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REPORT TO THE HOPI TRIBE ON THE RESEARCH & ANALYSIS OF HOPI WATER RESOURCES PLANNING & MANAGEMENT

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INTRODUCTION AND OVERVIEW

Water management and conservation are two of the most important and pervasive issues throughout the West and are particularly significant in Indian Country as tribes move beyond quantification of water rights to the active use, management and protection of tribal water resources. Although water rights quantification still is a paramount concern for many tribes, tribal leaders increasingly are focusing their attention on the management of the water resources for which they have fought so hard.

However, as tribes seek to establish comprehensive water management systems, they must be cognizant of the external pressures that will impact development of such systems. For example, examination of the Arizona water resources management structure reveals that the decision-making environment is becoming increasingly complex and competitive. Factors such as the depletion and scarcity of good quality water resources, water marketing and transfers, ground water overdraft, and other water resource problems exacerbated by the region's population growth not only influence non-Indian water management structures, but also will affect both short- and long-term water management strategies that tribes elect to pursue.

For the Hopi Tribe, water is an integral part of the tribe's religion, culture and tradition and also is crucial

to its present and future economic strength and stability. Tribal leaders possess a profound knowledge of Hopi tradition and must bring and apply such expertise to the decision-making process. Today's difficult decisions involve long-term commitments of land, water and human resources and hasten the need for a comprehensive examination of the role of water resources management in the exercise of tribal sovereignty.

Background of the Development of the Report to the Hopi Tribe on the Research and Analysis of Hopi Water Resources Planning and Management

Recognizing the need to develop an organizational framework and comprehensive management plan for the Hopi Water Resources Program, the Hopi Tribe solicited bids (Invitation to Bid 17-86) pursuant to its tribal policies and procedures. In response to the bid solicitation, the AILTP/American Indian Resources Institute (AIRI) submitted a proposal to the Hopi Tribe on November 21, 1986. AIRI's proposal was accepted by the tribe and a Memorandum of Agreement between the Hopi Tribe and the AILTP/American Indian Resources Institute was made and executed on March 6, 1987. This report contains the results of research conducted from March to August 1987 pursuant to the Memorandum of Agreement.

Scope of Work

Given the complex physical, legal, social, political and economic context of water resources management in the Little Colorado River basin and in the Southwest generally, this project involved the examination of selected issues identified in consultation with tribal natural resources staff during a series of field visits to the Hopi Reservation in April and May of 1987. The scope of work involved the following tasks:

(1) Development of an organizational framework for Hopi water resources management within the context of the institutional setting for water management both on the reservation and in the region and drawing upon other tribal resource management examples across the West.

(2) Analysis of current federal case law, statutes and regulations, tribal law and other statutes forming the basis for Hopi control, regulation and management of reservation land and water resources.

(3) Review and examination of Hopi water resources information, with an emphasis on identifying needed information, applicable to water resources planning and management and on establishing a data base for water management.

(4) Identification of funding sources for tribal water management programs.

(5) Development of a training session for water management personnel.

Organization of the Report

The report consists of five chapters and three appendices. Chapter One describes the location, physiography

and climate of the Hopi Reservation. In Chapter Two, regional political, legal and economic factors affecting tribal water management in the Little Colorado and the Colorado River basins are presented. State and federal water management initiatives, programs and policies applicable to the region and to Hopi water management are discussed. In Chapter Three, the legal basis for Hopi regulatory and administrative authority over water and land resources is addressed, with an emphasis on administrative and legal actions needed to further secure and implement tribal regulatory authority. Chapter Four provides a description of the source and quality of tribal surface and ground water resources, critical water resource information needs, the status of current investigative activities and the major water and land issues confronting tribal natural resource managers in the coming decades.

To integrate the information contained in previous chapters, Chapter Five proposes several alternative strategies for the organizational framework of a Hopi water resources program. The strategies were derived from a review of selected tribal resource management programs in different parts of the country, a review of current Hopi resource management activities, discussions with tribal resources staff and examination of other relevant material.

Appendices relevant to the material discussed in Chapter

Five include an update of litigation involving Indian water rights, a summary of potential funding sources for the development and implementation of tribal water management programs, and a list of regional water resource contacts.

Chapter One

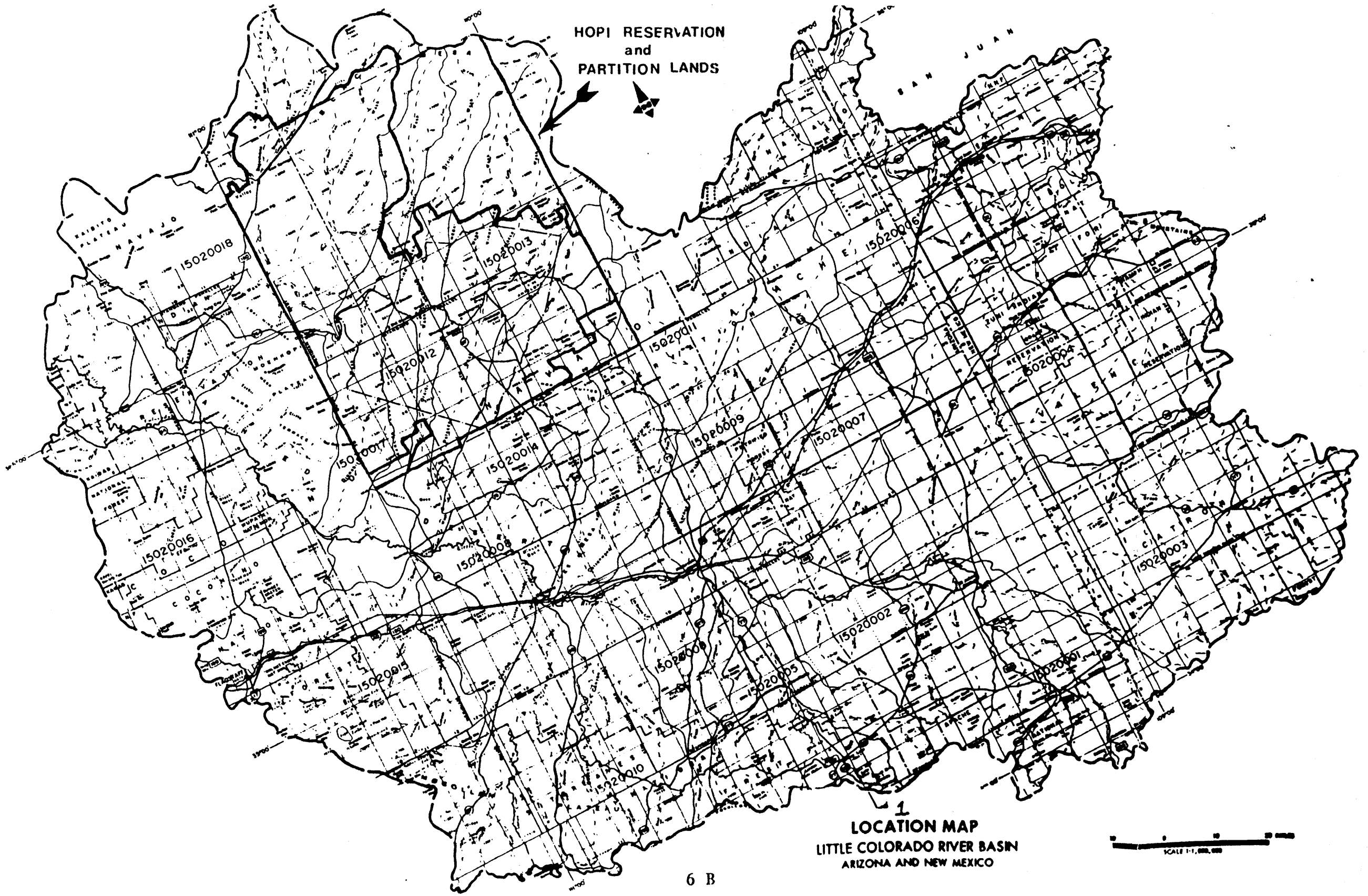
Tribal Lands: Location, Physiography & Climate

CHAPTER ONE

TRIBAL LANDS: LOCATION, PHYSIOGRAPHY AND CLIMATE

The Hopi people have inhabited the Little Colorado watershed from time immemorial, building villages on the mesa tops and planting crops in the valleys and other nearby land-holdings with suitable moisture retention characteristics. The aboriginal territory of the Hopi encompassed more than 2 million acres in the northwest corner of present-day Arizona, and currently consists of 1.8 million acres in the northern portions of the Little Colorado River watershed (figure 1). (See Chapter Three for a summary of the history and present status of tribal land.) Occupation of a predominantly arid region fostered an essential and integral relationship between the people and the water resource, as manifested in the ingenious planting methodologies as well as the religious practices of the people. Today, the water resource continues to shape the contours of tribal relations with the environment. This chapter describes the physical characteristics of the Hopi land and water base.

The Hopi Indian Reservation is located in the upland plateau physiographic province identified by Fenneman[1] (figure 2). The province is a region consisting of gently folded and faulted sedimentary rocks, eroded on large-scale to broad plateaus, buttes, plains, alluvial valleys, and steep canyons characteristic of the topography of the



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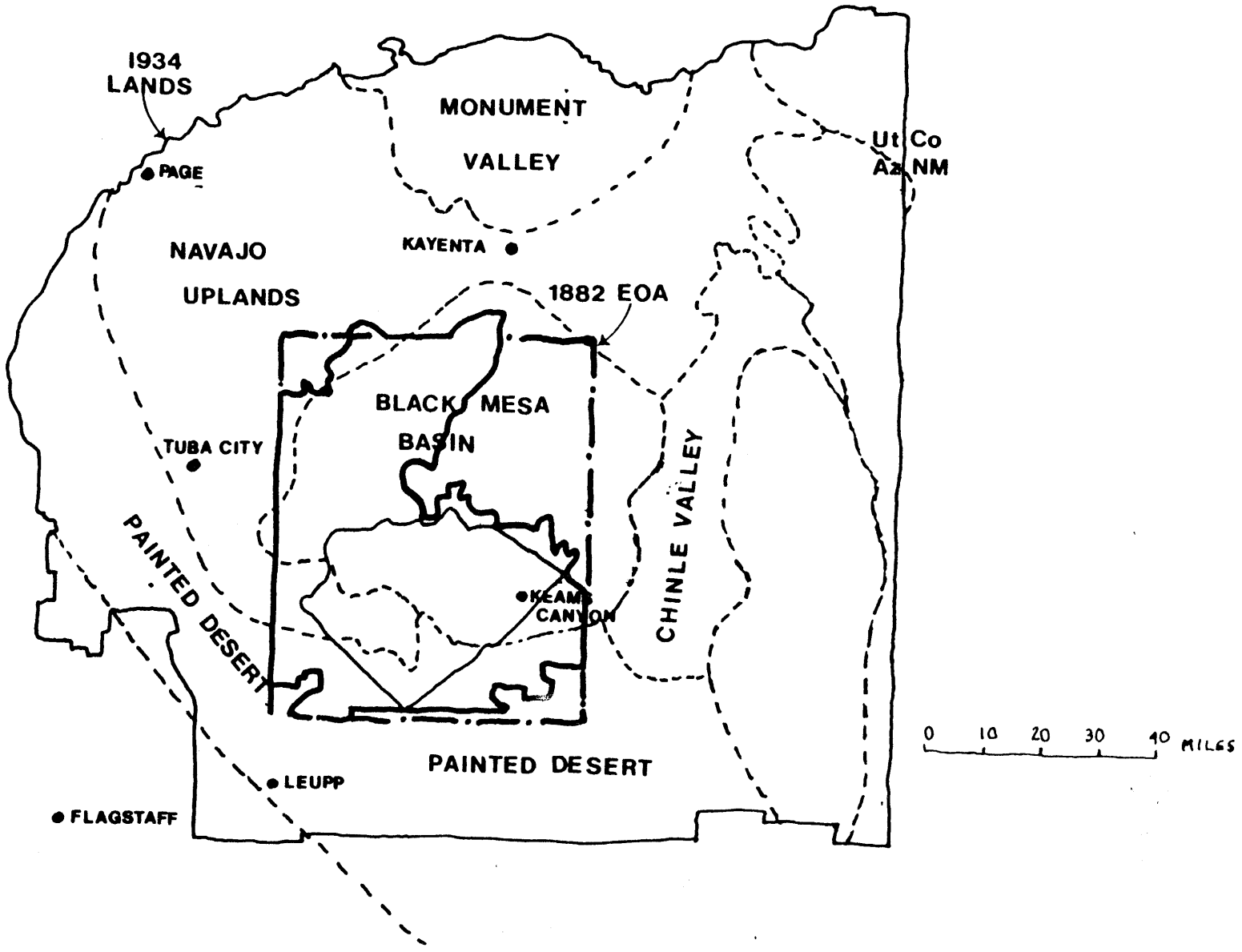
LOCATION MAP

LITTLE COLORADO RIVER BASIN
ARIZONA AND NEW MEXICO

Figure 2: Map showing physiographic provinces of the Hopi reservation

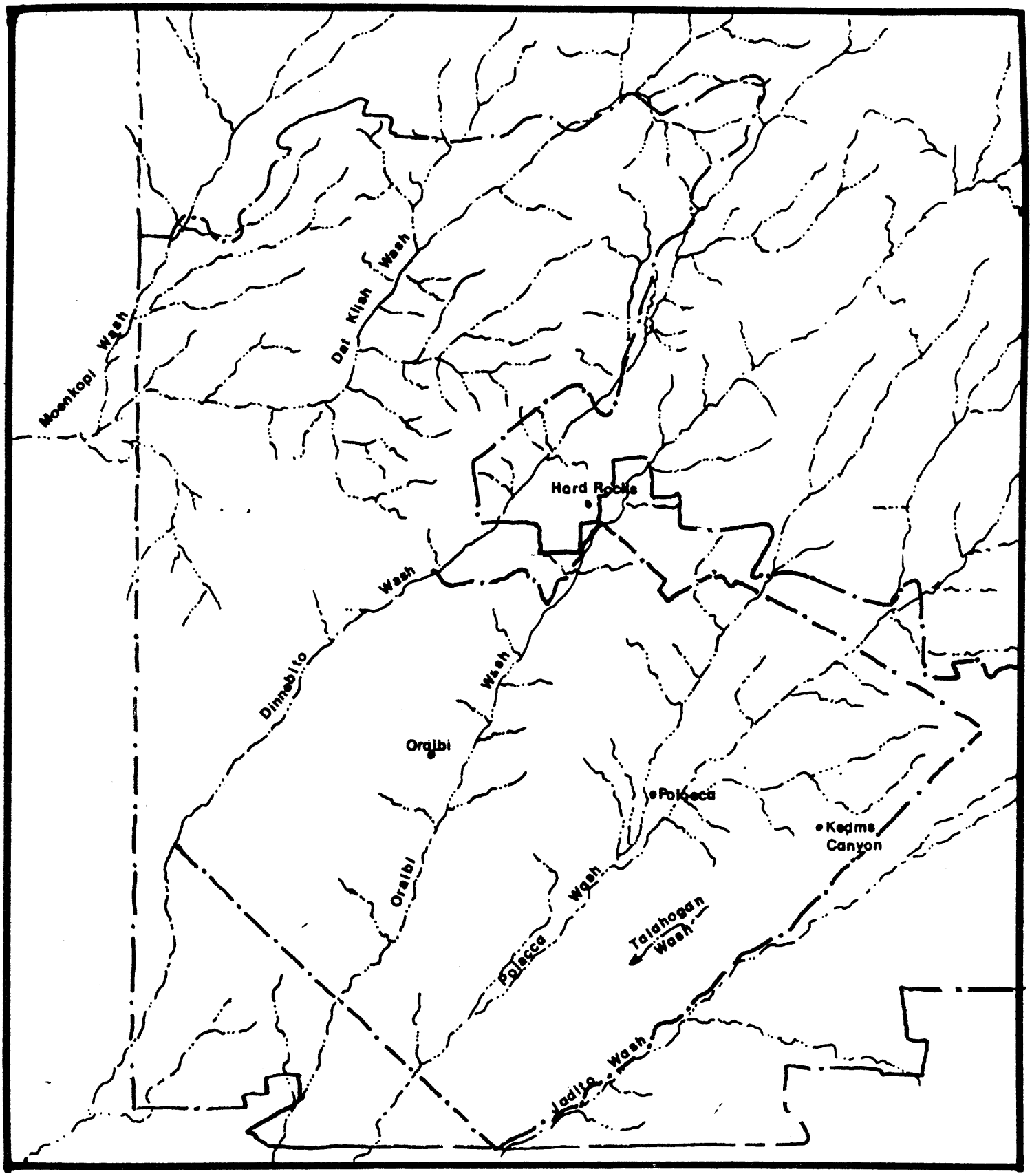


southern portion of the Colorado Plateau region.[2] The sedimentary rocks are underlain by volcanic and metamorphic rocks at depths ranging from 1,000 to 10,000 feet. Much of the Hopi region is blanketed by thin eolian, terrrace and alluvial sand and gravel deposits which locally serve as important sources and storage sites of water.[3] Elevations in the Hopi region range from 5,000 feet in the southern portion of the reservation to over 7,000 feet in the northern Hopi Partitioned Lands.

As mentioned previously, Hopi tribal lands are located almost wholly within the 26,000-mile watershed of the Little Colorado River. Although a small portion of reservation surface water resources drain northward toward the San Juan River, Hopi lands and sub-watersheds comprise approximately 10.5% of the Little Colorado River watershed. Although the reservation land base is small in comparison to the total land base of the Little Colorado River basin, tribal lands do produce significant quantities of water, mainly through winter stream flow and through ground water discharge as springs and seeps.[4] A map of major perennial and ephemeral streams on the Hopi Reservation is presented as figure 3.

The climate of the region is extremely variable, as a result of the broad meteorological processes evident within the region. Main moisture-bearing air masses are from the south and southwest during the winter and come from the southeast during June.[5] The air masses are affected by major

Figure 3: Perennial and Ephemeral Streams
on the Hopi Indian Reservation



topographic features (the San Francisco Peaks, and the Mogollon Rim mountains), thus much of the Hopi Reservation is within the "rain shadow" of the northeast (or leeward) side of the southern border of the Colorado Plateau. At higher elevations, smaller topographic features start to exert significant control: it is not uncommon to have completely different climatic regimes, rainfall amounts and temperatures in valleys as compared to the mesa tops.

Rainfall information has been gathered and analyzed by Hack (1942), Cooley (1969) and others. Although no detailed or long-term studies have been undertaken, the currently available data reveals a strong relationship between precipitation and elevation. Precipitation ranges from less than 6 inches below 4,000 feet to over 12 inches above 7,500 feet. Cooley (1969) initially divided the reservation into climatic zones while Ogden and LeVines (1974) produced a more detailed description of climatic zones and variability. The work of these authors is presented in figure 4.

Vegetation associations in the region are determined by soil type, elevation, topography and precipitation. Below 5,500 feet, grass-shrub associations are prevalent. This area includes extensive badlands and wind-scoured plains with rainfall averaging less than 8 inches annually. The pinyon-juniper zone generally occurs at altitudes of 6,000 feet or more. In this region, where the soil is underlain by

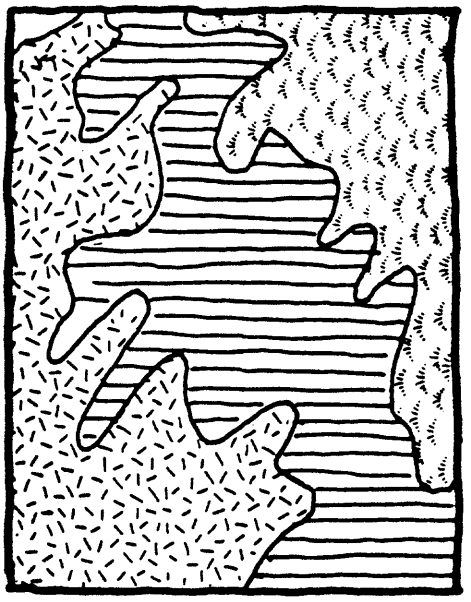


Figure 4. Diagram showing average annual precipitation on the Hopi Indian reservation (Modified from Ogden and LeVinnes, 1975).

Less than 8 Inches

8-12 Inches

More than 12 Inches

sandstone, the zone consists of good grass cover; where the soil is underlain by limestone or shale, the zone has poor to sparse grass cover.

The pine forest zone is found at altitudes above 7,400 feet, where dependable supplies of rainfall are greater than 12 inches per year. Extensive stands of pine, Douglas fir, aspen and oak are common and well-watered meadows are covered with blue grass, rushes and sedges.

The particular physical and climatic characteristics of the Hopi Reservation and the Little Colorado River basin necessitate a careful and planned approach to water resources management, data collection and hydrologic research. For example, certain techniques used to analyze sporadic rainfall would not be applicable to a region of steady, uniform rainfall. The sparseness of surface water flows has produced a reliance on ground water on many parts of the reservation. Because ground water resources are not recharged in significant quantities throughout the year, it is especially important to develop management provisions for the use of ground water.

REFERENCE NOTES TO CHAPTER ONE

1. R. Fenneman, Physiography of the United States (New York: McGraw-Hill, 1948).

2. See generally, D.K. Todd, Ground Water Resources of the United States (Berkeley: Premier Press, 1981), and M. E. Cooley, Hydrogeology of the Navajo and Hopi Indian Reservations, U.S.G.S. Professional Paper 531-C.

3. J.T. Hack, The Changing Physical Environment of the Hopi Indian Reservation, Peabody Museum Papers, Harvard University, 1942.

4. M. E. Cooley, Geohydrologic Data of the Navajo and Hopi Indian Reservations, 1969, Part IV: Maps showing location of wells, springs and stratigraphic sections.

5. William D. Sellers, Physical Climatology, (Chicago: University of Chicago Press, 1979).

CHAPTER TWO

THE REGIONAL CONTEXT FOR WATER MANAGEMENT

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Development of a tribal water management program involves more than a knowledge of the status and supply of reservation water resources. How water is managed off the reservation, who receives water, how much water is received and how it is used are all factors than can benefit or hinder tribal water management programs. Therefore, tribes must understand the regional water policy and management framework and how it can impact tribal water management. To understand the regional framework, it is necessary to assess and analyze local and regional water management institutions, overall state water management policies, programs and directions, and federal water policies and programs, including the interaction of federal agencies with tribal, local and regional water use and management organizations. This chapter addresses the regional framework for water management through an assessment of the legal, political and economic factors affecting water management in the Little Colorado River basin and in the state of Arizona. How such factors may affect Hopi tribal water management also is discussed.

THE WESTERN WATER POLICY ARENA AND INDIAN TRIBES

Until recently, the western water policy arena was often characterized as being dominated by the "iron triangle." As

the term implies, western water policy essentially was determined by three actors -- congressional committees, federal agencies and water development interests. Other interests had little or no influence in the process.[1] Today, however, there is less cohesion among the dominant interest groups. Increased environmental awareness, social diversity and demands for public participation in natural resource decision-making has led to the arrival of new interests and concerns in the allocation, use and management of water. The pressure on traditional water decison-makers is evident across the West, as Indian tribes, environmental groups and rural communities compete with municipalities, industries, and water marketing interests for dwindling water supplies.

An increasingly important influence in western water policy is the resolution of Indian claims to water. (In 1984, the Western Governor's Association estimated that Indians may be entitled to as much as 44 million acre-feet of water, about three times the flow of the Colorado River. Other estimates have placed the amount of water to which Indians potentially are entitled much higher.) This influence is evident particularly in Arizona, where for example, Indian tribes have played major roles in influencing Arizona's ground water management policy. Moreover, because many of the surface water supplies in the Southwest are already over-appropriated, the resolution of Indian claims to water will continue to be of pervasive importance in the

western water arena. Indian appropriations may result in curtailment of non-Indian water use, water transfers or reallocations, or a combination thereof.

THE REGIONAL WATER MANAGEMENT FRAMEWORK

Within the context of western water policy in general, the discussion now turns to an assessment of the regional setting for water resources management and policy development in both the Colorado River and Little Colorado River watersheds. Perhaps, the most significant feature of the region is its water scarcity. Because water is scarce, competition for it is keen. As a result, water resources have been the subject of several judicial decisions and interstate compacts involving apportionment of waters among state, tribal, federal and other interests. In addition, large-scale inter-basin water transfers exist and others are contemplated that will impact tribal water resource decision-making.

Colorado River Basin Development, Indian Tribes and Water Management in Arizona

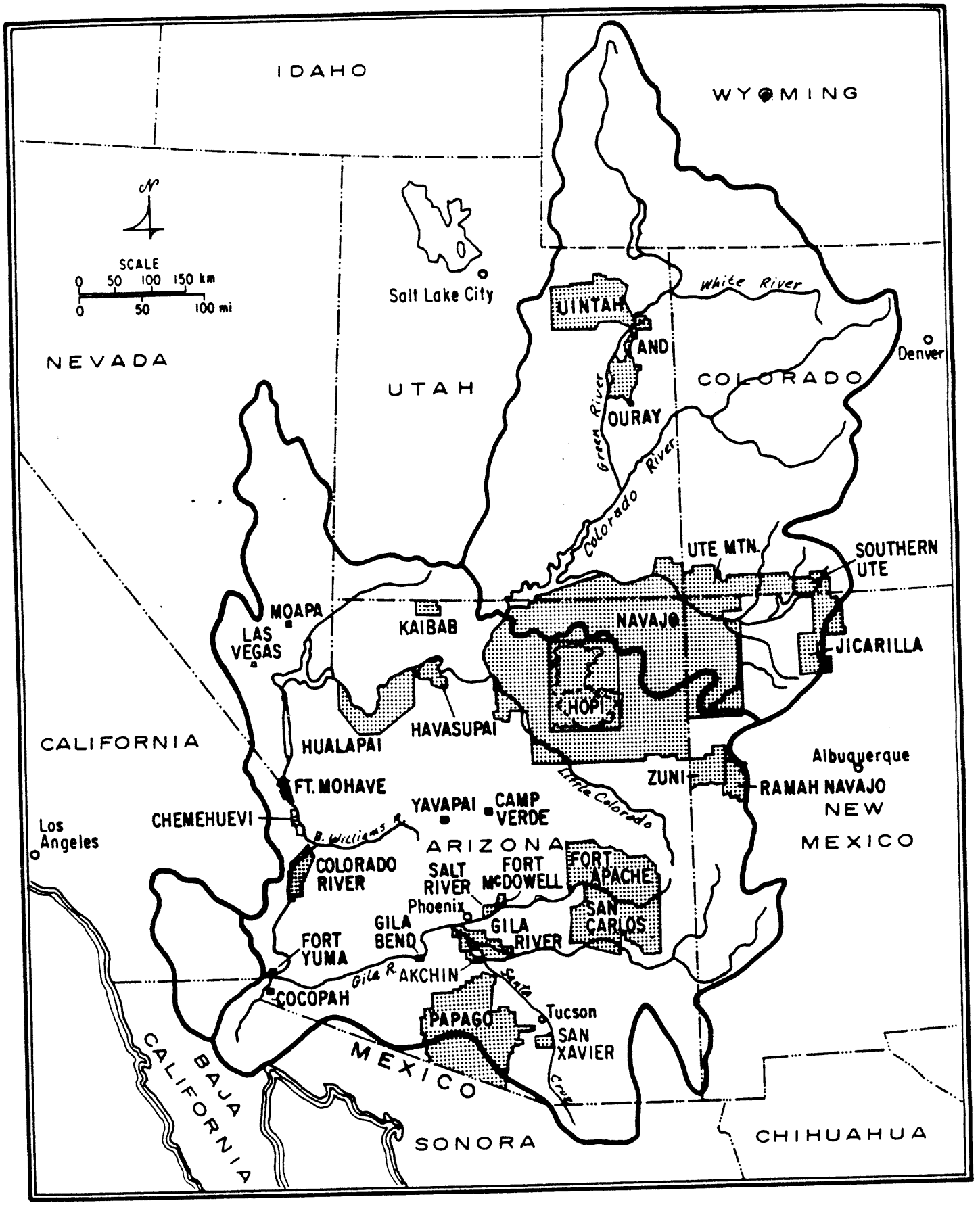
Apportionment of flows from the Colorado River has been the subject of both international (e.g., 1944 U.S.-Mexico Treaty) and interstate agreements (e.g., 1922 Colorado River Compact), as well as of judicial decisions (e.g., Arizona v. California litigation). Determining or estimating the

available amount of water in the Colorado River was, of course, integral to the determination of who was entitled to how much of the river's flows. Figure 1 presents the Colorado River basin.

For example, in 1922 the Colorado River Compact was ratified and provided for division of waters between the upper basin states (Colorado, Utah, New Mexico, Wyoming and parts of Arizona above the compact division point of Lee Ferry, Arizona) and the lower basin states (California, Nevada and parts of Arizona below the compact division point). The division of waters was based on an estimated available flow of 15 million acre-feet (maf) and was apportioned equally between the lower and upper basins with each basin receiving 7.5 maf. (The lower basin apportionment was later divided in the Arizona v. California adjudication with California receiving 4.4 maf, Arizona receiving 2.8 maf, and Nevada receiving 300,000 acre-feet.) The compact also contained provisions concerning apportionment of surplus water in high flow years, as well as fulfilling treaty obligations to Mexico. Other than article VII of the compact, which states: "Nothing in this compact shall be construed as affecting the obligations of the United States of America to Indian Tribes," there were no provisions in the compact concerning the rights of Indian tribes.

Unfortunately, the long-term 15 maf flow estimate upon

Figure 1: The Colorado River Watershed



which the 1922 compact was based has since been determined to be too high and revised estimates now indicate that the estimated annual flow is between 11.5 maf to 14 maf. Based on the more recent estimates, there is obviously a significantly lesser amount of water in the river than was thought initially. Although the upper basin states and Indian tribes have not yet developed their entitlement fully, the amount of water potentially appropriable in the Colorado River is considered negligible. Taken in this context, Indian claims to the waters of the Colorado River and its tributaries will force the reallocation of existing water supplies and most likely will result in an increase in water transfers in all states of the Colorado River watershed.[2]

Major developments on the Colorado River in the lower basin include several dams and power plants, four major diversions (two to California, one each to Utah and Arizona) and several other contemplated projects.[3] Indian diversions include 100,000 acre-feet for the Fort Mohave Tribe and several hundred thousand acre-feet for the Colorado River Indian Tribes. Several tribes, including the Navajo, Southern Ute and Ute Mountain Utes, have projects on major tributaries of the Colorado River.

Because the Colorado River also supplies a large portion of water to the growing cities of southern California, it is impossible to discuss the future of the river or other claims

to the Colorado without briefly discussing the ongoing debate about water in California. At present, more than half the water used by southern California is supplied by the Colorado River. Because the transfer of water from northern California to southern California has become politically unpopular in the state, as illustrated by the defeat by California voters of legislation involving the Peripheral Canal, California cities still seek access to the river's waters.

In 1984, the San Diego County Water Authority approved the expenditure of $10,000 to sign an option to guarantee further discussion with the Galloway Group, a private company in Colorado possessing and wanting to sell water rights near Meeker, Colorado.[4] Actions by the state of California have been opposed vigorously by several basin states, including Arizona and Colorado, and have spurred the passage of the 1983 Colorado Water Export Act. An attempted transfer of water by the Galloway Group to San Diego would test the "law of the river" -- that water allocated to each state must be consumed in that state -- and could lead to a reinterpretation of the Colorado River Compact of 1922.[5] Any tribal leasing of water similar to the "Galloway - San Diego transfer" would be expected also to test the 1922 compact. Tribal leasing currently is being contemplated by the Colorado River Indian Tribes.[6]

The Central Arizona Project

The Central Arizona Project (CAP) is the proposed future water supply for the cities in central and southern Arizona and represents a 40-year effort on the part of Arizona to use its share of the Colorado River. CAP will transport 1.2 maf of Colorado River water from a point just above Lake Havasu to Phoenix, Tucson, and eventually the Tohono O'odam (formerly, Papago) district of San Xavier. Authorized in 1968 at a cost of $832 million, the cost of the project to date is over $3 billion.

Federal funding of major portions of the CAP aqueduct was secured in great measure because CAP water would be used to satisfy major Indian claims. At present, 12 Arizona tribes have contracts with the Bureau of Reclamation for CAP water delivery. In all, the total Indian claim to CAP is some 400,000 acre-feet, and these claims all include provisions for the supply of an alternative source of water in times of shortage.[7]

The Bureau of Reclamation's supply estimates of CAP waters to be delivered annually during the first 50 years of the project's operation range from 400,000 acre-feet to more than 2 million acre-feet, with an average annual delivery of 1.2 maf.[8] Considerable variability in these estimates reflects projected upper basin development, resolution of Indian claims to water, and climatic variability. Other

supply estimates predict an even lesser amount of CAP water than the Bureau of Reclamation figures. Moreover, the quality of CAP waters is difficult to assure.[9] A further complication affecting the certainty of supply of CAP waters is California's assured priority of 4.4 maf from the Colorado River in dry years, even before CAP receives any water.[10]

As has been demonstrated by the previous analysis, water scarcity continues to be a major theme underlying state and local actions involving water resource management and the Colorado River. States can be expected to take an aggressive role in opposing actions that threaten the already insecure future of the Colorado River. For example, Arizona followed with great interest the Ute Mountain Ute and Southern Ute settlements with Colorado. At the same time, states, municipalities and other interests also can be expected to search for solutions to the allocation problem, as evidenced by the Arizona Water Transfer Study (1987) which identified the Mogollon Rim area (the Little Colorado River watershed) as a "prime area for water export to municipalities of the south."[11] Whether such solutions also represent a "solution" of tribal resource issues is a major concern that will vary from one tribal situation to another. Nevertheless, increasing scarcity, large-scale regional reallocation of supplies, continued interbasin transfers of water, and the resultant higher price for water will dominate the regional water environment through the next several decades.

Water Management in Arizona

The state of Arizona lies within three major river basins and three major physiographic provinces within the southwestern United States (figure 2). The river basins are the Gila River, the mainstem Colorado River, and the Little Colorado River. The Gila River basin contains approximately 90% of the state's population and depends on ground water for approximately 77% of its water supply. The mainstem Colorado River basin, which encompasses Yuma and Mohave counties, depends on surface water for 67% of its water supply, with the remaining 33% coming from ground water. Finally, in the Little Colorado region, ground water provides 30% of the total supply with the remaining 70% derived from surface water sources.[12] In the Little Colorado region, as in other portions of the state, 46% of the water is consumed by agriculture.

The extensive use of surface and ground water supplies for irrigation in Arizona has transformed the state into one of the most productive agricultural areas in the country. Yet, Arizona's average annual precipitation is 12 inches per year, and average annual runoff is only approximately .4 inches per year, one of the lowest runoff averages in the nation. More than 95% of the state's precipitation is lost through evapotranspiration, and much of the remaining available supply is consumed by agriculture.

Because of the variable and sparse nature of rainfall, the security of Arizona's water supply was made possible only through the construction of reservoirs and the exploitation of ground water. The Salt, Agua Fria, Verde and Gila rivers all have major reservoir storage systems; in the central highlands of the state, perennial streams are regulated by reservoirs that provide water used mainly for irrigation.

Periodic droughts and the continued expansion of agriculture in Arizona led to the first use of ground water in about the 1930s and early 1940s. Today, Arizona cities rely primarily on ground water supplies. Tucson has the reputation of being the largest city in the United States that is completely reliant upon ground water. The state, on the average, relies on ground water for almost 60% of its total supply.

Beginning in the early 1960s, and continuing to the present, extensive ground water pumping and expansion of irrigated agriculture led to a rapid drop in ground water levels. In some communities, ground water overdraft also led to the problem of subsidence, the drop in the land surface elevation as a result of the removal of ground water. The cities of Eloy and Picacho have land subsidence problems exceeding 10 feet in some locations.[13] In some areas, especially those containing Indian communities, the ground water level has dropped over 200 feet in less than 25 years.

Currently, developed aquifers in the state are being depleted at a rate exceeding 2.5 maf per year,[14] with the most serious problems affecting Pima, Pinal, Maricopa and Cochise counties.

Surprisingly, despite the early and substantial use of both surface and ground water, the management of the resource has been fraught with inconsistencies. A principal difficulty has involved the legal definitions of ground water, surface water and "percolating" water and the actual conjunctive management of surface and ground water resources. Failure to recognize the physical reality of surface and ground water connection resulted in large-scale ground water overdraft which, in some cases, began to impact surface water supplies. Moreover, Arizona's water rights laws, and western water law in general, developed without regard to the physical connection of water resources. In an analysis of western water law, Professor John Leshy (1987) suggests that: "A peculiar fact of history is the contrast between hydrogeologic reality and the western common law's dual system of appropriative rights applying to surface waters and underground streams, and ground water rights applying to percolating ground water subject to land ownership."

Although Arizona in recent decades has made considerable progress toward the development of water resource management programs, significant barriers to effective resource

management remain. An understanding of the development and implementation of Arizona water law, therefore, is critical to assessing the state's position regarding Indian claims and actions and in identifying the possible barriers and incentives for the implementation of tribal water management strategies.

(a) Arizona Water Law

Surface and ground water supplies are treated differently under Arizona water law. Surface water is defined as "the waters of all sources flowing in streams, canyons, ravines, or other natural channels, or in definite underground channels, whether perennial or intermittent, flood waste, or surface water, and of lakes, ponds and springs on the surface."[15] Rights to the surface water resource are governed by the doctrine of prior appropriation.

In 1919, Arizona enacted a comprehensive water code that established a statutory procedure for the acquisition of water rights. The procedure includes filing a claim with the Department of Water Resources proving beneficial use of waters. Tribes, of course, were not subject to the process, but a number of earlier decrees, including the Norvielle Decree,[16] still impact current water rights adjudication proceedings in the Little Colorado River basin.

Ground water is defined in the Arizona statutes as "water under the surface of the earth, regardless of the

geologic structure in which it is standing or moving. Ground water does not include water flowing in undergound streams with ascertainable beds and banks."[17] Until 1980, the rule governing ground water use was the rule of reasonable use, where property owners had the right to capture and remove ground water flowing beneath their property as long as the water was applied to reasonable use. The reasonable use rule essentially encouraged the uncontrolled pumping that led to the alarming water level declines that began in the late 1940s. The water level declines, in turn, spurred legislative reform in the definition, use and management of ground water in 1948 and 1977 and, again, in 1980.

The 1948 Critical Ground Water Code allowed the director of the Department of Water Resources to declare critical ground water areas where there was an insufficient supply to meet agricultural needs. The law, which was seen as weak and incapable of addressing the increasingly critical ground water problem, imposed no pumping restrictions, allowed the deepening of wells in critical ground water areas, and placed no new restrictions on new wells to be used for non-agricultural purposes.[18] In effect, the law defined ground water as a public resource subject to appropriation.

During the period 1948-1965, several legislative reforms of the measure were proposed, but failed. Many Arizona communities recorded the increased drilling of wells, expansion of irrigation areas, and major changes in water

quality as a result of land use practices which included use of sewage effluent as irrigation water. In 1977 the Critical Ground Water Code was amended to allow the transportation of ground water upon the issuance of a certificate by the Arizona State Land Commission; the code amendment also established the Arizona Ground Water Commission to study the ground water problem in Arizona. The work of the Commission was used as the basis for the Arizona Groundwater Management Act of 1980.

The Arizona Groundwater Management Act of 1980 provided for the establishment of Active Management Areas (AMAs) where the ground water overdraft problem is considered to be extreme. The law establishes a procedure by which each AMA is to achieve "safe yield" by the year 2025.[19] The concept of safe yield is based on the theory of balancing aquifer withdrawals with natural (or artificial) recharge. Broad goals for ground water management for each AMA were proposed and measures for partial funding of these programs through special taxes per acre-foot of water pumped were developed. The state intended to make up for ground water withdrawal with CAP water, and, in fact, a large measure of CAP funding also was secured on the guarantee that Arizona would come to grips with its ground water overdraft problem.[20]

The Groundwater Management Act also changed the administrative structure for water resource management in the

state, creating a Department of Water Resources that performs all state-wide surface and ground water functions. The department is headed by a director appointed by the governor; the director has broad authority to appoint AMA directors and to guide water policy for the state. Water quality management is administered by the newly created (1986) Arizona Department of the Environment (formerly this function rested with the Arizona Department of Health Services).

Significantly, the Act essentially eliminated water rights based on reasonable use within the AMAs and replaced these rights with a three-tiered system of rights: grandfathered rights; rights of a municipality, town, private water company or irrigation district; and rights granted through special permits from the Department of Water Resources.[21] Other important components of the Act are as follows:

(1) The Act ties agricultural ground water rights to the land; rights may be bought and transported in accordance with the transportation provisions of the Act only if the land is purchased.

(2) The Act clearly includes provisions for non-expansion of irrigation lands.

(3) Urban development is prohibited where no assured water supply is available.

Arizona has made significant progress in its overall effort to manage water. However, significant legal issues remain, including the effect of the Arizona Groundwater Management Act on water transfers, development of the legal

and administrative mechanisms to implement many portions of the Act, and the comprehensive management of surface and ground water resources. It is likely that these issues will be dealt with individually, such as in the Arizona Recharge and Recovery Law (1986), which developed procedures for ground water recharge projects. However, Indian tribes may force significant change in the state's system by demanding a comprehensive examination of the water resource as a means of acquiring an assured supply for tribes. There are numerous examples in Arizona of the impact tribes have had on the water management process. The current ongoing Gila River adjudication, discussed below, has implications for the manner in which the proceedings may be carried out and for the issues to be expected in the Hopi involvement with the Little Colorado River basin.

At present, the state is involved in two major general stream adjudications--one involves the Gila River system and the other involves the Little Colorado River watershed. Although both adjudications are in different phases, the description of major elements of the Gila River proceeding is useful for the purpose of determining the direction state and other parties are taking in the resolution of the issues and the overall significance of the proceedings--and Indian involvement--for Indian water rights and western water management in general. It is said that these two cases will

quantify the rights between Indian and non-Indian constituencies in the state of Arizona.

(b) Lessons From the Gila River Adjudication

In April 1978, the American Smelting and Refining Company (ASARCO) filed a petition with the Arizona State Land Department (SLD) requesting a determination of water rights in the San Pedro Basin. At this time Arizona's adjudication process was essentially administrative in nature. Arizona law placed all authority over determination of water rights with the State Land Department; the Arizona superior court was required only to confirm or modify the department's administrative determination of water rights.

ASARCO filed the petition requesting a determination of water rights primarily to protect the water supply for its mining operations near Hayden, Arizona. The plant in Hayden relied on ground water sources located on farm and ranch properties owned by ASARCO and also on surface water from Aravapai Creek. The company filed the petition because other parties in the region had asserted rights to Aravapai Creek water and also had asserted that ground water being pumped by ASARCO was part of the subflow of the San Pedro River and, therefore, should be considered surface water under Arizona law.

Gila River Indian Community Files Suit. Partly in response to the ASARCO petiton, in June 1978, the Gila River Indian Community (GRIC) filed a water rights suit in the federal district court against all other major water users along the San Pedro River from the Mexican border to its confluence with the Gila River. Over 534 non-Indian water users were named in the suit, including mining companies, utilities, cattle companies, construction companies and the cities of Sierra Vista and Tucson. All households intentionally were excluded from the suit because households are relatively small water users.[22]

In the suit, the GRIC requested a declaratory judgment from the district court that the GRIC had first and paramount rights to the use of waters of the San Pedro River. In addition, the tribe claimed any and all water around and under the reservation, including recharge. The tribe claimed a priority date of time immemorial and also stated that it needed all the water of the San Pedro to satisfy its tribal water rights for the purposes of agriculture and for the full utilization of reservation resources. In the complaint, the tribe also alleged that the San Pedro River flows into the Gila River and that if the tribe had access to this water, poverty on the reservation would be alleviated.

In a move designed to arrest ground water pumping in the San Pedro Basin, the Gila River Indian Community claimed

that defendants in the case had diminished the flow of the river, and GRIC requested an injunction to prevent San Pedro water users from pumping any additional water out of the basin. The suit also requested damage payments "arising from the wrongful use of water by the non-Indians while the tribe was immersed in poverty."[23] The tribe requested that all defendants account for such water use and that all profits realized on such water use be paid to the tribe along with an award for damages.

New Adjudication Law. After the GRIC filed its suit, the State Land Department commenced the adjudication proceedings in the San Pedro River basin by notifying approximately 7,000 landowners of the need to file statement of claimant forms with the department in order to protect their water rights.

However, in April 1979, the Arizona State Legislature passed a new adjudication law that transferred responsibility for conducting any adjudications in Arizona to the Arizona superior court. The Arizona Water Commission, now the Arizona Department of Water Resources, was delegated technical responsibilities under the new law. In enacting the adjudication law, the Arizona Legislature clearly was responding to a series of Supreme Court cases that upheld state court jurisdiction over adjudication of reserved water rights as long as certain conditions were met.

The Arizona adjudication law was intended to structure all adjudication proceedings so that they met the conditions set down by the Court and included the prohibition against administrative determinations of reserved rights. Under the new law, the San Pedro adjudication was transferred from the Cochise County Superior Court to the Maricopa County Superior Court; the Maricopa court immediately consolidated all other ongoing adjudications involving the Gila River system. The consolidation included the adjudications involving the Salt, Verde and Gila rivers. By consolidating the adjudications, the state hoped to avoid any multiplicity of litigation.

Gila River Indian Community Hearing. While these actions were proceeding at the state level, the federal district court in Tucson was hearing the GRIC action. Prior to the federal court hearing, the only action taken in the suit was that all water users who were summoned were required to respond to interrogatories. At the hearing in March 1980, the district court dismissed GRIC's first count, a petition seeking declaratory relief, and remanded the action to the state court. Citing the new adjudication law, and the fact that other sections of the Gila River also were included in the state adjudication, the judge ruled that the GRIC suit should be dismissed in favor of the state court proceedings. However, two of the GRIC's counts were stayed, including the request for injunctive relief and for damages from non-Indians, pending the outcome of the state court proceedings.

The stay was issued primarily to "prevent the waste of judicial resources" and also to allow the tribe to return to federal court for damage and remedy claims in the event that the tribe established rights to water in the state court proceeding.

The Tenneco West Motion. During the early stages of the state court proceedings, Tenneco West, one of the largest landholders in the San Pedro Basin, filed a motion with the court requesting a partial summary judgment stating that the GRIC had no right to ground water underlying Tenneco's property. Tenneco argued that the court should not consider the hydrological connection between ground water and surface water' but simply answer "the threshold question of whether there is any law which gives to the GRIC the right to ground water beneath Tenneco West land."[24] The motion requested that the court declare that the GRIC had no viable claims to underground waters of the San Pedro Basin.

As expected, the Tenneco motion was opposed by the tribe and by the United States government on a number of grounds, including the fact that the motion was premature because the statement of claimant forms were not yet filed and the conflict had not yet developed. The United States also argued that no hydrological study had yet been completed and any action on the motion would foreclose other important points that still had to be discussed. Finally, the United

States argued that if the motion were granted, all other claimants would file similar motions and the purpose of the proceedings would be thwarted through a series of unconnected, partial summary judgments.

The judge in the case, concurring with the United States, did not grant the Tenneco motion. The court chose instead to hold an evidentiary hearing in October 1987 to discuss the hydrologic connection between surface and ground water in the basin.

Jurisdictional Challenges. In 1982 and 1983, a number of Arizona tribes, along with other tribes in the West, filed suits in federal district courts challenging state jurisdiction over adjudication of Indian claims. While the tribal suits were proceeding through the federal court system, the state court judge suspended the state proceedings until the jurisdictional issues were resolved by the federal courts. In July 1983, in Arizona v. San Carlos Apache Tribe, the United States Supreme Court held that a federal proceeding for determining Indian water rights normally should be dismissed in favor of concurrent state court proceedings.

The San Carlos decision locked the Gila River adjudication in state court. However, a number of other jurisdictional questions regarding state law remained. Arizona Indian tribes and the U.S. Department of Justice continued to contest the constitutionality of the 1979

Arizona adjudication law. Both parties maintained that the federal courts would be fairer than state courts in allocating water to the tribes and raised a number of objections to the assertion of jurisdiction by the state. The parties also objected to the role of the Department of Water Resources (DWR) in the adjudication, claiming that the DWR is "an institutional adversary of Indian reserved rights" and that the department had a conflict of interest that violated the due process guarantees of the fourteenth amendment.

In 1984, the state court decided in favor of the state and rejected the arguments of the Indian tribes and the Justice Department. The judge refused to dismiss ten tribes from the Gila River adjudication, citing the San Carlos holding as the basis for the decision. The lower state court ruling was later reviewed and affirmed by the Arizona Supreme Court in January 1985. Significantly, at this time Arizona also clarified the role of the Department of Water Resources, stating that "the DWR is not involved as a claimant and may not file petitions for adjudication," and limited DWR's role to one of technical assistance.

Following the decision of the Arizona Supreme Court, the Gila River adjudication continued.

Pretrial Orders. On May 29, 1986, Judge Goodfarb issued his first pretrial order, which set forth the procedures the

court would follow in conducting the entire Gila River adjudication. The pretrial order had to conform with the Arizona adjudication law and with the Arizona Rules of Civil Procedure. The pretrial order was approved in August 1987 by the Arizona Supreme Court. The most significant features of the pretrial orders are summarized briefly in the following section.

Because of the large number and diversity of the parties involved, the order establishes a steering committee representing the interests involved in the adjudication.[26] Significantly, only one Indian interest is represented on the commmittee. In January 1987, the committee suggested a four-step process for the resolution of the adjudication which included: (1) definition resolution, (2) issues identification and resolution, (3) discovery, and (4) trials, appeals and hearings. The committee suggested additional pretrial orders might define more precisely the steps involved in each phase of the process. The steering committee can make only recommendations to the court, and only if a majority of the 14 members approve of the recommendation.

The mechanism through which the various issues are identified and resolved calls for the division of technical and legal issues and a prioritization of issues within each division. There are five major issues in the pretrial order:

(1) procedures;

(2) Hydrographic Survey Report (HSR)of rights based upon state law;

(3) legal investigation of rights based on state law;

(4) HSR investigations of rights based on federal law; and

(5) legal investigation of rights based upon federal law.

The most complete list of issues is contained in issue number 5, "rights based upon federal law." The court lists eight separate and significant issues which must be resolved:

(1) basis of right for existing water uses on federal reservations;

(2) legal theories for determining the extent and priority of federal law rights;

(3) the relationship between federal and state law on matters of potential conflict;

(4) factors to be considered in determining extent of rights under the doctrine of equitable apportionment;

(5) factors to be considered in determining the extent of rights under the doctrine of practicably irrigable acreage;

(6) primary purposes and secondary uses for which federal reservations were reserved;

(7) factors to be considered in determining extent of rights under other doctrines; and

(8) the application of the reserved rights doctrine to purchased Indian land.

The resolution of these eight issues alone is significant for Indian tribes in Arizona and across the western U.S. The outcome will have a direct bearing on the

issues discussed and considered in the pending Little Colorado River adjudication, and should be followed carefully. The court established the issue resolution process "to provide a forum for discussion of issues in a structured setting outside the presence of the court, to identify alternative ways of resolving the issues, and to encourage agreement by the parties on resolutions to be recommended to this Court." One analyst suggests, however, that in the "structured dialogue," the court will consider a very tough approach toward, and may even consider dropping, the practicably irrigable acreage (PIA) standard.[27] In this context, the court will be looking to alternative means of quantifying Indian water rights.

In a classic example of how present Arizona water law conflicts with, and likely will be modified by, current adjudication proceedings, the tribes in the present case have filed for water from a variety of sources. However, current surface and ground water law provides no mechanism for getting water from one place to another.[28]

Negotiation. Many of the parties in the Gila River adjudication have expressed continued interest in negotiating the Indian water rights claims. The Gila River Indian Community, in particular, has stated throughout the process that negotiations were preferable. When the suit initially was filed in 1978, the GRIC hoped to "negotiate an agreement

with the non-Indian water users that might include voluntary water conservation on the part of the non-Indians or an exchange agreement utilizing Central Arizona Project water."[29]

Early attempts at negotiations were stymied for a number of reasons. First, many non-Indians felt the amounts claimed by the Indians were "much too high" and claim amounts were "unreasonable." Citing the Papago and Ak-Chin settlements as examples, these parties argue that "there is simply not enough water or money to settle the remaining Indian claims in like manner."[30] Such an attitude is shared by many actors in the proceedings. Second, it has been difficult to engender support from Arizona's congressional delegation because of the size of the GRIC's claim (1.5 maf).[31] Other Indian attorneys argue that "Indian water rights were not taken seriously in the past and will not be taken so until forced by the Court to change water uses."[32]

However, interest in negotiation has increased over the past several months. The Department of Interior has requested that the hydrographic survey report (HSR) for the Gila River Indian Community be postponed while it pursues negotiation with the tribes. It is unlikely, however, that much progress will be made until the adjudication proceeds and the non-Indian interests get a clearer idea of what they may lose or gain through the adjudication process.

Continuing Challenges to Arizona Water Law. Challenges to Arizona water law continue to occur. One conflict in the San Pedro Basin, which resulted from DWR's refusal to issue an "adequate water supply certificate" to a developer, underscores the emerging surface and ground water issues in the state. The DWR action was in response to a U.S. Geological Survey (USGS) report that stated that "ground water pumping has reduced the total amount of discharge to the San Pedro and Babocomari rivers and thus altered the original stream-aquifer relations."[33] The DWR report stated "pumpage in the Sierra Vista-Fort Huachuca area has resulted in the diversion of waters of the San Pedro River. Diversion of the San Pedro River water [as a result of ground water pumping] even in this area may require legal surface water rights. Major conflicts are expected in the future."[34]

Summary and Implications of the Gila River Proceedings. As the previous brief history and analysis has demonstrated, Indian tribes in Arizona have had significant impact on Arizona water law. The significant impacts appear to be: (1) the passage of the Arizona adjudication law in response to tribal challenges of state court jurisdiction over reserved water rights, and (2) the major involvement of Arizona tribes in water rights adjudications. Moreover, tribal water rights issues have caused Arizona to begin to deal with the issue of conjunctive management of surface and ground water. Additionally, by claiming large amounts of

water, water which can only be provided by reallocation of existing uses, the tribes will force the state to acknowledge water transport and reallocation limits posed by its own laws.

Unlike other western states, notably Idaho, Colorado and Montana, the Arizona adjudication law contains no language regarding tribal-state relations or even a "good faith" clause regarding the state's intention to be fair in adjudicating water rights. It is likely that the tribes will have to assert their rightful role as an equal partner in water resources use and management because the state is not going to give the tribes the "benefit of the doubt."

. . The ground water resource has become significant in the Gila River adjudication. Although the hydrologic connection between surface and ground water is clear for the San Pedro and Gila River systems, the inclusion of ground water in the case marks one of the first times an adjudication has proceeded in such an all-inclusive manner with respect to the water resource. As a result of the hydrologic reality, ground water and its effect on surface water flow will be a major aspect of the Little Colorado River adjudication. Although the inclusion of both surface and ground water resources complicates the analysis of water rights, it is a inherently more complete resolution of the issues. The inclusion of ground water, only after major debate about the

issue, also is significant from the standpoint of suggesting that Indian ground water resources will be identified and included in adjudication proceedings. Some analysts suggest it is unlikely that the court will ignore a hydrologic connection between surface and ground water when the price of refusing to recognize the reality would mean a substantial diminution or even elimination of Indian claims. If non-Indians argue successfully at the trial level for a narrow interpretation or application of Winters rights, the result most likely will be a delay, by perhaps as much as a decade, of the resolution of the case while it is appealed to the U.S. Supreme Court.

The Gila River adjudication promises to be a lengthy and costly proceeding and demonstrates one of the disadvantages of a non-negotiation approach. Judge Minker, in the Little Colorado River adjudication, already has suggested that the parties seek negotiation as a viable means of resolving water rights claims. The judge established a "settling committee," headed by the Hopi tribal attorney, Harry Sachse, as opposed to the "steering committee" that advises the judge in the Gila River adjudication proceedings. However, it is likely that the large water users, such as mining interests, will oppose settlement and try to keep the case in court as long as possible.[35]

Summary and Implications: Arizona Water Law, Indian Tribes, and Water Management into the 21st Century

Water, now more than ever, has become the single most important issue in Arizona. The state recently rewrote several laws regarding surface and ground water rights and has implemented management measures in several active management areas around the state. At the same time, the legislature has taken a stand in favor of municipal and industrial water uses over agricultural and rural uses, as legal, technical and administrative mechanisms have been created to accommodate the shift in water use priorities. Although reluctantly, the state finally has begun to address tribal issues. While significant impediments remain to the full consideration of Indian water rights in Arizona, it is clear that tribal water rights and management will have an influence on state policy and practices.

Water supply continues to be the dominant focus in the state, with municipalities competing for water rights in rural areas outside the city limits and through buy-outs of agricultural lands and accompanying water rights. In 1987, the Arizona Water Transfer Study was completed by Franzoy and Corey Associates of Phoenix. The study was proposed and completed for the purpose of evaluating the hydrologic and economic impacts of water transfer in the state of Arizona and will be used by legislators to evaluate the need for additional legislation in Arizona governing the transfer of

water.[36] In the study, the Mogollon Rim area, which includes the Little Colorado River watershed, was designated as the "next watering hole" for the cities of central and southern Arizona. Other areas in the state designated for water transfers include the Yuma-Wellton area and La Paz and Pinal counties.

Significant impacts to rural communities have been suggested by the study. Some of the effects include a loss of tax revenue to communities whose land is bought by cities. Other losses include income associated with rural farming enterprises. The hydrologic impacts are expected to be considerable, but are difficult to evaluate without further data collection and analysis.

What factors will contribute to the actual transfer of water on the scale contemplated in the study? Rural water users appear to be united in their overall opposition to water transfers,[37] but have different objectives. The settlement of the numerous pending Indian claims to water may require the transfer of water from one area of the state to another, presumably using the CAP canal facilities in part. Moreover, Maricopa County, which holds the majority of seats in the Arizona Legislature and the majority of the state's population, is expected to exercise legal and financial resources to facilitate transfer. In this context, the agenda for the state legislature in the next year will be dominated by the means of addresssing the "third party

effects" previously described. Mines, municipalities, utilities and development interests will compete with rural communities, and perhaps Indian tribes, for increasingly limited water supplies in the foreseeable future.

Unlike the financial resources devoted to securing water supplies, including the $3 billion Central Arizona Project, resources devoted to the management of water quality in the state have been scarce. However, Arizona faces significant water quality problems, which include leaking underground storage tanks, landfills, several "Superfund" sites, municipal sewage disposal, non-point runoff and ground water pollution from agricultural lands, and waste products from mining and oil and gas activities. Finally, the Central Arizona Project waters also pose salinity hazards to agricultural lands and urban ground water resources.[38]

In 1986, a new Department of Environmental Quality was formed at the state level and is responsible for the enforcement of state water quality standards. The state felt that current EPA standards are more applicable to humid regions, while arid communities require different sets of standards to account, for example, for already high dissolved solids contents in waters. The state has not addressed non-point sources of pollution, and its current regulations do not apply to federal land.[39] As with the water supply issue, the physical reality of the water quality

issue, in the context of increasing demand for and increasing use of reclaimed wastewater to meet at least part of the regions's water needs, will force change in the state's water policy, moving it in a direction in which water supply and water quality are managed together.

The Federal Presence in the Region

No discussion of water in the region would be complete without analysis of the federal presence and its impact on tribal and state water management practices and policies. The major federal agencies active in the state include the United States Department of Justice, the Bureau of Indian Affairs (BIA), the USGS, the Bureau of Reclamation (which operates water resource control facilities in the region), the Department of Agriculture, Soil Conservation Service, the Bureau of Land Management, the Army Corps of Engineers, the Department of Energy (DOE), the Office of Surface Mining and the Environmental Protection Agency (EPA). While an exhaustive review of these agencies is beyond the scope of this project, it is useful to classify broad impacts of these agencies on tribal water management practices.

Bureau of Indian Affairs. The area and regional offices of the BIA exert profound influence on tribal water management programs and policies through the manner in which funds and expertise are distributed and through the control exerted over contract selection procedures. In addition, the

BIA administers a number of programs on the Hopi Reservation that provide services to the population. As a result of current litigation, millions of dollars have been spent by the BIA and by the Department of Justice in hiring legal counsel, technical consultants and others to provide information related to the litigation. Although the results of such activities will be discussed in Chapter Four, it is significant to note that few funds have been used to address long-term in-house planning or to provide technical expertise needed by the tribe in the overall management of its surface and ground water resources. Moreover, BIA policies and actions that impact water resources at the reservation level often fail to account for critical informational items or tribal policy goals regarding resource management.[40] In such an atmosphere, critical policy decisions regarding natural resource management that should be made by the tribe are made by the BIA.

Bureau of Reclamation. The Bureau of Reclamation (BR) has been quite active in regional water resource management issues. At present, the Bureau is responsible for the management of the major reservoirs on the mainstem Colorado River and on the Salt River in central Arizona. Additionally, the Bureau of Reclamation is the primary manager of the CAP facilities. Funding for the CAP project was withheld from the Bureau and the state of Arizona pending passage of legislation regarding ground water and as a result

of pressure to settle Indian claims. As a result, past, current and future Bureau of Reclamation operations of major water project facilities will continue to impact non-Indian and Indian water management decisions; BR facilities can transfer water to settle Indian claims. Bureau water may be called upon to assist the region in settlement of issues in a significant manner in the future.[41]

The remaining agencies, including the EPA and the DOE will be discussed in Chapter Four because their activities have direct bearing on certain specific resource management activities at Hopi. Nevertheless, the large number of federal agencies, and the interaction of these agencies with each other as well as with the tribes complicate the regulatory environment in which tribal actions can proceed.

BARRIERS AND INCENTIVES TO RESOURCE MANAGEMENT

Given the complex environment in which many parties and institutions exert a profound influence on water policy and management, it is useful to sort through the information to identify major incentives and barriers to tribal resource management from the institutional perspective. The incentives and barriers are summarized in Table 1. The resource issues identified will be addressed in Chapter Five, "Strategies for Tribal Water Management," and possible solutions proposed. The next chapter presents an analysis of the legal basis for tribal water and land management.

TABLE 1: BARRIERS AND INCENTIVES TO RESOURCE MANAGEMENT

Barriers	Incentives
Institutional Barriers	**Institutional Incentives**
1. Resolution of Indian claims in state courts, historically hostile to Indian claims;	1. Existing tribal structure & experience with resource management
2. Competition for scarce water supplies	2. Strong tribal mandate to protect and enhance tribal natural resources
3. Tribal competition from Navajo for water supplies for development; historical difficulties between two tribes.	3. Existing cooperation between Navajo and Hopi regarding the re-negotiation of the Peabody lease and dealing with the uranium tailings pil at Tuba City
4. Fragmented water resource management at State and Federal levels	4. Potential alliance of Hopi and rural water users regarding exportation of water outside of the Little Colorado River basin
5. BIA indifference and attitude toward tribal resource management	5. Structure of recently ammended federal water pollution control laws allowing tribes to develop their own water quality management programs and to qualify for funds to do so.
6. Lack of understanding of tribal goals objectives and governmental structure on the part of non-Indians.	6. Existing tribal governmental structu and its practice of sovereignty
7. Possible jurisdictional conflicts between villages and larger tribal council	7. Active national Indian efforts to secure and manage water resources.
8. Unwillingness on the part of large water users to negotiate claims rather than litigating	
9. Current moratorium by the Secretary of Interior on the development of tribal water codes	

TABLE 1, CONTINUED

Barriers	Incentives
Technical/Managerial Barriers	**Technical/Managerial Incentives**
1. Status of water resources information, which lacks critical planning data (see chapter 4)	1. Current water resources research will provide the bulk of data needed within the next 3 years
2. Tribal engineering, hydrologic capabilities for development and managment of water is lacking	2. Existing consultants encompass wide range of fields and should be able to provide analytical assistance
3. Water resources information is scattered among several agencies in New Mexico, Arizona and Colorado and among the different tribal departments	3. Existing computer facilites of the tribe would permit the development of a centralized data base
4. Current water level and water quality monitoring is almost non-existent	4. Current tribal activities will, in th next year, begin to collect water qual samples, water level measurements and rainfall data
5. Coordination of tribal resource management activities	5. Since all resoruce activities involve water to some degree, the potential to unify resource management activities around water is possible.
6. BIA technical decision-making regarding water resource studies is seldom sensitive to tribal information needs nor management plans	

Table 1, Continued

Barriers	Incentives
Legal Barriers	**Legal Incentives**
1. The legal status of the tribe's water right has not been quantified in court	1. Extensive water rights based on aboriginal occupancy, the treaty of Guadelupe Hildalgo and Winters rights
2. Litigation of rights may preclude clear determination of management responsibilities and requirements	2. Clarification of management responsibilities through negotiated settlement
3. Time invovled in dispute resolution may put tribal activities on hold	3. Appointment of settlement committ with the tribe's attorney as head to explore negotiation
4. Jurisdictional issues regarding ownership and management of subsurface waters with the Navajo tribe	4. Existence of tribal court to reso resource issues if necessary
5. Continuing land status issues in the 1882 EOA and 1934 lands	
6. The lack of a clear policy statement and objectives establishing guidelines for resource use	

REFERENCE NOTES TO CHAPTER TWO

1. See Daniel McCool, Command of the Waters, (Berkeley: University of California Press, 1987).

2. See Gary Weatherford, New Courses for the Colorado River, (Albuquerque: University of New Mexico Press, 1987).

3. See Western Network, Western Water Flows to the Cities, (Santa Fe, 1984).

4. Western Network, op. cit., p. 70.

5. See Gary Weatherford, op. cit.; also see Western Network, op. cit., p. 71.

6. Western Network, Water Marketing Update, September 1987.

7. Personal conversation with Gary Weatherford, November 1986.

8. U.S. Bureau of Reclamation, Final Environmental Impact Statement for the Central Arizona Project, January 1980.

9. Catherine Vandemoer, Hydrogeochemistry of Recharge Processes and Implication for Water Management in the Arid Southwestern United States (unpublished Ph.D Dissertation, University of Arizona, Tucson, 1987). See also CH2M Hill, Effluent Reuse Report for the City of Tucson, November 1983.

10. See Western Network, Western Water Flows to the Cities.

11. See Franzoy and Corey, Arizona Water Transfer Study, Prepared for the Arizona Department of Water Resources, 1987.

12. U.S. Department of Agriculture, Soil Conservation Service, Little Colorado River Basin Summary - Arizona, New Mexico, 1981.

13. J. Poland, Subsidence in the Eloy-Picacho Area, Central Arizona, American Society of Civil Engineers, Journal of the Hydraulics Division, 1972.

14. Personal conversation, Robin Grimes, Arizona Department of Water Resources, July 1987.

15. Ariz. Rev. Stat. section 45-401 et seq.

16. The Norviell Decree is a water rights decree in the Little Colorado River basin that establishes water rights for users downstream. This decree, and its impact on the Little Colorado River adjudication, may be significant and it effects are being researched at the present time. From personal conversation with Bill Warscow, Salt River Project, August 1987, and Mary G. Wallace, Research Associate, Water Resources Research Center, University of Arizona, September 1987.

17. Ariz. Rev. Stat. section 45-401 et seq.

18. See Jon L. Kyl, The 1980 Arizona Groundwater Management Act, 53 U. Colo. L. Rev. pp. 471-503 (1982).

19. Ariz. Rev. Stat. section 45-401 et seq.

20. The Tucson Citizen, July 26, 1979, p. 10.

21. Op. cit. note 19.

22. See Court Order In Re the General Adjudication of All Rights to Use Water in the Gila River System and Source, 1985.

23. Interview with Cox and Cox, Attorneys for the Gila River Indian Community, October 1985.

24. Interview with Mary G. Wallace, Research Associate, Water Resources Research Center, Univ. of Arizona, June 1987.

25. See Court Order, op. cit. at note 22.

26. Op. cit. at note 24.

27. Interview with Mary G. Wallace, Research Associate, Water Resources Research Center, Univ. of Arizona, June 1987.

28. See Rodney T. Smith, Trading Water: A Necessary Legal Framework for Water Marketing, Draft report, 1987.

29. Interview with Rodney Lewis, Gila River Indian Community Attorney, October 1985.

30. Interview with Bill Warscow, Water Resource Manager, Salt River Project, June 1987.

31. Interview with Mary G. Wallace, Research Associate,

Water Resources Research Center, Univ. of Arizona, June 1987.

32. Cox and Cox, GRIC attorneys, quoted by Mary G. Wallace, in "Conflict Mapping in the San Pedro Drainage Basin," unpublished research report, 1987.

33. U.S.G.S., Water Supply and Use in the San Pedro River Basin, Open File Report, 1982.

34. Arizona Department of Water Resources, certificate of denial, 1983.

35. Interview with Mary G. Wallace, Research Associate, Water Resources Research Center, Univ. of Arizona, August 1987.

36. See Franzoy and Corey, op. cit.

37. Interview with Gordon Henry, Arizona Water Users Association, June 1987.

38. See Catherine Vandemoer, op. cit. and "Water Quality Impacts of Recharging CAP Supplies," Proceedings of the 2nd Annual Conference of Artificial Recharge, Phoenix, May 1985.

39. Interview with Susan J. Keith, Water Quality Advisor to the City of Phoenix, September 1987.

40. Interview with Steve Hamp, Rights Protection Office, BIA, Albuquerque, May 1987.

41. Interview with Mary G. Wallace, Research Associate, Water Resources Research Center, Univ. of Arizona, July 1987.

CHAPTER THREE

LEGAL ANALYSIS OF TRIBAL AUTHORITY TO REGULATE SOURCES OF WATER POLLUTION

The Hopi Tribe, as a sovereign, has the right to use all of the economic benefits of its land and water without need for quantification of its right. In the more specific claim that follows, the Tribe does not waive this right nor does it waive its right, if quantification is required, to have additional water decreed to it if a need arises in the future, or to change the use of its water.

The Hopi Tribe has the complete right to administer its own water, and in filing this claim in no way submits to the jurisdiction of the State of Arizona or anyone else as to the control and administration of water decreed to the Hopi Tribe.

. . . .

The Hopi Tribe is a federally recognized Indian tribe with a Reservation located wholly within the Little Colorado Basin, in northeast Arizona. Since time immemorial the Tribe has resided in the Little Colorado Basin using the waters of the Little Colorado, the washes flowing into it and the groundwater of the Basin to sustain its society. . . .

. . . .

. . . As a sovereign, long predating the United States, and the historic guardian of its lands, the Hopi Tribe claims under its own retained sovereignty the right to all groundwater and surface water in, on, or serving lands owned by the Hopi Tribe or allotted or assigned to its members, or that may hereafter be recognized as belonging to it or its members.

. . . As the owner of lands and waters under both Spanish rule and Mexican rule, the Hopi Tribe further claims these waters under Articles VIII and IX of the Treaty of Guadalupe Hidalgo, Treaty between the United States and Mexico of February 2, 1848 (9 Stat. 922), reserving to citizens of Mexico the rights that they held under Mexican law.

> . . . Under the reserved rights doctrine established in Winters v. United States, 207 U.S. 564 (1908); Arizona v. California, 373 U.S. 546 (1963) and Cappaert v. United States, 426 U.S. 128 (1976) and as owner of all natural resources forming part of its land, United States v. Shoshone Tribe, 204 U.S. 111 (1938), the Hopi Tribe claims the right to all groundwater and surface water, in, on or serving lands owned by the Hopi Tribe or allotted or assigned to its members, or that may hereafter be recognized as belonging to it or its members.
>
> In making these claims the Hopi Tribe does so on behalf of and for the benefit of it villages, clans and people. . . .

Excerpted from Statement of Claims of the Hopi Tribe, In Re the General Adjudication of all Rights to Use Water In the Little Colorado River System and Source.

CHAPTER THREE

. . LEGAL ANALYSIS OF TRIBAL AUTHORITY TO REGULATE SOURCES OF WATER POLLUTION

While the regional institutional setting for water management is important to understand, the legal basis of the tribe's water right and the tribe's authority to manage and control surface and ground water resources also must be understood fully. Tribal leaders no doubt already possess a firm knowledge of the basis of the tribe's rights to water. Further, since the tribe is involved in the quantification of its water rights, legal issues relative to such efforts are not discussed in depth in this report. Instead Chapter Three, written by the Seattle, Washington law firm of Richard Du Bey, provides a legal analysis of the authority of the Hopi Tribe to regulate sources of water pollution.

A movement of significance in Indian Country today is the initiation of environmental protection programs as a result of the EPA's Indian policy and the recent "Indian" amendments to the Clean Water Act and the Safe Drinking Water Act. Tribes now have a greater opportunity to receive substantial funding for the development of tribal programs linked to the management and protection of water quality. Because management of water quality involves water and land use regulation and management, the development of tribal water quality programs is integral to comprehensive resource management and provides a tool that the tribe can use to further the exercise of its sovereign powers. Consequently, Chapter, Three describes in some detail the scope of the Hopi Tribe's authority to regulate water quality on the reservation.

I. INTRODUCTION

The Constitution and Bylaws of the Hopi Tribe empower and direct the Tribal Council to protect the health and welfare of the people and manage the land and water resources of the Tribe. In carrying out these obligations, the Council is authorized to negotiate cooperative agreements with tribal, federal, and state agencies and to enact and enforce Tribal ordinances to secure and protect such interests. The Council has also established a Tribal Court to resolve disputes associated with the implementation of Tribal law.

As discussed in this analysis, the Hopi Tribe, acting through its Tribal Council, and in concert with Federal Indian policy, possesses adequate civil regulatory authority to control all sources of pollution which may affect the quality of the Tribe's surface and groundwater resources.

As demonstrated by President Reagan's Indian Policy Statement of January 24, 1983, current Federal Indian Policy endorses the twin themes of tribal self-government and economic self-sufficiency. [1/] In furtherance of this policy, the United States Environmental Protection Agency ("EPA") in November, 1984, established its Indian Policy in the field of environmental protection and published an EPA Indian Policy acknowledging the primary role of tribal governments in the implementation of

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1/ President Reagan, Statement of Indian Policy, 19 Weekly Comp. Pres. Doc. 98 (January 24, 1983); See also, President Nixon, Statement of Indian Policy, 116 Cong. Rec. 23258 (1970).

Federal environmental law. The EPA Indian Policy noted the absence of state jurisdiction on Indian lands, and directed the Agency to establish "government-to-government" relationships with Indian Tribal governments to implement and enforce the Federal environmental laws on Indian lands. [2/] The Hopi Tribe has established such a relationship with EPA Region IX.

In late 1985, EPA adopted its "Interim Strategy for Implementation of the EPA Indian Policy," which recognized that:

> [F]orcing tribal governments to act through state governments that cannot exercise jurisdiction over them (Indian tribes) is not an effective way of implementing programs overall and certainly is in opposition to the federal policy of working with tribal governments directly. (Emphasis added). [3/]

Thus, by developing its environmental management programs, the Hopi Tribe is protecting tribal land and water resources, serving both Tribal and Federal interests. Effective implementation of a Hopi Water Quality Management Program ("HWQMP") would also further Tribal and Federal policy, and assist EPA in fulfilling its obligation to the Hopi Tribe under the Federal trust responsibility. This concept of tribal self-governance is supported by President Reagan's statement that:

> Tribal governments, like state and local governments, are more aware of the needs and

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[2/] A copy of EPA's Policy Statement is attached as Appendix A.

[3/] Office of Federal Activities, Office of External Affairs, "Interim Strategy for the Implementation of the EPA Indian Policy" (November, 1985). A copy of EPA's Interim Policy is attached as Appendix B.

> desires of their citizens than is the Federal Government and should, therefore, have the primary responsibility for meeting those needs... Our policy is to reaffirm dealing with Indian tribes on a government-to-government basis and to pursue the policy of self-government of Indian tribes without threatening termination. [4]/

Part II of this Analysis will describe the Hopi Tribe, the Tribal land base, and the framework of Tribal government. Part III is a comprehensive review of Federal common and statutory law, and Federal Indian Policy. The author concludes that the Hopi Tribe is capable of developing, implementing and enforcing a HWQMP to protect the water resources of the Hopi Tribe.

II. THE HOPI TRIBE

A. Land Ownership and Use

The current Hopi Reservation is located about 185 miles north of Phoenix, Arizona and about 230 miles west of Albuquerque, New Mexico. The Hopi Reservation is comprised of a central area of approximately 600,000 acres, referred to as District 6, and an adjacent area of approximately 900,000 acres, referred to as Hopi Partitioned Lands ("HPL"). The Hopi Tribe and the Navajo Tribe contest the ownership of an additional area of land to the west of District 6. District 6 is carved out of Hopi aboriginal lands, and serves as a

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[4]/ See supra note 1. A copy of the President's January 24, 1983, Indian Policy Statement is attached hereto as Appendix C.

permanent homeland for the Hopi Tribe. [5]/

Indian tribes and tribal lands have a unique status under Federal law. An 1832 Supreme Court decision by Chief Justice Marshall declared that Indian tribes were

> [D]istinct political communities having territorial boundaries, within which their authority is exclusive, and having a right to all the lands within those boundaries, which is not only acknowledged but guaranteed by the United States. [6]/

Although the "conceptual clarity" of Marshall's view has given way to a particularized case by case analysis of treaties, statutes and executive orders, the special status of Indian tribes and Indian lands has endured. [7]/ For instance, in 1981, the United States Court of Appeals for the Ninth Circuit recognized that to effectuate the purpose for which the Colville Indian Reservation was created, to provide "a homeland for the survival and growth of the Indians," this purpose must be liberally construed. [8]/

In 1882, the Hopi Reservation was set aside by President

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[5]/ Susanne and Jake Page, Hopi (1982).

[6]/ Worcester v. Georgia, 31 U.S. (6 Pet.) 515, 557 (1832).

[7]/ See Mescalero Apache Tribe v. Jones, 411 U.S. 145, 148 (1973).

[8]/ Colville Confederated Tribes v. Walton, 647 F.2d 42, 49 (9th Cir. 1981), cert denied, 454 U.S. 1092 (1981).

Arthur. [9]/ Hopi lands were subsequently invaded by Navajo Tribal Members who were being pursued by Kit Carson. Due to Navajo encroachment upon Hopi lands in the 1940s, the United States Department of the Interior, Bureau of Indian Affairs ("BIA") intervened and decided to treat the Hopi and Navajo reservations as one administrative unit. The BIA divided the entire area into nineteen Land Management Districts or Grazing Districts, and instituted a massive across the board stock reduction program. [10]/

In 1962, a three judge federal district court, in Healing v. Jones, ratified the management scheme, ruling that the Hopi District (District 6) was to be used exclusively by the Hopi and the remainder of the 1882 lands were to be considered a Joint Use Area ("JUA") to be shared by the Hopi Tribe and the Navajo Tribe. [11]/ Under Healing, the Tribes were to jointly share in the mineral rights to the JUA land within the Executive Rectangle, as well as share surface use of the land itself. The Navajo subsequently disregarded Healing, by using the surface area of the JUA to graze sheep and claiming exclusive mineral rights to the JUA. As a result, the Hopi Tribe was effectively excluded from the JUA.

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[9]./ Kapplan, Indian Affairs, Laws and Treaties Vol. I, p. 805 (2nd ed. 1904). A copy of this Executive Order is attached hereto as Appendix D.

[10]/ Page, supra note 5, at 209.

[11]/ Healing v. Jones, 174 F.Supp. 211 (D.Ariz. 1959), aff'd, 373 U.S. 758, 83 S.Ct. 1559 (1963).

Because the Navajo Tribe steadfastly refused to relocate onto Navajo Partitioned Lands ("NPL"), Congress in 1974 enacted a Settlement Act which divided the JUA in two halves; one half for the Hopi Tribe and one half for the Navajo Tribe. [12/] The 1974 Settlement Act provided that the Hopi Tribe had exclusive use of some 900,000 acres which comprised the Hopi Partitioned Lands ("HPL"). In effect, the HPL were approximately 900,000 acres shy of the original Hopi lands under the 1882 Executive Order. [13/]

In 1978, the Ninth Circuit Court of Appeals issued the Final Order of Partition, which established the JUA boundaries in effect today. [14/] Although subject to dispute, the JUA division affected surface use only, with each Tribe retaining an undivided one-half interest in all subsurface mineral rights of the former JUA. The surface areas are subject to the exclusive regulatory control of the Tribe to which it was partitioned.

The combined area of Hopi District 6 and the HPL includes some 1.5 million acres over which the Hopi Tribe exercises civil regulatory jurisdiction. The Tribe recognizes

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12/ Pub. L. 96-305, 94 Stat. 929 (July 8, 1980). This statute is known as the Navajo and Hopi Indian Relocation Amendments Act of 1980.

13/ Executive Order, supra note 9, at 805. See also, Page, supra note 5, at 210.

14/ Sekaquaptewa v. MacDonald, 575 F.2d 239 (9th Cir. 1978); Sekaquaptewa v. MacDonald, 626 F.2d 113 (9th Cir. 1980).

traditional authority over District 6 lands and all lands "outside District 6 and within the 1882 boundary ... (are) under the exclusive jurisdiction and authority of the Hopi Tribal Council." [15]/

Although individual Hopi Tribal members do not own separate parcels of land, they do maintain use rights in accordance with the land tenure systems adopted by the Tribal Council. [16]/ Each of the twelve villages which comprise District 6 is considered to have its own territory. The Hopi land tenure system has been undergoing change for some time. Although variations do exist among the villages, Hopi land ownership is generally passed from mother to daughter. [17]/

The principal land uses within District 6 and the HPL (hereinafter referred to collectively as the "Hopi Reservation"), include subsistence agriculture, livestock grazing and religious use. Generally, these activities are not income generating. In addition, few Hopi Tribal members are employed at the Peabody Coal Mine site located north of HPL. [18]/ Thus, Tribal members often combine two or more jobs in

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[15]/ Page, supra note, 5 at 209.

[16]/ See, Sidney, Ivan, Chairman of the Hopi, (Proposed) Hopi Tunat'ya: Hopi Comprehensive Development Plan, A Summary. (July 1987). This proposed comprehensive development plan is currently undergoing Tribal review and has not yet been adopted by the Tribal Council.

[17]/ See Hopi Tribal Resolution H-78-78.

[18]/ Hopi Tribe, Division of Economics and Natural Resources, "Draft Environmental Assessment - Black Mesa Mine, Project No. 14-20-0450-5743. (1976), at 31. "Mine employment,

order to make ends meet. For example, grazing stock and part-time work is common as is the sale and growing of corn.

There were approximately 9,454 members of the Hopi Tribe in 1986. [19]/ This figure does not include Navajos awaiting relocation, but does include approximately 200 non-Hopis living on the Reservation. The population growth rate for the twelve year period from 1970 to 1982 was approximately three percent per year, or a cumulative increase of forty-two percent. Over the course of the last five years, the Hopi population has grown at the rate of about two percent per year. At present, over half of the Hopi population is under twenty years of age. [20]/ 'If this growth rate continues, there will be 12,500 Hopi Tribal members in the year 2000.

B. HOPI TRIBAL GOVERNMENT

Preservation of the Reservation environment, the permanent homeland of the Tribe, is a major concern of the Tribal Council. Tribal government provides the Reservation with a wide range of public services to protect health and welfare and environmental policy.

The Tribal Council recently organized a Resource Committee and Water Rights Team to address specific land and water

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where salaries are high, is available only to 22 Hopis at the present time."

[19]/ Sydney, supra note 16, at 4.

[20]/ Id.

resource issues and to provide overall policy direction in the natural resource area. Several years ago the Tribe established a Division of Economic Resources, which continues to be active in the areas of erosion control and water system maintenance. The Tribe's Black Mesa Negotiating Team is now finalizing its negotiations with the Peabody Coal Company with regard to the Black Mesa Coal Mine. The Team's goal is to secure additional revenues for the Tribe while addressing the Tribe's environmental concerns with the ongoing mining operation.

Over the past ten years, the Hopi Tribe has made significant progress in the area of natural resource management and control by: inventorying its resource base; developing a Tribal management framework; and strengthening the technical capacity of Tribal staff. The Tribe has also developed working relationships with several federal agencies in the furtherance of this effort, including the Office of Surface Mining, the BIA, the Department of Energy, the Indian Health Service and most recently, EPA.

III. TRIBAL GOVERNMENTS AND FEDERAL ENVIRONMENTAL LAW

As a general rule, unless Congress specifically states otherwise, states do not posses civil regulatory jurisdiction on Indian lands or within the exterior boundaries of Indian

reservations. [21]/ The Clean Water Act neither acknowledges the existence of state authority over Indian reservations nor delegates Federal authority to states over Indian reservations. [22]/ Therefore, the reservation environment is excluded from the jurisdictional scope of state water quality control programs. Accordingly, state regulatory programs cannot meet provide for the comprehensive environmental regulation of Indian reservations. [23]/ Nevertheless, Indian lands are subject to comprehensive federal and tribal environmental regulation.

A. THE CLEAN WATER ACT

Congress, acting in concert with Federal Indian Policy,

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[21]/ See McClanahan v. Arizona State Tax Commission, 411 U.S. 164 (1973).

[22]/ EPA recognizes that federal, not state regulatory authority extends to Indian lands. Additionally, Congress has authorized EPA to treat tribes as states under the CWA. See, Bryan v. Itasca County, 426 U.S. 373 (1976) (articulating standards for construing Congressional grants of power over Indians to states).

[23]/ EPA has long recognized the inapplicability of State environmental regulatory jurisdiction over Indian reservations. See EPA General Counsel Opinion No. 77-6 re: State Jurisdiction Over Indians Living On Tribal Lands (May 31, 1977); EPA General Counsel Opinion No. 76-25 re: State Jurisdiction Over Federal Facilities and Indian Tribes under Part B of the Safe Drinking Water Act (Nov. 15, 1976); Furthermore, in its more recent approvals of state program delegations under the Safe Drinking Water Act Underground Injection Control Program the EPA has taken the following position with regard to a state's assertion of jurisdiction over Indian land: "EPA will assume that a State lacks authority unless the State affirmatively asserts its authority and supports its assertions with an analysis from the State Attorney General..." 47 Fed. Reg. 17578 (April 23, 1982); 48 Fed. Reg. 2938 (Jan. 21, 1983).

recently amended several key environmental statutes to provide a federally recognized role for tribal government in protecting the reservation environment. [24]/ For example, the 1987 Amendments to the Clean Water Act ("CWA") authorize EPA to treat Indian tribes as states. [25]/ Section 518(h)(1) of the CWA defines a Federal Indian Reservation as:

> All lands within the limits of any Indian reservation under the jurisdiction of the United States Government, notwithstanding the issuance of any patent, and including rights-of-way running through the reservation. [Emphasis supplied.]

Thus, both trust and fee lands within the exterior boundaries of an Indian reservation are within the scope of tribal regulatory jurisdiction under an EPA approved tribal water quality management program.

Section 518(e) of the CWA set out the test by which EPA will treat tribes as states. To achieve "state-like status" under the CWA, an Indian tribe must demonstrate to EPA that it has:

(a) A governing body carrying out substantial duties and powers;

(b) Managed on-reservation water resources; and

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[24]/ The trend began in June, 1986, with the passage of the Amendments to the Safe Drinking Water Act ("SDWA") 42 U.S.C. 300(f) et seq., which authorized EPA to treat Indian tribes as states. This trend continued in October, 1984, when Congress extended tribal authority over the environment with the passage of amendments to the Comprehensive Environmental Response, Compensation and Liability Act ("Superfund") 42 U.S.C. 9601 et seq.

[25]/ 33 U.S.C. 1251 et seq.

(c) The demonstrated capability to carry out water program management functions consistent with the CWA and its implementing regulations.

EPA recently published its proposed regulations for implementation of the "Indian Amendments" to the Safe Drinking Water Act ("SDWA") which further details the type of documentary showing necessary to satisfy this test. /[26] The SDWA Indian Primacy regulations are illustrative of the CWA regulations likely to be proposed by EPA for tribal water program approval.

Once approved by EPA, tribes have the ability to administer a broad range of water pollution control programs under the CWA. Tribes may request delegation from EPA to implement the point source pollution control program under Section 402 of the Act, and may also request funding from EPA to implement this program. CWA Section 518(e). Although not required, Section 518(d) of the CWA provides for the development of cooperative agreements between tribes and states. [27]/ For such cooperative agreements to be part of the

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[26]/ See 52 F.R. 22111-22122 (July 27, 1987).

[27]/ Cooperative agreements between tribes and states are not a new phenomenon. Hundreds of agreements have been negotiated. See American Law Center, Handbook of State-Tribal Relations (1983). Tribal-state agreements are commonly used to implement the Indian Child Welfare Act of 1978. Cooperative agreements have been entered into between tribes and states and between tribes and the federal government. See Cooperative Agreement, between U.S. EPA and Northern Cheyenne Tribe regarding implementation of the Northern Cheyenne Air Quality Program (April 16, 1984). See also American Indian Lawyer Training Program Handbook: The Indian Child Welfare Act (1983).

EPA approved program, they must be approved by EPA. If consistent with the Tribe's best interests, cooperative agreements could provide for joint tribal/state planning and administration of CWA programs.

In the area of grant funding, Section 518(f) of the CWA provides that one-third of one percent of EPA's appropriation under Section 319 is to be set aside and disbursed to approved tribal nonpoint source programs. Additional nonpoint source program grant funding for tribes is available under Section 205(j) of the CWA. To qualify for non-point program funding, an Indian tribe must meet the three basic Section 518(e)(1-3) criteria described above, as well as the requirements set forth in Section 319.

Under the CWA, tribes may now develop their own water quality standards ("WQS") for on-reservation surface waters. This is a very important development as WQS provide the foundation for enforceable pollution control measures under the CWA. Tribal WQS are translated into legally enforceable requirements through either: (1) point source discharge permits ("NPDES") under Section 402; or (2) nonpoint source best management practice ("BMPs"), under Section 319.

Although approved by the EPA, state WQS exist as a matter

Cooperative agreements, however, may not be implemented by unilateral action of one party. Cf. Kennerly v. District Court of Montana, 400 U.S. 423 (1971).

For a survey of cooperative agreements between tribes and states, See Commission on State-Tribal Relations, State-Tribal Agreements: A Comprehensive Study (May 1981).

of state and not Federal law. EPA's approval of state WQS is merely an affirmation of the adequacy of the state standards and a declaration that no Federal promulgation is necessary." 28/ Neither state WQS nor the underlying state water quality management program are applicable within the exterior boundaries of an Indian reservation.

Thus, Tribal or general Federal WQS must be in place in order for the CWA to have force and effect on Indian reservations. Tribal WQS are more likely to meet the individual needs of Indian tribes.

B. THE SAFE DRINKING WATER ACT

The 1974 Safe Drinking Water Act ("SDWA") was enacted to provide EPA with Federal authority to protect public health through the regulation of surface and subsurface drinking water sources. The SDWA establishes a national regulatory program to protect the quality of drinking water from known contaminating sources.

In 1986 the SDWA was amended and, under the new

28/ Memorandum Legal Opinion by G. William Frick, Associate General Counsel, Water to Daniel J. Snyder III, Regional Administrator, EPA Region III and John A. Green, Regional Administrator, EPA Region VIII. Subject : Revision of Water Quality Standards and Implementation Plans Under Section 303 of the Federal Water Pollution Act at 3 (Feb. 3, 1975). This legal opinion goes on to state that "the water quality standards are not directly enforceable. The water quality standards are to be implemented primarily through the issuance of permits pursuant to Section 402 and it is the provisions of the NPDES permits which are the actual enforceable requirements..." Id. at 4.

amendments, EPA is empowered to delegate primary SDWA enforcement authority to Indian tribal governments. Tribes may now regulate public water systems and the underground injection of wastes on their reservations. The SDWA was the first federal environmental law to authorize the Administrator of EPA to "treat Indian Tribes as States". [29/] The SDWA also made significant levels of grant funding and technical assistance available to Indian tribes.

On July 27, 1987, the Administrator of EPA, pursuant to Section 1451 of the SDWA, promulgated proposed regulations to guide EPA in determining which tribes may assume direct responsibility for implementing SDWA programs. [30/] Because the SDWA Amendments preceded the CWA Amendments by approximately seven months and the tribal "state-like status" approval criteria under the SDWA and CWA are almost identical, the proposed SDWA "primacy" regulations are directly relevant to tribal program development under the CWA.

The SDWA requires that an Indian tribe be recognized by the Secretary of the Interior and have a governing body carrying out substantial governmental duties and powers. Section 1451(b)(1)(A). Although the language is not identical

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[29/] 42 U.S.C. Section 1451 (a)(1). See 52 F.R. 28112 et seq. (July 27, 1987), (proposed primary regulations for implementation of Tribal SDWA programs).

[30/] EPA is also in the process of adapting regulations program to provide for EPA's direct implementation of the SDWA Underground Injection Control Program ("UIC") on Indian lands. 52 F.R. 17684 and 52 F.R. 17696.

under Section 518(e)(1) of the CWA, the definition of Indian tribe under section 518(e)(1) of the CWA, effectively incorporates the same requirement. In all other respects, the "tribe-state" governmental authority test is identical under the SDWA (Section 1451(b)(1)(A) and the CWA (Section 518(e)(1)). In sum, both statutes require that a tribe have a governing body carrying out substantial governmental duties and powers in the areas of natural resource management and control.

The Bureau of Indian Affairs ("BIA") has defined "substantial governmental functions" as the organized provision of services to tribal numbers. Such services include the administration of health and employment services. A similar definition, proposed by EPA in the SDWA primacy regulations, provides that:

> [T]ribal governments perform essential governmental functions traditionally performed by sovereign governments . Examples of such functions could include, but are not limited to, the power to tax, the power of eminent domain, and the police power (i.e., the power to provide for the public health, safety and general welfare of the affected population). 31/

Section 1451(b)(1)(B) of the SDWA requires that the functions exercised by tribal government be within the tribe's jurisdiction. Although somewhat more specific, the general intent of Section 518(e)(2) of the CWA is similar. Rather than adopting the SDWA approach of looking to the general jurisdiction of the tribe, the CWA requires that the functions

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31/ 52 FR 28133 (July 27, 1987).

to be exercised by the tribe pertain to the management and protection reservation water resources.

Section 1451(b)(1)(C) of the SDWA and section 518(e)(3) of the CWA are almost identical, in that each provides that:

> the Indian Tribe is reasonably expected to be capable, in the Administrator's judgment, of carrying out the functions to be exercised in a manner consistent with the terms and purposes of this Act and of all applicable regulations. [32]/

Although yet untested, the Administrator's decision making as to tribal qualifications under the SDWA and the CWA will be strongly influenced by Federal Indian Policy and the Federal trust responsibility.

Once the Administrator determines that a tribe has satisfied the Section 518(e) criteria of the CWA, the tribe may request that EPA delegate program responsibility to the tribe. Under the CWA a tribe is required to develop regulations no less stringent than the applicable federal regulations. The tribe must also demonstrate that it has adequate regulatory authority to enact and enforce tribal law to implement such programs.

The CWA provides for grant funding to help tribes develop and implement programs. For example, Section 106 provides for annual water quality management program implementation grants to assist tribes in carrying out pollution control programs.

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[32]/ SDWA Section 1451(b)(1)(C) used the word "title" instead of the word "Act"; however the meaning is the same.

One third of one percent of EPA's appropriations under Section 319 of the CWA may be used by tribes which qualify under Section 518(e)(1-3) and 319 for non-point source control programs. Additional funding is also available to tribes under Section 518(a) which allows 100% grant funding for development of tribal waste treatment management plans and construction of tribally owned sewage treatment works.

Thus, adequate funding should be available to minimize the financial impact on the tribe associated with the development and implementation of a tribal water quality management program. In developing programs, tribes must be aware of the various federal requirements which affect program funding, development and maintenance. [33/]

[33/] Once a tribe has been approved by the Administrator, and a program is in place, the tribe is required to do the following:

1. Develop water quality standards and an implementation plan; Section 303 requires the tribe to submit these standards to the Administrator for approval.

2. Prepare biennial reservation water quality inventories, which must also be submitted to the Administrator under Section 305. This report will describe the water quality of all navigable waters in the reservation, an analysis of the extent that navigable waters provide for protection and propagation of a balanced population of shellfish, fish and wildlife, and allow recreational activities in and on the water, an analysis of the extent that elimination of discharge of pollutants have been or will be achieved by the requirements of the Act and additional action necessary for achievement, an estimate of environmental impact, social and economic benefits of achievement and an estimated date of achievement, and finally, a description of the nature and extent of nonpoint sources of pollutants and recommendations as to the programs which must be undertaken to control each category of source with an estimate of costs for implementation.

The tribe also has the option to do the following:

1. A tribe may obtain Section 402 delegation from EPA to implement a point source pollution control program and Section

Once the EPA approved tribal water quality management program is in place, the CWA provides tribal regulatory jurisdiction over the inspection and monitoring as well as entry authority for point sources on the reservation. [34]/ Where a tribe fails to initiate or prosecute appropriate enforcement actions, federal enforcement action remains available. [35]/ Cooperative agreements or contracts between the tribe and EPA could serve to clarify this enforcement relationship. Additionally, no federal license or permit may be granted under the CWA until tribal 401 certification has been either obtained or otherwise waived. Where a tribe denies 401 certification, the federal license or permit must be denied.

C. WATER QUALITY PLANNING ON THE HOPI RESERVATION

The Hopi Tribe is dedicated to the protection, preservation and maintenance of their lands and waters, and the proposed Hopi Water Quality Management Program ("HWQMP") is part of the Tribe's overall environmental protection program. The Tribe is currently meeting with EPA to discuss and negotiate a cooperative agreement regarding the design and implementation of the Tribe's comprehensive non-point source

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404(g) delegation to administer a dredge and fill permit program for navigable waters under Section 518(e).

[34]/ 33 U.S.C. 1318.

[35]/ 33 U.S.C. 1319.

water quality management program.

Implementation of the HWQMP includes the establishment of base-line water quality data and preparation of an inventory of critical non-point sources of surface and ground water contamination. This data will in turn be used to identify strategies for the control of non-point pollution sources and to develop legally enforceable regulations. The Hopi expect that the development and implementation of the HWQMP will not only enhance their ability to address environmental issues, but also strengthen the government-to-government relationship between the EPA and the Hopi Tribe. [36/]

Section IV will review the legal authority of the Hopi Tribe to adopt and enforce regulatory measures applicable to activities which may impact surface and groundwater resources within the Hopi Reservation.

IV. TRIBAL POWER TO REGULATE WATER POLLUTION SOURCES

Tribal power to regulate those activities which may pollute Tribal resources is derived from two principal sources. One source is the Tribe's proprietary rights: the Tribe has all rights and powers of a property owner with respect to tribal property. A more fundamental and pervasive source, however, is

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[36/] See 40 C.F.R. 35.1503(g). EPA regulations provide that implementation may include construction of a sewage treatment works, point and non-point source control programs, legislative initiatives, enforcement and other activities necessary to meet Tribal water quality goals.

the Tribe's inherent sovereignty, which includes the power to regulate the use of property over which the Tribe has jurisdiction and control. [37]/

A. TRIBAL PROPRIETARY RIGHTS

Like any property owner, the Tribe may control activities on lands it owns in fee or which are held by the Federal government in trust for the benefit of the Tribe. [38]/ Given the extensive land holdings and subsurface rights of the Hopi Tribe, this is a significant source of control. [39]/

As a proprietor, the Tribe may condition entry upon its lands on compliance with Tribal law. The Tribe also has the power to exclude non-members from Indian lands. [40]/ The Tribe

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[37]/ See Powers of Indian Tribes, 55 I.D. 14 (1934), reprinted in I Opinions of the Solicitor 445, 467; Dept. of the Interior, Federal Indian Law 440 (1958); see also Merrion v. Jicarilla Apache Tribe, 102 S.Ct. 894, 901-906 (1982).

[38]/ See Morris v. Hitchcock, 194 U.S. 384 (1904); Barta V. Oglala Sioux Tribe, 259 F.2d 553, 556 (8th Cir. 1958).

[39]/ Proprietary rights allow tribes to manage both land and water resources. For example, several federal statutes exist which could help tribes manage their lands. See The Federal Land Management and Policy Act of 1976 ("FLMPA"), 42 U.S.C. 1701 et seq., (1982); National Environmental Protection Act ("NEPA"), 42 U.S.C 4321 et seq.; and the Public Range Land Improvement Act of 1978 ("PRIA"), Act of Oct. 25, 1978, Pub.L. No. 95-574, 92 Stat. 1803 (codified in part at 43 U.S.C. 1901 (1982).

For a general overview of these statutes and their limitations see R. Braun, "Emerging Limits On Federal Land Management Discretion: Livestock, Riparian Ecosystems, and Clean Water Law." 17 Environmental Law 43 (1986).

[40]. Merrion v. Jicarilla Apache Tribe, supra note 37, at 901-906.

may, by contract or lease condition, require that all proposed on-Reservation construction activities, mineral developments, or other pollution-causing activities comply with Tribal environmental regulations, including the proposed HWQMP.

Thus, development contracts or leases may include mechanisms to implement the Tribe's pollution control regulations. For example, compliance with BMPs, and the imposition of liquidated damages for noncompliance, can be included and made enforceable as lease conditions. In the related context of tribal air pollution regulation, one commentator observed that "the lease itself could replace the permit as the implementation tool." [41/] This in fact was done with regard to the imposition of BACT particulate emission controls for a proposed mining project to take place on the Colville Indian Reservation in the State of Washington. [42/]

In addition to its proprietary rights in Tribal lands, the Hopi Tribe possesses legally enforceable water rights. In United States v. Winters [43/], the Supreme Court found that the setting aside of an Indian reservation necessarily included the implied reservation of a proprietary water right. This holding

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[41/] National Commission on Air Quality, Draft Report on the Role of Indian Tribes 61 (1980).

[42/] "Air Quality Control Agreement - Mount Tolman Project," entered into by: U.S. Environmental Protection Agency; Confederated Tribes of the Colville Indian Reservation; U.S. Department of the Interior; Bureau of Indian Affairs; U.S. Geological Survey; and AMAX, Inc. (1981).

[43/] United States v. Winters, 207 U.S. 564, 576 (1908).

was based upon the Court's conclusion that without such a reserved Indian water right, the land of the Fort Belknap Reservation would be valueless. Implied Indian water rights have also been held to exist where water was "essential to the life of the Indian people." [44]/

In Colville Confederated Tribes v. Walton [45]/ the Ninth Circuit applied the reserved water right doctrine to the Colville Reservation and determined that:

> As in Winters, the Indians relinquished extensive land and water holdings when the reservation was created. Some gave up valuable tracts with extensive improvements....Congress intended to deal fairly with the Indians by reserving waters without which their lands would be useless....We hold that water was reserved when the Colville Reservation was created. [46]/

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[44]/ Arizona v. California, 373 U.S. 546, 599 (1963).

[45]/ Colville Confederated Tribes v. Walton, supra note 8.

[46]/ See Colorado v. New Mexico, 103 S.Ct. 539 (1982), (where the Court held that a state's right to water under the equitable apportionment doctrine imposes a duty on sister states to protect water quality); Pyramid Lake Paiute Tribe of Indians v. Morton, 354 F.Supp. 252 (D.D.C. 1973) (preventing a water diversion that would disrupt the salinity and erosion balance of Pyramid Lake and damage the tribal fishery resource); see also United States v. Washington, (Phase II) 506 F.Supp. 187 (W.D. Wash. 1980) (finding a reserved environmental right for tribes entitled to salmon in the Pacific Northwest) this decision was appealed to a three judge panel; Washington v. United States, 694 F.2d 1374 (9th Cir. 1982) which was vacated and heard by an en banc panel; the en banc opinion was vacated and a per curium opinion issued at 759 F.2d 1353 (9th Cir. 1985) cert. denied 106 S.Ct. 407 (1985) (basically deciding that question of reserved environmental right and responsibility of federal government to actively protect that right not yet ripe). See also "The Environmental Right to Habitat Protection: A Sohappy Solution" 61 University of Washington Law Review 731 (1986).

A necessary corollary to the Tribe's reserved water right is a Tribal right to unpolluted water. The value of the Tribe's reserved water right is, of course, inextricably intertwined with the quality of such waters. Traditionally, reserved rights have been enforced by suits for injunctive relief in federal court. [47]/ The U.S. Supreme Court has recognized, however, that the McCarran Amendment empowers state courts to serve as the forum for the adjudication of tribal water rights. [48]/ Indian reserved water rights are a communal property right owned by the tribal membership unless alienated. It is important to note that state courts must protect Indian reserved rights to the same degree that would otherwise be applicable under Federal law. [49]/

Congress, the Federal courts and EPA have consistently acknowledged tribal regulatory jurisdiction over on-reservation environmental matters. [50]/ Moreover, the Ninth Circuit has

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[47]/ See, e.g., Walton, supra note 8, at 53.

[48]/ See Arizona v. San Carlos Apache Tribe, 463 U.S. 545 (1983); Colorado Water Conservation District v. United States, 424 U.S. 800 (1976); White Mountain Apache Tribe v. Hodel, 784 F.2d 921, 924 (9th Cir. 1986).

[49]/ Colorado Water Conservation District v. United States, supra note 48, at 812-13 (recognizing that Indian interests may be protected by state law, but that legal conflicts involving reserved water rights can be reviewed by the U.S. Supreme Court).

[50]/ It is arguable that Congress may have expressly allowed tribes to adjudicate water rights within tribal jurisdiction through the 1987 Clean Water Act Amendments. Congress stated:

> It is the policy of Congress that the authority of each state [and Indian tribes are treated as

recognized the right of the Colville Confederated Tribes to control regulation of a stream that was located totally on the reservation. In Colville Confederated Tribes v. Walton the Court found that, "[r]egulation of water on a reservation is critical to the lifestyle of its residents and the development of its resources." [51]/

In this sense, there is a nexus between the power which stems from a tribe's proprietary rights and tribal regulatory authority which is a function of tribal sovereignty. The latter, and more pervasive, source of tribal governmental power is discussed further below.

B. TRIBAL SOVEREIGNTY: THE POLICE POWER

In addition to its proprietary rights, the Tribe's sovereignty gives rise to its governmental police powers which may be exercised by means of civil regulatory controls. "Perhaps the most basic principle of all Indian law" is that the powers of Indian tribes are the "inherent powers of a limited sovereignty which has never been extinguished." [52]/ A

> states for the purposes of this section - 33 U.S.C. 1377(a)] to allocate quantities of water within its jurisdiction shall not be superseded, abrogated or otherwise impaired by this Act. 33 U.S.C. 1251(g).

[51]/ Colville v. Walton, supra note 8, at 52.

[52]/ Powers of Indian Tribes, I Opinions of the Solicitor at 447. See Washington v. Confederated Tribes of the Colville Reservation, 447 U.S. 134, 152-54 (1980); United States v. Wheeler, 435 U.S. 313, 322-23 (1978); Worcester v. Georgia,

tribe's inherent sovereign powers extend to both its member and its territory.

In 1982 the Supreme Court held that a tribe had the power to levy a severance tax on a nonmember. The Court emphasized the territorial component of tribal sovereignty as follows:

> The power to tax is an essential attribute of Indian sovereignty because it is a necessary instrument of self-government and territorial management. This power enables a tribal government to raise revenues for its essential services. The power does not derive solely from the Indian tribes' power to exclude non-Indians from tribal lands. Instead, it derives from the tribes' general authority, as sovereign, to control economic activity within its jurisdiction, and to defray the cost of providing governmental services by requiring contributions from persons or enterprises engaged in economic activities within that jurisdiction. [Emphasis added.] 53/

As early as 1926, the Supreme Court recognized that one of the most basic incidents of sovereignty is a government's power to regulate land use to protect public health and welfare. 54/ Some eight years later, the Solicitor of the Department of the Interior asserted that:

> [O]ver all the lands of the reservation, whether owned by the tribes, by members thereof, or by outsiders, the tribe has the sovereign power of determining the conditions upon which persons shall be permitted to enter its domain, reside therein, and to do business, provided only such

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supra note 6, at 560-61.

52/ Merrion v. Jicarilla Apache Tribe, 102 S.Ct. 894, 901 (1982). See also New Mexico v. Mescalero Apache Tribe, 103 S.Ct. 2378, 2385 (1983).

54/ See Village of Euclid v. Ambler Realty Co., 272 U.S. 365 (1926)

> determination is consistent with applicable Federal laws and does not infringe any vested rights of persons now occupying reservation land under lawful authority. [Emphasis added.] [55]/

The Solicitor went on to conclude that:

> In its capacity as a sovereign, and in the exercise of local self-government, [a tribe] may exercise powers similar to those exercised by any State or nation in regulating the use or disposition of private property, save insofar as it is restricted by specific statutes of Congress. [56]/

Thus, Indian tribes retain all aspects of their sovereignty except those specifically withdrawn by Congress or inconsistent with overriding Federal interests. [57]/

1. Federal Common Law

Federal Indian policy favors tribal self-government and economic self-sufficiency. The presumption in favor of inherent tribal sovereignty forms the backdrop against which courts measure the applicability of vague or ambiguous federal statutes to tribal activities. [58]/ Historically, the Supreme Court has held that state regulation may not interfere with the sovereign rights of Indians to control their reservation. [59]/

57/ Powers of Indian Tribes, I Opinions of the Solicitor at 467 (1934).

61/ Id. at 471.

57/ See, e.g., Washington v. Confederated Tribes of the Colville Reservation, 447 U.S. 134, at 153-54.

58/ McClanahan v. Arizona State Tax Commission, 411 U.S. 164 (1973).

59/ Williams v. Lee, 358 U.S. 217 (1959).

Thus, the general rule is that states may not utilize their civil regulatory authority to regulate activities within Indian country. [60]/

In 1987 the Supreme Court again restated this general rule in California v. Cabazon Band of Mission Indians [61]/, where the Supreme Court held that California's bingo law was preempted and did not apply to the Cabazon Reservation. The Court reasoned that:

> [s]tate jurisdiction is pre-empted...if it interfered or is incompatible with federal and tribal interest reflected in federal law, unless the state interests are sufficient to justify the assertion of state authority...The inquiry is to proceed in light of traditional notions of Indian sovereignty and the 'overriding goal' of encouraging tribal self-sufficiency and economic development. [Citations omitted.] [62]/

Shortly after the Cabazon decision, the Ninth Circuit Court of Appeals, in Crow Tribe of Indians v. Montana [63]/ examined the issue of whether a state may apply its civil laws to activities within the exterior boundaries of Indian reservations. In Crow, the State of Montana attempted to tax coal mined on ceded lands, and other lands within the exterior boundary of the Crow Reservation. The Court held that such state laws were preempted both by Federal Indian Policy,

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[60]/ Bryan v. Itasca County, 426 U.S. 373 (1976).

[61]/ California v. Cabazon Band of Mission Indians, ____ U.S. __, 107 S.Ct. 1083 (1987).

[62]/ Id at 1097.

[63]/ Supra 14 I.L.R., at 2097.

promoting tribal self-sufficiency and economic development, and by the Crow Tribe's inherent sovereignty to manage the use of its territory and resources. [64]/

2. Statutory Interpretation

Unless Congress specifically provides otherwise, state environmental regulatory authority is not applicable to Indian lands. [65]/ Moreover, the Courts of Appeal in both the Ninth and Tenth Circuits have recently addressed the issue of state environmental jurisdiction over Indian lands and held that state law was preempted. In Phillips Petroleum Co. v. EPA, [66]/ the Court allowed Federal jurisdiction over reservation Underground Injection Control ("UIC") programs. Similarly in Washington DOE v. EPA, [67]/ the Ninth Circuit upheld an EPA decision to deny state jurisdiction over Indian lands under the Resource Conservation and Recovery Act ("RCRA"). [68]/

In Washington DOE v. EPA, the Agency, acting in accordance with Federal Indian Policy, refused to approve that part of the Washington State's RCRA program which asserted state regulation

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[64]/ Id, at 2098, 2100.

[65]/ See Washington Department of Ecology v. EPA, 752 F.2d 1465 (9th Cir. 1985).

[66]/ 803 F.2d 545, 549, (10th Cir. 1986). The State of Oklahoma made no attempt to assert jurisdiction over reservation lands.

[67]/ 752 F.2d 1465, supra, note 65.

[68]/ 42 U.S.C. 6901 et seq.

over Indian lands. Although RCRA is substantially silent with regard to the question of jurisdiction over Indian lands, the Ninth Circuit upheld EPA's action as consistent with recognized tribal sovereignty and in concert with Federal Indian Policy.

Likewise, the CWA demonstrates no express or implied Congressional intent to extend state jurisdiction over Indian Country. In fact, the express intent of Congress is to allow EPA to treat tribes as states to fulfill the purposes of the CWA. Congress has explicitly provided that Indian tribes may function "as states" to develop regulatory programs under the CWA and SDWA.

The Tenth Circuit specifically addressed the question of whether EPA was empowered to regulate Indian lands under the SDWA. [69]/ In supporting EPA's decision to establish Federal primacy, the Court found that Congress intended to include Indian lands in the scope of the SDWA. [70]/ The SDWA and general Federal Indian Policy clearly establish Federal as well as tribal authority to regulate the reservation environment, to the exclusion of state governments. [71]/ Furthermore, if an Indian tribe does not achieve program primacy, it is the

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[69]/ In that case, started before the 1986 SDWA Amendments, all parties agreed that "Oklahoma state government has no power to prescribe underground injection control program regulating the Osage Indian Reserve." Phillips v. EPA, supra, note 66, at 554.

[70]/ Id., 803 F.2d 545, at 555, 556.

[71]/ Of course, tribes can always cooperate with state governments to implement tribal programs, or tribes can adopt and implement state programs on reservation lands.

responsibility of EPA, and not the state, to retain on-reservation jurisdiction.

Recent lower court decisions have uniformly determined that, absent a specific statutory statement to that effect, Federal legislation should not be read to extend state regulatory authority over Indian lands. In People ex rel. Department of Transportation v. Naegele Outdoor Advertising Company of California [72], the California Supreme Court stated that "...Congressional authorization of state regulation or federal property will be found only where Congress' mandate is explicit." [73] The Court held that the Highway Beautification Act does not authorize state regulation of outdoor advertising on Indian reservation lands.

C. SCOPE OF TRIBAL REGULATORY JURISDICTION

Section 518(e)(2) of the CWA empowers an Indian tribe to regulate potential sources of water pollution for land owned by Indians, by the U.S. in trust for the Indians or "otherwise within the borders of the reservation". This provision effectively eliminates checkerboard enforcement on Indian reservations when land is owned both by Indians and non-Indians. The Indian tribe is responsible for regulating all lands and waters within the reservation.

Even prior to the 1987 CWA Amendments, tribal civil

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[72] 213 Cal.Rptr. 247, 38 Cal.3d 509, 698 P.2d 150 (1985).

[73] Id., 213 Cal.Rptr. at 252.

jurisdiction over nonmembers was recognized as a matter of federal common law in a variety of contexts. Recent court decisions have uniformly upheld the power of tribes to: adjudicate the contractual rights of non-Indians; impose taxes on the activities of non-Indians; apply tribal health and safety codes to non-Indian buildings; zone non-Indian lands; regulate non-Indian self-help remedies. [74]/ In sum, Indian tribes retain the inherent sovereign power to exercise a broad range of civil jurisdiction over all persons who reside or do business on Indian lands, including, nonmembers and non-Indians. [75]/

The Supreme Court has held that tribal courts are generally not empowered to exercise criminal jurisdiction over non-Indians. [76]/ However, this limitation does not apply to the

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[74]/ See, e.g., Williams v. Lee, supra note 66 (adjudication of contract disputes); Merrion v. Jicarilla Apache Tribe, supra note 53 (imposition of severance tax); Washington v. Confederated Tribes of Colville Reservation, supra note 57 (imposition of sales tax); Snow v. Quinault Indian Nation, 709 F.2d 1319 (9th Cir. 1983) (imposition of business activity tax); Cardin v. De La Cruz, 671 P.2d 363 (9th Cir. 1982), cert denied, 103 S.Ct. 293 (application of tribal building code); Knight v. Shoshone and Arapaho Tribes, 670 F.2d 900 (10th Cir. 1982) (application of tribal zoning ordinance); Babbitt Ford, Inc. v. Navajo Indian Tribe, 710 F.2d 587 (9th Cir. 1983) (regulation of possession of personal property).

[75]/ See also Montana v. United States, 450 U.S. 544, 565-66 (1981).

[76]/ Oliphant v. Suquamish Tribe of Indians, 435 U.S. 191 (1978). William Canby, formerly professor of law at Arizona State University and now a judge on the United States Court of Appeals for the Ninth Circuit, suggests that some criminal jurisdiction may survive Oliphant. Canby, "The Status of Indian Tribes in American Indian Law Today," 62 Wash.Law Rev. 1,10 (1987) ("an excellent case can be made for the proposition

exercise of tribal civil regulatory jurisdiction and tribal environmental programs are implemented as a matter of Tribal civil law. [77]

In Confederated Salish and Kootenai Tribes v. Namen, [78] the Ninth Circuit held that the tribes could regulate non-Indian owners' use of the bed and banks of Flathead Lake. In a footnote, the Court disposed of the assertions that "preventing intrusions on the non-Indians' personal liberties" was an overriding federal interest that divested tribal power, by stating that:

> The first alleged interest is too broad and vague -- it would seem to rule out any exercise by Indians of civil regulatory jurisdiction over non-Indians yet such exercises have been approved. [79]

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that, in light of the traditional bases of federal Indian law and the current practical situation...Oliphant...[was] wrongly decided"). The authors contend that a tribal court would still have power to enforce decorum in its courtroom by the use of the criminal contempt power against disruptive non-Indians. The exercise of such power may be essential to the very existence of the tribal court, and is therefore not inconsistent with the status of a tribe as a dependent sovereign. The same argument might also be used to support the use of contempt power to enforce subpoenas issued to non-Indians in the course of the trial court's exercise of its legitimate jurisdiction.

[77] See Cardin v. De La Cruz, supra note 76, where the Court refused to apply the Oliphant analogy to civil regulatory program involving the health and welfare of the Tribe. Note also that the SDWA amendments expressly recognize that criminal jurisdiction is not required for tribal SDWA primacy. SDWA, Section 1451(b)(2).

[78] 665 F.2d 951 (9th Cir. 1982)

[79] Id. n.30, at 963.

The Court responded to the second argument that the non-Indian owners' "justifiable expectations" served to divest tribal power by stating that it was outweighed by the Indians' legitimate expectation of retaining jurisdiction over lands on their reservation. In particular the Court said:

> It is difficult to see why there should be an overriding federal interest in vindicating only the [non-Indians'] expectations -- especially where the anti-tribal policy on which they rest was repudiated over 50 years ago. 80/

Therefore, on lands and waters within their reservations tribal governments, in general, may exercise the full scope of their civil jurisdiction to protect the health, welfare, and economic sovereignty of the tribe. This basic governmental power is now buttressed by the express intent of Congress under the SDWA and CWA to allow Indian tribes to function in the capacity of states for the purpose of regulating the reservation environment under color of Federal law.

D. TRIBAL REGULATION OF WATER QUALITY

In Montana v. United States, the Supreme Court firmly supported the exercise of tribal civil regulatory jurisdiction by stating as follows:

> To be sure, Indian tribes retain inherent sovereign power to exercise some forms of civil jurisdiction over non-Indians on their reservations, even on non-Indian fee lands. A tribe may regulate, through taxation, licensing or other means, the activities of nonmembers who enter consensual relationships with the tribes

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80/ Id.

> or its members, through commercial dealing, contracts, leases or other arrangements....A tribe may also retain inherent power to exercise civil authority over the conduct of non-Indians on fee lands within its reservation when that conduct threatens or has some direct effect on the political integrity, the economic security, or the health and welfare of the tribe. [81]/

Because water quality regulation is necessary to protect health and welfare and the economic integrity of the Tribe, it clearly is a retained sovereign power. [82]/

Three cases decided after Montana explicitly hold that tribes may exercise civil jurisdiction to protect reservation water quality, and a fourth case upholds tribal zoning of non-Indian land in order to "preserve and protect" the tribal homeland.

The first such case, decided by the Court of Appeals for the Ninth Circuit is Colville Confederated Tribes v. Walton, [83]/ where the Court defined that a water system was a "unitary resource":

> The actions of one user have an immediate and direct effect on other users...Regulation of

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[81]/ 450 U.S. 544, 566, supra, note 75.

[82]/ The Clean Water Act does not act to divest the Tribe of this authority nor does it delegate to states any federal regulatory authority over Indian reservations. See also, Bryan v. Itasca County, supra note 23. Congress must clearly manifest intent to abolish Indian immunity from state law in order to do so); Part I, above. See generally, Will, "Indian Lands Environment -- Who Should Protect It?" 18 Nat. Res. L.J. 165 (1978).

[83]/ Supra note 8, at 52. But cf., United States v. Anderson, 736 F.2d 1358 (1984). (The Court limited the Walton holding to water quantity resources totally confined to the reservation).

> water on a reservation is critical to the lifestyle of its residents and the development of its resources. Especially in arid and semi-arid regions of the West, water is the lifeblood of the community. [84]/

Then, citing Montana, the Court stated:

> A tribe retains the inherent power to exercise civil authority over non-Indians on fee lands within its reservation when that conduct threatens or has some direct effect on the health and welfare of the tribe....This includes conduct that involves the tribe's water rights. [85]/

Similarly, in Confederated Salish and Kootenai Tribes v. Namen [86]/, the Court held that conduct causing water pollution was subject to tribal regulation. There, the tribe sought to regulate existing and future structures on the bed and banks of Flathead Lake. The Court held that such tribal regulation was not inconsistent with any overriding Federal interest:

> [N]o significant federal interest would be impaired by tribal regulation of the riparian rights of non-Indian land owners on the Flathead Reservation. Indeed, the United States itself entered this lawsuit on the side of the Tribes, contending not only that no federal interest would be injured by the challenged tribal regulation but that the regulation would, in fact, advance federal anti-pollution efforts. [87]/

Moreover, the Court found that, under Namen, the use of the bed

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86/ Id., Colville v. Walton at 52.

87/ Id. at 52, citing Montana v. U.S., 450 U.S. 544, n. 15 at 586.

86/ 665 F.2d 951 (9th Cir. 1982).

89/ Id., at 963-64 (footnote omitted).

and banks of the lake was conduct squarely within the scope of tribal civil regulatory jurisdiction because of its potential impact on water quality:

> Such conduct, if unregulated, could increase water pollution, damage the ecology of the lake, interfere with treaty fishing rights, or otherwise harm the lake, which is one of the most important tribal resources. Hence, the challenged ordinance falls squarely within the exception recognized in Montana. [88]/

Following Namen, the U.S. District Court for the Western District of Washington in Lummi Indian Tribe v. Hallauer [89]/ held that the Lummi Tribe has the power to construct and operate a reservation-wide sewer system. The court held that the Lummi Tribe could require nonmembers to connect their dwellings to the Tribal system and could also require such non-members to pay fees assessed to support the system. Finding that the sewer system was designed to remedy unsanitary and unhealthful conditions on the Lummi Indian Reservation, the Court went on to conclude that construction and operation of the system was within the inherent sovereign power of the Tribe.

Finally, in Knight v. Shoshone and Arapahoe Indian Tribes, [90]/ the Supreme Court sustained a tribal zoning ordinance

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[88]/ Id. at 964 (footnote omitted).

[89]/ Lummi Indian Tribe v. Hallauer, No. C 79-682R (W.D. Wash. Feb. 5, 1982), 9 I.L.R. 3025, (order granting summary judgment motion).

[90]/ 670 F.2d 900 (10th Cir. 1982).

applicable to all reservation lands, including lands owned in fee by non-Indians. The Court, noting that neither the state nor any of its subdivision regulated land use within the reservation, held that the:

> [I]nterest of the Tribes in preserving and protecting their homeland from exploitation justifies the zoning code...(and that)... The power to control use of non-Indian owned land within the reservation flows from the inherent rights of self-government and territorial management. [91]/

Recent Supreme Court decisions have recognized that notions of comity apply to tribal courts in cases involving diversity jurisdiction and federal questions. In Iowa Mutual Insurance Company v. LaPlante, [92]/ the Court required the plaintiff to first exhaust tribal court remedies before accepting diversity jurisdiction in cases involving the on-reservation commercial relations between tribal members and nonmembers. Similarly, in National Farmers Union Insurance Company v. Crow Tribe, [93]/ the Supreme Court required that tribal remedies be exhausted before a Federal District Court would accept federal question-jurisdiction over a dispute.

E. REGULATORY POWERS ESTABLISHED BY FEDERAL PREEMPTION

General acts of Congress apply to all persons, including

93/ Id.at 903.

92/ ____ U.S.__, 47 CCH S.Ct. Bull. p. B1090 (1987).

93/ 471 U.S. 845 (1985).

Indians. [94]/ Federal environmental laws are general acts of Congress. Moreover, where Federal regulation is comprehensive, and leaves no room for state regulation, state law is preempted. Finally, under the Supremacy Clause Federal law overrides state law where there is direct conflict between state and Federal laws.

In contract, the doctrine of Indian or tribal preemption differs in several significant respects from Federal preemption. [95]/ Federal law and Federal Indian Policy are the primary sources of law in the field of Indian law. When jurisdictional conflicts arise in Indian country, preemption analysis is employed to determine which government -- federal, tribal or state -- has authority to address a given subject area. Where federal action supports federal or tribal presumption, state authority is excluded. If preemption is not present, the analysis will likely turn on the balance of state interests versus the tribes' interests in a given subject area.

Federal environmental laws generally occupy the field and serve to preempt state law. [96]/ Furthermore, Congress has not

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[94]/ Federal Power Commission v. Tuscarora Indian Nation, 362 U.S. 99 (1970).

[95]/ It was not until 1973, that the concept of Indian "preemption" was first acknowledged by the Courts. McClanahan, 411 U.S. 164, supra, note 21.

[96]/ Illinois v. Milwaukee, 406 U.S. 91, 92 S.Ct. 1385 (1972) (Milwaukee I); Milwaukee v. Illinois, 451 U.S. 304, 101 S.Ct. 1784 (1981) (Milwaukee II); Illinois v. Milwaukee, 731 F.2d 403 (1984) (Milwaukee III), cert. denied, 469 U.S. 1196, 105 S.Ct. 979 (1985) (Milwaukee III).

specifically provided that the CWA extend state jurisdiction over Indian lands. In fact, the opposite is true. Federal jurisdiction is applicable to Indian Country, unless EPA has delegated such program authority to the tribe. Even where a tribe elects to forego water quality management delegation under the CWA, this does not open the door to state jurisdiction. Rather, EPA retains responsibility for program implementation in Indian Country.

F. FEDERAL TRUST RESPONSIBILITY

The trust relationship between the federal government and the Indians evolved judicially over time. In Cherokee Nation v. Georgia, [97]/ Chief Justice John Marshall characterized the status of Indian tribes as "domestic dependent nations" whose relation to the United States resembles that of a ward to his guardian." [98]/ This characterization recognized that the Indian tribes were sovereign nations, capable of managing affairs and governing themselves, but also limited the tribes' power to operate as wholly independent nations. [99]/

Indian sovereignty was limited and subject to the power of

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[97]/ 30 U.S. (5 Pet.) 1 (1831).

[98]/ Id at 17.

[99]/ Id at 16.

the Federal government. [100]/ In Worcester v. Georgia, [101]/ Chief Justice Marshall strengthened his characterization of tribes as sovereign and also made it clear that the power to deal with Indian tribes was Federal, wholly excluding states.

Trust responsibilities are generally created by an explicit act of Congress or of the Executive. The scope of the trust relationship, however, extends to any Federal act. During the 20th century, the trust principles from Cherokee Nation v. Georgia and Worcester v. Georgia have been applied to specific situations to establish and protect rights of Indian tribes and individuals. [102]/ Noted Indian scholar Felix Cohen described the trust relationship as follows:

> Trust obligations define the required standard of conduct for federal officials and Congress. Fiduciary duties form the substantative bases for various claims against the federal government. Even more broadly, federal action toward Indians as expressed in treaties, agreements, statutes, executive orders, and administrative regulations is construed in light of the trust responsibility. [103]/

Thus, cases have held that Federal actions affecting an Indian tribe must reflect the Federal government's fiduciary duty

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[100]/ Two limitations to Indian sovereignty were: (1) they could not alienate land, except to the federal government, and (2) they could not engage in foreign relations with another nation.

[101]/ 31 U.S. (6 Pet.) 515 (1832), supra, note 6.

[102]/ See F. Cohen, Handbook of Federal Indian Law (1982 ed.).

108/ Id. at 220-21.

toward Indian tribal government. [104]/

The fiduciary relationship protects the tribe from injurious Federal action and also protects against potential state encroachment. [105]/ Because of the Federal government's trust relationship with the Hopi Tribe, EPA has a duty to work with the Tribe in development of Tribal water quality management program.

V. CONCLUSION

In light of the analysis set forth above, we conclude that the Hopi Tribe has ample legal authority to adopt and enforce regulatory measures applicable to all water pollution sources within the Hopi Reservation.

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[104]/ See Seminole Nation v. United States, 316 U.S. 286, 296 (1942); and Santa Rosa Band v. Kings County, 532 F.2d 655, 657 (9th Cir. 1975), cert. denied, 429 U.S. 1038 (1977).

[105]/ See United States v. Kagama, 118 U.S. 375, 383-84 (1886), cited in State of Washington DOE v. EPA, at 1470, supra, note 65.

CHAPTER FOUR

SUPPLY & QUALITY OF HOPI WATER RESOURCES

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SUPPLY AND QUALITY OF HOPI WATER RESOURCES

An understanding both of the supply and quality characteristics of the tribal water resource and of the link between tribal water resources, off-reservation water resources, and land management are essential elements in the design of tribal water policies and natural resource development programs. Such is especially true at Hopi, where, for example, the development of ground water has widespread geographic impacts and holds significant implications for present and future domestic, range and industrial development activities. Accordingly, Chapter Four focuses on the physical supply and quality characteristics of the water resource at Hopi, assessing the status and applicability of current water resources information to the development of a decision-making base for tribal leaders.

Currently, much of the impetus for water resources research on the reservation is in connection with: (1) the ongoing Little Colorado River basin adjudication, (2) the Peabody Coal Company mining operation, and (3) the uranium mill tailings site at Tuba City. Several water resource studies are pending, and although each study has a specific focus, there is a need to examine the collective result of these studies and their applicability to water resource management. Such an examination must occur prior to the design of strategies for the collection of missing

information needed by policymakers and water resource personnel. In the context of the increasing regional pressure on the water resource as discussed in Chapter Two, an assessment serves the purpose of reviewing past actions and providing guidelines for future strategies.

Developing a Framework: The Hydrologic Cycle, Hopi Water Resources, and Water Policy Planning

In order to describe the status of research, management activities and information regarding the long-term supply and quality of Hopi water resources, a framework must be used that can integrate numerous and diverse studies and pieces of information. In this chapter, the examination of the **hydrologic cycle** both in general and within a **watershed system** provides an opportunity to assess the status of water resources research and management activities and to identify the information needed for water policy planning purposes. The discussion begins with a definition of the hydrologic cycle and its application to Hopi watersheds through a description of the occurrence and quality of the water resource. Next, a discussion of the relation of such information to water policy planning is applied to the water resource circumstances and concerns facing Hopi tribal leaders. This section concludes with an analysis of critical information needs and water resource management issues affecting tribal resource management planning, programs and

strategies in the Little Colorado River basin.

WATERSHED SYSTEMS AND THE HYDROLOGIC CYCLE

The hydrologic cycle describes the movement of water through the environment; a schematic diagram of the cycle as it might be envisioned on the Hopi Reservation is shown in figure 1. As illustrated in the diagram, the water cycle has several components, including: (1) **evaporation** from the land surface, open bodies of water and vegetation (**evapotranspiration**); (2) **precipitation** or rainfall; (3) **runoff** from the land and shallow subsurface; (4) **infiltration**, where deep percolation becomes (5) **ground water**. The study of the hydrologic cycle on reservation lands thus involves the study of various pathways of water movement and the relative proportion of water stored in each component of the cycle.

A **water balance** investigation would identify the amount of water stored in, added to, or depleted from a water reservoir -- for example, the soil moisture reservoir, a ground water reservoir or a lake. The **residence time** of water in each reservoir is of prime importance in water management and defines the length of time that a unit of water is stored in any particular reservoir. The average residence time of streams, for example, is three days. Ground water from a portion of the Navajo sandstone in north-

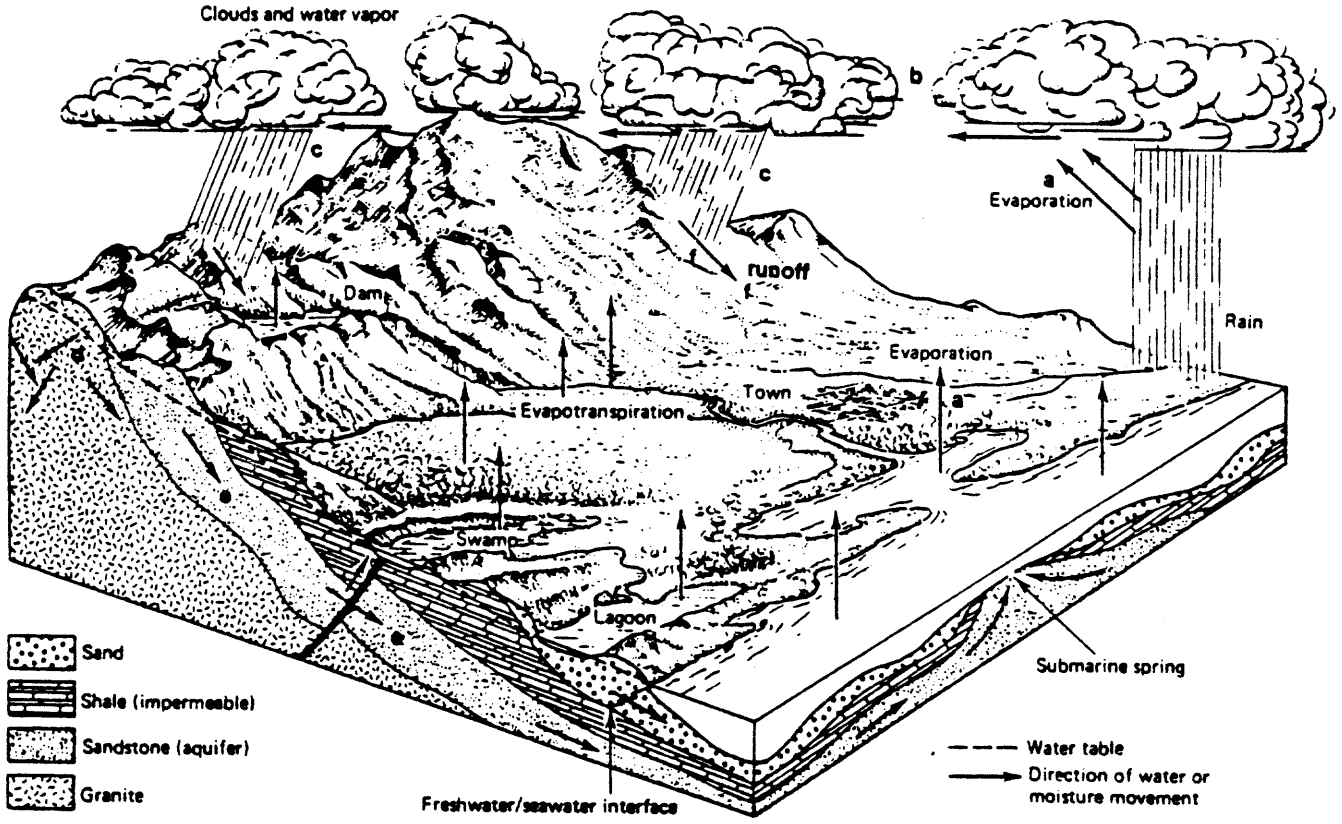


Figure 1 Schematic Diagram of the Hydrologic Cycle

central Black Mesa Basin was dated using carbon-14 age-dating techniques and reflected ages exceeding 10,000 years.[1] Table 1 presents the major elements of the hydrologic cycle, their residence time and items important in water resources planning.

When the hydrologic cycle is extended to a larger scale, the usefulness of a **watershed** approach is demonstrated. A watershed is a topographic and hydrologic unit in which surface water resources drain to a particular stream or stream system (figure 2). A water balance would attempt to quantify the amount of water flowing into and out of the watershed unit; this analysis can be performed for a small or sub-watershed, such as Moenkopi watershed, or for a larger watershed, such as the Little Colorado River watershed. A map showing major reservation watersheds is shown as figure 3. As the Hopi Tribe is well aware, the quantification of the water rights of the Little Colorado River basin in Arizona involves a large area and many water users, all claiming substantial rights to limited surface and ground water resources. The development of values for the volume of water generated by reservation watersheds is critical to the tribe's interest and claim in the Little Colorado River adjudication and is currently the subject of a proposed comprehensive surface water study for the region.[2]

The ground water reservoir may or may not follow the surface divide of a watershed. For example, the ground water

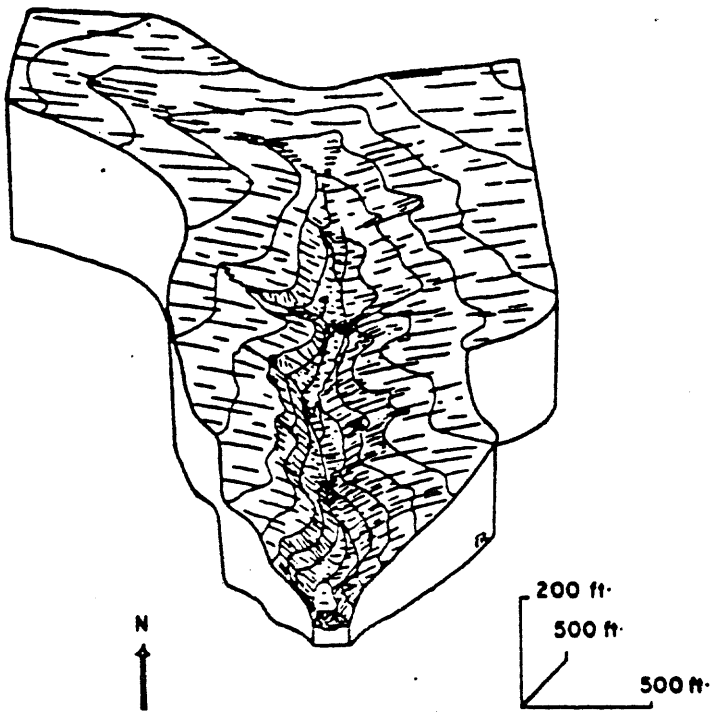


Figure 2 (a) Block Diagram Showing Topography of a Watershed (Bricker, 1972)

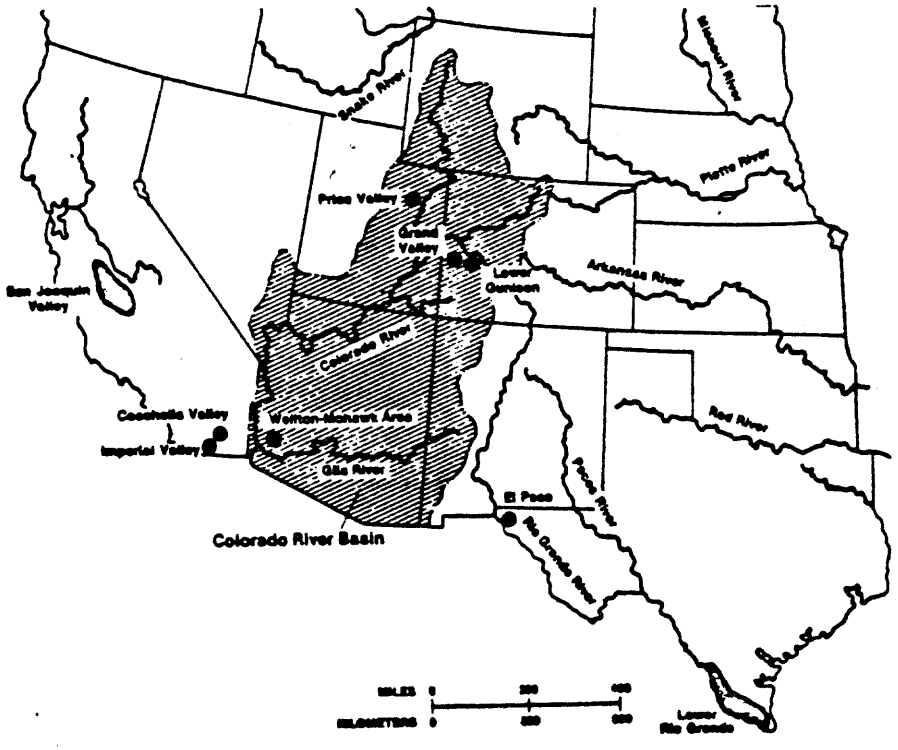


Figure 2 (b) The Watershed of the Colorado River Basin (Journal of Soil and Water Conservation, 1985)

Figure 3: Map showing location of Hopi watersheds

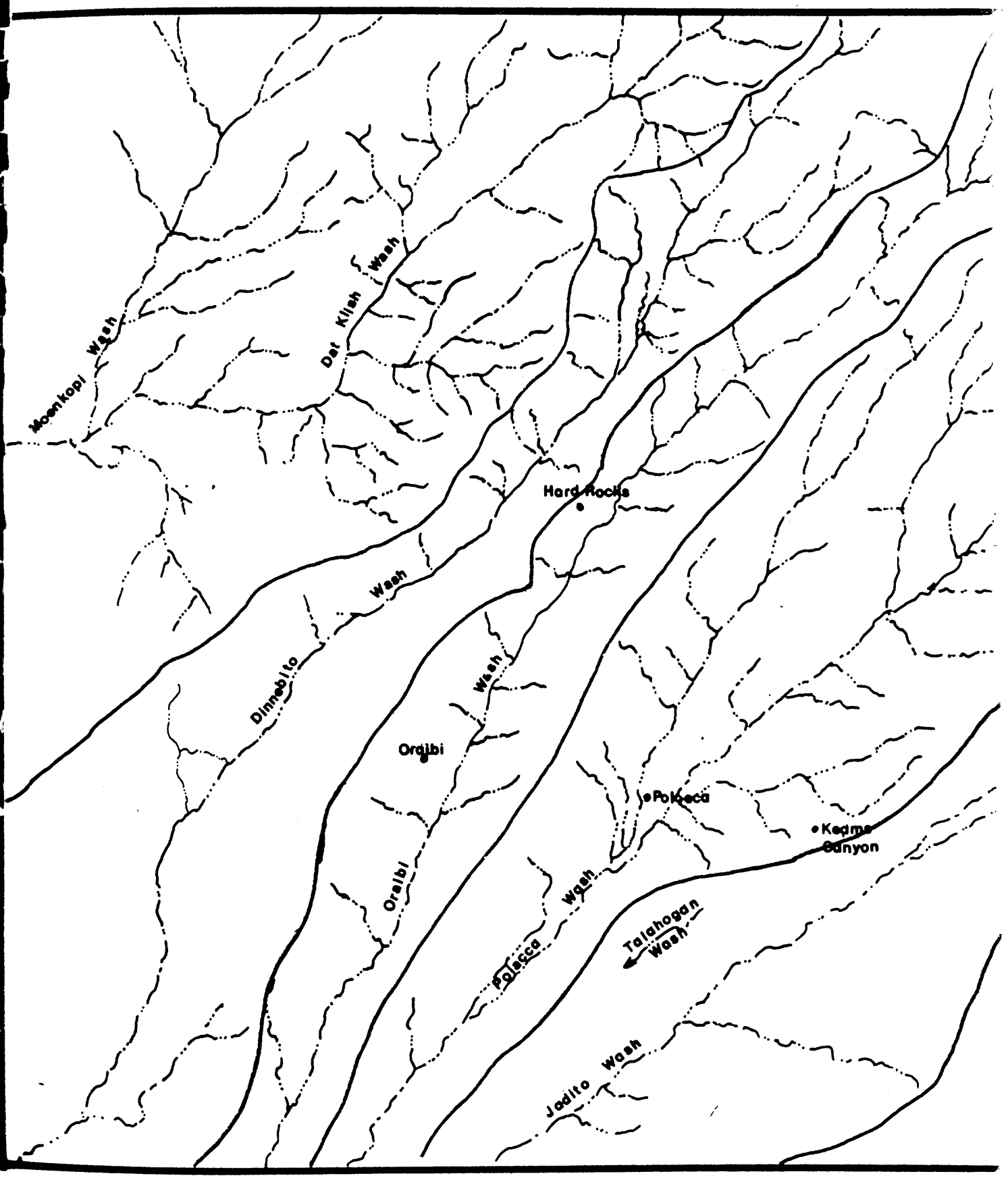


Table 1: Major components of the hydrologic cycle, the residence time of water in these separate components, and the major characteristics important in water resource investigations

Hydrologic Cycle Component	Residence Time in Hydrologic Reservoir	Characteristics Important in Water Resource Evaluation
Precipitation	hours to days	Intensity (in/hr) Duration (hours) Frequency (recurrence) Distribution Seasonal Characteristics
Evaporation	hours, calculated on a daily basis	Demand (climatic factors such as solar radiation, humidity, wind speed, air temp., cloud cover) Soil Factors Crop Requirements
Runoff	hours-days-weeks	Timing Volume Peak Flows Seasonal Characteristics Rainfall/Runoff Relations Watershed Characteristics: soil condition, land use, vegetation, soil moisture conditions, water quality)
Infiltration	hours to days	Infiltration Capacity of Soil Rainfall Characteristics Soil Type Soil Surface Condition Initial Moisture Content Unsaturated Hydraulic Conductivity
Ground Water	months to years	Storativity Hydraulic Conductivity Transmissivity Porosity Saturated Thickness Aquifer System Recharge

resources of the C, D and N multiple aquifer units, which comprise the major reservation water resources, extend across numerous sub-watersheds throughout the reservation. In addition, they extend off-reservation into Navajo and non-Indian communities to the south of the Hopi Reservation. Hence, development activities at great distances may impact water use, potential and quality far from the source of development.

An initial identification of sub-watersheds and their relevant water yield, vegetation, soil and topographic characteristics, followed by an identification of the major ground water reservoirs and their relationship to the sub-watersheds, are prerequisites to effective planning and protection of reservation water resources. For the Hopi Reservation, six major sub-watersheds originate and/or flow through tribal lands and feed the Little Colorado River basin within which the Hopi Reservation is located. Three major multi-aquifer systems comprise the major ground water reservoir. A number of smaller alluvial aquifers provide water to springs and shallow dug wells. As shown in figure 4, and the overlays that depict the extent of the aquifer systems, ground water boundaries do not follow watershed boundaries. However, the watersheds form important discharge points for ground water as springs and seeps.[3]

Taken together, such information has several

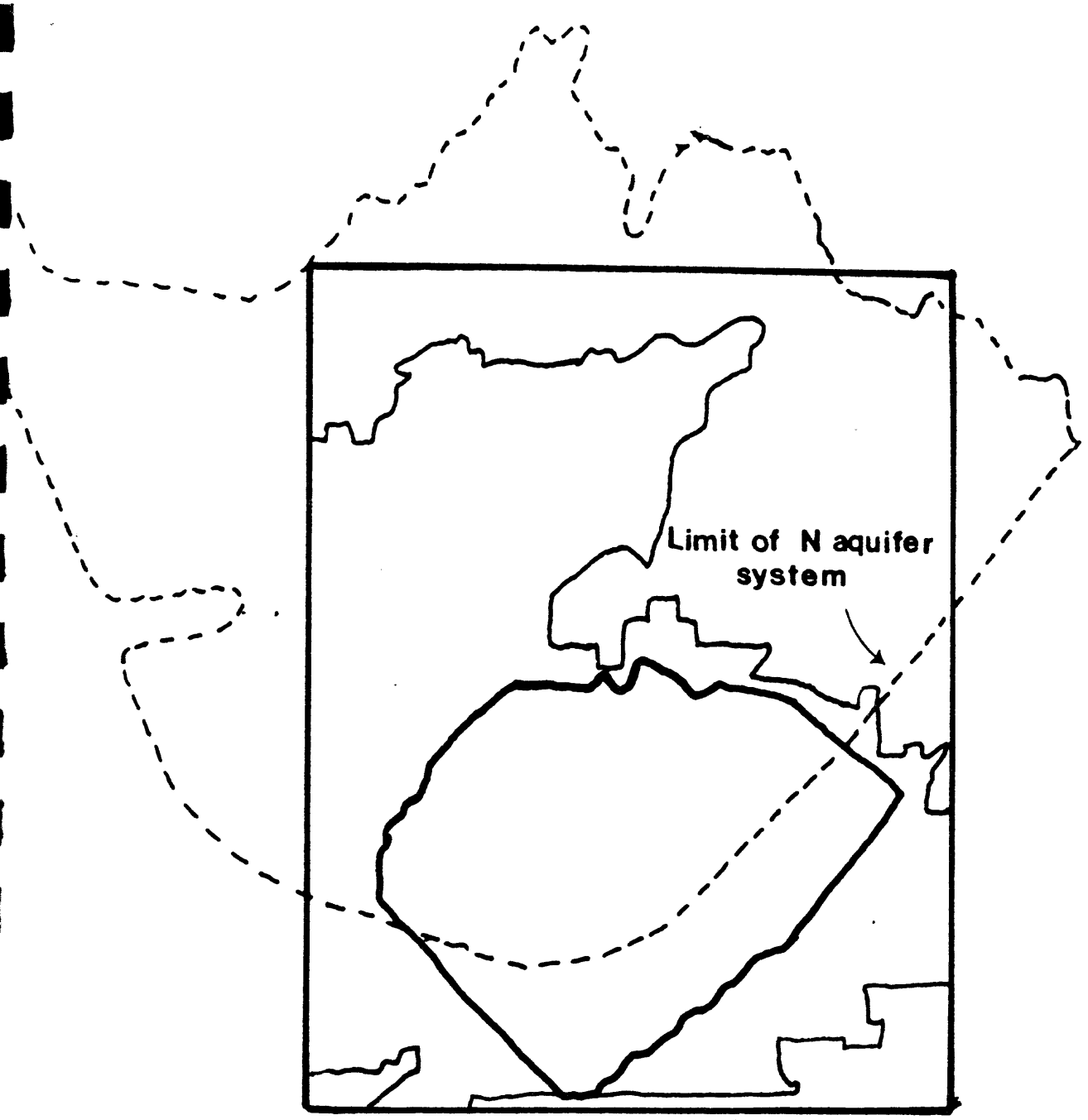
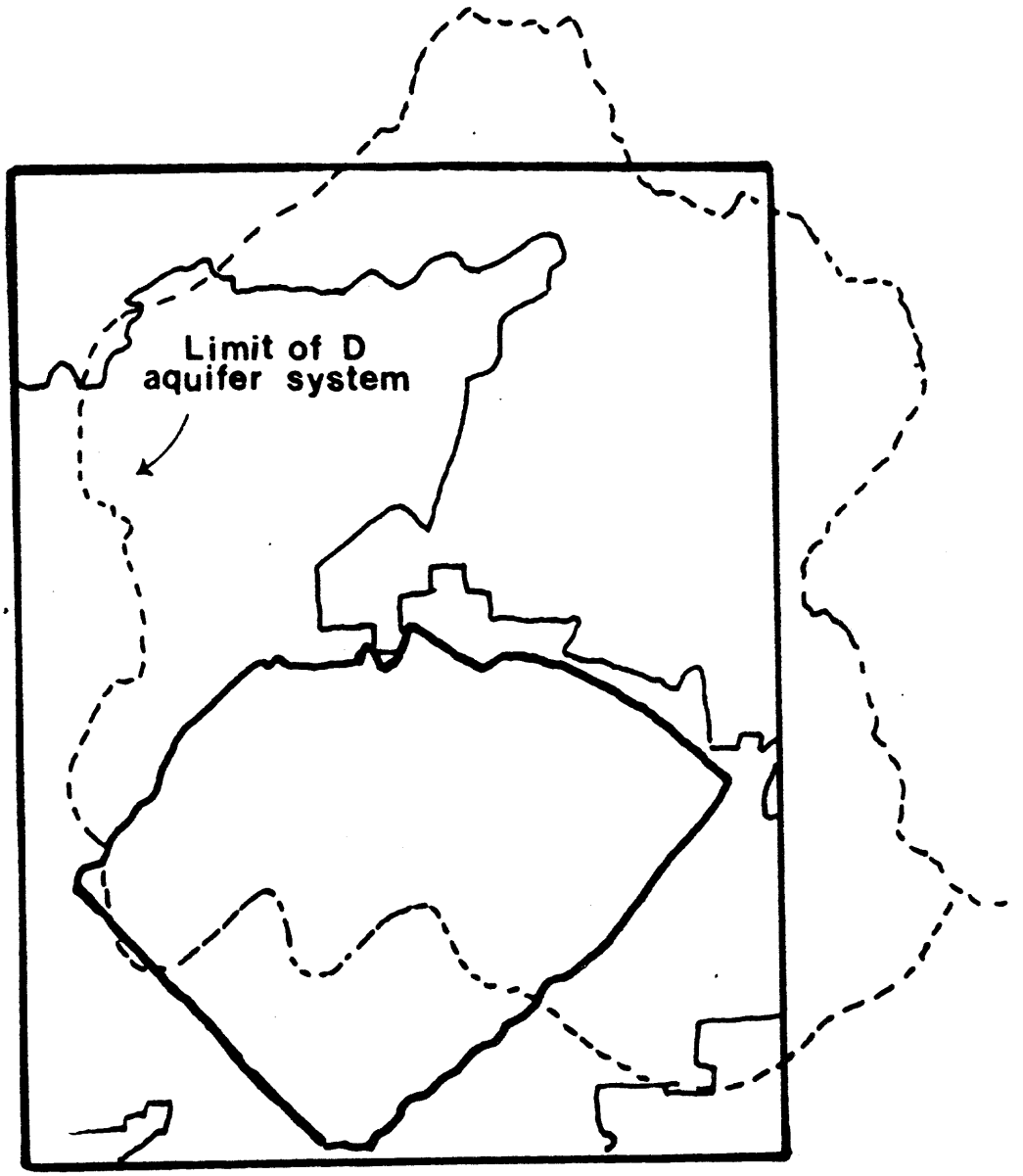
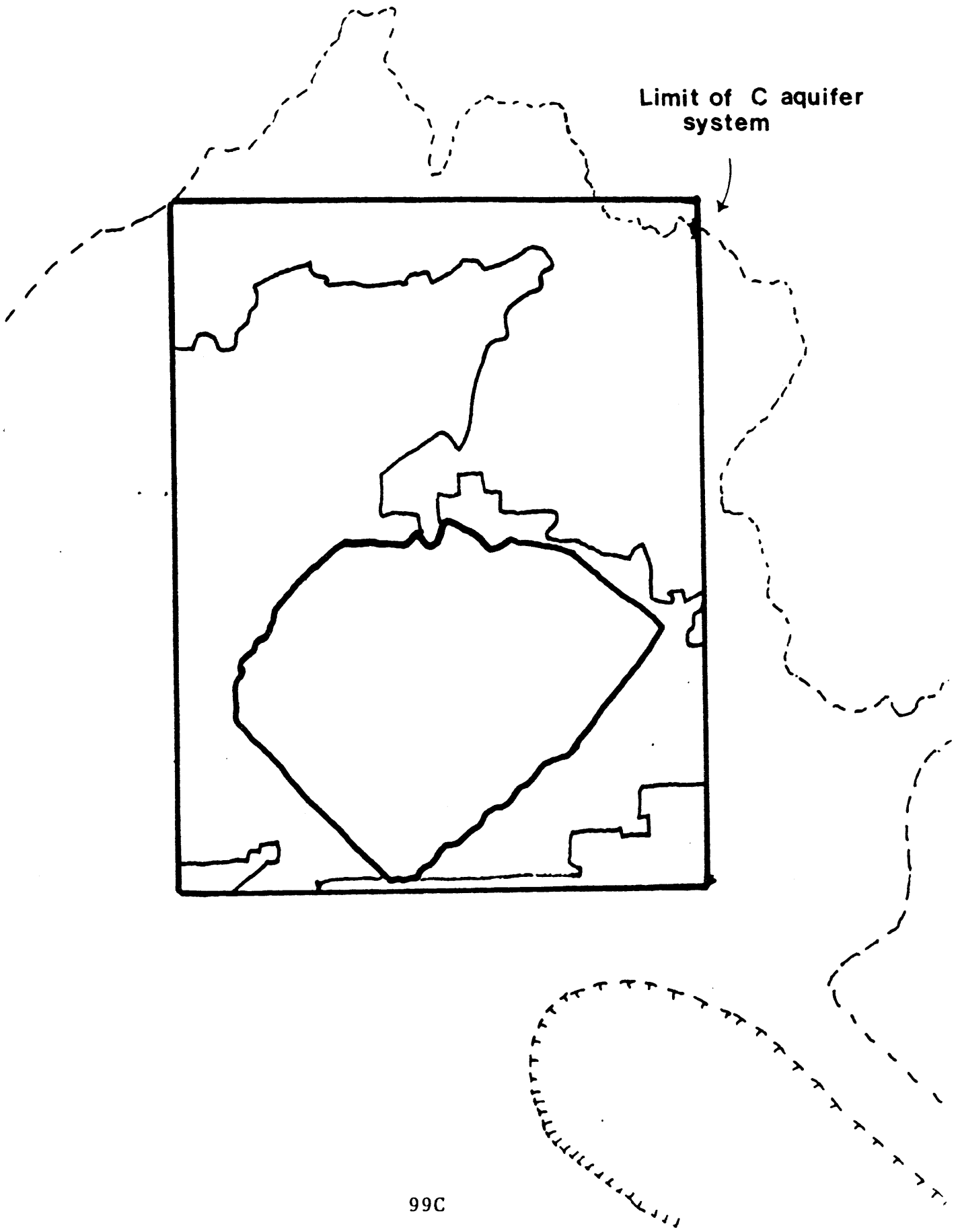


Figure 4: Map and overlays showing extent of Hopi aquifer systems


Limit of D
aquifer system


Limit of C aquifer system

implications for water and land management and reinforces the need to manage land and water resources together. For example, recharge areas for major aquifers, such as the Navajo sandstone, must be protected from land use practices such as those characterized by the abandoned uranium mill at Tuba City.[4] Impacts of the mill will be long-lasting. Soil erosion on the reservation affects the suitability of surface water supplies for agriculture and other uses and thus forms another dimension of the water management issue.

In defining and identifying a watershed approach to understanding water resources on the Hopi Reservation, a framework is developed by which to ascertain and classify major water resource information, issues, planning goals and objectives, and physical constraints and opportunities for resource development and management. The discussion from here proceeds to an analysis of Hopi water resources and water resource information and then in Chapter 5 returns to the discussion of policy and planning implications.

Previous Investigations

As a prelude to the analysis of Hopi water resources information, it is necessary to examine the scope and nature of previous Hopi water resources studies and the present direction of current investigative activities. The large volume of material related to Hopi water and land resources -- some 200 separate reports and articles -- would seem to

suggest that there was enough information about the resource. However, it appears that there is still a major need for basic water resources data for water resources planning. In addition, in order to be useful, the data base must be housed in a central location, in a format suitable to tribal needs, and integrated into ongoing tribal activities. Therefore, rather than providing yet another summary of water resources of the Hopi Reservation, this report examines the type of information previously collected and its application to water program planning.

Early Studies. The earliest studies of the water resources of the region were conducted by the U.S. Geological Survey during the 1930s, 40s and 50s. In a series of water supply and professional papers, Gregory (1951), Cooley (1969), Harshbarger (1965) and numerous others performed basic work on field geology, including stratigraphy, mineralogic properties, mineral resources, and selected work related to water resources. The results of these earlier studies are presented in Table 2, which displays each study, the Hopi watershed location of the study, the type of study and the element of the hydrologic cycle that was addressed within the study.

These studies form the basic corpus of information to which all subsequent studies refer and, in fact, represent some of the very few <u>field</u> studies that actually have been

Table2 : Classification of Barly Hopi Water Resource Studies

Study Name and Author	Date of Report	Type of Study	Component of Hydrologic Cycle
1. Gregory, H.E., "Geology of the Navajo Country", U.S.G.S. Prof. Paper 93	1917	Geological	Limited description of water-bearing properties of surficial geologic units primarily on the Navajo reservation
2. Harshbarger, J.W. and Repenning, "Stratigraphy of the Uppper Triassic and Jurassic Rocks of Navajo Country"	1957	Geological	Detailed description of mineralogy and character of the Navajo Sandstone and other important units on the reser vation
3. Hack, J.T. "The Changing Physical Environment of the Hopi Indians"	1942	Water Use Survey	One of the first studies to document Hopi use of surface water for agricul ture; rainfall data collection; survey of agricultural areas
" Sedimentation and Volcanism in the Hopi Buttes Area"	1942	Geological	Geologic history of surficial alluvial deposits and their relation to volcani in the Hopi area.
"Dunes of the Western Navajo Country"	1941	Reconnaissance	Field reconnaissance of the location, occurrence and movement of sand dunes in the Tuba City area.
4. Kelley, V.C. "Monoclines of the Colorado Plateau"	1955	Geological	Study of structural features on the Colorado Plateau
5. Akers, J.P. and Harshbarger, J., "Ground Water in Black Mesa Basin and Adjacent Areas"	1958	Ground Water Evaluation	One of the first ground water studies in the region to pull together geolog- ical studies and apply them to the location and supply of water.
6. Kelley, V.C., "Tectonics of the Black Mesa Region of Arizona "	1958	Structural Geology	Detailed broad structural features of Black Mesa and was the first study to suggest that these features may exert significant effect on ground water movement
7. New Mexico Geological Society "Guide Book to The BLack Mesa Basin", 9th Field Conference Publication	1958	Geology, Mineral Potential, Water Resources	The field conference was aimed at the mineral potential of the Black Mesa with few general water resource studies

carried out at Hopi.

Additional early work was completed in relation to the mineral potential of the Black Mesa Basin. In separate reports, Williams Brothers Engineering Company (1978), Stetson Engineers (1971), and many others described mineral potential and water resources development potential of selected aquifers; these data were used to develop the Peabody operation and the Rare Metals milling operation at Tuba City. Many of the studies reviewed were prepared for the Navajo Tribe, with very little work being done on the Hopi Reservation.

Studies Shift in the 1960s and 1970s. Partly in response to growing concern about the effects of land use practices on surface and ground water resources, during the 1960s and 1970s increased funds were made available to study water resource issues at Hopi. Undoubtedly, these studies were again spurred by existing mining activities and the passage of several federal environmental laws, including the Surface Mining and Reclamation Act, the National Environmental Policy Act and the Uranium Mill Tailings Remedial Action Act.

During this time period, the U.S. Geological Survey established the first ongoing ground water monitoring program in existence in the area, largely to evaluate the impacts of the Peabody pumping on water levels in the area. Data compiled from the monitoring program was used to construct a model of ground water flow in the Navajo sandstone. The

study (Echyaner, 1975) used data from existing wells in the area, involved no new construction of wells or logging of existing wells, and is currently the most often-used ground water model in the region. The recently completed Office of Surface Mining and Reclamation's comprehensive analysis of water resources and the Peabody mining operation used this model. The ground water flow model constructed by the USGS has not always met with great acceptance on the part of tribal resource managers, who cite the need for additional information.[5]

Also during the 1960s and 1970s, the first set of "comprehensive" analyses of water resources for stock puposes was conducted for the Navajo Nation by Halpenny and Associates. Their work does include some information regarding Hopi water resources.

Activity Spurred by the Little Colorado River Adjudication. As was described in Chapter Two, the Phelps Dodge Company filed for the determination of water rights in the Little Colorado River basin in 1978. After the passage of the Arizona adjudication law, the cases in the watershed were consolidated, and the state court ordered all claimants in the case to file claims before December 1985. The Hopi Tribe submitted claims to approximately 140,000 acre-feet of water. The data used in documenting the claims was collected over a period of years beginning in 1979.

The initial "comprehensive water resources study" was completed by Stetson Engineers in 1980 and involved a review of available data on ground water resources. The Stetson study drew extensively from the existing work outlined above and involved the inventory of well records of both the Navajo and Hopi tribes. Stetson also was able to draw upon previous extensive company experience with the well field at the Peabody site.

Without consulting the tribe, the Albuquerque BIA office commissioned another "comprehensive water resources study" and hired Cooper Consultants to perform the work. Essentially no new data came out of the project because it was another review of existing material. Cooper Consultants are now in the second phase of their work, which involves test drilling and aquifer testing to determine the extent of interaquifer leakage.

The statement of claims prepared by the Hopi Tribe was developed in 1985 by HKM Associates, in conjunction with Bliessner Engineers. Much of the work was completed under the pressure of time deadlines imposed by the court, and there is still work that needs to be done to provide a firmer footing for the tribe's water claims.[6] HKM and Stetson Engineers have been retained by the Bureau of Indian Affairs to perform a "scenario analysis" concerning the benefits and costs of reducing the flow of water in major streams of the Little Colorado River watershed that could result from tribal

claims in the Little Colorado River case. Additionally, a major surface water study in the region will soon be underway.

Currently, the consulting company, Hydrogeochem, Inc., of Tucson, Arizona, is conducting a hydrogeochemical investigation of ground water resources. The study was commissioned by the BIA in order to acquire more information about the ground water resources at Hopi. Through the use of ground water chemistry, the company hopes to obtain information on ground water flow directions and rates in selected aquifers, ages of ground water, recharge and interaquifer leakage characteristics.

A summary of the current water resource studies is presented in Table 3, which classifies studies by the type and extent of research.

In order to assess the role of past and current research in water resources, it is useful to present the basic physical factors characterizing the Hopi resource. The next section first discusses surface water resources and then moves to a discussion of ground water resources.

SURFACE WATER RESOURCES

Source

The Hopi Reservation lies within the Little Colorado River watershed, a watershed consisting of some 26,000 square

Table 3: Classification of Recent and Current Hopi Water Resources Studies

Study Name and Author	Date of Report	Type of Study	Component of Hydrologic Cycle
1. Halpenny, L., "Evaluation of Existing and Potential Water Resources, Joint Use Areas 3, 4, 5,and 6, Navajo and Hopi Indian Reservation"	1974	Water Resource Reconnaissance	Surface water supply, evaporation well yield, water well and spring inventory, stock pond inventory, limited water quality analyses for water wells.
2. U.S. Public Health Service "An Engineering Analysis of Domestic Water Supply for Hopi Indian Villages"	1961	Water Supply Engineering	Proposed water systems for 12 Hopi villages, including identification of sources, feasibility of water treatment, and water distribution systems.
3. Stetson, Thomas M. "Feasibility of Obtaining a Ground Water Supply from Black Mesa, Arizona"	1966	Water Supply Engineering	First known extensive aquifer test of the Hopi multi-aquifer systems; test drilling, well cuttings analysi ground water quality sampling, well drilling and development
4. Cooley, M.E., Akers, M. "Regional Hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico and Utah"	1969	Hydrogeology	Applied and investigative geology of ground water resources and broad outline of future water potential on reservation; general water quality mapping based on total dissolved solids content of selected wells; first details of the "D", "N", and "C" systems.
5. Repenning, C.A. and Cooley "Stratigraphy of the Chinle and Moenkopi Formations, Navajo and Hopi Reservations, Arizona, New Mexico and Utah"	1969	Hydrogeology	Completed hydrogeologic study of reservation water resources; ground water flow directions and discharge; aquifer mapping
6. Stetson, Thomas M. "Engineering Report for Peabody Coal Company on Black Mesa Well Field"	1969	Water Supply	Evaluation of well field performanc for the Peabody operation; aquifer properties; water quality analyses
7. Akers, J.P. "Hydrogeology of the Cenozoic Igneous Rocks, Navajo and Hopi Indian Reservations"	1971	Hydrogeology	Detailed hdyrogeolgic study of rece ent igneous rocks on the Hopi reservation
8. McGavok, E.H. "Maps Showing Ground Water Conditions in the Southern Part of the Black Mesa Area, Navajo, Apache and Coconino [illegible]"	1973	Water Level Mapping	Map showing ground water levels an and flow directions in the Navajo sandstone; this was the first of a series of maps detailing ground water conditions in the several aquifer units for 1973-1979.

Table 2 Continued
Classification of Current Hopi Water Resource Studies

Study Name and Author	Date of Report	Type of Study	Component of Hydrologic Cycle
9. Williams Brothers Engrs. "The Navajo Nation Water Plan"	1976	Water Supply Reconnaissance	Inventory of Navajo water wells, limited aquifer tests; evaluation of well field at the Peabody mine projection of future water needs of the tribe.
10. Fogel, Martin M. "Environmental Monitoring and Assessment of Coal Strip Mining and Reclamation in the Four Corners Area"	1982	Environmental Assessment	Evaluation of surface runoff and water quality changes resulting from coal strip mining
11. Echyaner, James	1983	Ground Water Investigation	Evaluation of pumping impacts of the Peabody operation; construc- of ground water model for the Navajo sandstone
12. Morrison-Maierle "Navajo Water Resources Evaluation"	1981	Reconnaissance	Reconnaissance level investigation and inventory of Navajo water resources
13. Cooper Consultants "Navajo-Hopi Ground Water Study"	1984	Reconnaissance	Summary and evaluation of exist- information on ground water resources of both tribes; identified a work plan for future investigations
14. Ott, Douglas "A Ground Water Flow Model of the Glen Canyon Aquifer in the Black Mesa Basin"	1981	Ground Water Modeling	Ground water movement in the Glenn Canyon aquifer system
15. U.S. Department of Energy "Final Environmental Impact Statement, Tuba City Site"	1985	Engineering assessment of clean up of uranium tailings.	Proposed methods and impacts of remedial action program for the tailings; the report discounted ground water contamination as feasible for clean up.
16. Hydrogeochem, Inc	CURRENT	Chemical investigation of ground water	Field work directed toward the identification of flow directions, rates, ages and inter-aquifer leakage
17. Cooper Consultants	CURRENT	Ground Water	Identification of ground water flow directions, interaquifer leakage
18. ----------	CURRENT	Surface Water Study	Comprehensive surface water investigation of reservation resources; sediment production

miles (figure 5). The reservation encompases some 1.8 million acres, or 10.5% of the Little Colorado River watershed. Important surface water drainages, including Moenkopi, Dinnebito, Oraibi, Wepo, Polacca and Jeddito watersheds convey significant quantities of water toward the Little Colorado River only in response to large rainfall events. Most of the runoff occurs during the months of July, August and September, with lesser amounts of runoff occurring during the period from October through March. Relevant planning information related to these watersheds, including area, elevation, estimates or measures of stream flow, and water quality information is presented in Table 4.

Significantly, very little information exists on surface water flows on the reservation, except for Moenkopi Wash, which has the longest flow record. There are periodic measurements of peak flows in Oraibi, Dinnebito and Polacca washes for the period between 1963 and 1975. Moreover, the precipitation recording network for the reservation is too sparse and records are too short to permit the detailed identification of precipitation-runoff relationships. However, it is clear from historical data, and even a cursory examination of existing flow data, that there is significant potential for the development of surface water supplies for irrigation or other uses contemplated by the tribe. Permanent rainfall and surface water recording devices should be established on a watershed basis.

Figure 5: Physiographic regions of the Hopi reservation

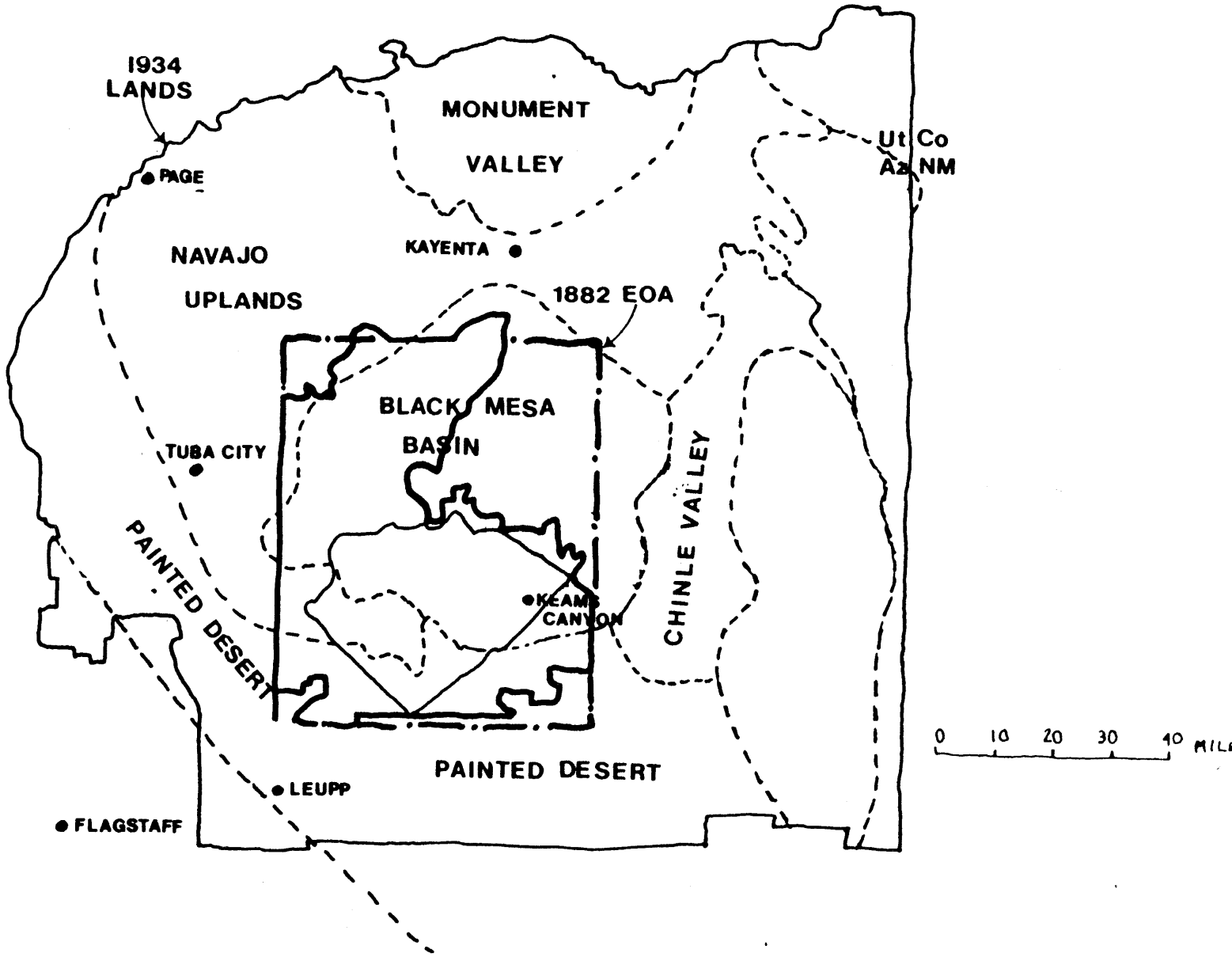


Table 4: Planning Information for Hopi Streams[1]

WATERSHED	AREA (sq.mi)	STREAM LENGTH (mi)	NUMBER OF TRIBUTARIES	PEAK DISCHARGE (cfs)	WATERSHED YIELD (cfs/sq mi)
Moenkopi	2,500	40	4 major, 12+ minor	5,303	2.1
Oraibi	1.76	25	2 major, 10+ minor	171	97.2
Dinnebito	261	27	2 major 9+ minor	13,787	52.8
Polacca	6.45	24	3 major, 10+ minor	397	61.6
Jadito	8.1 [2]	20	1 major	---- *	-----

* No data available
1/ Information from MOrrison - Maierle as modified by the U.S.Geological Survey
2/ Measured by AIRI

Water resources information such as rainfall-surface water runoff relations would assist planners in identifying potential water resources available during the region's rainy season and provide tribal engineers with the information needed to design, construct and plan tribal irrigation projects, diversion structures and any number of tribal resource use activities. At least two of the watersheds need additional detailed survey work in order to determine adequately flow volumes, conditions and potential additional storage sites. Fortunately, current surface water work being done in conjunction with the Little Colorado River adjudication will assist in providing such information.

It is important to note the significant and necessary role of field work in the adequate determination of flows. Too many of the studies undertaken in this area have been simply surveys -- with little or no attention given to long-term monitoring requirements or collection of original data. Moreover, many of the studies have applied "canned" models without field calibration or study and verification of model results. In addition, many of the studies have focused on the larger and more obvious streams in the region and have paid little attention to smaller, but perhaps more significant, washes that cross the reservation. Although gathering data on the larger streams is clearly a tribal priority in terms of a general stream adjudication, the

information generated from such work also might be directed toward developing a more comprehensive base for water management. Active tribal involvement in the water resources research, for example, in the survey of watershed conditions (channel geometry, slope, topography, soils, vegetation and water resources), would not only strengthen tribal management capabilities and authority, but also would secure presently needed information by defining and directing the research agenda.

Variability

The natural variability of the water resource -- from uncertain estimates of rainfall to under or overestimates of reliable stream flow -- is a critical factor in water resource decision-making. Whole treatises have been written about the subject of the uncertainty of rainfall and stream flow, yet application of this information to tribal resource management decisions, and even to tribal water resources research, is a relatively recent occurrence. In the arid Southwest, the variability of rainfall and stream flow led to the construction of dams and reservoirs. The subject is particularly relevant to the quantification of rights and the determination of procedures to deal with uncertainties such as droughts or floods. Moreover, it is critically important to tribal planners, natural resources staff and policymakers

in the overall effort to manage the reservations's resource base.

Uncertainties in the predictions of flows on the reservation's watersheds arise from lack of data as well as from the particular characteristics of the reservation's climate, which often produces flash floods of great magnitude. Despite the general lack of information, data from the Moenkopi watershed will be used to illustrate potential variability of reservation streams and what factors seem to contribute to uncertainty in flow predictions.

For all reservation streams in the region, runoff yield per watershed acre decreases with increasing watershed size, a relatively common occurrence in arid areas. Storms in the upper reaches of a watershed may produce large flows near the center of the storm, but the flows rapidly diminish downstream because of what is known as "channel loss" or "transmission losses" in the stream bed. Water essentially "disappears," only to sink into the alluvial sediments that blanket the floor of the stream channel. "Loss functions," such as the "exponential loss function" in a runoff model, would account for this phenomenon, but almost no work of this sort has been completed for reservation streams. However, transmission losses that occur in channels result in decreasing yield and pronounced "routing" of floods. In the smaller watersheds, there is not such a great transmission

loss because of the localized effect of thundercells in small, isolated areas.

Average annual stream flow for the 24-year period on Moenkopi Wash does not reflect the variability or monthly distribution of flows.[7] The mean annual ruonff for the period 1926-1974 was 12,960 acre-feet per year, or approximately .1 inch of runoff over the entire 2,500-square-mile drainage area of Moenkopi Wash. Of this total, approximately 8,500 acre-feet of runoff per year was produced above the downstream boundary of the 1882 Executive Order area; this represents approximately 65% of the stream flow.

Variability in stream flows is determined by statistical analysis of stream flow records. Using records collected for Moenkopi Wash, the statistics indicate that annual flows and flood peaks are extremely variable at Moenkopi Wash. However, annual stream flow in higher mountain watersheds is less variable. The data suggest that peak flows for the region will exceed 55% of the average in two of every three years. Annual stream flows exceed 57% of the average (greater than 6,000 acre-feet per year) in two of every three years. For 90% of the time, Moenkopi Wash produces runoff which exceeds 23% of the average annual flow. Thus average annual flow occurs only once in every three years, with most flows exceeding average annual flow.

For Moenkopi Wash, neither severe droughts nor high flow events relative to the mean flow are likely to occur for extended periods, as demonstrated by the 24-year record illustrated in figure 6. However, these figures may be questionable as the analysis of stream flow both in arid areas and in predominantly sand channel streams requires special analytical techniques.[8] Finally, the usefulness of a modeling technique is only as good as the records upon which the model is based. These records are nonexistent in the Hopi area. Therefore, it is difficult to predict the magnitude and occurrence of floods.

Surface Water Quality

Water quality information for surface water resources on the Hopi Reservation is also sparse. Small, selected portions of the Hopi Reservation have been studied, primarily in relation to the mine at Black Mesa. No surface water quality data exists for most reservation streams, and neither the U.S. Geological Survey nor the state of Arizona have stream quality monitoring stations near the reservation.

Using what limited data exists, the major problem with regard to surface water quality on the reservation appears to be sediment, produced as a result of extensive soil erosion in the area. As demonstrated in Table 5, the sediment and erosion rate on the reservation is severe, with rates approaching 4,500 tons per acre per year. In part this is a

FIGURE 6

NORMAL DEVIATES OF ANNUAL RUNOFF FOR MOENKOPI WASH NEAR TUBA CITY

(Source: Morrison-Maierle, 1981)

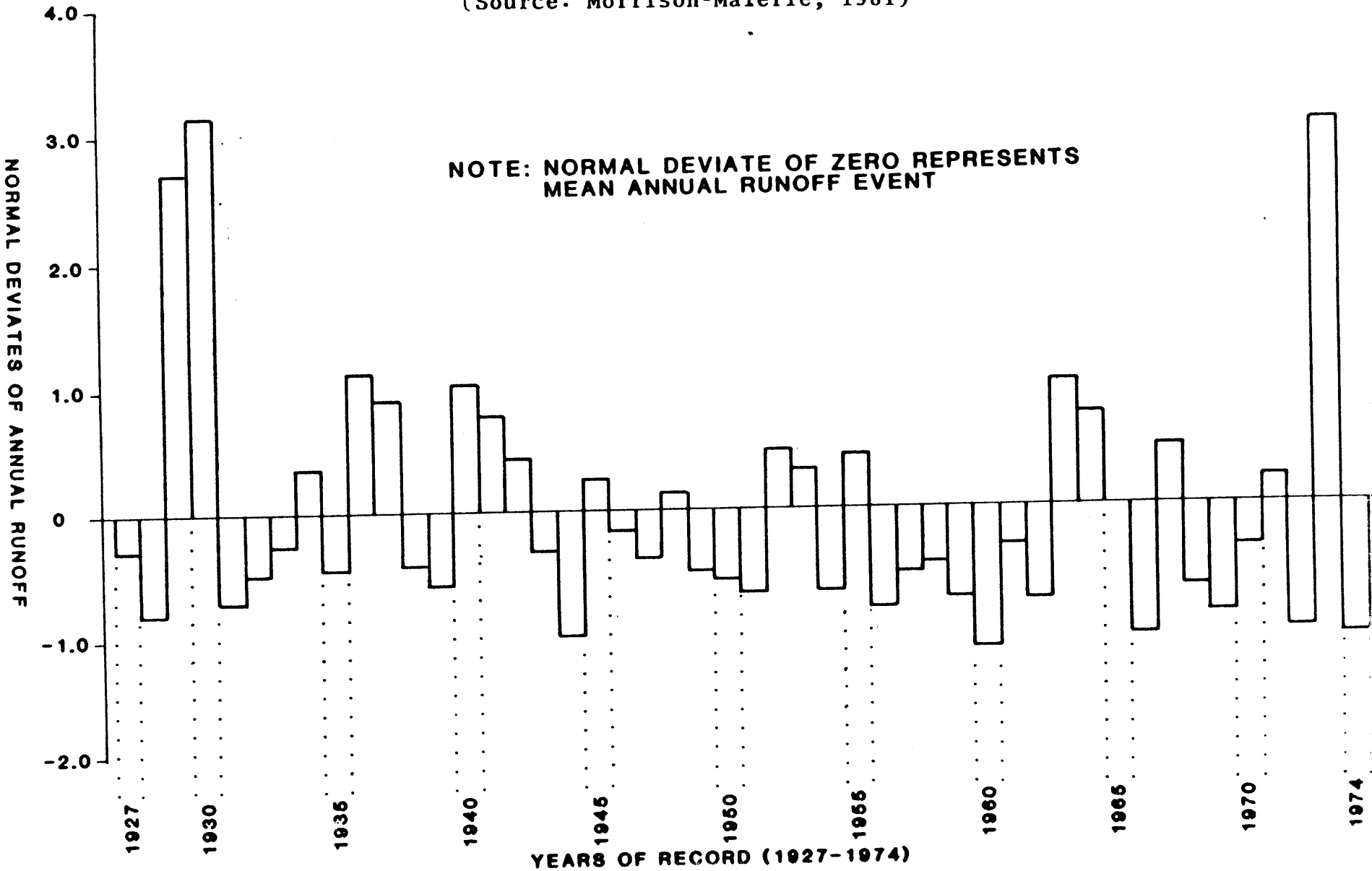


Table 5: Representative Erosion Rates for Little Colorado River Watershed lands 1/

Land Area/Region	Erosion Rate (tons/ac)[2]
Lower Hopi lands, District 6 lands	3.4 tons/ac/year
Eastern District 6 and Executive Order lands . .	3.1 tons/ac/year
Northern HPL lands	3.2 tons/ac/year

1/ Source: U.S.D.A., 1981, Little Colorado River Basin, Summary Report, Water Resources.

2/ Average annual **sediment delivery** to the Little Colorado river for these areas is 825,000 tons.

result of the geology and soils of the region, as well as the type and intensity of rainstorms, land use and surface cover. The sediment loss is also an economic loss in that soil productivity is reduced, ditches are clogged, reservoirs lose their storage capacity as a result of siltation, and farmlands are covered with silt. Additionally, large sedmient yield impacts water treatment facilities. Some kind of balance must be struck between the control of land use practices that impact soil erosion and the "natural" rate of erosion imposed on the area as a result of the particular soils and climatic characteristics.

Significantly, an investigation of runoff from the Peabody mining operation demonstrates the adverse impact of mining on surface water quality. The University of Arizona, School of Renewable Natural Resources documented a three-fold increase in sediment production from reclaimed mine spoils versus the natural condition. Although it was difficult to assess given the limits of the study, adverse water quality impacts are a result of the mining operation. Water quality data from the study is presented as Table 6.

Other important areas needing water quality investigation remain. For example, a considerable amount of stream flow in selected washes is derived from ground water discharge through the Toreva and Wepo formations in the northern part of the reservation. The water in these formations is high in dissolved solids, which is a result of

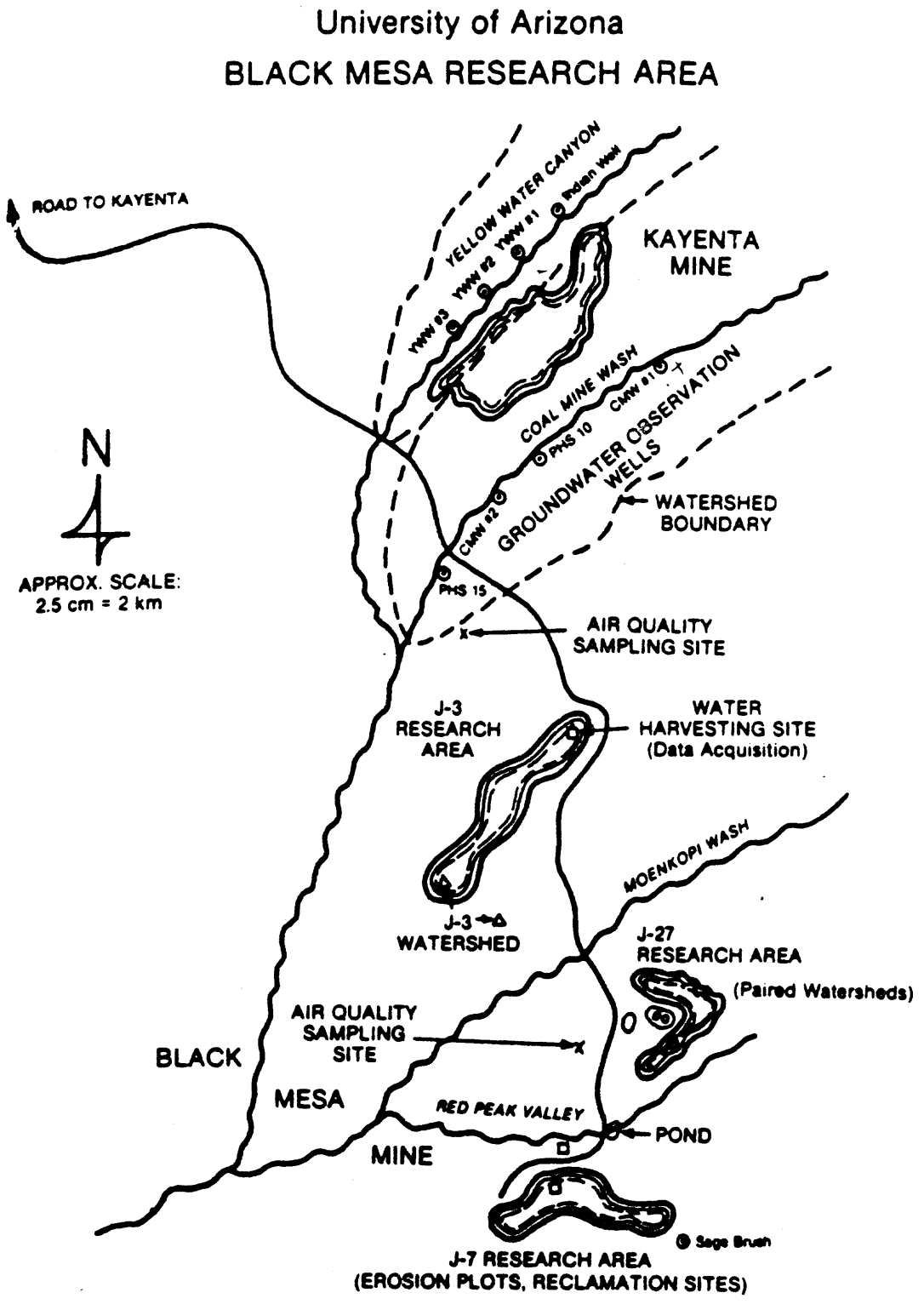
Table 6 Water Analysis for Black Mesa Shallow Wells
(Means in PPM)

	Number of Samples	T °C	EC x 10^3	PH	SAR	Ca	Mg	Na	Cl	K	SO_4	HCO_3	CO_3	F	NO_3	NO_2	PO_4	TSS	B
Wells Above the Mining Area																			
PHS-10, Coal Mine Wash	8	14.9	1.54	7.5	.63	192	76	39	20	8	586	312	0	.56	1.34	.33	.13	1230	.21
Indian Well on YWW	4	19.1	6.29	7.8	1.59	491	629	233	182	12	3458	365	0	.43	.54	.22	.14	5385	.36
Sage Brush Well above J-7	6	13.5	2.13	7.8	3.96	135	64	223	40	7	782	228	0	.78	5.6	.21	.08	1480	.17
Wells Below or in the Mining Area																			
PHS-15, Coal Mine Wash	8	14.5	3.42	7.5	2.14	379	192	202	46	10	1659	371	1	.74	16.0	.36	.17	2874	.32
Coal Mine Wash 2	7	11.1	2.83	7.6	1.96	345	161	153	34	6	1471	287	0	.79	8.1	.38	.09	2450	.32
YWW # 1 on YWW	5	11.6	3.69	7.6	1.65	343	338	179	67	5	2126	350	0	1.12	6.6	.33	.08	3371	.40
YWW # 2 on YWW	6	11.5	4.76	7.6	2.28	446	394	274	78	4	2611	389	0	1.00	2.2	.33	.08	4194	.39
YWW #3 on YWW	6	12.1	3.19	7.6	23.2	48	33	743	27	10	969	1086	1	3.00	1.3	.32	.09	2768	.34

Table 6 Trace Metal Water Analysis for Black Mesa Shallow Wells
(Means in PPM)

	Number of Samples	T °C	Fe	Zn	Cr	Mn	Pb	Cu	Cd	As	Co	Ba	Al	Be	Ag	Se	Hg
Wells Above the Mining Area																	
PHS-10, Coal Mine Wash	5	12.6	.06	.08	<.04	<.04	<.1	<.05	<.05	<.005	<.05	.45	<.5	<.05	<.05	<.005	<.002
Indian Well, YWW	3	17.1	.28	4.89	<.05	2.70	.13	<.05	<.05	<.002	<.05	.77	<.5	<.05	<.05	<.005	<.002
Wells Below or in Mining Area																	
PHS-15, Coal Mine Wash	4	10.3	.06	.24	<.05	.05	<.1	<.05	<.05	<.005	<.05	.88	<.5	<.05	<.05	<.005	<.002
Coal Mine Wash #2	5	11.3	.07	.18	<.05	<.04	<.1	<.05	<.05	<.005	<.05	.87	<.5	<.05	<.05	<.005	<.002
YWW# 1 on YWW	5	11.6	.17	.11	<.05	.04	<.1	<.05	<.05	<.005	<.05	.86	<.5	<.05	<.05	<.005	<.002
YWW #2 on YWW	5	11.9	.61	.27	<.05	.24	.12	<.05	<.05	<.005	<.05	1.03	.53	<.05	<.05	<.005	<.002

Table 3, continued: Location of Water Quality Sampling Points



University of Arizona Black Mesa research area

the geological characteristics of these two formations. To what extent does this poor quality water contribute to the overall quality of surface water on the reservation? At Tuba City, to what extent do airborne radioactive elements, carried to reservation streams, impact the quality of water in Moenkopi Wash?

Where surface water or springs are supplied by ground water discharge, such as in Pasture Canyon, the quality of water is related to the type of rock from which the spring emanates. In Pasture Canyon, and other selected areas, the quality of water is excellent for all uses (less than 150 ppm dissolved solids) primarily because the water emanates from the Navajo sandstone.[9]

Status of Surface Water Information

As mentioned earlier, there are several current surface water studies pending, and all of them were designed to address issues in the Little Colorado River adjudication. The primary emphasis of these future works will be to develop information for use in quantifying surface water flows. Moreover, the pending studies will develop information relating to sediment yield and content of reservation streams. However, no other water quality studies are contemplated by these projects.

In 1987, the Hopi Tribe received a $40,000 grant from the Environmental Protection Agency to develop a comprehensive non-point source water quality management program. The study contemplates a round of surface and ground water quality sampling as a means to provide better background data for development of the water quality management program. Depending on the allocation of funds to the project,[10] the study should provide some good water quality information.

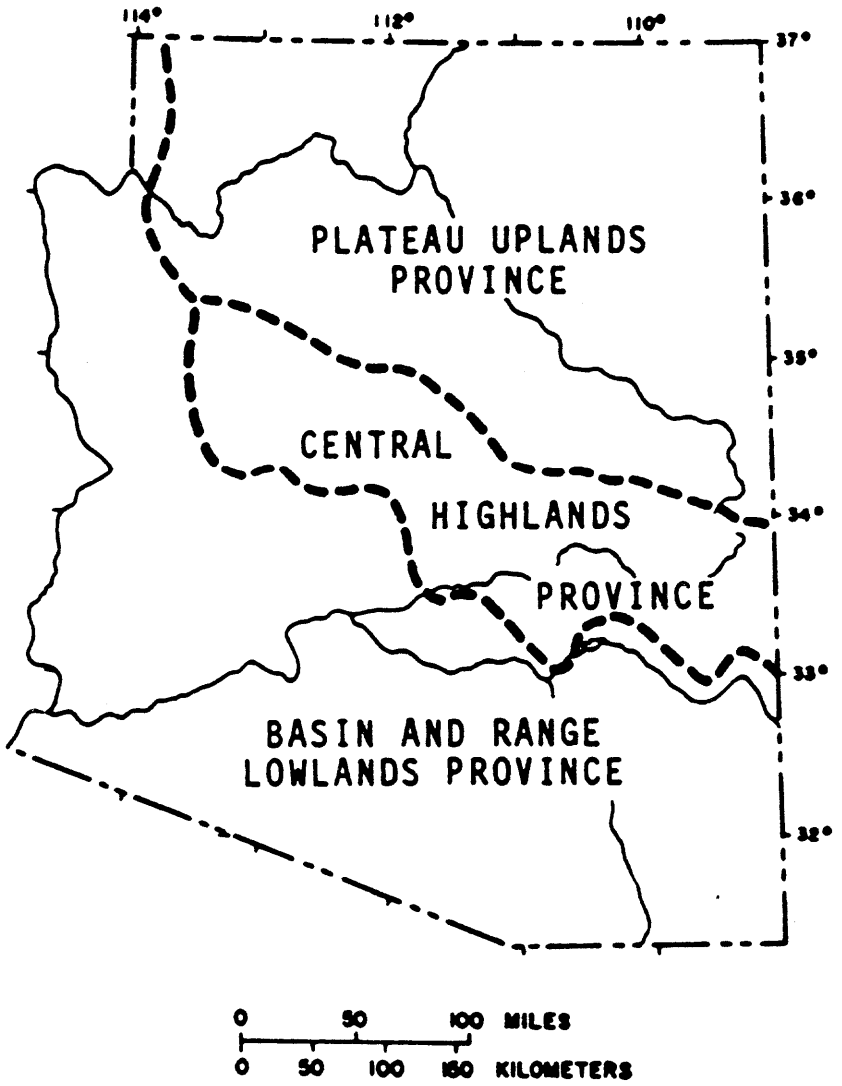
The role of the tribe in these studies is essential. The tribe must provide direction to the consultants in order to obtain information that is needed desperately by tribal planners and policymakers.

GROUND WATER RESOURCES

Ground Water Geology

As mentioned in the beginning of this chapter, the Hopi Reservation lies within three major physiographic provinces in the Little Colorado River basin (figure 7). The broad division of physiographic regions is based upon distinctions in major landforms resulting from differences in sedimentary strata and geologic structure. These same differences in strata and structure also are closely related to the occurrence and quality of ground water resources on the reservation. Hence, an understanding of the geology of the

Figure 7: Ground water Regions in Arizona



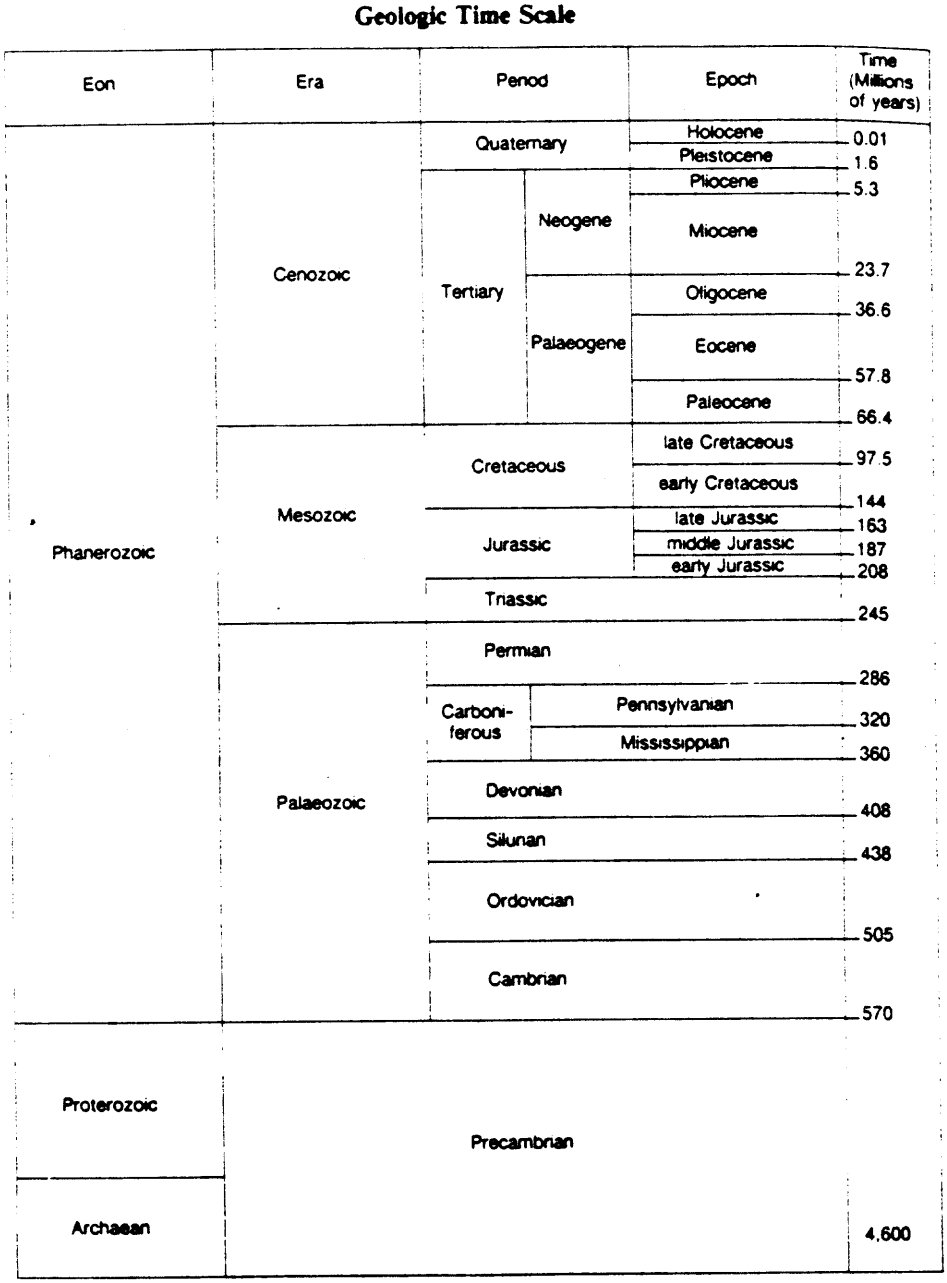
ARIZONA WATER PROVINCES

reservation is a prerequisite to understanding the ground water resource, identifying promising areas for ground water development, and assessing the nature of changes to the ground water resource.

To facilitate discussion, the geologic time scale is presented as figure 8. Geologists have divided "geologic time" into a series of eras and periods, wherein rock units are named both by the time in which they were deposited as well as by the type of rock unit present. Thus, the Jurassic Navajo sandstone was deposited in the region approximately 200 million years ago and is a body of rock that consists of consolidated sand. Table 7 presents a listing of the major geologic units on the reservation in order of decreasing age as one moves from the bottom of the figure to the top. According to the table, the youngest units on the reservation are the stream-deposited sediments in the washes and across the land surface, while the oldest consist of metamorphic and volcanic rocks that are buried deep beneath the Black Mesa Basin.

There are major differences between the rock types, which are the result of depositional conditions characterizing the formation of the rock. For example, the extensive coal resources in the region were formed initially from the burial of sediments deposited in a swamp at the margin of a large inland sea. The Redwall limestone, however, is a marine unit present in the region and was

Figure 8: The Geologic Time Scale



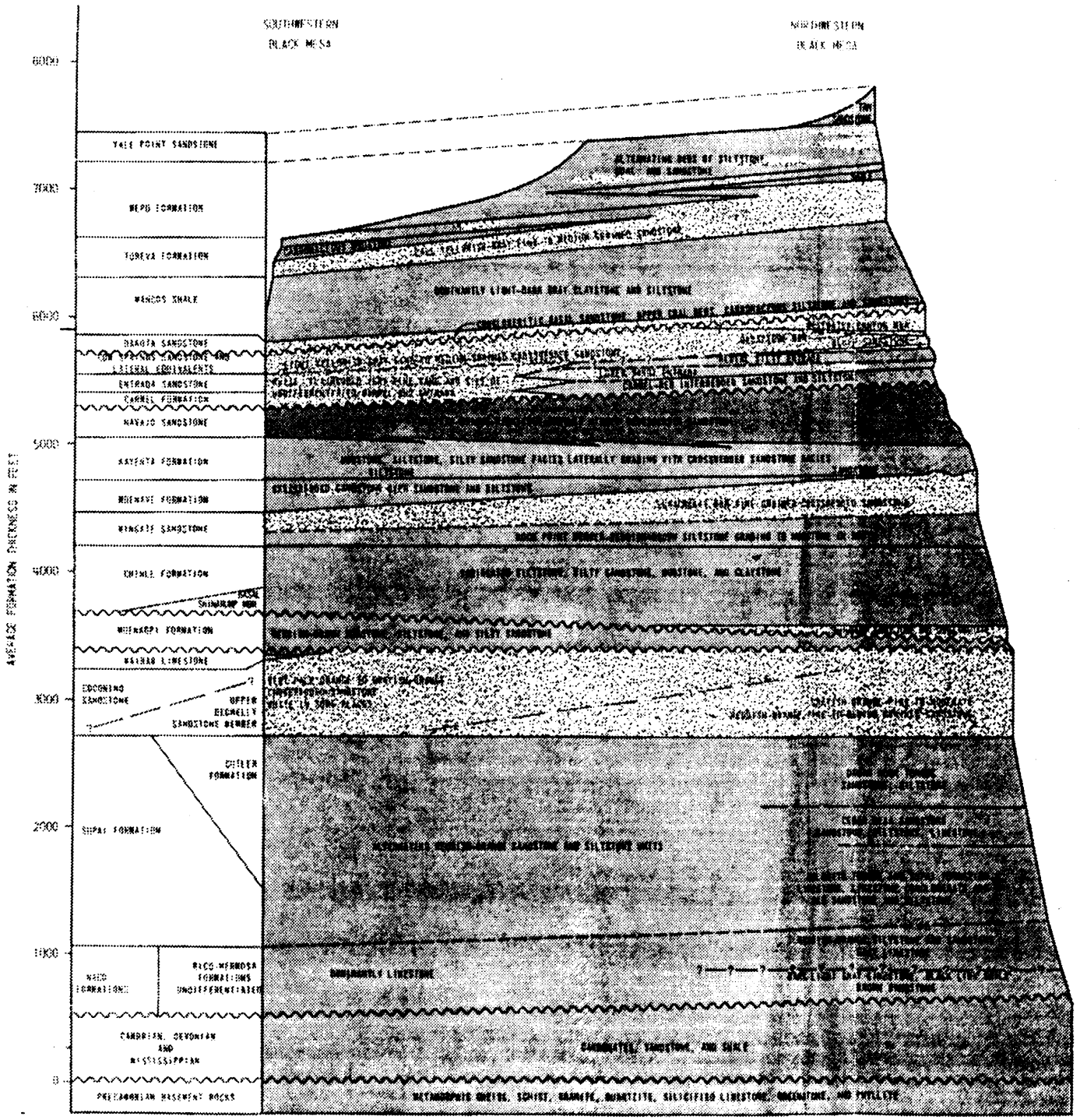


FIGURE 4.2 KNOWN AND POTENTIAL WATER-BEARING BEDROCK FORMATIONS OF THE EXECUTIVE ORDER AREA OF 1968

EXPLANATION

MAJOR AQUIFERS GENERALLY CAPABLE OF YIELDS OF 100GPM UP TO SEVERAL HUNDREDS OF GPM OR MORE UNDER SUSTAINED CONTINUOUS PUMPING CONDITIONS.

MINOR AQUIFERS CAPABLE OF YIELDING BETWEEN 10 AND 25 GALLONS PER MINUTE TO WELLS OPERATED UNDER SUSTAINED CONTINUOUS PUMPING CONDITIONS.

LOCALIZED WATER BEARING STRATA IN CONFINED FENSES CAPABLE OF YIELDS OF UP TO 10 GPM BUT NOT SUITABLE FOR SUSTAINED CONTINUOUS PUMPING.

AQUICLUDE MATERIALS WHICH STORE GROUND WATER BUT WHICH DO NOT TRANSMIT GROUND WATER TO WELLS AND ACT AS BARRIERS TO GROUND WATER MOVEMENT.

CONFORMABLE CONTACT BETWEEN UNITS

UNCONFORMITIES BETWEEN UNITS

EROSIONAL SURFACE BETWEEN UNITS

DASHED PORTION OF CONTACT INDICATES LATERAL GRADATION OR CONTACT OF UNKNOWN NATURE BETWEEN TRANSITIONAL UNITS OR LATERAL EQUIVALENTS. CONTACT DRAWN WHERE LOCATION QUESTIONABLE OR ARBITRARY

WELL PRODUCTION IN BOTH AQUIFERS INCREASES WHERE WELLS PENETRATE THROUGH SOME THICKNESS OF BOTH AQUIFERS OR PENETRATE THROUGH A MULTIPLE AQUIFER SYSTEM

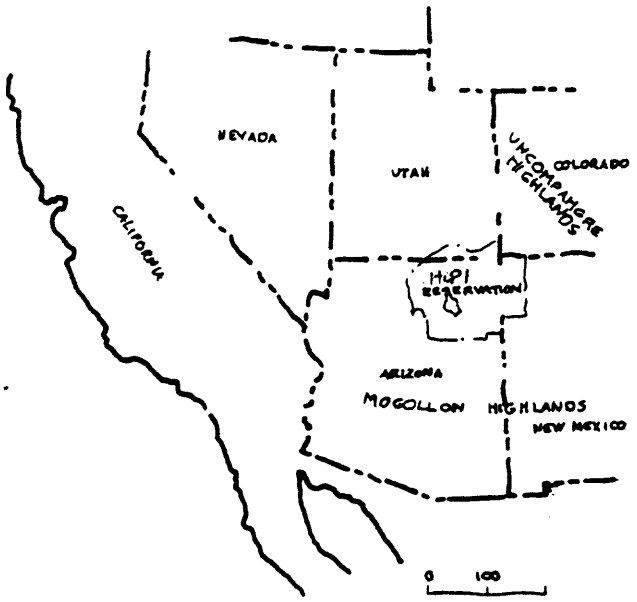
TABLE 7

KNOWN AND POTENTIAL WATER-BEARING FORMATIONS OF THE EXECUTIVE ORDER AREA OF 1968

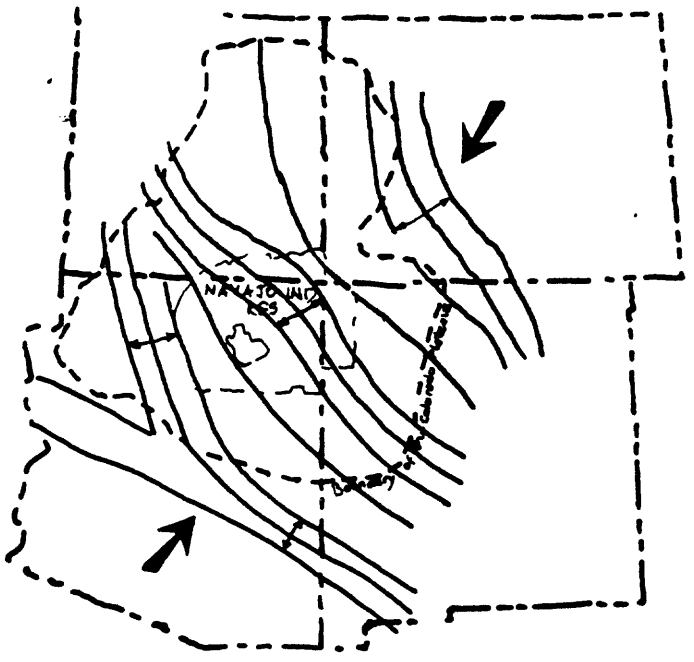
deposited in deep ocean waters. The Navajo sandstone, mentioned above, is a windblown deposit, essentially a large, shifting series of sand dunes. In general, the depositional environment of rocks in the Hopi area may be envisioned as a series of advancing and retreating oceans, that received sediments derived from surrounding highlands in geologic time (figure 9). This has created an exceedingly complex series of sediments, which intertongue with each other. The sedimentary units also thin and thicken in different areas, significantly affecting ground water availability and yield. For example, the Navajo sandstone thins toward the south and southeastern portions of the reservation. Consequently, the thickness of the water-bearing unit and the total stored and available water is substantially less than in the center of Black Mesa.

The type of rock and its depositional environment have everything to do with how much water is stored in the rock and how fast water will move through a rock or aquifer. Additionally, the type of rock also will influence water quality. Examples of the range in depositional environments characterizing the Hopi rock units and the consequent influence on ground water occurrence, quality and distribution are demonstrated aptly by the Navajo sandstone and the Toreva formation. The Toreva formation, a sandy siltstone with lenses of coal, has very poor quality water

Figure 9: Diagram showing geologic conditions characterizing the deposition of sediments at Hopi



Location of highland areas which served as sources of sediment for rock units.

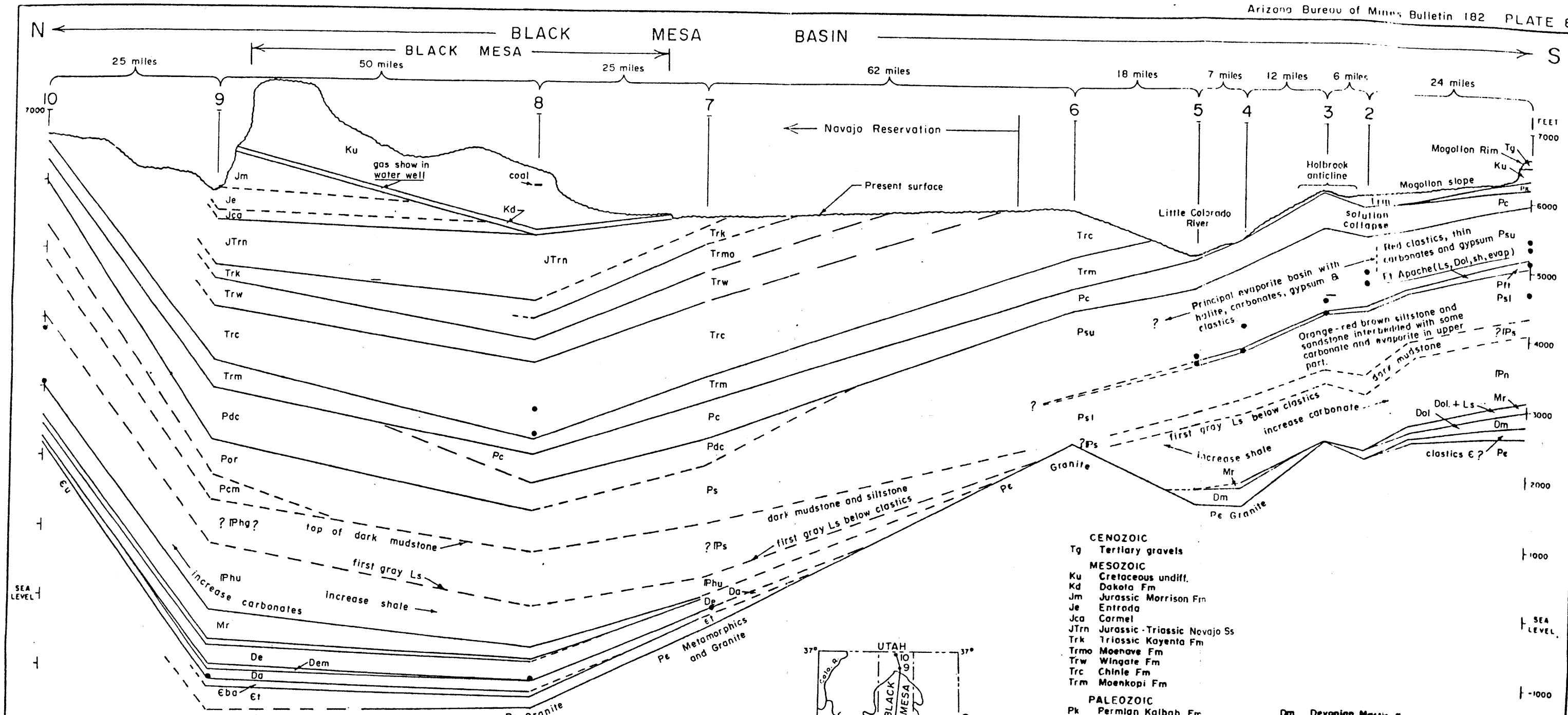


Arrows show major directions of tectonic forces which produced the geologic features seen on the reservation today.

and is high in dissolved solids, iron and sulfate. The Toreva also has a low yield, ranging from .5 to 40 gallons per minute (gpm). However, the Navajo sandstone, a clear, well-sorted quartz sandstone, both has an excellent yield (20-1000 gpm) and is a source of good quality water. Thus a clear delineation of these properties of rock is essential to water management.

The stratigraphy, or layering, of the rocks present in the Hopi area is presented as figure 10. Note that the rocks are arranged in a bowl-shaped basin. The structural geology of the rocks, as presented here, demonstrates the significance of the arrangement of the rocks to the location and occurrence of ground water (figure 11). For the Hopi region, the Navajo sandstone is found at great depths in the center of Black Mesa Basin just north of First, Second and Third mesas, while at Moenkopi and Pasture Canyon, the sandstone is exposed at the surface. The Toreva and Wepo formations, which also function as aquifers, are exposed at the surface of Black Mesa and are cut by Dinnebito, Oraibi and Polacca washes. This acts to "drain" the waters in this regional aquifer.

Information on the stratigraphy of the reservation's geologic units was acquired chiefly through the studies of Akers, Harshbarger and Cooley, who all drew on the earlier works of Davis. However, detailed stratigraphic information for the reservation is lacking because at the time of

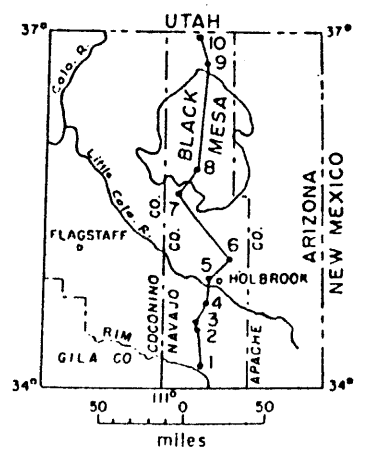


1. Composite of Tenneco 1-X Ft. Apache (Sec. 31-10N-21E) & 1 Fed (15-10N-19E)
2. Taubert & Steed 1 Fed Sec. 35-14N-19E
3. Union-Continental 1 NMAL Sec. 34-15N-19E
4. Pan Am 1A ALC Sec. 5-16N-20E
5. Cree 1 Scorse Fee Sec. 33-15N-20E
6. Gen'l. Pet Creager State 14-6 Sec. 6-19N-23E
7. Texaco 1A Hopi Sec. 15-26N-16E
8. Amerada 1 Hopi Sec. 8-29N-19E
9. Tenneco 1 Navajo Sec. 24-38N-19E
10. Texaco-Sinclair-Skelly 1A Navajo Sec. 34-42N-18E

● Recorded oil shows. (See table of shows in text.)

5 0 5
miles
Horizontal scale

2000
1000
0
feet
Vertical scale



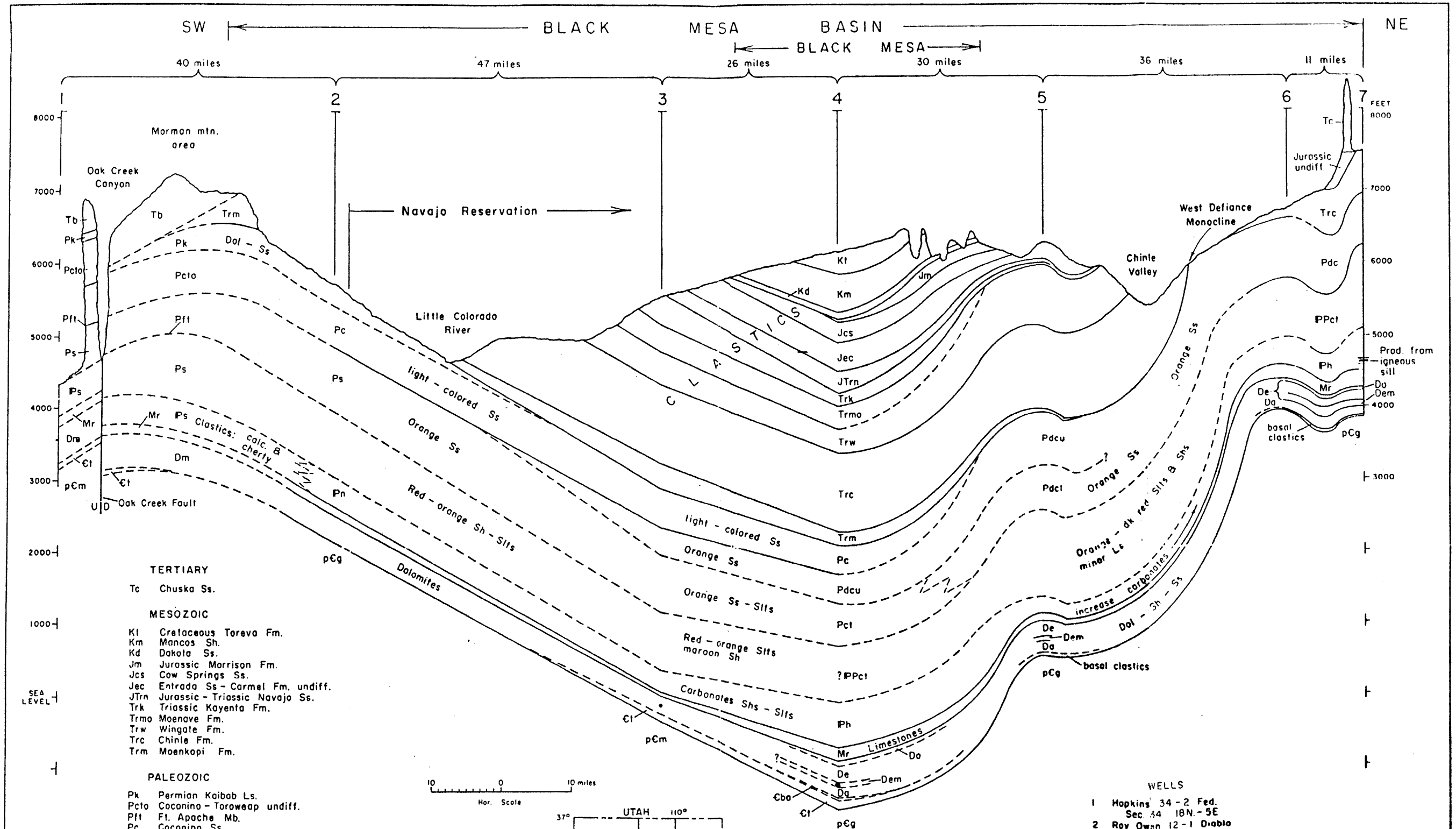
INDEX TO WELL LOCATIONS

CENOZOIC
- Tg Tertiary gravels

MESOZOIC
- Ku Cretaceous undiff.
- Kd Dakota Fm
- Jm Jurassic Morrison Fm
- Je Entrada
- Jca Carmel
- JTrn Jurassic-Triassic Navajo Ss
- Trk Triassic Kayenta Fm
- Trmo Moenave Fm
- Trw Wingate Fm
- Trc Chinle Fm
- Trm Moenkopi Fm

PALEOZOIC
- Pk Permian Kaibab Fm
- Pc Coconino-Glorieta Ss
- Pdc De Chelly Ss
- Psu upper Supai Fm
- Pfl Ft Apache Member
- Psl lower Supai Fm
- Ps Supai undiff.
- Por Organ Rock Fm
- Pcm Cedar Mesa Ss
- ?IPs Pennsylvanian (?) Supai
- ?IPhg? Penn. (?) Halgaito Fm (?)
- IPn Naco Fm
- IPhu Hermosa Group undiff.
- Mr Mississippian Redwall Ls
- Dm Devonian Martin Fm
- Do Ouray Ls
- De Elbert Fm
- Dem McCracken Ss Mb of Elbert
- Da Aneth Fm
- €? Cambrian (?)
- €ba Bright Angel Sh
- €t Tapeats Ss
- Pc Precambrian

Generalized geologic cross—section—Black Mesa to the Mogollon Rim



TERTIARY

Tc Chuska Ss.

MESOZOIC

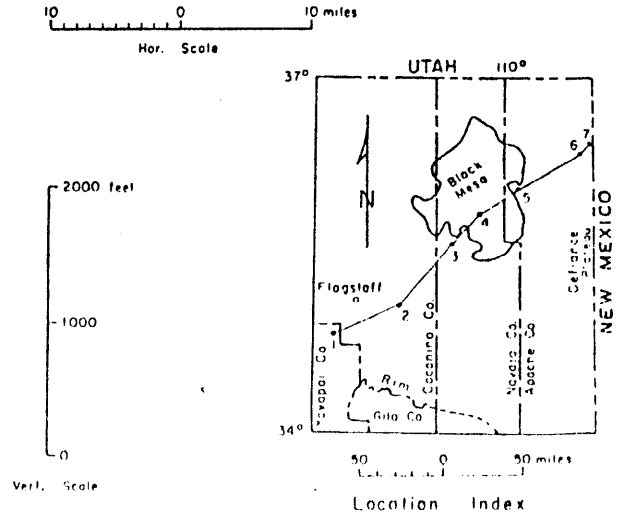
Kt Cretaceous Toreva Fm.
Km Mancos Sh.
Kd Dakota Ss.
Jm Jurassic Morrison Fm.
Jcs Cow Springs Ss.
Jec Entrada Ss - Carmel Fm. undiff.
JTrn Jurassic - Triassic Navajo Ss.
Trk Triassic Kayenta Fm.
Trmo Moenave Fm.
Trw Wingate Fm.
Trc Chinle Fm.
Trm Moenkopi Fm.

PALEOZOIC

Pk Permian Kaibab Ls.
Pcto Coconino - Toroweap undiff.
Pft Ft. Apache Mb.
Pc Coconino Ss.
Pdc De Chelly Ss.
Pdcu upper De Chelly Ss.
Pdcl lower De Chelly Ss.
Ps Supai Fm.
Pct Cutler Group undiff.
?PPct Pennsylvanian ? Permian Cutler Group.
PPs Pennsylvanian - Supai Fm.
PPn Naco Fm.
PPh Hermosa Group undiff.
Mr. Mississippian - Redwall Ls.
Do Devonian ? Ouray Ls.
De Elbert Fm.
Dem McCracken Ss. Mb. of Elbert.
Do Aneth Fm.
Cbo Cambrian - Bright Angel Sh.
Ct Tapeats Ss.

PRECAMBRIAN

pCg Granite
pCg Quartzite
pCm Metamorphics undiff.



Location Index

WELLS

1 Hopkins 34 - 2 Fed.
Sec. 34 18N. - 5E
2 Roy Owen 12 - 1 Diablo
Sec. 2 20N. - 11E
3 Texaco 1 - A Hopi
Sec. 5 26N. - 16E.
4 Amerada 1 Hopi
Sec. 9 29N. - 19E.
5 Amerada - Stanolind 1 Navajo
Sec. 5 31N. - 23E
6 Depco 1 Navajo
Sec. 7 7N - 7W (Navajo base)
7 Kerr - McGee 1 Navajo
Sec. 32 36N. - 30E.

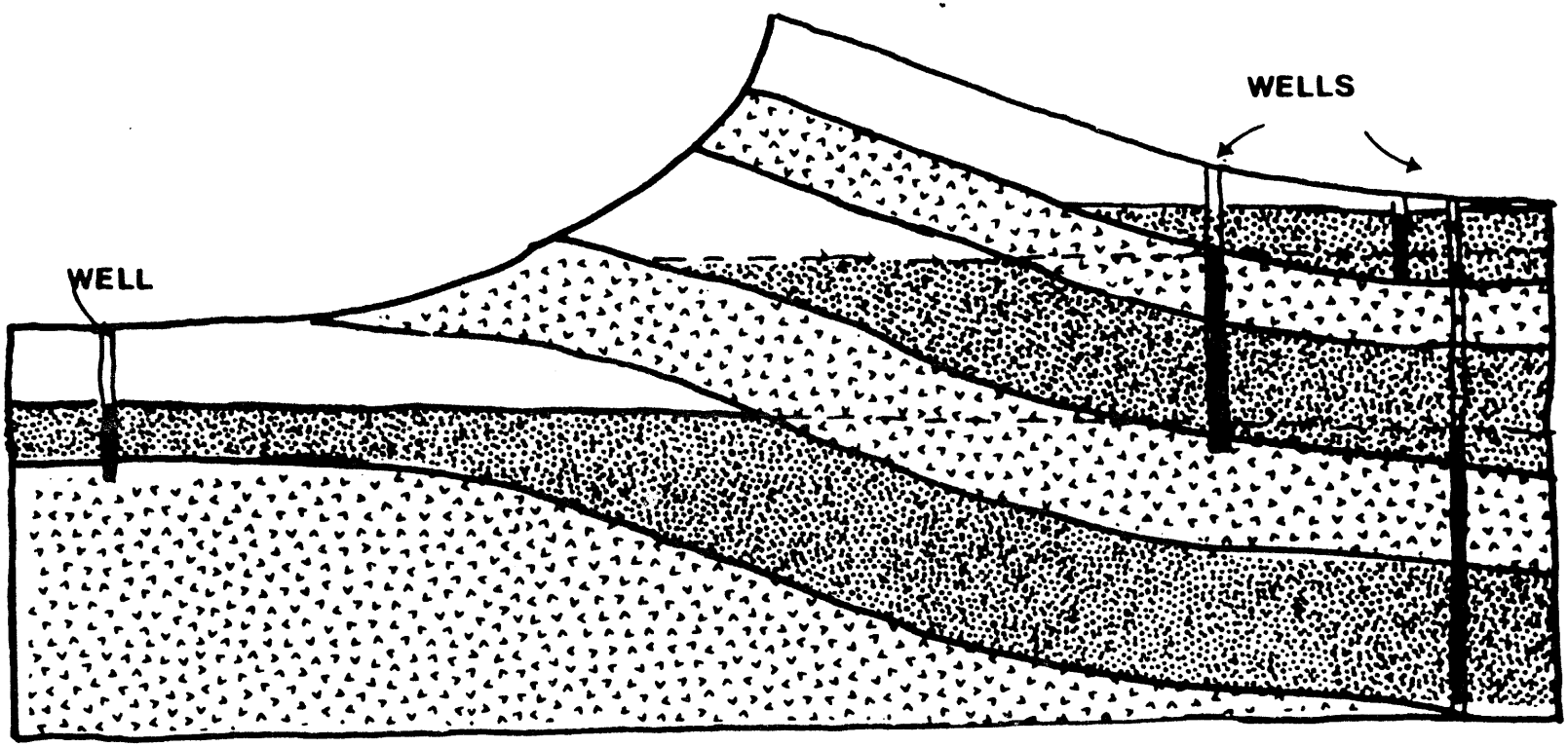
• Show

Product on

Local and intervening structural and stratigraphic details not shown.

Generalized geologic cross-section — Defiance uplift to Oak Creek Canyon

Figure 11: Diagram showing the effect of structural geology on ground water occurrence



drilling of most of the wells on the reservation, no detailed geologic cuttings were made nor were the units penetrated by the drill analyzed. The most extensive geologic information is contained in a series of reports regarding the Peabody well field.[11] In addition, there are a few other deep profile wells, and at least two more are contemplated as part of the Hopi's current water resources work.

Source and Occurrence of Ground Water

With the broad geologic background in mind, it is now possible to discuss the hydrogeologic characteristics of the source, recharge, occurrence and movement of ground water in the Hopi region. To facilitate the discussion, a list of ground water resources information essential to water resource planning and development is presented in Table 8. The availability of ground water information related to water policy planning for Hopi water resources is then summarized in Table 9 according to the criteria presented in Table 8.

Although all rock units within the Hopi Reservation yield some water, certain formations are more productive than others. Many years ago, hydrogeologists grouped the region's aquifers into multiple aquifer units, which are presumed to be hydraulically interconnected sandstones. The C, D and N multiple aquifer systems comprise the most significant units in the region, each being named after its principal geologic

Table 8: Ground Water Information Essential to Water Policy Planning

PHYSICAL SYSTEM	
Aquifer System	Location, area, thickness
Recharge to Aquifer	Amount, location, timing
Aquifer Properties	Transmissivity, Storativity, Porosity dispersion characteristics, yield
Withdrawal and Use	Pumping amounts, timing, ownership and use of water
Surface Water Connections and Interactions with ground water . .	Location, extent and magnitude of interaction
Water Quality	Variations, natural characteristics
INSTITUTIONAL SYSTEM	
Management System	Agencies, practices, arrangements
Priorities for Use	Agency biases toward certain uses
Intergovernmental Agreements governing use	Interstate compacts, decrees, joint management activities
Extent of Aquifer connection with off-reservation resources	Identify differing rules governing ground water use
LEGAL SYSTEM	
Status of the Tribe's water right	Quantified rights and authority to manage natural resources
Legal Status of ground water resource	Recharge, percolating water, springflow

Table 9: Availability of Planning Information for Hopi Water Resources

Study[1]	Physical: Aquifer System	Physical: Recharge	Physical: Aquifer Properties	Physical: Withdrawal/Use	Physical: Surface-Ground water connections	Institutional: Management System	Institutional: Priorities	Institutional: Intergovernmental Agreements	Institutional: Connection with off-reservation resources	Legal: Tribal Water Right	Legal: Legal Status of ground water resources
Early Studies											
1			x								
2	x		x						x		
3				x	x	x					
4											
5	x		x	x	x				x		
6	x										
7	x		x	x	x		x		x		
Current and Recent Work											
1	x		x	x					x		
2				x		x				x	
3	x	x	x	x			x		x		
4	x	x	x		x				x		
5	x	x	x		x						
6	x		x	x							
7	x		x								
8	x										
9	x			x		x			x	x	
10					x	x			x		
11	x	x	x	x					x		
12	x	x	x	x		x		x	x	x	
13	x	x	x	x	x						
14	x		x								
15	x	x						x			

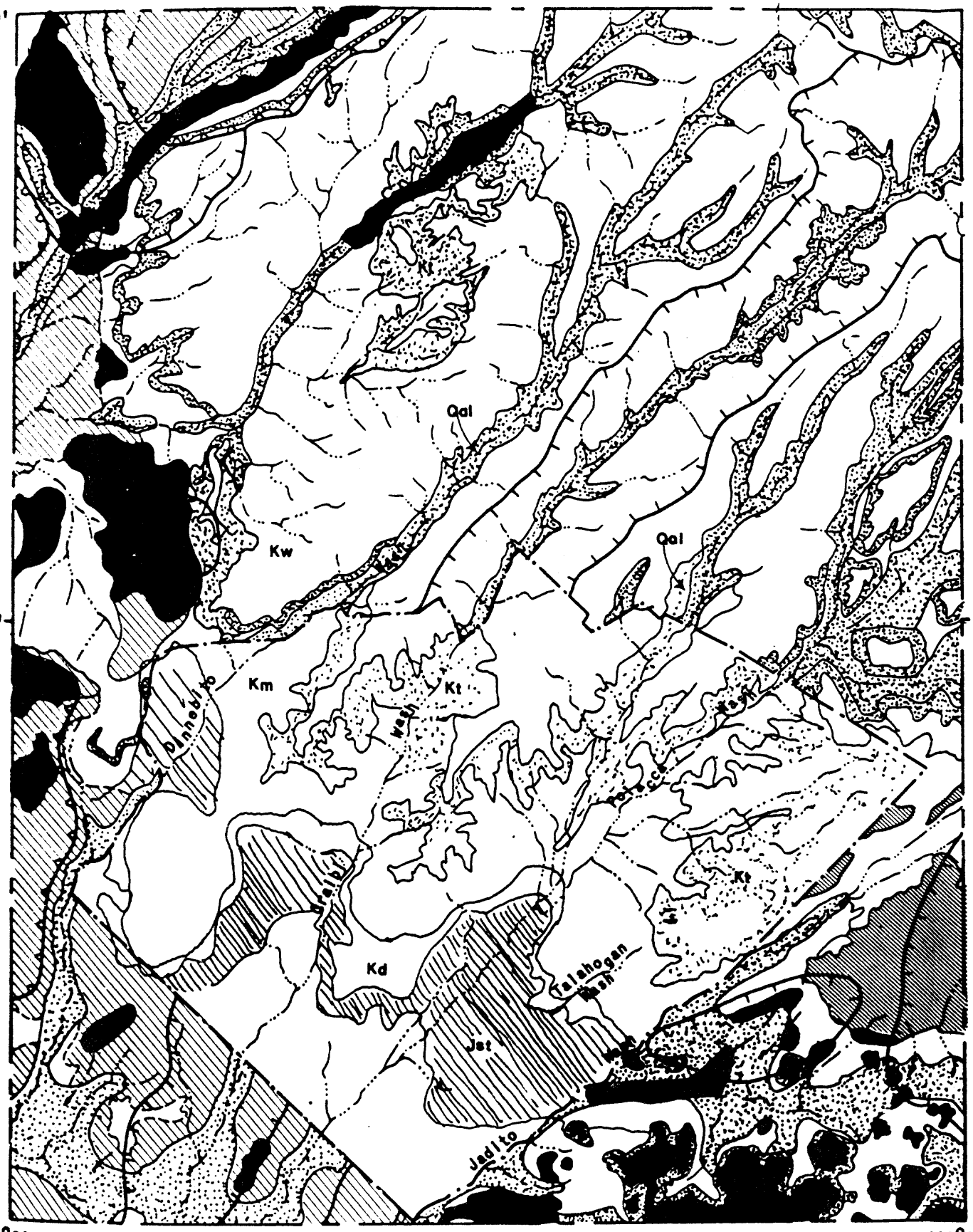
1. The title and author of each study can be found in Tables 2 and of this report.

unit: the Coconino sandstone, the Dakota sandstone and the Navajo sandstone, respectively. All of these aquifers have related units, as indicated in Table 10. By far, the most extensive study of the water resources on and near reservation lands has been focused on the Navajo sandstone.

Local, but important, aquifers to the Hopi people include the Toreva and Wepo formations found exposed at the surface in the northern HPL lands and thinning southward. Numerous stock wells are located in these units that provide water suitable for stock but not for domestic uses. Several known springs are linked to the Toreva formation, where water movement is predominantly along fractures in the formation. Available evidence indicates that the water moves and is "drained" to the south in the Toreva formation because much of the aquifer surface is cut by washes that serve as a natural discharge point for the Toreva and Wepo formations. The Toreva is recharged through direct rainfall, which seeps into cracks and fractures in the unit exposed in the northern HPL lands. Significantly, the Toreva formation is the source of coal beds currently being mined by Peabody.

Waters discharged to the washes by the Toreva contribute to recharge of the reservation's alluvial aquifers. A map of these aquifers, which are largely unexplored, is presented as figure 12. The alluvial material serves as a source of water for hand-dug wells. Recharge of the alluvial aquifers by stream flow during storm events is the source of the

Figure 12: Map showing alluvial aquifers
on the Hopi Indian reservation
(stippled areas are alluvial aquifers)



10 0 10 20

Table 10: Rock Units Comprising The
Multiple Aquifer Systems of the Hopi Reservation

Aquifer System	Major Rock Units
"D" Aquifer System	Carmel-Entrada Cow Springs Sandstone Morrison Formation Dakota Sandstone
"N" Aquifer System	Navajo Sandstone Kayenta Formation Wingate Sandstone
"C" Aquifer System	Chinle Formation Moenkopi Formation Kaibab Limestone Coconino Sandstone

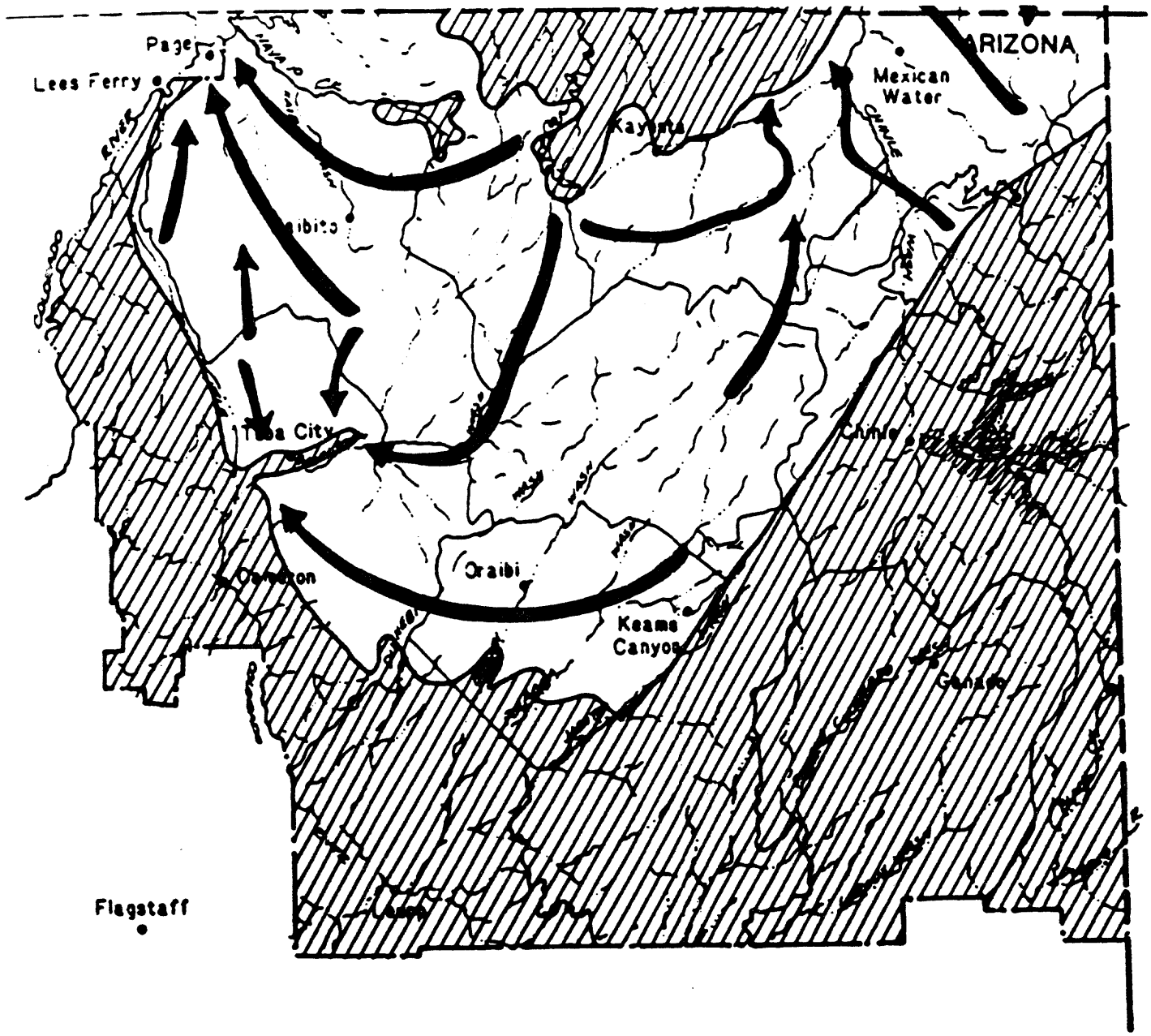
transmission loss discussed in the surface water section of this chapter. Water level measurements in such wells and field investigation of springs would delineate the seasonal fluctuation of the water table and may provide clues into the leakage of Toreva and Wepo waters into the wash sediments. Other aquifers discharge to the alluvial material.

The next most significant unit, the Dakota sandstone, and related units -- the Morrison formation, the Westwater Canyon member and the Cow Springs sandstone -- comprise the D multiple aquifer system. Ground water direction in this unit is presumed to be east to west, although there is very limited 'information for the system. Thus the system is recharged along the northern and eastern rims of Black Mesa and discharges along the western and southwestern edge of Black Mesa. Some discharge to the alluvial materials of the washes also occurs from the Dakota system. The Dakota sandstone and related units also most likely serve as a major source of spring discharge at the southern portion of Black Mesa. Water quality in the Dakota sandstone is variable, undoubtedly as a result of the several interbedded siltstone and sandstone layers and the relation of recharge traveling through the Mancos shale to the Dakota system. Additionally, the D system is recharged by several washes that cut directly across surface expressions of the unit.

The D system is hydrologically connected to the Navajo, or N, system in the central and northern portions of the HPL.[12] Therefore, pumping in certain areas of both the N and D systems may impact water levels and should be monitored. Significant water level declines in this system and in the Navajo sandstone have been documented in the Hopi area,[13] but the cause of these declines is still undetermined.

Much has been written about the next most hydrologically important aquifer system, the Navajo sandstone. As noted in Table 10, the Navajo sandstone system consists of three geologic units, which have been modeled as one single unit by the U.S. Geological Survey. The principal recharge area for the sandstone is in the western portion of the reservation (1934) lands, at Tuba City. The thickest portion occurs under HPL lands and the sandstone pinches out on the southeast portions of the reservation. There are several different patterns of ground water flow in the Navajo, as shown in figure 13. For the lands of the Hopi area, ground water at present is moving south and southwest. The Navajo sandstone also may be recharged south of the reservation lands. The recharge may occur through the dissecting of surface outcrops of the sandstone just south of the reservation. Depending on conditions here, the sandstone also may be the source of numerous springs just south of the Hopi Reservation.

Figure 13: Generalized direction of ground water flow in the Navajo sandstone (after Cooper, 1984)



A principal area of research of the N system is the extent of interaquifer leakage. The leakage is significant because pumping in the N system could induce poor quality water migration into the sandstone, as well as impact water levels in other major aquifer units. Another major research item includes the determination of the hydraulic characteristics of these units. A major aquifer test conducted at the Peabody well field revealed differences in values of transmissivity as determined from pumping and recovery data.[14] Finally, pumping restrictions that may result because of the thinning of the aquifer unit on the southeastern portions of the reservation should be addressed.

The final significant aquifer system consists of the Coconino sandstone, which is exposed in the Little Colorado riverbed, and also the Chinle, Moenkopi and Kaibab formations. Together, these units form the C multiple aquifer system. These latter units also are exposed in the Little Colorado riverbed, so that active recharge to the Coconino sandstone would depend on the extent of exposure to, and pumping of, the Coconino sandstone in the vicinity of Winslow and just north of that area.

The Coconino sandstone was considered economically infeasible for development purposes in the planning of the Peabody well field because it occurs at great depths there and in the HPL and District 6 lands. However, water quality analyses for a well north of the HPL indicates water is of

good quality, which contrasts with reports of variable quality elsewhere. The Coconino sandstone could be developed in the southwestern portion of District 6.

This very brief summary of the hydrology of ground water occurrence on the Hopi Reservation demonstrates the almost complete lack of data for Hopi-specific resources. Although there are several wells and windmills on the reservation, no well logs or well construction details were kept, essentially thwarting any effort to determine the subsurface structure in detail. The information presented in Table 8 also demonstrates the lack of water resource planning information available to the tribe, information that would help planners decide on well location and spacing, pumping volumes and promising areas for development. Fortunately, current investigations will begin to address these aquifers in a more than qualitative manner, but a considerable amount of work remains.

Quality of Hopi Ground Water Resources

Information on the quality of Hopi ground water resources is virtually nonexistent, with the exception of regular bacteriological sampling by the Indian Health Service (IHS) and a few selected comprehensive analyses of selected aquifers. Yet, water quality is known to vary as a direct function of the rock material in which water is located.

Three analyses from different aquifers on the reservation are presented in Table 11. These three analyses demonstrate the subtle, but real, variations in water quality. No information exists for the waters of the Toreva and Wepo systems or for springs in District 6 or the HPL lands.

SURFACE AND GROUND WATER POLLUTION

Identification of Pollution Sources

Because of the general lack of water quality data for the reservation, it is difficult to tell whether Hopi water resources are suffering any damage from pollution. However, there is the potential for ground water contamination resulting from the following general land use practices identified on the reservation:

(1) sewage disposal lagoons,

(2) landfills and solid waste disposal practices,

(3) leaking underground gasoline tanks,

(4) septic systems or individual outhouses.

These four items may threaten ground water quality in the general manner presented in figure 14, where contaminants travel down into the ground water resource from the surface. The threat to Hopi resources would be significant in areas where the soil is permeable enough to permit the rapid transfer of contaminants such as nitrate, bacteria, viruses, petroleum products and other carcinogens.

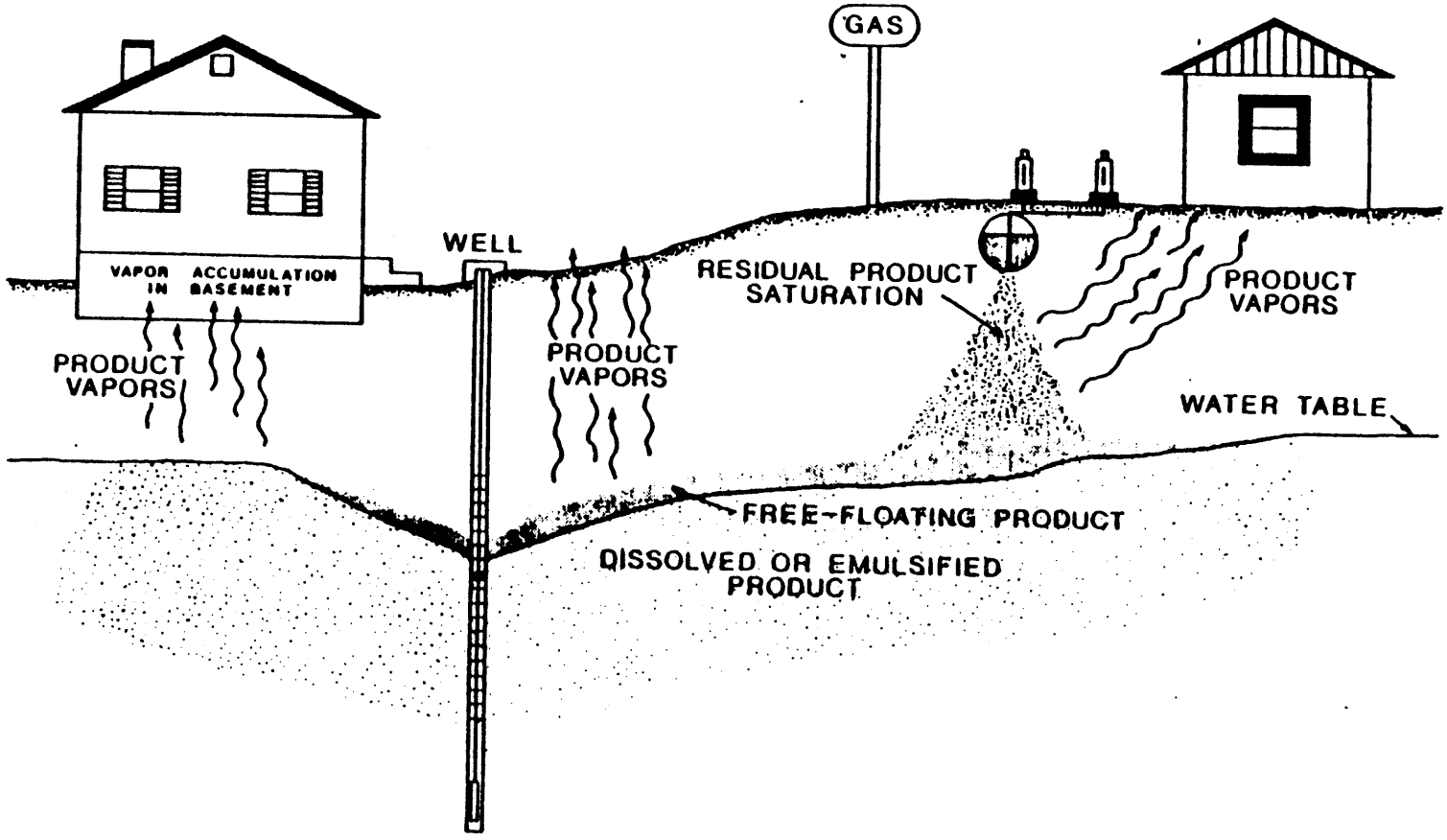


Figure 14: Contamination of ground water from selected land use practices. The figure shows gasoline contamination but the pathways for other contaminants remain the same (After McQuillan, 1986)

TABLE 11[3/]

WATER ANALYSES
BLACK MESA WELL FIELD

Item	Units	NAVAJO WELLS 2	3	5	6
Date Collected		8-17-67	4-29-68	6-12-68	6-29-68
Color	Units	-	2	3	2
Turbidity	"	-	8.0	5.8	13
pH		8.85	8.25	9.18	9.08
Saturation pH @ 60°F		8.70	-	-	-
@ 70°F		8.62	9.12	9.04	9.00
Water Temperature	°F	84	88	89	92
Conductivity	μmhos/cm	221	236	224	201
Calcium, Ca	mg/l	7	2.4	2.8	2.8
Magnesium, Mg	"	1	1.2	1.0	0.5
Sodium, Na	"	42	55	51	52
Potassium, K	"	1.2	0.9	0.9	0.9
Bicarbonate, HCO_3	"	76	127	81	81
Carbonate, CO_3	"	22 2/	0	22	25
Sulfate, SO_4	"	21	17	16	13
Chloride, Cl	"	5	4	3.5	3.0
Fluoride, F	"	0.1	0.61	-	0.45
Nitrate, NO_3	"	1	4	-	2.6
Carbon Dioxide, CO_2	"	0 1/	1.3	-	0.2
Phosphate, PO_4	"	-	0.5	-	0.4
Manganese, Mn	"	0.04	<0.02	<0.02	<0.02
Iron, Fe	"	0.05	0.02	0.02	0.07
Silica, SiO_2	"	18	30	-	34
Boron, B	"	0.11	0.3	-	0.3
Total Hardness, $CaCO_3$	"	21	11	11	9
Total Alkalinity, $CaCO_3$	"	-	104	98	106
Phen. Alkalinity, $CaCO_3$	"	-	0	18	22
Total Dissolved Solids	"	147	171	168 1/	170

1/ Calculated

2/ As $CaCO_3$

3/ Source: Stetson Engrs. 1966

Other sources of contamination are more obvious and include:

(1) Leakage of acid mine waters, also laden with heavy metals, into the ground water system as a result of Peabody's mining operation;

(2) Inducement of leakage of poor quality water into aquifers of good quality as a result of pumping activities;

(3) Ground water contamination with radionuclides, heavy metals and acid at the Tuba City abandoned uranium tailings pile;

(4) Contaminated radioactive runoff from the site leaking into well casings as a result of large runoff events and faulty well seals.

In order to determine the extent and potential magnitude of contamination of Hopi water resources, it is strongly recommended that the tribe establish a water quality monitoring program. Fortunately, under the auspices of the Hopi-EPA project, such an inventory will begin in the next fiscal year and the elements of a monitoring program will be established.

LAND AND WATER MANAGEMENT ISSUES AT HOPI

As described in earlier sections of this report, the Hopi Tribe is at a major turning point in water resources management. With the issue of quantification of rights on the horizon, there are major issues which face the tribe in its continued work in managing tribal homelands. The major land and water issues include:

(1) Quantification of surface and ground water resource characteristics on the reservation;

(2) Declining ground water levels in the eastern portions of the reservation;

(3) Development of springs and ground water supplies for use by HPL residents;

(4) Major soil erosion problems on reservation lands and in washes and the need to develop protective measures for all reservation lands;

(5) Suspected water contamination in wells and surface water resources;

(6) Additional storage capacity development for reservation communities and capabilities to supply additional water requirements for new housing units;

(7) Development of a comprehensive set of tribal resource management objectives to guide all land and water management activities;

(8) Development of reservation land and water resource quality standards that govern development, use and management;

(9) Development of mechanisms to manage land and water resources while retaining current tribal jurisdictional arrangements;

(10) Development of mechanisms for the management of resources that cross the exterior political boundaries of the reservation.

The resolution of these issues will require a coordinated effort on the part of tribal policymakers, natural resource managers and community representatives. A water resources information base, which could provide the framework for the development of solutions, is essential and

must be guided by the major issues facing the tribe in the coming decades.

DEVELOPING A WATER RESOURCES DATA BASE

The development of a water resources data base that would assist in decision-making is one of the key tasks facing tribal resource managers in the years to come. Clearly, financial resources should be allocated to this task. At present, water resources information relevant to the Hopi is scattered among a variety of agencies. Moreover, models that have been used to evaluate reservation water resources also are housed at other agencies. There is also a general gap in the current monitoring of water levels and water quality on a reservation-wide basis, with no agency assuming responsibility for overall water quality protection and monitoring. Yet this information is critical to evaluating tribal resource options and decisions. As a general consequence, the tribe has access to very little information about its own resource base.

A general strategy by which to remedy the situation is to develop a data base, which would involve the in-house collection of water resources materials, the classification of material in a manner that satisfies tribal resource management needs, and the selection and analysis of data for use in the development and management of specific tribal resource-oriented projects. To be useful, a data base must

be stored in a central location, have the capability of being updated without losing original information, be accessible for use by tribal resource managers and policymakers, and reflect the activities of the tribe. A possible structure for a water resources management data base is presented in figure 15; this provides the user with information and tools to perform a variety of hydrologic analyses. A range of possible information to be included in such a data base, and selected organizational frameworks, have been presented in Tables 1, 4 and 8 of this chapter.

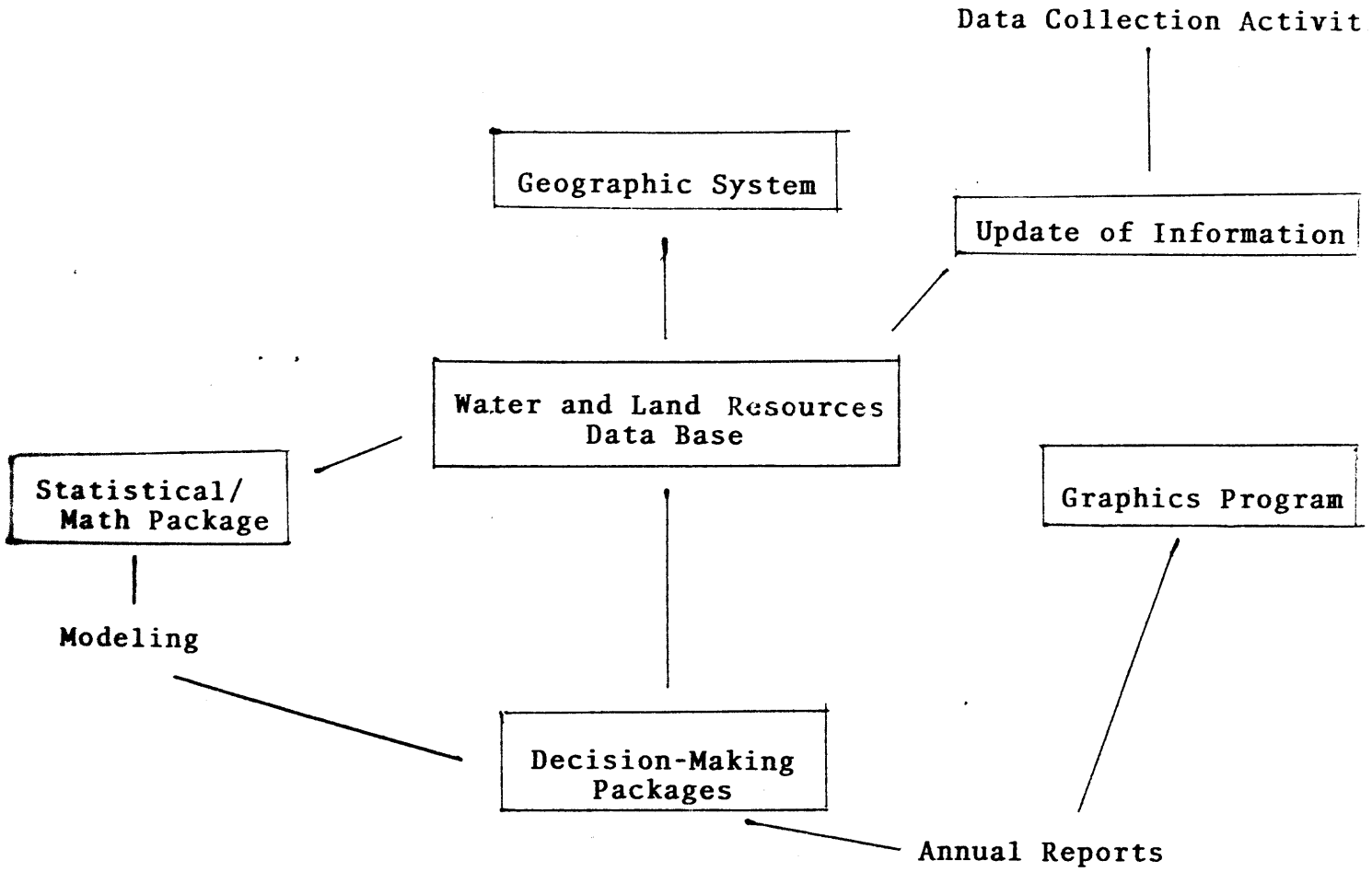
It is quite possible, within this realm, to delegate the water resources data management function to a specific individual or program within the tribe. There are many large water resources agencies that address information needs this way. A key task would be to build a structure that integrates all tribal natural resource management data bases.

One overriding fact remains clear. The tribe must develop procedures for the automatic and immediate transfer of data from its consultants, the BIA and other federal and state agencies to tribal headquarters.

SUMMARY AND CONCLUSIONS

In this chapter, the focus has been on a description of Hopi water resources, with an emphasis on the applicability of existing information to tribal water resource planning

Figure 15: A possible data management structure at Hopi



needs. In this context, it has been essential to place this information within the realm of pressing tribal water resource concerns, as a prelude to discussing the possible guiding principles behind the collection, analysis and monitoring of water resources.

Effective water management will require the application of natural resources information to the protection of tribal homelands. Possible frameworks with which to build the contours of a resource management system will be discussed next.

REFERENCE NOTES TO CHAPTER FOUR

1. William Back, U.S. Geological Survey, personal interview, January 1984.

2. The Hopi Tribe and the BIA are in the process of selecting consultants for this project, September 1987.

3. See generally M.E. Cooley (1969), and Cooper Consultants (1984) reports on Hopi water resources.

4. See U.S. Department of Energy, Remedial Action Program for the Tuba City Uranium Tailings Pile, 1985. Also see F. Marinelli, Terra Therma Associates, review papers for the Hopi Tribe.

5. Interview with Hopi natural resources staff, May 1987.

6. Memorandum to the Hopi Tribe by Harry Sachse, January 1987.

7. Data taken from the report of Morrison-Maierle, 1976.

8. Interview with David R. Dawdy, consulting hydrologist, July 1987.

9. C. Vandemoer, The Tuba City Uranium Tailings Pile: Water Quality Data, unpublished research report, University of Arizona, 1983.

10. At present CERT is the primary conduit for funds on the project. Depending essentially on CERT's administrative costs, baseline water quality data may or may not be collected.

11. Stetson Engineers, Feasibility of Obtaining A Ground Supply from Black Mesa, Arizona, 1966; see also additional reports by this company for Peabody Coal: Engineering Report for Peabody Coal Company on Black Mesa Well Field, Arizona, 1969 and Water Supply: Black Mesa Well #2 (March) and Navajo Well #3 (July), 1972.

12. Ibid.

13. Interviews with tribal natural resources staff, May 1987. See also the annual reports of the U.S. Geological Survey entitled Annual Report for Monitoring Wells on Black Mesa.

14. See Stetson Engineers, op. cit. Also see L.P. Halpenny, Evaluation of Water Supply of the Joint Use Area, 1972 and U.S.D.A., Little Colorado River Basin, Appendix 2, Water Resources.

CHAPTER FIVE

STRATEGIES FOR TRIBAL WATER MANAGEMENT

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The previous chapters of this report have documented selected dimensions of the water management concerns at Hopi, detailing the regional institutional setting for water management, the physical basis of the tribe's resource, and the legal basis of the tribe's water right and authority to regulate reservation land and water resources. Throughout the discussion, it has been emphasized repeatedly that the Hopi Tribe is in an extremely critical time period regarding its water rights and must bring its full expertise to the resolution of water resource issues and to the development of an organizational framework through which to implement and achieve tribal water and land planning objectives. Hopi actions in this regard will have a ripple effect across Indian Country since procedures and structures for natural resource management developed by any tribe will be looked at as providing possible models for other tribes. As discussed in Chapter Two, what the Hopi Tribe does regarding surface and ground water management, as well as watershed management, also may impact state water policies and practices significantly.

This chapter provides a collective analysis and application of the information contained in earlier chapters to the development of an organizational framework for water resources management at Hopi. Given that the Hopi Tribe

already is involved extensively in numerous resource management activities, the discussion will examine the possible structures for, and administrative consequences of, using the water resource as the primary focus for natural resource management activities.

DEVELOPING A FRAMEWORK FOR TRIBAL WATER MANAGEMENT

Water management refers to the complex process of using, monitoring, protecting and administering surface and ground water rights and quality. The practice of water management also involves the regulation of land use in relation to the protection and management of water supply and quality. Thus, water management actually involves a wide range of activities that may be grouped broadly into institutional issues, legal factors, questions of physical management of the resource and administration of water rights. To ascertain the numerous relevant factors in an organized manner, a management framework is useful.

It is important to recognize that water management is a **dynamic** process that evolves to meet the changing needs of the tribe. Consequently, in setting up a water management **agency**, one really is establishing a **process** through which **issues** affecting water may be resolved now and as they arise in future years. Within such a context, the water policy and management planning process is characterized by four factors:

(1) A preliminary determination of the tribe's priority for water management.

(2) A resource inventory, and a legal, political and economic assessment.

(3) The design and selection of a water management system.

(4) The implementation and enforcement of tribal water policy programs and objectives.

A flowchart, entitled the "Water Policy and Management Planning Process," is presented as figure 1. Note that the process consists of several "feedback loops," implying a continuous revision and application of policies as new data, circumstances or priorities emerge.

Each of the components of the process as they relate to the circumstances at Hopi are discussed in the following pages. The flowchart is not meant to be all inclusive but nevertheless sets out the general parameters of the water management process.

PRELIMINARY DETERMINATION OF PRIORITY FOR WATER MANAGEMENT

Prior to designing a water policy, the tribe must consider its goals and objectives for water management. A possible process for the determination of goals and identification of the priority for water management is illustrated in figure 2. As is illustrated, the essential first step identifies major development issues of the tribe and the relation of water resources management to those larger issues. Although there is not any one universal

Figure 1

Tribal Water Policy and Management Flow Chart

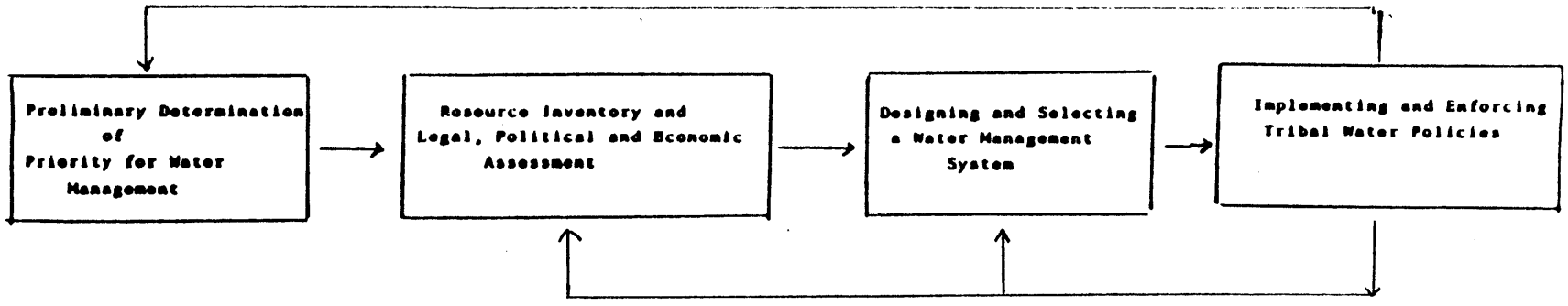
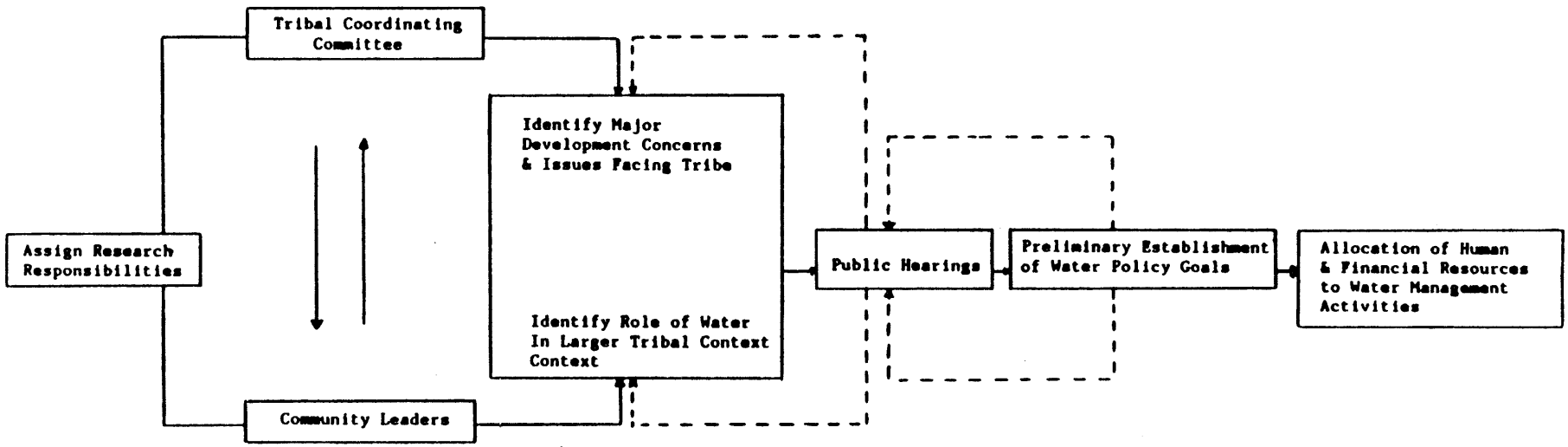


Figure 2: PRELIMINARY DETERMINATION OR PRIORITY FOR WATER MANAGEMENT



process for the identification of such issues, the figure contemplates that a combined committee of tribal policymakers and community leaders would identify issues through research and community meetings. Through a series of community meetings, the process suggests the identification of tribal water policy goals and the allocation of financial and human resources to investigate and/or pursue water management activities.

Several ongoing activities at Hopi are involved in the determination of items identified in figure 2. For example, the tribal council established the Water Resources Committee in 1982 to "develop a coordinated approach to the resolution of claims in the Little Colorado River adjudication." A water resources program was established pursuant to the formation of the committee. Although the committee was abolished in 1987, there is still a Natural Resources Committee on the tribal council level. Additionally, the Office of Hopi Partitioned Lands (HPL) currently is conducting community meetings regarding a proposed land use plan for the tribe.

Table 1 illustrates other items that have been identified at the tribal level in relation to the priority for water management. Note that water resource issues are related intimately to the priority development issues identified by tribal staff. Thus, tribal policymakers and

Table 1: Issues Identification for Hopi tribal Water Policy and Planning

Development Concerns of Tribe	Role of Water Management
Mineral Resources Development	
°Type, nature and level of mineral development	**Water for Energy and Minerals** °Water needed to sustain any level of minerals development; water quality can constrain mineral resource development; water use and quality guidelines should guide minerals development
°Tribal Enterprise development	
°Regulations Development	°Development of mining regulations invariably involve the impact of mining upon surface runoff, water quality, and ground water supply and quality
Land Uses and Land Tenure	**Water for Land Use, Development and Management**
°Policies for the accomodation of traditional, subsistence and other uses of land	°Decision-making regarding land use affect the water resource; intensive land uses impact water quality by agravating soil erosion. This has a chain effect as soil productivity is then reduced.
°Authority for Resource Management Decisions	
Rangeland Development and Use	**Water for Rangeland Development and Management**
°Grazing system development: Basis of Permits	°Development of grazing system for the reservation will involve the controlled development and distribution of water
°Jurisdiction over grazing areas	
°Improvement of rangelands	°Invariably involves the wise use of the water resource in enhancing the rangeland resource
Economy	**Water for Economic Development**
°Maximization of employment opportunities	°Industries and other job-producing activities use water for employee housing, industrial processes, and related development
°Deciding on the compatibility of land uses	°Incompatiblities arise over the conflict of land uses, involving tradeoffs between income, environmental consequences (which involve water), and other results of the proposed land use
Agriculture	**Water for Agriculture**
°Development and improvement of tribal agricultural lands	°Water of good quality and in plentiful supply will assist in the fulfillment of this goal; identification of agricultural lands is key as one of the standards for the basis of tribal claims in the Little Colorado River case.
°Ensure continued productivity of agricultural lands	

community leaders alike should give tribal water management a high priority. However, note that specific water policy goals have not been defined in sufficient detail to provide direction to tribal resource managers or to guide overall tribal natural resource decision-making.

Resource Inventory and Legal, Political and Economic Assessment

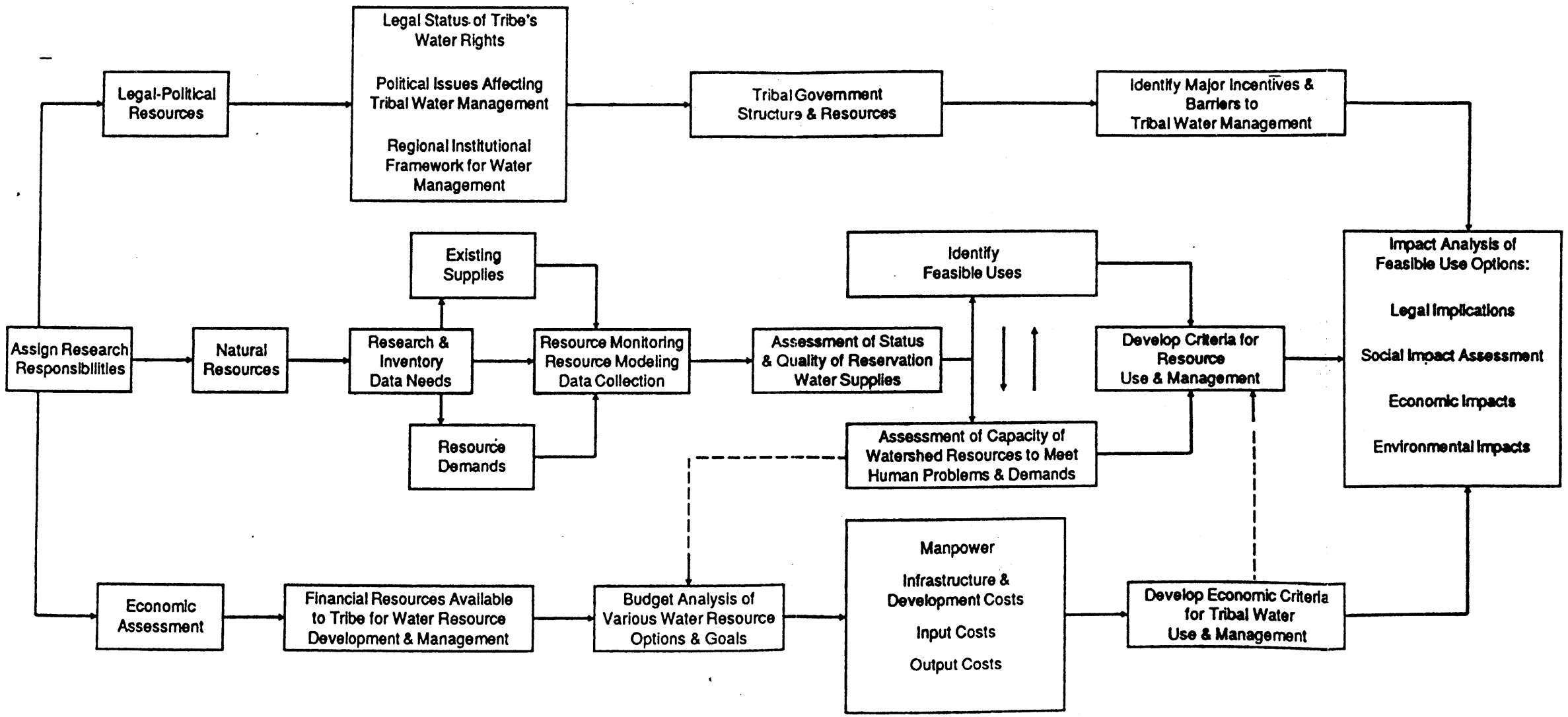
As part of an ongoing process, one of the major steps in developing a base for tribal decision-making is to conduct an inventory of the tribe's natural, legal, political and economic resources. Such an inventory provides an analysis of the framework in which the tribe will operate and identifies the barriers and constraints to resource management. The inventory process is essential to the determination of strategies the tribe must pursue, on a variety of fronts, to maintain, manage, control and secure water. A schematic of the elements involved in the inventory is presented as figure 3. Because the inventory is one of the most crucial steps in developing a water management program, each element of figure 3 will be discussed in some detail, focusing on the extent and scope of Hopi activities related to each task.

Legal and Political Resources

An assessment of the tribe's legal and political resources in the region is critical to the tribe's overall

Figure 5

Resource Inventory and Legal, Economic and Political Assessment

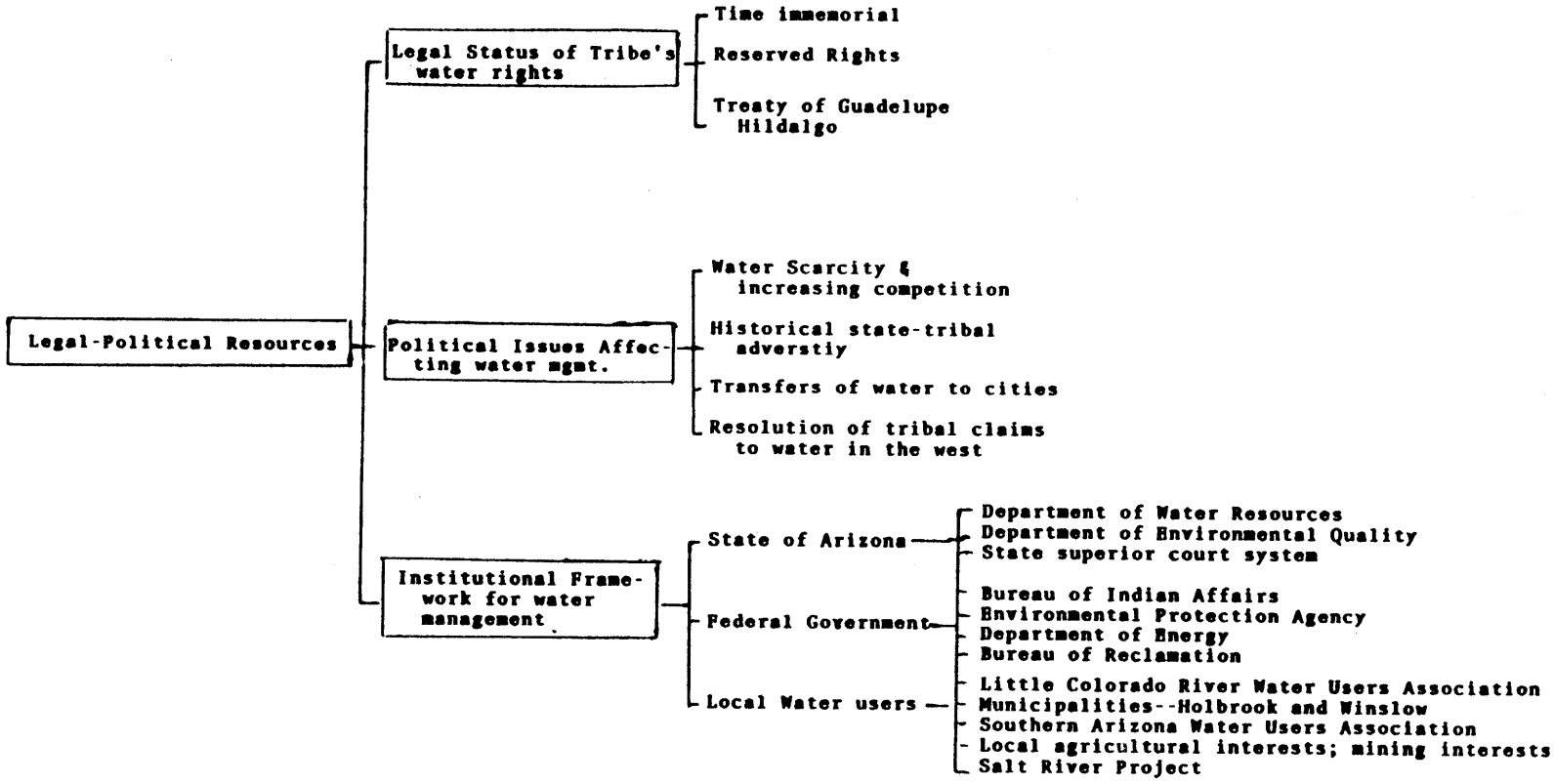


effectiveness as a government acting on behalf of the people. As demonstrated in figure 4, the legal status of the tribe's water right, and authority to manage land and water, is derived from several sources. Additionally, the tribe is exercising its governmental authority by actively managing its natural resources.

Political issues affecting water management, discussed in Chapter Two and illustrated in figure 4, combine with the regional institutional framework to produce an array of incentives and barriers to resource management as were documented in Table 1 of Chapter Two. Some of the most significant incentives for resource management involve the existing tribal natural resources management framework. However, development of a comprehensive statement of tribal goals and objectives to guide natural resource management planning, coordination of current consulting activities with tribal work, and development of the means by which tribal resource managers are able to use and apply this information are necessary so that the existing structure, in fact, may produce effective resource management.

Although not readily apparent, existing jurisdictional and land tenure arrangements may present a barrier to resource management by affecting coordinated resource use and development.

Figure 4: Diagram of Institutional Factors
Affecting Hopi Water Management



Natural Resources Inventory

As documented in Chapter Four, there are significant informational needs regarding land and water resources. The status of activity relevant to other components of the natural resources inventory described in figure 4 is presented in Table 2. Significantly, baseline surface, ground water and water quality data must be completed. In addition procedures must be established and funds acquired for the monitoring of land and water resources. Moreover, criteria must be established for the use of natural resources. At the present time, the Hopi Tribal Council has passed a resolution involving damage criteria for the quality of water emanating and/or resulting from Peabody's mining operations. Standards, including water use, quality, aquifer zoning and land use criteria, must be developed for all reservation resources. Finally, a critical item of information for tribal land use planners involves how much use of a particular resource can be allowed, both by the natural environment and by the cultural standards of the people. Information on the sustained yield of the reservation resources under different development conditions is nonexistent.

Economic Assessment

The development of tribal resource management programs and management organizations is expensive and involves

Table 2: Status of Resource Assessment/Inventory activities on the Hopi reservation by tribal departments

Tribal Program	Research & Inventory Data Needs	Resource Demand Est.	Supply Estimate	Resource Modeling	Resource Monitoring	Data Collection	Identification of feasible uses	Criteria development
Water Resources	X		X	X	X	X		
Range Program	X	X				X	X	
Mining Program	X	X	X	X	X	X		X
Office of Hopi Lands	X	X					X	X
Indian Health Service		X			X			
Bureau of Indian Affairs[1]		X			X			

1/ BIA office located at Keams Canyon; this column does not represent area office activities.

numerous trade-offs between environmental quality, income produced and actual costs of a particular project. In the Statement of Claims of the Hopi Tribe, submitted in the Little Colorado River adjudication, the tribe proposed numerous activities involving the use of the resource for economic development projects. Further economic analysis of the range of options available to the tribe from the use of the resource base is advised.

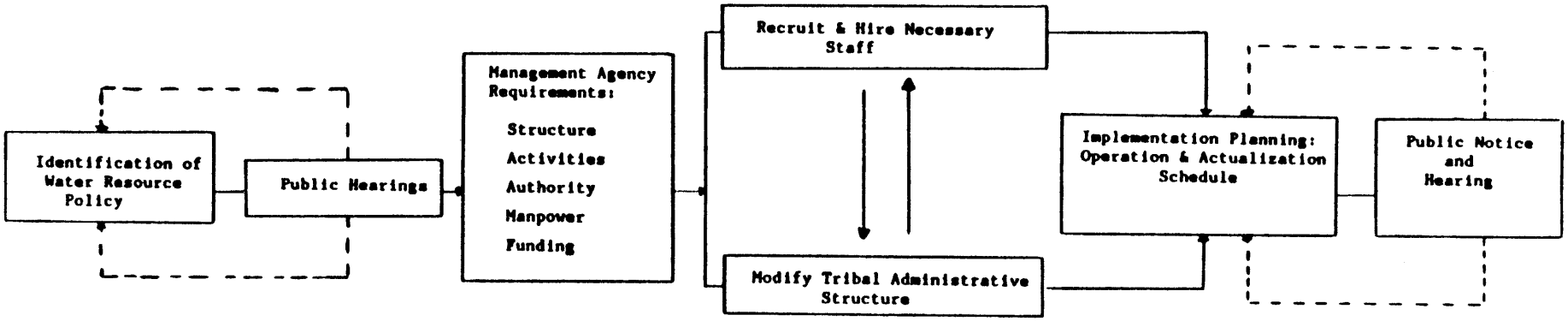
At the present time, economic analysis has been applied to the cost of water for Peabody Coal, to the valuation of coal resources, and to the cleanup of the abandoned uranium tailings pile at Tuba City. A list of potential funding sources for tribal water management planning and programs is presented in Appendix 2.

DESIGNING A WATER MANAGEMENT SYSTEM

The particular characteristics of the tribe's natural resource base, problems affecting resources, and goals and objectives articulated by the tribe form the governing principles behind the design of a water management system. The design of such a system provides an organizational framework within which the realization of tribal resource goals and objectives is possible. As is demonstrated by figure 5, the design of a water management agency based upon the realization of tribal goals may require the

Figure 5

DESIGNING AND SELECTING A WATER MANAGEMENT SYSTEM



reorganization or modification of existing agencies. At this juncture, it is important to assess the current water management structure at Hopi and how it interfaces with other resource programs within the tribe. Such an assessment provides the basis for suggestion of possible organizational structures for tribal water management.

Current Resource Management Structure

Hopi resource management activities currently are housed within the Division of Economic and Natural Resources (DENR). A structural diagram of the division illustrates the numerous resource management programs underway, including the Range Conservation and Range Protection Program (RCRP), the Mining Program, the Uranium Mill Tailings Remedial Action Program (UMTRA) and several others (figure 6). The Water Resources Program, created in 1984, also is housed within the DENR.

A detailed description of the activities of the water program is illustrated in figure 7. Note the large number and varied nature of the activities that currently occupy the program director and staff. As the current program has developed, selected management needs have emerged that encompass the legal, institutional, technical and administrative arenas discussed throughout this report. Briefly, the resource management needs are:

Figure 6: Structural Diagram of the Hopi Division of Economic and Natural Resources (1987)

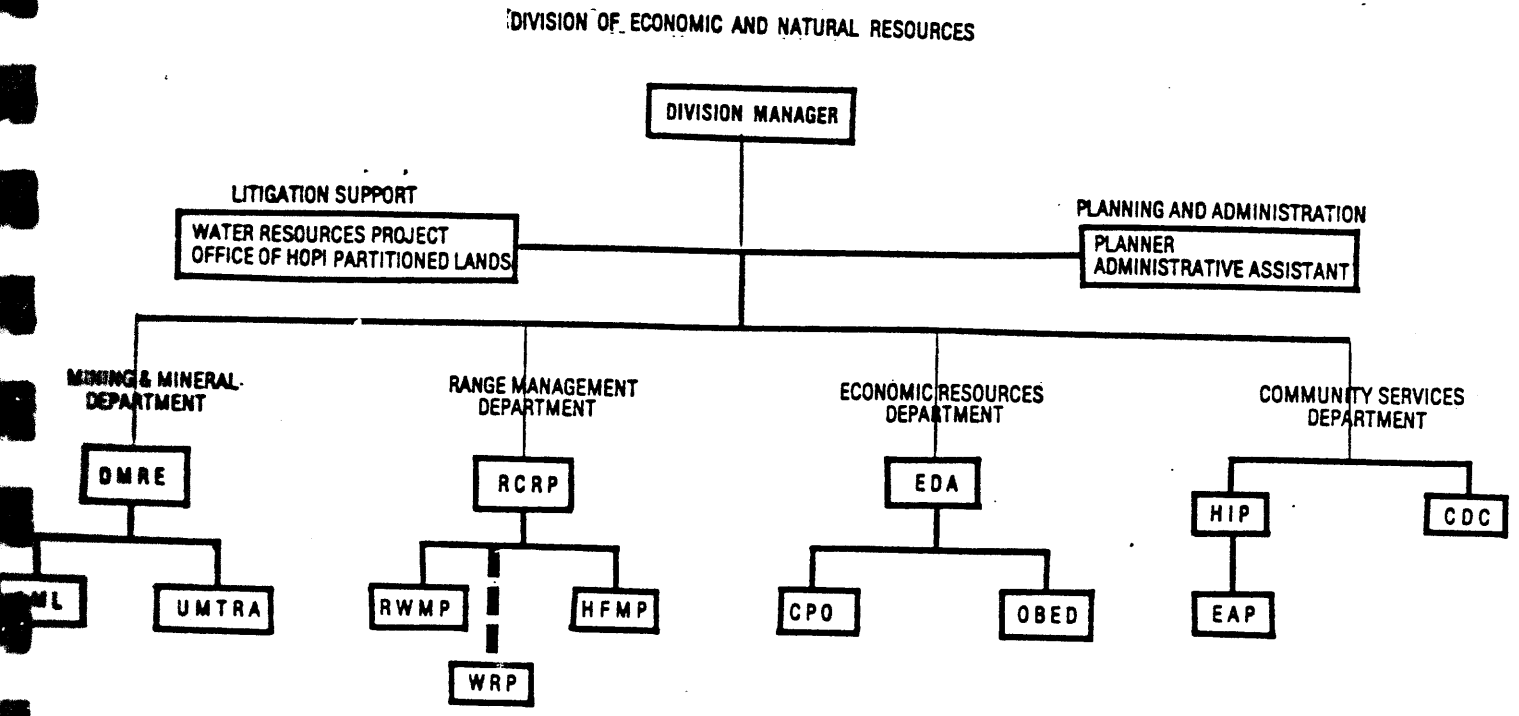
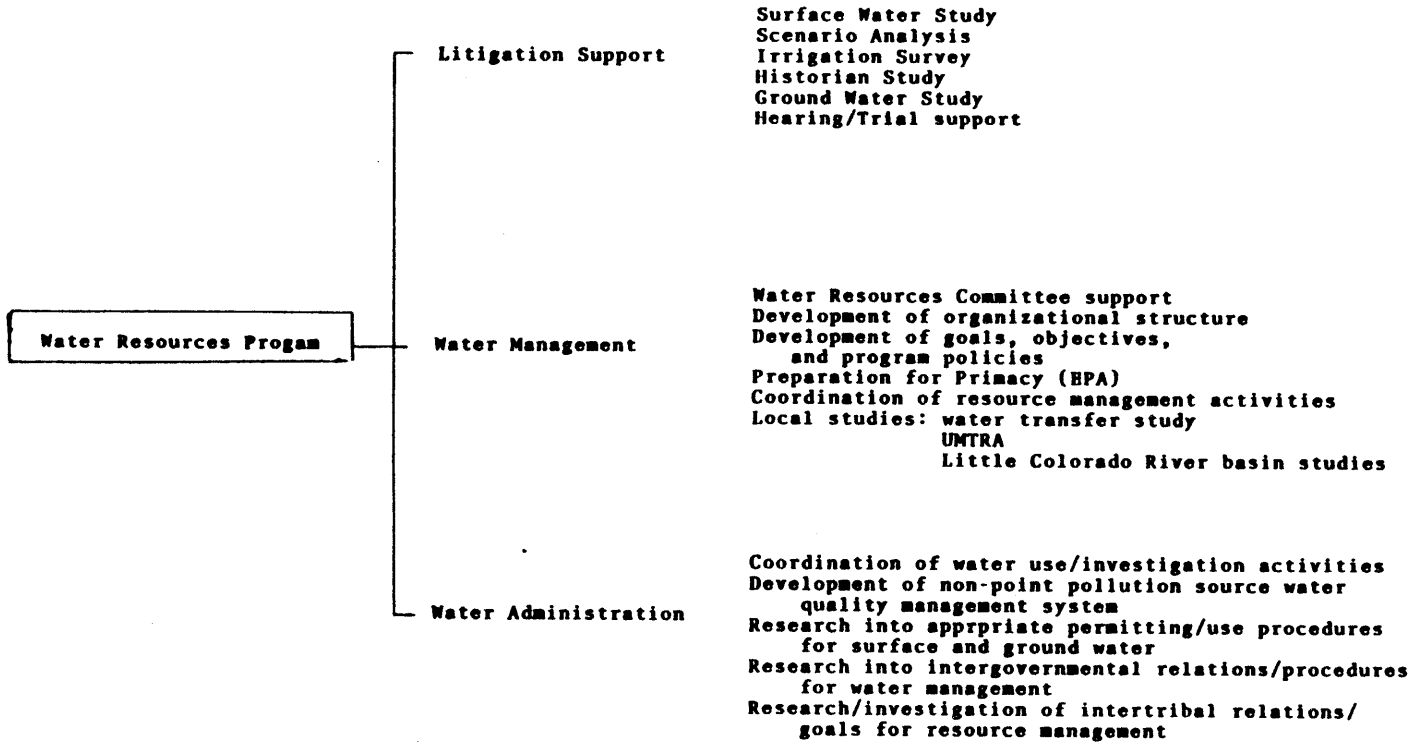


Figure 7: Diagram of Activities of the Hopi Water Resources Program



(1) Management and administration of surface and ground water use and supply;

(2) Protection of water quality;

(3) Development of standards and regulations for water resource use and protection;

(4) Support for activities related to pending adjudication of tribal water rights;

(5) Preparation for assumption of primacy requirements for water quality protection under the Hopi EPA water quality program;

(6) Coordination of water-related resource activities to assure protection and enhancement of tribal water resources;

(7) Interaction with non-tribal resource management agencies and interests in the management of water resources that cross the exterior boundaries of the reservation.

At present, water-related planning activities tend to occur within each tribal division and within the IHS and the BIA. Because there is no overall strategy, there is no need to channel water resource-related activities through a central agency for water management. However, it is becoming apparent that certain activities by some tribal departments will impact water-related objectives of other departments, so that eventually there will be a need to provide for more coordinated use of the water resource. For example the current HUD program on the reservation contemplates building additional housing units complete with water facilities.

Required Management Framework

As is illustrated in figure 5, a water management structure should have the following general functions:

(1) The authority to manage resources, with such authority codified in an appropriate governing document.

(2) The ability to determine water rights for surface water and ground water. When rights are disputed, there must be a forum and mechanism for the resolution of these issues.

(3) An enforcement mechanism -- through a tribal engineer, a tribal court or a water court -- to assure compliance with the tribe's objectives;

(4) The ability to administer water rights, including reservoirs, exchanges, minimum flows and ground water, and to regulate and integrate surface and ground water use;

(5) The ability to administer interstate or intertribal compacts affecting surface or ground water.

Alternative Water Management Structures

Two alternatives for the placement of the Hopi water resource program within the DENR are illustrated in figures 8 and 9. Alternative 1 builds upon the current structure, only increasing the capability of the program to manage surface and ground water quality. Note that a separate water quality department is not established apart from water resources. Significantly, a "Water Resources Task Force," consisting of tribal resource managers from each department functions to coordinate tribal resource activities to achieve

Figure 8: Alternative 1: Hopi water resources program structure and relation to Division of Economic and Natural Resources

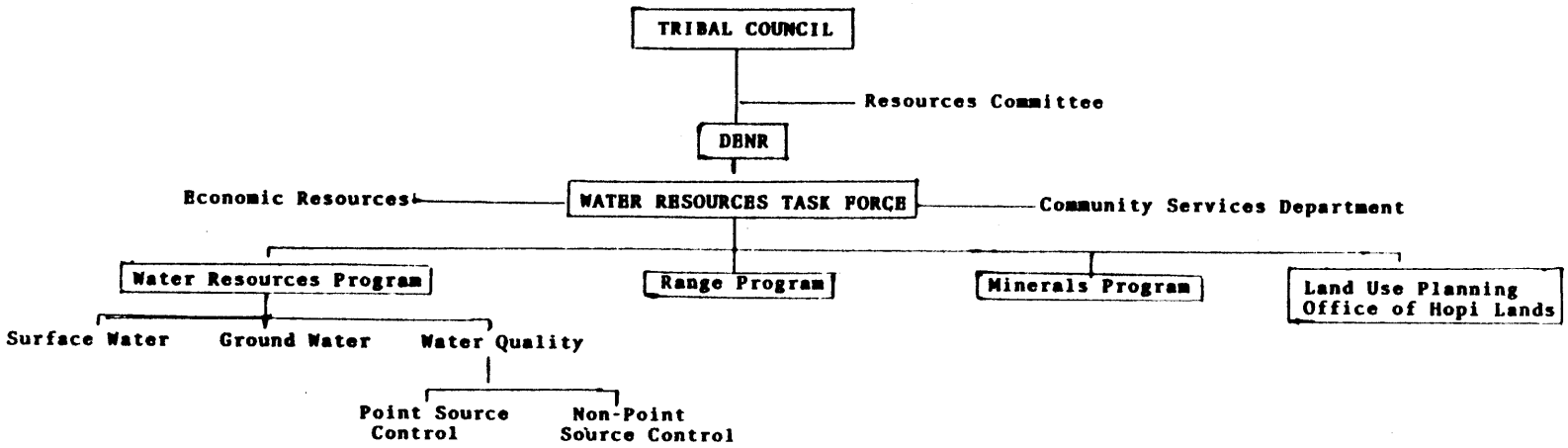
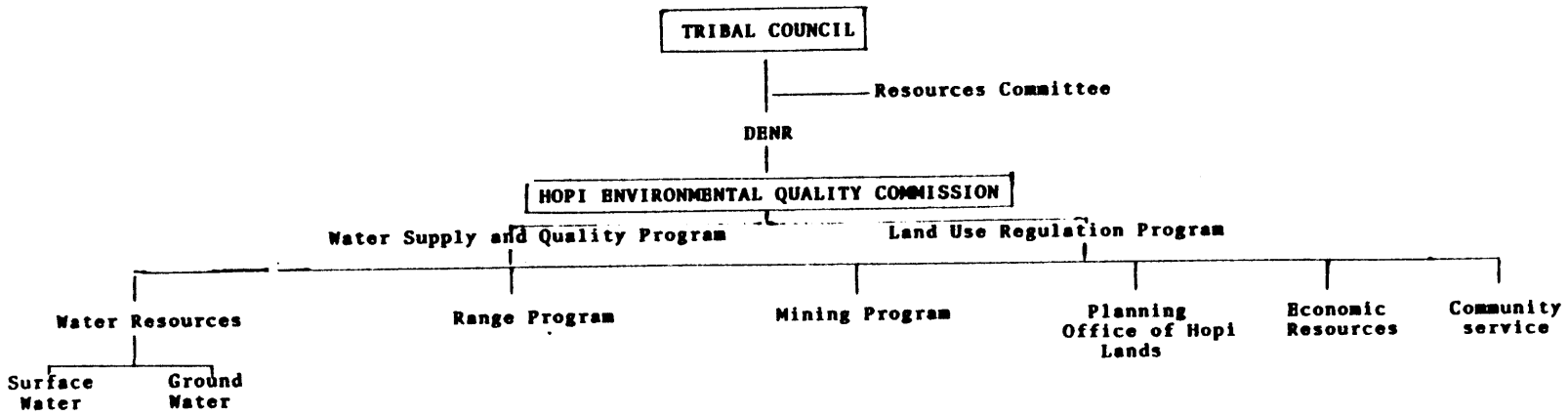


Figure 9: Alternative 2: Hopi Water Resources Program structure and relation to Division of Economic and Natural Resources



effective management of water. Under this alternative, the water resource program would administer all surface and ground water rights.

Alternative 2 establishes a Hopi Environmental Quality Commission (HEQC), which screens and evaluates all resource management activities for their relation to the protection of the quality of surface or ground water. This presumes that a high priority is placed on the establishment and use of water quality and other environmental criteria in decision-making regarding activities that impact the water resource. Under such an alternative, the HEQC would administer surface and ground water use, while relying on the water resources program primarily as a technical arm.

IMPLEMENTING AND ENFORCING TRIBAL WATER POLICIES

Some of the most critical tests of tribal government in the next few decades will occur within the context of resource management: coal, land, fisheries and timber. The water resource will most certainly be a key resource in the struggle, so that the development of tribal water management programs is integral to the exercise of tribal sovereign governmental powers. The development of a program, however, must be accompanied by the enforcement, administrative and technical tools necessary to implement the tribe's resource management goals and objectives.

SUGGESTED TRIBAL ADMINISTRATIVE AND MANAGEMENT INITIATIVES FOR WATER RESOURCE MANAGEMENT

Drawing upon previous research conducted through this study, a list of suggested legal, administrative and management initiatives that would bolster the internal administrative and legal capabilities for the management of natural resources is presented as Table 3. The list represents selected items that were deemed appropriate to recommend within the context of current tribal water resource concerns.

Table 3: Suggested Legal and Administrative Initiatives for Hopi Resource Management

Administrative Initiatives

1. Reestablish Water Resources committee at tribal council level as indicator of the priority for water management
2. Develop statement of goals and water/land resource management policy to serve as guidelines for tribal resource managers
3. Reorganize Division of Economic and Natural resources to accomodate emphasis on water resources; provide a mechanism through which all natural resource development proposals and actions can be reviewed for their impact on water supply and quality
4. Develop memorandums of understanding (MOU's) with BIA and other federal agencies for the prompt delivery and communication regarding natural resource information, proposed studies, and research results
5. Develop procedures for the coordination of resource management activities
6. Identify and provide training for tribal natural resource managers to increase the tribe's capability for resource management

Legal Initiatives

1. Establish system and procedures for surface and ground water use and withdrawal: permit system, decree, criteria, etc.
2. Develop a series of surface and ground water quality criteria that are both legally and administratively enforcable
3. Establish a tribal water resources and land use policy based on legal principles
4. Develop a tribal water code or ordinance as document of policy
5. Establish a dispute-resolution process that can resolve issues regarding the use of land and water under the rules of administrative procedure

APPENDICES

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