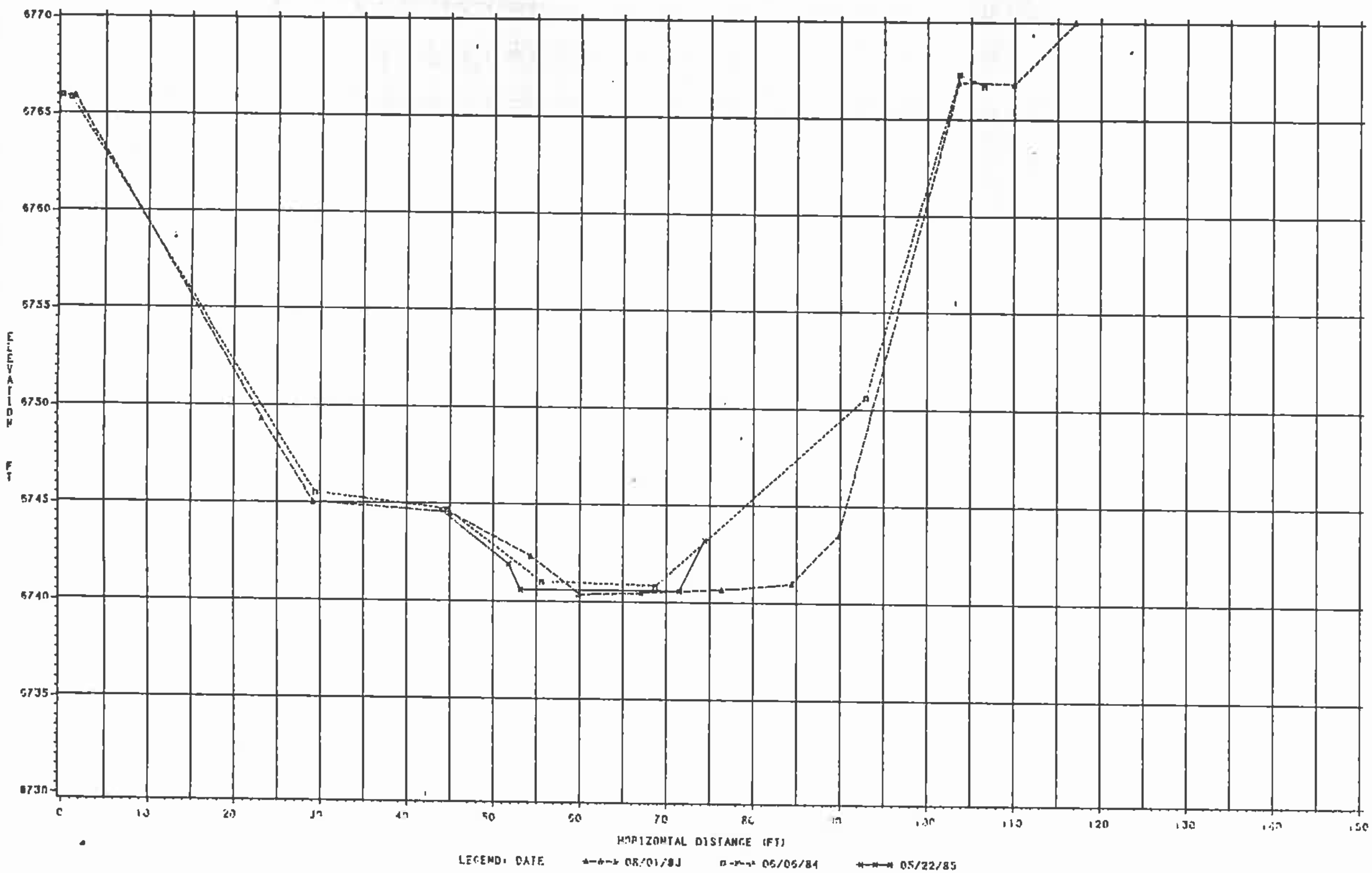
LINE 8 (THRU STATION)



VIEW LOOKING UPSTREAM
NOTE: STREAM STATION IS NOT SHOWN

CROSS SECTION AT SITE 50

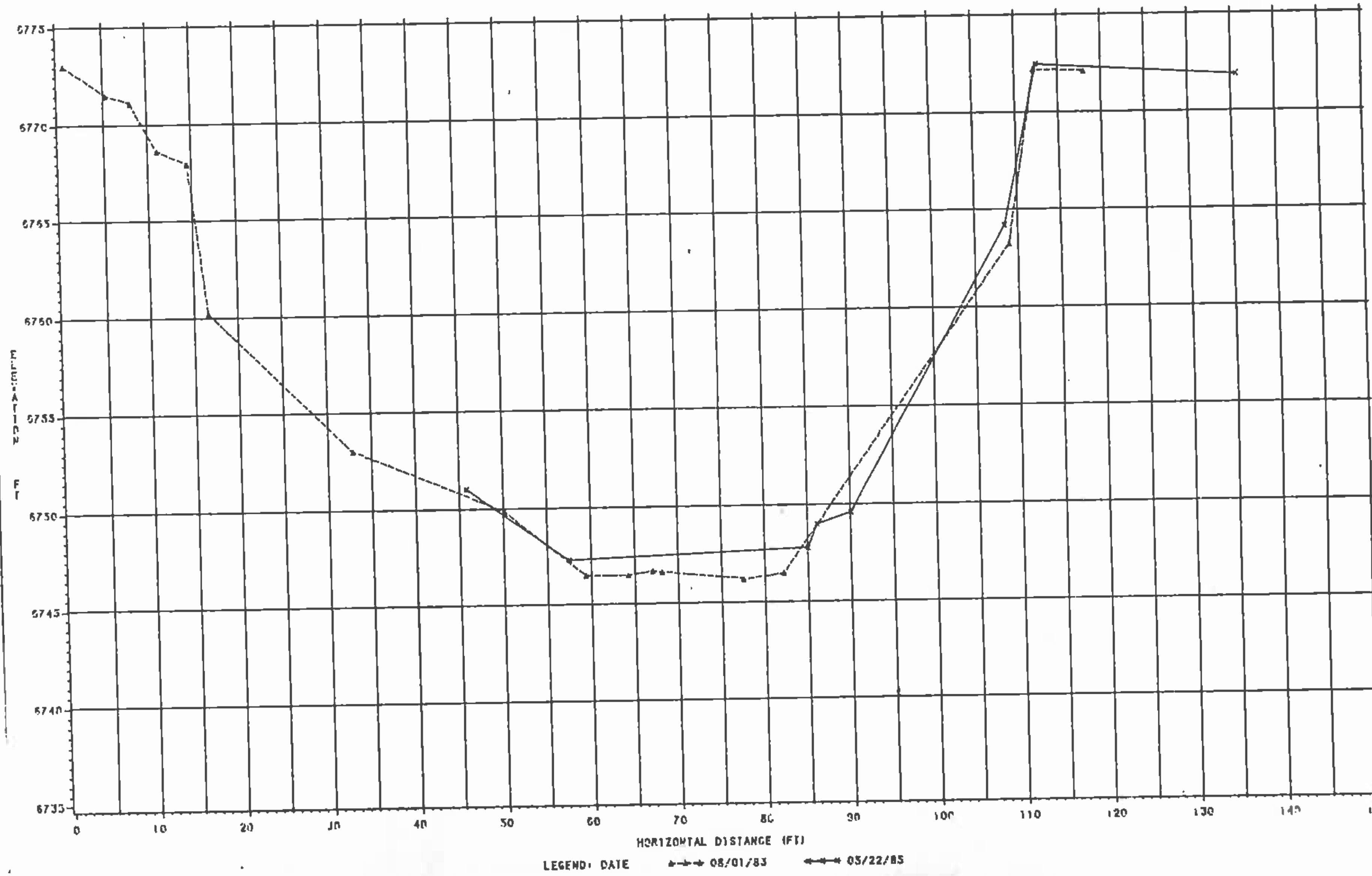
LINE 9



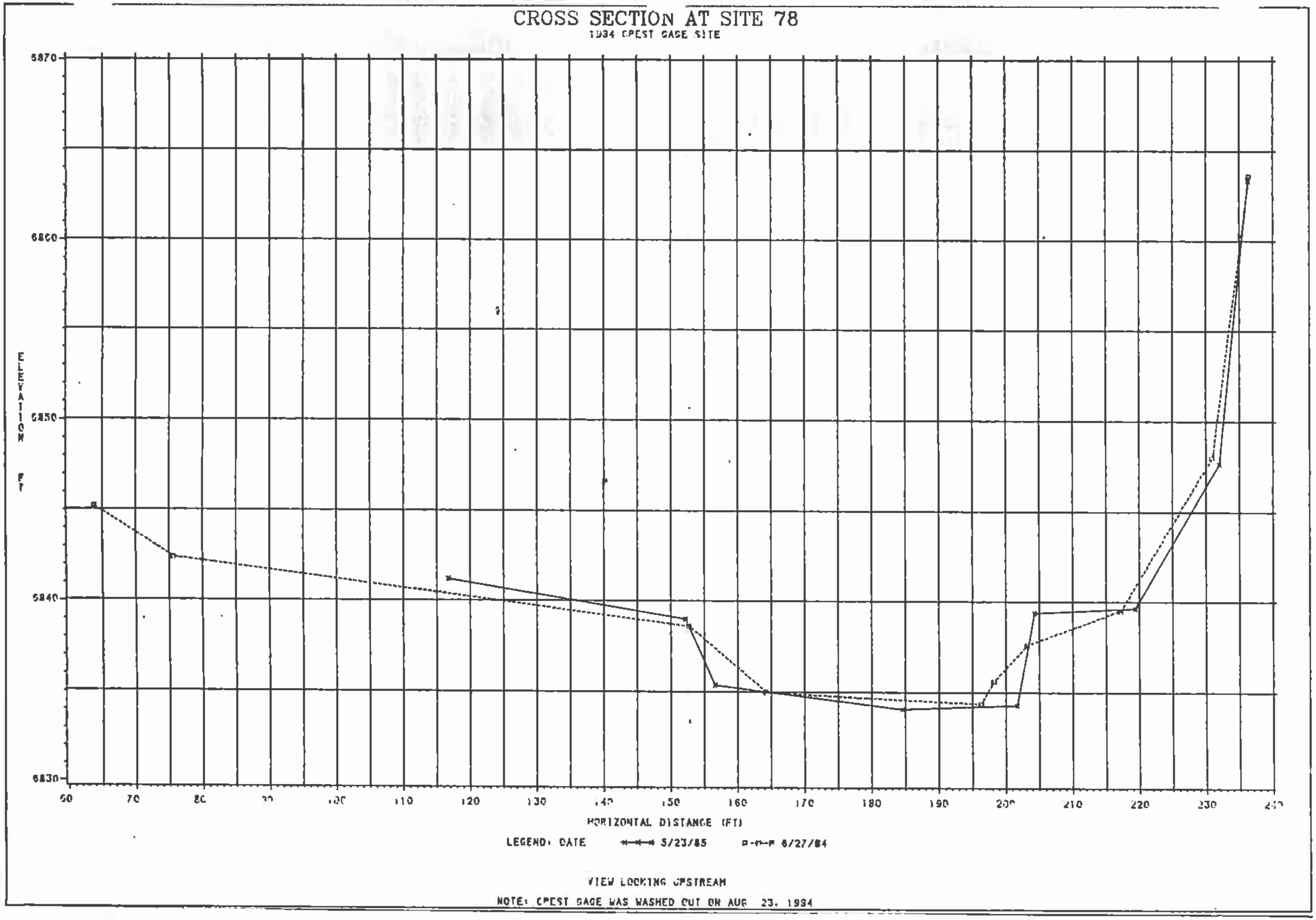
VIEW LOOKING UPSTREAM

CROSS SECTIC T SITE 50

LINE 13



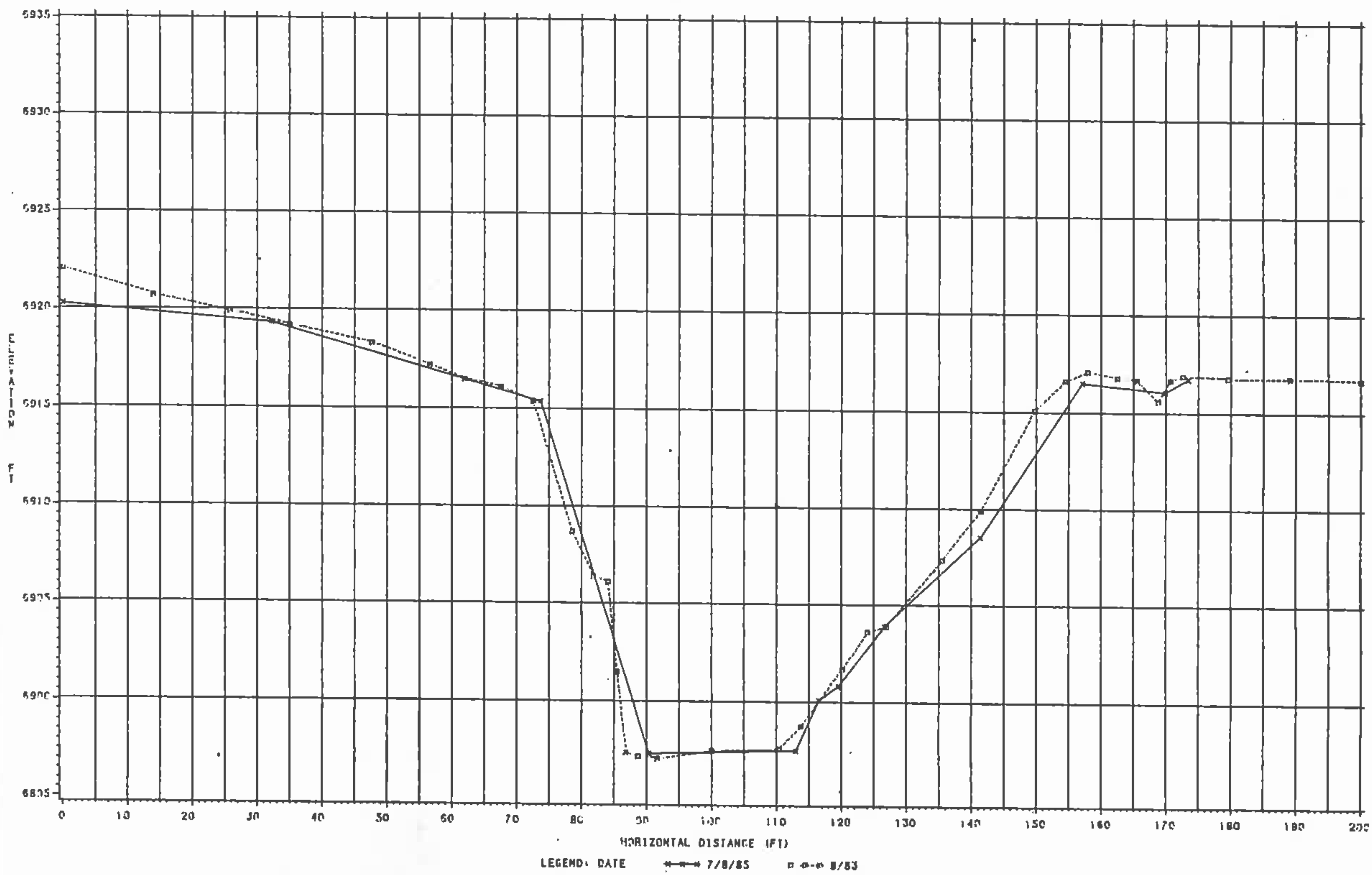
VIEW LOOKING UPSTREAM



CROSS SECTION AT SITE 78
1984 CREST GAGE SITE
ELEVATION FT
6830
6840
6850
6860
6870
60
70
80
120
130
160
170
180
190
210
220
230
HORIZONTAL DISTANCE (FT)
LEGEND: DATE
5/23/85
8/27/84
VIEW LOOKING UPSTREAM
NOTE: CREST GAGE WAS WASHED OUT ON AUG 23, 1984

CROSS SECTION AT SITE 78

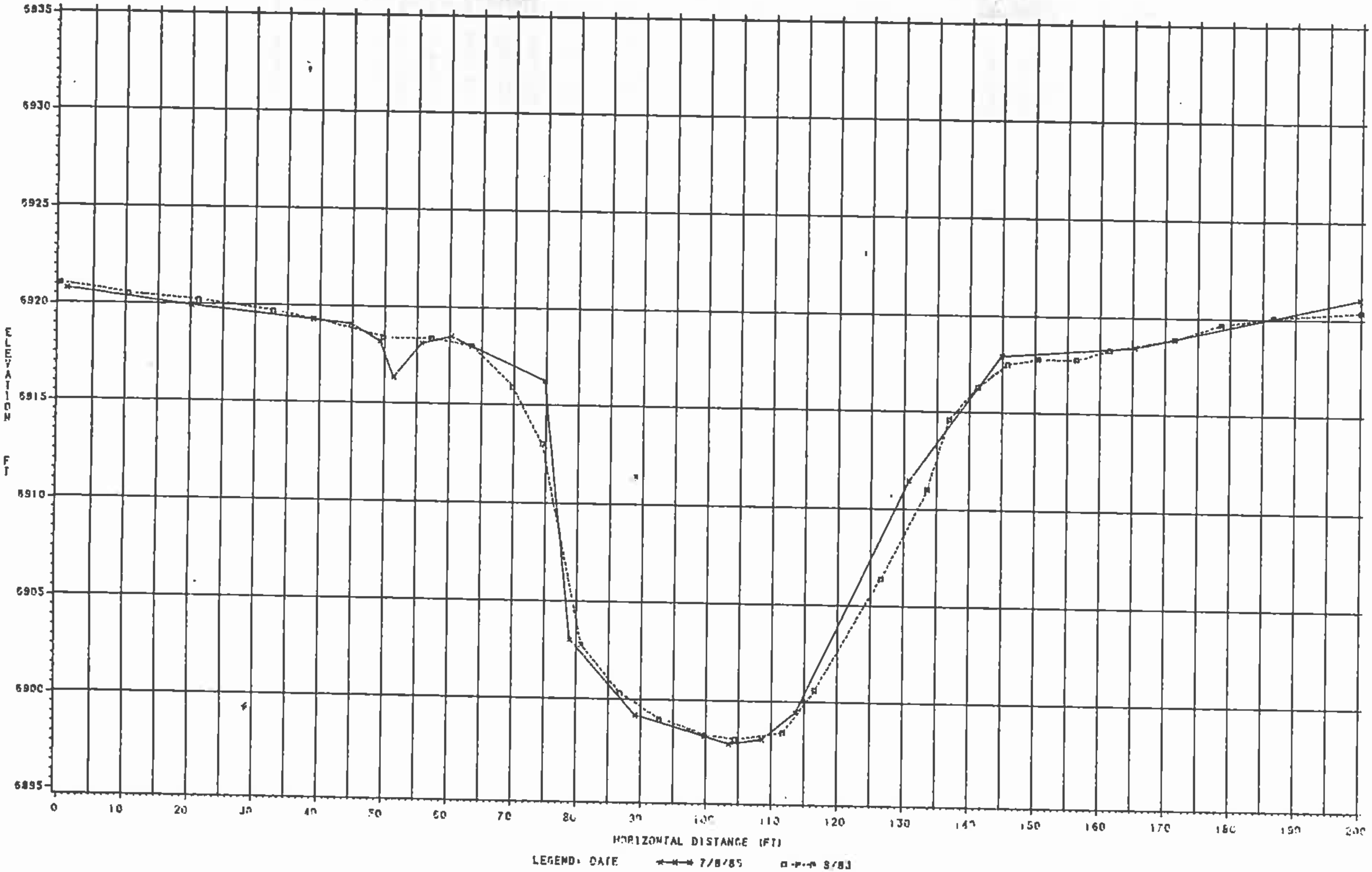
LINE 1



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 78

LINE 2

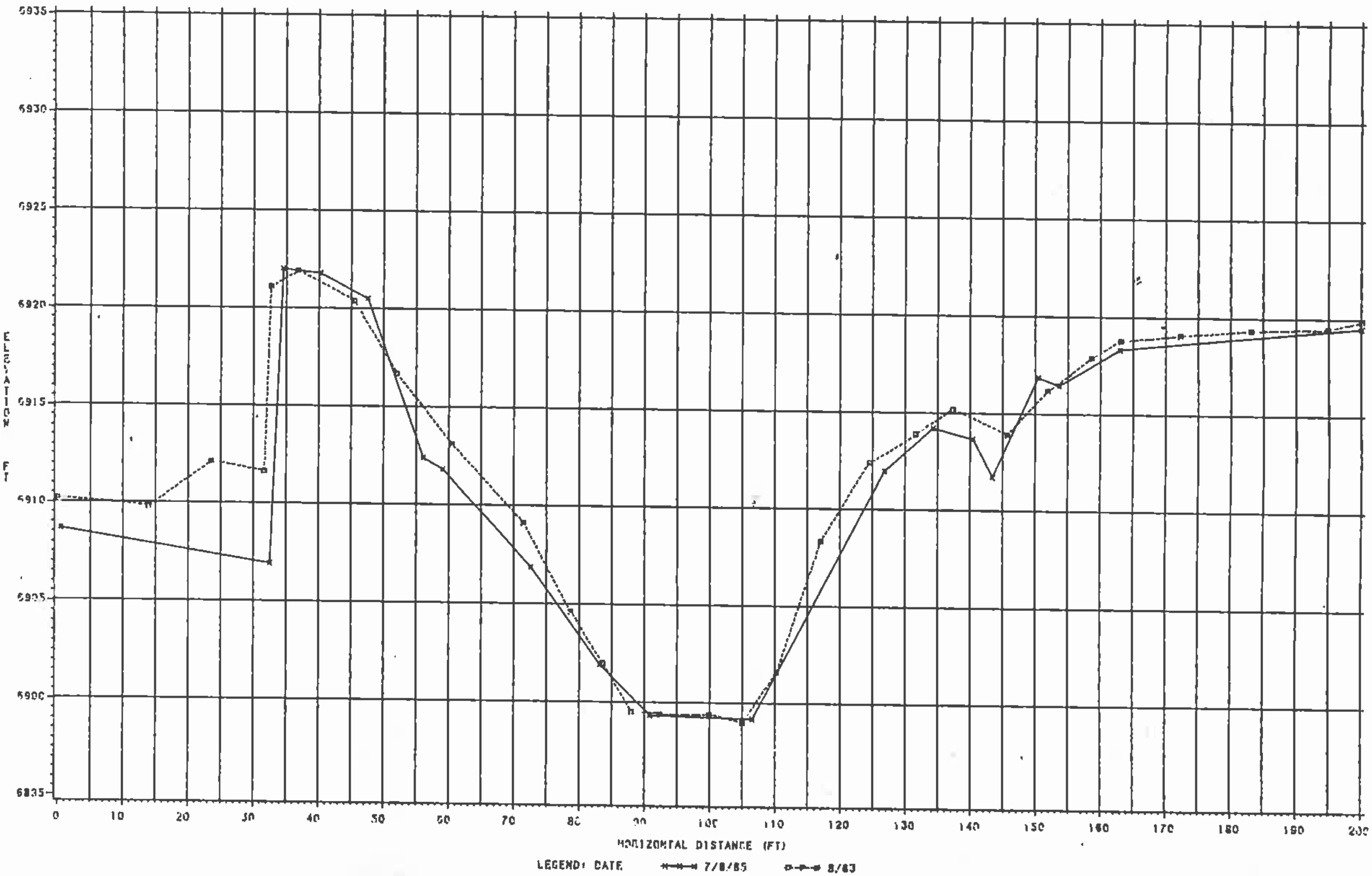


VIEW LOOKING UPSTREAM

8/83 LINE IS APPROX 1 FT UPSTREAM OF 7/85 LINE

CROSS SEC[illegible]N AT SITE 78

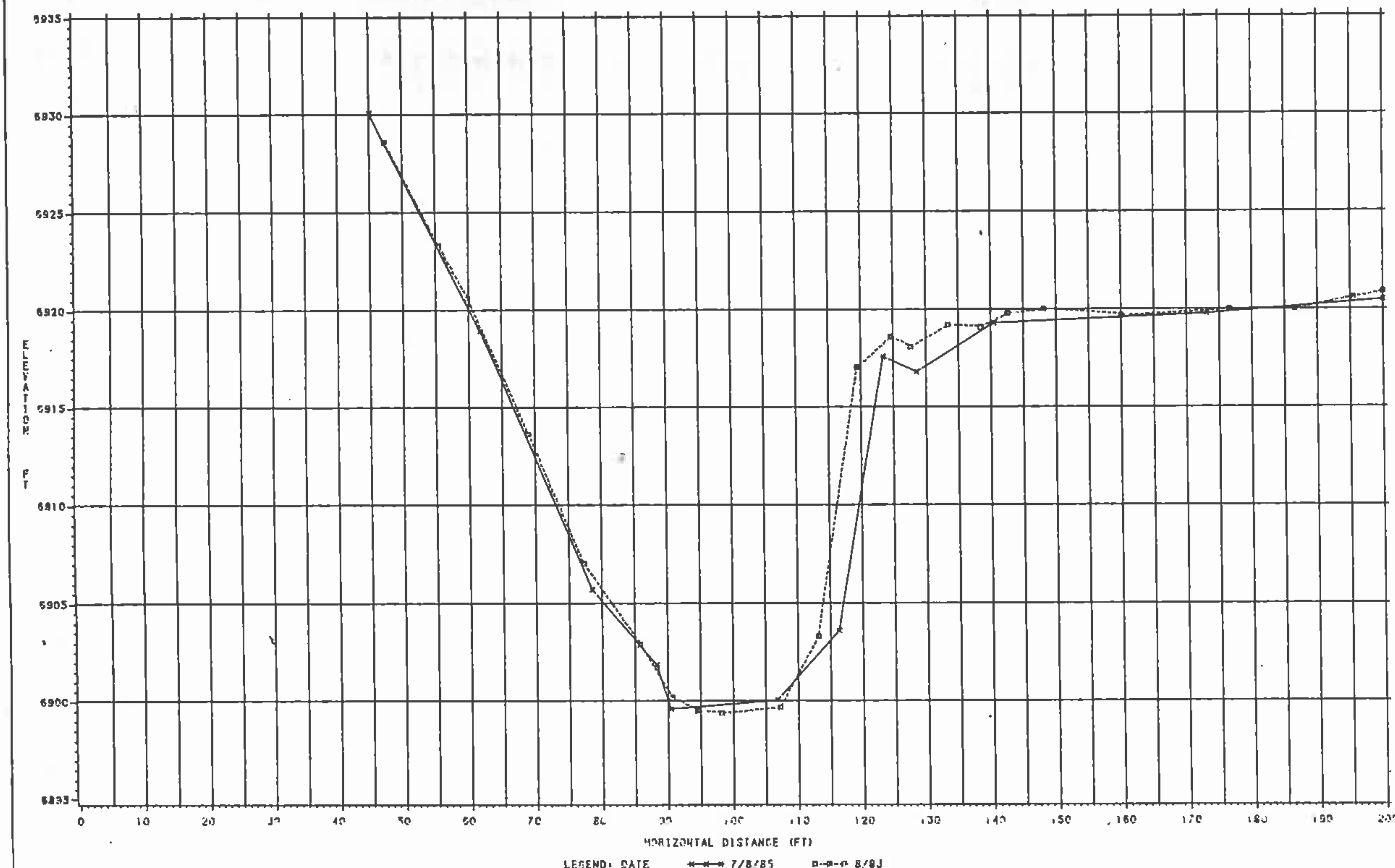
LINE 3



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 78

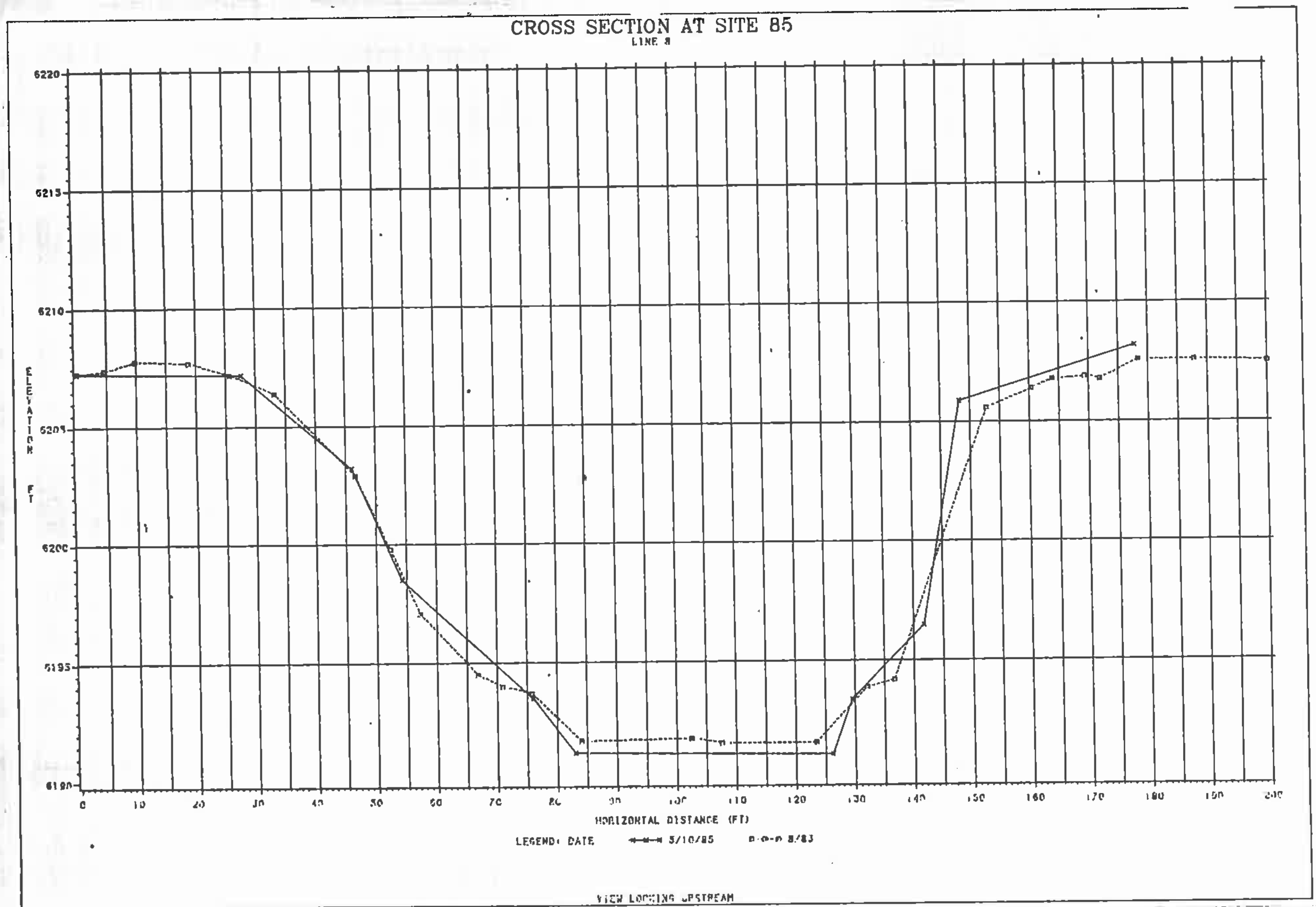
LINE 4



VIEW LOOKING UPSTREAM
8/83 LINE IS APPROX 2 FT UPSTREAM FROM THE 7/85 LINE
IN THE STREAM BOTTOM

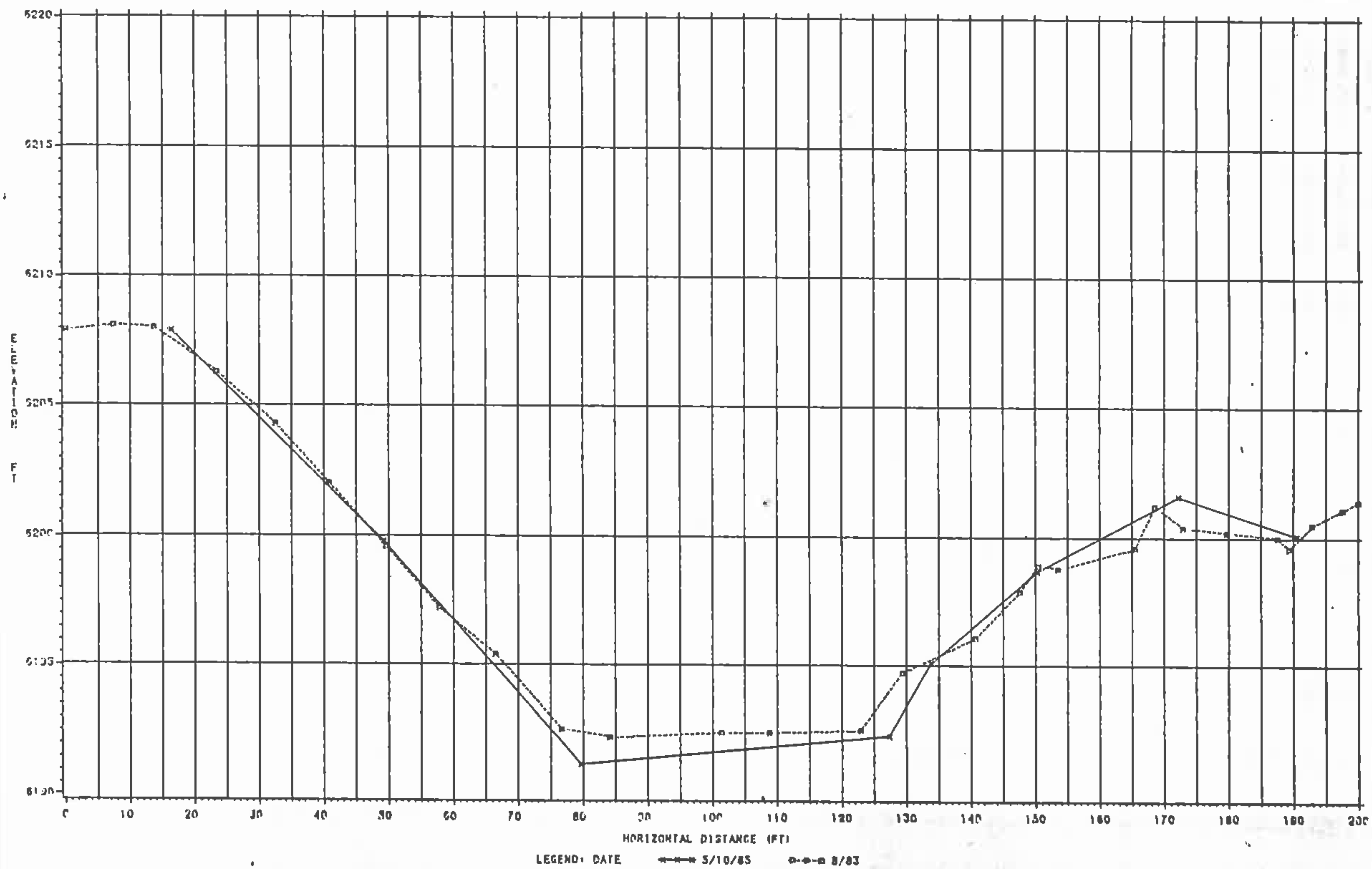
CROSS SECTI T SITE 78

VIEW LOOKING UPSTREAM
NOTE: 8/83 LINE IS 4 TO 5 FT DOWNSTREAM FROM 7/85 LINE
IN THE CHANNEL BOTTOM


CROSS SECTION AT SITE 85
LINE 8
ELEVATION FT
6220
6215
6210
6205
6200
6195
6190
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
HORIZONTAL DISTANCE (FT)
LEGEND: DATE 5/10/85 8/83
VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 85

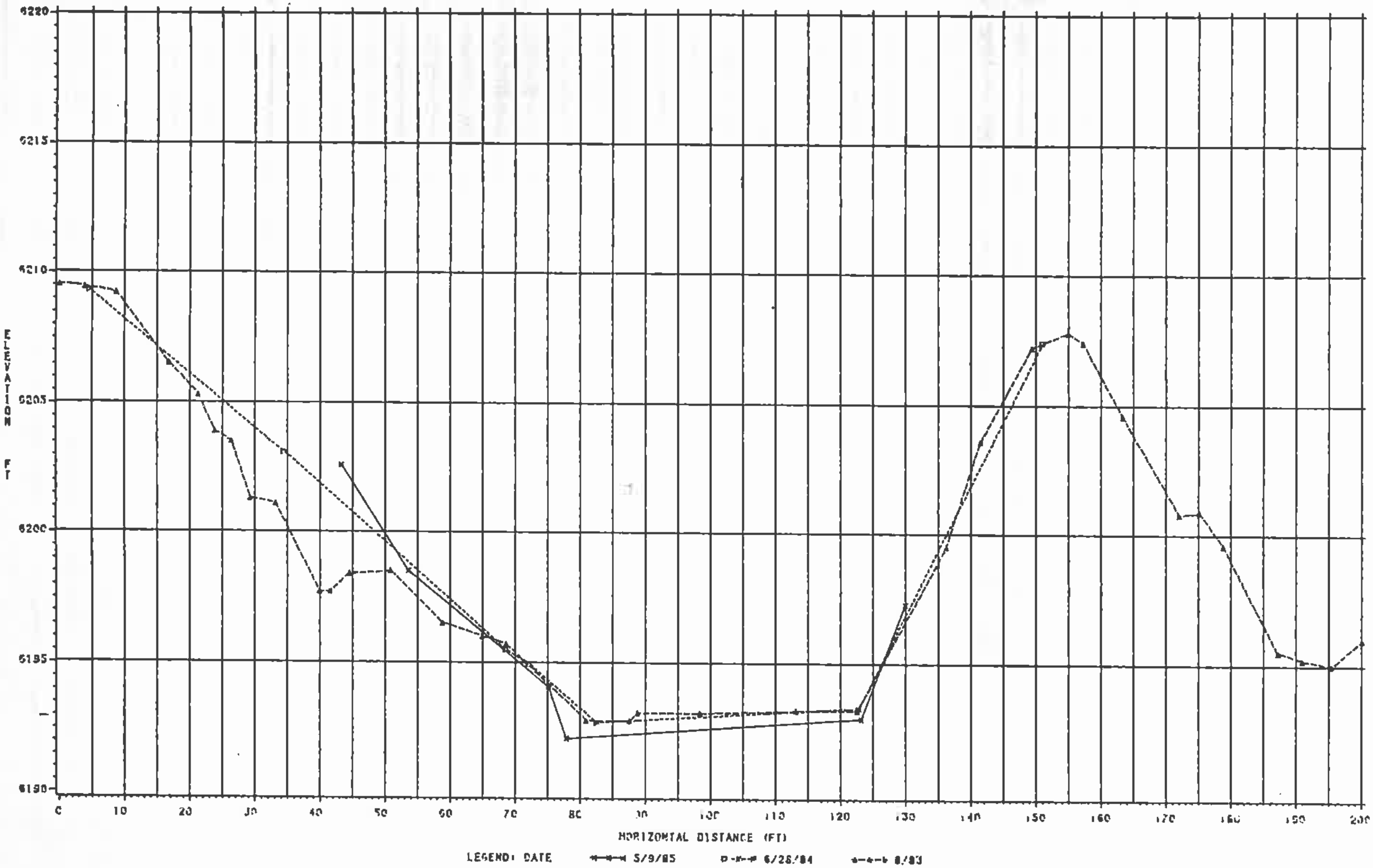
LINE 9



VIEW LOOKING UPSTREAM

CROSS SEC' AT SITE 85

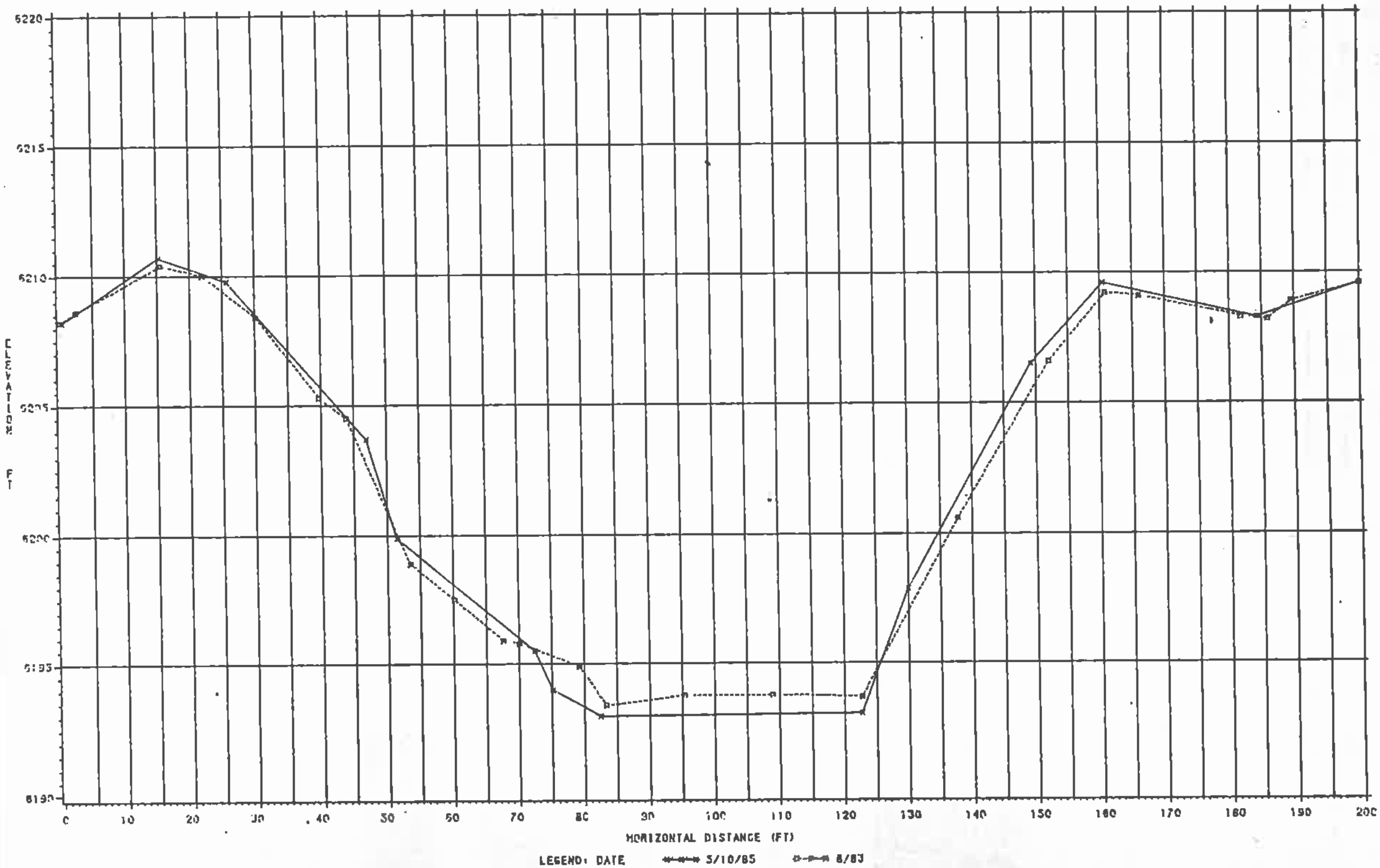
LINE10 (THRU CREST GAGE)



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 85

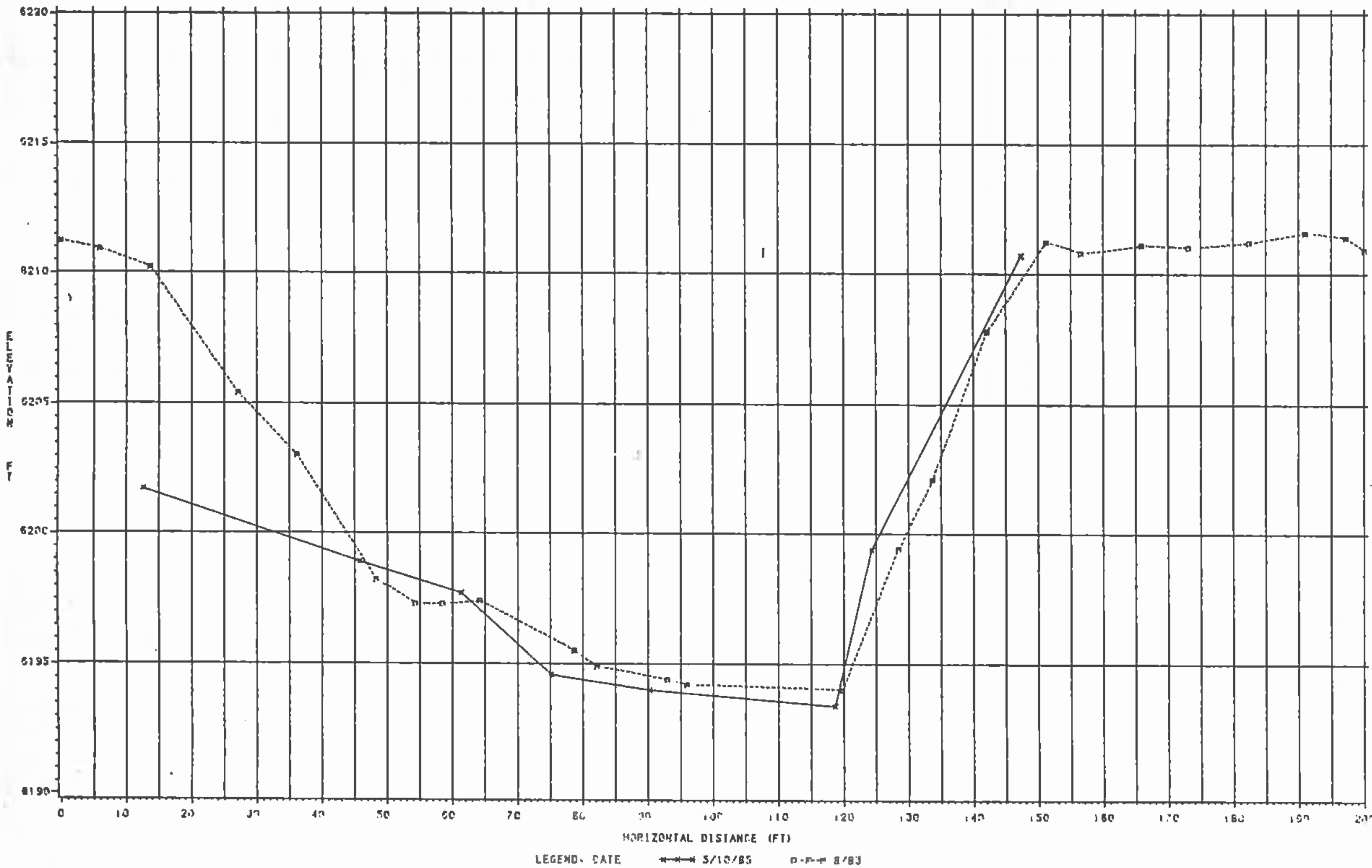
LINE 11



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 85

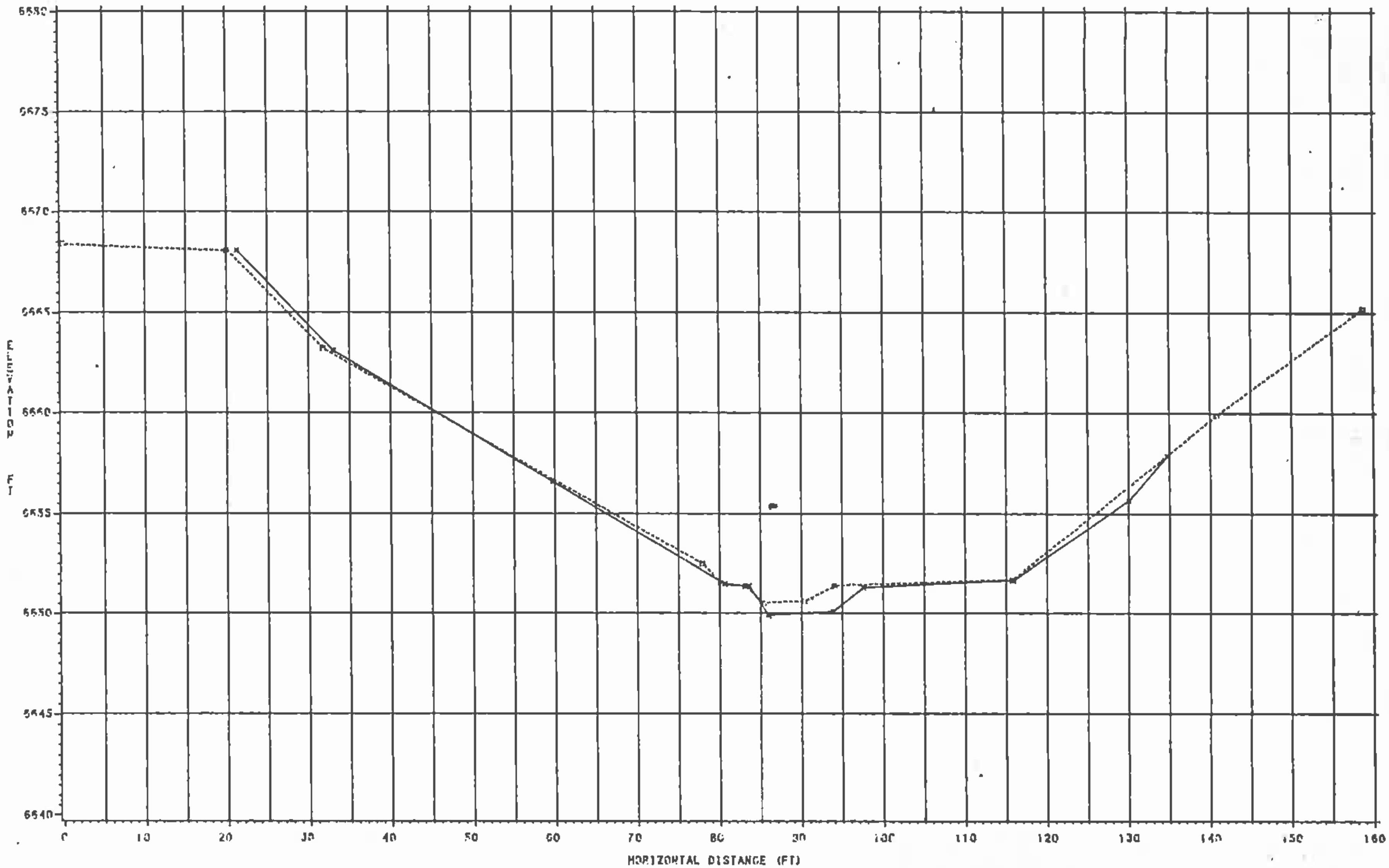
LINE 12



VIEW LOOKING UPSTREAM

CROSS SECTION AT SITE 157

THRU CREST GAGE



LEGEND: DATE 5/8/85 6/27/84

VIEW LOOKING UPSTREAM

NOTE: THIS SITE IS IN THE N-7/N-8 CHANNEL REALIGNMENT

ATTACHMENT 2

Summary of USGS Flow Data at Moenkopi Wash,
Chinle Wash and Laguna Creek (1964 to 1984)

Crest-stage partial-record stations

The following table contains annual maximum discharge for crest-stage stations. A crest-stage is a device which will register the peak stage occurring between inspections of the gage. A stage-discharge relation for each gage is developed from discharge measurements made by indirect measurements of peak flow or by current meter. The date of the maximum discharge is not always certain but is usually determined by comparison with nearby continuous-record stations, weather records, or local inquiry. Only the maximum discharge for each water year is given. Information on some lower floods may have been obtained, and discharge measurements may have been made for purposes of establishing the stage-discharge relation, but these are not published herein. The years given in the period of record represent water years for which the annual maximum has been determined. For most stations the initial year of record is incomplete, but annual maximums generally occur during the period July to September. Unless a specific starting date is given under period of record, discharges listed for the initial year are the maximum during the summer flood season. At some stations, flood marks from peaks occurring prior to installation of gage have been used to compute a discharge. The dates when these peaks occurred are unknown and the letter "a" has been entered in date column.

Annual maximum discharge at crest-stage partial-record stations

Station No.	Station name	Location	Drainage area (sq mi)	Period of record	Annual maximum: Date	Gage height (feet)	Discharge (cfs)
San Juan River basin							
3787.5	Gothic Creek near Mexican Water	Near middle of sec.15 (unsurveyed), T.41 N., R.27 E., at State Highway 64, 10 miles east of Mexican Water and 52 miles east of Kayenta.	8.53	1963-64	(a) 1963 8- -64	- - 2.00	280 (b) 63
3790.3	Black Mountain Wash near Chinle	In T.7 N., R.11 W. Navajo Meridian, at Navajo Highway 8, 1 mile south of Many Farms and 13 miles north of Chinle.	80.7	1963-64	8- 9-63 8- -64	5.79 7.84	(c) (c)
3790.6	Lukachukai Creek tributary near Lukachukai	Lat 36°28'10", long 109°24'20", at Navajo Highway 12, 6.8 miles southeast of Round Rock and 10 miles northwest of Lukachukai.	1.37	1963-64	8-31-63 7-31-64	3.01 3.99	15 33
3790.8	Chinle Wash tributary near Rock Point	Lat 36°47', long 110°40', at Navajo Reservation Road No. 12, 4.5 miles north of Rock Point.	2.5	1964	1964	-	d(4
3791.0	Long House Wash near Kayenta	Lat 36°34'50", long 110°28'45", at State Highway 64, 17 miles southwest of Kayenta.	e1.6	1963-64	(a) 8- 6-63 7-31-64	- 7.12 9.86	960 548 1,020
3795.6	El Capitan Wash near Kayenta	Lat 36°51'32", long 110°15'55", at State Highway 464, 9 miles north of Kayenta.	5.88	1963-64	8-30-63 7-31-64	7.17 4.26	663 161

GAGING-STATION RECORDS

SAN JUAN RIVER BASIN

9-3792. Chinle Wash near Mexican Water, Ariz.

Location.--Lat 36°56'40", long 109°42'30", in sec.19, T.41 N., R.25 E. (unsurveyed), in Navajo Indian Reservation, in midstream 150 ft upstream from State Highway 64, at Tres Nos Iah Trading Post, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from Laguna Creek, and 6 miles upstream from Arizona-Utah State line.
Drainage area.--3,660 sq mi, approximately, of which 360 sq mi is non-contributing.
Records available.--October 1964 to September 1965.
Gage.--Water-stage recorder and concrete control. Altitude of gage is 4,800 ft (from topographic map).
Extremes.--Maximum discharge during year, 732 cfs May 15 (gage height 4.25 ft); no flow for many days.
Highest flood since 1950 (information from a local resident) reached a stage of 7.2 ft (from floodmarks) Aug. 1, 1964 (discharge, 3,280 cfs) by slope-area measurement of peak flow.
Remarks.--Record good except those for periods of ice effect and those for periods of no gage-height record, which are poor. Some diversions upstream for irrigation, stock tanks, and domestic use. The largest is Many Farms Reservoir built in 1939 with an original capacity of 25,000 acre-feet, providing irrigation for 1,600 acres, but silting has reduced this capacity greatly.

Discharge measurements made prior to beginning of continuous discharge record

Date	Discharge (cfs)	Date	Discharge (cfs)	Date	Discharge (cfs)
Sept. 1, 1963	2,070	May 12	1.26	Aug. 1	3,280
Dec. 6	3.18	27	**0.05	7	69.4
Jan. 8, 1964	3.25	June 23	0	Sept. 9	7.82
Feb. 20	6.00	July 14	2.81		
Apr. 20	2.00	25	24.0		

** Field estimate.

Rating table, except periods of ice effect (gage height, in feet, and discharge, in cubic feet per second)
(Shifting-control method used Oct. 1 to Dec. 10)

1.75	0	2.3	16
1.8	.4	2.5	36
1.9	1.1	2.7	67
2.0	2.4	3.0	132
2.1	4.4	3.5	302
2.2	9.2	4.0	552

Discharge, in cubic feet per second, water year October 1964 to September 1965

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	5.4	4.0	2.6	3	11	4	3.8	47	3.2	0.6	40	1.0
2	5.4	3.8	2.6	2	8	3	2.6	124	1.8	.4	154	.7
3	5.4	4.0	2.6	2	6	4	8.2	153	1.2	.2	226	178
4	5.8	3.8	2.6	2	5	4	13	70	1.0	0	66	225
5	5.4	3.8	2.2	2	4	3	15	60	.9	0	15	44
6	5.4	3.6	2.4	4	7	3	15	192	.8	.4	6	31
7	4.4	4.0	2.4	150	11	3	8.2	162	1.0	.1	3	15
8	5.4	3.6	2.1	165	14	*4	8	130	1.0	.1	1	5
9	5.4	4.0	2.0	73	10	3	11	100	1.0	0	**.5	2
10	5.4	4.4	2.1	30	8	3	11	75	1.0	0	0	1
11	5.4	3.6	*2	15	6	2	12	50	1.6	0	0	.5
12	4.9	3.4	2	10	3	2	12	25	1.8	207	0	0
13	4.9	4.2	2	6	3	2	6.3	15	1.0	168	0	68
14	4.9	4.2	2	8	2	2	5.8	50	*6.3	15	0	15
15	4.9	4.0	2	7	2	2	*6.3	263	4.2	2	.9	2.2
16	5.8	4.0	2	8	3	3	6.8	421	2.0	0	0	2.2
17	5.8	3.2	2	8	3	2.6	4.4	322	1.2	0	29	.5
18	5.4	3.2	2	9	4	4.0	4.4	244	.9	.3	82	146
19	*4.9	3.0	2	*8	6	3.8	4.9	100	.8	132	64	160
20	5.4	3.0	2	8	27	2.2	3.6	15	.7	3	22	30
21	4.5	2.8	2	9	43	2.2	10	5.8	.8	0	15	20
22	4.4	2.4	2.8	9	29	2.0	174	2.1	.7	0	8.2	15
23	4.2	2.4	5.8	7	11	1.9	206	1.0	.8	52	2.1	10
24	4.0	*2.6	6.3	7	11	2.4	189	19	3.6	164	1.0	*11
25	4.0	3.0	23	6	11	11	177	32	1.9	289	.7	6.3
26	4.0	2.8	19	4	5	7.3	100	115	.6	180	.6	4.9
27	4.2	3.0	16	3	5.8	7	60	141	.3	50	.4	4.4
28	4.9	2.4	11	2	4.4	25	40	101	.4	34	.4	3.6
29	4.9	2.8	10	2	------	15	58	75	.3	35	.3	3.0
30	4.4	2.8	6	3	------	7	50	30	.4	117	.2	2.8
31	4.0	------	3	6	------	3.6	------	7	------	15	.2	------
Total	153.2	101.8	148.5	578	263.2	144.0	1,226.3	3,101.0	43.2	1,465.1	738.5	1,008.1
Mean	4.94	3.39	4.79	18.6	9.40	4.65	40.9	100	1.44	47.3	23.8	33.6
Ac-ft	304	202	295	1,150	522	286	2,430	6,150	86	2,910	1,460	2,000

Calendar year 1964: Max - Min - Mean - Ac-ft -
Water year 1964-65: Max 421 Min 0 Mean 24.6 Ac-ft 17,800

Peak discharge (base, 500 cfs)

Date	Time	Gage height	Discharge	Date	Time	Gage height	Discharge
5-15	2100	4.25	732	5-13	0200	4.03	573
7-12	2300	4.01	559				

* Discharge measurement or observation of no flow made on this day.
** Field estimate made on this day.
Note.--Stage-discharge relation affected by ice Dec. 29 to Jan. 2, Jan. 10 to Feb. 20, 23-26, Mar. 1-16, Apr. 8, 9. (No gage-height record Dec. 11-21, Mar. 27-30, Apr. 26-28, May 4, 5, 8-14, 19, 29-31, July 14-18, 20-22, 26, 27, 31, Aug. 5-8, Sept. 7-12, 17, 19-23.)

9-3792. Chinle Wash near Mexican Water, Ariz.

Location.--Lat 36°56'40", long 109°42'30", in sec.19, T.41 N., R.25 E. (unsurveyed), in Navajo Indian Reservation, in midstream 150 ft upstream from State Highway 64, at Tes Nez Iah Trading Post, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from Laguna Creek, and 6 miles upstream from Arizona-Utah State line.

Drainage area.--3,660 sq mi, approximately, of which 360 sq mi is non-contributing.

Records available.--October 1964 to September 1966.

Gage.--Water-stage recorder and concrete control. Altitude of gage is 4,800 ft (from topographic map).

Extremes.--Maximum discharge during year, 650 cfs Dec. 24 (gage height, 4.14 ft); no flow for many days.
1964-66: Maximum discharge 732 cfs May 15, 1965 (gage height, 4.25 ft); no flow at times in each year.
Highest flood since 1950 (information from a local resident) reached a stage of 7.2 ft (from floodmarks) Aug. 1, 1964 (discharge, 3,280 cfs) by slope-area measurement of peak flow.

Remarks.--Records fair. Some diversions upstream for irrigation, stock tanks, and domestic use. The largest is Many Farms Reservoir built in 1939 with an original capacity of 25,000 acre-feet, providing irrigation for 1,600 acres, but silting has reduced this capacity greatly.

Discharge, in cubic feet per second, water year October 1965 to September 1966

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	2.4	4.4	7	45	5	10	25	0.9	0.1	0.3	165	80
2	2.1	4.4	7	20	6	13	101	.9	.1	.2	47	92
3	2.2	4.9	8	13	4	9	107	1.0	.1	1.3	27	40
4	3.2	3.8	8	13	4	7	103	1.0	.1	.2	39	25
5	3.8	4.4	8	12	5	7	75	1.0	.1	0	75	15
6	4.0	4.4	8	10	8	3	45	1.1	.1	0	6.0	10
7	3.6	4.4	7	8	12	9	16	1.1	.1	0	1.8	6
8	3.2	4.9	7.8	6	13	17	9	1.0	.1	0	.5	3
9	3.2	4.0	11	5	13	72	3	1.0	.2	0	.2	2
10	3.2	5.8	17	15	9	75	2.2	.9	.3	0	21	2
11	3.2	4.9	55	15	5	45	1.5	1.5	.1	0	25	1
12	3.2	4.9	53	13	3	25	6.3	3.6	0	0	4.7	.5
13	3.2	4.9	35	9	3	20	3.8	1.9	0	0	2.4	.2
14	3.0	4.4	26	8	3	18	2.4	1.0	0	0	1.3	.2
15	3.0	4.9	20	8	4	16	1.4	.9	0	0	.4	0
16	44	4.4	15	10	4	12	1.1	.8	0	0	0	0
17	32	4.2	19	8	7	8	1.1	.8	0	0	0	0
18	76	5.8	17	8	9	4	.8	.7	0	0	0	0
19	96	6.3	14	4.2	10	2	1.5	.8	0	0	0	1.2
20	36	5.8	13	3	12	2	1.8	.8	0	0	0	19
21	18	5.8	12	4	19	12	1.5	.8	0	0	0	25
22	11	5.8	11	3	26	4.9	1.8	.6	0	0	0	10
23	7.8	19	74	4	23	4.4	1.8	.4	0	0	0	5
24	6.3	184	350	4	21	3.8	2.2	.5	0	5.3	6.5	3.5
25	5.4	37	128	5	18	2.6	2.8	.7	0	7.6	24	2
26	4.9	155	28	6	16	2	1.2	.8	0	3.0	11	1.5
27	4.9	92	25	6	15	3.0	2.0	.7	0	.5	4.4	1.4
28	4.9	36	15	7	12	39	2.1	.7	0	.6	2.4	1.0
29	4.4	27	16	7	-	40	1.1	.2	0	7.5	1.4	1.3
30	4.4	13	101	8	------	21	1.0	.2	.1	48	.8	1.8
31	4.4	------	160	8	------	16	------	.9	------	45	67	------
Total	406.9	670.5	1,275.8	295.2	289	522.7	525.4	29.2	1.5	119.5	533.8	349.6
Mean	13.1	22.4	41.2	9.52	10.3	16.9	17.5	0.94	0.05	3.85	17.2	11.7
Ac-ft	807	1,330	2,530	586	573	1,040	1,040	58	3.0	237	1,060	693

Calendar year 1965: Max 421 Min 0 Mean 29.9 Ac-ft 21,660
Water year 1965-66: Max 350 Min 0 Mean 13.8 Ac-ft 9,960

Peak discharge (base, 500 cfs).--Nov. 24 (0200) 528 cfs (3.97 ft); Dec. 24 (1830) 650 cfs (4.14 ft).

9-3792. Chinle Wash near Mexican Water, Ariz.

Location.--Lat 36°56'40", long 109°42'30", in sec.19, T.41 N., R.25 E. (unsurveyed), in Navajo Indian Reservation, in midstream 150 ft upstream from bridge on State Highway 64, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from Laguna Creek, and 6 miles upstream from Arizona-Utah State line.

Drainage area.--3,660 sq mi, approximately, of which 360 sq mi is non-contributing.

Records available.--October 1964 to September 1967.

Gage.--Water-stage recorder and concrete control. Altitude of gage is 4,800 ft (from topographic map).

Extremes.--Maximum discharge during year, 1,230 cfs Aug. 10 (gage height, 4.80 ft); no flow for many days.
1964-67: Maximum discharge, that of Aug. 10, 1967; no flow at times in each year.
Highest flood since 1950 (information from a local resident) reached a stage of 7.2 ft (from floodmarks) Aug. 1, 1964 (discharge, 3,280 cfs) by slope-area measurement of peak flow.

Remarks.--Records fair except those below 30 cfs, which are poor. Some diversions upstream for irrigation, stock tanks, and domestic use. The largest is Many Farms Reservoir built in 1939 with an original capacity of 25,000 acre-feet, providing irrigation for 1,600 acres, but silting has reduced this capacity greatly.

Discharge, in cubic feet per second, water year October 1966 to September 1967

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	2.1	.70	3.0	1.0	14	.40	1.3	.80	13	0	60	255
2	5.4	1.5	5.0	1.0	14	.40	1.0	.90	9.0	0	63	40
3	6.0	1.8	5.0	1.0	8.5	.30	.80	1.7	4.7	0	30	20
4	1.7	1.2	2.0	1.0	7.0	.30	.80	1.8	5.0	0	20	10
5	.80	1.2	2.0	1.0	4.4	.20	.80	1.4	12	0	15	5.0
6	79	1.2	2.0	1.0	7.0	.20	.70	1.8	30	0	10	5.0
7	79	1.2	2.0	1.0	7.0	.20	.70	3.0	15	0	10	5.0
8	34	1.4	5.0	1.0	8.0	.20	.50	2.1	5.0	0	7.0	5.0
9	7.5	10	3.0	1.0	10	.50	.50	1.7	4.0	.10	43	5.0
10	1.4	33	3.0	1.0	6.0	.90	.70	1.3	3.0	0	353	5.0
11	1.4	11	3.0	1.0	5.0	.50	.70	1.2	3.0	0	222	5.0
12	1.4	10	3.0	1.2	4.7	1.6	.50	1.2	3.0	0	189	60
13	1.4	5.0	3.0	1.2	6.0	.90	.70	1.2	2.1	0	177	15
14	1.4	5.0	3.0	1.2	4.4	.70	.70	1.6	3.7	7.5	148	7.0
15	1.4	3.0	3.0	1.3	3.8	.50	.70	1.6	2.1	32	19	4.4
16	1.3	3.0	3.0	1.3	3.5	.80	.50	2.0	2.0	14	14	3.8
17	.90	3.0	3.0	1.4	2.0	.90	.70	2.0	1.8	137	7.0	3.3
18	.80	3.0	3.0	1.4	1.4	1.0	.70	1.8	1.8	321	7.0	5.0
19	1.3	3.0	3.0	1.5	.20	.90	.70	1.8	4.1	102	2.4	1.7
20	1.4	2.0	3.0	1.5	.20	.80	.40	1.7	5.0	10	1.5	1.4
21	1.6	2.0	4.1	1.6	.20	.80	.50	1.7	14	1.4	1.0	2.4
22	1.3	2.0	1.4	1.7	.20	.80	.80	1.7	11	1.3	1.2	5.5
23	1.3	1.5	.50	2.1	.10	1.0	.80	1.7	6.0	1.2	4.4	5.0
24	1.6	1.5	.80	2.1	.40	.30	.90	1.7	.80	77	1.8	3.6
25	1.2	1.5	1.2	3.5	.50	1.0	1.0	1.7	0	7.0	1.6	84
26	1.6	1.5	1.7	5.0	.50	.80	1.3	29	0	3.0	1.2	120
27	1.7	1.5	2.0	5.0	.40	.80	.60	10	0	2.0	.90	30
28	1.3	1.5	1.4	5.0	.30	.80	.70	7.8	0	1.0	.50	15
29	1.0	1.0	1.4	7.5	-----	.80	.70	9.5	0	0	8.4	10
30	.90	1.0	1.4	21	-----	.80	.60	4.1	0	30	9.5	7.0
31	.80	-----	1.4	10	-----	.80	-----	7.0	-----	153	82	-----
Total	243.90	116.20	79.30	87.5	119.70	20.90	22.00	108.50	161.10	900.50	1,510.40	744.1
Mean	7.87	3.87	2.56	2.82	4.28	.67	.73	3.50	5.37	29.0	48.7	24.8
Max	79	33	5.0	21	14	1.6	1.3	29	30	321	353	255
Min	.80	.70	.50	1.0	.10	.20	.40	.80	0	0	.50	1.4
Ac-ft	484	230	157	174	237	41	44	215	320	1,790	3,000	1,480

Cal yr 1966: Total 3,105.30 Mean 8.51 Max 165 Min 0 Ac-ft 6,160
Wtr yr 1967: Total 4,114.10 Mean 11.3 Max 353 Min 0 Ac-ft 8,160

Peak discharge (base, 500 cfs).--Aug. 10 (1200) 1,230 cfs (4.80 ft); Sept. 1 (1000) 834 cfs (4.43 ft).

SAN JUAN RIVER BASIN

9-3792. Chinle Wash near Mexican Water, Ariz.

Location.--Lat 36°56'40", long 109°42'30", in sec.19, T.41 N., R.25 E. (unsurveyed), in Navajo Indian Reservation, in midstream 150 ft upstream from bridge on State Highway 64, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from Laguna Creek, and 6 miles upstream from Arizona-Utah State line.

Drainage area.--3,660 sq mi, approximately, of which 360 sq mi is non-contributing.

Records available.--October 1964 to September 1968.

Gage.--Water-stage recorder and concrete control. Altitude of gage is 4,800 ft (from topographic map).

Extremes.--Maximum discharge during year, 1,040 cfs Aug. 8 (gage height, 4.62 ft); no flow for many days.
1964-68: Maximum discharge, 1,230 cfs Aug. 10, 1967 (gage height, 4.80 ft); no flow at times in each year.
Highest flood since 1950 (information from a local resident) reached a stage of 7.2 ft (from floodmarks) Aug. 1, 1964 (discharge, 3,280 cfs) by slope-area measurement of peak flow.

Remarks.--Records fair except those below 15 cfs, which are poor. Some diversions upstream for irrigation, stock tanks, and domestic use. The largest is Many Farms Reservoir built in 1939 with an original capacity of 25,000 acre-feet, providing irrigation for 1,600 acres, but silting has reduced this capacity greatly.

DISCHARGE, IN CFS, WATER YEAR OCTOBER 1967 TO SEPTEMBER 1968

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7.0	4.1	5.0	.50	100	2.7	1.7	1.4	.41	0	97	1.7
2	7.0	4.4	6.5	.50	50	7.0	1.7	1.4	.47	0	194	1.0
3	6.5	5.0	5.0	.50	30	3.3	1.7	1.4	.53	0	208	1.7
4	6.5	4.7	4.4	.50	28	2.7	1.7	1.3	.47	.05	227	1.0
5	6.5	4.4	4.1	.50	26	2.7	1.6	1.6	.31	.12	20	2.1
6	5.0	5.5	3.3	.50	25	2.7	1.7	1.4	.11	.20	10	2.0
7	4.1	5.5	3.6	.50	22	3.6	1.6	1.2	.19	.27	81	1.8
8	3.8	6.5	5.0	.50	22	3.0	1.6	1.2	.75	.27	317	1.2
9	4.1	6.0	3.6	.50	26	3.0	1.6	1.2	1.0	.10	112	.88
10	3.6	6.0	3.2	1.0	25	4.1	1.6	1.0	1.3	.10	32	1.3
11	3.8	6.0	3.5	1.5	17	4.4	1.6	1.0	1.0	.02	279	1.0
12	3.8	5.5	4.0	1.0	14	3.3	1.4	1.0	.75	.01	268	1.2
13	3.6	7.5	3.0	1.0	12	2.7	1.3	1.0	.47	.05	164	4.7
14	2.7	6.5	3.0	1.0	14	2.0	1.4	.75	.35	0	34	13
15	3.8	6.0	3.5	1.0	12	2.0	1.3	.61	.35	0	22	8.5
16	3.6	6.5	3.5	1.0	8.0	2.0	1.3	.67	.27	0	15	5.5
17	3.6	6.5	3.0	1.0	3.3	1.8	1.2	.53	.33	0	7.5	1.8
18	3.6	6.5	2.5	1.0	6.5	2.1	1.2	.87	.47	0	3.3	2.0
19	3.3	5.5	2.5	1.0	7.5	3.6	1.0	.67	.47	0	1.6	2.1
20	3.3	6.0	2.0	1.0	7.5	2.4	1.3	.67	.35	0	7.4	.10
21	4.1	6.0	2.0	1.0	6.0	2.4	1.3	.53	.15	0	3.0	0
22	3.0	5.0	2.5	1.0	5.5	3.3	1.8	.35	.15	0	2.1	.72
23	3.0	4.7	2.5	1.0	9.0	1.8	1.7	.35	.17	0	.88	1.4
24	2.5	7.5	2.0	1.0	12	.75	1.6	.47	.26	0	1.3	1.0
25	2.4	7.0	1.5	1.0	8.0	.06	1.6	.53	0	.27	1.6	1.0
26	4.1	6.0	1.5	1.0	4.4	3.1	1.6	.75	0	75	1.7	1.0
27	4.1	4.7	1.5	1.0	3.8	1.7	1.4	.88	0	137	1.8	1.7
28	3.8	4.1	1.5	4.7	3.6	1.7	1.4	.61	.11	111	8.7	2.0
29	3.6	5.0	1.5	206	3.0	1.7	1.4	.61	0	93	16	2.0
30	4.4	4.5	1.0	188	------	1.7	1.4	.47	0	81	6.5	2.1
31	3.8	------	.80	135	------	1.8	------	.47	------	22	4.1	------
TOTAL	128.0	169.1	92.50	556.70	511.1	81.11	44.7	26.89	11.19	520.46	2,147.48	67.50
MEAN	4.13	5.64	2.98	18.0	17.6	2.62	1.49	.87	.37	16.8	69.3	2.25
MAX	7.0	7.5	6.5	206	100	7.0	1.8	1.6	1.3	137	317	13
MIN	2.4	4.1	.80	.50	3.0	.06	1.0	.35	0	0	.88	0
AC-FT	254	335	183	1,100	1,010	161	89	53	22	1,030	4,260	134

CAL YR 1967 TOTAL 4,064.30 MEAN 11.1 MAX 353 MIN 0 AC-FT 8,060
WTR YR 1968 TOTAL 4,356.73 MEAN 11.9 MAX 317 MIN 0 AC-FT 8,640

Peak discharge (base, 500 cfs).--Aug. 8 (1100) 1,040 cfs (4.62 ft); Aug. 11 (1300) 770 cfs (4.30 ft).

GAGING-STATION RECORDS

SAN JUAN RIVER BASIN

9-3792. Chinle Wash near Mexican Water, Ariz.

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft upstream from bridge on State Highway 64, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from Laguna Creek, and 6 miles upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 sq mi, approximately, of which 360 sq mi is noncontributing.

PERIOD OF RECORD.--October 1964 to current year.

GAGE.--Water-stage recorder and concrete control. Altitude of gage is 4,720 ft, revised (from topographic map).

AVERAGE DISCHARGE.--5 years, 15.0 cfs (10,870 acre-ft per year).

EXTREMES.--Current year: Maximum discharge, 590 cfs Jan. 15 (gage height, 4.05 ft); no flow for many days.
Period of record: Maximum discharge, 1,230 cfs Aug. 10, 1967 (gage height, 4.80 ft); no flow at times in each year.
Highest flood since 1950 (information from a local resident) reached a stage of 7.2 ft (from floodmarks) Aug. 1, 1964, discharge, 3,280 cfs by slope-area measurement of peak flow.

REMARKS.--Records fair except those for period of no gage-height record and those for winter months, which are poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir built in 1939 with an original capacity of 25,000 acre-ft, provides irrigation for 1,600 acres, but silting has reduced this capacity greatly.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1968 TO SEPTEMBER 1969

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.6	3.0	1.3	5.5	5.0	4.5	39	10	.06	0	25	8.0
2	3.0	5.5	1.8	5.0	5.0	4.1	40	8.0	.18	0	15	3.0
3	3.3	3.5	1.8	5.0	5.0	4.1	45	6.0	.31	0	10	1.0
4	44	5.0	1.0	5.0	5.0	4.4	43	5.0	.31	0	135	3.0
5	299	3.0	1.0	5.0	5.0	7.0	7.5	5.0	.11	0	80	2.0
6	90	2.5	1.0	5.0	5.0	6.5	5.0	5.0	.15	0	50	1.0
7	10	2.0	1.0	5.0	8.0	5.5	20	8.0	.18	0	30	1.0
8	5.0	2.0	1.0	5.0	9.5	5.0	45	68	.15	0	20	1.0
9	3.0	2.0	1.0	5.5	6.5	4.1	14	73	.03	0	15	1.0
10	2.0	2.0	1.0	6.5	7.5	4.7	10	54	0	0	10	1.0
11	2.0	2.0	2.0	6.5	7.5	7.0	6.0	51	0	0	20	3.0
12	2.0	5.0	1.5	7.0	13	7.0	5.0	35	0	0	7.0	15
13	2.0	30	1.0	7.0	14	5.0	5.0	20	0	0	2.0	6.0
14	2.0	30	1.0	7.5	14	36	25	15	.23	0	20	3.0
15	2.7	25	1.0	180	16	20	43	10	0	0	70	2.0
16	3.0	20	1.0	40	14	10	39	8.0	0	0	15	1.0
17	2.4	14	1.0	10	11	8.5	76	6.0	0	0	7.0	1.0
18	2.4	10	1.0	7.0	11	6.0	60	4.0	1.4	6.5	1.0	1.0
19	3.3	9.0	1.0	5.0	11	85	10	3.0	.15	22	1.0	1.0
20	3.8	6.5	1.0	5.0	10	121	7.0	2.0	0	274	5.0	1.0
21	3.8	6.0	1.0	5.0	9.5	15	6.0	1.0	0	106	4.0	1.0
22	4.1	4.7	1.0	5.0	8.0	13	5.0	.61	0	158	2.0	1.0
23	4.1	4.1	1.0	5.0	7.0	12	5.0	.47	0	60	1.0	1.0
24	3.8	4.1	1.0	5.0	6.0	12	10	.41	0	29	1.0	1.0
25	3.8	3.8	1.0	5.0	5.0	11	92	.47	.02	78	1.0	1.0
26	3.8	3.3	1.0	5.0	4.7	4.4	79	.47	1.3	30	1.0	1.0
27	4.1	1.8	3.0	5.0	4.4	4.0	64	.09	.23	15	1.0	1.0
28	2.1	1.8	4.4	5.0	4.7	3.5	40	0	0	10	4.0	1.0
29	1.8	1.7	4.1	5.0	------	7.1	30	0	0	110	2.0	1.0
30	1.8	1.3	5.5	5.0	------	9.0	15	.67	0	100	7.0	1.0
31	1.8	------	5.5	5.0	------	4.0	------	.11	------	50	15	------
TOTAL	523.5	214.6	51.9	382.5	232.3	450.4	890.5	400.30	4.81	1,048.5	577.0	66.0
MEAN	16.9	7.15	1.67	12.3	8.30	14.5	29.7	12.9	.16	33.8	18.6	2.20
MAX	299	30	5.5	180	16	121	92	73	1.4	274	135	15
MIN	1.8	1.3	1.0	5.0	4.4	3.5	5.0	0	0	0	1.0	1.0
AC-FT	1,040	426	103	759	461	893	1,770	794	9.5	2,080	1,140	131

CAL YR 1968 TOTAL 4,757.13 MEAN 13.0 MAX 317 MIN 0 AC-FT 9,440
WTR YR 1969 TOTAL 4,842.31 MEAN 13.3 MAX 299 MIN 0 AC-FT 9,600

PEAK DISCHARGE (BASE, 500 CFS).--Jan. 15 (1330) 590 cfs (4.05 ft); July 20 (0800) 531 cfs (3.96 ft).

NOTE.--No gage-height record July 21 to Sept. 30.

GAGING-STATION RECORDS

SAN JUAN RIVER BASIN

09379200. Chinle Wash near Mexican Water, Ariz.

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft upstream from bridge on U.S. Highway 164, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from Laguna Creek, and 6 miles upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 sq mi, approximately, of which 360 sq mi is noncontributing.

PERIOD OF RECORD.--October 1964 to current year.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft.

AVERAGE DISCHARGE.--6 years, 16.5 cfs (11,950 acre-ft per year).

EXTREMES.--Current year: Maximum discharge, 9,880 cfs Sept. 7 (gage height, 7.55 ft), from rating curve extended as explained below; no flow for several days.

Period of record: Maximum discharge, 9,880 cfs Sept. 7, 1970 (gage height, 7.55 ft), from rating curve extended above 600 cfs on basis of slope-area measurements at gage heights 5.4 and 7.55 ft; no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

REMARKS.--Records fair except those for period of no gage-height record and those for winter months, which are poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, built in 1939 with an original capacity of 25,000 acre-ft, provides irrigation for 1,600 acres, but silting has reduced this capacity greatly.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.0	4.7	2.4	2.7	2.4	1.4	1.0	3.8	0	0	0	2.4
2	1.0	4.7	2.1	2.4	2.0	2.8	1.0	2.4	.27	0	0	2.1
3	10	3.6	2.4	1.7	2.0	3.0	1.0	1.8	2.0	0	0	2.1
4	50	4.7	3.6	1.7	2.7	2.5	1.0	1.7	.53	0	.80	3.0
5	20	4.7	4.7	1.4	2.4	2.0	1.0	1.6	.53	0	5.6	433
6	10	4.7	5.0	1.3	2.4	1.9	1.0	1.3	.75	0	11	435
7	8.0	4.7	5.0	1.2	7.0	1.8	1.0	1.4	.88	38	2.1	4,070
8	6.0	4.7	4.4	.58	7.0	1.7	.75	1.8	.88	15	.18	231
9	4.7	4.7	4.4	1.2	6.0	1.6	.61	4.4	1.3	4.1	3.1	42
10	3.8	6.0	4.1	1.2	6.0	1.5	.53	2.4	1.3	5.5	1.4	30
11	3.6	6.5	3.6	1.3	5.0	1.4	.47	1.3	.88	7.5	.03	20
12	2.7	6.0	2.7	1.6	4.4	1.3	.47	.88	.47	4.4	0	10
13	2.1	5.5	2.4	1.4	2.1	1.2	.47	1.0	.18	1.5	0	5.0
14	3.0	4.7	2.4	1.6	1.8	1.1	.27	1.0	.06	1.0	.08	68
15	3.8	5.0	2.4	1.7	1.8	1.0	.47	.88	.02	.50	1.8	290
16	3.8	5.0	2.7	2.1	1.7	1.0	.61	1.2	.15	0	.35	74
17	3.0	10	3.3	2.4	1.7	1.0	1.2	1.2	.11	0	.27	30
18	3.3	4.7	5.0	15	1.6	1.0	1.6	1.2	.11	0	18	15
19	3.3	5.0	4.4	35	1.4	1.0	1.3	.88	.11	0	64	10
20	2.4	4.7	4.7	20	1.6	1.0	3.7	.88	.06	0	60	5.0
21	42	4.1	8.5	18	1.6	1.0	4.1	.67	.04	.02	599	5.0
22	279	3.8	10	17	1.7	1.0	3.3	.88	.01	0	148	5.0
23	590	3.6	9.0	16	1.7	1.0	3.3	.88	.01	.11	26	5.0
24	82	4.1	7.5	12	2.0	1.0	2.7	.67	0	.11	11	5.0
25	10	4.4	7.0	8.0	2.3	1.0	2.0	.32	0	0	6.5	5.0
26	8.0	4.7	6.0	6.0	3.0	1.0	1.7	.62	0	0	6.0	5.0
27	6.0	3.8	6.0	5.0	2.1	1.0	1.6	.75	0	0	11	5.0
28	5.0	3.6	4.1	4.5	1.6	1.0	1.7	.67	0	.01	6.5	5.0
29	5.0	3.6	3.3	4.1	------	1.0	1.7	.09	0	.02	7.5	5.0
30	5.0	2.7	2.4	1.7	------	1.0	8.1	0	0	0	4.4	5.0
31	4.7	------	1.6	2.0	------	1.0	------	0	------	0	2.4	------
TOTAL	1,182.2	142.2	136.4	191.78	79.0	42.2	49.65	38.57	10.65	77.77	997.01	5,827.6
MEAN	38.1	4.74	4.40	6.19	2.82	1.36	1.66	1.24	.36	2.51	32.2	194
MAX	590	10	10	35	7.0	3.0	8.1	4.4	2.0	38	599	4,070
MIN	1.0	2.7	1.6	.58	1.4	1.0	.27	0	0	0	0	2.1
AC-FT	2,340	282	271	380	157	84	98	77	21	154	1,980	11,560

CAL YR 1969 TOTAL 5,513.11 MEAN 15.1 MAX 590 MIN 0 AC-FT 10,940
WTR YR 1970 TOTAL 8,775.03 MEAN 24.0 MAX 4,070 MIN 0 AC-FT 17,410

PEAK DISCHARGE (BASE, 500 CFS)

DATE	TIME	G.H.	DISCHARGE	DATE	TIME	G.H.	DISCHARGE
10-23	1330	4.33	794	9- 7	0230	7.55	9,880
8-21	0730	5.38	2,070	9-15	1630	3.52	583
9- 5	1300	4.95	1,420				

NOTE.--No gage-height record Mar. 3 to Apr. 8.

09379200. Chinle Creek near Mexican Water, Ariz.
(Formerly published as Chinle Wash near Mexican Water)

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft upstream from bridge on U.S. Highway 164, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from confluence of Chinle Wash and Laguna Creek, and 6 miles upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 sq mi, approximately, of which 360 sq mi is noncontributing.

PERIOD OF RECORD.--October 1964 to current year.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft above mean sea level.

AVERAGE DISCHARGE.--7 years, 15.5 cfs (11,230 acre-ft per year).

EXTREMES.--Current year: Maximum discharge, 1,050 cfs Aug. 23 (gage height, 4.63 ft); no flow for several days.
Period of record: Maximum discharge, 9,860 cfs Sept. 7, 1970 (gage height, 7.55 ft), from rating curve extended above 600 cfs on basis of slope-area measurements at gage heights 5.4 and 7.55 ft; no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

REMARKS.--Records fair except those for winter periods, which are poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 miles upstream, was built in 1939 with an original capacity of 25,000 acre-ft. The reservoir provides off-channel storage for irrigation of about 1,600 acres.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.0	3.6	4.1	2.8	7.6	1.0	1.0	1.2	.03	.04	.67	15
2	4.0	3.3	7.1	3.3	10	1.2	1.3	1.0	0	.10	.60	5.9
3	4.0	2.7	5.0	3.4	8.0	2.0	1.3	.75	.02	.10	.53	6.3
4	3.0	2.4	4.3	2.7	4.1	3.7	1.2	.60	.39	0	.30	17
5	121	2.7	2.8	2.7	2.4	5.0	1.2	1.0	1.2	0	.83	7.1
6	21	3.0	2.7	1.8	2.1	13	1.3	1.3	.35	.18	.27	2.7
7	11	3.3	3.0	.50	2.4	7.0	1.3	1.4	.35	.31	29	3.2
8	6.5	2.5	3.2	0	1.6	5.0	1.2	1.4	.35	.18	41	3.3
9	4.1	3.8	7.0	0	1.7	4.0	1.2	1.3	.31	.03	9.1	4.3
10	3.6	4.4	8.0	0	2.1	4.0	1.2	1.0	.47	0	3.6	4.6
11	3.6	3.6	5.6	0	2.1	4.0	1.2	1.0	.31	0	2.1	2.5
12	2.4	3.6	3.9	.60	5.0	4.0	1.2	1.2	.27	0	3.4	.75
13	1.8	4.1	2.4	1.0	4.7	3.0	1.2	1.2	.41	0	10	3.0
14	1.7	3.6	2.1	.88	4.7	3.0	1.2	2.7	.41	0	3.6	2.7
15	1.4	3.6	2.6	1.2	3.6	2.0	1.3	1.7	.31	0	1.6	1.5
16	1.3	3.6	3.6	1.2	3.8	2.0	1.3	.88	.31	0	1.2	.53
17	3.6	3.3	2.3	1.3	5.5	2.0	1.2	.47	.15	0	9.4	1.4
18	2.4	3.0	4.6	1.6	4.7	1.0	1.2	.14	.18	0	18	1.4
19	1.8	3.6	3.1	1.7	4.4	1.0	.85	1.1	.22	0	16	.31
20	2.4	4.3	4.7	2.3	4.1	1.5	1.4	.88	.15	58	87	.22
21	2.1	2.7	4.6	11	3.6	1.5	1.3	.53	.10	92	186	.11
22	2.7	3.6	4.2	16	2.0	1.5	1.3	.35	.10	25	234	.19
23	3.3	5.0	2.9	7.8	2.2	1.5	1.6	.60	.10	10	255	3.3
24	2.7	4.7	2.1	6.5	2.7	1.5	1.6	.75	.01	4.0	165	3.0
25	3.8	5.0	2.0	6.8	3.1	1.3	1.2	.88	0	2.0	323	2.7
26	3.8	5.0	2.7	7.0	3.2	1.3	1.2	.67	.16	1.0	390	2.4
27	2.7	5.5	1.4	6.4	2.7	1.2	1.4	.53	0	1.0	384	2.1
28	3.0	11	1.4	6.1	2.0	1.2	1.3	.35	0	.60	124	1.8
29	2.4	9.0	2.1	8.1	------	1.2	1.3	.41	0	1.2	65	1.7
30	1.7	5.5	3.3	7.2	------	1.3	1.2	1.0	0	.75	30	3.6
31	3.0	------	3.6	8.1	------	1.0	------	.82	------	.67	20	------
TOTAL	236.8	125.0	113.2	119.98	106.1	83.9	37.65	29.11	6.66	197.16	2,414.20	104.61
MEAN	7.64	4.17	3.65	3.87	3.79	2.71	1.26	.94	.22	6.36	77.9	3.49
MAX	121	11	8.0	16	10	13	1.6	2.7	1.2	92	390	17
MIN	1.3	2.4	1.4	0	1.6	1.0	.85	.14	0	0	.27	.11
AC-FT	470	249	225	238	210	166	75	58	13	391	4,790	207

CAL YR 1970 TOTAL 7,789.23 MEAN 21.3 MAX 4,070 MIN 0 AC-FT 15,450
WTR YR 1971 TOTAL 3,574.37 MEAN 9.79 MAX 390 MIN 0 AC-FT 7,090

PEAK DISCHARGE (BASE, 500 CFS)

DATE	TIME	G.H.	DISCHARGE	DATE	TIME	G.H.	DISCHARGE
8-22	0400	4.03	576	8-26	0830	4.41	858
8-23	1200	4.63	1,050	8-27	1130	4.22	710
8-25	0530	4.29	762				

GAGING-STATION RECORDS

SAN JUAN RIVER BASIN

09379200. Chinle Creek near Mexican Water, Ariz.

LOCATION.--Lat 36°56'39", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft upstream from bridge on U.S. Highway 164, 3 miles upstream from Walker Creek, 4 miles west of Mexican Water, 5 miles downstream from confluence of Chinle Wash and Laguna Creek, and 6 miles upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 sq mi, approximately, of which 360 sq mi is noncontributing.

PERIOD OF RECORD.--October 1964 to current year. Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft above mean sea level.

AVERAGE DISCHARGE.--8 years, 14.7 cfs (10,650 acre-ft per year).

EXTREMES.--Current year: Maximum discharge, 850 cfs Aug. 28 (gage height, 4.40 ft); no flow June 30 to July 16, July 29 to Aug. 2.
Period of record: Maximum discharge, 9,880 cfs Sept. 7, 1970 (gage height, 7.55 ft), from rating curve extended above 600 cfs on basis of slope-area measurements at gage heights 5.4 and 7.55 ft; no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

REMARKS.--Records fair above 200 cfs and poor below. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 miles upstream, was built in 1939 with an original capacity of 25,000 acre-ft. The reservoir provides off-channel storage for irrigation of about 1,600 acres.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	177	5.0	6.5	2.0	2.1	4.9	1.4	1.3	.53	0	0	2.0
2	50	5.0	9.5	2.0	2.0	4.6	1.4	1.4	.53	0	0	2.0
3	30	5.0	8.5	2.0	3.0	4.4	1.4	1.3	.53	0	3.5	2.0
4	20	5.0	9.5	2.0	2.4	4.1	1.4	1.2	.61	0	1.5	2.0
5	13	5.0	5.0	1.5	3.0	3.9	1.6	1.0	.67	0	1.0	2.0
6	8.0	5.0	3.3	1.5	2.7	3.6	1.4	1.2	1.6	0	.90	4.0
7	5.0	5.0	2.4	1.8	2.7	2.6	1.4	1.0	4.1	0	1.5	6.0
8	3.0	5.0	2.0	3.0	5.4	3.0	1.4	1.1	3.3	0	1.0	2.0
9	3.0	5.0	2.0	2.0	8.0	3.0	1.4	1.0	2.7	0	1.0	2.0
10	3.0	5.0	3.0	1.7	11	3.0	1.2	1.0	3.6	0	.80	2.0
11	3.0	5.0	3.0	2.1	9.5	3.0	1.4	.41	1.4	0	.80	3.0
12	3.0	5.0	3.0	2.8	7.5	2.7	1.6	1.2	1.2	0	.30	2.0
13	3.0	5.0	3.0	4.6	5.5	2.1	1.3	1.0	.47	0	.80	10
14	3.0	5.0	3.0	4.5	3.0	1.8	1.4	1.0	.31	0	.90	4.0
15	3.0	20	3.0	3.7	9.0	2.4	1.4	1.2	.31	0	.50	2.0
16	3.0	15	3.0	3.9	9.0	2.0	1.4	1.4	.27	0	.80	2.0
17	[illegible]	10	3.0	4.3	11	1.8	1.2	.99	.27	50	.80	2.0
18	362	10	3.0	4.2	9.0	1.7	1.0	.75	.20	40	.80	2.0
19	350	10	3.0	5.3	7.5	1.7	1.0	.67	1.4	30	.80	2.0
20	150	9.0	3.0	6.9	7.5	1.7	1.0	.53	.27	20	.80	2.0
21	100	9.0	3.0	6.0	7.2	1.8	1.2	.47	.18	10	.80	2.0
22	85	9.0	3.0	4.7	7.0	1.8	1.3	.61	8.0	5.0	.80	2.0
23	55	9.0	3.0	7.9	6.7	1.7	1.3	.61	27	3.0	.80	2.0
24	35	7.5	150	8.5	6.5	1.8	1.3	1.0	5.0	1.0	.80	2.0
25	25	7.5	80	7.0	6.2	1.9	1.0	.67	3.0	2.0	.80	2.0
26	25	7.0	40	6.0	5.9	1.3	1.0	.61	1.0	1.0	15	2.0
27	15	7.5	25	5.5	5.7	1.4	1.2	.61	.80	1.0	24	2.0
28	10	9.5	16	5.5	5.4	1.5	1.2	.67	.50	.50	244	2.0
29	6.5	7.5	10	4.0	5.1	1.7	1.2	.75	.20	0	70	2.0
30	5.0	7.0	6.5	3.0	------	1.6	1.0	.67	0	0	5.0	2.0
31	5.0	------	4.0	3.0	------	1.6	------	.67	------	0	3.0	------
TOTAL	1,597.5	226.5	424.2	122.2	180.5	77.2	38.4	28.08	69.90	163.50	384.20	77.0
MEAN	51.5	7.55	13.7	3.94	6.22	2.49	1.28	.91	2.33	5.27	12.4	2.57
MAX	362	20	150	9.5	11	4.9	1.6	1.4	27	50	244	10
MIN	3.0	5.0	2.4	1.5	2.0	1.3	1.0	.41	0	0	0	2.0
AC-FT	3,170	449	841	242	358	153	76	56	139	324	762	153

CAL YR 1971 TOTAL 5,347.57 MEAN 14.7 MAX 390 MIN 0 AC-FT 10,610
WTR YR 1972 TOTAL 3,389.18 MEAN 9.26 MAX 362 MIN 0 AC-FT 6,720

PEAK DISCHARGE (BASE, 500 CFS).--Oct. 19 (0100) 681 cfs (4.18 ft); Aug. 28 (0730) 850 cfs (4.40 ft).

NOTE.--No gage-height record Oct. 19 to Nov. 23, Dec. 7 to Jan. 5, June 24 to Aug. 25, Aug. 29 to Sept. 30.

GAGING-STATION RECORDS

SAN JUAN RIVER BASIN

09379200. Chinle Creek near Mexican Water, Ariz.

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft (46 m) upstream from bridge on U.S. Highway 160 (renumbered), 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) west of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi² (9,480 km²), approximately, of which 360 mi² (932 km²) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year. Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) above mean sea level.

AVERAGE DISCHARGE.--9 years, 18.4 ft³/s (0.521 m³/s), 13,330 acre-ft/yr (16.4 hm³/yr).

EXTREMES.--Current year: Maximum discharge, 984 ft³/s (27.9 m³/s) about Oct. 20 (gage height, 4.56 ft or 1.390 m, from recorded range-in-stage); no flow on several days.
Period of record: Maximum discharge, 9,880 ft³/s (280 m³/s) Sept. 7, 1970 (gage height, 7.55 ft or 2.301 m), from rating curve extended above 600 ft³/s (17.0 m³/s) on basis of slope-area measurements at gage heights 5.4 and 7.55 ft (1.65 and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm³). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km²).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.0	8.0	5.0	5.0	5.0	50	50	180	150	5.0	1.0	2.7
2	2.0	8.0	5.0	5.0	5.0	60	50	150	150	5.0	1.0	3.3
3	2.0	8.0	5.0	5.0	5.0	70	50	150	150	5.0	1.0	2.4
4	40	8.0	5.0	5.0	5.0	70	102	150	150	5.0	1.0	1.4
5	132	8.0	5.0	5.0	5.0	60	80	180	150	5.0	1.0	.53
6	65	7.0	5.0	5.0	10	50	50	200	100	2.0	1.0	.15
7	414	7.0	5.0	5.0	10	40	40	200	100	2.0	.80	0
8	502	7.0	5.0	5.0	20	25	30	200	100	2.0	1.0	0
9	50	7.0	5.0	5.0	20	30	28	200	100	2.0	.90	0
10	30	7.0	5.0	5.0	10	28	25	200	100	2.0	.80	3.4
11	10	7.0	3.0	5.0	5.0	25	25	200	100	0	.70	18
12	22	7.0	3.0	5.0	5.0	22	66	200	100	0	.40	25
13	10	7.0	3.0	5.0	5.0	20	128	200	100	0	.50	11
14	8.0	7.0	3.0	5.0	5.0	18	130	220	100	0	.20	4.1
15	7.0	7.0	3.0	5.0	5.0	16	155	220	100	0	0	2.1
16	10	6.0	3.0	5.0	5.0	15	130	220	50	0	0	1.0
17	350	6.0	3.0	5.0	5.0	15	100	220	50	0	0	.30
18	800	6.0	3.0	5.0	5.0	14	100	220	50	1.0	0	.30
19	750	6.0	3.0	5.0	5.0	15	135	220	50	1.0	0	.30
20	850	6.0	3.0	5.0	5.0	16	100	220	50	1.0	0	.30
21	150	6.0	3.0	5.0	5.0	14	100	180	25	1.0	40	.30
22	60	6.0	3.0	5.0	5.0	15	100	180	25	1.0	20	.30
23	40	6.0	3.0	5.0	5.0	19	100	180	25	1.0	5.5	.30
24	20	6.0	3.0	5.0	5.0	27	100	175	25	1.0	3.3	.30
25	15	6.0	3.0	5.0	5.0	46	100	170	25	1.0	1.6	.30
26	10	6.0	3.0	5.0	5.0	43	150	170	10	1.0	.61	.30
27	10	6.0	3.0	5.0	10	40	200	150	10	1.0	.47	.30
28	10	6.0	10	5.0	20	64	250	150	10	1.0	.06	.30
29	10	6.0	20	5.0	------	60	250	150	10	1.0	0	.20
30	8.0	6.0	20	5.0	------	50	200	150	10	1.0	.26	.20
31	8.0	------	10	5.0	------	50	------	150	------	1.0	.35	------
TOTAL	4,397.0	200.0	161.0	155.0	205.0	1,096	3,124	5,755	2,175	49.0	83.45	79.28
MEAN	142	6.67	5.19	5.00	7.32	35.4	104	186	72.5	1.58	2.69	2.64
MAX	850	8.0	20	5.0	20	70	250	220	150	5.0	40	25
MIN	2.0	6.0	3.0	5.0	5.0	14	25	150	10	0	0	0
AC-FT	8,720	397	319	307	407	2,170	6,200	11,420	4,310	97	166	157

CAL YR 1972 TOTAL 5,898.98 MEAN 16.1 MAX 850 MIN 0 AC-FT 11,700
WTR YR 1973 TOTAL 17,479.73 MEAN 47.9 MAX 850 MIN 0 AC-FT 34,670

PEAK DISCHARGE (BASE, 500 CFS).--Oct. 7 (1730) 866 cfs (4.42 ft); about Oct. 20 (time unknown) 984 cfs (4.56 ft, from recorded range-in-stage).

NOTE.--No gage-height record Oct. 14 to Mar. 16, Apr. 20 to Aug. 22 (daily staff-gage reading Aug. 6-13, 22).

09379200. Chinle Creek near Mexican Water, Ariz.

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft (46 m) upstream from bridge on U.S. Highway 160 (renumbered), 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) west of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi^2 (9,480 km^2), approximately, of which 360 mi^2 (932 km^2) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year. Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) above mean sea level.

AVERAGE DISCHARGE.--10 years, 17.0 ft^3/s (0.481 m^3/s), 12,320 acre-ft/yr (15.2 hm^3/yr).

EXTREMES.--Current year: Maximum discharge, 646 ft^3/s (18.3 m^3/s) Mar. 2 (gage height, 4.13 ft or 1.259 m); no flow on several days.
Period of record: Maximum discharge, 9,880 ft^3/s (280 m^3/s) Sept. 7, 1970 (gage height, 7.55 ft or 2.301 m), from rating curve extended above 600 ft^3/s (17.0 m^3/s) on basis of slope-area measurements at gage heights 5.4 and 7.55 ft (1.65 and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm^3). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km^2).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.30	3.3	8.0	4.0	3.0	30	1.0	.15	0	0		0
2	.30	2.4	9.0	1.0	3.0	230	1.0	.03	0	0		0
3	.30	2.4	9.0	1.0	3.0	250	1.0	2.0	0	0		0
4	.30	2.4	9.0	1.0	3.0	30	1.0	.75	0	0		0
5	.30	2.4	6.0	1.0	3.0	9.0	1.0	1.0	0	0		0
6	.30	2.0	6.0	1.0	3.0	7.0	1.0	1.2	.18	0		0
7	.30	2.0	6.0	1.0	3.0	7.0	1.0	1.2	.70	0		0
8	.40	2.4	3.0	1.0	3.0	7.0	1.0	1.0	.02	0		0
9	2.1	3.0	2.0	2.0	3.0	7.0	1.0	.88	.02	0		0
10	1.1	3.6	2.0	2.0	3.0	7.0	.90	.67	.04	0		0
11	1.2	3.6	2.0	2.0	3.0	7.0	.90	.75	.05	0		0
12	5.0	3.8	2.0	2.0	3.0	7.0	.90	.61	.03	0		0
13	4.4	3.8	5.0	3.0	5.0	7.0	.90	.27	0	0		0
14	3.3	4.1	5.0	3.0	10	7.0	.90	.31	0	0		0
15	3.6	4.1	5.0	3.0	9.0	6.5	.90	.27	.09	0		0
16	3.3	3.8	5.0	3.0	4.0	6.0	.90	.06	0	0		0
17	3.0	3.6	2.0	3.0	3.0	4.1	.75	.15	0	0		0
18	3.0	3.0	2.0	3.0	3.0	2.7	.75	.35	.06	11		14
19	2.7	6.6	2.0	3.0	3.0	2.0	.67	.22	0	9.8		27
20	2.7	7.5	2.0	3.0	3.0	2.0	.67	.15	0	39		9.0
21	2.7	8.0	2.0	8.0	3.0	2.5	.75	.27	0	9.5		4.1
22	3.0	8.5	2.0	10	3.0	2.0	.88	.35	0	83		1.4
23	2.7	8.5	5.0	10	2.0	1.2	.88	.35	0	71		3.0
24	2.4	6.0	5.0	10	2.0	1.1	.88	.35	0	40		1.6
25	2.4	6.5	5.0	10	2.0	1.0	1.0	.35	0	30		2.0
26	2.4	9.5	3.0	5.0	2.0	1.0	1.0	.35	0	10		1.3
27	2.4	9.0	3.0	3.0	3.0	1.0	.75	.27	0	5.0		1.2
28	2.0	9.0	3.0	3.0	8.0	1.0	.75	.09	0	2.0		1.8
29	2.4	8.0	3.0	3.0	------	1.0	.75	.01	0	.50		1.4
30	3.3	8.0	4.0	3.0	------	1.0	.47	.03	0	0		1.2
31	3.0	------	4.0	3.0	------	1.0	------	.10	------	0		------
TOTAL	66.60	152.8	131.0	111.0	101.0	649.1	26.25	14.54	1.19	310.80	0	69.0
MEAN	2.15	5.09	4.23	3.58	3.61	20.9	.88	.47	.040	10.0	0	2.30
MAX	5.0	9.5	9.0	10	10	250	1.0	2.0	.70	83	0	27
MIN	.30	2.0	2.0	1.0	2.0	1.0	.47	.01	0	0	0	0
AC-FT	132	303	260	220	200	1,290	52	29	2.4	616	0	137

CAL YR 1973 TOTAL 13,072.13 MEAN 35.8 MAX 250 MIN 0 AC-FT 25,930
WTR YR 1974 TOTAL 1,633.28 MEAN 4.47 MAX 250 MIN 0 AC-FT 3,240

PEAK DISCHARGE (BASE, 500 CFS).--Mar. 2 (1600) 646 cfs (4.13 ft).

09379200. Chinle Creek near Mexican Water, Ariz.

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft (46 m) upstream from bridge on U.S. Highway 160, 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) southwest of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi² (9,480 km²), approximately, of which 360 mi² (932 km²) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year. Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) above mean sea level.

AVERAGE DISCHARGE.--11 years, 18.7 ft³/s (0.530 m³/s), 13,550 acre-ft/yr (16.7 hm³/yr).

EXTREMES.--Current year: Maximum discharge, 3,680 ft³/s (104 m³/s) about July 13 (gage height, 6.1 ft or 1.86 m, from profile past gage), from rating curve extended above 600 ft³/s (17 m³/s) on basis of slope-area measurements at gage heights 5.4, 6.1 and 7.55 ft (1.65, 1.86 and 2.301 m); no flow May 26 to July 10.

Period of record: Maximum discharge, 9,880 ft³/s (280 m³/s) Sept. 7, 1970 (gage height, 7.55 ft or 2.301 m), from rating curve extended above 600 ft³/s (17 m³/s) on basis of slope-area measurements at gage heights 5.4 and 7.55 ft (1.65 and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm³). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km²).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.4	25	2.7	1.4	3.0	17	50	20		0	14	.90
2	2.0	31	2.2	1.0	4.0	44	27	20		0	2.0	.60
3	2.0	93	2.6	1.6	2.0	223	15	100		0	1.0	0
4	1.8	72	2.7	1.5	5.0	195	10	50		0	.50	0
5	2.1	27	3.0	1.5	4.0	100	6.0	197		0	.50	.90
6	4.3	3.0	10	1.5	4.0	20	175	288		0	.50	1.1
7	2.7	3.0	10	1.5	3.0	13	222	124		0	.50	1.4
8	2.1	14	5.5	1.5	2.0	18	150	20		0	.50	1.8
9	2.2	43	5.5	1.5	2.0	49	60	79		0	.50	173
10	2.7	5.0	4.1	1.5	2.0	34	30	230		0	.50	100
11	5.6	5.0	.70	1.0	2.0	25	10	282		10	.50	18
12	3.7	5.0	1.5	1.0	2.0	30	4.0	230		20	.50	158
13	8.4	5.0	1.4	1.0	2.0	45	2.0	266		2000	.50	168
14	24	5.0	.60	.50	2.0	41	2.0	186		1000	.50	386
15	121	5.0	1.2	.40	2.0	51	2.0	136		450	.50	200
16	17	5.0	1.0	.30	2.0	272	2.0	108		150	.50	60
17	9.0	5.0	1.0	.30	2.0	64	2.0	172		80	.50	10
18	2.0	5.0	1.0	.30	2.0	15	2.0	238		35	.50	7.0
19	2.0	4.8	1.2	.30	2.0	4.0	2.0	100		10	.50	7.0
20	2.0	4.8	1.0	.50	2.0	4.0	2.0	50		8.0	.50	6.0
21	2.0	4.3	1.4	1.0	2.0	1.0	2.0	20		7.0	.30	6.0
22	2.0	4.3	2.1	1.0	2.0	1.0	2.0	9.0		6.0	.30	6.0
23	2.0	4.8	1.1	1.0	2.0	1.0	2.0	4.0		5.0	.30	5.0
24	28	5.2	1.1	1.0	2.0	1.0	2.0	2.0		4.5	.30	5.0
25	10	4.5	2.7	1.0	2.0	1.0	2.0	1.0		2.7	.30	4.5
26	3.0	4.0	2.4	2.0	1.9	4.0	2.0	0		2.1	.30	4.0
27	19	2.4	2.2	3.0	36	4.0	111	0		1.4	.80	3.7
28	189	4.0	2.2	6.0	18	5.9	213	0		1.1	.80	3.5
29	118	2.7	1.2	4.0	---	48	100	0		1.7	.70	3.0
30	526	3.7	1.4	6.0	---	29	20	0		122	.90	2.7
31	184	---	1.5	4.0	---	56	---	0	---	90	1.1	---
TOTAL	1301.0	405.5	78.20	50.10	116.9	1415.9	1231.0	2932.0	0	4006.5	31.60	1345.10
MEAN	42.0	13.5	2.52	1.62	4.18	45.7	41.0	94.6	0	129	1.02	44.8
MAX	526	93	10	6.0	36	272	222	288	0	2000	14	388
MIN	1.4	2.4	.60	.30	1.9	1.0	2.0	0	0	0	.30	0
AC-FT	2580	804	155	99	232	2810	2440	5820	0	7950	63	2670

CAL YR 1974 TOTAL 3067.58 MEAN 8.40 MAX 526 MIN 0 AC-FT 6080
WTR YR 1975 TOTAL 12913.80 MEAN 35.4 MAX 2000 MIN 0 AC-FT 25610

PEAK DISCHARGE (BASE, 500 CFS)

DATE	TIME	G. H.	DISCHARGE	DATE	TIME	G. H.	DISCHARGE
10-30	1000	4.13	646	9-14	1200	3.92	507
*7-13	unknown	†6.1	3,680				

* About.
† From profile past gage.
NOTE.--No gage-height record July 2-23.

09379200. CHINLE CREEK NEAR MEXICAN WATER, ARIZ.

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, in Navajo Indian Reservation, in midstream 150 ft (46 m) upstream from bridge on U.S. Highway 160, 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) southwest of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi^2 (9,480 km^2), approximately, of which 360 mi^2 (932 km^2) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year. Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) above mean sea level.

AVERAGE DISCHARGE.--12 years, 17.9 ft^3/s (0.507 m^3/s), 12,970 acre-ft/yr (16.0 hm^3/yr); median of yearly mean discharges, 14 ft^3/s (0.40 m^3/s), 10,100 acre-ft/yr (12 hm^3/yr).

EXTREMES.--Current year: Maximum discharge, 1,620 ft^3/s (45.9 m^3/s) about Sept. 25 (gage height, 5.1 ft or 1.55 m), from rating curve extended above 600 ft^3/s (17 m^3/s) on basis of slope-area measurements at gage heights 5.4, 6.1 and 7.55 ft (1.65, 1.86 and 2.301 m); no flow for several days.

Period of record: Maximum discharge, 9,880 ft^3/s (280 m^3/s) Sept. 7, 1970 (gage height, 7.55 ft or 2.301 m), from rating curve extended above 600 ft^3/s (17 m^3/s) on basis of slope-area measurements at gage heights 5.4 and 7.55 ft (1.65 and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm^3). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km^2).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.7	5.5	3.0	2.0	8.8	11	1.1	.90	.60	0	3.0	.50
2	3.3	7.3	3.0	2.0	6.0	14	1.0	1.0	.40	0	2.0	.50
3	4.0	12	3.0	2.0	9.7	11	1.0	1.0	.20	0	3.0	.50
4	3.3	7.7	3.0	2.0	16	8.0	1.1	1.0	.20	0	1.0	.50
5	3.7	6.2	3.0	2.0	28	8.4	1.1	1.0	.20	0	1.0	.50
6	3.7	5.5	3.0	2.0	44	6.2	1.1	1.0	.10	.10	1.0	.50
7	3.5	5.5	3.0	2.0	45	7.0	1.1	1.1	.10	.10	.50	.50
8	3.0	5.5	3.0	2.0	30	8.4	1.1	22	.10	0	.50	1.0
9	3.0	5.2	2.5	2.0	27	8.0	1.0	234	0	0	.50	1.0
10	3.0	4.8	2.5	2.0	85	7.7	3.5	122	0	0	.50	63
11	3.0	4.0	2.5	2.0	40	7.0	2.7	80	0	0	.50	10
12	3.5	2.7	2.5	2.0	25	6.5	1.6	2.5	0	0	.50	2.0
13	3.0	3.0	2.5	2.0	15	6.0	1.0	1.5	0	0	.50	1.0
14	2.7	3.0	2.5	2.0	20	5.5	1.4	1.0	0	0	.50	1.0
15	2.7	3.0	2.5	2.0	10	5.0	1.5	1.0	0	0	.40	1.0
16	4.0	3.0	2.5	2.0	10	4.0	1.4	1.0	0	0	.40	1.0
17	3.3	3.0	2.5	2.0	9.0	3.0	1.6	1.0	0	11	.30	1.0
18	4.0	3.0	2.5	4.0	8.0	2.5	1.6	1.0	0	27	.30	1.0
19	4.0	3.0	2.5	9.6	8.0	2.0	1.5	1.0	0	16	.30	1.0
20	4.0	3.0	2.0	10	7.0	1.4	1.2	1.2	0	7.7	.40	1.0
21	4.3	3.0	2.0	9.9	5.9	1.2	1.4	1.5	0	6.6	.40	1.0
22	4.5	3.5	2.0	12	3.7	1.2	2.1	2.4	0	3.7	.60	6.0
23	4.3	3.7	2.0	10	5.9	1.2	1.8	13	0	2.6	.50	1.0
24	4.0	2.7	2.0	8.4	7.3	1.1	1.6	11	0	1.8	.50	1.2
25	4.0	3.7	2.0	8.4	8.0	1.0	1.8	4.8	0	1.4	.50	350
26	4.0	4.0	2.0	14	5.2	1.0	1.5	2.7	0	62	.50	400
27	4.5	4.0	2.0	13	4.3	1.0	1.5	1.9	0	313	.50	100
28	4.3	4.0	2.0	8.3	4.5	1.0	1.6	1.5	0	50	.50	50
29	5.2	3.5	2.0	8.3	6.2	1.0	1.4	1.2	.20	25	.50	25
30	4.5	3.5	2.0	10	---	1.0	1.0	1.0	.10	15	.50	20
31	4.8	---	2.0	9.6	---	1.0	---	.60	---	5.0	.50	---
TOTAL	115.8	131.5	75.5	169.5	502.5	144.3	44.3	518.00	2.20	548.00	22.60	1042.70
MEAN	3.74	4.36	2.44	5.47	17.3	4.65	1.48	16.7	.073	17.7	.73	34.8
MAX	5.2	12	3.0	14	85	14	3.5	234	.60	313	3.0	400
MIN	2.7	2.7	2.0	2.0	3.7	1.0	1.0	.80	0	0	.30	.50
AC-FT	230	261	150	336	997	286	88	1030	4.4	1090	45	2070

CAL YR 1975 TOTAL 11451.90 MEAN 31.4 MAX 2000 MIN 0 AC-FT 22710
WTR YR 1976 TOTAL 3316.90 MEAN 9.06 MAX 400 MIN 0 AC-FT 6580

PEAK DISCHARGE (BASE, 500 CFS)

DATE	TIME	G. H.	DISCHARGE	DATE	TIME	G. H.	DISCHARGE
5- 9	0430	4.31	778	7-27	1000	4.55	975
5-10	2300	4.03	576	9-25*	(unknown)	5.1	1,620

* About.

NOTE.--No gage-height record Nov. 30 to Jan. 18, June 3 to July 6.

09379200 CHINLE CREEK NEAR MEXICAN WATER, AZ

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, Hydrologic Unit 14080204, in Navajo Indian Reservation, in midstream 150 ft (46 m) upstream from bridge on U.S. Highway 160, 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) southwest of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi² (9,480 km²), approximately, of which 360 mi² (932 km²) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year. Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) above mean sea level.

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm³). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km²).

AVERAGE DISCHARGE.--13 years, 18.5 ft³/s (0.524 m³/s), 13,400 acre-ft/yr (16.5 hm³/yr); median of yearly mean discharges, 15 ft³/s (0.42 m³/s), 10,900 acre-ft/yr (13 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 9,880 ft³/s (280 m³/s) Sept. 7, 1970 (gage height, 7.55 ft or 2.301 m), from rating curve extended above 600 ft³/s (17 m³/s) on basis of slope-area measurements at gage heights 5.4, 6.1, and 7.55 ft (1.65, 1.86, and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*), (from rating curve extended above 850 ft³/s or 24 m³/s on basis of slope-area measurement of peak flow) and peak discharges above base of 500 ft³/s (14 m³/s):

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)	Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
Aug. 12	1200	2,760	78.2	6.75	2.06	Aug. 19	1430	*7,120	202	8.3	2.53
Aug. 17	0030	3,050	86.4	6.9	2.10						

No flow for many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	18	5.0	4.0	4.0	4.0	2.0	2.0	2.0	.00	.00	2.0	2.6
2	15	4.0	4.0	4.0	4.0	2.0	2.0	2.0	.00	.00	1.0	1.6
3	15	2.2	4.0	4.0	4.0	2.0	2.0	2.0	.00	.00	1.0	30
4	15	4.5	4.0	4.0	4.0	2.0	2.0	2.0	.00	.10	1.0	85
5	15	5.5	4.0	4.0	4.0	2.0	2.0	2.0	.00	1.2	1.0	87
6	14	4.5	4.0	4.0	4.0	2.0	2.0	2.0	.00	1.0	1.0	27
7	5.2	4.0	4.0	4.0	4.0	2.0	2.0	2.0	.00	.70	1.0	12
8	4.6	4.0	4.0	4.0	4.0	2.0	2.0	2.0	.00	.70	1.0	4.8
9	8.4	4.0	4.0	4.0	4.0	2.0	2.0	1.0	.00	.40	1.0	3.5
10	5.9	4.0	4.0	4.0	4.0	2.0	2.0	1.0	.00	.10	1.0	3.5
11	5.6	4.0	4.0	4.0	3.0	2.0	2.0	1.0	.00	.00	7.3	1.5
12	4.0	4.0	4.0	4.0	3.0	2.0	2.0	1.0	.00	.00	602	24
13	4.5	4.0	4.0	4.0	3.0	2.0	2.0	.90	.00	.00	105	92
14	4.0	4.0	4.0	4.0	3.0	2.0	2.0	.90	.00	.00	21	23
15	4.0	4.0	4.0	4.0	3.0	2.0	2.0	.80	.00	.00	178	9.1
16	3.3	4.0	9.6	4.0	3.0	2.0	2.0	.70	.00	.00	432	3.3
17	3.7	4.0	7.7	4.0	3.0	2.0	2.0	.70	.00	.00	1830	.70
18	3.5	4.0	4.0	4.0	3.0	2.0	2.0	.70	.00	.00	1050	.40
19	3.7	4.0	4.0	4.0	3.0	2.0	1.6	.60	.00	5.3	2900	3.2
20	3.7	4.0	4.0	4.0	3.0	2.0	1.6	.60	.00	46	200	2.1
21	4.5	4.0	4.0	4.0	3.0	2.0	1.8	.50	.00	140	20	.90
22	4.5	4.0	4.0	4.0	3.0	2.0	1.8	.50	.00	68	5.0	.60
23	5.2	4.0	4.0	4.0	3.0	2.0	1.8	.50	.00	130	10	.60
24	5.0	4.0	4.0	4.0	3.0	2.0	1.8	.40	.00	174	20	.40
25	5.0	4.0	4.0	4.0	3.0	2.0	2.0	.40	.00	61	58	.40
26	5.0	4.0	4.0	10	3.0	2.0	2.0	.40	.00	49	20	.40
27	5.0	4.0	4.0	9.0	3.0	2.0	2.0	.30	.00	42	8.8	.40
28	5.0	4.0	4.0	8.0	3.0	2.0	2.0	.30	.00	55	3.7	.40
29	4.0	4.0	4.0	7.0	---	2.0	2.0	.30	.00	11	2.1	.40
30	5.5	4.0	4.0	6.0	---	2.0	2.0	.20	.00	4.0	1.8	.40
31	5.5	---	4.0	5.0	---	2.0	---	.00	---	2.0	1.8	---
TOTAL	210.3	121.7	133.3	145.0	94.0	62.0	58.4	29.70	.00	791.50	7487.5	421.40
MEAN	6.78	4.06	4.30	4.68	3.36	2.00	1.95	.96	.000	25.5	242	14.0
MAX	18	5.5	9.6	10	4.0	2.0	2.0	2.0	.00	174	2900	92
MIN	3.3	2.2	4.0	4.0	3.0	2.0	1.6	.00	.00	.00	1.0	.40
AC-FT	417	241	264	288	186	123	116	59	.00	1570	14850	836

CAL YR 1976 TOTAL 3459.40 MEAN 9.45 MAX 400 MIN .00 AC-FT 6860
WTR YR 1977 TOTAL 9554.80 MEAN 26.2 MAX 2900 MIN .00 AC-FT 18950

NOTE.--No gage-height record Nov. 7 to Dec. 15, Dec. 18 to Jan. 25, Jan. 27 to Apr. 18, and May 18 to June 29.

SAN JUAN RIVER BASIN

09379200 CHINLE CREEK NEAR MEXICAN WATER, AZ

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, Hydrologic Unit 14080204, in Navajo Indian Reservation, in midstream 150 ft (46 m) upstream from bridge on U.S. Highway 160, 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) southwest of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi² (9,480 km²), approximately, of which 360 mi² (932 km²) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year. Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) National Geodetic Vertical Datum of 1929.

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm³). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km²).

AVERAGE DISCHARGE.--14 years, 17.8 ft³/s (0.504 m³/s), 12,900 acre-ft/yr (15.9 hm³/yr); median of yearly mean discharges, 14 ft³/s (0.40 m³/s), 10,100 acre-ft/yr (12 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 9,880 ft³/s (280 m³/s) Sept. 7, 1970, gage height, 7.55 ft (2.301 m), from rating curve extended above 600 ft³/s (17 m³/s) on basis of slope-area measurements at gage heights 5.4, 6.1, and 7.55 ft (1.65, 1.86, and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*) and peak discharges above base of 500 ft³/s (14 m³/s):

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
Mar. 6	2000	505	14.3	4.78	1.457
July 18	1130	*751	21.3	5.13	1.564
Aug. 20	2330	660	18.7	5.00	1.524

No flow for many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.40	1.0	.40	2.0	2.0	7.8	.30	80	.00	.00	.10	.00
2	.40	1.0	.40	2.0	2.0	67	.10	200	.00	.00	.00	.00
3	.40	1.0	.40	2.0	2.0	75	.50	100	.00	.00	.00	.00
4	.40	5.0	.40	2.0	2.0	154	4.6	40	.00	.00	.00	.00
5	.40	10	.40	2.0	2.0	28	4.8	50	.00	.00	.00	.00
6	1.0	30	.40	2.0	2.0	91	.80	60	.00	.00	.00	.00
7	1.0	50	.40	2.0	2.0	53	.40	50	.00	.00	.00	.00
8	1.0	40	.40	2.0	10	32	.20	40	.00	.00	.00	.00
9	1.0	38	.40	2.0	9.2	16	.30	30	.00	.00	.00	.00
10	1.0	44	.40	2.0	15	7.4	.40	20	.00	.00	.00	.00
11	1.0	10	.40	2.0	12	7.7	.40	25	.00	33	.00	.00
12	1.0	2.0	.40	2.0	28	8.8	.40	30	.00	11	.00	.00
13	1.0	1.0	.40	2.0	23	7.7	.40	31	.00	2.7	.00	.00
14	1.0	.80	.40	2.0	12	11	.50	15	.00	1.0	.00	.00
15	1.0	.60	.40	2.0	9.6	2.2	.80	4.0	.00	.40	.00	.00
16	1.0	.40	.40	2.0	10	1.4	30	1.4	.00	.20	.00	7.8
17	1.0	.40	.40	2.0	10	1.0	22	.70	.00	.00	.00	8.4
18	1.0	.40	1.0	2.0	5.1	.90	26	.20	.00	240	.00	.90
19	1.0	.40	2.0	2.0	6.6	.80	40	.30	.00	22	.00	.90
20	1.0	.40	2.0	2.0	4.0	1.0	38	.40	.00	5.5	64	.70
21	1.0	.40	2.0	2.0	3.0	1.1	58	19	.00	1.5	168	.90
22	1.0	.40	2.0	2.0	8.9	1.0	52	18	.00	.20	15	8.0
23	1.0	.40	2.0	2.0	14	2.0	26	12	.00	.10	4.8	5.0
24	1.0	.40	2.0	2.0	12	12	14	6.2	.00	.00	2.4	2.0
25	1.0	.40	2.0	2.0	9.6	6.0	12	2.2	.00	.00	1.0	1.0
26	1.0	.40	2.0	2.0	7.7	5.9	17	.70	.00	.00	.20	.00
27	1.0	.40	2.0	2.0	5.2	3.7	27	.40	.00	.00	.00	.00
28	1.0	.40	2.0	2.0	4.5	1.1	11	.20	.00	.00	.00	.00
29	1.0	.40	2.0	2.0	---	.70	13	.20	.00	.00	.00	.00
30	1.0	.40	2.0	2.0	---	.40	10	.10	.00	.70	.00	.00
31	1.0	---	2.0	2.0	---	.40	---	.00	---	.90	.00	---
TOTAL	28.00	240.40	33.80	62.0	233.4	610.00	410.90	837.00	.00	319.20	255.50	35.60
MEAN	.90	8.01	1.09	2.00	8.34	19.7	13.7	27.0	.000	10.3	8.24	1.19
MAX	1.0	50	2.0	2.0	28	154	58	200	.00	240	168	8.4
MIN	.40	.40	.40	2.0	2.0	.40	.10	.00	.00	.00	.00	.00
AC-FT	56	477	67	123	463	1210	815	1660	.00	633	507	71

CAL YR 1977 TOTAL 9391.70 MEAN 25.7 MAX 2900 MIN .00 AC-FT 18630
WTR YR 1978 TOTAL 3065.80 MEAN 8.40 MAX 240 MIN .00 AC-FT 6080

NOTE.--No gage-height record Oct. 1 to Feb. 8.

09379200 CHINLE CREEK NEAR MEXICAN WATER, AZ

LOCATION.--Lat 36°56'38", long 109°42'30", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, Hydrologic Unit 14080204, in Navajo Indian Reservation, in midstream 150 ft (46 m) upstream from bridge on U.S. Highway 160, 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) southwest of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi² (9,480 km²), approximately, of which 360 mi² (932 km²) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year (monthly discharge only for 1979). Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) National Geodetic Vertical Datum of 1929.

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm³). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km²).

AVERAGE DISCHARGE.--15 years, 19.6 ft³/s (0.555 m³/s), 14,200 acre-ft/yr (17.5 hm³/yr); median of yearly mean discharges, 15 ft³/s (0.42 m³/s), 10,900 acre-ft/yr (13 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 9,880 ft³/s (280 m³/s) Sept. 7, 1970, gage height, 7.55 ft (2.301 m), from rating curve extended above 600 ft³/s (17 m³/s) on basis of slope-area measurements at gage heights 5.4, 6.1, and 7.55 ft (1.65, 1.86, and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*) and peak discharges above base of 500 ft³/s (14 m³/s):

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
Nov. 12	Unknown	*1,390	39.4	5.83	1.78
Nov. 25	Unknown	960	27.2	5.40	1.65

No flow for many days.

MONTHLY DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

Month	Total	Mean	Runoff in acre-feet
October	417.9	13.5	829
November	1,166.0	38.9	2,310
December	407.9	13.2	809
CAL YEAR 1978	4,755.4	13.0	9,420
January	80.4	2.59	159
February	948	33.9	1,880
March	880	28.4	1,750
April	5,325	178	10,560
May	6,766	218	13,420
June	404	13.5	801
July	0	0	0
August	56.0	1.81	111
September	0	0	0
WTR YEAR 1979	16,451.2	45.1	32,670

NOTE.--No gage-height record Nov. 3-19, 24-30, Dec. 22 to Apr. 25, June 9 to Aug. 12, Aug. 18 to Sept. 30.

09379200 CHINLE CREEK NEAR MEXICAN WATER, AZ

LOCATION.--Lat 36°56'55", long 109°42'30", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, Hydrologic Unit 14080204, in Navajo Indian Reservation, on right bank 150 ft (46 m) upstream from bridge on U.S. Highway 160, 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) southwest of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,600 mi² (9,480 km²), approximately, of which 360 mi² (932 km²) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year (monthly discharge only for 1979). Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) National Geodetic Vertical Datum of 1929.

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm³). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km²).

AVERAGE DISCHARGE.--16 years, 22.6 ft³/s (0.640 m³/s), 16,370 acre-ft/yr (20.2 hm³/yr); median of yearly mean discharges, 16 ft³/s (0.45 m³/s), 11,600 acre-ft/yr (14 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 9,880 ft³/s (280 m³/s) Sept. 7, 1970, gage height, 7.55 ft (2.301 m), from rating curve extended above 600 ft³/s (17 m³/s) on basis of slope-area measurements at gage heights 5.4, 6.1, and 7.55 ft (1.65, 1.86, and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*) and peak discharges above base of 500 ft³/s (14 m³/s):

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)	Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
Oct. 21	Unknown	816	23.1	a4.92	1.500	May 8	1700	1,020	28.9	5.17	1.576
Feb. 20	Unknown	1,190	33.7	a5.34	1.628	Sept. 10	1200	*1,630	46.2	5.73	1.746

No flow for many days.

a From high-water mark in gage well.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1979 TO SEPTEMBER 1980
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.00	3.0	3.0	2.0	30	76	13	600	22	.00	.00	.00
2	.00	3.0	3.0	2.0	21	64	18	500	18	.00	.00	.00
3	.00	3.0	3.0	2.0	17	54	19	500	11	.00	.00	.00
4	.00	3.0	3.0	2.0	14	47	17	400	8.0	.00	.10	.00
5	.00	3.0	3.0	2.0	12	42	21	400	8.4	.00	.00	.40
6	.00	3.0	4.0	2.0	10	37	73	400	4.3	.00	.00	1.0
7	.00	3.0	5.0	3.0	10	34	102	500	1.1	.00	.00	5.8
8	.00	100	6.0	4.0	9.0	31	140	744	1.2	.00	.00	13
9	.00	70	7.0	4.0	8.0	28	136	624	.40	.00	.00	19
10	.00	35	8.0	5.0	8.0	25	158	558	.10	.00	.00	323
11	.00	23	10	200	7.0	23	160	445	.00	.00	.00	265
12	.00	18	10	180	7.0	21	184	440	.00	.00	.00	80
13	.00	12	10	160	70	20	134	400	.00	.90	.00	32
14	.00	10	10	145	66	19	117	322	.00	9.2	13	17
15	.00	9.0	10	130	66	18	109	301	.00	2.5	12	11
16	.00	7.0	10	118	64	17	114	259	.00	.00	25	7.0
17	.00	7.0	10	105	62	16	134	241	.00	.00	7.7	4.5
18	.00	6.0	10	96	60	15	172	204	.00	.00	1.3	4.3
19	.00	5.0	10	86	60	14	196	194	.00	.00	.10	4.0
20	.00	5.0	10	80	1000	6.0	244	184	.00	.00	.00	3.3
21	125	4.0	10	80	824	2.0	307	170	.00	.00	.00	3.0
22	80	4.0	10	36	594	2.0	490	140	.00	.00	.00	2.7
23	45	4.0	10	21	390	3.0	520	120	.00	.00	.00	2.4
24	24	4.0	10	15	283	2.0	546	100	.00	.00	.00	2.1
25	10	4.0	10	12	232	4.0	540	80	.00	.00	48	1.9
26	6.0	4.0	10	11	186	4.0	405	60	.00	.00	50	1.7
27	5.0	4.0	7.0	9.0	158	3.0	330	63	.00	.00	22	1.5
28	4.0	4.0	4.0	8.0	138	4.0	382	51	.00	.00	5.9	1.3
29	4.0	4.0	2.0	8.0	104	4.0	480	42	.00	.00	1.1	1.1
30	4.0	4.0	2.0	8.0	---	3.0	630	30	.00	.00	.40	1.0
31	4.0	---	2.0	50	---	8.0	---	28	---	.00	.00	---
TOTAL	311.00	368.0	222.0	1586.0	4512.0	646.0	6893	9100	74.50	12.60	186.60	809.00
MEAN	10.0	12.3	7.16	51.2	156	20.8	230	294	2.48	.41	6.02	27.0
MAX	125	100	10	200	1000	76	630	744	22	9.2	50	323
MIN	.00	3.0	2.0	2.0	7.0	2.0	13	28	.00	.00	.00	.00
AC-FT	617	730	440	3150	8950	1280	13670	18050	148	25	370	1600

CAL YR 1979 TOTAL 15360.40 MEAN 42.1 AC-FT 30467
WTR YR 1980 TOTAL 24720.70 MEAN 67.5 MAX 1000 MIN .00 AC-FT 49030

09379200 CHINLE CREEK NEAR MEXICAN WATER, AZ

LOCATION.--Lat 36°56'38", long 109°42'36", in sec.19, T.41 N., R.25 E. (unsurveyed), Apache County, Hydrologic Unit 14080204, in Navajo Indian Reservation, on right bank 150 ft (46 m) upstream from bridge on U.S. Highway 160, 3 mi (5 km) upstream from Walker Creek, 4 mi (6 km) southwest of Mexican Water, 5 mi (8 km) downstream from confluence of Chinle Wash and Laguna Creek, and 6 mi (10 km) upstream from Arizona-Utah State line.

DRAINAGE AREA.--3,660 mi² (9,480 km²), approximately, of which 360 mi² (932 km²) is noncontributing.

PERIOD OF RECORD.--October 1964 to current year (monthly discharge only for 1979). Prior to October 1970 published as Chinle Wash near Mexican Water.

GAGE.--Water-stage recorder and concrete control. Datum of gage is 4,720 ft (1,439 m) National Geodetic Vertical Datum of 1929.

REMARKS.--Records poor. Some diversions upstream for irrigation, stock tanks, and domestic use. Many Farms Reservoir, about 25 mi (40 km) upstream, was built in 1939 with an original capacity of 25,000 acre-ft (30.8 hm³). The reservoir provides off-channel storage for irrigation of about 1,600 acres (6.48 km²).

AVERAGE DISCHARGE.--17 years, 21.7 ft³/s (0.614 m³/s), 15,720 acre-ft/yr (19.4 hm³/yr); median of yearly mean discharges, 15 ft³/s (0.42 m³/s), 10,900 acre-ft/yr (13 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 9,880 ft³/s (280 m³/s) Sept. 7, 1970, gage height, 7.55 ft (2.301 m), from rating curve extended above 600 ft³/s (17 m³/s) on basis of slope-area measurements at gage heights 5.4, 6.1, and 7.55 ft (1.65, 1.86, and 2.301 m); no flow at times in each year. The flood of Sept. 7, 1970, is the highest since at least 1950 (information from a local resident).

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 3,270 ft³/s (92.6 m³/s) July 14, 0930 hours, gage height, 6.83 ft (2.082 m), base discharge, 500 ft³/s (14 m³/s); no flow for several days in June, July, August.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1980 TO SEPTEMBER 1981
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.5	4.5	8.8	5.0	3.0	1.8	5.2	.70	59	.40	11	5.0
2	1.4	4.5	7.3	5.0	3.0	1.6	3.5	1.0	20	19	3.0	3.0
3	1.2	4.5	7.0	5.0	3.0	1.8	3.7	1.0	10	8.0	.70	1.0
4	2.1	4.8	7.0	4.0	3.0	5.2	3.7	.60	30	1.1	.50	1.0
5	2.1	4.5	7.0	4.0	3.0	8.4	3.7	.60	22	.00	.20	5.0
6	2.6	4.8	6.6	3.0	3.0	6.6	4.0	.50	8.8	.00	.00	5.0
7	2.2	4.5	9.6	3.0	3.0	9.2	3.0	.50	3.5	.00	.00	3.0
8	1.8	4.5	10	3.0	3.0	6.6	2.7	.40	1.9	.00	.00	1.0
9	2.4	4.5	5.9	3.0	7.0	7.6	3.0	.50	.60	.00	.00	10
10	2.1	4.5	5.2	3.0	5.0	5.2	2.1	.40	.20	1.5	.40	5.0
11	2.2	4.7	5.0	3.0	5.0	4.8	1.5	.50	.10	.60	.30	5.0
12	2.2	4.5	5.0	3.0	5.0	4.3	.80	.40	.00	77	.30	3.0
13	2.4	5.2	5.0	3.0	4.0	6.2	.50	.40	.00	270	.30	3.0
14	4.3	5.5	5.0	3.0	4.0	8.0	.90	.40	.00	700	.50	3.0
15	10	5.2	5.0	3.0	3.0	6.2	22	.40	.00	64	3.3	3.5
16	22	4.8	5.0	3.0	3.0	7.0	26	5.5	.00	.00	3.5	11
17	12	3.5	5.0	3.0	3.0	7.3	11	48	.00	124	.50	3.5
18	8.4	2.1	5.0	3.0	2.7	4.5	4.3	24	.00	27	.00	2.2
19	6.2	1.8	5.0	3.0	1.2	4.0	3.0	11	.00	41	.00	2.2
20	4.0	1.8	5.0	3.0	1.2	2.2	1.6	5.5	.00	7.3	.00	1.9
21	5.2	1.8	5.0	3.0	1.1	1.9	2.1	2.7	.00	2.6	.00	1.8
22	4.3	1.6	5.0	3.0	1.5	1.8	3.0	1.9	.00	1.2	10	1.5
23	4.5	2.4	5.0	3.0	2.2	1.9	2.7	1.2	.00	.70	5.0	1.6
24	4.3	4.5	5.0	3.0	2.4	1.9	2.6	1.2	.00	6.2	3.0	8.8
25	4.0	6.6	5.0	3.0	1.4	1.8	2.6	1.2	.00	26	1.0	12
26	4.5	7.0	5.0	3.0	3.5	1.8	2.2	1.0	.00	30	.00	7.3
27	5.2	4.8	5.0	3.0	3.0	3.0	1.6	1.0	.00	2.4	.00	3.7
28	4.5	3.5	5.0	3.0	2.7	4.3	1.2	1.8	.00	1.5	.00	2.2
29	4.8	4.3	5.0	3.0	---	4.0	1.0	8.0	.00	.50	.00	2.4
30	4.5	5.9	8.0	3.0	---	7.3	.70	5.9	.00	.40	.00	1.8
31	4.5	---	5.0	3.0	---	7.7	---	8.9	---	5.0	10	---
TOTAL	143.4	127.1	182.4	101.0	85.9	145.9	125.90	137.10	156.10	1417.40	53.50	120.4
MEAN	4.63	4.24	5.88	3.26	3.07	4.71	4.20	4.42	5.20	45.7	1.73	4.01
MAX	22	7.0	10	5.0	7.0	9.2	26	48	59	700	11	12
MIN	1.2	1.6	5.0	3.0	1.1	1.6	.50	.40	.00	.00	.00	1.0
AC-FT	284	252	362	200	170	289	250	272	310	2810	106	239

CAL YR 1980 TOTAL 24272.60 MEAN 66.3 MAX 1000 MIN .00 AC-FT 48140
WTR YR 1981 TOTAL 2796.10 MEAN 7.66 MAX 700 MIN .00 AC-FT 5550

Table 8.--Discharge data, Chinle Creek near Mexican Water, 1982 water year

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1981 TO SEPTEMBER 1982
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	10	3.0	30	3.0	8.4	19	13	140	.00	.00	22	75
2	120	3.0	17	4.0	4.0	12	7.7	151	.00	.00	147	70
3	405	3.0	7.0	4.0	4.0	9.2	4.0	150	.00	.00	402	65
4	437	3.0	5.0	4.0	5.0	9.6	2.6	166	.00	.00	278	60
5	79	3.5	4.0	5.0	5.0	10	3.3	832	.00	.00	72	50
6	27	4.0	4.0	5.0	5.0	8.8	4.8	850	.00	.00	28	40
7	21	4.3	4.0	5.0	5.0	7.7	2.1	260	.00	.00	13	40
8	7.7	4.0	4.0	6.0	5.0	7.3	1.5	160	.00	.00	32	40
9	5.9	4.0	4.0	6.0	5.0	13	1.5	100	.00	.00	66	40
10	3.5	4.5	4.0	6.0	7.0	15	1.5	80	.00	.00	52	40
11	2.1	4.3	4.0	7.0	7.0	8.8	1.8	70	.00	.00	46	40
12	1.6	4.3	4.0	7.0	7.0	7.3	3.3	80	.00	.00	34	40
13	1.0	4.0	4.0	7.0	7.0	153	2.2	70	.00	.00	27	40
14	.70	4.3	4.0	8.0	7.0	202	1.5	60	.00	.00	23	40
15	3.0	4.0	4.0	8.0	7.0	182	1.4	50	.00	.00	20	40
16	3.5	3.7	4.0	8.0	7.0	164	1.5	40	.00	.00	17	35
17	5.9	3.7	5.5	9.0	7.0	103	1.4	40	.00	.20	143	35
18	3.3	3.7	2.7	9.0	7.0	76	28	40	.00	.10	194	35
19	3.5	3.7	3.3	9.0	7.0	62	25	30	.00	.00	38	35
20	3.0	3.3	4.3	10	9.0	57	68	30	.00	.00	34	35
21	2.7	3.3	4.0	10	9.0	23	62	30	.00	.00	82	35
22	3.0	3.3	9.2	11	10	14	50	30	.00	.00	4000	35
23	3.3	3.3	7.3	11	15	9.6	19	20	.00	.00	12000	35
24	3.3	4.3	3.3	12	18	6.6	56	20	.00	.00	5000	35
25	3.0	5.2	4.3	12	23	4.5	40	15	.00	.00	3000	30
26	3.0	4.0	3.3	13	128	3.3	35	10	.00	.00	1000	30
27	3.0	3.7	3.3	12	68	23	78	5.0	.00	.00	750	30
28	3.0	3.5	3.3	15	37	71	90	2.0	.00	13	200	30
29	3.0	6.2	3.0	14	---	63	126	1.0	.00	85	140	30
30	3.0	27	3.0	18	---	56	134	.00	.00	83	100	30
31	3.3	---	3.0	10	---	38	---	.00	---	58	80	---
TOTAL	1177.30	139.1	169.8	268.0	433.4	1438.7	866.1	3532.00	.00	239.30	28040	1215
MEAN	38.0	4.64	5.48	8.65	15.5	46.4	28.9	114	.000	7.72	905	40.5
MAX	437	27	30	18	128	202	134	850	.00	85	12000	75
MIN	.70	3.0	2.7	3.0	4.0	3.3	1.4	.00	.00	.00	13	30
AC-FT	2340	276	337	532	860	2850	1720	7010	.00	475	55620	2410

WTR YR 1982 TOTAL 37518.70 MEAN 103 MAX 12000 MIN .00 AC-FT 74420

Table 9.--Discharge data, Chinle Creek near Mexican Water, 1983 water year

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1982 TO SEPTEMBER 1983
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	100	3.0	8.0	8.0	76	217	367	360	112	.35	20	.00
2	80	3.0	30	4.8	56	236	356	307	46	.30	8.0	.00
3	40	3.0	12	5.3	32	211	257	263	33	.20	4.0	.00
4	20	3.0	8.0	5.7	28	198	254	251	26	.10	2.0	.00
5	10	3.0	4.0	5.7	46	284	185	338	23	.10	1.0	.00
6	8.0	3.0	4.0	4.4	127	254	133	413	21	.10	.40	.00
7	8.0	4.0	4.0	4.4	190	188	121	453	18	.38	.20	.00
8	8.0	4.0	4.0	5.3	198	168	96	397	18	.71	.10	.00
9	8.0	4.0	6.0	2.5	193	190	82	413	15	87	.00	.00
10	6.0	6.0	12	4.1	148	254	76	496	12	150	.00	.00
11	6.0	4.0	30	6.2	77	288	93	492	8.4	200	.00	.00
12	6.0	4.0	25	8.0	52	297	137	462	6.2	180	.00	.00
13	6.0	4.0	20	20	41	317	137	331	4.4	80	.00	.00
14	6.0	4.0	18	17	41	307	137	248	1.4	40	.00	.00
15	6.0	4.0	16	17	55	314	133	231	1.4	30	.00	.00
16	6.0	4.0	14	18	62	324	119	201	1.0	20	.00	.00
17	6.0	4.0	14	4.0	71	245	127	222	.36	10	.00	.00
18	6.0	4.0	12	43	74	173	198	240	.20	9.0	.00	.00
19	6.0	8.0	12	160	69	159	212	200	.10	9.0	.00	.00
20	6.0	16	10	160	60	166	225	220	.10	4.0	.00	.00
21	6.0	12	10	140	65	157	214	280	.00	2.0	.00	1.0
22	5.0	10	11	140	69	173	203	240	.00	1.0	.00	.40
23	4.0	18	26	120	69	173	242	200	.00	60	.00	.20
24	4.0	26	166	120	72	157	195	180	.38	10	.00	.10
25	4.0	20	95	150	138	159	164	180	1.2	3.0	.00	.00
26	3.0	12	25	150	193	157	228	171	.60	1.0	.00	.00
27	3.0	8.0	8.0	124	211	155	304	171	.30	50	.00	.00
28	3.0	6.0	5.7	166	180	139	304	173	.30	1500	.00	.00
29	3.0	4.0	8.8	288	---	142	352	164	1.0	200	.00	.00
30	3.0	4.0	12	171	---	166	352	166	1.5	60	.00	70
31	3.0	---	8.0	125	---	291	----	148	---	30	.00	---
TOTAL	389.0	212.0	638.5	2197.4	2693	6659	6003	8611	352.84	2738.24	35.70	71.70
MEAN	12.5	7.07	20.6	70.9	96.2	215	200	278	11.8	88.3	1.15	2.39
MAX	100	26	166	288	211	324	367	496	112	1500	20	70
MIN	3.0	3.0	4.0	2.5	28	139	76	148	.00	.10	.00	.00
AC-FT	772	421	1270	4360	5340	13210	11910	17080	700	5430	71	142

CAL YR 1982 TOTAL 34139.60 MEAN 93.5 MAX 6000 MIN .00 AC-FT 67720

WTR YR 1983 TOTAL 30601.38 MEAN 83.8 MAX 1500 MIN .00 AC-FT 60700

09401260. MOENKOPI WASH AT MOENKOPI, ARIZ.

LOCATION.--Lat 36°06'18", long 111°12'04", in NW¼NE¼ sec.3, T.31 N., R.11 E. (unsurveyed), Coconino County, in Navajo Indian Reservation on left bank 100 ft (30 m) upstream from bridge on State Highway 264, 1.3 mi (2.1 km) southeast of Moenkopi, 2.5 mi (4.0 km) downstream from former gaging station 09401250, and 12.5 mi (20.1 km) downstream from Begashibito Wash.

DRAINAGE AREA.--1,660 mi^2 (4,300 km^2), approximately.

PERIOD OF RECORD.--July to September 1976.

GAGE.--Water-stage recorder and concrete control. Altitude of gage is 4,610 ft (1,405 m), from topographic map.

EXTREMES.--Maximum discharge during period, 5,420 ft^3/s (153 m^3/s) Sept. 25 (gage height, 9.9 ft or 3.02 m, from profile of floodmarks past gage), from rating curve extended above 140 ft^3/s (4.0 m^3/s) based on velocity-area study; no flow for many days.
A discharge of 15,100 ft^3/s (428 m^3/s) occurred Aug. 4, 1929, at former gaging station site 3.5 mi (5.6 km) downstream.

REMARKS.--Records poor. Records of chemical analyses, water temperature, and suspended-sediment loads are published on following pages.

DISCHARGE, IN CUBIC FEET PER SECOND, JULY TO SEPTEMBER 1976

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1										0	14	0
2										0	4.0	0
3										0	2.8	0
4										0	1.3	0
5										0	.10	0
6										0	0	0
7										0	0	3.2
8										0	20	4.9
9										0	7.8	1.8
10										0	2.8	1.8
11										0	.90	1.5
12										0	.30	1.8
13										0	.10	.90
14										0	0	.70
15										0	0	.40
16										0	0	.20
17										0	0	.10
18										0	0	0
19										0	0	0
20										3.2	46	.10
21										1.9	4.4	.60
22										0	1.1	3.6
23										0	.30	3.6
24										0	.40	2.8
25										0	.10	1,600
26										66	0	600
27										52	0	100
28										27	0	11
29										40	0	4.0
30					------					4.0	0	2.8
31		------			------		------		------	238	0	------
TOTAL										432.1	106.40	2,345.80
MEAN										13.9	3.43	78.2
MAX										238	46	1,600
MIN										0	0	0
AC-FT										857	211	4,650

PEAK DISCHARGE (BASE, 1,200 CFS).--Sept. 25 (0900) 5,420 cfs (9.9 ft, from profile of floodmarks past gage).

09401260 MOENKOPI WASH AT MOENKOPI, AZ

LOCATION.--Lat 36°06'18", long 111°12'04", in NW¼NE¼ sec.3, T.31 N., R.11 E. (unsurveyed), Coconino County, Hydrologic Unit 15020018, in Navajo Indian Reservation on left bank 100 ft (30 m) upstream from bridge on State Highway 264, 1.3 mi (2.1 km) southeast of Moenkopi, 2.5 mi (4.0 km) downstream from former gaging station 09401250, and 12.5 mi (20.1 km) downstream from Begashibito Wash.

DRAINAGE AREA.--1,660 mi² (4,300 km²), approximately.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--July 1976 to current year. Records for October 1973 to July 1976 at site 2.5 mi (4.0 km) upstream, not equivalent below 1.5 ft³/s (0.042 m³/s) due to channel losses.

GAGE.--Water-stage recorder and concrete control. Altitude of gage is 4,610 ft (1,405 m), from topographic map.

REMARKS.--Records poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 5,420 ft³/s (153 m³/s) Sept. 25, 1976 (gage height, 9.9 ft or 3.02 m, from profile of floodmarks past gage), from rating curve extended above 140 ft³/s (3.96 m³/s) on basis of slope-area measurement of peak flow. No flow at times each year.

EXTREMES OUTSIDE PERIOD OF RECORD.--A discharge of 15,100 ft³/s (428 m³/s) occurred Aug. 4, 1929, at former gaging station site 3.5 mi (5.6 km) downstream.

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*), (from rating curve extended above 140 ft³/s or 3.96 m³/s on basis of slope-area measurement of peak flow) and peak discharges above base of 1,200 ft³/s (34 m³/s):

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)	Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
July 21	0330	*4,120	117	8.85	2.697	Aug. 12	1400	2,530	71.6	7.60	2.316
July 23	0030	unknown	†	unknown	†	Sept. 2	2000	4,100	116	8.83	2.691

No flow for many days.

† No record of peak. Gage height of 7.4 ft (2.26 m) observed at 0730 on July 23; discharge, 2,300 ft³/s (65.1 m³/s).

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.8	1.5	2.0	5.0	2.1	2.8	2.0	1.0	.40	.00	.30	.50
2	2.1	1.5	2.0	5.0	2.1	2.1	2.0	1.0	.30	.00	.00	500
3	1.8	1.5	2.0	4.0	2.1	2.1	3.0	1.3	.30	.00	.00	1100
4	1.8	1.5	2.0	4.0	1.8	2.4	2.0	1.5	.20	.00	.00	100
5	2.1	1.5	2.0	3.0	2.4	1.5	2.0	1.1	.20	.00	.00	8.0
6	2.1	1.8	2.0	3.0	2.8	2.8	2.0	.80	.20	.00	.00	5.0
7	1.8	1.8	2.0	4.0	2.1	2.8	2.0	.80	.30	.00	.00	3.0
8	1.5	1.8	2.0	3.0	2.1	2.1	2.0	1.1	.40	.00	.70	1.0
9	1.5	2.1	2.0	3.0	1.8	2.8	2.0	1.1	.40	.00	.20	.70
10	1.5	2.1	2.4	3.0	2.1	2.8	2.0	1.1	.40	.00	.00	.60
11	1.3	2.4	2.1	3.0	2.4	2.8	1.0	1.0	.40	.00	.00	10
12	1.3	2.1	2.8	2.0	2.1	1.5	2.0	1.0	.40	13	185	12
13	1.3	2.1	2.8	2.0	2.1	2.8	2.0	1.0	.40	4.0	30	22
14	1.3	1.8	1.8	2.0	2.1	3.0	2.0	2.0	.40	.80	6.0	5.4
15	1.5	1.5	2.4	2.0	2.4	1.5	2.0	2.0	.00	.30	40	4.4
16	1.5	2.0	2.8	2.0	2.4	2.1	2.0	2.0	.00	2.3	9.0	1.8
17	1.8	2.0	2.8	2.0	2.4	2.4	2.0	1.0	.00	13	4.0	.70
18	1.8	2.0	3.6	3.0	2.4	2.1	2.0	.70	.00	30	60	.50
19	1.8	2.0	2.8	3.0	2.1	2.1	2.0	.70	.00	40	23	.50
20	1.8	2.0	2.8	3.6	2.1	2.1	2.0	.70	.00	60	4.4	.50
21	2.1	2.0	2.4	3.6	2.1	2.4	2.0	.70	.00	430	2.4	.50
22	2.1	2.0	2.8	3.6	2.8	2.0	2.0	1.0	.00	18	1.8	.50
23	2.1	2.0	2.8	4.4	2.4	2.0	2.0	.70	.00	1900	.80	.50
24	2.1	2.0	2.8	5.4	2.1	2.0	2.0	.70	.00	300	.60	.50
25	1.8	2.0	2.8	2.8	2.1	2.0	2.0	.70	.00	20	14	.50
26	1.5	2.0	2.8	3.6	2.8	3.0	2.0	1.0	.00	3.0	6.5	.40
27	1.5	2.0	2.8	2.4	3.2	2.0	2.0	.70	.00	1.8	2.1	.40
28	1.3	2.0	3.0	2.4	3.2	2.0	1.0	.50	.00	.70	1.1	.50
29	1.3	2.0	2.0	2.4	---	2.0	2.0	.80	.00	.70	.50	.50
30	1.5	2.0	3.0	2.4	---	2.0	1.0	.70	.00	.50	.30	.60
31	1.5	---	3.0	2.1	---	2.0	---	.50	---	.50	.40	---
TOTAL	52.2	57.0	77.3	96.7	64.6	70.0	58.0	30.90	4.70	2838.60	393.10	1781.50
MEAN	1.68	1.90	2.49	3.12	2.31	2.26	1.93	1.00	.16	91.6	12.7	59.4
MAX	2.1	2.4	3.6	5.4	3.2	3.0	3.0	2.0	.40	1900	185	1100
MIN	1.3	1.5	1.8	2.0	1.8	1.5	1.0	.50	.00	.00	.00	.40
AC-FT	104	113	153	192	128	139	115	61	9.3	5630	780	3530

WTR YR 1977 TOTAL 5524.60 MEAN 15.1 MAX 1900 MIN .00 AC-FT 10960

NOTE.--No gage-height record Mar. 22 to May 3, May 11 to July 13.

09401260 MOENKOPI WASH AT MOENKOPI, AZ

LOCATION.--Lat 36°06'18", long 111°12'04", in NW¼NE¼ sec.3, T.31 N., R.11 E. (unsurveyed), Coconino County, Hydrologic Unit 15020018, in Navajo Indian Reservation on left bank 100 ft (30 m) upstream from bridge on State Highway 264, 1.3 mi (2.1 km) southeast of Moenkopi, 2.5 mi (4.0 km) downstream from former gaging station 09401250, and 12.5 mi (20.1 km) downstream from Begashibito Wash.

DRAINAGE AREA.--1,660 mi² (4,300 km²), approximately.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--July 1976 to current year. Records for October 1973 to July 1976 at site 2.5 mi (4.0 km) upstream, not equivalent below 1.5 ft³/s (0.042 m³/s) due to channel losses.

GAGE.--Water-stage recorder and concrete control. Altitude of gage is 4,610 ft (1,405 m), from topographic map.

REMARKS.--Records poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 5,420 ft³/s (153 m³/s) Sept. 25, 1976, gage height, 9.9 ft (3.02 m), from profile of floodmarks past gage, from rating curve extended above 140 ft³/s (3.96 m³/s) on basis of slope-area measurement of peak flow. No flow at times each year.

EXTREMES OUTSIDE PERIOD OF RECORD.--A discharge of 15,100 ft³/s (428 m³/s) occurred Aug. 4, 1929, at former gaging station site 3.5 mi (5.6 km) downstream.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 262 ft³/s (7.420 m³/s) Sept. 25, gage height, 5.03 ft (1.533 m), no peak above base of 1,200 ft³/s (34 m³/s); no flow for many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.70	1.5	2.4	2.8	4.4	20	1.8	1.3	.50	.00	.00	.00
2	.70	1.5	2.4	2.8	3.6	27	1.8	1.3	.50	.00	.00	.00
3	.50	1.5	2.4	2.8	3.6	13	1.8	1.1	.40	.00	.00	.30
4	.50	2.1	2.4	2.8	3.6	9.0	1.8	1.1	.50	.00	.00	.00
5	.50	2.1	2.4	2.8	7.2	13	1.8	1.1	.50	.00	.00	.00
6	.70	2.1	2.4	2.8	4.0	15	1.1	1.1	.50	.00	.00	.00
7	1.5	2.8	2.4	2.8	4.9	6.0	1.1	1.1	.60	.00	.00	.00
8	.70	4.9	2.4	2.8	7.2	4.0	1.1	1.1	.50	.00	.00	.00
9	1.1	3.2	1.8	2.8	4.0	4.0	1.1	1.1	.50	.00	.00	.00
10	1.1	2.4	1.8	3.2	4.0	1.8	1.1	.70	.50	.00	.00	.00
11	1.1	2.4	1.8	3.6	4.0	1.8	1.1	.80	.20	.00	.00	.00
12	1.1	2.4	1.8	3.6	4.9	4.0	1.8	.70	.00	.00	.00	.00
13	1.1	2.4	2.4	3.2	4.0	1.8	1.8	.60	.00	.00	.00	.00
14	1.1	2.4	2.4	2.8	4.0	6.0	1.8	.50	.00	.00	.00	.00
15	1.1	2.4	2.4	2.8	4.0	1.8	1.8	.50	.00	.00	.00	.00
16	.70	2.4	2.4	3.2	4.0	1.8	1.8	.40	.00	.00	.00	.00
17	.70	2.4	2.4	4.9	4.0	1.8	1.8	.60	.00	.00	.00	.00
18	1.1	2.4	2.4	5.4	3.2	1.8	1.8	.60	.00	3.3	.00	.00
19	1.1	2.4	2.4	5.4	4.0	1.8	1.8	.70	.00	.90	.00	.00
20	.70	2.4	2.4	5.4	4.4	1.8	2.8	.70	.00	.30	.00	.00
21	.70	1.8	2.4	4.4	4.4	1.8	2.8	.60	.00	.00	.00	.00
22	1.1	1.5	2.4	4.4	4.0	1.8	2.8	.50	.00	.00	.00	.00
23	1.5	1.5	2.4	4.4	4.0	1.8	2.8	.50	.00	.00	.00	.30
24	1.5	1.5	2.4	3.6	4.0	1.8	2.8	.50	.00	.00	.00	91
25	1.5	1.5	2.4	3.6	4.0	1.8	2.8	.40	.00	7.2	.00	15
26	1.5	1.5	2.8	4.4	4.0	1.8	2.8	.50	.00	3.8	.00	4.0
27	1.5	1.5	2.8	5.4	4.0	1.8	2.8	.50	.00	1.8	.00	.70
28	1.5	1.5	3.6	4.4	5.4	1.8	1.8	.50	.00	1.1	.00	.50
29	1.5	2.1	4.4	4.4	---	1.8	1.5	.50	.00	.20	.00	.20
30	1.5	2.4	3.6	3.6	---	1.8	1.5	.50	.00	.00	.00	---
31	1.5	---	2.8	5.4	---	1.8	---	.50	---	.00	.00	---
TOTAL	33.10	64.9	77.6	116.7	120.8	157.0	57.2	22.60	5.20	18.60	.00	111.70
MEAN	1.07	2.16	2.50	3.76	4.31	5.06	1.91	.73	.17	.60	.000	3.72
MAX	1.5	4.9	4.4	5.4	7.2	27	2.8	1.3	.60	7.2	.00	91
MIN	.50	1.5	1.8	2.8	3.2	1.8	1.1	.40	.00	.00	.00	.00
AC-FT	66	129	154	231	240	311	113	45	10	37	.00	222

CAL YR 1977 TOTAL 5513.70 MEAN 15.1 MAX 1900 MIN .00 AC-FT 10940
WTR YR 1978 TOTAL 785.40 MEAN 2.15 MAX 91 MIN .00 AC-FT 1560

NOTE.--No gage-height record Oct. 14 to Nov. 21, Nov. 29 to Feb. 17, Mar. 3 to Apr. 3.

09401260 MOENKOPI WASH AT MOENKOPI, AZ

LOCATION.--Lat 36°06'18", long 111°12'04", in NW¼NE¼ sec.3, T.31 N., R.11 E. (unsurveyed), Coconino County, Hydrologic Unit 15020018, Navajo Indian Reservation on left bank 100 ft (30 m) upstream from bridge on State Highway 264, 1.3 mi (2.1 km) southeast of Moenkopi, 2.5 mi (4.0 km) downstream from former gaging station 09401250, and 12.5 mi (20.1 km) downstream from Begashibito Wash.

DRAINAGE AREA.--1,660 mi² (4,300 km²), approximately.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--July 1976 to current year. Records for October 1973 to July 1976 at site 2.5 mi (4.0 km) upstream, not equivalent ... flow 1.5 ft³/s (0.042 m³/s) due to channel losses.

GAGE.--Water-stage recorder. Altitude of gage is 4,610 ft (1,405 m), from topographic map.

REMARKS.--Records poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 5,420 ft³/s (153 m³/s) Sept. 25, 1976, gage height, 9.9 ft (3.02 m), from profile of floodmarks past gage, from rating curve extended above 140 ft³/s (3.96 m³/s) on basis of slope-area measurement of peak flow. No flow at times each year.

EXTREMES OUTSIDE PERIOD OF RECORD.--A discharge of 15,100 ft³/s (428 m³/s) occurred Aug. 4, 1929, at former gaging station site 3.5 mi (5.6 km) downstream.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 330 ft³/s (9.346 m³/s) Nov. 12, gage height, 5.40 ft (1.646 m), no peak above base of 1,200 ft³/s (34 m³/s); no flow for many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.5	1.8	2.8	1.5	6.0	5.0	.40	1.3	.20	.00	.00	.00
2	1.5	4.7	3.2	1.5	5.0	4.0	.40	1.1	.50	.00	.00	.00
3	1.5	25	3.6	1.5	6.0	5.0	.50	1.3	4.9	.00	.00	.00
4	1.5	26	2.8	1.5	7.0	8.0	.60	1.1	1.1	.00	.00	.00
5	1.3	5.4	3.2	1.5	7.0	8.0	.80	1.1	.30	.00	.00	.00
6	1.5	2.8	4.0	1.5	8.0	6.0	.80	1.1	.20	.00	.00	.00
7	1.5	1.5	2.4	1.5	8.0	10	1.3	1.3	.20	.00	.00	.00
8	1.8	1.5	1.5	1.5	8.5	10	1.3	1.1	.20	.00	.00	.00
9	1.8	1.5	1.5	1.5	9.0	8.0	1.3	.80	.10	.00	.00	.00
10	1.5	1.8	1.8	1.5	9.0	5.0	2.1	1.1	.10	.00	.00	.00
11	1.5	6.6	1.8	1.5	50	5.0	2.4	1.3	.10	.00	.00	.00
12	1.5	171	1.1	1.5	25	3.0	1.8	1.1	.10	.00	.00	.00
13	1.8	15	1.1	1.5	25	3.0	1.3	.70	.10	.00	.00	.00
14	1.5	6.5	10	1.5	150	3.0	1.1	.70	.00	.00	.00	.00
15	1.8	4.9	12	20	150	2.0	.80	1.1	.00	.00	.00	.00
16	2.1	3.3	25	15	95	2.0	.80	.80	.00	.00	30	.00
17	2.4	3.6	150	10	45	.50	.70	1.3	.00	.00	9.0	.00
18	2.4	3.6	75	30	60	.50	.60	.50	.00	.00	4.4	.00
19	2.1	3.6	25	25	40	.60	.60	.50	.00	.00	3.6	.00
20	2.1	3.6	10	10	35	.70	.60	.40	.00	.00	1.9	.00
21	1.8	3.6	8.0	4.0	25	.80	.70	.50	.00	.00	.00	.00
22	10	4.4	8.0	4.0	10	.50	.70	.80	.00	.00	.00	.00
23	6.0	4.4	8.0	4.5	5.0	.50	1.1	.80	.00	.00	.00	.00
24	3.2	4.9	8.0	4.5	4.0	.50	1.1	1.1	.00	.00	.00	.00
25	3.2	5.4	8.0	5.0	4.0	.50	1.1	3.2	.00	.00	.00	.00
26	2.1	4.4	7.0	5.0	4.0	.50	1.3	11	.00	.00	.00	.00
27	1.8	4.4	7.0	5.5	5.0	.50	1.3	11	.00	.00	.00	.00
28	2.1	4.4	10	5.5	6.0	.70	1.1	1.5	.00	.00	.00	.00
29	2.1	4.4	10	6.0	---	2.1	.80	.20	.00	.00	.00	.00
30	2.1	4.4	5.0	6.0	---	1.3	.80	.20	.00	.00	.00	.00
31	2.1	---	1.5	6.0	---	.50	---	.20	---	.00	.00	---
TOTAL	71.1	338.4	418.3	187.0	811.5	99.70	30.20	50.20	8.10	.00	48.90	.00
MEAN	2.29	11.3	13.5	6.03	29.0	3.22	1.01	1.62	.27	.000	1.58	.000
MAX	10	171	150	30	150	10	2.4	11	4.9	.00	30	.00
MIN	1.3	1.5	1.1	1.5	4.0	.50	.40	.20	.00	.00	.00	.00
AC-FT	141	671	830	371	1610	198	60	100	16	.00	97	.00

CAL YR 1978 TOTAL 1437.60 MEAN 3.94 MAX 171 MIN .00 AC-FT 2850
WTR YR 1979 TOTAL 2063.40 MEAN 5.65 MAX 171 MIN .00 AC-FT 4090

NOTE.--No gage-height record Dec. 11 to Mar. 16, June 5 to Aug. 16, and Aug. 20 to Sept. 30.

09401260 MOENKOPI WASH AT MOENKOPI, AZ

LOCATION.--Lat 36°06'18", long 111°12'04", in NW¼NE¼ sec.3, T.31 N., R.11 E. (unsurveyed), Coconino County, Hydrologic Unit 15020018, in Navajo Indian Reservation on left bank 100 ft (30 m) upstream from bridge on State Highway 264, 1.3 mi (2.1 km) southeast of Moenkopi, 2.5 mi (4.0 km) downstream from former gaging station 09401250, and 12.5 mi (20.1 km) downstream from Begashibito Wash.

DRAINAGE AREA.--1,660 mi² (4,300 km²), approximately.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--July 1976 to current year. Records for October 1973 to July 1976 at site 2.5 mi (4.0 km) upstream, not equivalent below 1.5 ft³/s (0.042 m³/s) due to channel losses.

GAGE.--Water-stage recorder. Altitude of gage is 4,610 ft (1,405 m), from topographic map.

REMARKS.--Records poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 5,420 ft³/s (153 m³/s) Sept. 25, 1976, gage height, 9.9 ft (3.02 m), from profile of floodmarks past gage, from rating curve extended above 140 ft³/s (3.96 m³/s) on basis of slope-area measurement of peak flow. No flow at times each year.

EXTREMES OUTSIDE PERIOD OF RECORD.--A discharge of 15,100 ft³/s (428 m³/s) occurred Aug. 4, 1929, at former gaging station site 3.5 mi (5.6 km) downstream.

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*) and peak discharges above base of 1,200 ft³/s (34 m³/s):

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
Aug. 15	0100	1,040	46.4	a6.73	2.051
Sept. 3	0230	1,570	44.5	6.66	2.030
Sept. 10	1900	*1,740	49.3	6.87	2.094

No flow for many days.
a From outside high-water mark.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1979 TO SEPTEMBER 1980
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.00	1.5	4.0	3.0	3.6	2.0	2.0	2.1	1.0	.60	.00	.00
2	.00	1.5	4.0	3.0	3.2	2.0	2.0	2.1	1.0	.00	.00	.00
3	.00	1.1	4.0	3.0	3.2	2.0	2.0	2.1	1.0	.00	2.7	.00
4	.00	.60	4.0	3.0	2.8	2.0	2.0	2.1	.40	.00	2.6	.00
5	.00	.60	4.0	3.0	2.4	2.0	2.0	2.1	.40	.00	.80	.00
6	.00	.70	4.0	3.0	2.8	2.0	2.0	2.0	.30	.00	.10	108
7	.00	1.1	4.0	3.0	4.0	2.0	2.0	2.0	.20	.00	.00	19
8	.00	11	4.0	3.0	3.6	2.0	2.0	2.0	.20	4.1	.00	88
9	.00	8.4	4.0	3.0	3.6	2.0	2.1	2.0	.10	3.5	.00	538
10	.00	3.2	4.0	3.0	3.2	2.0	2.4	2.0	.10	.00	.00	337
11	.00	1.8	4.0	3.0	3.6	2.0	2.8	2.0	.00	.00	.00	173
12	.00	2.1	3.6	3.0	3.6	2.0	2.1	2.0	.00	.00	.00	15
13	.00	2.4	3.2	3.0	4.6	2.0	2.1	2.0	.00	.00	.00	7.8
14	.00	2.4	3.0	3.0	3.2	2.0	2.1	2.0	.00	.00	7.1	1.8
15	.00	2.1	3.0	3.0	2.8	2.0	2.4	2.0	.00	.00	142	1.0
16	.70	2.1	3.0	3.0	2.4	2.0	2.4	2.0	.00	.00	8.8	1.0
17	.60	2.1	3.0	3.0	2.4	2.0	2.1	2.0	.00	.00	4.4	1.0
18	.50	2.4	3.0	3.0	3.2	2.0	2.1	1.0	.00	.00	.40	.80
19	.50	2.8	3.0	3.0	4.1	2.0	2.1	1.0	.00	.00	.40	.80
20	1.0	4.4	3.0	3.0	37	2.0	2.1	1.0	.00	.00	.40	.80
21	75	4.4	3.0	3.0	12	2.0	2.1	1.0	.00	.00	.40	.60
22	13	3.2	3.0	3.0	6.0	2.0	2.1	1.0	.00	.00	.40	.60
23	3.2	5.4	3.0	4.0	3.6	2.0	2.1	1.0	.00	.00	.40	.60
24	1.8	6.5	3.0	4.9	2.1	2.0	2.4	1.0	.00	.00	21	.40
25	1.5	6.5	3.0	6.0	1.8	2.0	3.2	1.0	.00	.00	11	.40
26	1.3	6.0	3.0	7.2	2.0	2.0	2.4	1.0	.00	.00	13	.40
27	1.5	6.0	4.0	5.4	2.0	2.0	2.1	1.0	.00	.00	5.2	.20
28	1.8	4.4	5.0	4.9	2.0	2.0	2.1	1.0	.00	.00	.00	.20
29	2.4	4.4	5.0	4.9	2.0	2.0	2.1	1.0	.00	.20	.00	.20
30	2.4	4.0	5.0	4.9	---	2.0	2.4	1.0	.00	.00	.00	.00
31	1.5	---	3.0	4.4	---	2.0	---	1.0	---	.00	.00	---
TOTAL	108.70	105.10	107.8	112.6	132.8	62.0	65.8	48.5	4.70	7.80	220.70	1291.60
MEAN	3.51	3.50	3.48	3.63	4.58	2.00	2.19	1.56	.16	.25	7.12	43.1
MAX	75	11	5.0	7.2	37	2.0	3.2	2.1	1.0	4.1	142	538
MIN	.00	.60	3.0	3.0	1.8	2.0	2.0	1.0	.00	.00	.00	.00
AC-FT	216	208	214	223	263	123	131	96	9.3	15	438	2560

CAL YR 1979 TOTAL 1557.20 MEAN 4.27 MAX 150 MIN .00 AC-FT 3090
WTR YR 1980 TOTAL 2268.10 MEAN 6.20 MAX 538 MIN .00 AC-FT 4500

NOTE.--No gage-height record Dec. 14 to Jan. 23, Feb. 25 to Apr. 8, May 6 to Aug. 14.

09401260 MOENKOPI WASH AT MOENKOPI, AZ

LOCATION.--Lat 36°06'18", long 111°12'04", in NW¼NE¼ sec.3, T.31 N., R.11 E. (unsurveyed), Coconino County, Hydrologic Unit 15020018, in Navajo Indian Reservation on left bank 100 ft (30 m) upstream from bridge on State Highway 264, 1.3 mi (2.1 km) southeast of Moenkopi, 2.5 mi (4.0 km) downstream from former gaging station 09401250, and 12.5 mi (20.1 km) downstream from Begashibito Wash.

DRAINAGE AREA.--1,660 mi² (4,300 km²), approximately.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--July 1976 to current year. Records for October 1973 to July 1976 at site 2.5 mi (4.0 km) upstream, not equivalent below 1.5 ft³/s (0.042 m³/s) due to channel losses.

GAGE.--Water-stage recorder. Altitude of gage is 4,610 ft (1,405 m), from topographic map.

REMARKS.--Records poor.

AVERAGE DISCHARGE.--5 years, 7.59 ft³/s (0.215 m³/s), 5,500 acre-ft/yr (6.78 hm³/yr).

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 5,420 ft³/s (153 m³/s) Sept. 25, 1976, gage height, 9.9 ft (3.02 m), from profile of floodmarks past gage, from rating curve extended above 140 ft³/s (3.96 m³/s) on basis of slope-area measurement of peak flow. No flow at times each year.

EXTREMES OUTSIDE PERIOD OF RECORD.--A discharge of 15,100 ft³/s (428 m³/s) occurred Aug. 4, 1929, at former gaging station site 3.5 mi (5.6 km) downstream.

EXTREMES FOR CURRENT YEAR.--Maximum discharge (*), (from rating curve extended above 140 ft³/s or 3.96 m³/s on basis of slope-area measurement at gage height, 9.9 ft or 3.02 m) and peak discharges above base of 1,200 ft³/s (34 m³/s):

Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)	Date	Time	Discharge (ft³/s)	Discharge (m³/s)	Gage height (ft)	Gage height (m)
July 13	0430	2,050	58.1	7.13	2.173	Aug. 13	2230	3,050	86.4	8.00	2.438
July 14	0130	*4,640	131	9.28	2.828	Sept. 23	2030	1,610	45.6	6.60	2.012

No flow for many days.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1980 TO SEPTEMBER 1981
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.20	.20	2.0	2.0	3.5	2.0	2.0	1.0	2.0	.42	.00	54
2	.20	.20	1.0	2.0	2.5	2.0	2.0	1.5	.70	15	.00	26
3	.20	.20	.10	2.0	2.5	2.0	2.0	1.0	.70	5.2	.00	8.2
4	.20	.20	.10	2.0	2.5	2.0	6.0	.50	.50	2.0	.00	3.0
5	.20	.20	.10	2.0	2.5	2.0	3.0	.50	.40	1.0	.00	3.0
6	.20	.20	.10	2.0	2.5	2.0	3.0	.50	.30	.00	.00	52
7	.20	.20	.10	2.5	2.5	2.0	3.0	.50	.10	.00	.00	7.0
8	.20	.20	.00	3.2	2.0	2.0	3.0	.50	.00	.00	.00	4.0
9	.20	.20	.00	2.4	2.0	2.0	3.0	.50	.00	7.1	5.0	2.0
10	.20	.20	.00	1.8	2.0	2.0	2.0	.50	.00	33	2.0	1.5
11	.20	.20	.00	.80	2.0	2.0	2.0	.50	.00	5.0	1.5	.50
12	.40	.20	.00	2.8	2.0	2.0	2.0	.50	.00	110	1.0	.00
13	.30	.20	.10	3.0	2.0	2.0	2.0	.50	.00	735	275	.00
14	.40	.20	.10	3.0	2.0	2.0	2.0	.50	.00	781	40	.00
15	.40	.20	.20	3.0	2.0	2.0	2.0	.50	.00	26	10	8.1
16	.30	.20	.20	3.0	2.0	2.0	3.2	.50	.00	12	7.0	9.0
17	.20	.20	.20	3.0	2.0	2.0	2.0	.50	.00	76	5.0	22
18	.20	.20	.20	3.0	2.0	2.0	2.0	.50	.00	7.2	3.0	26
19	.20	.20	.20	3.5	2.0	2.0	2.0	.50	.00	4.0	2.0	22
20	.20	.20	.50	3.5	2.0	2.0	2.0	.50	.00	2.0	1.5	8.0
21	.20	4.3	.60	3.5	2.0	2.0	2.0	.40	.00	1.0	1.5	5.0
22	.20	4.4	.70	4.0	2.0	2.0	2.0	.40	.00	1.0	1.5	4.0
23	.20	.30	.70	4.0	2.0	2.0	1.0	.30	.00	4.8	1.5	272
24	.20	1.5	.80	4.0	2.0	2.0	1.0	.30	.00	2.0	1.5	50
25	.20	1.0	1.0	4.0	2.0	2.0	1.0	.20	.00	1.0	1.5	6.0
26	.50	2.8	1.0	4.0	2.0	2.0	1.0	.20	.00	.00	1.5	4.0
27	.50	4.9	1.0	4.0	2.0	2.0	1.0	.10	.00	.00	1.5	3.0
28	.20	4.9	2.0	3.5	2.0	2.0	1.0	2.1	.00	.00	1.5	3.0
29	.20	4.0	2.0	3.5	---	2.0	1.0	9.9	.00	.00	1.0	2.5
30	.20	2.0	2.1	2.0	---	2.0	1.0	4.0	.00	.00	1.0	2.0
31	.20	---	2.0	2.0	---	2.0	---	3.2	---	.00	1.0	---
TOTAL	7.60	34.10	19.10	89.00	60.5	62.0	62.2	33.10	4.70	1873.30	368.00	607.80
MEAN	.25	1.14	.62	2.87	2.16	2.00	2.07	1.07	.16	60.4	11.9	20.3
MAX	.50	4.9	2.1	4.0	3.5	2.0	6.0	9.9	2.0	781	275	272
MIN	.20	.20	.00	.80	2.0	2.0	1.0	.10	.00	.00	.00	.00
AC-FT	15	68	38	177	120	123	123	66	9.3	3720	730	1210

CAL YR 1980 TOTAL 2007.30 MEAN 5.48 MAX 538 MIN .00 AC-FT 3980
WTR YR 1981 TOTAL 3221.40 MEAN 8.83 MAX 781 MIN .00 AC-FT 6390

Table 7.--Discharge data, Moenkopi Wash at Moenkopi, 1982 water year

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1981 TO SEPTEMBER 1982
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.5	1.5	8.0	1.0	3.8	6.0	2.0	2.0	.10	.00	.20	1.5
2	2110	1.0	8.0	1.0	3.6	6.0	2.0	2.0	.10	.00	.00	1.5
3	331	1.0	7.0	.80	3.6	5.5	1.8	22	.10	.00	.10	1.5
4	8.4	1.0	7.0	.80	3.4	5.0	1.8	9.0	.10	.00	.60	1.5
5	8.0	1.0	6.0	.60	3.0	4.5	1.6	160	.10	.00	.20	1.5
6	7.0	1.0	6.0	2.0	2.5	4.0	1.6	23	.10	.00	.00	15
7	6.0	1.5	5.0	1.0	2.5	4.0	1.6	13	.00	.00	.00	17
8	5.0	1.0	4.0	1.0	2.5	4.5	1.4	9.0	.00	.00	.00	3.0
9	4.0	.80	3.0	1.0	2.5	4.5	1.4	8.4	.00	.00	4.8	2.0
10	4.0	.80	3.0	1.0	2.5	4.5	1.4	6.5	.00	.00	4.0	2.0
11	3.5	.80	3.0	1.0	2.5	6.5	1.2	6.5	.00	.00	.50	200
12	3.5	.80	3.0	1.0	2.5	6.0	1.4	5.0	.00	.00	9.9	50
13	3.5	.80	3.0	1.0	2.8	6.0	1.2	13	.00	.00	34	25
14	3.0	.60	3.0	1.0	3.0	5.5	1.2	9.0	.00	.00	9.0	10
15	3.5	.60	2.5	1.0	3.0	5.5	1.2	9.0	.00	.00	1.5	6.0
16	3.0	.60	2.5	1.0	3.2	5.5	1.2	6.0	.00	.00	62	3.0
17	2.5	.60	2.5	1.0	3.4	5.0	1.0	4.0	.00	4.2	12	2.0
18	2.5	.40	2.5	1.0	3.4	4.5	1.0	3.5	.00	1.0	5.4	2.0
19	2.5	.40	2.5	1.0	5.0	4.0	1.0	3.0	.00	.00	1.3	2.0
20	2.5	.40	2.5	2.0	6.0	3.5	1.0	2.5	.00	.00	5.4	1.5
21	2.0	.40	3.0	2.0	7.2	3.5	1.0	2.0	.00	.00	35	1.5
22	2.0	.40	2.5	2.0	15	3.5	1.5	1.5	.00	18	227	1.5
23	2.0	.40	2.0	2.5	12	3.0	7.8	1.0	.00	8.9	40	1.5
24	2.0	.40	2.0	3.0	11	3.0	6.0	1.0	.00	8.3	15	1.5
25	2.0	.40	2.0	4.0	8.5	3.0	4.0	.80	.00	1.5	600	1.5
26	1.7	.40	1.8	5.0	6.5	5.0	3.0	.70	.00	10	60	1.5
27	1.5	1.0	1.6	4.6	6.0	4.5	2.0	.60	.00	.50	30	350
28	2.0	3.0	1.4	4.5	6.0	4.0	1.8	.50	.00	.50	15	65
29	2.0	10	1.2	4.5	—	3.0	1.8	.40	.00	7.9	7.0	15
30	1.5	9.0	1.0	4.0	---	2.1	2.0	.30	.00	1.6	3.0	7.0
31	1.5	---	1.0	4.0	---	2.0	---	.20	—	.60	2.0	—
TOTAL	2535.1	42.00	103.5	61.30	136.9	137.1	58.9	325.40	.60	63.00	1184.90	794.0
MEAN	81.8	1.40	3.34	1.98	4.89	4.42	1.96	10.5	.020	2.03	38.2	26.5
MAX	2110	10	8.0	5.0	15	6.5	7.8	160	.10	18	600	350
MIN	1.5	.40	1.0	.60	2.5	2.0	1.0	.20	.00	.00	.00	1.5
AC-FT	5030	83	205	122	272	272	117	645	1.2	125	2350	1570

WTR YR 1982 TOTAL 5442.70 MEAN 14.9 MAX 2110 MIN .00 AC-FT 10800

Table 8.--Discharge data, Moenkopi Wash at Moenkopi, 1983 water year

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1982 TO SEPTEMBER 1983
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7.0	3.5	4.8	3.0	3.0	3.5	1.1	1.6	.10	.00	70	.00
2	6.0	3.1	4.4	3.0	3.0	3.5	.95	1.6	.10	.00	50	.00
3	6.0	2.3	1.6	3.0	3.0	3.5	.95	1.6	.00	.00	20	.00
4	5.0	2.3	2.3	3.0	3.0	3.5	.80	1.1	.00	.00	250	.00
5	5.0	3.5	1.6	3.0	3.0	6.4	.95	.95	.00	.00	50	.00
6	5.0	4.0	1.6	3.0	3.0	5.6	1.1	.95	.00	.00	80	.00
7	4.0	4.0	2.0	3.0	3.0	3.5	2.0	1.3	.00	.00	100	.00
8	4.0	4.4	2.0	3.0	3.0	3.1	2.0	1.6	.00	.00	160	.00
9	4.0	4.8	1.6	3.0	3.0	1.6	1.3	1.1	.00	.00	100	.00
10	3.0	5.2	3.1	3.0	3.0	1.1	.80	1.3	.00	.00	50	.00
11	3.0	5.2	2.3	3.0	3.0	1.1	.95	1.6	.00	.00	20	.00
12	3.0	4.8	2.0	3.0	3.0	1.1	.95	2.3	.00	.00	400	.00
13	2.0	4.4	2.0	3.0	3.0	1.1	.95	2.0	.00	.00	50	.00
14	2.0	4.0	1.6	3.0	3.0	1.3	2.0	1.3	.00	.00	20	.00
15	2.0	4.0	1.6	3.0	3.0	2.7	2.0	1.1	.00	.00	7.0	.00
16	2.0	4.0	1.6	3.0	3.0	2.3	1.6	1.1	.00	.00	2.0	.00
17	2.0	4.4	2.7	3.0	3.0	1.3	1.3	2.0	.00	.00	.00	.00
18	2.0	4.8	2.7	3.0	3.0	2.3	1.1	1.3	.00	.00	.00	.00
19	2.3	4.4	2.0	3.0	3.0	2.7	1.3	1.1	.00	.00	20	.00
20	2.3	4.4	2.0	3.0	3.0	2.3	1.3	1.3	.00	.00	5.0	.00
21	2.3	4.0	2.0	3.0	3.0	2.3	1.6	1.3	.00	.00	.00	.00
22	2.3	4.0	2.0	3.0	3.0	3.1	2.7	.80	.00	.00	.00	.00
23	2.3	3.1	2.0	3.0	3.5	3.5	2.3	.80	.00	.00	.00	50
24	2.7	2.3	2.0	3.0	3.5	2.7	1.6	.70	.00	46	.00	20
25	2.7	2.0	2.0	3.0	3.5	2.0	1.1	.60	.00	500	.00	5.0
26	2.3	1.6	2.0	3.0	3.5	2.3	1.3	.52	.00	50	.00	2.0
27	2.3	1.6	2.0	3.0	3.5	2.7	1.3	.52	.00	20	.00	20
28	2.3	1.6	2.0	3.0	3.5	1.3	1.3	.10	.00	10	.00	10
29	2.3	2.0	2.0	3.0	---	1.3	1.1	.10	.00	10	.00	400
30	2.3	4.4	2.0	3.0	---	2.0	1.3	.20	.00	10	.00	3500
31	3.1	---	2.0	3.0	---	4.4	---	.20	---	20	.00	---
TOTAL	98.5	108.1	67.5	93.0	87.0	81.1	41.00	34.04	.20	666.00	1454.00	4007.00
MEAN	3.18	3.60	2.18	3.00	3.11	2.62	1.37	1.10	.01	21.5	46.9	134
MAX	7.0	5.2	4.8	3.0	3.5	6.4	2.7	2.3	.10	500	400	3500
MIN	2.0	1.6	1.6	3.0	3.0	1.1	.80	.10	.00	.00	.00	.00
AC-FT	195	214	134	184	173	161	81	68	.4	1320	2880	7950

CAL YR 1982 TOTAL 3036.20 MEAN 8.32 MAX 600 MIN .00 AC-FT 6020
WTR YR 1983 TOTAL 6737.44 MEAN 18.5 MAX 3500 MIN .00 AC-FT 13360

DISCHARGE AT PARTIAL-RECORD STATIONS AND MISCELLANEOUS SITES

Discharge measurements at miscellaneous sites

Measurements of streamflow at points other than gaging stations are given in the following table. Those that are measurements of base flow are designated by an asterisk (*); measurements of peak flow by a dagger (†).

Discharge measurements made at miscellaneous sites during water year 1982

Stream	Tributary to	Location	Drainage area (mi^2)	Measured previously (water years)	Measurements: Date	Measurements: Discharge (ft^3/s)
San Juan River basin						
Laguna Creek	Chinle Wash	Lat 36°44'57", long 110°08'08", unsurveyed, Navajo County, about 7 mi east of Kayenta.	229	-------	12-17-81 12-17-81 4-28-82 6- 8-82	3.74 3.94 2.60 0.02

Average Winter Low Flow Discharge Data for Laguna Wash

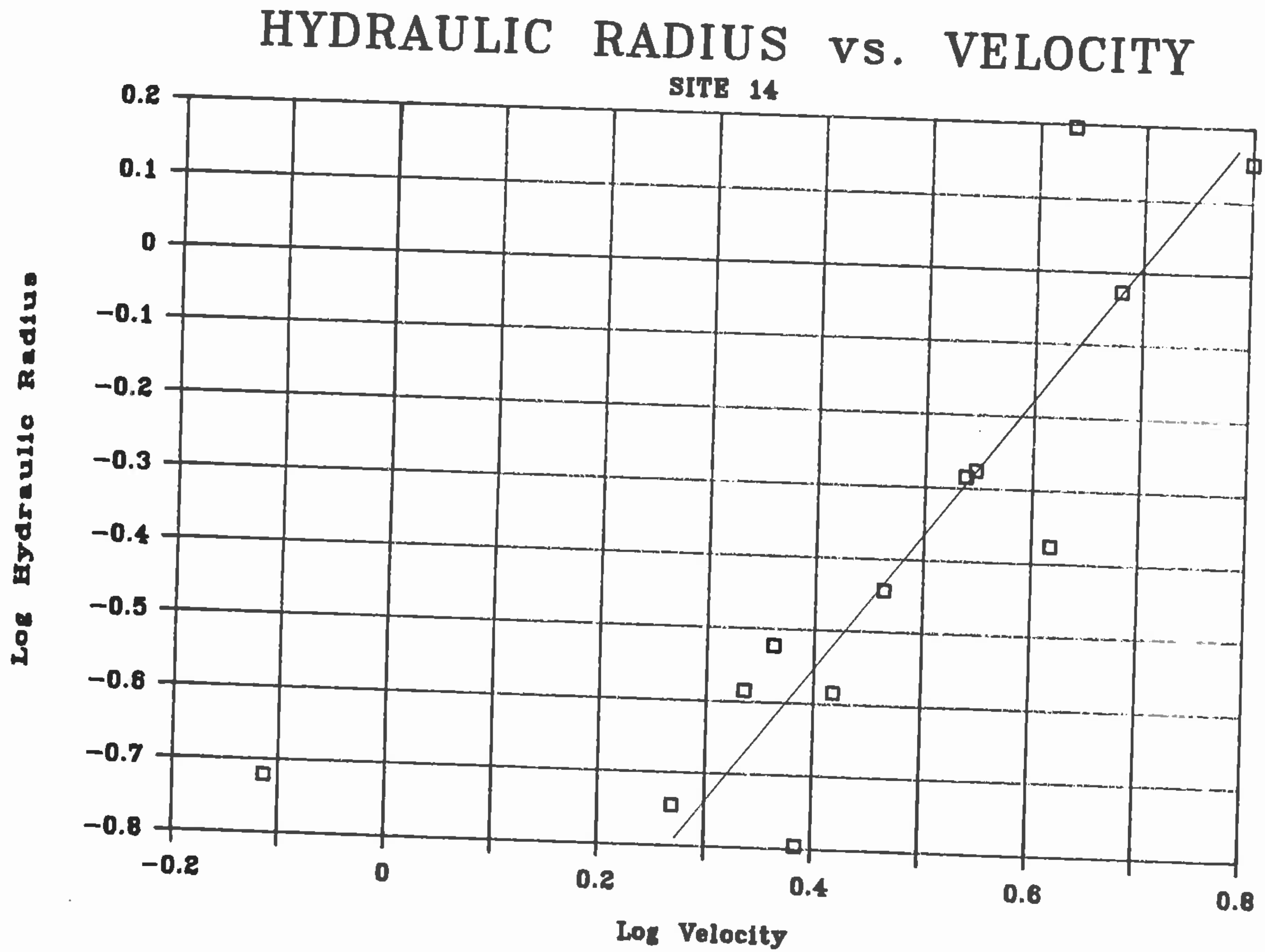
Year	Discharge
1982	3.9 cfs
1983	3.9 cfs
1984	3.3 cfs

ATTACHMENT 3

Hydraulic Radius Versus Velocity;

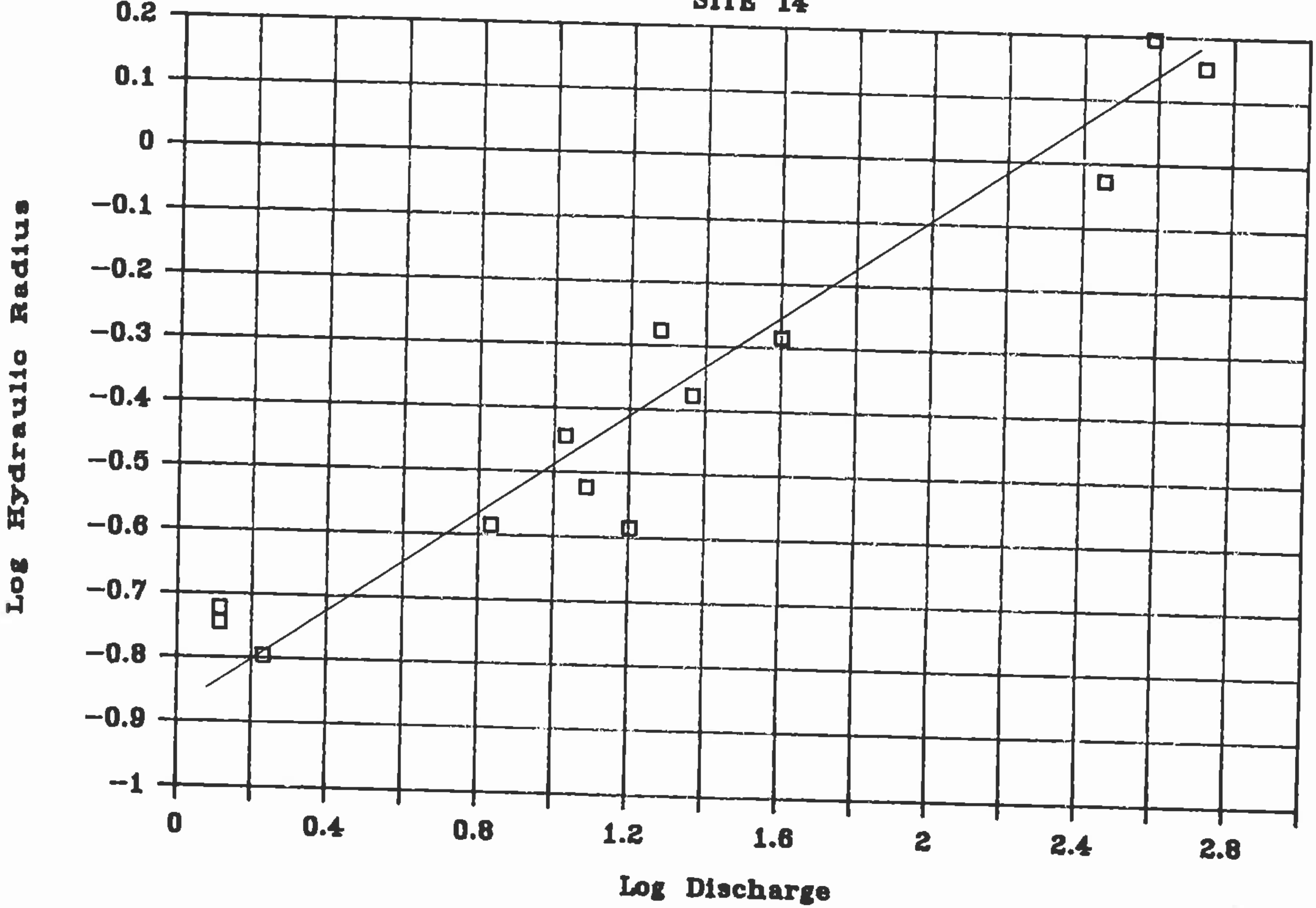
Hydraulic Radius Versus Discharge;

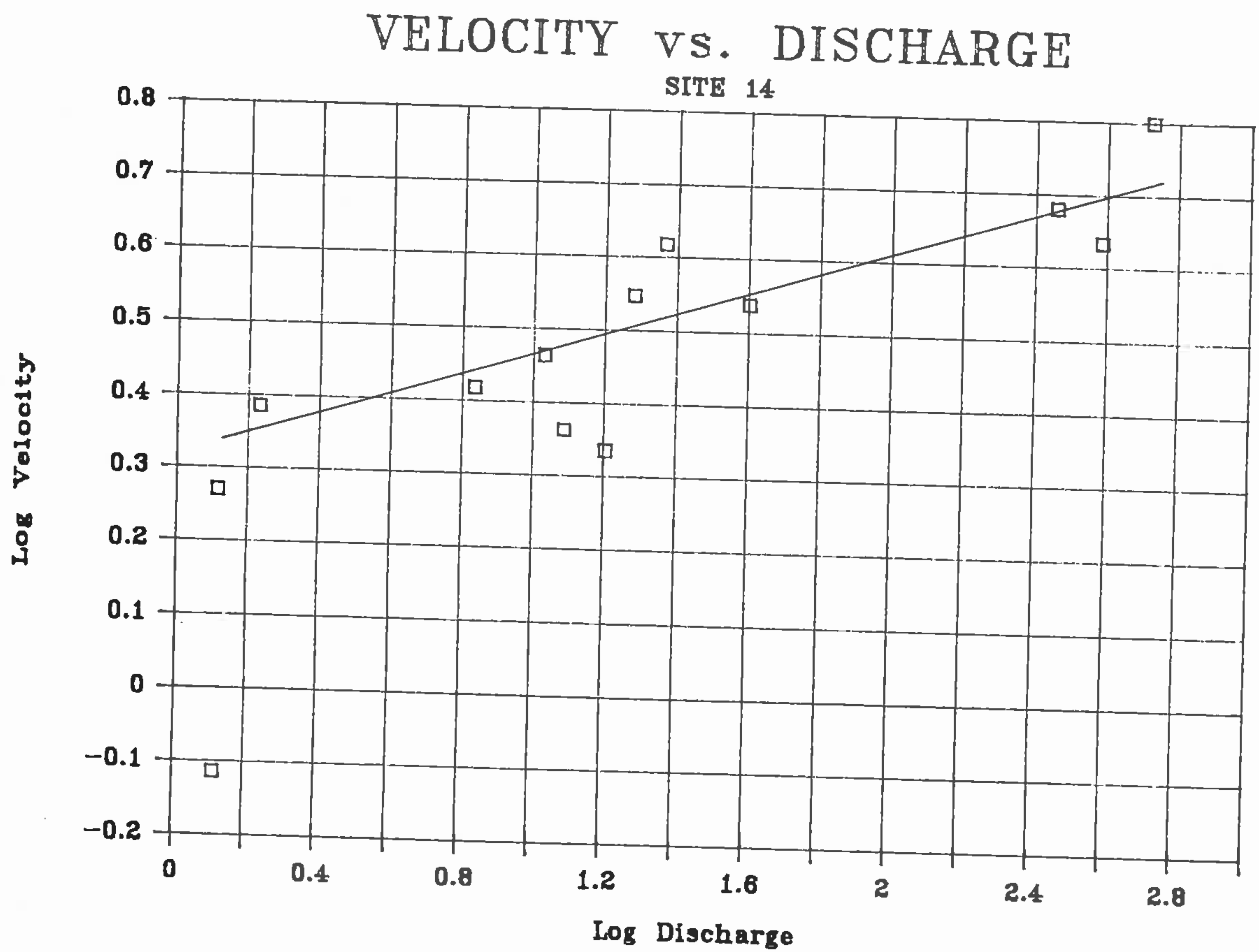
Velocity Versus Discharge Plots for Stream Monitoring Sites


HYDRAULIC RADIUS vs. VELOCITY
SITE 14
Log Hydraulic Radius
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.2
0
0.2
0.4
0.6
0.8
Log Velocity

HYDRAULIC RADIUS vs. DISCHARGE

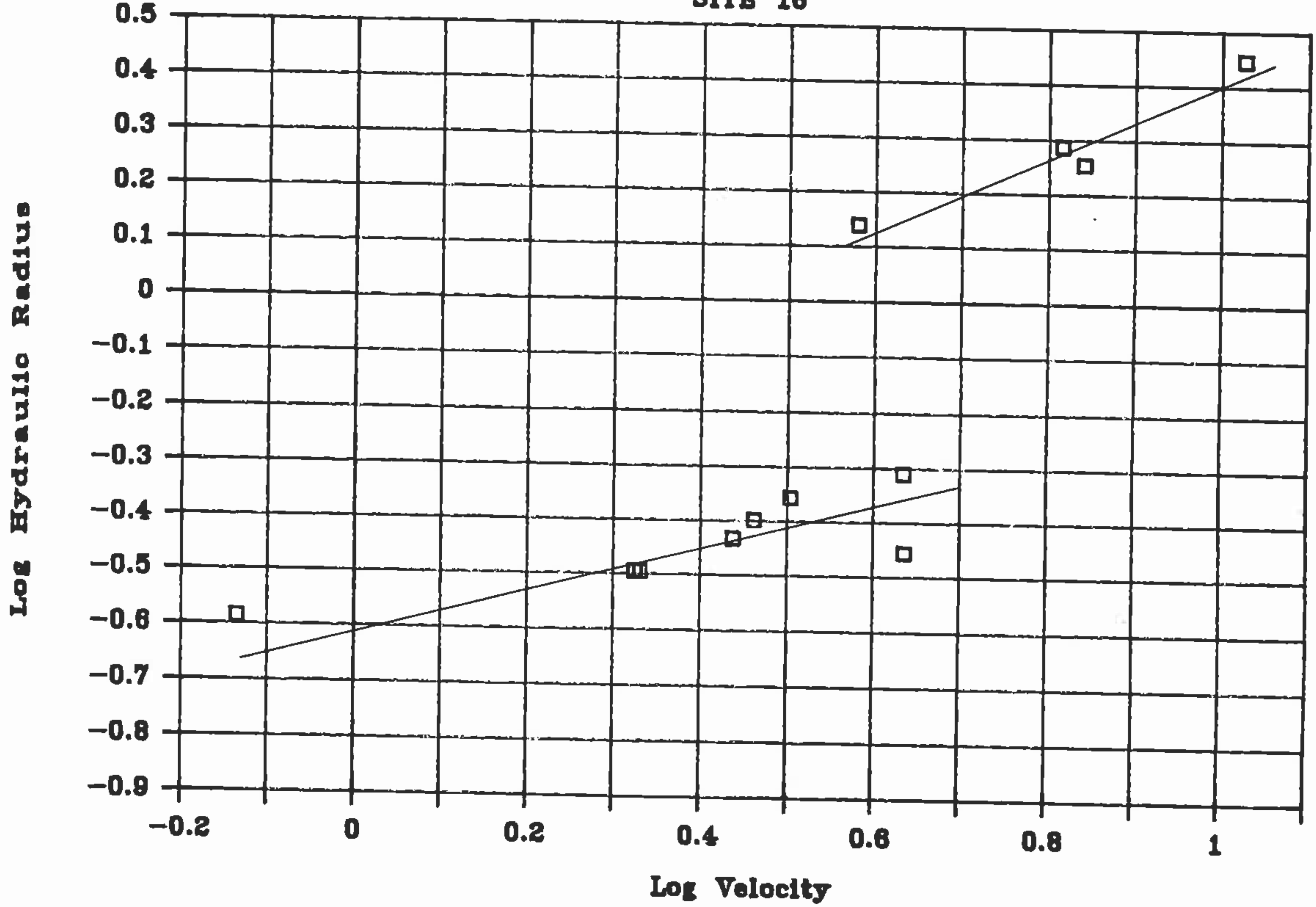
SITE 14




VELOCITY vs. DISCHARGE
SITE 14
Log Velocity
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
0.4
0.8
1.2
1.6
2
2.4
2.8
Log Discharge

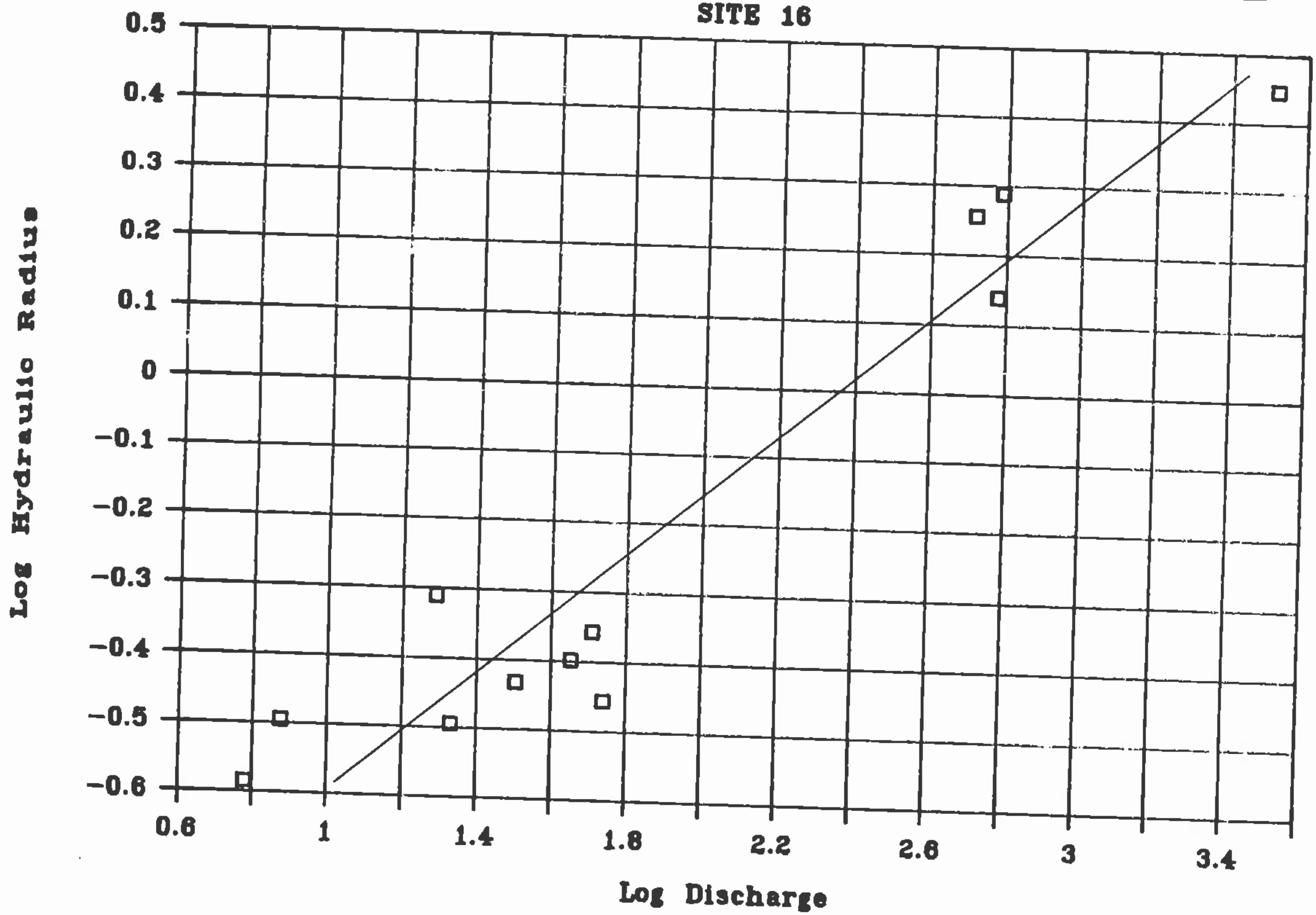
HYDRAULIC RADIUS vs. VELOCITY

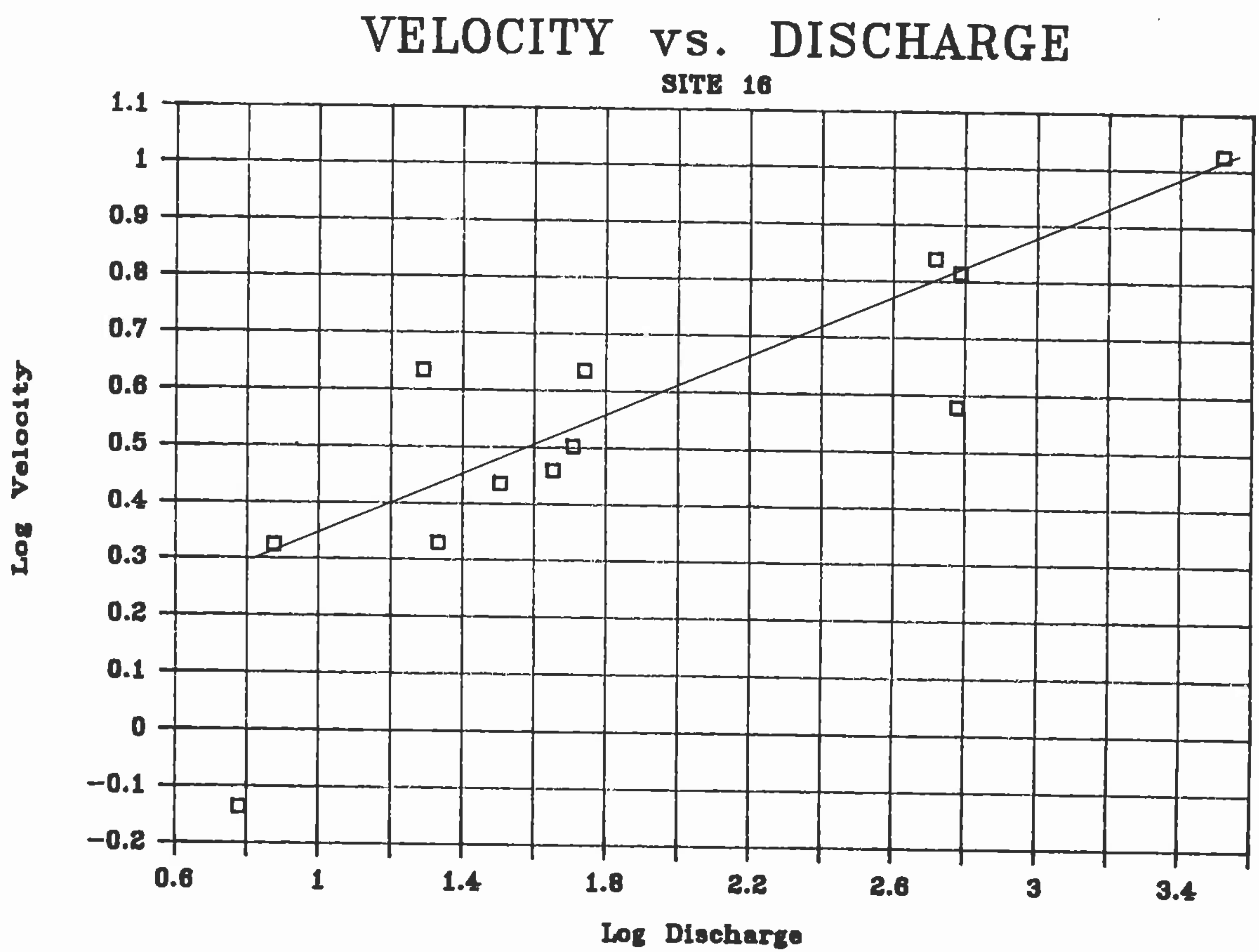
SITE 16

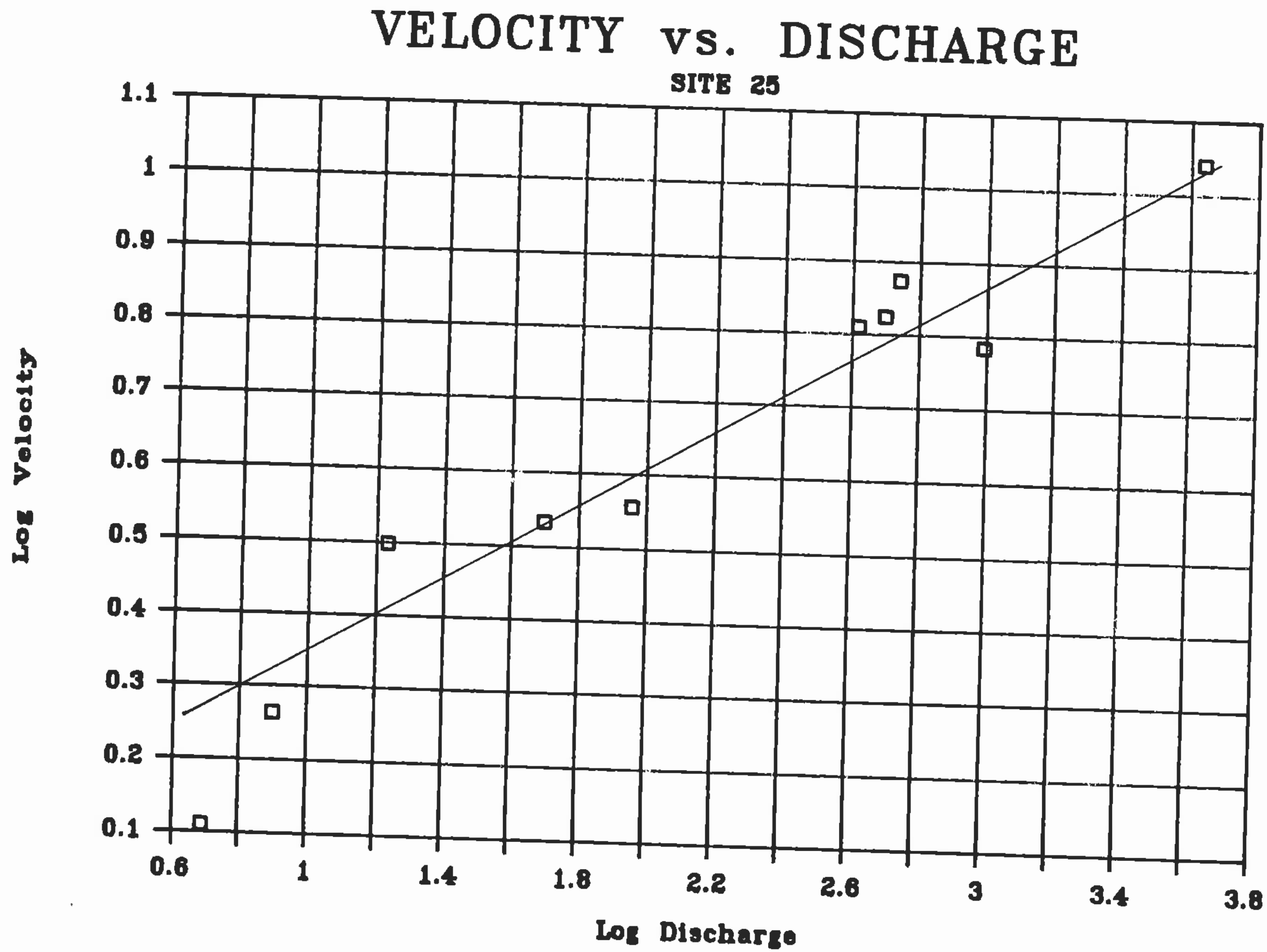


HYDRAULIC RADIUS vs. DISCHARGE

SITE 16

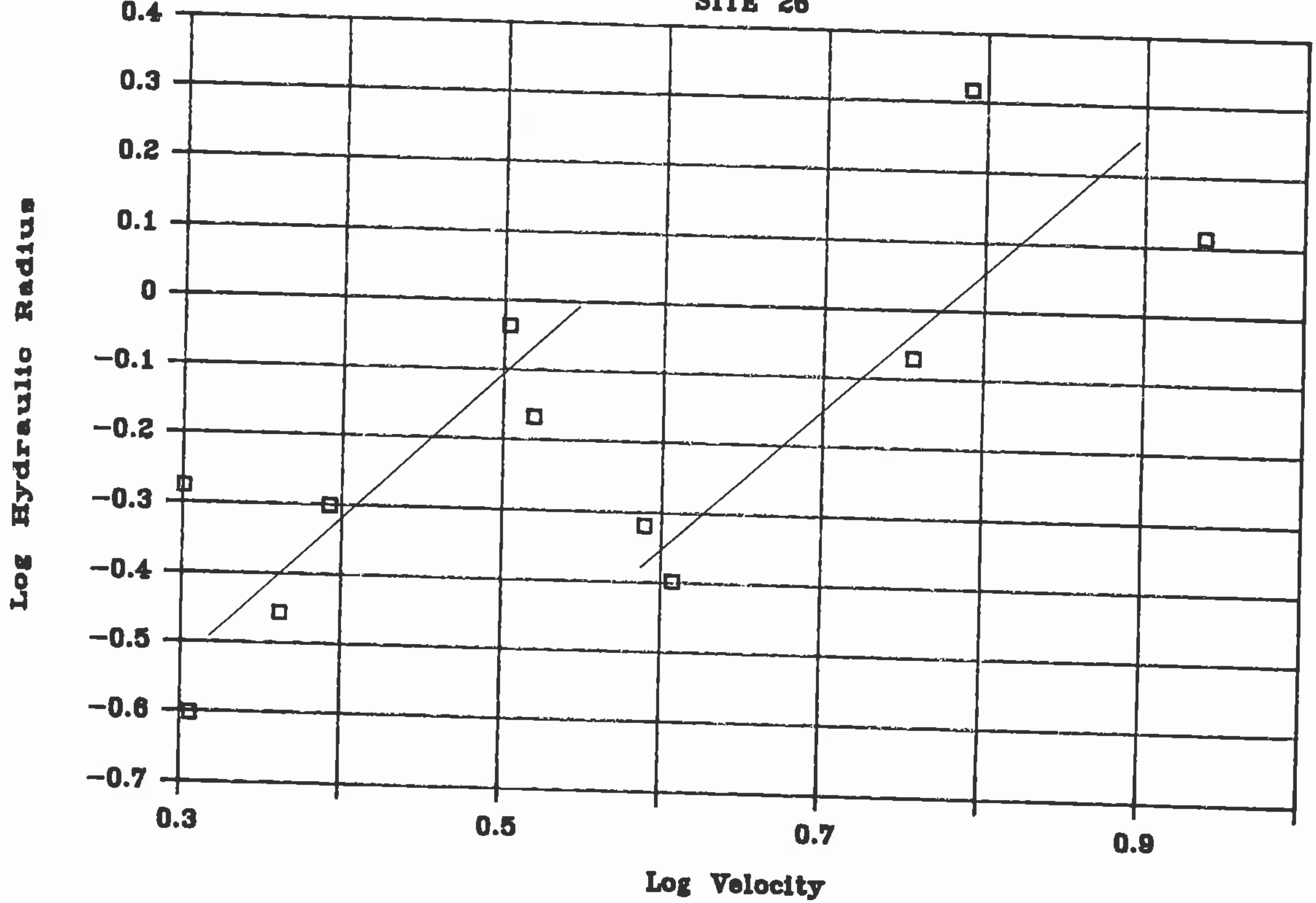


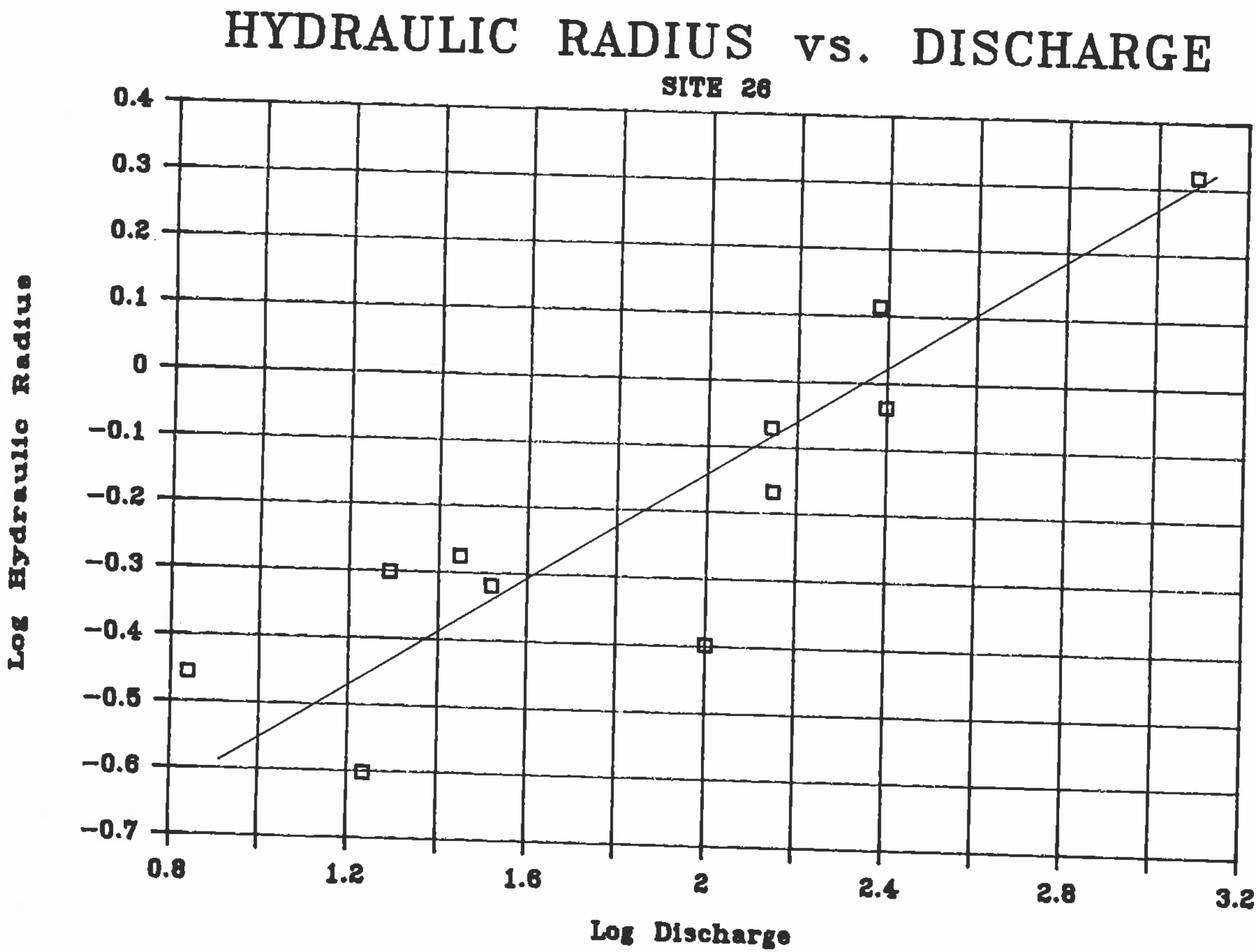

VELOCITY vs. DISCHARGE
SITE 16
Log Velocity
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0.6
1
1.4
1.8
2.2
2.6
3
3.4
Log Discharge

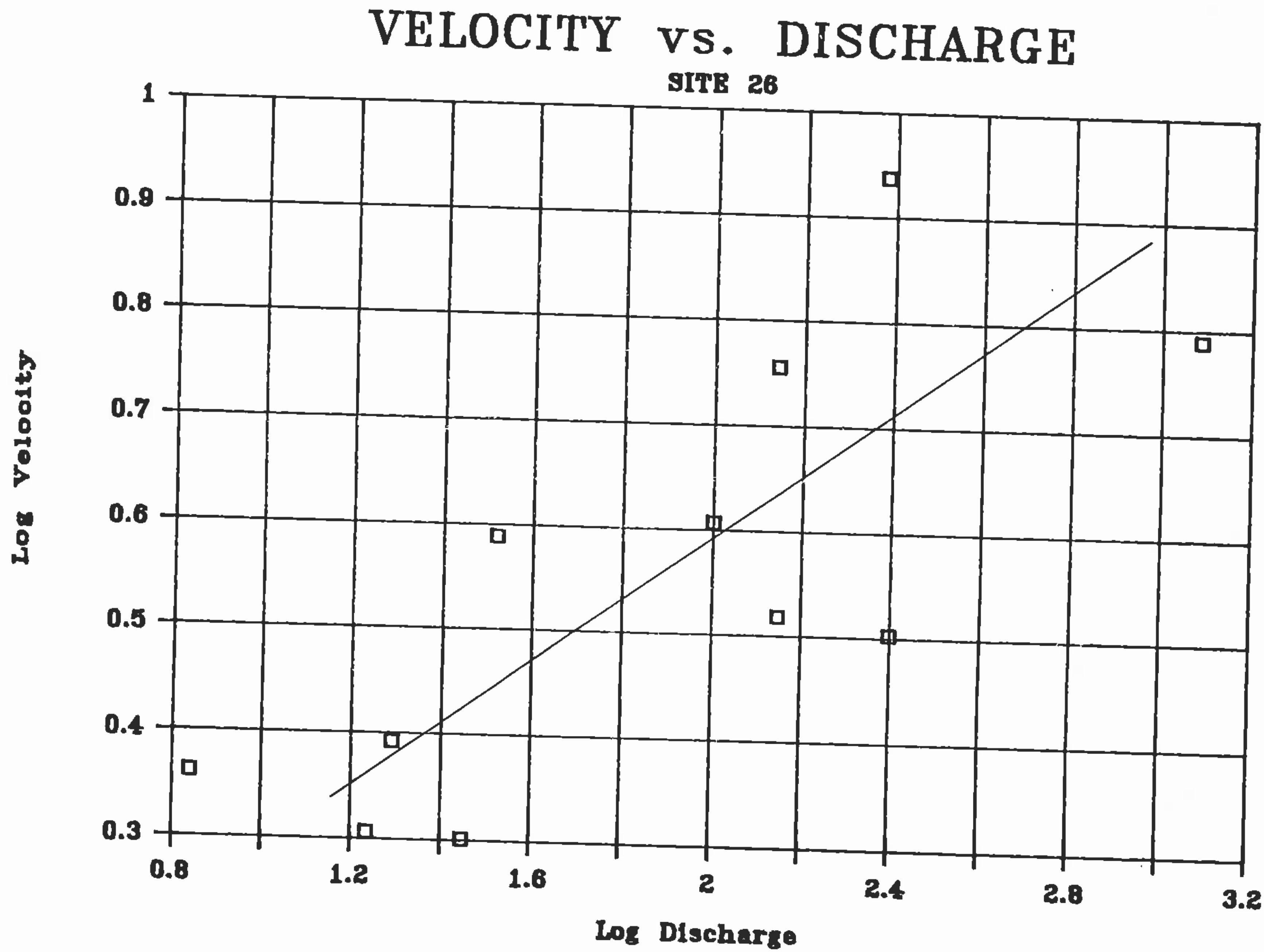

VELOCITY vs. DISCHARGE
SITE 25
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Log Velocity
0.6
1
1.4
1.8
2.2
2.6
3
3.4
3.8
Log Discharge

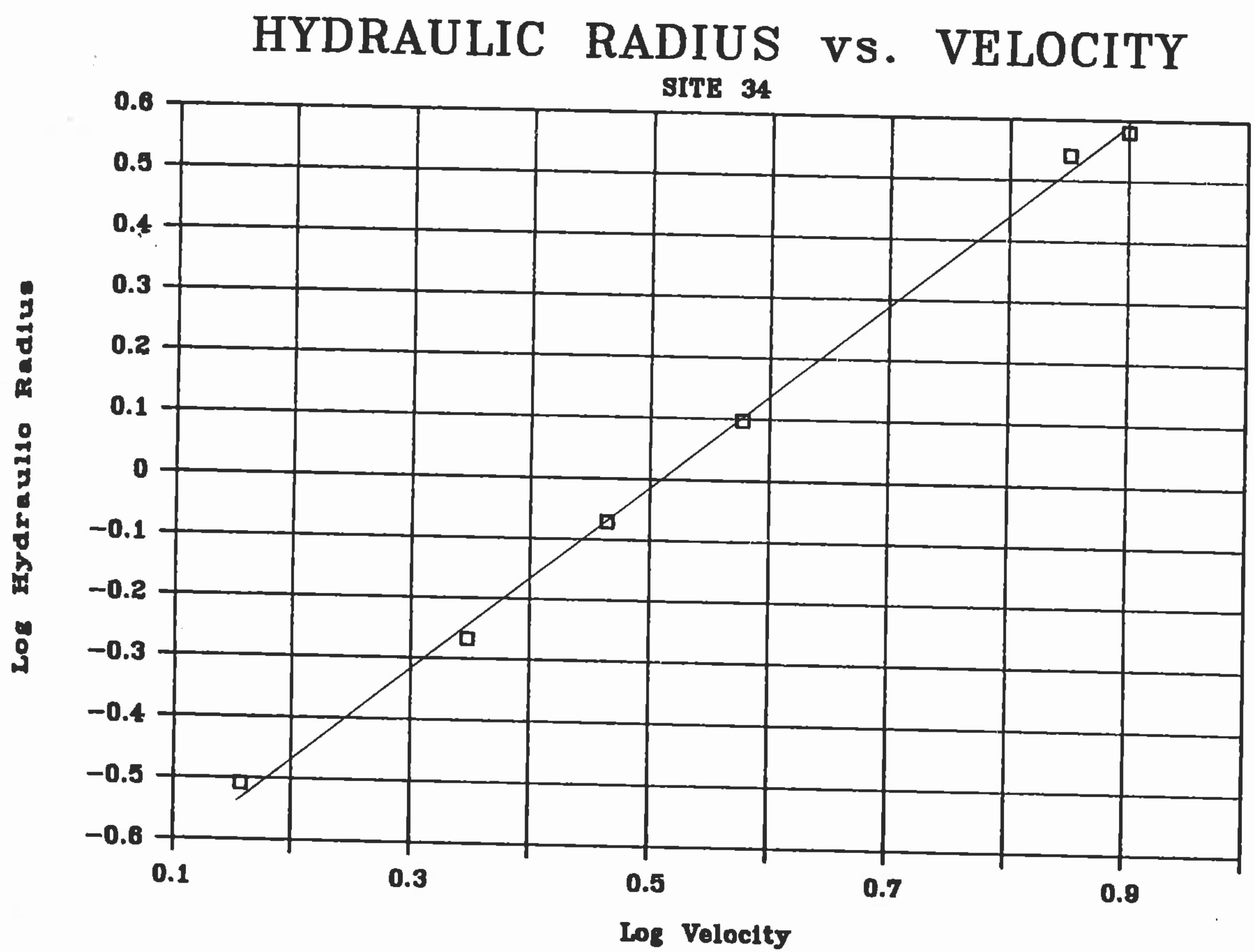
HYDRAULIC RADIUS vs. VELOCITY

SITE 26




HYDRAULIC RADIUS vs. DISCHARGE
SITE 26
Log Hydraulic Radius
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0.8
1.2
1.6
2
2.4
2.8
3.2
Log Discharge

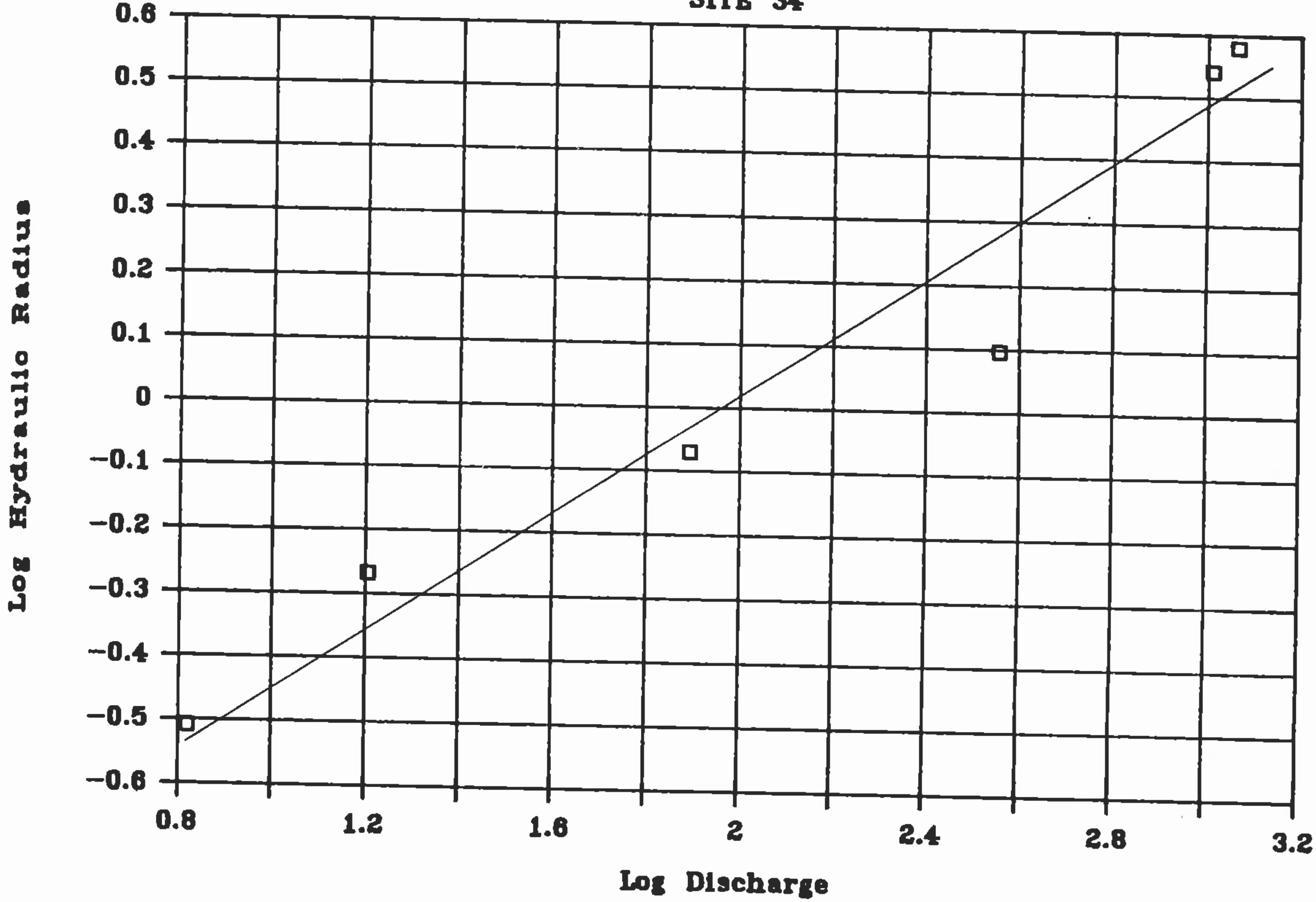

VELOCITY vs. DISCHARGE
SITE 26
Log Velocity
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.8
1.2
1.6
2
2.4
2.8
3.2
Log Discharge



HYDRAULIC RADIUS vs. VELOCITY
SITE 34
Log Hydraulic Radius
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
0.1
0.3
0.5
0.7
0.9
Log Velocity

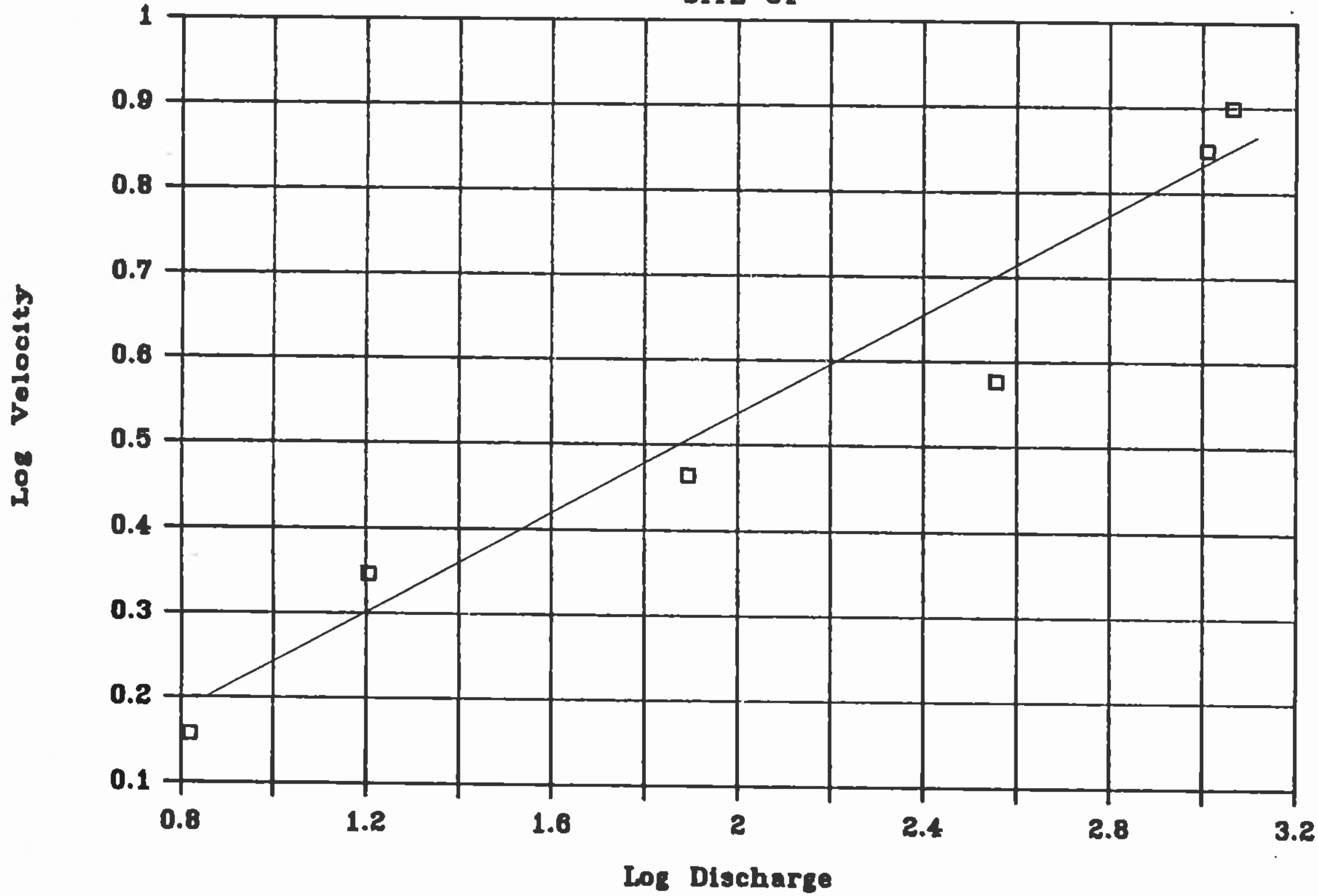
HYDRAULIC RADIUS vs. DISCHARGE

SITE 34



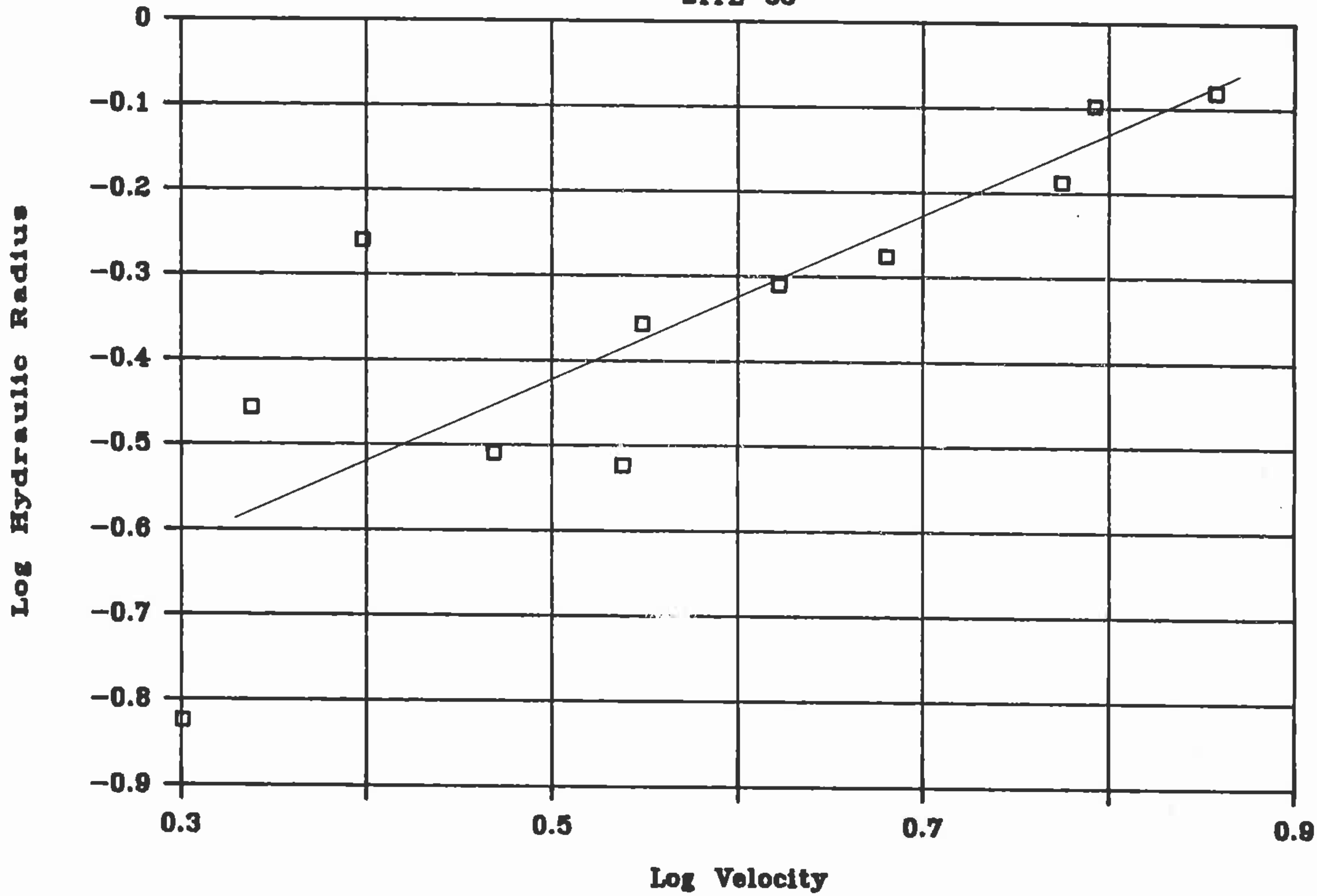
VELOCITY vs. DISCHARGE

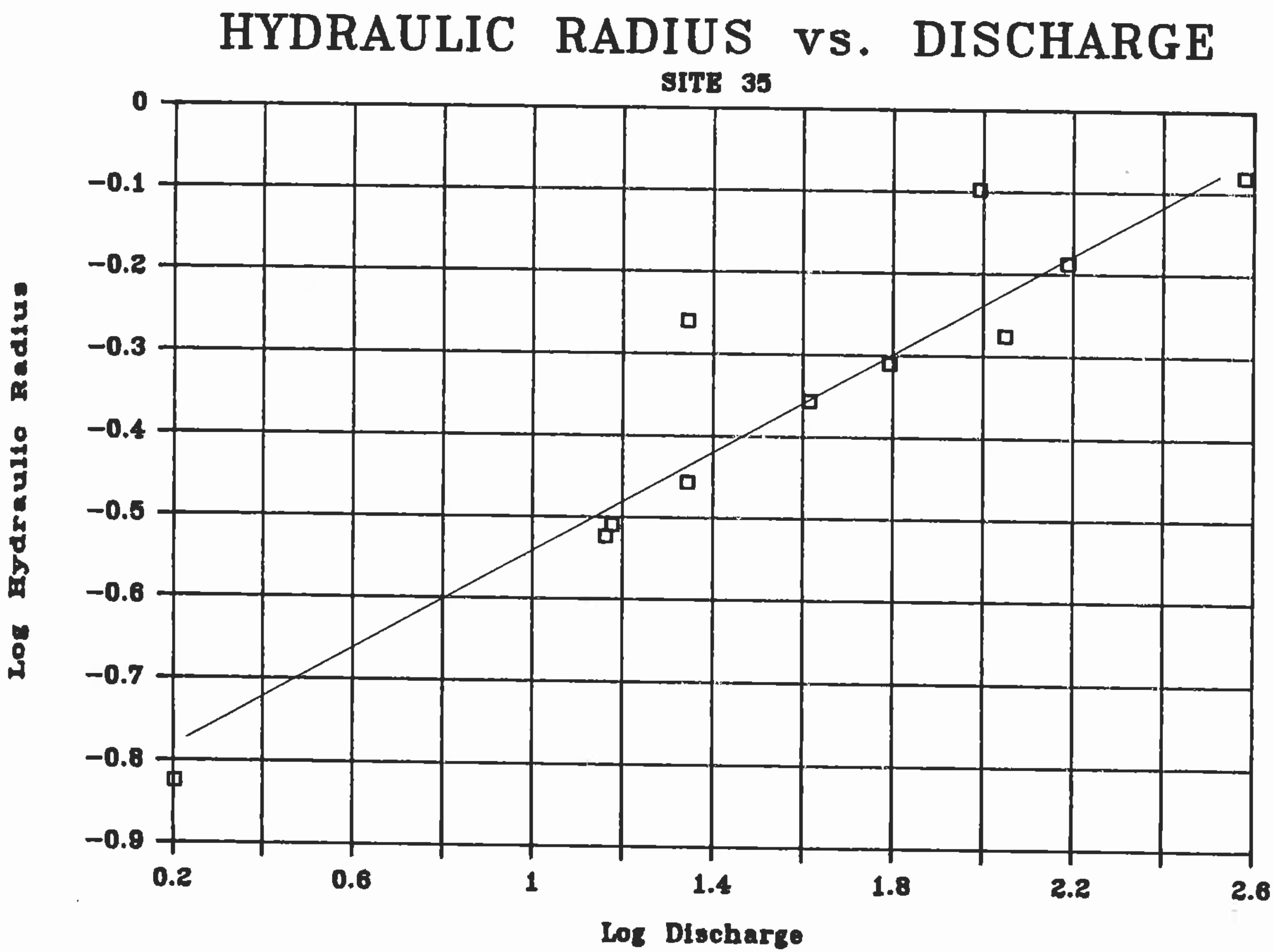
SITE 34



HYDRAULIC RADIUS vs. VELOCITY

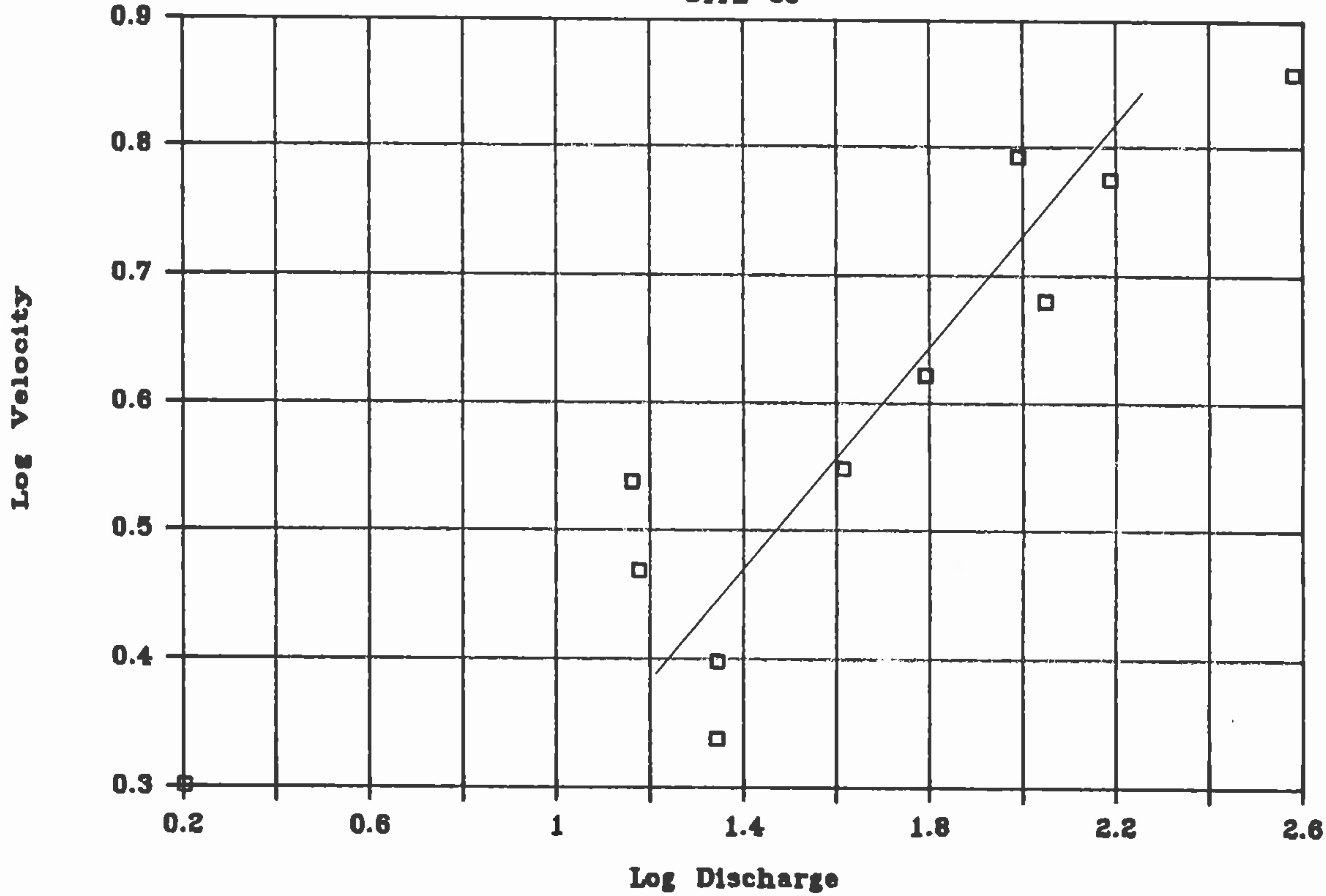
SITE 35

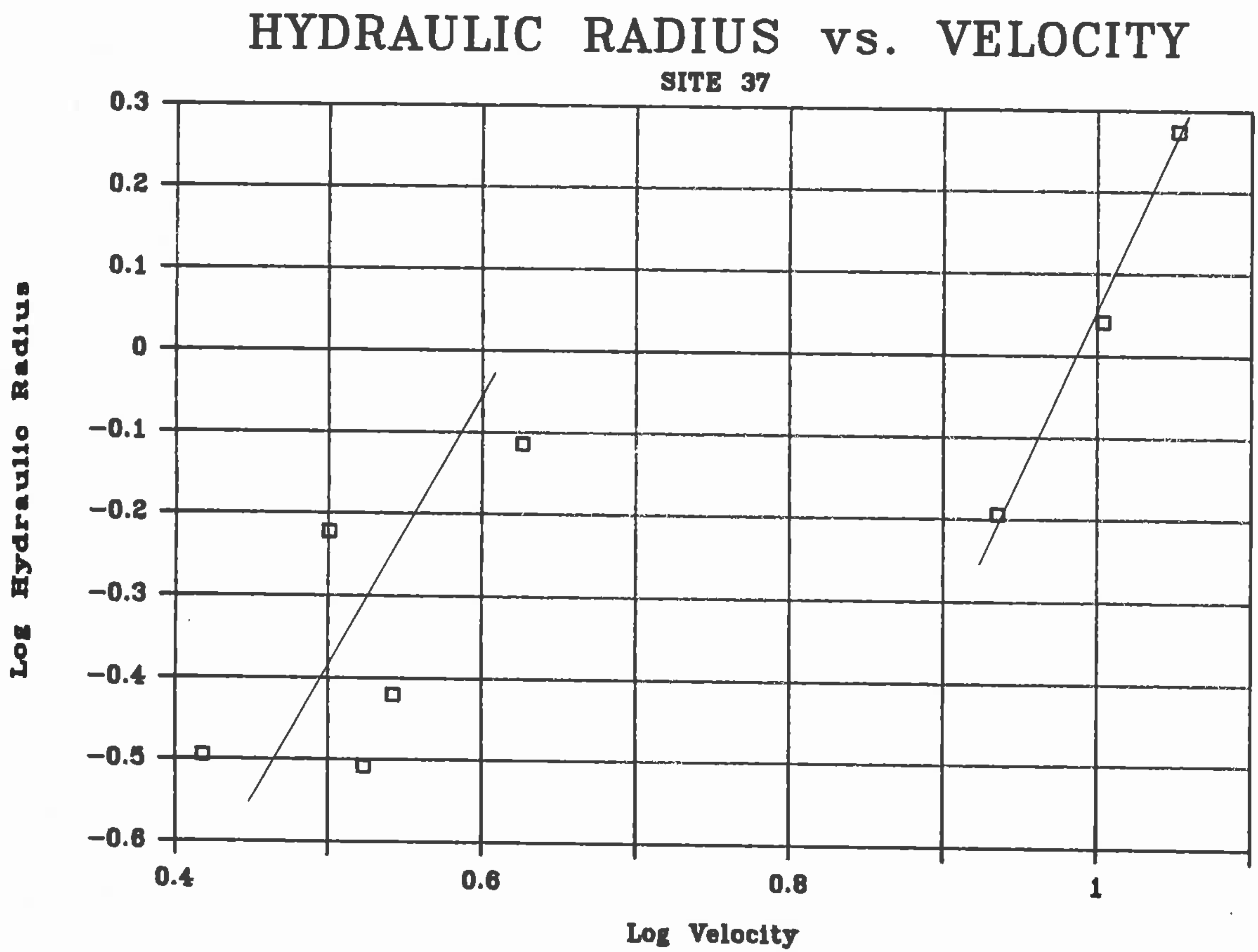


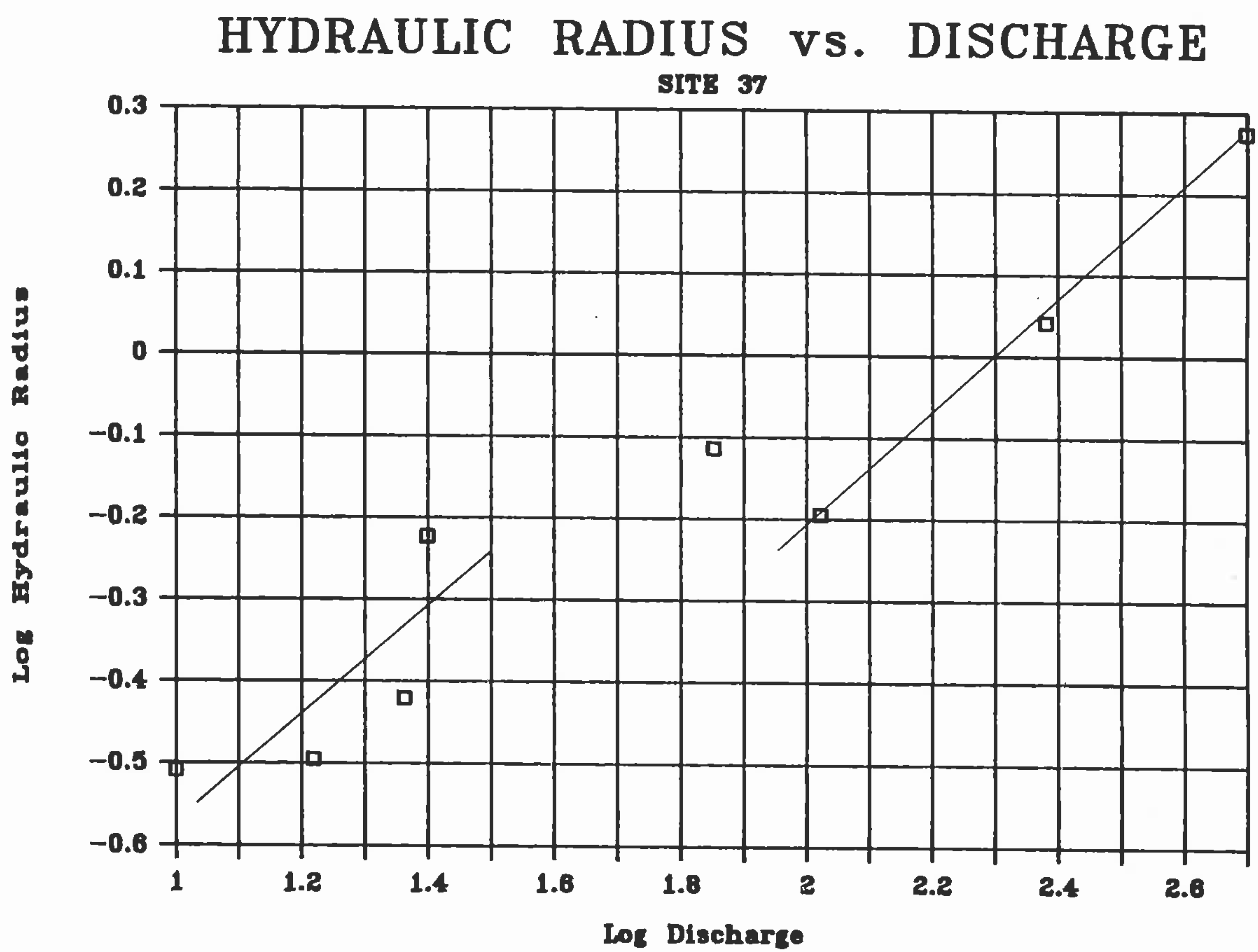

HYDRAULIC RADIUS vs. DISCHARGE
SITE 35
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
Log Hydraulic Radius
0.2
0.6
1
1.4
1.8
2.2
2.6
Log Discharge

VELOCITY vs. DISCHARGE

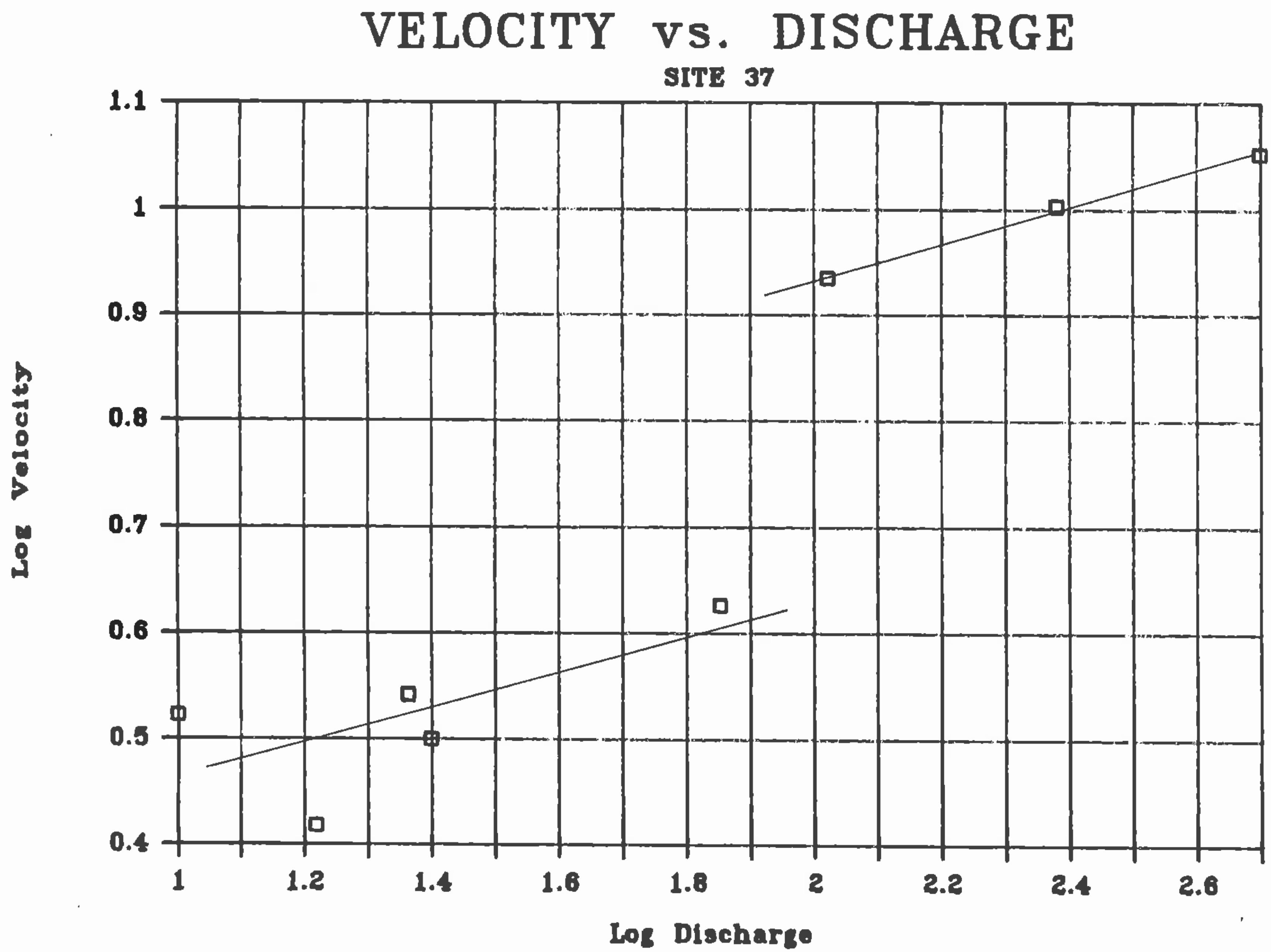
SITE 35

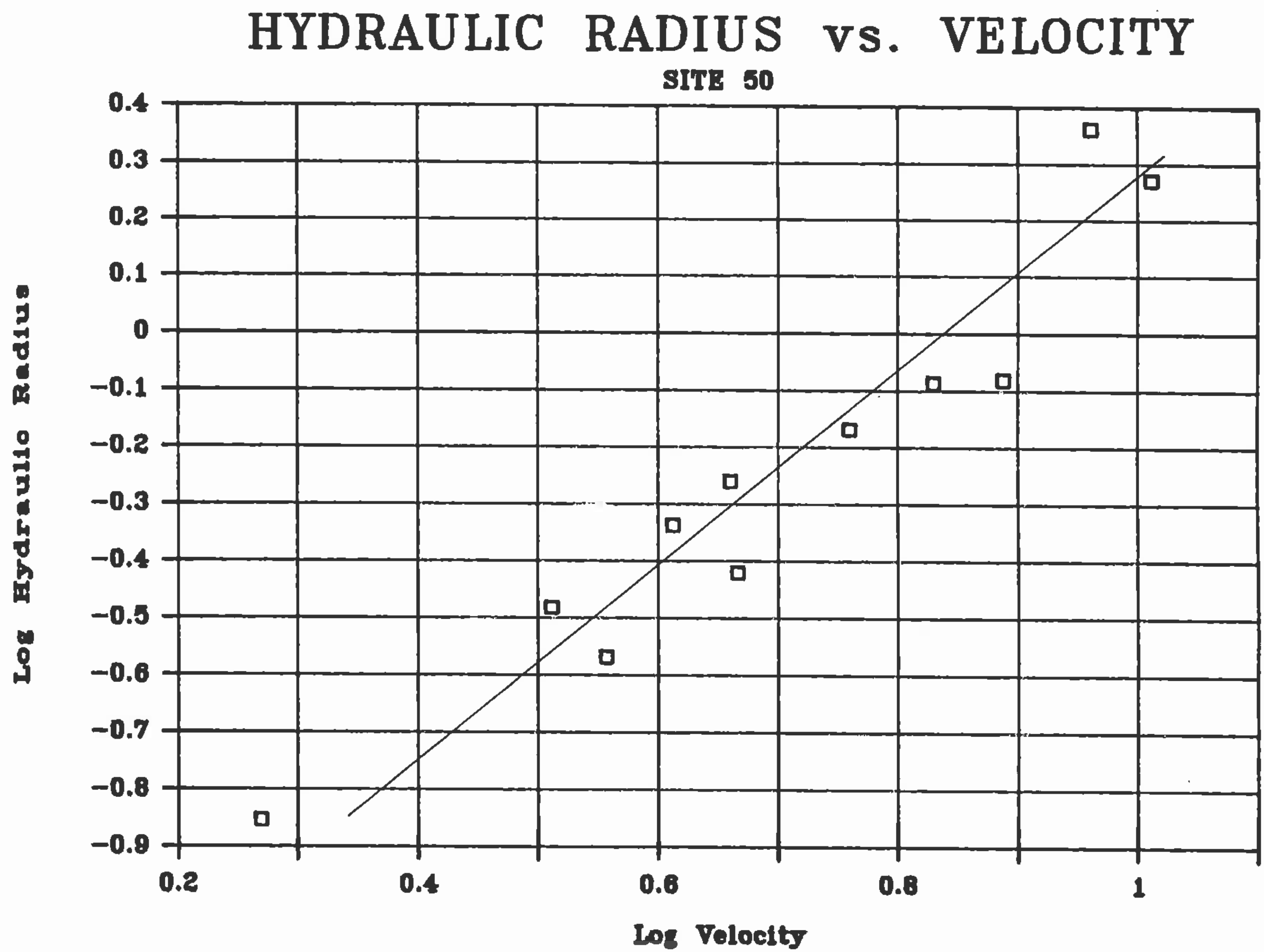



HYDRAULIC RADIUS vs. VELOCITY
SITE 37
Log Hydraulic Radius
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0.4
0.6
0.8
1
Log Velocity



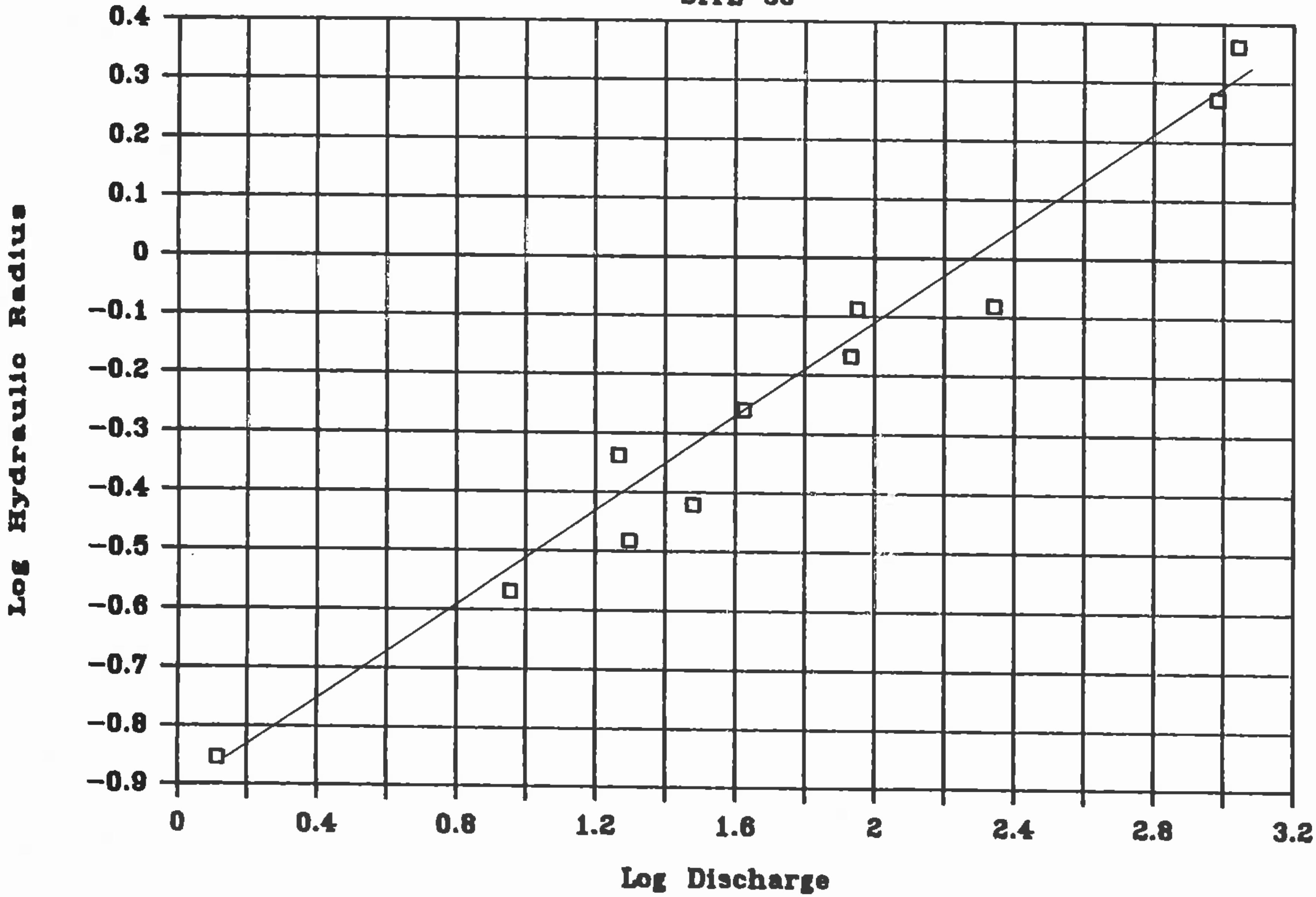
HYDRAULIC RADIUS vs. DISCHARGE
SITE 37
Log Hydraulic Radius
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
Log Discharge

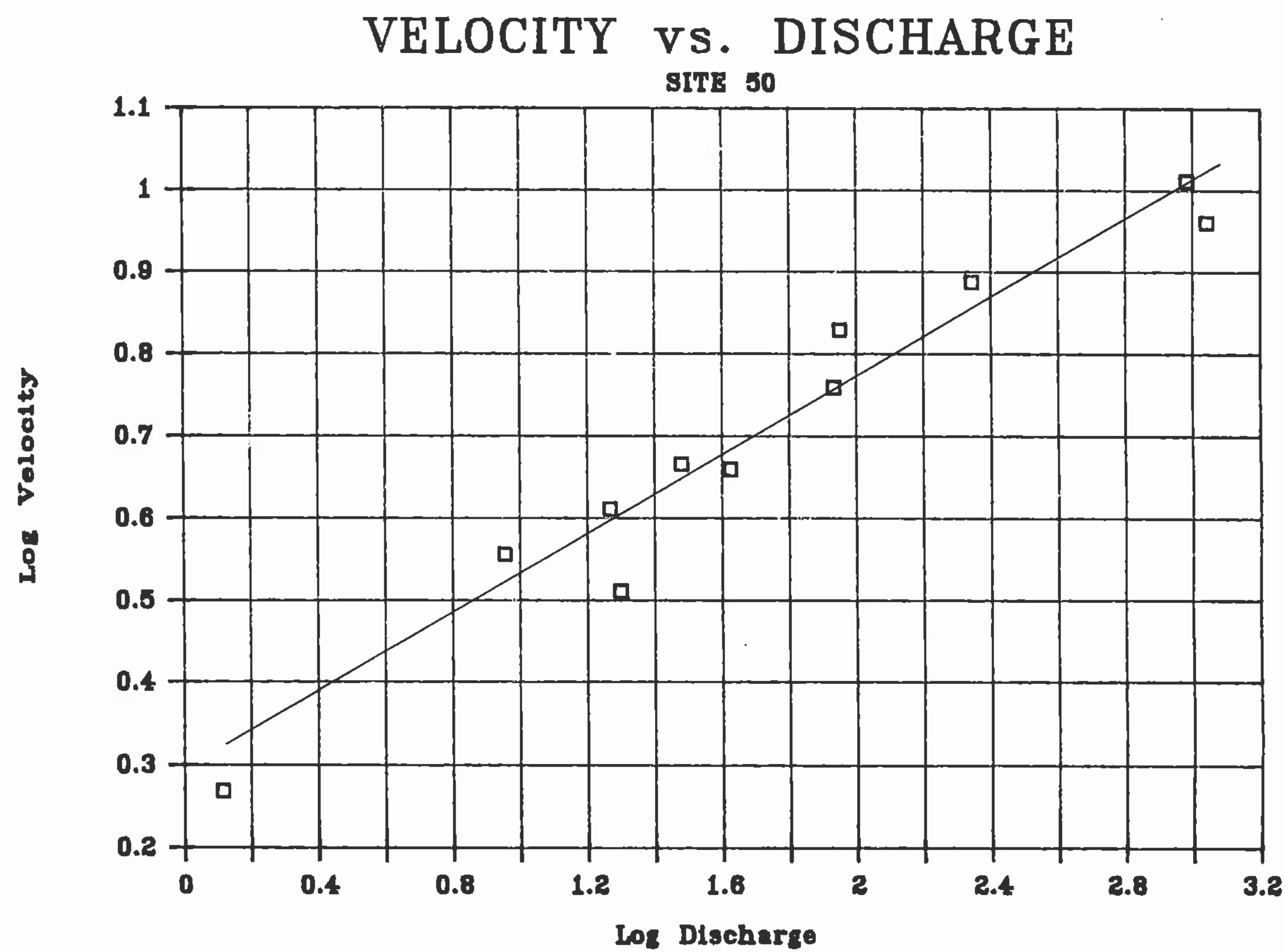

VELOCITY vs. DISCHARGE
SITE 37
Log Velocity
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
Log Discharge

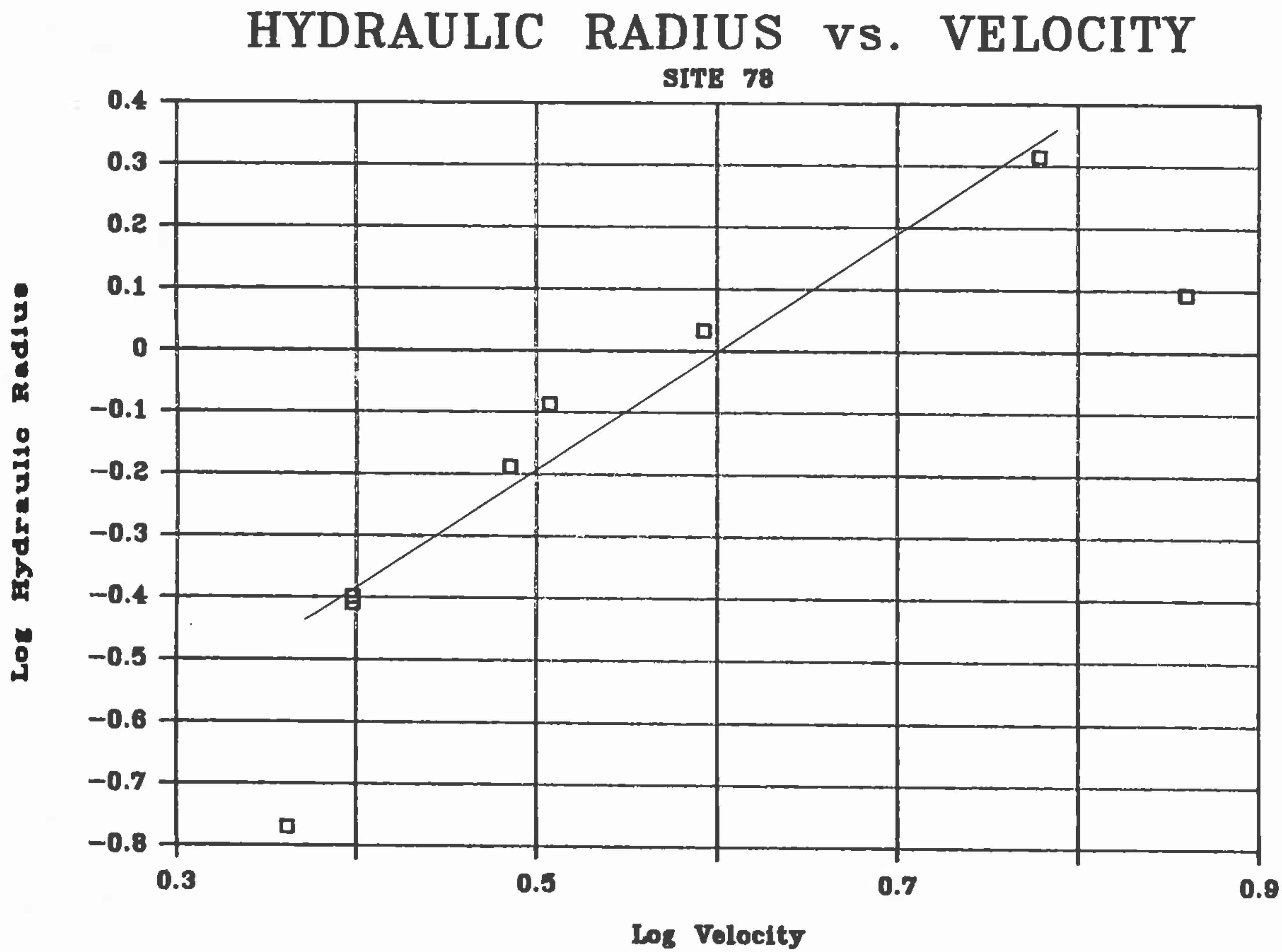

HYDRAULIC RADIUS vs. VELOCITY
SITE 50
Log Hydraulic Radius
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
0.2
0.4
0.6
0.8
1
Log Velocity

HYDRAULIC RADIUS vs. DISCHARGE

SITE 50



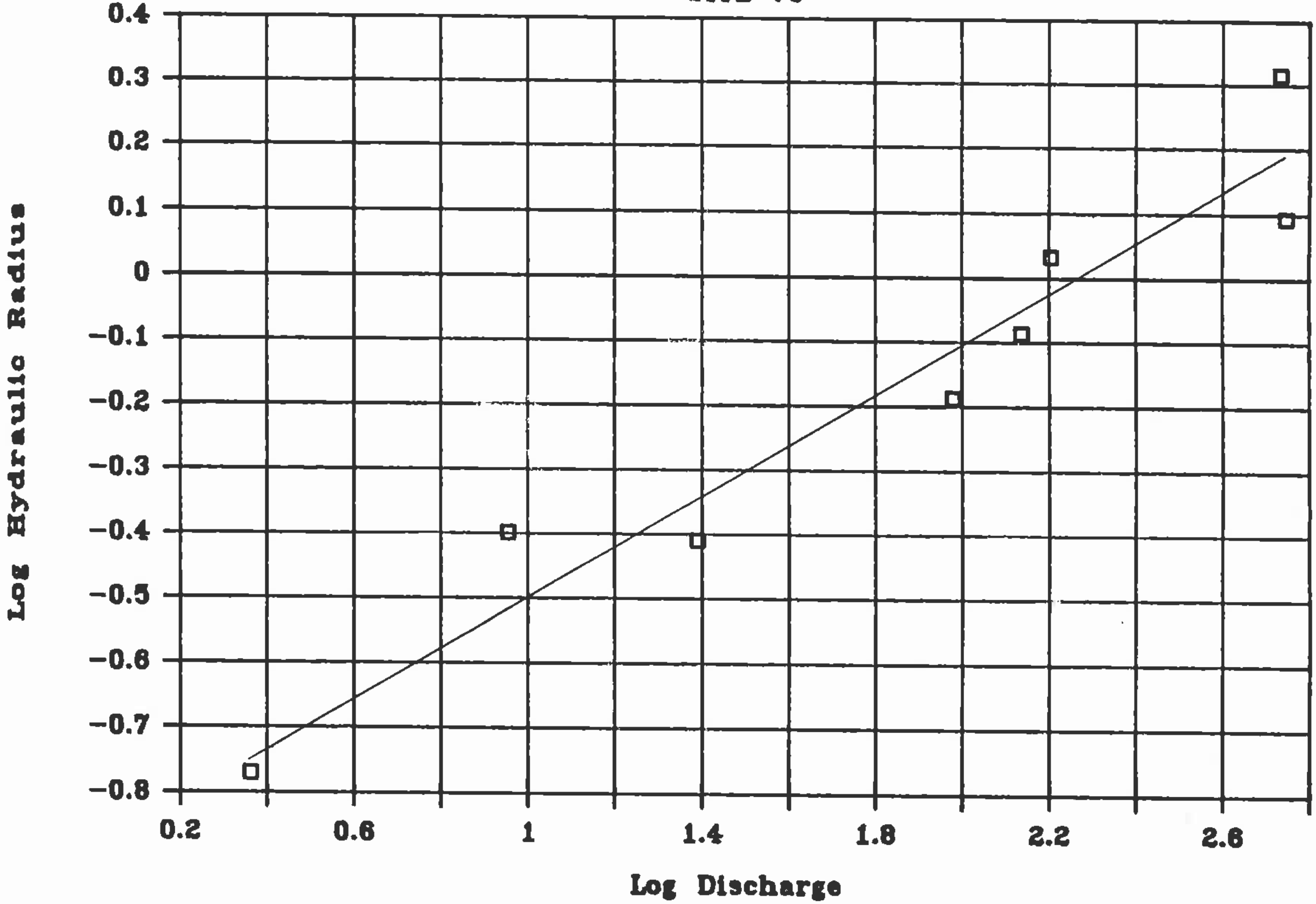

VELOCITY vs. DISCHARGE
SITE 50
Log Velocity
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
Log Discharge

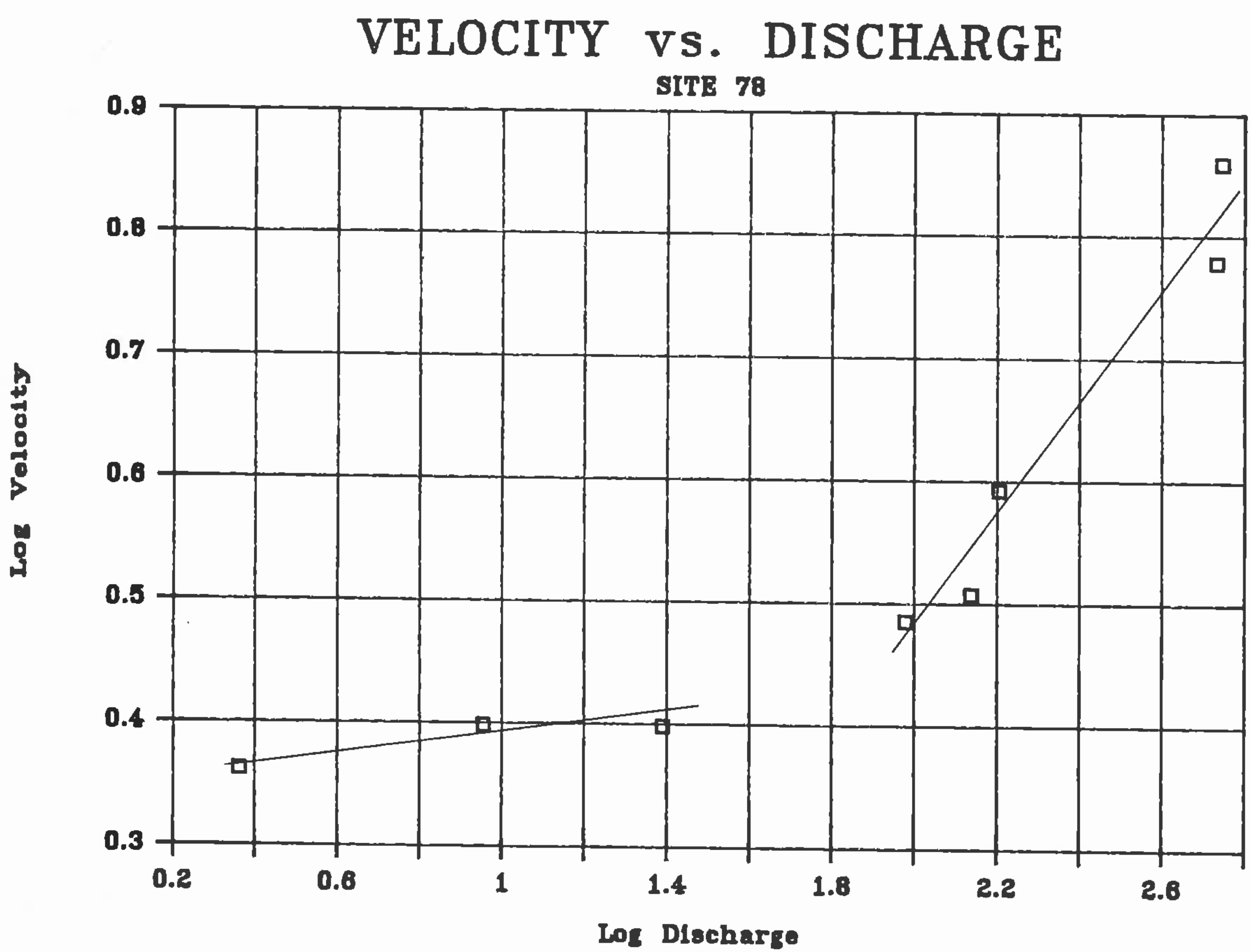


HYDRAULIC RADIUS vs. VELOCITY
SITE 78
Log Hydraulic Radius
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
0.3
0.5
0.7
0.9
Log Velocity

HYDRAULIC RADIUS vs. DISCHARGE

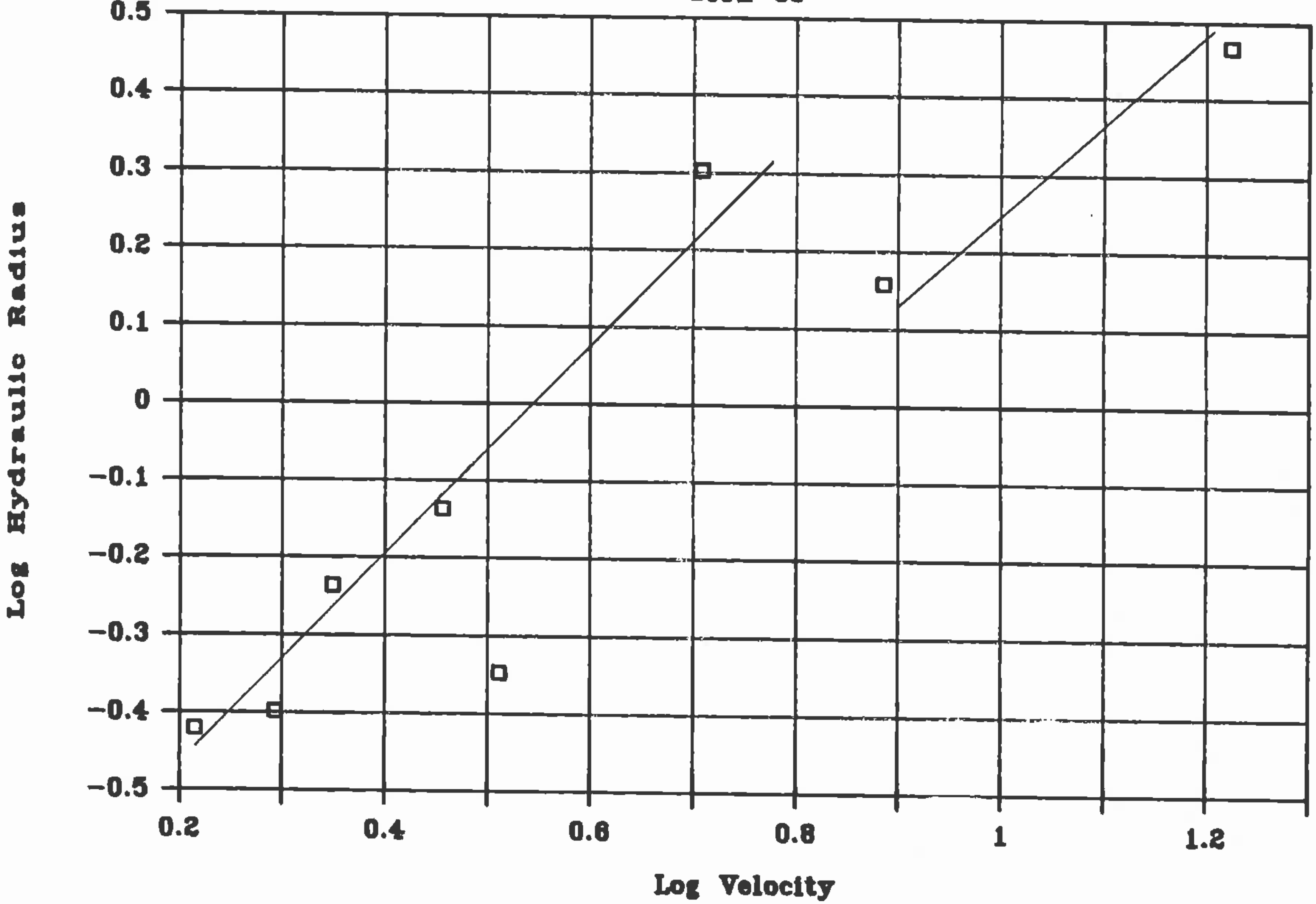
SITE 78




VELOCITY vs. DISCHARGE
SITE 78
Log Velocity
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.6
1
1.4
1.8
2.2
2.6
Log Discharge

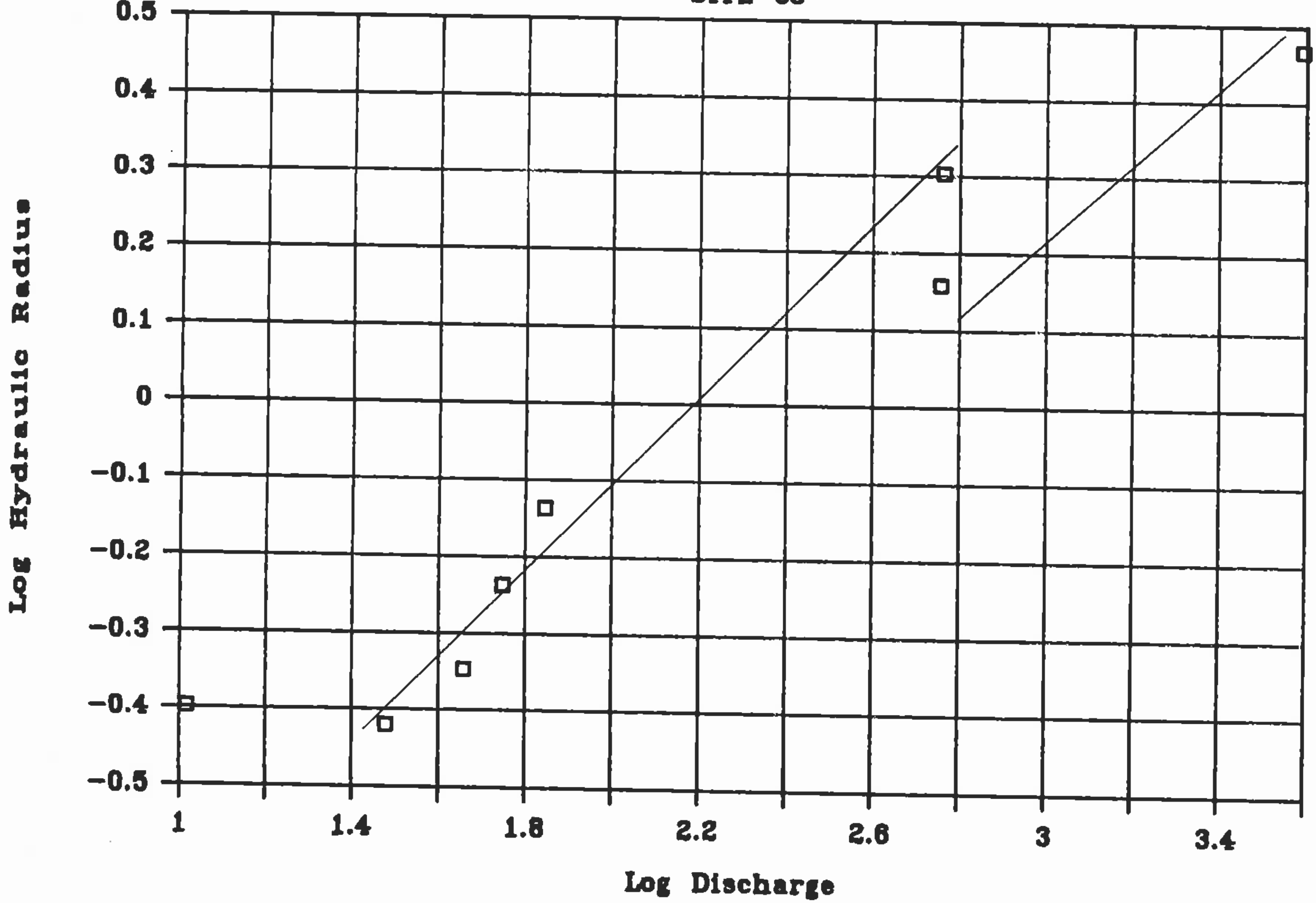
HYDRAULIC RADIUS vs. VELOCITY

SITE 85



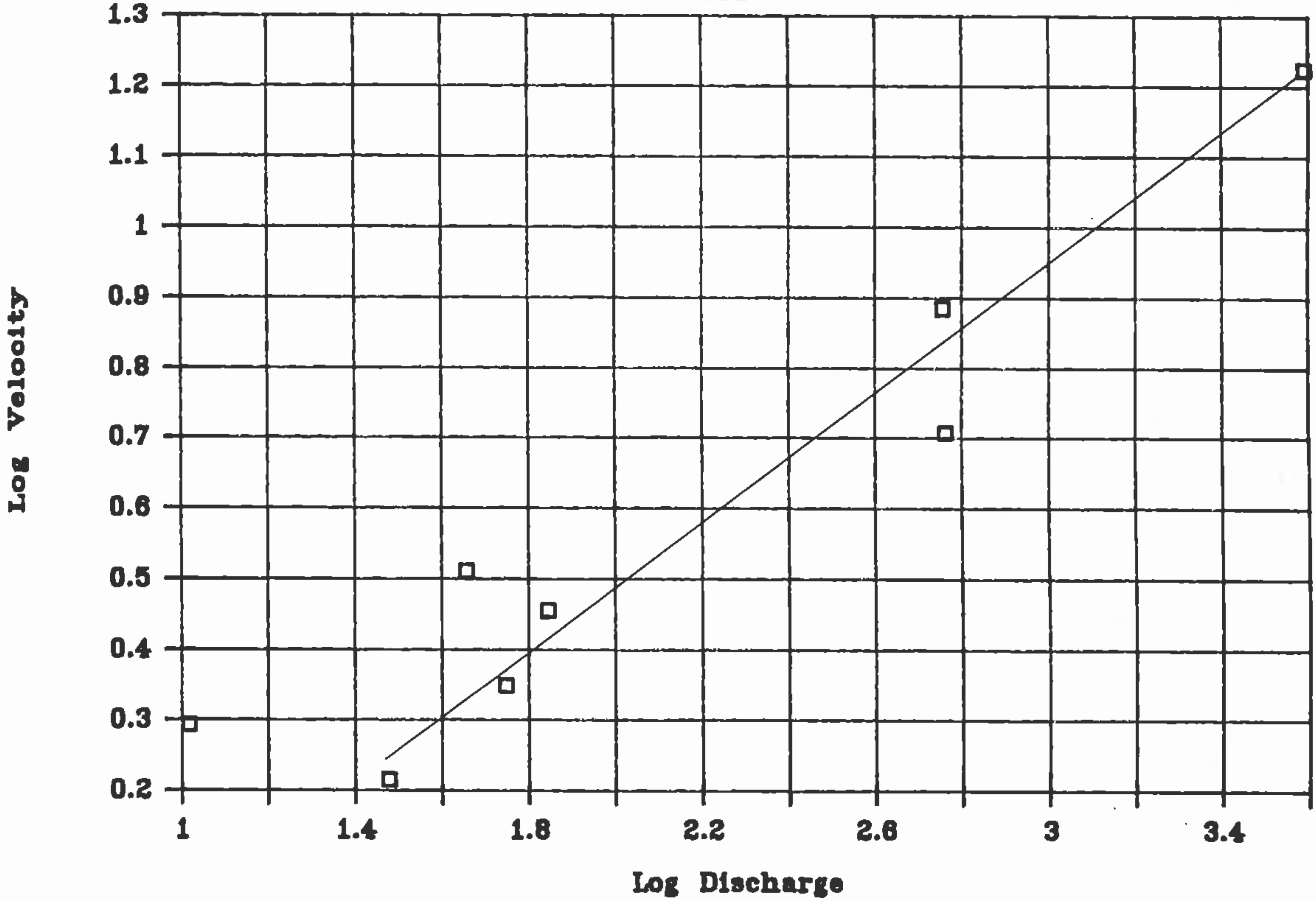
HYDRAULIC RADIUS vs. DISCHARGE

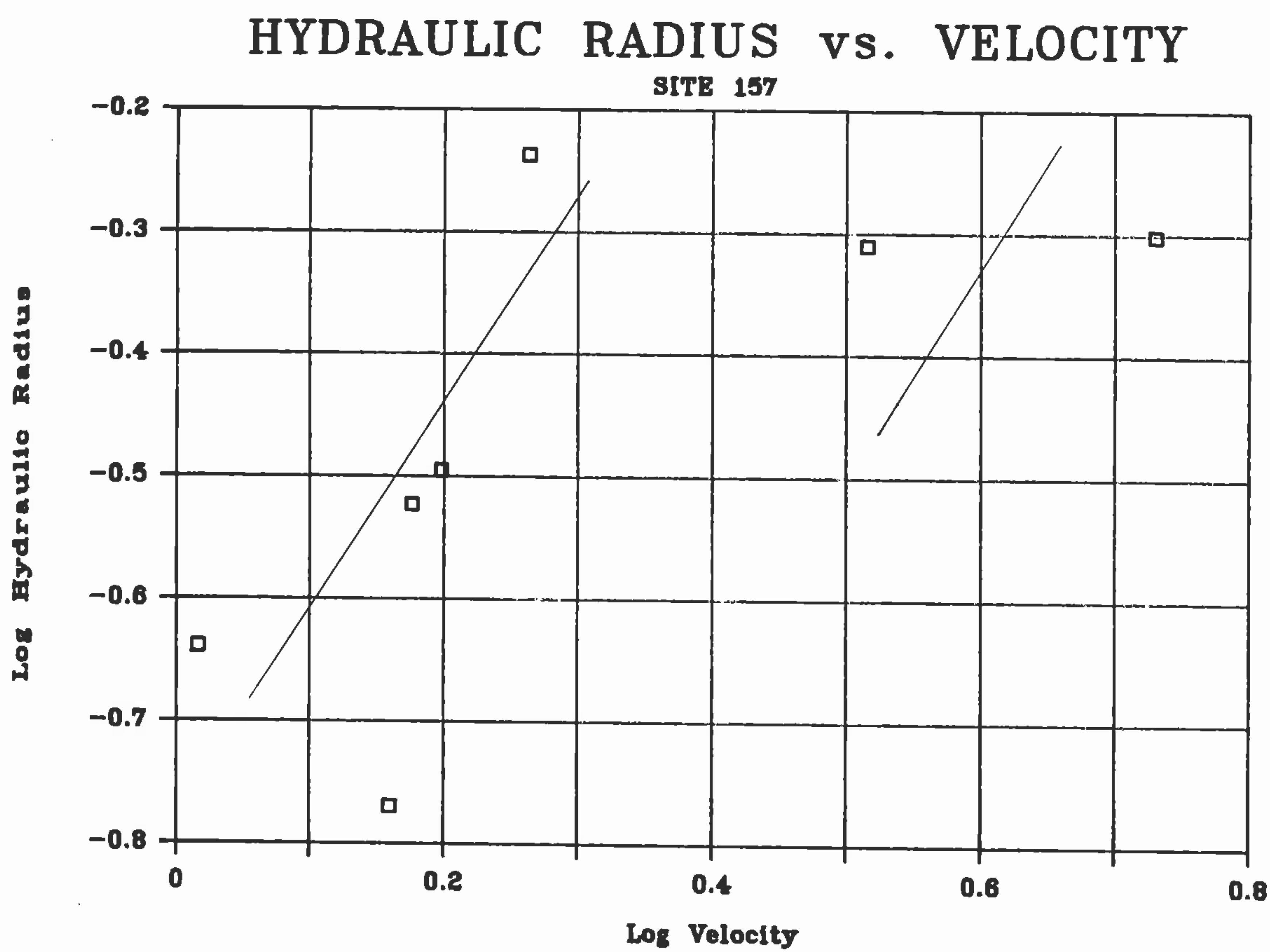
SITE 85



VELOCITY vs. DISCHARGE

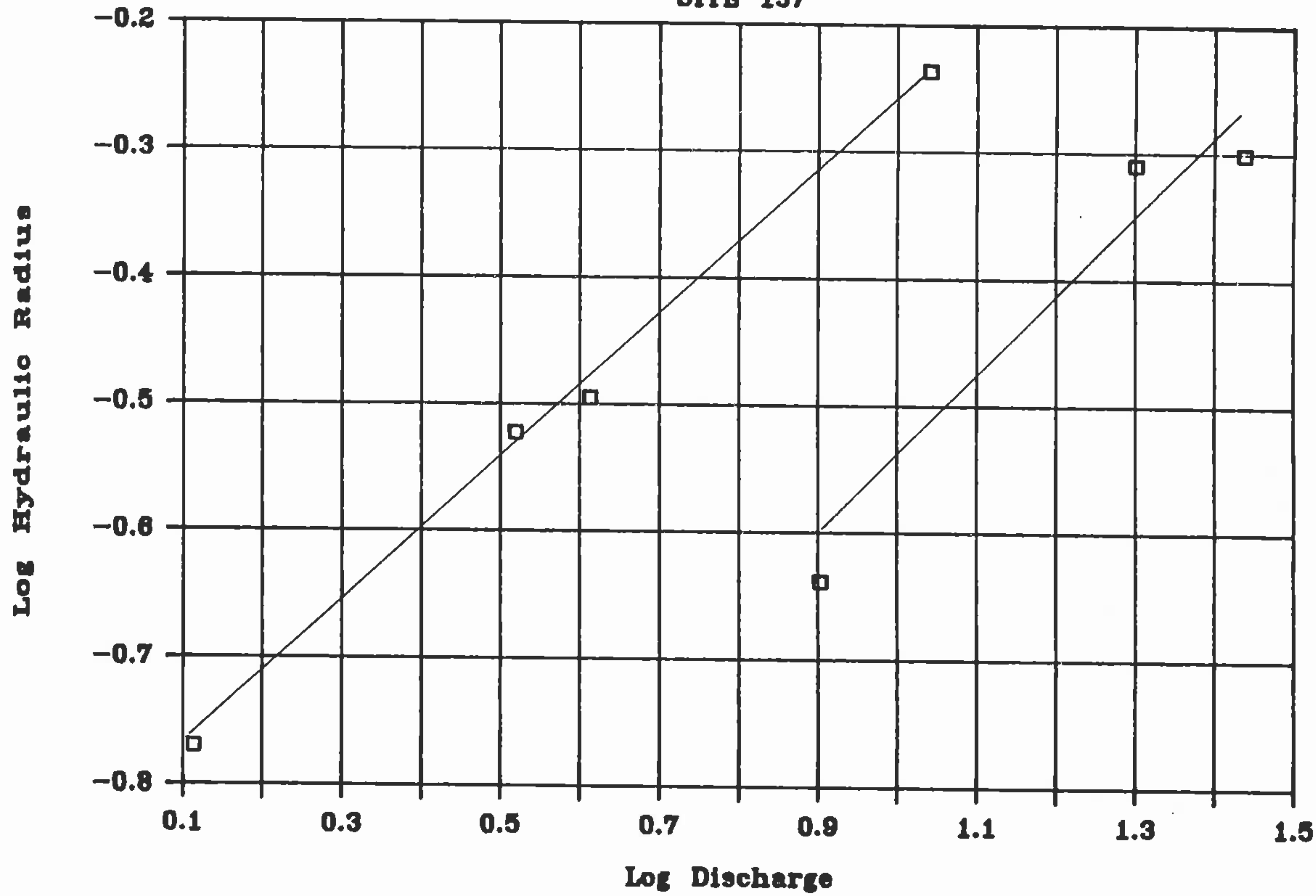
SITE 85




HYDRAULIC RADIUS vs. VELOCITY
SITE 157
Log Hydraulic Radius
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
0
0.2
0.4
0.6
0.8
Log Velocity

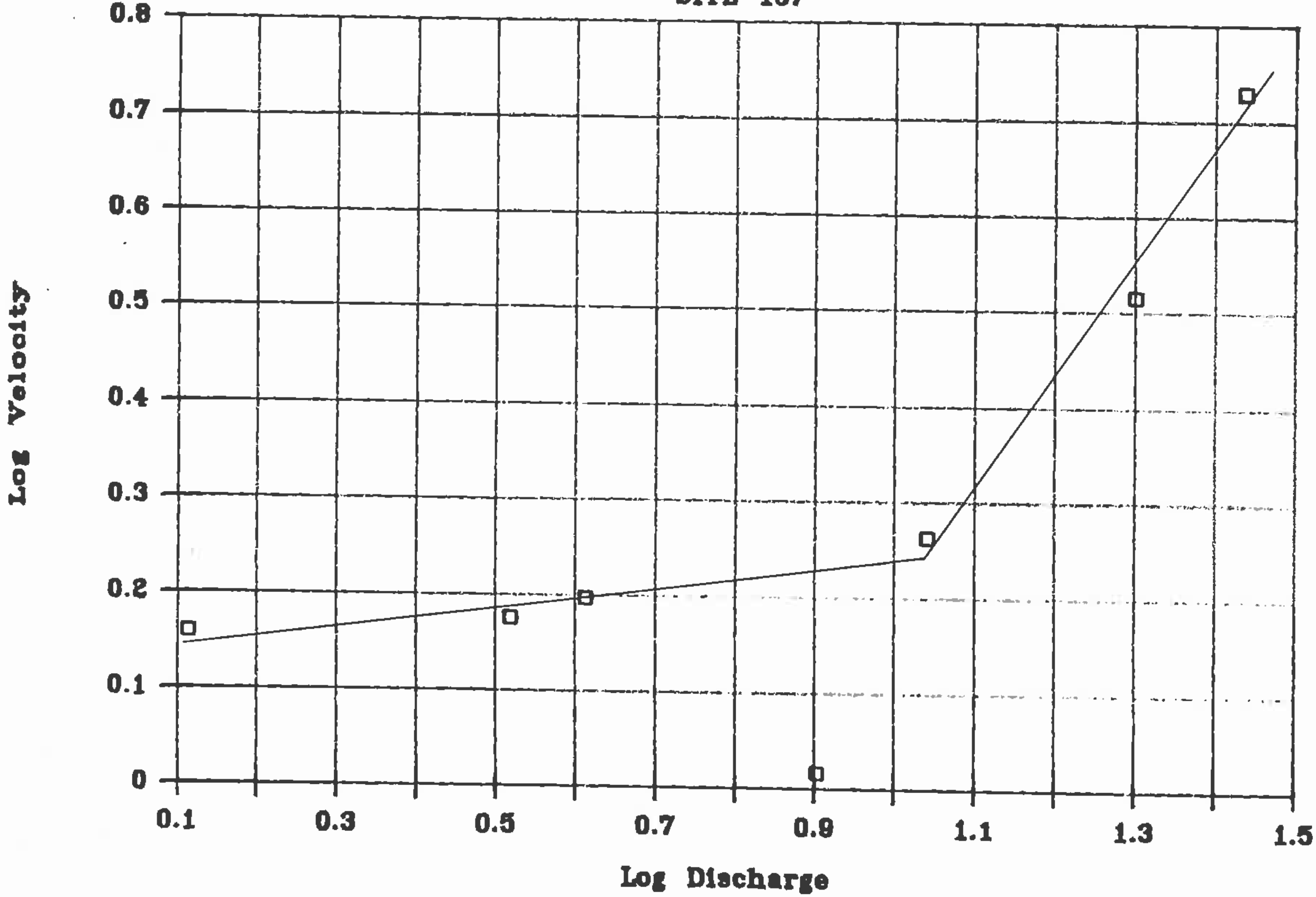
HYDRAULIC RADIUS vs. DISCHARGE

SITE 157



VELOCITY vs. DISCHARGE

SITE 157



ATTACHMENT 4

Suspended Sediment Concentrations and Discharges
For Moenkopi Wash at Moenkopi, Arizona (USGS 1974-1980)

Table 3.--Stream and suspended-sediment discharge, water years 1974-76, for gaging station 09401260, Moenkopi Wash at Moenkopi, Arizona

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DAY	OCTOBER MEAN DISCHARGE (CFS)	OCTOBER MEAN CONCEN-TRATION (MG/L)	OCTOBER SEDIMENT DISCHARGE (TONS/DAY)	NOVEMBER MEAN DISCHARGE (CFS)	NOVEMBER MEAN CONCEN-TRATION (MG/L)	NOVEMBER SEDIMENT DISCHARGE (TONS/DAY)	DECEMBER MEAN DISCHARGE (CFS)	DECEMBER MEAN CONCEN-TRATION (MG/L)	DECEMBER SEDIMENT DISCHARGE (TONS/DAY)
1	1.0	400	1.1	1.8	363	1.8	2.7	1330	9.7
2	.90	390	.95	1.8	744	3.6	3.0	1370	11
3	.80	364	.79	1.6	288	1.2	2.7	581	4.2
4	.70	400	.76	1.6	315	1.4	2.8	856	6.5
5	.70	599	1.1	1.5	536	2.2	2.7	850	6.2
6	.70	600	1.1	1.5	934	3.8	1.9	825	4.2
7	.80	600	1.3	1.5	295	1.2	2.0	811	4.4
8	.90	600	1.5	1.5	286	1.2	2.5	1440	9.7
9	1.0	600	1.6	1.4	197	.74	2.7	918	6.7
10	1.1	600	1.8	1.4	294	1.1	2.4	1190	7.7
11	1.2	588	1.9	1.5	623	2.5	2.7	889	6.5
12	1.2	370	1.2	1.5	273	1.1	2.5	822	5.5
13	1.1	133	.40	1.5	263	1.1	2.4	1040	6.7
14	1.0	292	.79	1.3	257	.90	2.5	1060	7.2
15	1.0	251	.68	1.2	255	.83	1.5	628	2.5
16	.90	251	.61	1.3	773	2.7	1.6	794	3.4
17	.90	278	.68	1.3	445	1.6	1.9	957	4.9
18	1.0	283	.76	1.3	336	1.2	2.2	928	5.5
19	1.1	263	.78	2.2	1320	7.8	2.0	971	5.2
20	1.2	245	.79	2.2	1740	10	1.1	554	1.6
21	1.3	244	.86	2.0	1040	5.6	1.1	453	1.3
22	1.4	230	.87	1.9	504	2.6	1.6	447	1.9
23	1.4	237	.90	2.7	547	4.0	2.0	623	3.4
24	1.4	228	.86	2.0	1320	7.1	1.5	778	3.2
25	1.3	235	.82	1.9	730	3.7	1.6	450	1.9
26	1.4	278	1.1	1.9	654	3.4	1.5	422	1.7
27	1.4	304	1.1	1.4	544	2.1	1.8	473	2.3
28	1.4	623	2.4	1.3	722	2.5	2.4	967	6.3
29	1.4	283	1.1	1.4	445	1.7	3.5	966	9.1
30	1.8	366	1.8	2.0	1010	5.4	3.9	1850	19
31	1.6	496	2.4	---	---	---	.86	790	1.8
TOTAL	35.20	---	34.80	49.4	---	86.07	67.56	---	171.2

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

DAY	JANUARY MEAN DISCHARGE (CFS)	JANUARY MEAN CONCEN-TRATION (MG/L)	JANUARY SEDIMENT DISCHARGE (TONS/DAY)	FEBRUARY MEAN DISCHARGE (CFS)	FEBRUARY MEAN CONCEN-TRATION (MG/L)	FEBRUARY SEDIMENT DISCHARGE (TONS/DAY)	MARCH MEAN DISCHARGE (CFS)	MARCH MEAN CONCEN-TRATION (MG/L)	MARCH SEDIMENT DISCHARGE (TONS/DAY)
1	1.3	256	.90	3.0	846	6.9	16	30700	2260
2	1.8	482	2.3	3.0	936	7.6	53	81900	12300
3	2.4	506	3.3	2.3	962	6.0	54	58300	7900
4	3.7	519	5.2	2.8	749	5.7	24	25400	1650
5	3.0	363	2.9	3.0	821	6.6	6.9	18000	335
6	2.8	394	3.0	2.4	660	4.3	3.9	5700	60
7	3.9	960	10	2.3	660	4.1	2.2	3420	20
8	3.0	964	7.8	2.4	749	4.8	1.9	1410	7.2
9	3.0	1740	14	2.7	1130	8.2	2.2	1410	6.4
10	3.0	1640	15	3.2	1110	9.6	2.8	1420	11
11	3.0	1820	15	3.7	1900	19	2.7	1860	14
12	3.0	1800	15	3.7	1430	14	2.8	1450	11
13	3.9	823	8.7	3.0	996	8.1	2.8	1310	9.9
14	3.5	820	7.7	3.0	981	7.9	2.8	1260	9.5
15	3.5	863	8.2	3.9	1070	11	2.7	926	6.8
16	3.7	787	7.9	3.9	966	10	2.4	750	4.9
17	4.1	913	10	3.7	770	6.7	2.0	696	3.8
18	3.9	897	9.4	4.1	751	8.3	1.9	554	2.8
19	3.9	902	9.5	3.9	786	8.3	1.8	476	2.3
20	4.1	972	11	2.8	706	5.3	2.0	538	2.9
21	3.7	803	8.0	2.7	571	4.2	2.0	489	2.6
22	2.7	885	6.5	3.5	567	5.4	1.8	548	2.7
23	2.4	775	5.0	2.7	542	4.0	1.8	413	2.0
24	2.4	810	5.2	2.0	719	3.9	1.8	413	2.0
25	3.0	880	7.1	2.2	691	4.1	1.8	360	1.7
26	3.0	1220	9.9	2.8	452	5.4	1.8	378	1.8
27	3.0	858	6.9	2.7	664	4.8	1.8	316	1.5
28	3.0	749	6.1	2.4	660	3.8	1.8	453	2.2
29	2.8	1020	7.7	---	---	---	1.8	382	1.9
30	2.1	953	5.4	---	---	---	1.6	449	1.9
31	3.0	1900	15	---	---	---	1.4	311	1.2
TOTAL	95.6	---	249.60	83.3	---	195.3	210.2	---	24641.0

Table 3.--Stream and suspended-sediment discharge, water years 1974-76, for gaging station 09401260 Moenkopi Wash at Moenkopi, Arizona--Continued

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

	APRIL			MAY			JUNE		
DAY	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
1	1.4	398	1.5	1.3	226	.79			
2	2.2	1150	6.8	1.3	174	.61			
3	2.5	1460	9.9	1.1	172	.51			
4	2.0	540	2.9	.94	189	.48			
5	1.6	394	1.7	.94	225	.57			
6	1.8	423	2.1	.94	229	.58			
7	1.6	361	1.6	.86	185	.43			
8	1.4	337	1.3	.94	186	.47			
9	1.4	966	3.7	.86	198	.46			
10	1.3	494	1.7	.61	182	.30			
11	1.4	370	1.4	.57	164	.25			
12	1.4	802	3.0	.53	317	.45			
13	1.3	386	1.4	.44	178	.21			
14	1.3	340	1.2	.27	218	.16			
15	1.4	620	2.3	.23	219	.14			
16	1.5	340	1.4	.12	314	.10			
17	1.6	296	1.3	.07	310	.06			
18	1.8	308	1.5	.25	289	.20			
19	1.6	294	1.3	.40	279	.30			
20	1.4	275	1.0	.27	511	.37			
21	1.4	253	.96	.31	472	.40			
22	1.5	271	1.1	.55	403	.58			
23	1.5	250	1.0	.57	262	.40			
24	1.4	256	.97	.61	222	.37			
25	1.5	247	1.0	.53	167	.24			
26	1.5	317	1.3	.40	195	.21			
27	1.3	326	1.1	.31	177	.15			
28	1.3	218	.77	.17	162	.07			
29	1.3	197	.69	0	0	0			
30	1.3	194	.68	0	0	0			
31	---	---	---	0	0	0			
TOTAL	45.9	---	58.57	16.37	---	9.86			

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1973 TO SEPTEMBER 1974

	JULY			AUGUST			SEPTEMBER		
DAY	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
1	0	0	0	.07	34	.01	.17	25	.01
2	0	0	0	.05	31	0	.17	25	.01
3	0	0	0	8.5	40300	3150	.15	20	.01
4	0	0	0	16	91000	4850	.07	10	0
5	0	0	0	22	114000	7210	.17	25	.01
6	0	0	0	4.3	54000	627	10	70800	2860
7	0	0	0	2.3	33000	205	1.5	37500	152
8	0	0	0	1.2	3500	11	.70	858	1.6
9	0	0	0	.57	565	.87	.50	472	.64
10	0	0	0	.27	351	.26	.40	399	.43
11	0	0	0	.19	43	.02	.20	433	.23
12	0	0	0	.21	28	.02	.10	410	.11
13	0	0	0	.04	24	0	0	0	0
14	0	0	0	.01	21	0	.20	450	.24
15	0	0	0	.04	20	0	.40	450	.49
16	0	0	0	.15	40	.02	1.1	450	1.3
17	0	0	0	.11	20	.01	1.2	575	1.9
18	0	0	0	.07	10	0	2.0	700	3.8
19	240	131000	152000.0	.05	10	0	1.2	576	1.9
20	35	85000	8030	.11	20	.01	6.5	52600	1160
21	30	189000	15300	.02	10	0	4.1	33500	371
22	26	66000	4630	0	0	0	3.9	6320	67
23	23	65000	4040	.05	10	0	9.0	39000	948
24	18	85000	4130	.13	20	.01	3.0	23000	186
25	2.7	55000	401	.13	20	.01	1.8	2580	13
26	.94	31000	79	.17	25	.01	1.4	1580	6.0
27	.40	4080	4.4	.09	10	0	1.4	1020	3.9
28	.25	330	.22	.13	20	.01	1.2	741	2.4
29	1.2	307	.99	.13	20	.01	1.3	526	1.8
30	.40	400	.43	.15	25	.01	1.4	697	2.6
31	.17	419	.19	.19	30	.02	---	---	---
TOTAL	378.06	---	188616.8	57.43	---	16054.30	55.23	---	5786.38

Table 3.--Stream and suspended-sediment discharge, water years 1974-76, for gaging station 09401260, Moenkopi Wash at Moenkopi, Arizona--Continued

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

	APRIL			MAY			JUNE		
DAY	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
1	2.3	399	2.5	1.4	126	.48	1.3	102	.36
2	2.2	362	2.2	1.4	202	.76	2.0	84	.45
3	2.0	444	2.4	1.4	189	.71	1.0	123	.33
4	2.0	374	2.0	1.3	205	.72	1.0	135	.36
5	2.0	366	2.0	1.4	226	.85	1.0	118	.32
6	2.0	333	1.8	1.8	287	1.4	1.0	144	.39
7	2.0	320	1.7	1.5	204	.83	.90	126	.30
8	2.0	317	1.7	1.5	129	.52	.80	139	.30
9	2.0	328	1.8	2.0	114	.62	.70	124	.23
10	2.0	276	1.5	2.0	130	.70	.70	108	.20
11	2.0	304	1.6	2.0	242	1.3	.48	131	.17
12	2.0	438	2.4	2.0	134	.72	.53	124	.18
13	2.0	446	2.4	2.0	134	.72	.53	87	.12
14	2.0	502	2.7	2.0	127	.69	.44	147	.17
15	2.0	293	1.6	2.0	104	.54	.25	95	.06
16	2.0	243	1.3	3.0	148	1.2	.11	136	.04
17	2.0	260	1.4	3.0	150	1.2	0	0	0
18	2.0	268	1.4	3.0	133	1.1	0	0	0
19	2.0	307	1.7	3.0	144	1.2	.07	10	0
20	2.0	315	1.7	2.0	141	.76	.53	85	.12
21	2.0	270	1.5	2.0	193	1.0	.31	50	.04
22	2.0	310	1.7	1.4	304	1.1	.05	10	0
23	2.0	153	.83	1.5	162	.66	0	0	0
24	2.0	172	.93	1.4	157	.59	0	0	0
25	2.0	173	.93	1.3	136	.48	0	0	0
26	1.0	177	.48	1.3	167	.59	0	0	0
27	1.0	156	.42	1.2	110	.36	0	0	0
28	2.0	180	.97	1.3	133	.47	0	0	0
29	2.0	159	.86	1.4	105	.40	0	0	0
30	1.5	260	1.1	1.4	149	.56	0	0	0
31	---	---	---	1.3	185	.65	---	---	---
TOTAL	58.0	---	47.52	55.2	---	23.90	13.70	---	4.14

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

	JULY			AUGUST			SEPTEMBER		
DAY	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
1	0	0	0	3.0	68	.55	.13	10	0
2	0	0	0	2.0	36	.19	.21	20	.01
3	0	0	0	2.0	24	.13	.27	22	.02
4	0	0	0	2.0	132	.71	.53	40	.06
5	.15	50	.02	2.0	66	.36	.53	40	.06
6	3.0	2000	16	1.0	37	.10	.44	50	.06
7	.86	502	1.2	.80	40	.09	.57	185	.29
8	.66	418	.74	.50	52	.07	6.3	11700	788
9	1.0	861	2.3	.50	45	.06	50	93400	12800
10	.44	495	.59	.50	30	.04	46	74900	9270
11	44	61200	12800	.20	10	.01	8.7	66000	1550
12	300	188000	169000.0	2.8	80	.60	35	66300	9430
13	500	179000	242000.0	1.0	102	.28	595	100000	200000.0
14	52	143000	23000	.48	38	.05	179	93000	44900
15	460	130000	161000.0	.31	70	.06	20	55000	2970
16	10	86000	2320	.27	36	.03	6.3	22000	476
17	130	97000	34000	.27	67	.05	2.5	5000	34
18	10	80000	2160	.27	75	.05	102	15400	49000
19	6.0	37000	599	.19	52	.03	260	137000	105000.0
20	4.0	6000	65	.05	20	0	30	89000	7210
21	3.0	1240	10	.43	50	.06	90	105000	25500
22	2.0	100	.54	.96	76	.20	6.0	45000	729
23	2.0	45	.25	.57	50	.08	3.5	14000	132
24	2.0	38	.21	.31	47	.04	1.6	2700	12
25	2.0	118	.64	.17	42	.02	1.4	436	1.6
26	1.0	149	.40	.09	42	.01	1.1	321	.95
27	4.0	153	1.7	.09	88	.01	.86	111	.26
28	3.0	66	.53	.13	30	.01	.86	103	.24
29	150	104000	72000	.09	30	.01	.86	72	.17
30	6.0	31000	502	.07	10	0	.86	22	.05
31	4.0	3910	42	.09	5	0	---	---	---
TOTAL	1701.11	---	719523.1	23.14	---	3.98	1450.52	---	469804.8
YEAR	3856.77		1213535						

Table 3.--Stream and suspended-sediment discharge, water years 1974-76, for gaging station 09401265, Moenkopi Wash at Moenkopi, Arizona--Continued

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DAY	OCTOBER MEAN DISCHARGE (CFS)	OCTOBER MEAN CONCEN-TRATION (MG/L)	OCTOBER SEDIMENT DISCHARGE (TONS/DAY)	NOVEMBER MEAN DISCHARGE (CFS)	NOVEMBER MEAN CONCEN-TRATION (MG/L)	NOVEMBER SEDIMENT DISCHARGE (TONS/DAY)	DECEMBER MEAN DISCHARGE (CFS)	DECEMBER MEAN CONCEN-TRATION (MG/L)	DECEMBER SEDIMENT DISCHARGE (TONS/DAY)
1	1.0	700	1.9	3.0	10000	81	2.0	455	2.5
2	1.0	670	1.8	2.0	26000	140	2.0	542	2.9
3	1.0	630	1.7	15	44500	1800	2.0	660	3.6
4	.90	540	1.3	5.0	16000	216	2.0	643	3.5
5	1.0	520	1.4	2.0	4000	22	2.0	1130	6.1
6	2.0	625	3.4	2.0	1900	10	2.0	395	2.1
7	2.0	790	4.3	2.0	810	4.4	2.0	381	2.1
8	2.0	980	5.3	1.8	750	3.6	2.0	464	2.5
9	2.0	900	4.9	2.5	1100	7.4	2.0	610	3.3
10	2.0	850	4.6	2.2	1230	7.3	2.0	606	3.3
11	2.0	810	4.4	1.9	720	3.7	2.0	533	2.9
12	2.0	710	3.8	1.9	570	2.9	2.0	428	2.3
13	2.0	920	5.0	1.9	630	3.2	3.0	567	4.6
14	2.0	1340	7.2	1.9	670	3.4	2.0	349	1.9
15	2.0	1030	5.6	1.9	570	2.9	2.0	501	2.7
16	2.0	850	4.6	2.0	560	3.0	3.0	578	4.7
17	2.0	750	4.0	2.0	520	2.8	3.0	542	4.4
18	2.0	670	3.6	2.0	480	2.6	3.0	606	4.9
19	2.0	630	3.4	2.0	470	2.5	3.0	495	4.0
20	2.0	610	3.3	2.0	463	2.5	2.0	615	3.3
21	2.0	890	4.8	2.0	414	2.2	2.0	797	4.3
22	3.0	7000	57	2.0	528	2.9	2.0	740	4.0
23	18	55600	3210	2.0	553	3.0	2.0	513	2.8
24	8.6	40800	996	2.0	435	2.3	2.0	509	2.7
25	3.5	31000	293	2.0	438	2.4	2.0	152	.82
26	1.5	10000	41	2.0	663	3.6	6.0	258	4.2
27	1.9	10700	55	2.0	978	5.3	4.0	154	1.7
28	38	87000	11400	2.0	560	3.0	5.0	240	3.2
29	20	55900	3200	2.0	540	2.9	4.0	263	2.8
30	15	31600	1330	2.0	426	2.3	4.0	309	3.3
31	9.2	22500	559	---	---	---	3.0	292	2.4
TOTAL	155.60	---	21221.3	77.0	---	2351.1	81.0	---	99.82

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1974 TO SEPTEMBER 1975

DAY	JANUARY MEAN DISCHARGE (CFS)	JANUARY MEAN CONCEN-TRATION (MG/L)	JANUARY SEDIMENT DISCHARGE (TONS/DAY)	FEBRUARY MEAN DISCHARGE (CFS)	FEBRUARY MEAN CONCEN-TRATION (MG/L)	FEBRUARY SEDIMENT DISCHARGE (TONS/DAY)	MARCH MEAN DISCHARGE (CFS)	MARCH MEAN CONCEN-TRATION (MG/L)	MARCH SEDIMENT DISCHARGE (TONS/DAY)
1	3.0	225	1.8	3.0	696	5.6	2.0	380	2.1
2	6.0	228	3.7	2.0	912	4.9	2.0	3110	17
3	4.0	297	3.2	3.0	515	4.2	2.5	2550	14
4	4.0	389	4.2	3.0	494	4.0	2.0	2520	14
5	4.0	286	3.1	3.0	523	4.2	2.0	2400	13
6	3.0	163	1.3	2.0	407	2.2	2.0	1200	6.5
7	3.0	165	1.3	2.0	508	2.7	2.5	900	6.1
8	3.0	320	2.6	2.0	485	2.6	2.5	890	6.0
9	3.0	277	2.2	2.0	455	2.5	2.8	840	6.4
10	3.0	509	4.1	2.0	535	2.9	2.5	790	5.3
11	3.0	331	2.7	2.0	514	2.8	2.5	700	4.7
12	4.0	318	3.4	2.0	337	1.8	3.2	610	5.3
13	3.0	391	3.2	2.0	422	2.3	3.5	850	8.0
14	5.0	306	4.1	2.0	432	2.3	3.5	1020	9.6
15	6.0	344	5.6	2.0	457	2.5	3.7	1100	11
16	6.0	202	3.3	2.0	332	1.8	4.3	2370	28
17	5.0	239	3.2	2.0	339	1.8	4.1	4480	50
18	5.0	364	4.9	2.0	340	1.8	2.8	2410	18
19	3.0	261	2.1	2.0	230	1.2	2.5	1120	7.6
20	2.0	350	1.9	2.0	238	1.3	2.2	900	5.3
21	2.0	352	1.9	2.0	218	1.2	1.8	636	3.1
22	2.0	343	1.9	2.0	214	1.2	1.6	492	2.1
23	2.0	385	2.1	2.0	372	2.0	1.6	509	2.2
24	2.0	460	2.5	2.0	358	1.9	1.5	370	1.5
25	3.0	691	5.6	2.0	261	1.4	1.5	415	1.7
26	4.0	1440	16	2.0	356	1.9	1.8	408	2.0
27	3.0	1200	9.7	2.0	237	1.3	2.2	426	2.5
28	2.0	687	3.7	2.0	393	2.1	2.5	567	3.8
29	2.0	758	4.1	---	---	---	2.8	577	4.4
30	2.0	749	4.0	---	---	---	2.3	578	3.6
31	3.0	796	6.4	---	---	---	2.3	364	2.3
TOTAL	105.0	---	119.8	60.0	---	68.4	76.5	---	267.1

Table 3.--Stream and suspended-sediment discharge, water years 1974-76, for gaging station 09401260, Moenkopi Wash at Moenkopi, Arizona--Continued

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976

	OCTOBER			NOVEMBER			DECEMBER		
DAY	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
1	.86	35	.08	2.3	272	1.7	3.0	438	3.5
2	.78	10	.02	2.4	291	1.9	3.0	490	4.0
3	.78	15	.03	2.4	300	1.9	3.0	363	2.9
4	.78	17	.04	2.4	296	1.[illegible]	3.0	456	3.7
5	.86	21	.05	2.4	316	2.0	3.0	646	5.2
6	.86	19	.04	2.4	280	1.8	3.0	538	4.4
7	1.0	24	.06	2.3	408	2.5	3.0	558	4.5
8	1.0	124	.33	2.4	330	2.1	3.0	402	3.3
9	1.0	40	.11	2.3	311	1.9	3.0	402	3.3
10	1.0	27	.07	2.3	285	1.8	3.0	388	3.1
11	1.0	50	.14	2.2	250	1.5	3.0	460	3.7
12	1.0	42	.11	1.9	266	1.4	3.3	393	3.2
13	1.0	46	.12	1.8	272	1.3	3.5	289	2.7
14	1.1	60	.18	1.9	399	2.0	3.5	280	2.6
15	.94	55	.14	2.2	389	2.3	1.2	286	.93
16	1.4	369	1.4	2.3	384	2.4	1.3	279	.98
17	1.6	140	.60	2.3	336	2.1	1.6	258	1.1
18	1.8	104	.50	2.3	341	2.1	1.6	284	1.2
19	1.8	106	.51	2.3	363	2.3	1.6	266	1.1
20	1.6	106	.46	2.0	489	2.6	2.0	260	1.4
21	1.8	93	.45	2.2	334	2.0	2.7	229	1.7
22	1.8	106	.52	2.2	339	2.0	4.3	444	5.2
23	1.6	116	.50	2.0	350	1.9	5.0	792	11
24	1.5	87	.35	2.0	476	2.6	2.8	454	3.4
25	1.5	88	.36	2.0	608	3.3	1.8	375	1.8
26	1.8	116	.56	2.0	550	3.0	1.4	365	1.4
27	1.9	141	.72	3.0	470	3.8	1.6	367	1.6
28	2.0	125	.68	4.0	1290	14	2.3	365	2.3
29	1.9	109	.56	4.0	1340	14	1.2	375	1.2
30	1.9	115	.59	3.0	620	5.0	2.5	195	1.3
31	2.2	114	.68	---	---	---	2.2	273	1.6
TOTAL	42.06	---	10.96	71.2	---	91.1	80.1	---	89.31

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976

	JANUARY			FEBRUARY			MARCH		
DAY	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)	MEAN DISCHARGE (CFS)	MEAN CONCEN-TRATION (MG/L)	SEDIMENT DISCHARGE (TONS/DAY)
1	2.4	277	1.8	2.0	390	2.1	2.0	272	1.5
2	1.4	371	1.4	3.0	700	5.7	2.0	292	1.6
3	1.0	246	.66	4.0	942	10	2.0	283	1.5
4	1.0	192	.52	5.0	1450	20	2.0	282	1.5
5	2.0	209	1.1	10	980	26	2.0	342	1.8
6	2.0	248	1.3	6.0	625	10	2.0	376	2.0
7	2.0	253	1.4	4.0	734	7.9	2.0	327	1.8
8	2.0	251	1.4	2.0	383	2.1	2.0	315	1.7
9	2.0	268	1.4	2.0	337	1.8	2.0	287	1.5
10	2.0	316	1.7	2.0	330	1.8	2.0	250	1.4
11	2.0	477	2.6	2.0	315	1.7	2.0	223	1.2
12	2.0	376	2.0	2.0	198	1.1	2.0	208	1.1
13	2.0	381	2.1	2.0	203	1.1	2.0	221	1.2
14	2.0	390	2.1	2.0	191	1.0	2.0	179	.97
15	2.0	479	2.6	2.0	179	.97	2.0	216	1.2
16	2.0	426	2.3	2.0	195	1.1	2.0	228	1.2
17	2.0	552	3.0	2.0	218	1.2	2.0	214	1.2
18	2.0	485	2.6	2.0	258	1.4	2.0	352	1.9
19	2.0	508	2.7	2.0	155	.85	1.9	355	1.8
20	2.0	525	2.8	2.0	134	.72	1.8	310	1.5
21	2.0	456	2.5	2.0	152	.82	2.0	178	.96
22	2.0	510	2.8	2.0	127	.69	2.2	152	.90
23	2.0	498	2.7	2.0	306	1.7	2.2	246	1.5
24	2.0	450	2.4	2.0	251	1.4	1.9	321	1.6
25	2.0	413	2.2	2.0	270	1.5	1.8	266	1.3
26	2.0	351	1.9	2.0	236	1.3	1.5	200	.81
27	2.0	597	3.2	2.0	240	1.3	1.6	300	1.3
28	2.0	424	2.3	2.0	178	.96	1.8	282	1.4
29	2.0	367	2.0	2.0	166	.90	1.9	207	1.1
30	2.0	414	2.2	---	---	---	1.8	182	.88
31	2.0	459	2.5	---	---	---	1.9	191	.98
TOTAL	59.8	---	64.18	78.0	---	109.11	60.3	---	42.30

Table 3.--Stream and suspended-sediment discharge, water years 1974-76, for gaging station 09401260, Moenkopi Wash at Moenkopi, Arizona--Continued

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976

DAY	APRIL MEAN DISCHARGE (CFS)	APRIL MEAN CONCEN-TRATION (MG/L)	APRIL SEDIMENT DISCHARGE (TONS/DAY)	MAY MEAN DISCHARGE (CFS)	MAY MEAN CONCEN-TRATION (MG/L)	MAY SEDIMENT DISCHARGE (TONS/DAY)	JUNE MEAN DISCHARGE (CFS)	JUNE MEAN CONCEN-TRATION (MG/L)	JUNE SEDIMENT DISCHARGE (TONS/DAY)
1	1.9	177	.91	1.3	760	2.7	.48	182	.24
2	1.8	167	.81	1.4	746	2.8	.31	175	.15
3	1.9	168	.86	1.6	197	.85	.25	196	.13
4	2.0	164	.89	1.8	210	1.0	.17	181	.08
5	2.0	184	.99	2.0	218	1.2	.13	180	.06
6	2.3	193	1.2	1.8	166	.81	.11	180	.05
7	2.3	231	1.4	1.9	195	1.0	.05	180	.02
8	2.0	193	1.0	1.9	218	1.1	.05	180	.02
9	1.8	195	.95	2.0	229	1.2	.01	68	.01
10	1.8	254	1.2	2.0	185	1.0	0	0	0
11	1.8	166	.81	2.0	192	1.0	0	0	0
12	1.5	167	.68	1.9	206	1.1	0	0	0
13	1.4	176	.67	1.8	174	.84	0	0	0
14	1.9	214	1.1	1.3	158	.55	0	0	0
15	2.5	262	1.8	1.3	160	.56	0	0	0
16	3.0	269	2.2	1.2	185	.60	0	0	0
17	2.5	258	1.7	1.1	140	.42	0	0	0
18	2.0	185	1.0	1.2	156	.51	0	0	0
19	2.0	178	.96	1.3	186	.65	0	0	0
20	2.0	175	.94	1.4	166	.63	0	0	0
21	1.9	176	.90	5.0	30000	405	0	0	0
22	1.8	187	.91	3.0	6670	54	0	0	0
23	1.7	196	.90	1.5	610	2.5	0	0	0
24	1.6	179	.77	1.4	760	2.9	0	0	0
25	1.5	230	.93	1.3	250	.88	0	0	0
26	1.4	201	.76	1.2	220	.71	0	0	0
27	1.3	185	.65	1.0	204	.55	0	0	0
28	1.4	212	.80	.44	294	.35	0	0	0
29	1.5	198	.80	.40	158	.17	0	0	0
30	1.4	198	.75	.36	164	.16	0	0	0
31	---	---	---	.44	188	.22	---	---	---
TOTAL	55.9	---	30.24	48.24	---	487.96	1.56	---	.76

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976

DAY	JULY MEAN DISCHARGE (CFS)	JULY MEAN CONCEN-TRATION (MG/L)	JULY SEDIMENT DISCHARGE (TONS/DAY)	AUGUST MEAN DISCHARGE (CFS)	AUGUST MEAN CONCEN-TRATION (MG/L)	AUGUST SEDIMENT DISCHARGE (TONS/DAY)	SEPTEMBER MEAN DISCHARGE (CFS)	SEPTEMBER MEAN CONCEN-TRATION (MG/L)	SEPTEMBER SEDIMENT DISCHARGE (TONS/DAY)
1	0	0	0	14	88800	3840	0	0	0
2	0	0	0	4.0	39000	421	0	0	0
3	0	0	0	2.8	14500	110	0	0	0
4	0	0	0	1.3	850	3.0	0	0	0
5	0	0	0	.10	193	.05	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	3.2	765	6.7
8	0	0	0	20	95300	7720	4.9	811	11
9	0	0	0	7.8	107000	2250	1.8	97	.47
10	0	0	0	2.8	75500	571	1.8	131	.64
11	0	0	0	.90	64000	156	1.5	451	1.8
12	0	0	0	.30	10000	8.1	1.8	380	1.8
13	0	0	0	.10	1000	.27	.90	301	.73
14	0	0	0	0	0	0	.70	136	.26
15	0	0	0	0	0	0	.40	75	.08
16	0	0	0	0	0	0	.20	139	.08
17	0	0	0	0	0	0	.10	101	.03
18	0	0	0	0	0	0	0	585	0
19	0	0	0	0	0	0	0	121	0
20	3.2	32500	527	46	73900	16300	.10	165	.04
21	1.9	5000	26	4.4	41000	487	.60	254	.41
22	0	0	0	1.1	154	.46	3.4	5500	54
23	0	0	0	.30	29	.07	3.6	25800	251
24	0	0	0	.40	276	.30	2.8	108000	816
25	0	0	0	.10	100	.03	1600	262000	1600000
26	66	150000	26700	0	0	0	600	60000	97200
27	52	147000	23300	0	0	0	100	36000	9720
28	27	174000	13200	0	0	0	11	21000	624
29	40	215000	23200	0	0	0	4.0	920	9.9
30	4.0	74000	799	0	0	0	2.8	206	1.6
31	238	208000	252000.0	0	0	0	---	---	---
TOTAL	432.10	---	339752.0	106.40	---	31867.28	2345.80	---	1708701

YEAR 3381.46 2081246

09401260. MOENKOPI WASH AT MOENKOPI, ARIZ.--CONTINUED

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976
SUMMATION VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.08	1.7	3.5	1.8	2.1	1.5	.91	2.7	.24	0	3840	0
2	.02	1.9	4.0	1.4	5.7	1.6	.81	2.6	.15	0	421	0
3	.03	1.9	2.9	.66	10	1.5	.86	.85	.13	0	110	0
4	.04	1.9	3.7	.52	20	1.5	.89	1.0	.08	0	3.0	0
5	.05	2.0	5.2	1.1	26	1.8	.99	1.2	.06	0	.05	0
6	.04	1.6	4.4	1.3	10	2.0	1.2	.81	.05	0	0	0
7	.08	2.5	4.5	1.4	7.9	1.8	1.4	1.0	.02	0	0	6.7
8	.33	2.1	3.3	1.4	2.1	1.7	1.0	1.1	.02	0	7720	11
9	.11	1.9	3.3	1.4	1.8	1.5	.95	1.2	.01	0	2250	.47
10	.07	1.8	3.1	1.7	1.8	1.4	1.2	1.0	0	0	571	.64
11	.14	1.5	3.7	2.6	1.7	1.2	.81	1.0	0	0	156	1.8
12	.11	1.4	3.2	2.0	1.1	1.1	.68	1.1	0	0	8.1	1.6
13	.12	1.3	2.7	2.1	1.1	1.2	.67	.84	0	0	.27	.73
14	.18	2.0	2.6	2.1	1.0	.97	1.1	.55	0	0	0	.26
15	.14	2.3	.93	2.6	.97	1.2	1.8	.56	0	0	0	.08
16	1.4	2.4	.98	2.3	1.1	1.2	2.2	.60	0	0	0	.08
17	.60	2.1	1.1	3.0	1.2	1.2	1.7	.42	0	0	0	.03
18	.50	2.1	1.2	2.6	1.4	1.9	1.0	.51	0	0	0	0
19	.51	2.3	1.1	2.7	.85	1.8	.96	.65	0	0	0	0
20	.48	2.6	1.4	2.8	.72	1.5	.94	[illegible]	0	527	16300	.04
21	.45	2.0	1.7	2.5	.82	.96	.90	405	0	26	487	.41
22	.52	2.0	5.2	2.8	.69	.90	.91	54	0	0	.46	54
23	.50	1.9	11	2.7	1.7	1.5	.90	2.5	0	0	.07	251
24	.35	2.6	3.4	2.4	1.4	1.6	.77	2.9	0	0	.30	816
25	.38	3.3	1.8	2.2	1.5	1.3	.93	.88	0	0	.03	1600000
26	.55	3.0	1.4	1.9	1.3	.81	.76	.71	0	26700	0	97200
27	.72	3.8	1.6	3.2	1.3	1.3	.65	.55	0	23300	0	9720
28	.66	14	2.3	2.3	.96	1.4	.80	.35	0	13200	0	624
29	.56	14	1.2	2.0	.90	1.1	.60	.17	0	23200	0	9.9
30	.59	5.0	1.3	2.2	---	.88	.75	.16	0	799	0	1.6
31	.66	---	1.6	2.5	---	.98	---	.22	---	252000	0	---
TOTAL	10.78	91.1	89.31	64.18	109.11	42.3	30.24	487.96	.76	339752	31867.28	1708700.54

YEAR TOTAL 2081245.56

PARTICLE-SIZE DISTRIBUTION OF SUSPENDED SEDIMENT, WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976
(ANALYSES MADE IN DISTILLED WATER)

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	TEMPERATURE (DEG C)	SUSPENDED SEDIMENT (MG/L)	SUSPENDED SEDIMENT DISCHARGE (T/DAY)	SUS. SED. FALL DIAM. % FINER THAN .002 MM	SUS. SED. FALL DIAM. % FINER THAN .004 MM	SUS. SED. FALL DIAM. % FINER THAN .016 MM	SUS. SED. FALL DIAM. % FINER THAN .062 MM	SUS. SED. FALL DIAM. % FINER THAN .125 MM	SUS. SED. FALL DIAM. % FINER THAN .250 MM
JUL											
31...	1000	640	20.0	493000	852000	32	39	52	94	97	100
AUG											
06...	0800	45	14.0	189000	23000	45	56	78	93	97	100
20...	1430	26	26.0	73600	5170	57	69	91	99	100	--

SUSPENDED-SEDIMENT CONCENTRATION (MG/L), WATER YEAR OCTOBER 1975 TO SEPTEMBER 1976
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	35	272	438	277	390	272	177	760	182	0	88800	0
2	10	251	490	371	700	292	167	746	175	0	39000	0
3	15	300	363	246	942	283	168	197	196	0	14500	0
4	17	256	456	192	1450	282	164	210	181	0	850	0
5	21	316	646	209	980	342	184	218	180	0	193	0
6	19	260	538	248	625	376	193	166	160	0	0	0
7	24	408	556	253	734	327	231	195	180	0	0	765
8	124	330	402	251	383	315	193	218	180	0	95300	811
9	40	311	402	268	337	287	195	224	68	0	107000	97
10	27	265	388	316	330	250	254	185	0	0	75500	131
11	50	250	460	477	315	223	166	192	0	0	64000	451
12	42	266	393	376	198	208	167	206	0	0	10000	380
13	45	272	289	381	203	221	176	174	0	0	1000	301
14	60	359	280	390	191	179	214	158	0	0	0	136
15	55	389	286	479	179	216	262	160	0	0	0	75
16	369	384	279	426	195	228	269	165	0	0	0	139
17	140	326	258	552	218	214	258	140	0	0	0	101
18	104	341	284	485	258	352	185	156	0	0	0	585
19	106	323	266	508	158	355	178	186	0	0	0	121
20	106	409	260	525	134	310	175	166	0	32500	73900	165
21	93	334	229	456	152	178	176	30000	0	5000	41000	254
22	106	339	444	510	127	152	187	6670	0	0	154	5500
23	116	350	792	498	306	246	196	610	0	0	89	25800
24	87	476	454	450	251	321	179	760	0	0	276	108000
25	88	608	375	413	270	266	230	250	0	0	100	262000
26	116	550	365	351	236	200	201	220	0	150000	0	60000
27	141	470	367	597	240	300	185	204	0	147000	0	36000
28	125	1250	365	424	178	282	212	294	0	174000	0	21000
29	109	1340	375	367	166	207	198	158	0	215000	0	920
30	115	620	195	414	---	182	198	164	0	74000	0	206
31	114	---	273	459	---	191	---	188	---	208000	0	---

YEAR MAX 262000 MIN 0

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

SUSPENDED-SEDIMENT, WATER YEAR OCTOBER 1976 TO SEPTEMBER 1977

DAY	OCTOBER MEAN CONCEN-TRATION (MG/L)	OCTOBER LOADS (T/DAY)	NOVEMBER MEAN CONCEN-TRATION (MG/L)	NOVEMBER LOADS (T/DAY)	DECEMBER MEAN CONCEN-TRATION (MG/L)	DECEMBER LOADS (T/DAY)	JANUARY MEAN CONCEN-TRATION (MG/L)	JANUARY LOADS (T/DAY)	FEBRUARY MEAN CONCEN-TRATION (MG/L)	FEBRUARY LOADS (T/DAY)	MARCH MEAN CONCEN-TRATION (MG/L)	MARCH LOADS (T/DAY)
1	106	.52	134	.54	121	.65	133	1.8	157	.89	702	5.2
2	128	.73	103	.42	106	.57	279	3.8	158	.90	326	2.4
3	114	.55	108	.44	129	.70	592	6.4	197	1.1	361	1.8
4	112	.54	109	.44	196	1.1	221	2.4	172	.84	141	1.0
5	109	.62	97	.39	206	1.1	349	2.8	203	1.3	177	.72
6	82	.46	89	.43	173	.93	339	2.7	177	1.3	104	.79
7	117	.57	84	.41	211	1.1	219	2.4	289	1.6	109	.82
8	81	.33	87	.42	188	1.0	228	1.8	162	.92	108	.61
9	65	.26	209	1.2	188	1.0	221	1.8	192	.93	124	.94
10	59	.24	199	1.1	150	.97	117	.95	204	1.2	116	.88
11	63	.22	162	1.0	235	1.3	132	1.1	174	1.1	160	1.2
12	62	.22	145	.82	252	1.9	127	.69	128	.73	112	.45
13	73	.26	150	.85	219	1.7	130	.70	136	.77	100	.76
14	73	.26	147	.71	215	1.0	86	.46	152	.86	97	.79
15	73	.30	98	.40	188	1.2	111	.60	146	.95	190	.77
16	78	.32	556	3.0	237	1.8	87	.50	138	.89	150	.85
17	72	.35	124	.67	139	1.1	71	.38	133	.86	169	1.1
18	89	.43	121	.65	227	2.2	74	.60	214	1.4	142	.81
19	97	.47	122	.66	219	1.7	118	.94	121	.69	124	.70
20	86	.42	131	.71	248	1.9	124	1.2	123	.70	181	1.0
21	111	.63	131	.71	210	1.4	100	.97	120	.68	102	.66
22	104	.59	108	.58	197	1.5	114	1.1	442	3.3	126	.68
23	142	.81	131	.71	194	1.5	133	1.6	166	1.1	115	.62
24	112	.64	127	.69	173	1.3	300	4.4	163	.92	113	.61
25	100	.49	110	.59	157	1.2	340	2.6	174	.99	101	.55
26	109	.44	137	.74	208	1.6	333	3.2	116	.88	100	.81
27	102	.41	173	.93	198	1.5	276	1.8	108	1.2	106	.57
28	90	.32	158	.85	154	1.2	277	1.8	631	4.4	134	.72
29	142	.50	143	.77	119	.64	317	2.1	---	---	113	.61
30	147	.60	136	.73	126	1.0	254	[illegible]	---	---	100	.54
31	135	.55	---	---	126	1.0	150	.85	---	---	113	.61
TOTAL	---	14.05	---	22.56	---	38.76	---	56.06	---	33.40	---	30.57

DAY	APRIL MEAN CONCEN-TRATION (MG/L)	APRIL LOADS (T/DAY)	MAY MEAN CONCEN-TRATION (MG/L)	MAY LOADS (T/DAY)	JUNE MEAN CONCEN-TRATION (MG/L)	JUNE LOADS (T/DAY)	JULY MEAN CONCEN-TRATION (MG/L)	JULY LOADS (T/DAY)	AUGUST MEAN CONCEN-TRATION (MG/L)	AUGUST LOADS (T/DAY)	SEPTEMBER MEAN CONCEN-TRATION (MG/L)	SEPTEMBER LOADS (T/DAY)
1	256	1.4	29	.08	72	.08	0	.00	52	.04	100	.14
2	127	.69	43	.12	70	.06	0	.00	0	.00	40000	54000
3	135	1.1	20	.07	69	.06	0	.00	0	.00	93000	276000.0
4	102	.55	126	.51	74	.04	0	.00	0	.00	62000	16700
5	88	.48	82	.24	71	.04	0	.00	0	.00	51000	1100
6	48	.26	74	.16	61	.03	0	.00	0	.00	29000	392
7	53	.29	121	.26	77	.06	0	.00	0	.00	4100	33
8	32	.17	102	.30	54	.06	0	.00	100	.19	292	.79
9	31	.17	72	.21	69	.07	0	.00	50	.03	103	.19
10	36	.19	47	.10	91	.10	0	.00	0	.00	254	.41
11	34	.09	76	.21	80	.08	0	.00	0	.00	44000	1190
12	30	.16	70	.19	60	.06	118000	4140	131000	84200	83900	2920
13	27	.15	92	.25	40	.04	79000	853	91500	7410	79200	6040
14	41	.22	91	.49	20	.02	4610	10	54000	875	50500	736
15	32	.17	99	.53	0	.00	97	.08	69800	9100	60500	719
16	45	.24	95	.51	0	.00	9840	853	51500	1250	38000	185
17	45	.24	62	.17	0	.00	54500	2590	52800	570	2200	4.2
18	48	.26	76	.14	0	.00	10400	30200	90000	14600	130	.18
19	56	.30	67	.13	0	.00	166000	24800	72600	4510	237	.32
20	31	.17	91	.17	0	.00	163000	38700	55000	653	115	.15
21	34	.18	171	.32	0	.00	207000	373000.0	12000	78	98	.13
22	22	.12	50	.14	0	.00	93000	4520	355	1.7	64	.09
23	32	.17	94	.18	0	.00	147000	840000.0	145	.31	62	.08
24	61	.33	72	.14	0	.00	86000	69700	55	.09	28	.04
25	80	.43	60	.11	0	.00	43000	2320	65900	4260	56	.08
26	28	.15	55	.15	0	.00	38000	308	51000	895	36	.04
27	49	.26	70	.13	0	.00	11300	55	7500	43	412	.44
28	40	.11	68	.09	0	.00	172	.33	250	.74	94	.13
29	29	.16	71	.15	0	.00	164	.31	150	.20	45	.06
30	36	.10	54	.10	0	.00	42	.06	100	.08	72	.12
31	---	---	68	.09	---	---	50	.07	60	.06	---	---
TOTAL	---	9.31	---	6.44	---	0.80	---	1392049.85	---	128447.44	---	360022.59

SUSPENDED LOAD FOR YEAR: 1880731.83 TONS.

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

WATER QUALITY DATA, WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	TEMPER-ATURE (DEG C)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT DIS-CHARGE, SUS-PENDED (T/DAY)	SED. SUSP. FALL DIAM. % FINER THAN .002 MM	SED. SUSP. FALL DIAM. % FINER THAN .004 MM
MAR							
02...	1200	20	10.0	48500	2670	68	78
02...	1600	17	10.0	44600	2060	70	85
JUL							
26...	1800	10	28.0	109000	3180	59	82
SEP							
25...	1200	114	18.0	123000	37900	55	67

DATE	SED. SUSP. FALL DIAM. % FINER THAN .016 MM	SED. SUSP. FALL DIAM. % FINER THAN .062 MM	SED. SUSP. SIEVE DIAM. % FINER THAN .062 MM	SED. SUSP. FALL DIAM. % FINER THAN .125 MM	SED. SUSP. SIEVE DIAM. % FINER THAN .250 MM	SED. SUSP. FALL DIAM. % FINER THAN .500 MM	SED. SUSP. SIEVE DIAM. % FINER THAN .500 MM
MAR							
02...	92	--	99	--	99	--	100
02...	96	--	99	--	--	--	100
JUL							
26...	96	--	99	--	99	--	100
SEP							
25...	88	98	--	99	--	100	--

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

SUSPENDED-SEDIMENT CONCENTRATION (MG/L), WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	87	214	364	284	181	30700	238	180	110	---		---
2	82	190	352	249	386	52600	568	196	163	---		---
3	75	204	360	233	178	19200	556	228	101	---		---
4	48	256	329	286	429	3600	618	129	85	---		---
5	78	267	308	246	144	8360	317	104	92	---		---
6	96	1350	412	247	166	11300	326	111	102	---		---
7	123	1360	340	200	205	9320	284	119	90	---		---
8	142	1330	304	200	167	2770	237	120	94	---		---
9	54	511	312	378	157	483	263	102	104	---		---
10	50	506	416	365	192	359	162	87	121	---		---
11	62	454	354	326	395	466	154	139	---	---		---
12	80	346	385	320	391	379	144	109	---	---		---
13	77	339	347	227	296	389	211	90	---	---		---
14	96	340	364	214	206	563	129	92	---	---		---
15	114	322	444	217	212	365	154	98	---	---		---
16	120	228	442	393	238	211	110	90	---	---		---
17	96	356	155	358	300	634	112	96	---	---		---
18	107	351	160	235	199	190	116	78	---	---		---
19	71	378	206	234	141	248	139	87	---	27700		---
20	120	353	164	240	233	223	153	100	---	2400		---
21	114	302	291	461	262	173	164	84	---	300		---
22	144	309	312	324	152	695	126	78	---	---		---
23	77	303	298	218	220	241	101	90	---	---		---
24	125	320	294	224	191	220	108	142	---	---		500
25	151	266	534	252	222	193	168	94	---	50500		114000
26	140	251	407	285	202	243	134	77	---	50500		46200
27	156	295	520	306	408	220	100	113	---	57000		10300
28	162	282	318	300	366	196	90	101	---	4210		3000
29	103	286	352	300	---	186	107	196	---	296		345
30	232	295	439	274	---	176	98	155	---	22		252
31	204	---	331	317	---	231	---	105	---	---		---

SUSPENDED-SEDIMENT DISCHARGE (TONS/DAY), WATER YEAR OCTOBER 1977 TO SEPTEMBER 1978
SUMMATION VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.16	.87	2.4	2.2	2.2	3060	1.2	.63	.15	.00	.00	.00
2	.15	.77	2.3	1.9	3.8	4020	2.8	.69	.22	.00	.00	.00
3	.10	.83	2.3	1.8	1.7	654	2.7	.68	.11	.00	.00	.00
4	.06	1.5	2.1	2.2	4.2	87	3.0	.38	.11	.00	.00	.00
5	.11	1.5	2.0	1.9	2.8	284	1.5	.31	.12	.00	.00	.00
6	.18	7.7	2.7	1.9	1.8	465	.97	.33	.14	.00	.00	.00
7	.50	10	2.2	1.5	2.7	151	.84	.35	.15	.00	.00	.00
8	.27	18	2.0	1.5	3.2	30	.70	.36	.13	.00	.00	.00
9	.16	4.4	1.5	2.9	1.7	5.2	.78	.30	.14	.00	.00	.00
10	.15	3.3	2.0	3.2	2.1	1.7	.48	.16	.16	.00	.00	.00
11	.18	2.9	1.7	3.2	4.3	2.3	.45	.30	.10	.00	.00	.00
12	.24	2.2	1.9	3.1	5.2	4.1	.70	.21	.00	.00	.00	.00
13	.23	2.2	2.2	2.0	3.2	1.9	1.0	.15	.00	.00	.00	.00
14	.30	2.2	2.4	1.6	2.2	9.1	.63	.12	.00	.00	.00	.00
15	.34	2.1	2.9	1.6	2.3	1.8	.75	.13	.00	.00	.00	.00
16	.23	1.5	2.9	3.4	2.6	1.0	.53	.10	.00	.00	.00	.00
17	.18	2.3	1.0	4.7	3.2	3.1	.54	.16	.00	.00	.00	.00
18	.32	2.3	1.0	3.4	1.7	.92	.56	.13	.00	.00	.00	.00
19	.21	2.4	1.3	3.4	1.5	1.2	.68	.16	.00	335	.00	.00
20	.23	2.3	1.1	3.5	2.8	1.1	1.2	.19	.00	7.7	.00	.00
21	.22	1.5	1.9	5.5	3.1	.84	1.2	.14	.00	.24	.00	.00
22	.43	1.3	2.0	3.8	1.6	3.4	.95	.11	.00	.00	.00	.00
23	.31	1.2	1.9	2.6	2.4	1.2	.76	.12	.00	.00	.00	.00
24	.51	1.3	1.9	2.2	2.1	1.1	.82	.19	.00	.00	.00	1.8
25	.61	1.1	3.5	2.4	2.4	.94	1.3	.10	.00	.00	.00	34700
26	.57	1.0	3.1	3.4	2.2	1.2	1.0	.10	.00	2180	.00	2050
27	.63	1.2	3.9	4.5	4.4	1.1	.76	.15	.00	641	.00	138
28	.66	1.1	3.1	3.6	5.3	.95	.44	.14	.00	20	.00	5.7
29	.42	1.6	4.2	3.6	---	.90	.43	.26	.00	.88	.00	.47
30	.94	1.9	4.3	2.7	---	.86	.40	.21	.00	.02	.00	.14
31	.83	---	2.5	4.6	---	1.1	---	.14	---	.00	.00	---
TOTAL	10.43	84.47	72.2	89.8	78.7	8798.01	30.07	7.50	1.53	3184.84	0.00	36896.11

WTR YR 1978 TOTAL 49253.66

SUSPENDED-SEDIMENT, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DAY	APRIL MEAN CONCEN-TRATION (MG/L)	APRIL LOADS (T/DAY)	MAY MEAN CONCEN-TRATION (MG/L)	MAY LOADS (T/DAY)	JUNE MEAN CONCEN-TRATION (MG/L)	JUNE LOADS (T/DAY)	JULY MEAN CONCEN-TRATION (MG/L)	JULY LOADS (T/DAY)	AUGUST MEAN CONCEN-TRATION (MG/L)	AUGUST LOADS (T/DAY)	SEPTEMBER MEAN CONCEN-TRATION (MG/L)	SEPTEMBER LOADS (T/DAY)
1	150	.16	95	.33	150	.08	0	.00	0	.00	0	.00
2	150	.20	92	.27	500	.68	0	.00	0	.00	0	.00
3	150	.20	104	.37	40000	529	0	.00	0	.00	0	.00
4	150	.24	86	.26	20000	59	0	.00	0	.00	0	.00
5	150	.32	96	.29	2000	1.6	0	.00	0	.00	0	.00
6	150	.32	84	.25	500	.27	0	.00	0	.00	0	.00
7	100	.35	93	.33	200	1.1	0	.00	0	.00	0	.00
8	100	.35	111	.33	200	.11	0	.00	0	.00	0	.00
9	200	.70	101	.22	150	.40	0	.00	0	.00	0	.00
10	200	1.1	96	.29	100	.03	0	.00	0	.00	0	.00
11	150	.97	100	.35	100	.03	0	.00	0	.00	0	.00
12	150	.73	106	.31	50	.01	0	.00	0	.00	0	.00
13	150	.53	106	.20	50	.01	0	.00	0	.00	0	.00
14	150	.45	104	.20	0	.00	0	.00	0	.00	0	.00
15	150	.32	166	.49	0	.00	0	.00	0	.00	0	.00
16	150	.32	69	.15	0	.00	0	.00	57200	5750	0	.00
17	158	.30	76	.27	0	.00	0	.00	49000	1190	0	.00
18	140	.23	60	.08	0	.00	0	.00	195	2.3	0	.00
19	132	.21	61	.08	0	.00	0	.00	250	2.4	0	.00
20	118	.19	40	.04	0	.00	0	.00	139	.88	0	.00
21	152	.29	50	.07	0	.00	0	.00	0	.00	0	.00
22	132	.25	50	.11	0	.00	0	.00	0	.00	0	.00
23	127	.38	50	.11	0	.00	0	.00	0	.00	0	.00
24	127	.38	100	.30	0	.00	0	.00	0	.00	0	.00
25	103	.31	4800	41	0	.00	0	.00	0	.00	0	.00
26	111	.39	5200	154	0	.00	0	.00	0	.00	0	.00
27	123	.43	4780	142	0	.00	0	.00	0	.00	0	.00
28	110	.33	5040	20	0	.00	0	.00	0	.00	0	.00
29	102	.22	2000	1.1	0	.00	0	.00	0	.00	0	.00
30	94	.20	800	.43	0	.00	0	.00	0	.00	0	.00
31	---	---	500	.27	---	---	0	.00	0	.00	---	---
TOTAL	---	11.37	---	364.50	---	592.32	---	0.00	---	6945.58	---	0.00

TOTAL LOAD FOR YEAR: 230402.56 TONS.

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	TEMPER-ATURE, WATER (DEG C)	SEDI-MENT, SUS-PENDED (MG/L)	SEDI-MENT DIS-CHARGE, SUS-PENDED (T/DAY)	SED. SUSP. FALL DIAM. % FINER THAN .002 MM	SED. SUSP. FALL DIAM. % FINER THAN .004 MM	SED. SUSP. FALL DIAM. % FINER THAN .016 MM	SED. SUSP. FALL DIAM. % FINER THAN .062 MM	SED. SUSP. FALL DIAM. % FINER THAN .125 MM	SED. SUSP. FALL DIAM. % FINER THAN .250 MM
NOV 04...	1600	17	16.0	7120	327	77	92	100	--	--	--
DEC 17...	1600	150	--	73000	29600	44	49	69	83	95	100
FEB 13...	1530	25	6.0	56600	3960	35	42	59	84	97	100
MAR 08...	1600	9.8	15.5	43500	1150	57	71	92	100	--	--

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

SUSPENDED-SEDIMENT, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

DAY	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)
	OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH	
1	56	.23	175	.85	216	1.6	310	1.3	326	5.1	11900	161
2	101	.41	42600	746	301	2.7	313	1.3	243	3.3	9900	107
3	550	2.2	44400	2600	264	2.6	300	1.2	320	5.2	11100	150
4	64	.25	13100	1220	186	1.4	338	1.4	448	8.5	37000	799
5	129	.45	23300	540	238	2.1	346	1.4	426	8.1	41500	896
6	200	.81	8900	67	200	2.2	410	1.7	427	9.2	41000	886
7	40	.16	694	2.8	196	1.3	454	1.8	431	9.3	45000	1220
8	54	.26	652	2.6	224	.91	445	1.8	574	13	44500	1200
9	82	.40	698	2.8	209	.85	464	1.9	602	15	---	1020
10	122	.49	769	3.7	370	1.8	660	2.7	604	15	---	230
11	132	.53	40400	1070	196	.95	679	2.7	41500	5600	---	27
12	553	2.2	97100	47200	140	.42	698	2.8	55500	3750	---	8.1
13	201	.98	24700	1000	175	.52	676	2.7	58000	3920	---	5.7
14	106	.43	1140	20	890	24	604	2.4	108000	43700	---	4.0
15	112	.54	1340	18	1060	34	2300	120	103000	41700	---	2.7
16	297	1.7	1260	11	563	38	2540	103	36000	9230	---	2.2
17	340	2.2	382	3.7	67000	27100	2260	61	15200	1850	300	.40
18	1270	8.2	394	3.8	66500	13500	8150	660	15700	2540	250	.34
19	640	3.6	375	3.5	28000	1890	8270	558	13600	1490	150	.24
20	140	.79	322	3.1	1800	49	7970	220	13100	1240	150	.28
21	150	.73	324	3.1	1770	38	583	6.3	8600	580	150	.32
22	2680	86	334	4.0	1500	32	606	6.5	5900	159	150	.20
23	3450	56	282	3.4	1450	31	164	2.0	1900	26	150	.20
24	2030	18	306	4.0	1160	25	185	2.2	408	4.4	150	.20
25	1460	13	252	3.7	1180	25	176	2.4	410	4.4	150	.20
26	1260	7.1	194	2.3	1040	20	186	2.5	9000	97	150	.20
27	700	3.4	204	2.4	926	18	246	3.7	16500	222	150	.20
28	520	2.9	188	2.2	1330	36	244	3.6	16900	274	500	.94
29	189	1.1	222	2.6	1320	36	265	4.3	---	---	200	1.1
30	247	1.4	230	2.7	774	10	270	4.4	---	---	200	.70
31	242	1.4	---	---	355	1.4	304	4.9	---	---	150	.20
TOTAL	---	217.87	---	54549.35	---	42926.75	---	1791.9	---	116478.5	---	6724.42

09401260 MOENKOPI WASH AT MOENKOPI, AZ--Continued

SUSPENDED-SEDIMENT, FOR PERIOD OCTOBER 1979 TO DECEMBER 1979

DAY	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)
	OCTOBER		NOVEMBER		DECEMBER	
1	0	.00	329	1.3	227	2.5
2	0	.00	338	1.4	388	4.2
3	0	.00	265	.79	330	3.6
4	0	.00	241	.39	356	3.8
5	0	.00	251	.41	280	3.0
6	0	.00	482	.91	478	5.2
7	0	.00	500	1.5	228	2.5
8	0	.00	12700	362	107	1.2
9	0	.00	2250	51	246	2.7
10	0	.00	2330	20	368	4.0
11	0	.00	420	2.0	169	1.8
12	0	.00	462	2.6	224	2.2
13	0	.00	326	2.1	167	1.4
14	0	.00	291	1.9	158	1.3
15	0	.00	292	1.7	188	1.5
16	30	.06	337	1.9	178	1.4
17	30	.05	250	1.4	233	1.9
18	32	.04	217	1.4	312	2.5
19	45	.06	142	1.1	206	1.7
20	46	.12	766	9.1	148	1.2
21	70000	15700	470	5.6	226	1.8
22	58800	2250	430	3.7	384	3.1
23	7260	63	315	4.6	226	1.8
24	6020	29	360	6.3	382	3.1
25	1240	5.0	431	7.6	190	1.5
26	482	1.7	146	2.4	374	3.0
27	388	1.6	202	3.3	528	5.7
28	519	2.5	132	1.6	1160	16
29	410	2.7	132	1.6	367	3.0
30	514	3.3	102	1.1	326	2.6
31	493	2.0	---	---	366	3.0
TOTAL	---	18061.13	---	502.70	---	94.2

TOTAL LOAD FOR PERIOD: 18658.03 TONS

ATTACHMENT 5

Statistical Summary of Selected Water Quality Parameters for Stream Monitoring Sites (1980 - 1985)

PEABODY COAL COMPANY
ARIZONA DIVISION
STREAM WATER QUALITY STATISTICS

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
MINENO=0252 SAMPPT=0015										
AK4	ALK AS CACO3, PH 4.5	MG_L	58	188.74	247.49	64.00	1688.00	32.50	10946.70	61250.36
CD	CADMIUM, DISSOLVED	UG_L	57	7.32	5.16	4.00	30.00	0.68	417.00	26.58
CA	CALCIUM, DISSOLVED	MG_L	58	178.23	237.74	32.00	1875.00	31.22	10337.60	56520.05
CL	CHLORIDE	MG_L	58	18.92	17.53	1.00	78.90	2.30	1097.10	307.40
F	FLUORIDE	MG_L	57	0.37	0.14	0.11	0.80	0.02	21.10	0.02
FET	IRON, TOTAL	MG_L	55	390.61	738.91	0.10	3850.00	99.64	21483.79	545994.51
PB	LEAD, DISSOLVED	UG_L	41	56.34	56.29	20.00	230.00	8.79	2310.00	3168.78
MG	MAGNESIUM, DISSOLVED	MG_L	57	87.50	116.85	0.50	596.00	15.48	4987.70	13654.35
MNT	MANGANESE, TOTAL	MG_L	55	10.93	14.32	0.18	62.10	1.93	600.92	204.97
N_3	NITRATE NITROGEN _N	MG_L	58	1.55	1.34	0.06	5.20	0.18	89.81	1.80
K	POTASSIUM, DISSOLVED	MG_L	57	8.14	3.36	4.00	20.60	0.45	464.00	11.31
SE	SELENIUM, DISSOLVED	UG_L	58	10.78	7.65	5.00	50.00	1.01	625.00	58.60
NA	SODIUM, DISSOLVED	MG_L	58	52.26	67.73	5.00	384.00	8.89	3030.90	4586.76
SD	SOLIDS, DISSOLVED	MG_L	56	1395.84	1560.02	180.00	9050.00	208.47	78167.00	2433652.03
SO4	SULFATE	MG_L	58	827.21	1107.32	25.00	5910.00	145.40	47978.00	1226150.06
MINENO=0252 SAMPPT=0016										
AK4	ALK AS CACO3, PH 4.5	MG_L	33	117.18	63.80	31.20	368.00	11.11	3867.00	4070.39
CD	CADMIUM, DISSOLVED	UG_L	33	5.52	2.02	2.00	10.00	0.35	182.00	4.07
CA	CALCIUM, DISSOLVED	MG_L	33	70.78	42.74	17.00	200.00	7.44	2335.60	1826.30
CL	CHLORIDE	MG_L	32	8.24	6.27	1.00	31.00	1.11	263.80	39.26
F	FLUORIDE	MG_L	33	0.27	0.14	0.10	0.80	0.02	8.98	0.02
FET	IRON, TOTAL	MG_L	32	345.43	360.11	0.10	1220.00	63.66	11053.90	129679.01
PB	LEAD, DISSOLVED	UG_L	27	37.41	51.19	20.00	280.00	9.85	1010.00	2619.94
MG	MAGNESIUM, DISSOLVED	MG_L	33	19.94	31.41	0.70	180.00	5.47	658.10	986.28
MNT	MANGANESE, TOTAL	MG_L	32	10.70	16.96	0.09	100.00	3.00	342.56	287.53
N_3	NITRATE NITROGEN _N	MG_L	33	0.78	0.50	0.12	2.20	0.09	25.58	0.25
K	POTASSIUM, DISSOLVED	MG_L	33	6.17	2.43	1.30	16.00	0.42	203.50	5.88
SE	SELENIUM, DISSOLVED	UG_L	33	8.73	2.17	5.00	10.00	0.38	288.00	4.70
NA	SODIUM, DISSOLVED	MG_L	33	12.07	22.31	2.00	120.00	3.88	398.20	497.71
SD	SOLIDS, DISSOLVED	MG_L	32	449.13	337.99	136.00	1990.00	59.75	14372.00	114234.76
SO4	SULFATE	MG_L	33	169.82	223.52	3.00	1260.00	38.91	5604.00	49959.15

PEABODY COAL COMPANY
ARIZONA DIVISION
STREAM WATER QUALITY STATISTICS

MINENO=0252 SAMPPT=0034

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
AK4	ALK AS CACO3, PH 4.5	MG_L	8	191.97	128.23	74.00	410.00	45.33	1535.80	16441.95
CD	CADMIUM, DISSOLVED	UG_L	8	6.63	2.20	5.00	10.00	0.78	53.00	4.84
CA	CALCIUM, DISSOLVED	MG_L	8	234.25	137.52	72.00	520.00	48.62	1874.00	18911.64
CL	CHLORIDE	MG_L	8	24.64	23.48	6.00	80.00	8.30	197.10	551.36
F	FLUORIDE	MG_L	8	0.40	0.26	0.10	0.80	0.09	3.23	0.07
FET	IRON, TOTAL	MG_L	8	365.97	363.93	0.70	850.00	128.67	2927.80	132441.85
PB	LEAD, DISSOLVED	UG_L	7	38.57	18.64	20.00	60.00	7.05	270.00	347.62
MG	MAGNESIUM, DISSOLVED	MG_L	8	130.95	152.69	32.50	500.00	53.99	1047.60	23315.39
MNT	MANGANESE, TOTAL	MG_L	8	9.78	8.66	0.06	21.90	3.06	78.26	74.93
N_3	NITRATE NITROGEN _N	MG_L	8	4.12	8.20	0.20	24.30	2.90	32.94	67.18
K	POTASSIUM, DISSOLVED	MG_L	8	9.11	2.67	4.60	13.50	0.95	72.90	7.15
SE	SELENIUM, DISSOLVED	UG_L	8	8.75	2.31	5.00	10.00	0.82	70.00	5.36
NA	SODIUM, DISSOLVED	MG_L	8	143.75	219.49	19.00	680.00	77.60	1150.00	48177.64
SD	SOLIDS, DISSOLVED	MG_L	8	1997.88	1808.42	668.00	6270.00	639.37	15983.00	3270395.55
SO4	SULFATE	MG_L	8	1186.50	1201.35	252.00	4000.00	424.74	9492.00	1443251.14

MINENO=0252 SAMPPT=0035

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
AK4	ALK AS CACO3, PH 4.5	MG_L	24	170.00	184.56	51.70	923.00	37.67	4080.10	34061.19
CD	CADMIUM, DISSOLVED	UG_L	24	7.00	4.67	4.00	23.00	0.95	168.00	21.83
CA	CALCIUM, DISSOLVED	MG_L	24	157.92	134.83	33.00	408.00	27.52	3790.20	18178.16
CL	CHLORIDE	MG_L	24	15.96	20.97	1.00	90.00	4.28	383.00	439.67
F	FLUORIDE	MG_L	23	0.39	0.18	0.10	0.70	0.04	9.06	0.03
FET	IRON, TOTAL	MG_L	22	384.22	464.76	0.15	1500.00	99.09	8452.82	216005.85
PB	LEAD, DISSOLVED	UG_L	20	49.00	62.15	20.00	220.00	13.90	980.00	3862.11
MG	MAGNESIUM, DISSOLVED	MG_L	24	88.74	129.09	1.80	420.00	26.35	2129.70	16664.56
MNT	MANGANESE, TOTAL	MG_L	22	8.37	6.41	0.04	20.00	1.37	184.10	41.05
N_3	NITRATE NITROGEN _N	MG_L	24	1.59	2.48	0.01	12.30	0.51	38.07	6.15
K	POTASSIUM, DISSOLVED	MG_L	24	8.14	3.20	4.00	18.20	0.65	195.40	10.23
SE	SELENIUM, DISSOLVED	UG_L	24	12.92	11.51	5.00	50.00	2.35	310.00	132.43
NA	SODIUM, DISSOLVED	MG_L	24	65.46	107.55	3.00	370.00	21.95	1571.00	11567.24
SD	SOLIDS, DISSOLVED	MG_L	24	1311.63	1521.61	220.00	4890.00	310.60	31479.00	2315285.64
SO4	SULFATE	MG_L	24	766.13	1050.95	38.00	3060.00	214.52	18387.00	1104493.94

PEABODY COAL COMPANY
ARIZONA DIVISION
STREAM WATER QUALITY STATISTICS

MINENO=0252 SAMPPT=0037

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
AK4	ALK AS CACO3, PH 4.5	MG_L	15	303.31	420.99	52.50	1382.00	108.70	4549.70	177233.09
CD	CADMIUM, DISSOLVED	UG_L	15	6.60	2.26	5.00	11.00	0.58	99.00	5.11
CA	CALCIUM, DISSOLVED	MG_L	15	149.63	144.21	34.10	600.00	37.24	2244.50	20797.53
CL	CHLORIDE	MG_L	15	19.22	27.41	1.00	110.00	7.08	288.30	751.04
F	FLUORIDE	MG_L	15	0.38	0.21	0.15	0.90	0.05	5.77	0.05
FET	IRON, TOTAL	MG_L	14	644.32	556.30	0.10	1900.00	148.68	9020.42	309465.11
PB	LEAD, DISSOLVED	UG_L	13	46.92	50.40	20.00	200.00	13.98	610.00	2539.74
MG	MAGNESIUM, DISSOLVED	MG_L	15	61.40	68.97	4.80	260.00	17.81	921.00	4756.61
MNT	MANGANESE, TOTAL	MG_L	14	13.76	11.73	0.04	40.50	3.14	192.65	137.66
N_3	NITRATE NITROGEN _N	MG_L	15	2.41	6.17	0.06	24.50	1.59	36.12	38.07
K	POTASSIUM, DISSOLVED	MG_L	15	7.23	2.39	3.80	11.70	0.62	108.40	5.73
SE	SELENIUM, DISSOLVED	UG_L	15	11.67	10.80	5.00	50.00	2.79	175.00	116.67
NA	SODIUM, DISSOLVED	MG_L	15	95.21	135.58	2.60	510.00	35.01	1428.20	18381.49
SD	SOLIDS, DISSOLVED	MG_L	15	1204.87	1264.63	224.00	4890.00	326.53	18073.00	1599282.98
SO4	SULFATE	MG_L	15	648.40	758.26	40.00	2920.00	195.78	9726.00	574961.69

MINENO=0252 SAMPPT=0050

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
AK4	ALK AS CACO3, PH 4.5	MG_L	46	198.20	200.07	27.80	1203.50	29.50	9117.10	40026.9
CD	CADMIUM, DISSOLVED	UG_L	44	5.68	2.15	2.00	12.00	0.32	250.00	4.6
CA	CALCIUM, DISSOLVED	MG_L	44	174.95	179.47	24.20	1147.00	27.06	7697.60	32208.2
CL	CHLORIDE	MG_L	46	22.48	21.89	1.00	97.50	3.23	1034.10	479.3
F	FLUORIDE	MG_L	45	0.33	0.13	0.10	0.90	0.02	14.74	0.0
FET	IRON, TOTAL	MG_L	43	458.83	609.14	0.10	2630.00	92.89	19729.75	371052.9
PB	LEAD, DISSOLVED	UG_L	31	36.77	26.00	20.00	110.00	4.67	1140.00	675.9
MG	MAGNESIUM, DISSOLVED	MG_L	43	66.43	86.06	6.80	500.00	13.12	2856.40	7406.6
MNT	MANGANESE, TOTAL	MG_L	43	17.22	23.76	0.06	132.00	3.62	740.65	564.4
N_3	NITRATE NITROGEN _N	MG_L	46	1.44	1.60	0.19	7.38	0.24	66.06	2.6
K	POTASSIUM, DISSOLVED	MG_L	45	6.10	2.60	3.00	13.80	0.39	274.60	6.8
SE	SELENIUM, DISSOLVED	UG_L	45	10.89	8.74	5.00	50.00	1.30	490.00	76.5
NA	SODIUM, DISSOLVED	MG_L	44	28.82	42.42	4.00	270.00	6.39	1267.90	1799.2
SD	SOLIDS, DISSOLVED	MG_L	46	1868.89	4053.64	142.00	26300.00	597.68	85969.00	16431966.2
SO4	SULFATE	MG_L	46	581.54	760.09	21.00	3950.00	112.07	26751.00	577743.4

PEABODY COAL COMPANY
ARIZONA DIVISION
STREAM WATER QUALITY STATISTICS

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
MINENO=0252 SAMPPT=0078										
AK4	ALK AS CACO3, PH 4.5	MG_L	18	167.96	225.19	27.30	1043.00	53.08	3023.20	50709.60
CD	CADMIUM, DISSOLVED	UG_L	18	7.39	4.39	4.00	20.00	1.04	133.00	19.31
CA	CALCIUM, DISSOLVED	MG_L	18	206.63	123.06	30.00	470.00	29.00	3719.40	15143.05
CL	CHLORIDE	MG_L	18	27.08	25.12	1.00	106.70	5.92	487.40	630.92
F	FLUORIDE	MG_L	18	0.37	0.21	0.10	0.78	0.05	6.65	0.04
FET	IRON, TOTAL	MG_L	17	559.02	499.57	0.30	1720.00	121.16	9503.40	249567.66
PB	LEAD, DISSOLVED	UG_L	16	85.63	128.99	20.00	540.00	32.25	1370.00	16639.58
MG	MAGNESIUM, DISSOLVED	MG_L	18	105.06	140.09	1.20	589.00	33.02	1891.10	19625.05
MNT	MANGANESE, TOTAL	MG_L	17	11.00	10.92	0.12	36.50	2.65	186.99	119.17
N_3	NITRATE NITROGEN _N	MG_L	18	0.98	0.85	0.02	3.88	0.20	17.68	0.72
K	POTASSIUM, DISSOLVED	MG_L	18	9.21	4.15	3.90	20.00	0.98	165.70	17.19
SE	SELENIUM, DISSOLVED	UG_L	18	10.83	10.04	5.00	50.00	2.37	195.00	100.74
NA	SODIUM, DISSOLVED	MG_L	18	96.50	102.10	7.00	415.00	24.07	1737.00	10424.27
SD	SOLIDS, DISSOLVED	MG_L	17	1822.65	1530.25	200.00	6564.00	371.14	30985.00	2341662.74
SO4	SULFATE	MG_L	18	1063.39	1022.67	48.00	4450.00	241.04	19141.00	1045848.02
MINENO=0252 SAMPPT=0157										
AK4	ALK AS CACO3, PH 4.5	MG_L	11	82.99	12.09	64.00	110.00	3.65	912.90	146.24
CD	CADMIUM, DISSOLVED	UG_L	11	5.00	0.00	5.00	5.00	0.00	55.00	0.00
CA	CALCIUM, DISSOLVED	MG_L	11	37.91	14.12	24.00	71.40	4.26	417.00	199.47
CL	CHLORIDE	MG_L	11	4.27	3.66	1.00	11.00	1.10	47.00	13.42
F	FLUORIDE	MG_L	11	0.30	0.11	0.10	0.50	0.03	3.30	0.01
FET	IRON, TOTAL	MG_L	10	270.97	242.99	0.69	710.00	76.84	2709.69	59044.62
PB	LEAD, DISSOLVED	UG_L	8	20.00	0.00	20.00	20.00	0.00	160.00	0.00
MG	MAGNESIUM, DISSOLVED	MG_L	11	8.75	5.04	2.00	17.00	1.52	96.30	25.42
MNT	MANGANESE, TOTAL	MG_L	10	7.85	3.36	4.00	14.00	1.06	78.50	11.29
N_3	NITRATE NITROGEN _N	MG_L	11	0.80	0.38	0.20	1.50	0.11	8.80	0.14
K	POTASSIUM, DISSOLVED	MG_L	11	6.75	2.28	4.00	12.00	0.69	74.30	5.21
SE	SELENIUM, DISSOLVED	UG_L	11	10.00	0.00	10.00	10.00	0.00	110.00	0.00
NA	SODIUM, DISSOLVED	MG_L	11	6.19	5.25	1.50	15.00	1.58	68.10	27.55
SD	SOLIDS, DISSOLVED	MG_L	11	229.27	68.19	160.00	386.00	20.56	2522.00	4649.22
SO4	SULFATE	MG_L	11	55.36	42.15	13.00	162.00	12.71	609.00	1776.85

PEABODY COAL COMPANY
ARIZONA DIVISION
STREAM WATER QUALITY STATISTICS

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
MINENO=0250 SAMPPT=0014										
AK4	ALK AS CACO3, PH 4.5	MG_L	24	143.64	106.93	41.40	420.00	21.83	3447.30	11433.62
CD	CADMIUM, DISSOLVED	UG_L	23	12.83	32.37	3.00	160.00	6.75	295.00	1047.70
CA	CALCIUM, DISSOLVED	MG_L	23	67.46	64.18	21.00	283.00	13.38	1551.60	4118.84
CL	CHLORIDE	MG_L	24	12.07	19.47	1.00	67.60	3.97	289.70	379.16
F	FLUORIDE	MG_L	24	0.35	0.17	0.10	0.70	0.04	8.39	0.03
FET	IRON, TOTAL	MG_L	22	507.65	515.34	0.12	1600.00	109.87	11168.21	265574.81
PB	LEAD, DISSOLVED	UG_L	20	46.00	50.30	20.00	170.00	11.25	920.00	2530.53
MG	MAGNESIUM, DISSOLVED	MG_L	23	45.65	85.50	1.60	276.00	17.83	1049.90	7310.05
MNT	MANGANESE, TOTAL	MG_L	22	22.48	62.51	0.04	300.00	13.33	494.49	3907.44
N_3	NITRATE NITROGEN _N	MG_L	24	3.62	8.08	0.20	30.50	1.65	86.91	65.23
K	POTASSIUM, DISSOLVED	MG_L	23	5.73	3.26	1.90	15.50	0.68	131.70	10.63
SE	SELENIUM, DISSOLVED	UG_L	23	10.65	8.83	5.00	50.00	1.84	245.00	77.96
NA	SODIUM, DISSOLVED	MG_L	23	61.00	117.65	5.60	389.00	24.53	1402.90	13840.60
SD	SOLIDS, DISSOLVED	MG_L	23	782.83	1205.59	130.00	4117.00	251.38	18005.00	1453443.88
SO4	SULFATE	MG_L	24	349.67	657.65	4.00	2340.00	134.24	8392.00	432499.97
MINENO=0250 SAMPPT=0018										
AK4	ALK AS CACO3, PH 4.5	MG_L	27	193.39	190.46	70.00	854.00	36.65	5221.40	36274.07
CD	CADMIUM, DISSOLVED	UG_L	27	18.56	39.97	5.00	210.00	7.69	501.00	1597.33
CA	CALCIUM, DISSOLVED	MG_L	27	149.17	113.42	43.00	546.00	21.83	4027.60	12863.44
CL	CHLORIDE	MG_L	27	20.70	14.86	1.00	55.00	2.86	558.90	220.87
F	FLUORIDE	MG_L	26	1.33	5.03	0.17	26.00	0.99	34.55	25.33
FET	IRON, TOTAL	MG_L	23	226.75	366.01	0.13	1200.00	76.32	5215.35	133966.61
PB	LEAD, DISSOLVED	UG_L	24	100.00	173.58	20.00	810.00	35.43	2400.00	30130.43
MG	MAGNESIUM, DISSOLVED	MG_L	27	139.34	236.80	3.80	923.00	45.57	3762.10	56072.88
MNT	MANGANESE, TOTAL	MG_L	24	6.05	8.24	0.12	27.00	1.68	145.18	67.91
N_3	NITRATE NITROGEN _N	MG_L	27	4.76	9.91	0.20	47.90	1.91	128.47	98.18
K	POTASSIUM, DISSOLVED	MG_L	27	10.57	5.18	4.30	25.20	1.00	285.50	26.88
SE	SELENIUM, DISSOLVED	UG_L	27	14.07	13.01	5.00	50.00	2.50	380.00	169.30
NA	SODIUM, DISSOLVED	MG_L	27	123.63	187.17	5.00	868.00	36.02	3338.10	35031.05
SD	SOLIDS, DISSOLVED	MG_L	25	1622.88	2205.02	254.00	9580.00	441.00	40572.00	4862098.86
SO4	SULFATE	MG_L	26	1157.08	1578.98	82.00	6020.00	309.66	30084.00	2493180.55

PEABODY COAL COMPANY
ARIZONA DIVISION
STREAM WATER QUALITY STATISTICS

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
MINENO=0250 SAMPPT=0025										
AK4	ALK AS CACO3, PH 4.5	MG_L	15	198.88	108.97	78.00	439.70	28.13	2983.20	11873.54
CD	CADMIUM, DISSOLVED	UG_L	15	10.53	11.90	5.00	50.00	3.07	158.00	141.55
CA	CALCIUM, DISSOLVED	MG_L	15	187.29	122.22	52.00	450.00	31.56	2809.30	14938.65
CL	CHLORIDE	MG_L	15	20.72	12.41	8.00	49.60	3.20	310.80	153.94
F	FLUORIDE	MG_L	15	0.33	0.14	0.10	0.50	0.04	4.95	0.02
FET	IRON, TOTAL	UG_L	15	277.00	349.67	0.20	1200.00	90.28	4155.04	122267.20
PB	LEAD, DISSOLVED	UG_L	15	64.67	66.53	20.00	190.00	17.18	970.00	4426.67
MG	MAGNESIUM, DISSOLVED	MG_L	15	118.86	135.18	6.50	500.00	34.90	1782.90	18273.09
MNT	MANGANESE, TOTAL	MG_L	15	13.18	30.48	0.10	121.00	7.87	197.74	928.78
N_3	NITRATE NITROGEN _N	MG_L	15	3.28	3.59	0.20	14.00	0.93	49.19	12.92
K	POTASSIUM, DISSOLVED	MG_L	15	8.91	1.88	6.00	12.00	0.48	133.70	3.52
SE	SELENIUM, DISSOLVED	UG_L	15	12.00	10.66	5.00	50.00	2.75	180.00	113.57
NA	SODIUM, DISSOLVED	MG_L	15	125.59	105.89	20.00	350.00	27.34	1883.90	11212.51
SD	SOLIDS, DISSOLVED	MG_L	15	1853.20	1436.39	350.00	4297.00	370.87	27798.00	2063216.74
SO4	SULFATE	MG_L	14	1061.21	1013.97	100.00	2950.00	271.00	14857.00	1028142.03
MINENO=0250 SAMPPT=0026										
AK4	ALK AS CACO3, PH 4.5	MG_L	27	307.99	444.09	89.00	2350.00	85.47	8315.70	197217.12
CD	CADMIUM, DISSOLVED	UG_L	27	12.04	18.46	5.00	100.00	3.55	325.00	340.81
CA	CALCIUM, DISSOLVED	MG_L	27	224.19	136.20	28.50	497.00	26.21	6053.10	18551.07
CL	CHLORIDE	MG_L	27	23.32	14.78	2.00	54.80	2.85	629.60	218.57
F	FLUORIDE	MG_L	27	0.41	0.21	0.10	0.80	0.04	11.17	0.04
FET	IRON, TOTAL	MG_L	24	362.92	416.87	0.10	1320.00	85.09	8710.16	173777.74
PB	LEAD, DISSOLVED	UG_L	24	80.00	69.97	20.00	220.00	14.28	1920.00	4895.65
MG	MAGNESIUM, DISSOLVED	MG_L	26	126.07	126.93	0.60	550.00	24.89	3277.70	16110.73
MNT	MANGANESE, TOTAL	MG_L	25	9.66	11.75	0.12	50.00	2.35	241.43	138.04
N_3	NITRATE NITROGEN _N	MG_L	27	1.59	1.71	0.20	8.10	0.33	43.06	2.93
K	POTASSIUM, DISSOLVED	MG_L	27	10.33	3.75	5.60	22.20	0.72	278.80	14.07
SE	SELENIUM, DISSOLVED	UG_L	27	16.67	15.38	5.00	50.00	2.96	450.00	236.54
NA	SODIUM, DISSOLVED	MG_L	26	124.15	96.99	18.00	330.00	19.02	3227.90	9406.40
SD	SOLIDS, DISSOLVED	MG_L	26	1986.85	1346.66	360.00	4804.00	264.10	51658.00	1813479.98
SO4	SULFATE	MG_L	27	1169.70	912.97	121.00	3060.00	175.70	31582.00	833522.45

PEABODY COAL COMPANY
ARIZONA DIVISION
STREAM WATER QUALITY STATISTICS

MINENO=0250 SAMPPT=0085

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
AK4	ALK AS CACO3, PH 4.5	MG_L	13	140.58	218.76	17.50	860.00	60.67	1827.60	47856.28
CD	CADMIUM, DISSOLVED	UG_L	13	5.23	2.35	2.00	10.00	0.65	68.00	5.53
CA	CALCIUM, DISSOLVED	MG_L	13	52.06	47.87	18.00	188.00	13.28	676.80	2291.43
CL	CHLORIDE	MG_L	13	6.87	5.62	1.00	17.90	1.56	89.30	31.63
F	FLUORIDE	MG_L	13	0.30	0.14	0.10	0.60	0.04	3.95	0.02
FET	IRON, TOTAL	MG_L	11	380.67	434.06	1.00	1460.00	130.87	4187.40	188409.00
PB	LEAD, DISSOLVED	UG_L	11	37.27	30.03	20.00	100.00	9.05	410.00	901.82
MG	MAGNESIUM, DISSOLVED	MG_L	13	9.24	7.56	4.20	32.00	2.10	120.10	57.12
MNT	MANGANESE, TOTAL	MG_L	11	8.42	7.06	1.90	23.00	2.13	92.64	49.83
N_3	NITRATE NITROGEN _N	MG_L	13	0.66	0.51	0.06	1.90	0.14	8.55	0.26
K	POTASSIUM, DISSOLVED	MG_L	12	4.12	1.42	1.40	7.00	0.41	49.50	2.03
SE	SELENIUM, DISSOLVED	UG_L	13	11.92	11.64	5.00	50.00	3.23	155.00	135.58
NA	SODIUM, DISSOLVED	MG_L	13	12.63	6.40	5.00	23.90	1.78	164.20	40.96
SD	SOLIDS, DISSOLVED	MG_L	13	289.46	177.04	130.00	814.00	49.10	3763.00	31343.10
SO4	SULFATE	MG_L	13	117.85	158.26	2.00	500.00	43.89	1532.00	25046.47

MINENO=0250 SAMPPT=0155

VARIABLE	LABEL		N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE
AK4	ALK AS CACO3, PH 4.5	MG_L	5	121.60	62.15	78.00	226.00	27.79	608.00	3862.80
CD	CADMIUM, DISSOLVED	UG_L	5	5.00	0.00	5.00	5.00	0.00	25.00	0.00
CA	CALCIUM, DISSOLVED	MG_L	5	62.00	61.70	22.00	170.00	27.60	310.00	3807.50
CL	CHLORIDE	MG_L	5	8.36	7.97	1.00	22.00	3.57	41.80	63.55
F	FLUORIDE	MG_L	5	0.40	0.20	0.20	0.60	0.09	2.00	0.04
FET	IRON, TOTAL	MG_L	4	514.75	338.11	260.00	1000.00	169.05	2059.00	114316.92
PB	LEAD, DISSOLVED	UG_L	5	20.00	0.00	20.00	20.00	0.00	100.00	0.00
MG	MAGNESIUM, DISSOLVED	MG_L	5	18.10	22.50	4.90	58.00	10.06	90.50	506.33
MNT	MANGANESE, TOTAL	MG_L	5	8.96	9.59	0.02	25.00	4.29	44.82	91.92
N_3	NITRATE NITROGEN _N	MG_L	5	1.24	1.42	0.20	3.70	0.63	6.20	2.00
K	POTASSIUM, DISSOLVED	MG_L	5	4.10	2.09	1.30	6.30	0.94	20.50	4.39
SE	SELENIUM, DISSOLVED	UG_L	5	10.00	0.00	10.00	10.00	0.00	50.00	0.00
NA	SODIUM, DISSOLVED	MG_L	5	34.60	37.65	10.00	100.00	16.84	173.00	1417.80
SD	SOLIDS, DISSOLVED	MG_L	5	469.60	485.40	140.00	1320.00	217.08	2348.00	235610.80
SO4	SULFATE	MG_L	5	160.60	244.83	3.00	590.00	109.49	803.00	59943.80

ATTACHMENT 6

Summary of Water Quality Data for US Geological Survey Periodic Surface Water Stations