A POSSIBLE LEGAL RESPONSE TO DEVELOPED WATER IN ARIZONA

by

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ABSTRACT

Since the 1950's, vegetation modification has been studied as a method for augmenting water supplies. The lack of a legal basis for claiming developed water free from the claims of prior appropriators may discourage full scale water yield improvement activities. Creating a legal classification for water developed by vegetation modification would allow a developer first claim to use.

This thesis evaluates a legal classification of water for Arizona in terms of general criteria and in the context of the Salt and Verde watersheds. These drainages are the most promising area in the State for watershed modification due to water yield improvement opportunities and growing water demand in the downstream Phoenix metropolitan area. In the Salt-Verde system however, the largest portion of the additional water produced would spill at Granite Reef Dam because of insufficient storage capacity. Additional environmental contraints also limit the feasibility of a full-scale program at this time.

Research concerning economic feasibility and environmental tradeoffs should be encouraged. Then, information would be available as augmentation programs are prepared during the second management plan mandated by the Groundwater Management Act of Arizona.

CHAPTER 1

INTRODUCTION

The ability of Arizona to support additional population growth and economic activity could eventually be constrained by the lack of locally available water supplies. Recognition that water is a scarce and valuable resource in the arid West is evident in the long political struggle for tne Central Arizona Project (CAP), whose purpose is to deliver Arizona's allocation of Colorado River water.

Almost all of the existing surface water supply, besides the unused portion of Arizona's entitlement of Colorado River water, is now stored and/or diverted for use. The rate of ground water consumption is presently more than double the rate of natural recharge.

The Ground Water Management Act of 1980 will impose restrictions ground water use in certain designated locations called Active Management Areas (AMA's). The Act requires that any new development within an AMA establish an "assured water supply". An assured supply is a ground or surface water source of adequate quality that will satisfy the proposed use for at least 100 years.

The Director of the Department of Water Resources (DWR) has designated service areas of cities, towns and private water companies where an assured supply is now thought to exist. If a city or town has received an allocation for CAP water, that service area is also deemed to have an assured supply. Within these designated areas anyone

offering subdivided land for sale is exempt from applying for a certificate of assured water supply. In order to obtain a certificate outside of these designated areas, a developer must either prove that a 100 year supply of ground water exists or else provide evidence of an allocation for sufficient CAP water.

Those cities and private water companies which have been granted an assured water supply because of a CAP allocation will be subject to review by the Director of DWR after December 31, 2000. If the Director finds that the requirement of an assured supply cannot be met, limitations can be placed on development. In areas where there is no assured water supply, the State Real Estate Department may not approve property reports nor may the local governing body approve a subdivision plat (Pontius 1980).

As this deadline approaches, cities will be investigating alternatives for supplementing existing water supplies. There are numerous options; given the physical, political, social, and economic constraints of a specific locale some are more feasible than others. These alternatives could include, but are not limited to, the following: purchase and retirement of farmland in order to obtain grandfathered ground water rights, conservation of existing supplies, effluent reuse, additional surface water storage facilities, trans-basin diversions of surface and ground water, water harvesting, weather modification, ground water recharge, reservoir evaporation suppression, and vegetation modification. The last approach listed is the subject of this thesis.

Experiments conducted in the United States since 1909 indicate that water yield can be increased by altering the amount and type of vegetation on a watershed (National Water Commission 1973). Forest cutting patterns can also affect the amount and timing of water yield.

In Arizona, the possibility of improving water yield by vegetation management began to receive serious attention in the 1950's following the release of the Barr Report, an appraisal of vegetation manipulation possibilities in the Salt and Verde River watersheds (Barr 1956). Since that time, use of vegetation manipulation has been promoted by the Arizona Water Resources Committee, through the research and action projects of the Arizona Watershed Program (AWP).

The AWP research and experimental program has been financed, promoted and/or conducted by a number of state and federal agencies including the State Land Department, Arizona Water Commission, USDA Forest Service, U. S. Geological Survey, and the Bureau of Indian Affairs. This program's objective has been to further knowledge of vegetation modification's feasibility as a method for increasing surface water yields and improving watershed characteristics (Cortner and Berry 1978).

Land managed by the Forest Service is among the most important water producing property in the state. Consequently, the Forest Service has played a critical role in watershed management in Arizona through research activities of the Rocky Mountain Forest and Range Experiment Station. At the present time, this experiment station is studying hydrologic interactions that could affect water quantity resulting from

vegetation modification. The group is also attempting to identify users and uses that could benefit from additional flows. This work is being done for three river systems: the Rio Grande, the Colorado and the Salt-Verde.

The Arizona Water Resources Committee's effort to develop the AWP research program has achieved considerable success in demonstrating the technical feasibility of vegetation modification. Political factors rather than lack of scientific information have been responsible for the lack of success in implementing an operational program. Those factors include overstated goals, unrealistic assumptions about the political feasibility of treatment types, extent and intensity of the program, failure to recognize the emergence of significant decision-making participants, and unsettled questions concerning program costs and beneficiaries (Cortner and Berry 1978).

The issue of who is entitled to use the "new" water and the nature of their rights is of primary concern. Users of additional water produced by vegetation modification must be identified to determine the value attached to modification activities. Such a determination might also provide incentives to individuals or institutions other than the Forest Service to engage in this kind of activity.

The Arizona Water commission has urged the development of additional water through watershed management, but has pointed out that ". . . to have optimum management value and to permit mitigation of localized overdraft conditions, an equitable means of distributing new

supplies obtained through induced recharge and watershed management must be provided" (Arizona Water Commission 1978).

In Arizona, as in most western sites, allocation of surface water is governed by the doctrine of prior appropriation. The primary basis of this doctrine is that one who appropriates water is protected against all subsequent appropriators.

If water produced by a vegetation modification program is subject to the prior appropriation doctrine, a user could claim augmented water supplies only after the claims of all prior appropriators have been met. In overappropriated systems the augmenter may receive little, if any, of the water produced by his efforts. Some critics argue that this method of allocation removes any incentive for undertaking an augmentation project (Danielson, Sherk and Grant 1976, Stodt and Sherk 1979, Soice and Blatchley 1979).

However, the general equity concept of the appropriation doctrine also recognizes that he, who by his efforts has increased the flow in the natural stream, has the right to the benefit of such increase against all others, including prior appropriators from that stream (Fischer 1976). The increment of increase in streamflow has been called such things as "salvaged", "artificial", and "developed" water (Hutchins 1971).

As an alternative to the present allocation doctrine, it has been suggested that water resulting from an augmentation program be classified as developed water (Danielson, Sherk and Grant 1976, Fischer 1976, Davis 1978). If augmented water was exempted from the prior

appropriation doctrine, the developer would be entitled to claim the developed water, free from the claims of existing appropriators.

A Montana court case dealing with developed water referred to both the right and the burden of the developer:

> If by their own exertions they have developed a supply of water theretofore not a part of the waters (of the stream) and not before available to the users of the stream, they have the first right to take and use the increase. . . It is only the actual increase resulting from the addition of water to a natural stream which would not otherwise pass down either its surface or subterranean channel to the benefit of other prior appropriators which the law recognizes as an increase of that character which can be diverted as against those entitled to its natural flow. . .
>
> Whoso asserts that he is entitled to the exclusive use of water by reason of its development by him must assure the court by satisfactory proof that he is not intercepting the supply to which his neighbor is rightly entitled. Thus the burden was on the respondent (developer) to prove that they developed the. . . water awarded them by the court. . . this proof necessarily would have given assurance that in taking the alleged new supply they did not diminish the quantity of the principal stream Smith v. Duff, 39 Mont. 382, 102 P. 984 (1909).

A determination of whether the developer has the right to additional water would depend on proving the amount, on the availability of augmented water supplies in a quantity significant to sustain a claim, and on the absence of an injury to any prior rights.

Of the prior appropriation states, only Colorado has developed specific statutory provisions concerning water augmentation. This statute is primarily intended to address the problem of integrating ground and surface water use and to encourage the development of alternative sources in order to protect senior appropriators, rather than to resolve the ownership question (Danielson, Sherk and Grant 1976). Augmentation is defined by Colorado statutes as an increase in

the supply of water "by development of a new or alternate means or point of diversion, by a pooling of water resources, by water exchange projects, by providing substitute supplies of water, by the development of new sources of water, or by any other appropriate means" (Colo. Re. Stat. Ann. 37-92-103, 9, Supp. 1976). It would appear that water yield improvement by modifying vegetation could be included within this definition.

Purpose and Scope of Thesis

This thesis will determine if claiming water produced by an augmentation program will be made possible by creating a legal classification of developed water in Arizona.

Focus On Vegetation Modification

In establishing a comprehensive augmentation policy, it is desirable to design a response suitable for all forms of water supply augmentation. However, this does not appear feasible or realistic for several reasons. First, the augmentation methods are very different in terms of how they affect the hydrologic cycle. As a result, the problems associated with identifying and quantifying the increase in water are different. Second, the nature of each augmentation activity determines which areas are suitable. Whereas vegetation modification is limited to those parts of the State where certain plant communities are located, ground water recharge is confined to areas with high infiltration rates, such as alluvial valleys. The location involves land ownership and the social and environmental considerations which

will affect an augmentation project. Third, the nature of the activity also determines cost, the required technical expertise and the time frame of a project. These factors may limit who is able to undertake a project and the resulting state response.

Because of differences in various augmentation methods, the following analysis will be limited to the suitability of a legal class of developed water produced by watershed modification.

Focus on the Salt and Verde Watersheds

A 1978 report made to the Groundwater Study Commission by the Department of Water Resources determined that the potential for augmenting water yield through vegetation modification was greatest on the Salt-Verde and Gila River watersheds (Higdon 1981).

Surface water diversions from the Gila River are primarily for agricultural purposes. For instance, in the Safford Basin, which includes the drainage area of the Gila River from the confluence with the San Francisco River downstream to San Carlos Lake, the total amount of surface and ground water diverted in 1975 was 257,000 acre feet. Of this amount, 254,000 acre feet, or 98.8 percent, were agricultural withdrawals (Arizona Water Commission 1978). Agriculture is considered low value water use; as long as it remains the primary water use in the area, water yield improvement measures will probably not be undertaken in the Gila watershed.

The situation in the Salt and Verde River watersheds is quite different, however. Most of the research and experimental work with

vegetation modification in Arizona has been carried out in these watersheds. This area snows the greatest potential for improved water yields through watershed modification because of the size of the treatable area, the vegetation types present and the available precipitation. Moreover, there is a growing demand for additional water in the downstream Phoenix metropolitan area. Water storage facilities also already exist on the Salt and Verde Rivers.

Water distribution canals on the Salt and Verde, as well as the dams and reservoirs, are managed and operated by the Salt River Project (SRP). The water in this system has been allocated by court decree and by numerous contracts and agreements between SRP and other water users in the area. Because of the complex way in which water is currently allocated and managed in this system; the problems associated with establishing a legal claim to water produced by vegetation modification are different than elsewhere in the State.

The following analysis will focus on opportunities and constraints of establishing a legal claim to water developed in the Salt and Verde watersheds. This area is chosen because of its significant potential for improving water yield, and because of the exceptional nature of water allocation and management in the Salt-Verde system.

The proposal will also be evaluated for the entire State in terms of general criteria. Based on the general analysis and the case study of the Salt-Verde system, conclusions regarding the suitability of a legal class of developed water for Arizona will be made. Policy

recommendations which might facilitate the development of a vegetation modification program will also be presented.

Methodology

In order to evaluate the appropriateness of a new legal classification for water developed by watershed modification, the following approach was used.

1. The initial task was a search for major assessments and research reports dealing with vegetation modification. This search was made to characterize attempted vegetation manipulation methods and the effects of these techniques both on the hydrologic cycle and other watershed resources. This information is incorporated in Chapter 2 which also contains a summary by vegetation type of the location, extent and ownership of land with the greatest potential for water yield improvement. Conclusions regarding the nature, location and extent of future vegetation modification activities are presented, based on the physical opportunities and constraints discussed in the Chapter.

2. The second task was to establish the current legal and institutional setting for Arizona. This includes both state and federal laws and institutions which are relevant to any future vegetation manipulation projects.

State statutes governing the allocation and use of surface and ground water were examined. Arizona judicial opinions which might be relevant to establishing a claim to developed water were also reviewed.

Changes which could affect the allocation and use of water in Arizona were identified. These changes include the Central Arizona

Project and attendant water storage facilities, the ongoing Gila River adjudication and the settlement of Indian water right claims. Information concerning the general legal and institutional setting is found in Chapter 3.

3. The next task was to identify water users, water management institutions and the various contracts, agreements, decrees and court decisions which govern water distribution, allocation and use in the Salt-Verde system. This information is in Chapter 4.

4. The next step involved identifying criteria to be used in evaluating the suitability of a class of developed water. These criteria were identified from statutory and case law and literature concerning water augmentation, water rights administration and water management.

The most important consideration is whether the proposed change would eliminate the legal uncertainty of the present system and thereby stimulate water augmentation efforts. The remaining criteria are generic criteria which could be used in evaluating any systematic change in water allocation and water resource administration. The proposed change should provide for the protection of existing water rights. In addition, the proposal should be consistent with overall water management and additional land management objectives. The proposed change should make sense in terms of the natural hydrologic system and finally, the proposal should be administratively feasible.

These criteria were subsequently used to evaluate the suitability of a class of developed water for Arizona. The proposed

change was then examined within the legal and institutional context of the Salt-Verde system to determine if such a change would be necessary, appropriate and effective. These analyses and the conclusions which followed are presented in Chapter 5.

5. The final task was to identify policy recommendations, based on the prior analysis, which would indicate changes in law and administrative arrangements for incorporating vegetation modification as part of an overall water augmentation management program in Arizona. This information is found in Chapter 6.

CHAPTER 2

PHYSICAL ASPECTS OF VEGETATION MODIFICATION

This chapter is an introduction to the physical aspects of increasing watershed runoff by modifying vegetation. Included is a general discussion of vegetation modification and its effect on the hydrologic cycle. Vegetation types, location, extent and ownership of land with the greatest potential for water yield improvement are also summarized. Conclusions based on both past assessments of increasing water yield in Arizona and on apparent physical constraints, are presented in relation to future vegetation modification activities.

Vegetation Modification

Vegetation affects the water supply by intercepting snow and rainfall. This moisture can then be lost by transpiration, evaporation from the soil and by affecting snow accumulation. Water yield can be increased by modifying vegetation to manipulate snowpack in forest or alpine areas or to reduce water losses through evaporation and transpiration in forest and brush areas.

The amount of additional water which can be produced depends on the existing vegetation type, climate, site capability and on the extent and intensity of treatment. Treatment usually involves complete or partial removal of existing vegetation and in some cases, the permanent replacement of one cover type with another.

In type conversion, deep-rooted trees and shrubs are replaced by shallow-rooted grasses and forbs. These herbaceous species intercept less precipitation, remain dormant for a part of the year and transpire less. This is because their shallow root systems have less access to moisture than the roots of trees and shrubs which can penetrate deeper soil layers. As a consequence, less moisture is necessary to recharge the soil mantle, and runoff of surplus moisture begins sooner and lasts longer.

In forested areas, vegetation modification involves reducing stand density by thinning or clearing to decrease transpiration and interception. In addition, specific management practices such as patch cutting or strip cutting can be used to promote redistribution of snow by wind in order to affect rates and timing of snowmelt. These factors affect the amount of snow which is lost through sublimation and evaporation.

Vegetation Modification in Arizona

Water yield research in Arizona since the 1950's has focused on broad vegetation types: chaparral, pinyon-juniper, ponderosa pine and mixed conifer (which includes spruce-fir). However, only chaparral, ponderosa pine and mixed conifer show significant potential for vegetation modification. The location of these three vegetation types is shown in Figure 1 and a discussion of each follows.

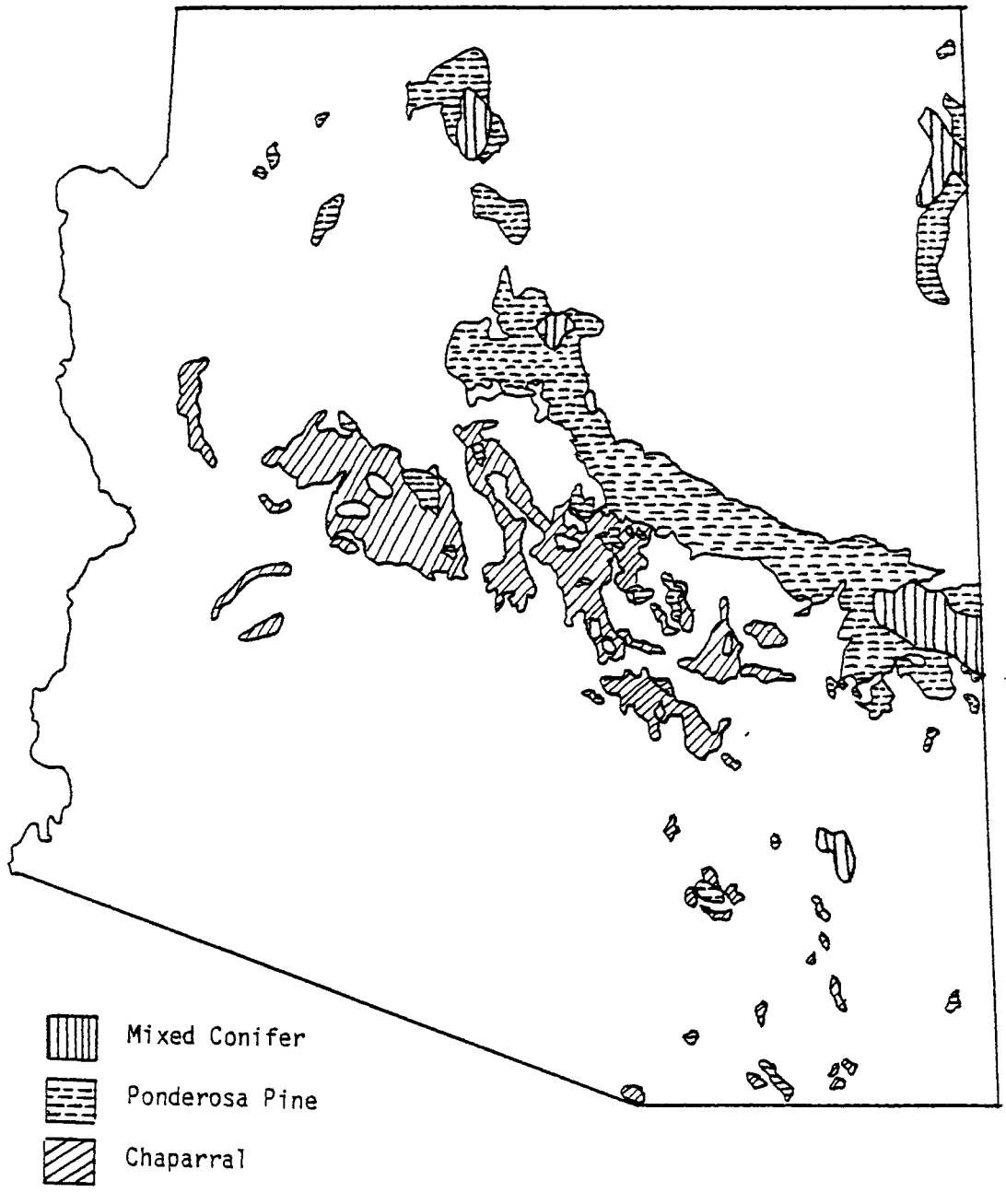

Figure 1. Distribution of Mixed Conifer, Ponderosa Pine, and Chaparral Vegetation Types in Arizona.

(Adapted from Ffolliott and Thorud 1975)

Mixed Conifer Forests

The total increase in water yield for the mixed conifer zone is small because of the limited extent of this vegetation type in Arizona. The mixed conifer type, which includes the spruce-fir association, is found principally in the northern part of the state. Approximately 315,000 acres are located between the elevations of 8,000 and 11,500 feet in the White, Chuska, and San Francisco Mountains and on the Kaibab Plateau (Solomon and Schmidt 1981). The mixed conifer forests are all under some type of federal ownership or trusteeship. Approximately 182,000 acres or 58 percent are within national forest boundaries (Solomon and Schmidt 1981). The remainder is federal land held in trust for the Indians.

Vegetation modification techniques in the mixed conifer zone include conversion (clearing) of overstories and reduction of overstory density levels (thinning) or a combination of the two techniques (Ffolliott and Thorud 1975). The total water yield possible depends on the intensity of treatment and the area treated. With tne exception of complete conversion, the largest increase is achieved from patch cutting or group selection harvests which maximize snow accumulation (Solomon and Schmidt 1981).

Most of the water yield increase can be attributed to the reduction in evapotranspiration (Thompson 1975). In addition, openings in the forest tend to trap snow; wind currents may redistribute snow to these areas protected from the sun and subsequent sublimation and evaporation. In addition, more rapid melting of snow occurs in the

cutover areas, reducing the opportunities for evaporation losses. Water yield is also increased because of a reduction in interception losses and a change in the hydrologic properties of soils and forest floors (Ffolliott and Thorud 1975).

Substantial problems could limit tne management of mixed conifer forests for water yield. Access to many of the mixed conifer stands is poor or nonexistant; roads are expensive and difficult to build, especially from an environmental standpoint. Cleanup after logging also adds to the cost. In addition, there can be problems and costs associated with controlling regeneration of desirable species (Hurst 1974).

Ponderosa Pine Forests

Ponderosa pine forests contribute about 90 percent of the total streamflow in Arizona. It is believed that the opportunity for increasing water yield within the ponderosa pine zone has already been partially realized from past management practices. Solomon and Schmidt (1981) have estimated that fifty thousand acre feet per year of water are currently being produced by timber harvesting activities in the State.

About 85 percent of the 4.3 million acres of ponderosa pine forests, or 3,657,000 acres, is commercial timberland. Most of this has been cut at least once by different systems of partial harvesting. An estimated 60,000 to 65,000 acres have been cleared (Ffolliott and Thorud 1975).

The bulk of the 4.3 million acres of ponderosa pine forests in Arizona is found along the Mogollon Rim. The remaining ponderosa are located on land adjoining the north and south rims of the Grand Canyon, as well as in small, high elevation islands on mountain ranges in the southern part of the state. The Carrizo and Chuska Mountains in the northeast corner of the state also include ponderosa forests.

Of the commercial timberland in ponderosa pine forest, 63 percent is managed by the USDA Forest Service, 24 percent is Indian land, and 8 percent is land managed by the Arizona State Land Department. The remaining 5 percent is private land or is under the management of the Bureau of Land Management and other federal agencies (Ffolliott and Thorud 1975). Of the total 4.3 million acres of ponderosa pine in Arizona, about three quarters or 3.3 million acres, are managed by the Forest Service (Solomon and Schmidt 1981).

Vegetation modification methods employed to increase water yield in ponderosa pine forests involve clearing forest overstories, reducing forest overstory density levels, or a combination of the two. Clearing and thinning of overstories result in a decrease of interception losses by evaporation. However, water yield is increased primarily because of the decrease in water loss by transpiration. By reducing the soil moisture deficit, the surface soil reaches saturation sooner and more water from melting snow runs off. In addition, cutting patterns trap snow and increase its melting rate and delivery to channels (Hibbert 1979). Response to treatment will vary because of differences in

watershed characteristics, climatic variability and the intensity of treatment.

Chaparral

Chaparral is considered to have the highest potential for increasing water yield in Arizona. This conclusion is based on the favorable outcome of brush conversion studies carried out in the state. Between 1962 and 1972, chaparral was converted to grass-forb cover on a total of 49,500 acres of national forest land by various management techniques (Ffolliott and Thorud 1975).

Chaparral vegetation accounts for about 2.8 million acres in Arizona, most of which are drained by the Gila River and its tributaries (Solomon and Schmidt 1981). The major reservoirs in the state are located within the chaparral zone and control much of the flow in these drainages.

Chaparral occurs on rough, discontinuous, mountainous terrain. South of the Mogollon Rim, the most extensive and continuous chaparral stands are found on, or adjacent to, the Prescott and Tonto National Forests, and on Indian lands in the Salt River Valley.

Like the mixed conifer and ponderosa pine vegetation types, most of the chaparral stands are found on land under federal ownership or trusteeship, although some areas are under state and private jurisdiction. About 55 percent, or 1.6 million, is managed by the USDA Forest Service (Ffolliott and Thorud 1975).

Chaparral is usually associated with rock types that produce deeply weathered, coarse-grained regolith which facilitates rooting to

great depths. As a result, these shrubs have access to a potentially large soil water reservoir which they deplete by transpiration.

The objective of vegetation manipulation in the chaparral zone is to convert deeply rooted shrubs to shallow-rooted grasses and forbs that use less water. Not only do herbaceous species have less access to soil moisture because of their shallow roots (and therefore less potential for transpiration), but they also undergo a period of dormancy when minimal transpiration occurs. In addition, they intercept and vaporize less precipitation than shrubs. Methods used to eradicate chaparral include prescribed burning, chemical treatment, mechanical treatment or some combination of these methods.

Each of these methods has a drawback which limits its use. Prescribed burning is expensive, can result in a temporary impairment of air quality and does not result in permanent control since some shrubs resprout from the root crowns (Dieterich 1975). Mechanical treatment (e.g. rootplowing) is also a temporary suppression technique because of shrub resprouting. It is also expensive and limited to moderate slopes which are free from large rocks (Dieterich 1975).

Chemical treatment is costly as well because successive treatments are required for success and because treatment is limited to those chemicals which have been registered for watershed or range use. The Ninth Circuit Court of Appeals has ruled that before a federal agency can spray, they must conduct research or a "worst-case analysis" to satisfy any health question left unanswered during the registration of a herbicide (Kay 1984). This will increase the cost of using

herbicides as well. Probably the most significant constraint to the use of chemicals for chaparral eradication is public opposition. This opposition to their use on public lands has arisen because of the potential for contamination of water supplies and because of toxicity to humans, wildlife and livestock.

According to a recent assessment, only about 20 percent or less of the chaparral in Arizona may be convertible to grass because of multiple use, physical, social and economic constraints (Hibbert 1983).

Past Assessments of Water Yield Improvement Potential in Arizona

Assessments of the potential in Arizona for increasing water yield through vegetation modification are found in three principal reports. Other evaluations have been made of the western United States; these assessments are not included because of the difficulty in separating the increase in water yield attributable to Arizona from the total.

The Barr Report (a result of a cooperative agreement among the Salt River Water Users Association, the Arizona State Land Department, and the University of Arizona), examined the potential for increasing water yield through management of mixed conifer forest, ponderosa pine, pinyon-juniper, and lower riparian vegetation in the Salt and Verde River watersheds. The report concluded that vegetation modification could be one of the most promising methods for increasing water supplies, and may provide up to an additional 285,000 acre feet of water each year (Barr 1956).

The Ffolliott-Thorud Report, an update to the Barr Report, was released in 1974. This report provided estimates of potential water yield increases for the entire state that might be realized by implementing identified vegetation management practices in all vegetation types. The estimates, based on information obtained from published documents, source data and summaries produced since 1956, ranged from 602,561 acre feet per year to 1,229,946 acre feet per year (Ffolliott and Thorud 1975).

The USDA Forest Service is responsible for the most recent analyses of water yield improvement potential in Arizona. These assessments were completed for chaparral, ponderosa pine, pinyon-juniper, and mixed conifer (Brown et al. 1974, Hibbert et al. 1974, Rich and Thompson 1974, Clary et al. 1974). The assessment of pinyon-juniper indicated that the potential for increasing water yield in this vegetation type was much less than originally thought. An evaluation was then completed of the total water yield opportunities on national forest land in Arizona based on these analyses (Solomon and Schmidt 1981). These projections indicated that previous estimates by the Barr Report and the Ffolliott-Thorud Report were too high, although significant opportunities did exist for increasing water yield on Arizona's national forest land.

Assessments of the potential for water yield increases in mixed conifer, ponderosa pine and chaparral are summarized in Tables 1 and 2. Estimates of the additional water yield provided by these evaluations vary for several reasons. The Barr Report numbers are for the Salt and

Table 1. Potential increase in water yield resulting from vegetation treatment; listed by vegetation types of the Salt and Verde watersheds (after Barr 1956 and Ffolliott and Thorud 1975).

Barr Report

Cover Type	Treatable Area (acres)	Probable Increase (inches)	(acre ft.)
Subalpine area[1]	105,000	3-4	28,000
Ponderosa Pine	1,180,000	2	126,000
Pinyon-Juniper	1,700,000	0.6	71,000
Lower Riparian Area	40,000	18	60,000
Total	3,025,000		285,000

[1] Includes mixed spruce-fir, pure spruce and aspen

Ffolliott-Thorud Report

Cover Type	Treatable Area (acres)	Management Option	Water Yield Increase (acre ft./yr.)
Mixed Conifer	36,045	Convert 1/3	3,604
		Convert 2/3	18,022
Ponderosa Pine	978,952	Clear 1/3	97,895
		Clear 2/3	195,789
Chapparral	573,441	Convert 40%	57,344
		Convert 60%	114,688
Total		Range:	158,843 to 328,499

Table 2. Potential increase in water yield resulting from vegetation treatment; listed by vegetation types of Arizona (after Ffolliott and Thorud 1975 and Solomon and Schmidt 1981).

Ffolliot-Thorud Report

Cover Type	Treatable Area[1] (acres)	Potential Increase (inches)	(1000 acre ft.) Low	High
Mixed Conifer	88,000	1.2-6.0	8	41
Ponderosa Pine	4,826,000	1.2-6.0	343	686
Chapparral	3,068,000	1.2-2.4	251	503
Total			602	1,230

[1] Based on annual precipitation. National Parks were eliminated.

Forest Service Assessment (Solomon and Schmidt)

Cover Type	National Forest Treatable Area[2] (acres)	Potential Increase[3] (inches)	(1000 acre ft.) Low	High
Mixed Conifer	90,000	3-4 (1-2)	3	7
Ponderosa Pine	2,000,000	1-3 (0.1-1)	15	30
Chapparral	700,000	1-5 (2.4)	25	70
Total			43	107

[2] Removes wilderness or special use designations, noncommercial forestland and acres ecologically unsuited.

[3] Estimates in parentheses reflect multiple use or other considerations (after Hibbert 1979).

Verde watersheds only. Discrepancies among estimates used in the various reports for the amount of land found in eacn vegetation type are apparent. These are due to differences in the classification system used. Also, estimates of acres suitable for treatment vary depending on the physical criteria (eg. slopes less than 60 percent for chaparral) and the management criteria used (eg. wilderness areas excluded). Moreover, different assumptions were made concerning the treatment method, extent and intensity.

A considerable amount of research has been done to demonstrate the technical feasibility of water yield improvement through vegetation modification. Projections based on this information indicate there are additional opportunities to realize a water yield increase through land management practices.

Uncertainties Associated With Vegetation Modification

Water yield improvement opportunities will be limited to the extent that increases nave already been realized. The extent to wnich potential increases in water yield have already been achieved because of past management practices is unknown.

There are also physical and management constraints to maximum application of watershed modification techniques. Some of these have been accounted for in past research but limitations have not been considered and uncertainties were not resolved. This is primarily because much of the vegetation modification research has been carried out on small, experimental watersheds. Management conditions for

experimental watersheds could not be duplicated on most operation forests which must also be managed for other uses (Robinson 1975).

Experimental treatments were not always intended to represent management practices nor can experimental watersheds be considered representative for all areas with similar vegetation. For example, the Three Barr and Whitespar watersheds, areas where experimental cover type conversion was conducted, are among the wettest in Arizona's chaparral. Consequently, they probably reflect the upper limits of potential increase from brush conversion (Hibbert and Ingebo 1971).

Variability in watershed characteristics limits the extent to which experimental findings can be extrapolated to other areas. As a result, specific management plans for implementation will require more refined and intensive basic data on a site-by-site basis, as well as rigorous analyses of associated impacts.

Current estimates of the potential for increased runoff will be reduced as the problems inherent in large scale application of vegetation modification and site specific constraints are taken into consideration. Some of the additional considerations include multiple use management of federal lands, the impact of large scale application of vegetation manipulation on other resource values (particularly water quality), water losses associated with transmission and storage of increased water yield, and quantification of actual increases.

Multiple Use Land Management

The largest share of land appropriate for vegetation modification in Arizona is under Forest Service management. This is

especially true for the Salt and Verde watershed where 73 percent of the area in mixed conifer, ponderosa pine and chaparral is administered by the Forest Service (Barr 1956).

This federal land must be managed for multiple use objectives. The Multiple Use Act of 1960, ordered that the national forests "shall be administered for outdoor recreation, range, timber, watershed and wildlife and fish purposes . . ." The Act called for "harmonious and coordinated management of the various resources . . . not necessarily (to) give the greatest dollar return or the greatest unit output".

Management for maximum water yields involving removal of vegetative cover from an entire watershed is not compatible with a number of other uses. A resource management plan which provides a compromise among all of the objectives of public land management can be expected to reduce the actual water yield increase from vegetation modification to some level less than that which would result from maximum application of vegetation modification techniques. The relative importance and demand for other natural resource values present on the watershed will dictate the extent to which vegetation manipulation can be practiced. For instance, any watershed management practice which changes density, composition or structure of vegetation is likely to affect one or more wildlife species (Reynolds 1972). This effect can be favorable, as in the case where all or most of the forest overstory is removed and a more abundant crop of understory forage plants palatable to deer and elk are produced (Neff 1972). However, stands can become too open for optimum use by deer (Reynolds 1972).

Likewise, modification of chaparral can be advantageous or detrimental to wildlife, depending on the treatment techniques employed. Chaparral eradication by broadcast spraying of chemicals tends to eliminate the more palatable shrubs first, and standing stems pose a problem of penetration by grazing animals (Reynolds 1972). On the other hand, deer avidly use new sprout growth of shrubs and herbaceous vegetation after a controlled burn (Pase and Pond 1964).

It is clear then that vegetation type and nature and intensity of the treatment will dictate the extent to which other resource values are affected. In a similar fashion, the presence of and allowance for other watershed resources will determine the treatment intensity. For instance, one researcher has determined that no more than 60 percent of an area of chaparral could be converted because of an allowance for wildlife and aesthetic values (Hibbert 1979).

Water Quality

Additional water may be produced at the expense of water quality. Any treatment that tends to reduce protective cover and infiltration is likely to increase erosion, at least temporarily. Elimination of deeply rooted shrubs may also contribute to soil instability (Hibbert, Davis and Scholl 1974).

Vegetation manipulation can also result in accelerated leaching of nutrients from treated areas. Nutrients which are normally recycled can be lost by leaching and runoff when plants are killed.

Leaching of nutrients and accelerated erosion will result in the enrichment of streams and lakes, an increase in the total suspended solids and an increase in the rate of sedimentation in downstream lakes and reservoirs (Hibbert, Davis and Scholl 1974). The ability to analyze and predict sediment yields is difficult because of a limited sediment data base and because of the variability in precipitation amounts, intensities and frequencies (Baker and Brown 1974).

An increase in water yield may also result in stream channel morphology changes. Under prolonged increased flow, channel erosion may accelerate until the system conforms to the new level of activity (Hibbert, Davis and Scholl 1974). Stream channeling will also contribute to a deterioration in water quality and sedimentation in downstream lakes and reservoirs.

Flooding

The possibility of flooding may also be affected by vegetation modification. To the extent that vegetation reduces rapid flow of water into stream channels due to infiltration and percolation through the soil, removal of vegetation will change both the quantity and timing of runoff and stream flow (Sopper 1971). The potential for flooding may increase if watershed manipulation is carried out over a large area.

Storage Facilities

Because water supply increases from vegetation modification are greatest in wet years when flows are already high and because those increases are available during the high flows of spring and early

summer, storage facilities are necessary to capture this water. If these facilities are not available or are inadequate, water yield increases may be lost.

In the Salt-Verde system, sufficient water storage is present on the Salt River. However, it is likely that any additional water on the Verde would be lost due to inadequate storage space; this is particularly possible in a wet year.

Storage and Transmission Losses

Losses associated with transmission and storage have not been adequately accounted for in assessing the amount of water which would be made available by vegetation modification. The watershed of origin is usually located some distance from the area where augmented water is finally used. Transmission and storage losses between the point of production and the point of ultimate use will decrease the total expected increase in water supplies.

For example, in a low-yielding watershed, where winter runoff does not normally recharge the alluvial aquifers each year, an increased flow must first satisfy deficits along the stream course before downstream yield can increase significantly (Hibbert and Ingebo 1971). If a significant proportion of the increased yield is evaporated, transpired, or lost by deep seepage before it can be beneficially used downstream, treatment benefits will be lessened accordingly (Thorud 1974).

Quantification of Increase in Water Yield

There is also difficulty in quantifying the actual magnitude of runoff increase from vegetation modification. The amount of expected increase is directly proportional to the amount of normal streamflow. Because of variation in annual precipitation, there can be considerable differences in streamflow from year to year. In a year of less than normal precipitation, the expected increase in runoff will be much less than in a year of normal precipitation. The inability to predict the magnitude of increase is also a result of variation in edaphic, physiographic, and hydrologic factors between watersheds.

Use of statistical analysis or of simulation techniques to prove the amount and availability of augmented water supplies has been proposed as a way of quantifying increased yields (Fischer 1976). However, each of these techniques has drawbacks.

Statistical analysis cannot "prove" the amount of water, but at best only show the incidence of probability. The validity of the probability of the result is dependent entirely upon the validity of the assumed hypotheses (Fischer 1976). As a result, predictions through statistical analysis may not be adequate to establish the amount of the additional flow.

A simulation or modeling approach attempts to imitate the natural system by using symbols, usually mathematical in form. To predict increases in water yield, the model must be adapted to a given area, verified and modified. A problem with the use of models for this purpose is that data is seldom available for site specific calibration

or validation (Ponce and Meriman 1983). This might limit augmentation activities to areas where adequate historical data already exist. Otherwise collection of additional local data would be required to calibrate system models so that they can perform at an acceptable level.

It is important to recognize that present margins of possible error in quantification may be so large and the amount of water that can be confidently claimed so small, that development of an augmentation program may be uneconomical.

Future Vegetation Modification Activities

In Arizona, the greatest potential for water yield increases from vegetation modification is found in mixed conifer forests, ponderosa pine forests and chaparral. Of the total area encompassed by these vegetation types, a percentage has been eliminated from further consideration because of physical and management constraints recognized by past assessments.

Additional acreage can be eliminated from consideration for the purpose of this analysis for the following reasons. First, a large portion of each of the three vegetation types is located on Indian land. These lands and the current and potential water supplies within reservation boundaries are not subject to state regulation or the state system of water allocation. Consequently, the legal change in Arizona's water allocation system proposed by this thesis would not apply to the allocation of Indian water. Second, land within the watershed boundaries of the main stem of the Colorado River can also be eliminated for purposes of this discussion. Any additional water yield from this

watershed would be subject to the compacts and treaties which govern the allocation of Colorado River water. Third, those areas with water improvement potential which are located at a great distance from the point of water use can also be eliminated. Transmission losses might be so large as to make the amount of increased flow at the point of use negligible. In addition, transportation costs involved in delivering increased flows when there is no natural conduit to the area of water demand might be prohibitive.

The remaining land with potential for successful vegetation modification is located in the Central Highlands and the eastern mountain areas of the state. This area includes the watersheds of the Gila and Salt-Verde Rivers. Because additional water in the Gila River would be used primarily for agriculture and because of the relatively low value of this use, it is unlikely that a vegetation modification program would be carried out in this watershed, at least at this time.

Therefore, the Salt and Verde River watersheds are the most likely site for a vegetation modification program. The location of these watersheds is shown in Figure 2. This area has significant water yield improvement potential, is upstream from an area of growing water demand for industrial and municipal purposes, and also contains water storage facilities for capturing increased flow generated by modification activities.

The area of each vegetation type in the Salt and Verde watersheds and the administering agencies are shown in Table 3. Because the federal government is responsible for approximately 96 percent of

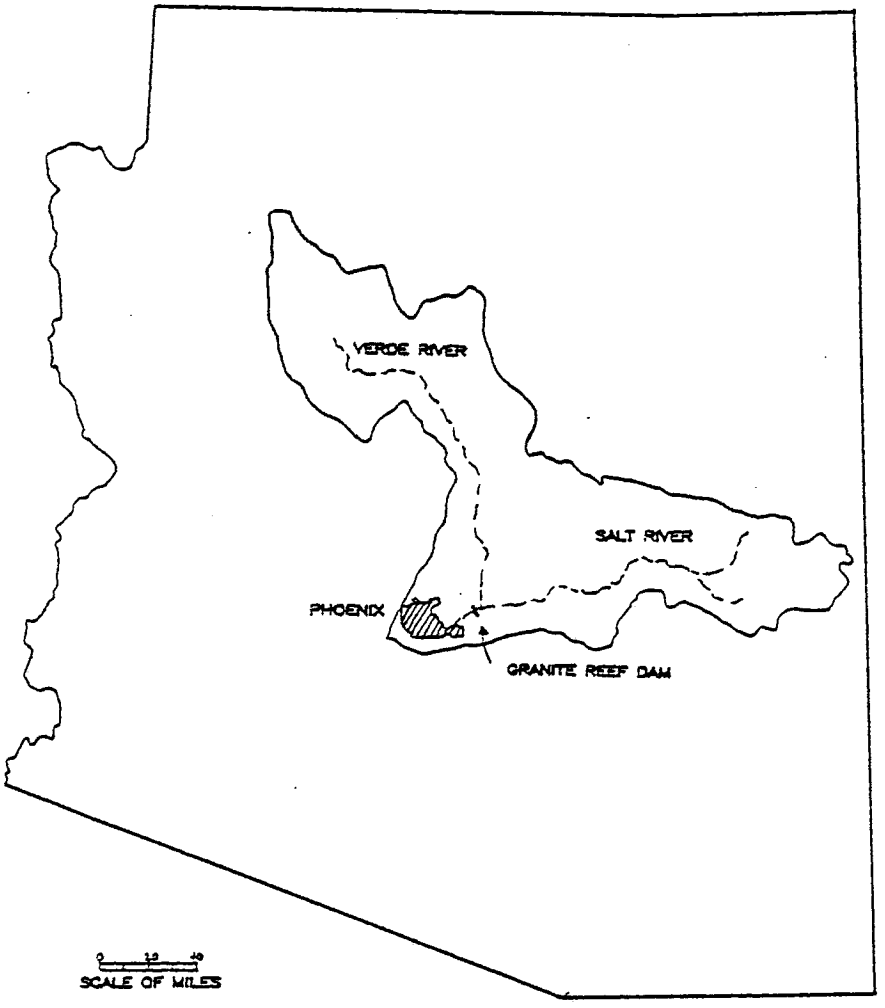

FIGURE 2. SALT AND VERDE RIVER WATERSHED

Table 3. Area of vegetation types on the Salt and Verde watersheds (after Barr 1956).

Administering Agency	Chaparral (acres)	Ponderosa Pine (acres)	Mixed Conifer (acres)	Total
USDA Forest Service	1,993,700	970,100	80,900	73%
Indian Reservations	317,400	600,500	46,600	23%
Other Federal[1]	600	24,000		1%
Private and State	109,200	1,200		3%

[1] National Park Service and Bureau of Land Management.

the land in the three vegetation types, it is safe to conclude that the federal government, through the Forest Service, would be involved in a watershed modification program in this area.

CHAPTER 3

LEGAL-INSTITUTIONAL SETTING

The following chapter provides an overview of statutory law in Arizona concerning water allocation and water rights. Although water produced by vegetation modification would be treated as surface water, the law governing ground water use is also discussed as it will affect future augmentation programs.

Arizona judicial opinions which might be relevant in establishing a legal claim to developed water are discussed. Because the Forest Service is likely to be involved with any large-scale vegetation modification in Arizona, relevant policies and laws which guide national forest planning and management are presented.

Several developments will affect future water supplies, water allocation and water use in Arizona; these are also discussed in this Chapter. They include the Central Arizona Project and attendant water storage facilities, the adjudication of surface water rights in the Gila River system, and the possible settlement of Indian water claims.

State Water Code

The doctrine of prior appropriation developed in response to the arid environment of the West. It is designed to protect a water user's interest in a scarce supply by establishing a priority of right based on the appropriation date. Should a shortage occur, older appropriators

have the prior and superior right to the exclusion of junior appropriators.

The right to appropriate water was affirmed by the first legislature of the Territory of Arizona in 1864 through the Bill of Rights in the Howell Code. Here it was declared that all streams, lakes, and ponds of water capable of being used for navigation or irrigation were public property and the right to appropriate them exclusively to private use, except under legislative regulation, was denied (Terr. Ariz. Bill of Rights, Art. 22, 1864).

Persons who appropriate such public waters acquire a vested property right in their use, not in the water itself. This usufructary right is limited to a beneficial use. Beneficial use is the "basis, the measure and limit to the use of water" (Ariz. Const., Art. 17, Sec. 2). In 1974, beneficial use was defined by statute to "include, but is not limited to, use for domestic, municipal, recreation, wildlife, including fish, agriculture, mining, stock watering and power purposes" (ARS 45-180).

Waters subject to appropriation in Arizona now include ". . . 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 surplus water. . ." (ARS 45-131).

A surface water right is appurtenant or attached to the land to which the water rights were originally granted. In some instances, the transfer of a water right without loss of priority is allowed, but subject to certain limitations and conditions.

The exclusive method of acquiring an appropriation right is through application to the Arizona Department of Water Resources (DWR) for a permit. If the proposed use of the water is beneficial, is in keeping with the public interest and safety and does not interfere with existing rights, a Certificate of Water Right is issued to the applicant.

Rights to the use of surface water have also been established by court law through decrees rendered during the settlement of specific disputes. These decrees may place certain additional limitations on the allocation of developed water. For instance, the Groundwater Study Commission estimated that the Upper Gila watershed would yield 10,000-15,000 acre feet per year through vegetation modification, but due to the provisions of the Gila Decree only half of this would be available for use in the Pinal Active Management Area (Briggs 1981).

Ground Water Law

The 1980 Groundwater Management Act gave the Department of Water Resources (DWR) significant power to manage ground water. The Act initially established four Active Management Areas (AMA's) which generally correspond to ground water basins where the overdraft has been most severe.

The Act establishes a management goal of "safe-yield" by January 1, 2025, or sooner. Safe yield is defined by the Act as a "management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of ground water withdrawn. . . and the amount of natural and artificial recnarge" (ARS 45-561,5).

In order to achieve this goal, ground water management plans will be written every ten years. In each successive management period, conservation requirements are to become as stringent as necessary in order to attain safe yield.

Each management plan will contain a mandatory conservation program for all ground water users. Agricultural users in an AMA will receive a "water duty" limiting pumping to the minimum necessary for crops historically grown in the area. Mines and other industries will be required to use the best conservation technology available. Per capita consumption reductions will be required of municipal users.

New development in areas where the developer cannot show an assured water supply is effectively prohibited. An assured supply means a sufficient ground or surface water supply of adequate quality to satisfy the proposed use for at least 100 years. Unless the DWR finds that an assured water supply exists, the State Real Estate Department may not approve the property report nor may the local governing body approve a subdivision plat. Anyone offering subdivided land for sale within the service area of cities, towns and private water companies with assured supplies is exempt from applying for a certificate.

If a city, town or private water company has received an allocation for Central Arizona Project water, the service area and extensions of the service area are deemed to have an assured supply until December 31, 2000 (45-576). Thereafter, the determination is subject to review by the Director of the DWR.

As cities attempt to meet this requirement, more attention may be given to vegetation modification as an alternative source of water, particularly in the Phoenix and Prescott AMA's where the potential exists for increasing water yields.

The Arizona Groundwater Management Act also requires that the second management plan, to be promulgated in 1988, include a program for water supply augmentation (45-565). The Act provides for augmentation of all water supplies, not just ground water.

The Act allows the imposition of a ground water withdrawal fee of up to two dollars per acre foot for the water supply augmentation program (45-611). The fee may be levied after a vegetation modification program has been developed and implemented as part of the AMA management plan. Money collected under this taxing program will be held in a separate fund intended solely for augmentation efforts (Briggs 1981).

The Arizona Groundwater Management Study Commission recognized that existing water law presents problems regarding ownership, classification and distribution of augmented waters (Arizona Groundwater Management Study Commission 1979). However, these uncertainties have not been resolved by the Groundwater Management Act.

Uncertainties of Existing Water Law

Some uncertainty exists as to how an application to use water produced by vegetation modification would be handled by the present allocation system. Several interpretations of Arizona law could be applied to this situation.

The water resulting from vegetation modification could be treated as public water subject to appropriation only after the rights of senior appropriators had been satisfied. However, water which is a consequence of vegetation manipulation physically conforms to a very specific definition of surface water that was given by the Arizona Court of Appeals. Diffused surface waters were defined as:

> . . . those waters which flow on the land from the skies or arise in springs and diffuse themselves over the surface of the ground, following no defined course or channel and are lost by being diffused over the ground through percolation, evaporation, or natural drainage and the essential characteristics of surface water are that their flows are shortlived and that the waters are spread over the ground and are not concentrated or confined in bodies of water conforming to the definition of lakes or ponds. Espil Sheep Co. v. Black Bill and Doney Parks Waters Users Ass'n, 16 Ariz. App. 201, 492 P.2d 450 (1972).

In Espil Sheep Co., the plaintiff allegedly appropriated the right to use "surface waters". The definition given by the court for surface water had been established in two previous cases; S. Pacific Co. v. Proebstel. 61 Ariz. 412, 150 P.2d 81 (1944), and Kirkpatrick v. Butler, 14 Ariz. App. 377, 483 P.2d 790 (1971). The court decided that ARS 45-131 does not provide for appropriation of diffused surface water and as such they are not appropriable.

A legislative classification of water "subject to an availability to appropriation" acts as a limit on rights to so acquire water not classified for such purposes, Bristor v. Cheatham, 75 Ariz. 227, 222 P.2d 173 (1953). The assumption might therefore be made that water resulting from augmentation activities forms an exception to the Court's definition of diffused surface water, requiring either a

legislative determination that it is appropriable or a finding that the nature of its origin requires a separate legal classification. Such a special classification is not found in the Arizona statutes.

Arizona courts have determined rights to water which would have been lost from beneficial use had it not been for the effort of an individual claiming the right to use such water. In Santa Cruz Reservoir Co. v. Rameriz, the Arizona Court of Appeals, in modifying a decree of a lower court, declared that by applying means to save water that would otherwise be lost to current transportation methods, the defendant company could acquire the right to use that water. The defendant has a right "to conserve, if it can, such waters, and apply them to beneficial use", 16 Ariz. 64,70-71, P.2d 120 (1914).

A 1966 opinion of the Arizona Court of Appeals took a somewhat different approach to the question of conserved water. In Salt River Valley Users' Association v. Kovacovich, the court held that water saving procedures inure to the benefit of other water users and not to those who institute the savings, 411 P.2d 201 (1966). In this case, Kovacovich saved water by lining his irrigation ditches to reduce loss through seepage. He then cultivated an additional 40 acres of land not previously irrigated, but adjacent to the 35 acres of land for which he held a valid water right. In the process, he used no more water for the total acreage than was previously used on the original 35 acres.

The court found that the doctrine of beneficial use precludes the transfer of appropriated water "gained by water conservation practices to lands other than those to which the water was originally

appurtenant" 411 P.2d 201 (1933). The court recognized the water right as a right to irrigate land, not a right to divert a quantity of water. Kovacovich pertained to artificial water courses and may have no application to the interpretation of water rights stemming from improving watershed yields.

Under surface water law, actual molecules of water made available by vegetation modification, that are present on the watershed, would be classified as diffused surface water which is not subject to appropriation. Once these molecules of water become part of a stream system, they are subject to the "call of the river" and would be used to fill the demands of appropriators whose needs are not met by the existing supply. Only after these vested rights are satisfied, could one obtain a right to use the additional supplies.

USDA Forest Service

The Forest Service will be instrumental to the development of a vegetation modification program in Arizona, including the Salt and Verde watershed. A large portion of the land in these watersheds is managed by the Forest Service. The agency has been involved in almost all of the work that has been done to date in vegetation modification in Arizona and has an ongoing interest in these activities.

The importance of watershed protection and management was recognized by the Organic Act of 1897 which stipulated as follows: "No national forest shall be established, except to improve and protect the forest within the boundaries, or for the purpose of securing favorable conditions of water flows, and to furnish a continuous supply of timber

for the use and necessities of citizens of the United States. . ." 16 U.S.C. 475 (1964). The Forest Service Manual describes the goals of watershed management as follows: "The objective is to plan for the management of the National Forest System watershed for optimum water for National Forest purposes and downstream water uses in accordance with the principles of multiple use and sustained yield" (U.S.D.A. Forest Service 1981a). The basic charter of the Forest Service is the Multiple Use-Sustained Yield Act of 1969 which directs the Secretary of Agriculture to manage the national forests for multiple use and sustained yield of several resources including outdoor recreation, range, timber, watershed, wildlife and fish.

The National Forest Management Act of 1976 also contains important provisions affirming and strengthening the policies of multiple use and sustained yield (16 U.S.C.A. 1600 et seq., Supp. 1977). Management plans developed under this Act must "insure consideration of the economic and environmental aspects of various systems of renewable resource management, including the related systems of silviculture and protection of forest resources" (1604 g.3 A).

The Forest Service is required to comply with provisions of the National Environmental Policy Act (NEPA) of 1969 in managing the national forest system. The Act requires federal agencies to analyze and evaluate environmental factors relevant to all decisions and to prepare a detailed statement for major federal actions which significantly affect the environment.

These policies are important tools for balancing long-range interests and noneconomic values against pressure for immediate development which could irreversibly injure the forest resources (Hahn, Post and White 1978).

The Forest Service maintains that the United States

> has retained the power to reserve from future appropriation under State law the unappropriated nonnavigable waters on the public domain, as well as the power to utilize them itself and to provide for their utilization by others. The reservation of the unappropriated rights to use the waters on public lands results from the withdrawal or reservation of such lands for a particular Federal purpose. . . (U.S.D.A. Forest Service 1981b).

The extent of federal reserved rights may have been limited to the original purposes for which the reservation was made. In the Supreme Court decision in United States v. New Mexico, the court stated that "(w)here water is only valuable for a secondary use of the reservation, . . . there arises the. . . inference that Congress intended. . . that the United States would acquire water in the same manner as any other public or private appropriator".

The Forest Service maintains a policy of "caution and reasonableness in its deliberate use of water" and "shall endeavor to work cooperatively with the states" (U.S.D.A. Forest Service 1981b). In fact, the Forest Service tries to quantify and inform the state of its existing and future water uses. Allocation of water and water rights outside these uses is the function of the state regulatory agency.

Present and projected water needs on Forest Service lands are very small when compared to potential water yield from such land. The primary reason the Forest Service might claim additional water which

results from vegetation modification is to establish ownership for resale to other users. Revenues from the sale of augmented water would accrue to the Forest Service for purposes of financing the modification program.

Appropriation and use of water originating on public lands has not been subject to user fees and charges. Nonetheless, fees have been charged which either reflect the opportunity cost of water projects or are otherwise related to use of water (Public Land Law Review Commission 1969). For example, charges for construction and maintenance of reclamation projects are assessed on an acreage basis in order to recover projects costs.

Central Arizona Project

In 1968, the Colorado River Basin Project Act (P.L. 90-537) authorized the Central Arizona Project (CAP) the conveyance and storage facilities necessary to deliver Arizona's entitlement of Colorado River water. This water will be used primarily to supplement existing water supplies and reduce ground water pumping.

Deliveries to the Phoenix area are scheduled to begin in 1985. Pinal County will receive water by 1986 and Pima County in 1991. Northern Arizona communities, including Indian tribes located along the Salt and Verde Rivers, have been tentatively granted a share of CAP water.

Allocations of CAP water to water users in the Verde and Salt watersheds will probably be effectuated through exchange agreements with

downstream water rights holders, such as the Salt River Project. For instance, Verde Valley users would take more water from the valley and would pay a proportionate compensation for CAP water to be brought into the Salt River Valley.

The Colorado River Basin Project Act also required that Arizona designate one official agency with which the Secretary of the Interior could contract for repayment of CAP construction and delivery costs. This agency, in turn, could enter into contracts with the ultimate users. The Central Arizona Water Conservation District (CAWCD) was formed in 1971 to act as the central contracting entity and to guarantee the repayment of reimbursable CAP costs (ARS 45-2610 et seq.). The agency's powers were expanded in 1981 to include operation and maintenance of the CAP facilities.

The Central Arizona Water Control Study (CAWCS) was initiated in July, 1978, by the Bureau of Reclamation in cooperation with the U.S. Army Corps of Engineers. The purpose of this study, carried out under the Regulatory Storage Division of the CAP, was to aid in identifying alternative plans providing both flood control for the Salt and Gila Rivers and regulatory storage for the CAP. Concurrent with the CAWCS, the Bureau had been conducting a study of Safety of Dams (SOD) on the Salt and Verde Rivers. Consequently, the Bureau of Reclamation widened the focus on the CAWCS to include SOD as a major objective.

In April, 1984, the Secretary of the Interior approved "Plan 6" as the preferred alternative plan. Plan 6 includes a New Waddell Dam to replace the existing Waddell Dam on the Agua Fria River for regulatory

storage purposes and incidental flood control. Stewart Mountain Dam on the Salt River would be modified or replaced for SOD only. A new or enlarged Roosevelt Dam would be constructed on the Salt River, and Cliff Dam would be constructed on the Verde River between the existing Horseshoe and Bartlett Dams. Both new dams would provide flood control, additional water conservation and improved safety. Cliff Dam was the only component of Plan 6 which was not approved by the Secretary of the Interior, but was instead recommended for six months of additional study.

Although the final allocation plan for CAP has not been published by the Secretary of the Interior, municipal and industrial users are tentatively expected to receive 640,000 acre feet of the total 1,298,000 acre feet per year, with Phoenix receiving approximately 120,000 acre feet (Clark 1983). Twelve Indian tribes or communities have been allocated 310,000 acre feet per year for irrigation or for maintaining tribal homelands. The remaining water would be available for use by 23 irrigation districts or farming operations. However, in the case of allocations for non-Indian agriculture, irrigators must reduce their ground water pumping by the amount of project water they receive.

Central Arizona Project water will have an impact on regional development trends. Places receiving CAP water allocations also will receive a certificate of assured water supply from the Arizona Department of Water Resources. New urban development will generally take place in areas where there is an assured water supply. Areas that

are dependent on ground water and do not receive CAP allocations may experience limited development.

The Central Arizona Project is also important because CAP storage facilities provided for in Plan 6 will provide additional surface water in the Salt-Verde system. Under Plan 6, CAP yield would be increased by 137,000 acre feet per year through regulatory storage at New Waddell on the Agua Fria River, by dual use of the sediment pool at Roosevelt Dam, and by new conservation space at Cliff Dam (Bureau of Reclamation 1983). If these facilities are constructed, water in excess of what could reasonably be provided by vegetation modification in the Salt and Verde watersheds would become available. However, it is also possible that Plan 6 will render vegetation modification more feasible by capturing the additional streamflow.

Gila River Adjudication

Water rights in the Gila River drainage system, from the New Mexico state line to the Colorado River, are now in the process of adjudication. An adjudication is a court determination of the status of all rights to use water from a river system and source. The court will determine the extent and priority of all appropriative water rights and all water claims based on federal law.

The Department of Water Resources (DWR) assists the court by notifying all property owners in the watershed and by tabulating, mapping, investigating and verifying the statement-of-claimant forms once they are submitted. The Department also investigates water supplies and compares them to amounts claimed. Once the DWR submits its

report to the superior court, a special master is appointed to take testimony and submit his findings to a judge who has been appointed by the State Supreme Court (DWR 1981).

Shortly after basin-wide adjudications were initiated in state court by non-Indian water users, Indian communities and the United States on behalf of the Indians filed actions in federal court requesting adjudication of water rights. The tribes were asking for removal of state adjudications to federal court and for declaratory and injunctive relief preventing any further adjudication of their rights in state court. They were also requesting independent federal determinations of their water rights. This suit was dismissed by the district court in favor of state adjudications pursuant to the McCarran Amendment, which waives the sovereign immunity of the United States in comprehensive state water right adjudications.

On appeal, the Ninth Circuit Court of Appeals in February, 1982, overruled the holding of the district court. The basis for the Ninth Circuit's decision was that Arizona was a "disclaimer" state and that disclaimer removed from the state's jurisdiction the adjudication of Indian water rights. The Court of Appeals held that the Enabling Act under which Arizona was admitted to statehood (36 Stat. 557, 1910) and the Arizona Constitution (Art. 20, 94) disabled Arizona from adjudicating Indian water claims. The case was remanded to the district court to determine whether Arizona nevertheless "properly asserted jurisdiction pursuant to Public Law 280" (668 F.2d at 1098, sec. 668 F.2d at 1102).

The Supreme Court granted certiorari to hear the San Carlos case. Certiorari is a discretionary writ from a higher court to a lower one requesting the record of a case for review. The fundamental issue decided by the Supreme Court on July 1, 1983, related to the jurisdiction of state courts to adjudicate Indian water rights, Arizona et al. v. San Carlos Apache Tribe of Arizona et al., 103 S.Ct. 3201. The 6 to 3 majority decision in San Carlos held that the disclaimer provision in Arizona's enabling act did not prohibit Arizona from adjudicating Indian water rights. The Court also held that if comprehensive, state-wide adjudications were underway the process may be an acceptable forum for determining Indian water rights.

The Arizona Department of Water Resources is now proceeding with its adjudication efforts. This action is significant to water management in Arizona primarily for two reasons. First, Indian water claims, which are discussed in the following section, will be included in the adjudication. Establishing Indian water rights will facilitate long-range water planning by eliminating the uncertainty of these demands. Second, the problem of incomplete, uncertain or inaccurate descriptions of water rights will also be remedied by the administrative function carried out by DWR as an agent of the court. Once the identity, location, purpose, priority, place of use and quantity are determined, water administration and planning will become more efficient. It could also facilitate the development of a water market and more efficient water transfers or exchanges.

Indian Water Rights

Although Indians living on reservations in Arizona represent less than 6 percent of the State's population, Indian reservations encompass over 27 percent of the Arizona's land (Arizona Water Commission 1977). Allocation of future water supplies could change considerably as a result of quantifying Indian Winters Doctrine rights and aboriginal rights.

The Winters Doctrine, so called because of its origin in the Supreme Court case, Winters v. United States, affirms the power of the federal government to reserve sufficient waters to satisfy purposes for which the lands were reserved, 207 U.S. 564 (1908). In contrast to aboriginal rights, which are based on established prior uses, Winters rights are measured by the potential for water use on the reservation.

Since Winters, other court decisions have established the nature of the reserved water right. It is a private right which cannot be lost by nonuse nor by legal action, and which is held in trust by the United States for the benefit of the Indians. The right is not dependent upon application of water to beneficial use. Winters rights date to the creation of the reservation and are for an unspecified quantity of water sufficient to supply present and future needs of the Indians.

In the Case of Arizona v. California, the Supreme Court established the measure of reserved rights for five tribes located along the lower Colorado River as the amount of water necessary to irrigate the "practicably irrigable acres" on the reservation, 373 U.S. 546 (1963). The Court said, "the Master's choice or irrigable acreage as a

measure was based on the conclusion that it provided an estimation of the amount eventually needed to make the otherwise arid lands productive. The Indians' actual use of the water remains unrestricted. Practicable irrigable acreage, then, is a rough measuring stick, a tool toward an informed equitable estimate of the Indians' needs, both present and future." This standard of quantification is not appropriate for all reservations but constituted the law for the reservation under consideration.

Quantification of Indian reserved water rights in the Salt and Verde River watersheds could have a considerable effect on current water users in the area since most land in these watersheds is encompassed by Indian reservations or is under Forest Service management. Both the Salt River Community and the Fort McDowell Reservation claim federal reserved rights to water in addition to that now supplied by ground water pumping and SRP. If Indian claims to additional water are satisfied even in part, water could be transferred from existing non-Indian users or new sources of supply would have to be developed.

At hearings held by the U.S. Senate Select Committee on Indian Affairs, Arizona's position regarding Indian water claims was set forth by Wesley E. Steiner, executive director of the Arizona Water Commission:

> . . . the rights of the Salt River and Fort McDowell Reservations to waters of the Salt and Verde River were established in the case of Abbot v. Hurley - the Kent Decree - in a general adjudication of water rights in the lower reaches of those two rivers.
>
> It is our belief that the Kent and Gila decrees recognized the Winters doctrine and constitute an adjudication

> of the surface water rights of the Salt River, Fort Mcdowell, and Gila Indian Reservations to the waters of the Salt, Verde and Gila Rivers (Steiner 1975).

With regards to rights to ground water Steiner said:

> Certainly it was not the intent in the formation of any of the five central Arizona reservations to reserve more water than could be diverted from local streams to support an agricultural economy. There was no knowledge of the ground water resource and hence they did not figure in either the intent or in the reservation of water (Steiner 1975).

Steiner also stated that the reserved rights of the Indians were limited ". . . to the supplies that could be developed, transported, and applied economically at the time that the reservations were formed".

Claims of the Indians greatly exceed limits suggested by Steiner. However, because of the physical limit to the availability of both surface and ground water in central Arizona, it is unlikely that the Indians will receive the entire additional amount which they claim.

Summary and Conclusions

Under ground water law, the Department of Water Resources has the authority to both implement and finance an augmentation program. However, the law does not specify who, if anyone, has the right to use waters produced by such a program.

Under surface water law, actual molecules of water present on the watershed and made available by vegetation modification, would be classified as diffused surface water not subject to appropriation. Once these molecules of water become part of a stream system, they are subject to the "call of the river" and would be used to fill demands of appropriators whose needs are not met by the existing supply. Only

after these vested rights are satisfied, could one obtain a right to use additional supplies.

There is now no classification in Arizona statutes applying to water obtained from an augmentation program that would allow a developer first claim to water resulting from his efforts. Where the efforts of an individual were recognized by an Arizona court, that same individual was not given the right to use the water which had been saved. As a result, there is little legal incentive for a developer to undertake a program which will increase the water supply.

There are water yield improvement opportunities which have yet to be realized in Arizona. It has been shown that a possible constraint to their realization is the lack of a legal basis for acquiring a right to use the increment of flow produced by watershed modification, free from the claims of prior appropriators.

With this description of the existing legal and institutional system and future changes in water development, allocation and use, the following conclusions are made regarding future vegetation modification activities.

Water yield improvement through vegetation manipulation appears more feasible because of incentives provided by the Groundwater Management Act. The 100 year assured supply requirement will encourage consideration of alternative water supplies by cities and towns located in Active Management Areas. The pump tax for augmentation programs could provide a mechanism for financing a vegetation modification program.

Water storage facilities of Plan 6, the regulatory storage component of the Central Arizona Project, will render vegetation modification more or less feasible depending on who is allocated rights to new storage space in reservoirs on the Salt and Verde Rivers. It will also depend on how these reservoirs will be operated once the facilities are in place. Both of these uncertainties have yet to be resolved.

The Gila River adjudication will improve feasibility of vegetation modification for two reasons. First, the administrative function of the Department of Water Resources in the adjudication process will establish the nature and extent of existing rights relative to the amount of water in the system. This baseline information will be important to establishing a claim to new water and to proving that vested rights are not being infringed upon.

The adjudication will also be important in terms of the quantification of Indian reserved rights. If the Special Master recognizes Indian claims to additional water and these claims are not met by transferring water from existing uses or some form of compensation, then new sources of water will have to be developed. Vegetation modification is one method which might be considered.

CHAPTER 4

THE SALT-VERDE SYSTEM

The Salt and Verde River watersheds are the most likely areas for a future vegetation manipulation program because of their potential for water yield improvement. Increasing demand for water in the downstream Phoenix area, and the presence of storage facilities on the Salt and Verde Rivers are also factors suggesting these watersheds as possible augmentation sites. However, water in this system is not allocated strictly by state surface water law but is governed by the Kent Decree as well as various contracts and agreements between the Salt River Project and other water users.

Allocation, management and use of water in the Salt-Verde system is described in this chapter. In addition, population and growth projections are summarized; future water demand will help determine the feasibility of a vegetation modification program.

Physical Setting

The Salt and Verde Rivers, and their tributaries, are the principal stream systems found in the Central Highlands Province of Arizona. This geologic area is the source of approximately 50 percent of all streamflow originating in the state. The Salt and Verde Rivers provide about 93 percent of the developed surface supply in the Salt River Basin (Arizona Water Commission 1978).

The watershed of the Salt River above Granite Reef Dam is 6,249 square miles and consists of the White and Black River drainages. There are 6,649 square miles in the Verde River drainage area above Granite Reef Dam.

The largest landowner in both watersheds is the federal government. Through activities of the Forest Service, and as trustee for the Indian tribes, the government manages approximately 93 percent of the land (Barr 1956).

Above Granite Reef Dam the Salt River watershed primarily includes portions of the San Carlos Indian Reservation, the Fort Apache Indian Reservation and the Apache and Tonto National Forests. The Verde River watershed contains portions of the Tonto, Coconino and Prescott National Forests, the Salt River Pima-Maricopa Indian Reservation, and all of the Fort McDowell Indian Reservation.

There are six reservoirs in the Salt-Verde system: Bartlett and Horseshoe on the Verde, and Stewart Mountain, Mormon Flat, Horse Mesa and Roosevelt on the Salt. The reservoirs were designed to store water for use when needed on Salt River Project lands. The combined storage of these reservoirs is 2,061,000 acre feet (Arizona Water Commission 1978).

Below Bartlett Dam, water is diverted for use by the City of Phoenix and the Fort McDowell Indian Reservation. The remainder is diverted 27 miles downstream at Granite Reef Dam on the Salt River for agricultural, municipal and industrial use. The total dependable supply

diverted from the Salt and Verde Rivers is estimated to be 860,000 acre feet (Arizona Water Commission 1978).

Verde Valley Water Use

In the Verde Valley, surface water is used primarily for recreation and irrigation, but use is limited in the area due to downstream water rights (Department of Water Resources 1983). About 12,500 acres in the valley are now irrigated, including 7,781 acres on level areas near Camp Verde and the Verde River (NACOG 1979). The amount of surface water used for irrigation is estimated to be 31,000 acre feet per year (Department of Water Resources 1983).

Ground water is presently the principal source of domestic and public supplies. Annual draft on the system is estimated to be 8,000 acre feet per year with less than ten percent used for irrigation (Department of Water Resources 1983). The ground water system still represents equilibrium conditions.

Upper Salt River Valley Water Use

Municipal and industrial water needs of the Salt River watershed are met by ground water; the town of McNary is an exception because it diverts surface water from the North Fork of the White River. Surface water is diverted for irrigation of approximately 4,000 acres from the White River, Carrizo Creek near Show Low, Cibecue Creek near Chrysotile and the Salt River (USGS 1983).

Downstream Water Use

Water use in the Salt and Verde watersheds is small relative to water use in the downstream Phoenix metropolitan area and surrounding irrigation districts. This area has developed as an industrial and distribution center for the Southwest. Services, retail trade, manufacturing and government were the most important employment sectors in Maricopa County in 1982 (Maricopa County Dept. of Planning 1983).

Although agriculture is not a significant employer in the area, it is important in terms of the income it generates. In 1980, agriculture ranked eighth as an income source for county residents. Crops and livestock contribute almost equally to total agriculture income. Over 750 square miles of the county are devoted to farming and ranching; more than 60 percent of this land is located just outside the Phoenix metropolitan area. Major crops grown are cotton, alfalfa, hay, grains, vegetables and citrus. Although the amount of agricultural land has been decreasing, crops and livestock still account for the largest share of water use in the county (Maricopa County Dept. of Planning 1983).

Ground water is the largest water source in Maricopa County, accounting for 70 percent of all use. The Salt-Verde system supplies 93 percent of the surface water with the remaining 7 percent coming from Phoenix's "gatewater" account and reservoirs located on the Agua Fria and Gila Rivers.

Salt River Project

The Salt River Project (SRP), the first multipurpose project constructed under the Reclamation Act of 1902, is a nonprofit organization incorporating the Salt River Valley Water Users' Association and the Salt River Project Agricultural Improvement and Power District. The District is a political subdivision of the State of Arizona and operates the Project's electric facilities which supply residential, commercial, industrial and agricultural power users. Parts of Maricopa, Gila and Pinal counties are included in the District's 2,900 square mile service area. In the year ending April 30, 1983, 11.5 percent of the power distributed by the District came from hydroelectric facilities located at each of the four Salt River dams. Other sources of power are coal and gas.

The Salt River Valley Water Users' Association is a nonprofit Arizona corporation responsible for administration of shareholders' water rights. In this capacity, it maintains a high level of interest in Forest Service management of the 13,000 square mile Salt and Verde watersheds (Warskow 1983). As agent for the District, the Association operates and maintains the irrigation transmission and distribution system which provides water for agricultural, industrial and municipal uses in the Project's 250,000 acre area. Project lands lie on both sides of the Salt River to the north and east of its confluence with the Gila.

The SRP delivers water primarily to agricultural, municipal and industrial users within Project boundaries, but because of a number of

contracts and agreements, it also delivers water to non-member land both within and outside the Project area. A discussion of these users and the nature and extent of their water rights follows.

Project Deliveries to Member Lands

At the present time, approximately 41 percent of land within Project boundaries is in agricultural production (Salt River Project 1983). Deliveries to agriculture, both on and off Project land, account for 60 percent of the present water demand (Jetton 1983). This share will continue to decrease as urban development increases.

Agricultural land is being converted at the rate of 4,000 to 7,000 acres a year (Salt River Project 1982). When land use changes from agriculture to municipal or industrial uses, the city of jurisdiction usually assumes payment of the SRP assessment. Then the city, acting as an agent for the landowner, receives, treats and delivers the lands' share of water. Municipalities under domestic contract with SRP to receive Project irrigation water are Phoenix, Mesa, Glendale, Tempe, Scottsdale, Chandler, Gilbert and Peoria. In addition, water is delivered for urban irrigation, which includes parks, schools, churches and residential water.

Three classes of water are delivered to Project land: normal flow water, stored water, and developed water. The principle of normal flow rights was established by Judge Edward Kent; this decree was handed down in 1910 and adjudicated surface water rights in the Salt River valley.

The Kent Decree determined water rights dating from 1869 to 1909 for about 4,800 early irrigators. Judge Kent followed the doctrine of prior appropriation in determining rights to the normal river flow and storage waters from Roosevelt Dam. Three classifications of land were designated. Land which had been in continuous cultivation since its first irrigation (referred to as Class A land) was decreed a right to unregulated Salt and Verde River flows. Relative distribution of the normal flow between water right holders was based on the appropriation date. Class B land is that which had been in discontinuous production. Land not cultivated as of 1909 and located in areas served by the canal system was referred to as Class C. In addition, the Kent Decree increased the amount of water to which Salt River Indian Reservation Indians were entitled and also recognized rights of the Fort McDowell Indian Reservation. Water rights of upper Verde River lands and pumpage of ground water in the Salt River Valley were not covered by this Decree.

Normal flow refers to river water at its varying stages, minus any storage facilities. Only land continuously cultivated since its first irrigation between 1869 and 1909 was decreed normal flow rights. The amount of water available for use on a specific piece of land depends on the quantity in the river and the priority of appropriation, as specified in the Kent decree.

Unused normal flow and surplus water stored by reservoirs on the Salt and Verde Rivers constitute the second class of water. Stored water is available to Project landowners on an equal basis, upon payment

of an annual assessment fee. Each acre of land is entitled to two acre feet per acre and an equal share of any "excess" water. The amount of excess water available is determined prior to each irrigation season by the SRP Board of Governors.

Developed water refers to ground water supplied by SRP wells. This is the most expensive class of water delivered by the Project and can be acquired, if and when needed, by landowners who have purchased a pump water right. Pump water rights were offered for sale by the Project to all its landowners in 1929 and again in 1948. Although these rights are appurtenant to all lands within the Project, only those landowners who are shareholders in the cooperative pump program are entitled to delivery. Since 1977, there has been a moratorium on new lands joining.

Private wells on Project land are also used by some farmers to provide supplemental ground water as needed. The SRP is not now supplying, nor has it ever supplied, the full agricultural requirement of farm lands within its boundaries. The dependable supply of surface water for use on lands within SRP boundaries is slightly more than two acre feet per acre (Salt River Project 1982). The farmer must either pump his own supplemental water or have SRP pump it for him.

Approximately one-third of total Project water deliveries over the past 40 years, about 350,000 acre feet per year, has been ground water. The greatest pumping occurs in the summer months when surface flow is low and demand is greatest.

Project Deliveries to Non-Member Lands

Delivery of water to land outside of SRP boundaries is made to the Salt River Indian Reservation, the City of Phoenix and to several irrigation districts. Salt River Indians were given priority rights over all normal flow rights by the Kent Decree. This right is for 17,660 acre feet per year. They are also entitled to 20 percent of water stored in Bartlett and Horseshoe Reservoirs on the Verde River according to an agreement between the Project and the federal government.

The City of Phoenix receives Project water for use on non-member and off-project lands. These water rights were acquired through construction of spillway gates on Horseshoe Dam in 1949. Although actual space created by addition of these gates can store only 75,000 acre feet of water, the City can gain credits of up to 150,000 acre feet at a time on this gatewater account.

When the water level in the Verde system is such that Indian and SRP storage rights have been satisfied, Phoenix gains credit in its account for any water added. As an additional 75,000 acre feet of credit physically accumulate in the Salt system they are subject to loss from spillage.

The Roosevelt Water Conservation District has an appropriative right to 5.6 percent of all agricultural water diverted at Granite Reef Dam. The District acquired this contractual right as a result of lining irrigation canals to reduce water loss from seepage.

The Buckeye Irrigation District, located southwest of Phoenix, has surface flow rights to the Gila and Salt Rivers which amount to 1.1 percent of all water diverted at Granite Reef Dam. This water is delivered by SRP because Project pumping in the 1920's lowered ground water levels to the point that surface flow disappeared.

The Roosevelt Irrigation District, through an agreement with SRP, has a contract right to pump up to 155,000 acre feet of ground water per year from the west side of Project lands. The District is a strip bordered by the Agua Fria River to the east and the Hassayampa River to the west.

Two small irrigation districts, St. John's and Peninsular-Horowitz, are located within boundaries of the SRP. Both receive pump water through the Project delivery system in lieu of an appropriative surface water right.

Other Project Agreements

Horseshoe Dam was built in 1946 by the Phelps Dodge Corporation in conjunction with the Salt River Valley Water Users' Association and the federal government through the U.S. Defense Corporation. In exchange for water stored at Horseshoe, Phelps Dodge received a one-time credit of 250,000 acre feet to be diverted from the Black River to Eagle Creek at the eastern edge of the Salt River drainage. The water is used in copper production at Morenci.

Phelps Dodge replaces water in the Salt system by pumping water from Show Low Lake into the Salt River by way of its tributaries. In addition, water is diverted into the East Verde River from Blue Ridge

Reservoir. Phelps Dodge currently has 171,478 acre feet remaining of their original allotment (Chase 1981).

Project Operating Rules

The Project storage system consists of six Bureau of Reclamation reservoirs. Bartlett and Horseshoe Dam are on the Verde River, while Horse Mesa, Mormon Flat, Stewart Mountain and .cp3 Roosevelt Dam are on the Salt River. Granite Reef Dam lies below the confluence of the Salt and Verde.

The system is operated to optimize hydroelectric production and minimize ground water pumping. In the spring, the Verde system is lowered to a predetermined quantity to be certain of sufficient storage capacity for spring runoff. Demands from storage facilities on the Salt River are then made for both electricity generation and water supplies during the summer months.

The Indians have first priority to reservoir storage capacity on the Verde River. After Indian storage has been satisfied, water is stored in the Verde system for use by the Salt River Project. Additional storage on the Verde side is credited to the City of Phoenix. Water for Phoenix, the Roosevelt Water Conservation District and Phelps Dodge Corporation spills first when the reservoir system on the Salt has reached its capacity.

When the decision must be made to waste this water, the Project will make available any that can be put to beneficial use. This waste water is offered free of charge to all Project landowners.

Population and Growth Projections

Demand for additional land and water will continue to increase both in the Salt and Verde Valleys and in downstream areas. Population growth in the upper Verde watershed is occurring mostly in the Verde Valley and is closely associated with growing interest in this area as a retirement location (Dept. of Water Resources 1983). Land use is changing as farms and ranches are subdivided. Because availability of surface water is limited due to downstream water rights, development of additional water supplies will eventually depend on ground water and deliveries of Colorado River water through the Central Arizona Project.

Long-range population projections for the major population centers in the Verde Valley are shown in Table 4. Based on these estimates, the population in the Upper Verde Valley will more than double in the next 50 years.

The water supply and demand situation is similar in the Salt River watershed. Population projections for major centers in this watershed are also shown in Table 4. Projections indicate that the number of people living in the Salt drainage area will more than double in the next 50 years. Development of additional water supplies will depend on ground water (now the major source of municipal and industrial supplies), and on deliveries of Colorado River water.

The greatest increase in demand for land and water will occur in the Phoenix metropolitan area. Phoenix, the nation's ninth largest city, had a population of 800,000 in 1980 (Chase 1983). In 1982,

Table 4. Population projections for selected Arizona cities, towns and Indian communities (after U.S.D.I. Bureau of Reclamation 1982).

Upper Verde Valley Communities	Population Projections[1] 1985	2034
Camp Verde	4,620	13,550
Clarkdale		5,950
Cottonwood Water Co.	4,925	17,385
Jerome		965
Pine-Payson	8,095	30,355
Prescott	21,120	49,515
Salt River Valley Communities		
Globe	8,785	25,000
Miami-Claypool	7,310	11,960
Indian Communities[2]		
Camp Verde	650	1,580
Ft. McDowell	442	854
Gila River	10,538	17,390
Salt River	3,472	5,424
Tonto Apache (Payson)	69	77
Yavapai (Prescott)	82	137

[1] Projection for 2034 based on revised estimates from Bill Twoler, NACOG.

[2] Allocation is for irrigation on the Salt River Reservation. All other allocations are for tribal homeland purposes.

Maricopa County had an estimated population of 1.6 million people (Maricopa Dept. of Planning 1983).

The County's population is expected to reach 2.6 million by the year 2000 as a result of continued immigration induced by both the climate and growth-related employment opportunities. In the ten year period preceding 1982, urban development resulted in conversion of 123 square miles of agricultural land. Conversion of an additional 210 square miles is expected between now and the year 2000; 95 percent will probably occur on agricultural land (Maricopa Dept. of Planning 1983).

The Salt River Project area is being urbanized at the rate of 4,000 to 7,000 acres a year. The SRP predicts that by 2000, approximately 90 percent of its area will be urbanized; in 2034 all of its land will be urbanized (SRP 1982).

As this process continues, water demand by agriculture will decrease while demand by municipal and industrial users will increase. Predicted components of water demand and the source of the expected supply is illustrated in Figure 3.

Development which occurs outside Project boundaries or on non-member lands within the boundaries, must obtain water for additional development from municipal or private water companies. Potential supplies include CAP water, effluent reuse, conservation of existing supplies or development of new sources. Ground water could also be acquired by purchasing grandfathered irrigation rights and retiring the agricultural land.

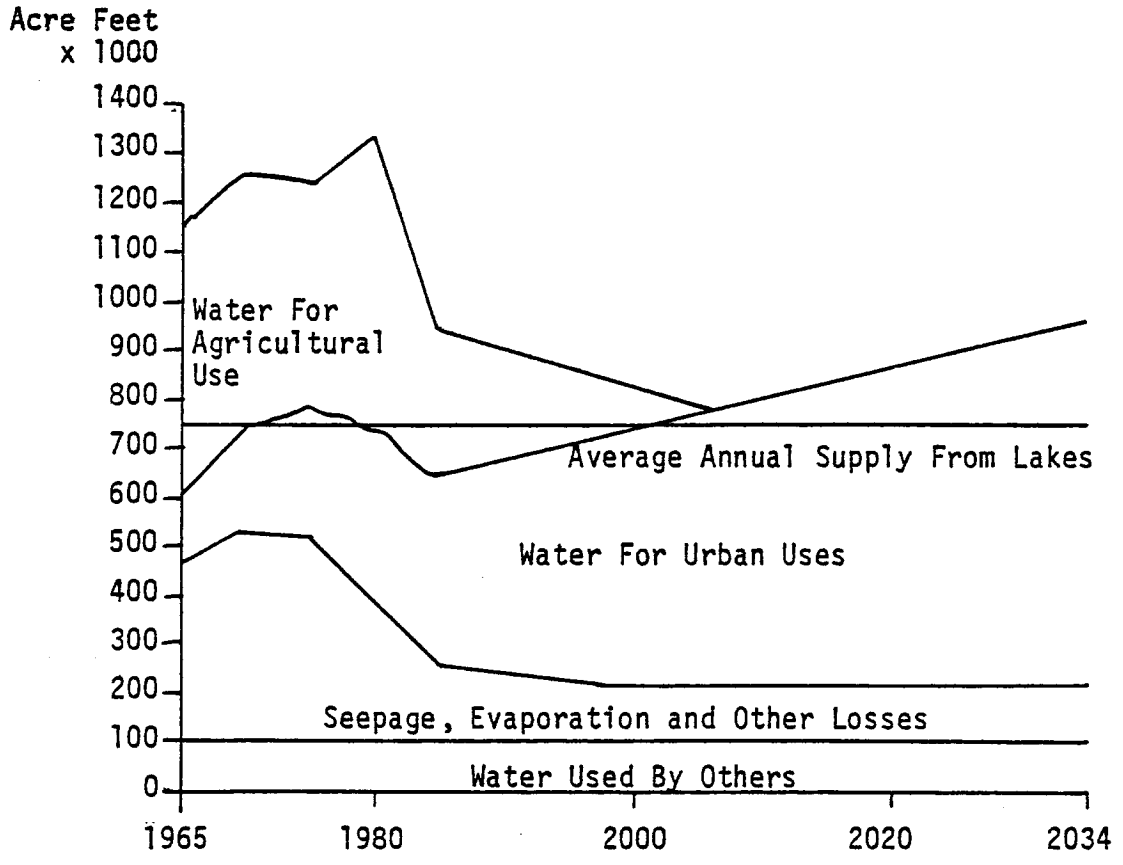

Figure 3. Components of Salt River Project Water Demand

(Source: Salt River Project 1982)

Projections of water demand for the Phoenix water system range from 350,000 acre feet per year to 500,000 acre feet per year by 2035. These figures more than double the 1980 water demand (Chase 1983).

Conclusions

Allocation of water from the Salt-Verde system is determined by a complicated set of laws, contracts and agreements which must be considered in any claim to water developed by vegetation modification. Population and water demand in the downstream Phoenix metropolitan area are expected to increase. This may necessitate consideration of vegetation modification as one method for augmenting the existing water supply.

CHAPTER 5

ANALYSIS OF A CLASS OF DEVELOPED WATER

This chapter contains a two-part evaluation of a class of developed water. The class would be Arizona's response for resolving legal uncertainty associated with a developer claiming first use of water produced by vegetation modification. This proposal will first be evaluated by six general criteria identified in 1) the statutory and case law of appropriation doctrine states, 2) literature discussing the legal and institutional problems of augmentation and 3) literature dealing with water administration and management.

The proposed change will then be examined in the context of how the developed water would be allocated and distributed by the Salt-Verde system. The Salt and Verde watersheds are the most likely area for implementation of a vegetation modification program; in the near future it is possibly the only place that such an activity might be carried out. Therefore, it is important that the proposed change be appropriate and workable.

Discussion of Criteria

Criterion 1

Does the proposed change stimulate augmentation activities?

Given the certainty of an increase in water demand, particularly in the Phoenix metropolitan area, it is imperative that use of existing

supplies be maximized and that the development of new supply sources be encouraged.

The previous discussion of Arizona water law has shown that opportunities to increase supplies may be foregone when the supply source does not fall within the bounds of existing legal definitions. Private individuals or organizations who cannot derive a direct benefit from their activity will not undertake a vegetation modification program; the investment is too high unless legal and institutional assurances of ownership are provided.

A special classification would legally separate the developed water from those waters now subject to appropriation. The developer would be entitled to claim the water, free from the claims of existing appropriators. This would remove the legal uncertainty and would provide some incentive to those considering a vegetation modification program.

Criterion 2

Does the proposal protect existing surface water rights?

A system of certain and secure water rights is necessary in order to promote and protect investments. Existing state water laws and procedures have been designed to protect and preserve water rights obtained and exercised pursuant to those laws.

Once a pattern of use has been established in a river basin and the waters are fully appropriated along the stream, as is the case in the Gila River system, any change in location or use may alter the quantity of supply available to other users. Any change in the water

administration and allocation system must recognize the doctrine of prior appropriation and provide a means of protecting prior rights.

Those using water under prior rights will want solid assurance that their water is not being appropriated. Unless they have assurance that their prior rights will not be infringed upon by those claiming rights to use "new" water, there is bound to be opposition to any policy or program which recognizes the new claims. This assurance would require tnat the individual applying for the right to the new increment could establish that the water claimed is not part of the natural source of supply and can be delivered on a sustained basis to the satisfaction of the courts.

No accepted standard of proof has yet been established nor are there any guidelines as to what would constitute "adequate" proof. Statistical analysis and simulation techniques that prove the amount and availability of augmented water supplies have been proposed as alternatives for quantifying increased yields (Fischer 1976). These methods are discussed on page 31.

If judicial notice of specific methods of proof were taken, then it would only be necessary to show that a specific statistical method is appropriate and that it demonstrates the magnitude of the claim (Danielson, Sherk and Grant 1976). This notice would resolve some of the possible restrictions identified on the use of these techniques.

Criterion 3

Does the proposal make sense in terms of the hydrologic cycle? Law and hydrology differ fundamentally in the way that they characterize the hydrologic system. Science recognizes the unity of the system but distinguishes phases of water, such as surface, atmospheric and ground, for purposes of classification and study. The law in Arizona does not recognize the interrelationship of different phases of the hydrologic cycle but treats each as a distinct category with specific rules for each concerning ownership and use.

An important consideration for any modification of the existing allocation system would be whether the proposed change makes sense in terms of the physical relationships and processes of the natural world. Does it provide a scientific basis for the decision-making process or only add to the complexity and confusion of the current legal allocation system?

A new classification would contribute to the legal system's artificial categories which do not account for the interrelationship of all phases of the hydrologic cycle. However, opportunities to develop water are foregone when the source of supply does not fall within the bounds of existing legal definitions.

In order to sustain a claim to the developed water, the claimant must establish that there is new water available. Establishing proof will require some kind of analysis and interpretation of the hydrologic system pertinent to the vegetation modification project. In this

regard, consideration would be given to the project's effect on the hydrologic environment.

Criterion 4

Does the proposal make sense in terms of overall water management objectives? Water management involves water rights administration, water quality control, flood control, erosion and sedimentation control and ground water management, in addition to water supply development. Any change in tne way water is developed, allocated or used should consider how these other water management objectives will be affected. Moreover, the development of new water supplies should proceed only after the range of available alternatives for increasing water supplies has been considered and compared.

The Department of Water Resources would be responsible for approval and administration of a "developed" water right. In order to insure that there are no conflicts with other water management objectives (eg. an increase in the potential for downstream flooding), the Department would also need to regulate vegetation modification activities. And, to insure that other augmentation strategies are not being overlooked, the Department should also be involved in a vegetation modification program by planning for the overall development of water supplies. Only in this way could the other objectives of water management be integrated into the development of a vegetation modification program.

Criterion 5

Does the proposal make sense in terms of the management of other watershed resources?

What is done with water will have some impact on what can be done with the land. More importantly, what is done with the land has a significant impact on what happens to our water. Because of the interrelationship of physical processes, management objectives for different resources cannot be considered in an isolated and piecemeal fashion. Water management should fit into the use of other natural resources in a logical and integrated manner.

The National Water Commission (NWC) has recommended that water and land use planning be coordinated (NWC 1973). Similarly, the United Nations Water Conference recommended that countries should "ensure that land and water are managed in an integrated manner" (National Water Commisssion 1973).

Intelligent decisions cannot be made on watershed management techniques unless the environmental ramifications are carefully considered. And unless there is a method for evaluating and modifying the environmental impacts of an augmentation program, public interest in other resource values will not be adequately protected.

No process at the state level now exists for evaluating and modifying the management of private land for various resource values. Although past recommendations on management of Arizona's resources have suggested that all resources and activities which affect them should be

considered as they relate to and have impact on one another", no such mechanism to achieve this now exists (Arizona Academy 1970).

However, most land suitable for vegetation modification is under federal management. Most of the suitable non-Indian land is managed by the Forest Service. Since the early 1970's, the Forest Service has been developing a planning system which seeks to coordinate use of the various resource systems (Hahn, Post and White 1978).

Criterion 6

Is the proposal administratively feasible?

If the proposed change is to be effective, it must be possible to implement and administer. This requires that the implementing agency, the Arizona Department of Water Resources (DWR), have the necessary authority, the operational capability and the fiscal resources to administer tne rights to developed water.

The proposed change would require enactment of legislation which would specify a definition of developed water and a procedure for acquiring a right to use that water. This legislation would also designate the DWR as the implementing authority.

In its capacity as the primary state water management institution in Arizona, the DWR has the institutional capability, the required expertise and an existing mechanism for evaluating and administering a right to developed water. Therefore, a new legal classification for claiming augmented supplies would not require any significant structural change.

General Analysis

A class of developed water would meet most of the general criteria that have been mentioned. It provides a basis for establishing a legal claim to use water produced by vegetation modification. All other considerations aside, this legal assurance would provide incentive for those interested in undertaking a vegetation modification project.

The water claimant would be required to provide assurances that there is additional water in the system as a result of watershed modification activities. In this way, vested water rights would be recognized and protected.

The Arizona Department of Water Resources (DWR) would be involved in the administration of claims and rights in developed water. To the extent that DWR is already involved in water planning and management, any proposed augmentation program could be evaluated within the context of overall water management objectives.

Most of the non-Indian land suitable for water yield improvement is under Forest Service jurisdiction and must be managed in accordance with the principle of multiple use. Because it is unlikely that a vegetation modification program would be initiated without some Forest Service participation, management objectives of other watershed resources would be considered when planning and implementing an augmentation program.

The Department of Water Resources is now responsible for approving applications toward a surface water right. If a new legal class of water were established, the process by which it would be

obtained need not differ from the procedure now used for acquiring an appropriative right. A claimant would be required to prove 1) there was new water in the system, 2) the amount of that additional water and 3) that vested rights would not be injured by the diversion and use of the new flow.

The Department already has the administrative capability to evaluate, and approve or deny an application for developed water. Therefore the proposal is administratively feasible.

The primary criticism of the proposal is that it is an artificial category which does recognize hydrologic reality. However, scientific evidence would be used in providing acceptable proof of augmented flow. Consequently, the physical system would be taken into account when approving or rejecting a water right application.

Analysis of the Salt-Verde System

The following analysis of the Salt and Verde system is based on an unpublished study completed for the Rocky Mountain Forest and Range Experiment Station by the School of Renewable Natural Resources at the University of Arizona. The purpose of this study was to determine what would be the physical and legal outcome of any additional runoff produced by vegetation modification in tne Verde River watershed and allocated by existing legal and institutional arrangements and operating rules of the Salt-Verde system.

Study Description

Using the Verde River watershed as a site for analysis, the Forest Service assumed that to obtain the maximum level of runoff increase, 457,000 acres of ponderosa pine forest and 51,126 acres of chaparral in the Coconino, Kaibab and Prescott National Forests would be treated. Treatment of the ponderosa pine involves intensive thinning. Approximately 60 percent of the treatable chaparral acres would be converted to grasses and forbs.

The streamflow of the Verde River was simulated using a first-order Markov model based on historical flow data. The assumption was made that none of the additional flow from vegetation modification is lost in transit from the watershed to the point of inflow to the reservoir system on the Verde River. The flows were routed through the Salt River Project reservoir system according to current reservoir management rules. Reservoir operation was simulated using a modified version of the Bureau of Reclamation's SRP SIM model. This model simulates the interdependent operation of the reservoir system on the Salt and Verde Rivers and ground water pumping by the Project.

The expected values for the allocation of additional water in the system are based on 100 ten year runs of simulated data. Multiple runs were made to account for the stochastic nature of stream flow. A ten year time period was used to account for the effect of storage facilities on water use. In years when there is more water supply than demand, the excess can be carried over into the next year or until that time when inflow is not adequate to meet water demand.

Two levels of increase in additional flow are discussed. The first assumes maximum treatment of the identified treatment acreage in the Verde watershed which will produce an increase of 369,500 acre feet in a ten year period. The second level of increase is 10 percent of the maximum or 37,000 acre feet for a ten year period. Because of political, economic and environmental constraints, the 10 percent level of increase is probably the most feasible alternative.

Study Results

Table 5 illustrates allocation of the hypothetical additional streamflow under existing legal and institutional arrangements. The numbers represent acre feet per ten year periods at two levels of additional flow. Values are tabulated in the following categories:

1. Total inflow credits assigned to the Phoenix gatewater account and the Salt River Project.

2. Water losses due to seepage and evaporation assigned to the Phoenix gatewater account and the Salt River Project.

3. Water spills at Granite Reef Dam. This category includes water which is physically lost from use in the Phoenix metropolitan area and "free" water which is offered to SRP members.

4. Water spills on the Salt side which are debited to the Phoenix gatewater account.

5. The net credit to the Salt River Project which is their total inflow credit minus losses.

Table 5. Allocation of the hypothetical additional flow resulting from vegetation modification in the Verde River watershed under existing legal and institutional arrangements, reservoir storage capacities and operating rules; numbers are in acre feet for a ten year time period (data from Forest Service study in progress).

Assigned To:	Maximum Additional Streamflow	Percent of Total	10 Percent of Maximum	Percent of Total
Total Inflow Credits				
Salt River Project	115,800		12,000	
Phoenix Gatewater Account	39.300		4,400	
Losses and Spills				
Spills at Granite Reef Dam	229,000	62	23,300	63
Salt River Project Losses	9,900	3	1,400	4
Phoenix Losses	4,600	1	500	1
Gatewater Spilled	17,400		1,800	
Net Inflow Credits				
Salt River Project[1]	105,900	29	10,600	29
Phoenix Gatewater Account[2]	17,300	5	2,100	6
Indians	-	-	100	<1
Total Additional Flow	369,500	100	37,000	104

[1] Difference between the total SRP inflow credits minus SRP losses.

[2] Total gatewater account credits minus Phoenix losses and gatewater spilled.

6. The net credit to the Phoenix gatewater account which is their total credit minus losses minus gatewater spills.

7. The net credit to the Indians.

A portion of the additional flow has been counted twice, once with the total inflow credit to the Phoenix gatewater account and once in the total inflow credit to the Salt River Project. This water is subsequently spilled and debited to the Phoenix gatewater account. Because they are still counted with SRP's net credits, gatewater spills are not included when summing volumes or percentages.

At the 10 percent level of increase there is a slight discrepancy between the sum of the individual allocations and the total additional inflow. This is because the numbers represent average expected values which are the midpoint for a range of values. The allocation can actually vary in either direction from the midpoint.

Spills at Granite Reef Dam. At both levels of additional flow, approximately 63 percent will be lost as spills at Granite Reef Dam. Some of the spilled streamflow will be lost to use in the Phoenix metropolitan area but may be used farther downstream. The remaining portion is offered as "free" water by the Salt River Project and is available when the inflow to the system is in excess of the total storage capacity.

The water spilled at Granite Reef Dam comes from both the Salt and Verde Rivers. Water from the Verde is spilled when inflow exceeds the storage capacity of Bartlett and Horseshoe Reservoirs. The Salt River Project has calculated the yearly average for spills from the

Verde system using data from 1889 through 1979. The average yearly spill is 203,590 acre feet, approximately 41 percent of the average yearly streamflow. Spills from the Verde River account for 51 percent of the average yearly spills at Granite Reef Dam for the entire system. The amount of inflow to the Verde system and the volume of releases will affect what happens on the Salt side.

Salt River Project Allocation. The Salt River Project (SRP) would receive 29 percent of the additional flow at both levels of hypothetical additional streamflow after evaporation and seepage losses have been deducted. At the maximum level, SRP is allocated 105,900 acre feet per ten year period, which is approximately one percent of their pre-increase surface water allocation. In a ten year period, at the level of 10 percent of maximum increase, SRP will receive less than one percent of their pre-increase allocation.

This water would be available to all Project members and might be used for agricultural irrigation, municipal and industrial purposes or urban irrigation. The proportion of total demand of each sector in 1982 was 62 percent agriculture, 26 percent municipal and industrial and 12 percent urban irrigation, which includes water for parks, playgrounds, homes, schools and churches (Salt River Project 1982).

By the year 2000, agriculture's share is predicted to decline to 14 percent. Municipal and industrial demand will increase to 72 percent and urban irrigation demand will increase to 14 percent. Estimates of the relative and total demand for SRP member lands are shown in Figure 3, page 72.

Ground water is more expensive than surface water ($27 for an acre foot as compared to $7.50 an acre foot for surface water, 1982 figures). Therefore SRP would probably use the additional surface water to offset ground water pumping. Additional incentive to reduce ground water pumping will be provided by conservation requirements of the Groundwater Management Act.

Allocations to the Phoenix Gatewater Account. At both levels of additional flow, the net gatewater account credit is approximately 6 percent of the total additional flow. The net credit to the gatewater account is the total Phoenix inflow credit minus losses due to evaporation and seepage minus gatewater spills. Phoenix gatewater is the first water to be spilled on the Salt side when reservoir inflow exceeds storage capacity. In a ten year period, at the maximum level of increase, Phoenix will receive 17,300 acre feet, which is about 7 percent of their pre-increase net gatewater credits. At 10 percent of the maximum level of increased flow, Phoenix will be credited for a net flow of 2,100 acre feet per ten year period, or less than one percent of their pre-increase credits.

The City of Phoenix does not consider gatewater a reliable source of water for planning purposes because the amount available depends on extremely variable rainfall and limited storage space. As a result, this additional water would probably be used to offset ground water pumping rather than to supply new demands.

Other Allocations. The Indians' right to normal water flow in the Verde system is the prior right nd therefore the first right to be

satisfied. The Indians' right to developed water is also the first to be satisfied in the system, but it is a limited right. With the maximum level of additional flow, they will receive none of the additional water. At the 10 percent level of additional flow, they will receive 100 acre feet per ten year period.

Other water users who might benefit from an increase in the water supply of the SRP reservoir system are the Roosevelt Water Conservation District and the Buckeye Irrigation District. These districts would receive small amounts of additional water since their allocation is based on a percent of the amount of water diverted at Granite Reef Dam. The allocation for Buckeye is 1.1 percent of all water diverted and the allocation for Roosevelt is 5.6 percent of all agricultural water diverted.

Analysis

The greatest production of runoff will occur in wet years. In addition, because runoff resulting from vegetation modification activities would occur mostly in spring and early summer, storage facilities must be available so that runoff can be stored for use later in the year or in subsequent dry years. Results of the Forest Service study indicate that additional storage capacity would be necessary in the Salt-Verde system in order to capture most of the additional streamflow.

In average years, under the existing reservoir management and allocation system, the largest share of the water produced by manipulation of the Verde River watershed would be lost as spills at

Granite Reef Dam. In high streamflow years, the percent of additional flow which is spilled will increase because both the total streamflow and the added increment of flow from vegetation modification are greater. In low flow years, any of the additional water will probably not spill because the volume of total streamflow will be less and the additional increment of flow will be less than in an average year.

Under the existing arrangements, primary recipients of the unspilled additional flow would be the Salt River Project and the City of Phoenix. The amount of water credited to the Phoenix gatewater account depends on the level of water in the reservoirs; credits can accumulate for up to 150,000 acre feet at any one time. Because there is no fixed yearly limit to their allocation and because they are the last user of the Verde reservoir system to be satisfied, the City would have interest in any additional water from the watershed. In addition, water demand in Phoenix is steadily increasing. For these reasons, the City would probably oppose a claim by another developer to any additional water from the Verde watershed.

The Salt River Project (SRP) would have an interest in the additional flow because it would allow them to reduce ground water pumping. This is important in terms of economics; surface water is cheaper to supply than ground water. In addition, the Project will eventually be required to reduce ground water pumping as the conservation requirements of the Groundwater Management Act are implemented through plans of the Phoenix Active Management Area.

The Salt River Project also has an interest in the management of the Salt and Verde watersneds, in the management of its water storage and power facilities, and in the administration and protection of Project water rights. It would be impossible for any other developer to establish a valid claim to an augmented water supply without their cooperation.

A new legal class of water would provide little additional incentive for the development of additional flow in these watersheds. This is because Phoenix and SRP, as the water users with the greatest interest in existing and future water supplies, would also be the prime beneficiaries under the existing account crediting system.

Conclusion

Additional legal and institutional considerations strongly influence analysis of vegetation modification in the Verde watershed. The existing water allocation and management structure would seriously challenge a claim to water developed by someone other than Phoenix or the Salt River Project; only the City and SRP have enough assurance of benefit to be considered as potential project sponsors. The loss of the greatest portion of the additional flow because of inadequate storage presents an economic constraint. Other constraints to vegetation modification will place additional limitations on the feasibility of a large scale program. Among those constraints are the effect of vegetation modification on other resources and water quality, the potential for increased downstream flooding and the difficulty of quantifying the increase in streamflow. For these reasons, a new legal

class of water would not be an adequate or an appropriate response to generating interest in vegetation modification in the Salt and Verde watersheds.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

To efficiently meet future water needs, water management institutions must have the flexibility to develop and secure the most appropriate uses of available water supplies. This development must lie within economic, environmental, equity and public choice constraints. This thesis determines if a new legal class of developed water that assures developers of a water claim would be necessary or effective in stimulating vegetation modification programs.

Summary and Conclusions

In Chapter 1, a legal classification of developed water was proposed to resolve the uncertainty of establishing a claim to water produced by vegetation modification. Increasing water demand, the limit to existing water supplies and the Groundwater Management Act requirement of an assured supply for all new development in the Active Management Areas will require examination of alternative forms of supply augmentation.

In the second chapter, techniques used to modify vegetative cover and their effect on watershed resources were characterized. Mixed conifer forests, ponderosa pine forests and chaparral are the cover types with the greatest potential for water yield improvement. Although there are some areas of non-federal lands on which vegetation

modification measures could be applied effectively, the majority of the more productive water yielding areas are public lands, including those of the Forest Service. The Forest Service has been extensively involved in vegetation modification research and has an ongoing interest in these activities.

Although opportunities exist for vegetation modification in the Gila River watershed, it is unlikely that a water yield improvement program will be implemented there, at least in the near future. This is because the primary use of water from the Gila is agricultural, a relatively low-value use. The Salt and Verde River watersheds are the most likely areas for a future vegetation manipulation program because of their potential for water yield improvement, the increasing demand for additional water in the downstream Phoenix area and the presence of water storage facilities on the Salt and Verde Rivers. However, the facilities are not adequate for capturing and storing significant increases in streamflow. Approximately 73 percent of the land in the Salt and Verde watersheds is managed by the Forest Service.

A considerable amount of experimental work has been done in Arizona and elsewhere with vegetation modification, but uncertainties must still be resolved before a full-scale program can be implemented. These include multiple-use considerations which will limit vegetation modification on public land, water quality effects, water losses associated with transmission and storage, the potential for increased flooding in downstream areas and quantification of additional runoff.

The general legal and institutional setting in Arizona was outlined in Chapter 3. The Groundwater Management Act gives the Department of Water Resources the authority to both implement and finance an augmentation program but does not specify who has the right to use the new water supply. Arizona statutory law now provides for the appropriation and use of surface water only after prior appropriators have been satisfied. Arizona court decisions have not recognized the right of a developer to first use of the water produced by the developer's efforts. The policy reasons for our surface water law system seem inappropriate in determining who gets the right to augmented streamflow.

The Central Arizona Project, the Gila River adjudication, and quantificantion of Indian water rights were discussed as future changes which would affect water development, allocation and use in Arizona. Plan 6, the regulatory storage component of the Central Arizona Project may or may not improve the feasibility of a vegetation modification program. The additional storage capacity would capture increased flow from vegetation modification which otherwise would spill out of the existing system on the Salt and Verde Rivers. On the other hand, the planned storage capacity in this river system might supply enough additional water so that "creating" additional flow through vegetation modification would neither be necessary or economically feasible. Botn the adjudication process and quantification of Indian water rights may render vegetation modification more feasible by clarifying the nature

and extent of existing rights; depending on the scale of Indian allocations, more demand may be generated for additional water supplies.

In Chapter 4 the management, allocation and use of water in the Salt-Verde system was considered. Water in this system has been allocated by court decree, and by contracts and agreements between the Salt River Project and other water users in the Phoenix area. The Project is responsible for the storage and distribution system which controls this water. The Project also has an interest in Forest Service management of the Salt and Verde River watersheds. Allocation of the water in the Verde system is based on account crediting which depends on the level of water in the reservoir system at any particular time. The peculiarities of water allocation and management for the entire system would create substantial barriers for new developers establishing a claim to water.

The potential change considered in this research is a class of developed water recognized by Arizona law. This class was evaluated in Chapter 5 in terms of six general criteria. The proposal would, as a general proposition, increase incentive for those undertaking a vegetation modification program by providing the basis for a legal claim to the new water free from the claims of existing appropriators. Vested water rights would be protected under the proposal because the developer would be required to prove the existence of additional streamflow.

As the administering agency of the proposed change, as well as the State's principal water resources planning agency, the Department of Water Resources could explore the utility of a vegetation modification

program in light of overall water management objectives. As the principal landowner, the Forest Service will inevitably be involved in any significant future augmentation activities. The effect of an augmentation program on other watershed resources must be taken into consideration in National Forest planning and mangement activities under federal law. If the Forest Service were to carry out a vegetation modification program, the agency would be required to consider the consequences of their activities not only on National Forest lands but also on all other affected communities and interests.

A primary criticism of the proposal is that it ignores the continuous nature of the hydrologic cycle by establishing an artificial category for water. The body of law governing other aspects of water management shares this shortcoming.

The proposed change was found to be an inappropriate response to vegetation manipulation in the Salt and Verde watersheds, which is the most promising area for vegetation modification in Arizona. In a year of average streamflow under the existing water allocation and mangement system, the largest share of the additional water would be spilled at Granite Reef Dam because of insufficient storage capacity. This spillage has consequent effects on economic feasibility.

Additional constraints to vegetation modification also limit the feasibility of a full-scale program. These include the effect on other watershed resources and water quality, the potential for increased downstream flooding and the difficulty of quantifying the amount of increase. Because the proposed change is inadequate and inappropriate

for the Salt-Verde system and because water yield opportunities are limited elsewhere, the State of Arizona should not establish a new classification for water developed by vegetation modification.

Recommendations

Based on the opportunities and constraints to vegetation modification at this time, a fundamental change in the water allocation system is not warranted. However, water management institutions should still seek to facilitate rather than discourage the development of potential new water supplies. Land managers should be encouraged to incorporate the principles of water yield enhancement in ongoing land management activities such as timber harvests, fire suppression and grazing management.

As the Active Management Areas attempt to meet the Groundwater Management goal of safe yield for ground water supplies, vegetation modification will again come under consideration. Beginning in the second management period, the AMA's are required to include in their management plans a program for water supply augmentation. Policy changes which might facilitate vegetation modification programs may be prudently deferred until it can be determined how such a program would fit into overall water augmentation and management schemes.

In the meantime, those AMA's for which vegetation modification might become a feasible augmentation strategy should work toward understanding the Forest Service multiple use planning and management system. The constraints this system will place on the location and extent of potential water yield improvement activities should also be

understood. Research which deals with the economics of vegetation modification and the tradeoffs with other resource values should be continued.

A final suggestion is that the State continue to study the integration of surface, ground and effluent water use and management. Water derived from vegetation modification and other augmentation activities might then be considered within this framework; a determination of the right of use could be bargained out in specific situations rather than through legal doctrines.

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