Research Technical Completion Report

GROUND WATER MANAGEMENT UNDER THE APPROPRIATION DOCTRINE

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ABSTRACT

The purpose of this research is to better understand the characteristics of ground water management under the prior appropriation doctrine in the western United States. The general objective is to summarize the legal and administrative controls on ground water use in eight western states and to compare the impacts of these controls on ground water systems.

The history of ground water management in the states of Montana, Utah, Oregon, Washington, Idaho, Colorado, New Mexico and Arizona suggests a temporal development pattern of management stages. Different management stages may be identified depending on whether the state considers the resource as renewable or nonrenewable. For a renewable resource, the stages are: 1) initial development, 2) local impacts of development, 3) regional impacts of development and 4) controlled use. For a nonrenewable resource, only two stages may be identified: 1) initial development and 2) controlled mining. Ground water management in most states is based on consideration of ground water as a renewable resource. Arizona is the only example of the controlled use stage of management of ground water as a renewable resource. Areas in New Mexico plus nontributary and designated areas in Colorado are characterized by controlled mining of ground water. Management activities become increasingly complex and restrictive as ground water development proceeds, regardless of whether the resource is considered renewable or nonrenewable.

State water management agencies often do not utilize fully the statutory powers which are available. Difficulty is encountered in applying the priority principal to controlling ground water pumpage because of the storage or stock aspects of the resource. Most states have

developed management area programs to identify areas of ground water overuse and to reduce pumpage. However, in practice, the states have universally utilized the designations to limit the development of ground water by preventing new appropriations rather than achieving the statutory goals of a recharge-discharge balance and maintenance of reasonable and economically feasible pumping lifts.

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Statement of the Problem

Ground water management problems result from conflicts between resource characteristics, existing and potential water uses, and state management goals and activities. Although each management problem is unique, states which regulate ground water under the prior appropriation doctrine share many similarities in their systems of management. Effective ground water management activities developed in one appropriation doctrine state provide a resource for planning future regulatory activities in other states which use the doctrine. Few opportunities exist for interstate exchange of valuable management experiences.

Purpose and Objectives

The purpose of this research is to better understand the characteristics of ground water management under the prior appropriation in the western United States. The general objective of this thesis is to summarize the legal and administrative controls on ground water use in the states of Montana, Utah, Washington, Oregon, Idaho, Colorado, New Mexico, and Arizona and to document and compare the impacts of these controls on ground water systems. The specific objectives are:

1) to review recent literature addressing the general topics of ground water management under the appropriation doctrine.
2) to summarize the legal and regulatory controls on ground water management in each state, based on statutes and agency regulations.
3) to summarize the administrative activities and problems of ground

water management in each state, based on literature and personal interviews with state management officials.

4) to identify a ground water management case study area in each state which is well documented and illustrative of state ground water management policy, and to document the development and management history of each area.

5) to analyze the similarities and differences between states.

Previous Research

Literally hundreds of articles have been written on the subject of ground water management under the doctrine of prior appropriation. A number of selected documents are discussed here to place this research in the context of significant recent articles on the subject. The discussion addresses the issues of 1) prior appropriation as a water distributing system, 2) management options available under prior appropriation, and 3) conjunctive use. The issue of interstate ground water management is not discussed because it is beyond the scope of this project.

Prior Appropriation Doctrine

Many authors discuss and debate the basic principles of prior appropriation management of ground water. Corker (1971) provides the most complete treatment of this subject. Corker (1971, p. 110) discusses all of the major water distribution doctrines of the United States, and outlines the four basic tenants of prior appropriation:

1) An individual establishes the right to use water through the act of diverting the water and using the water beneficially.

2) The relative priority of use is based on the date when a water right

is established. In times of water scarcity those users senior in time receive their full entitlement and junior users are cut off.

3) A water right is appurtenant to the land on which the water is used.

4) A water right is lost if it is not exercised (abandoned rights disappear).

Corker notes that the appropriation system was developed in the 1800's to allocate limited surface water supplies. The system worked well because water availability was easily seen and measured. If the stream went dry the junior users were cut off accordingly. There is considerable uncertainty, however, in determining how much ground water is available for use, and Corker identifies this as the central problem in prior appropriation management of ground water.

The issue of ground water availability is discussed in Ralston (1974). Availability can be conceptualized in its most basic form using the continuity equation:

Inflow (aquifer recharge) = outflow (aquifer discharge)
+ changes in aquifer storage

In an undisturbed basin, ground water in storage is about constant; aquifer recharge is about equal to aquifer discharge. Consumptive ground water pumpage alters this balance. The pumped water may come from any of three potential sources: 1) a decrease in ground water storage, 2) a decrease in natural aquifer discharge, and 3) an increase in aquifer recharge. Given enough time, a small rate of constant pumpage from a system will result in a re-equilibration in the above continuity equation, with an associated decrease in water in storage. If pumpage is of sufficient volume, however, decreases in natural discharge and increases of recharge will not effectively balance the pumpage, and continual water

level declines and decreases in storage occur. This continued reduction of aquifer storage volume is called ground water mining.

Corker notes that the issue of ground water availability is problematic because it is technically very difficult to determine if ground water mining is occurring; all ground water pumpage results in some water level decline. The uncertainty caused by this technical problem makes it very difficult to justify the closure of junior appropriators. The problem is acute because in the short term it is economically advantageous to mine an aquifer. The costs of mining ground water are realized by future generations. Corker labels this situation the "central problem of water law, management and administration," (1971, p. 21) and lists eight questions which it raises (pages x-xix):

1) To what extent shall use exceed recharge?
2) How can ground water mining be effectively restricted to prolong the life of the resource?
3) Should mining be permitted when recharge is substantial?
4) What is the permissible risk, and how might it be described, in permitting new or continued uses of stored ground water?
5) Should the same criteria apply to permitting new appropriation as to terminating established junior use?
6) Should ground water rights be protected, and if so, to what extent, and how shall protection be defined?
7) May water be stored artificially in a basin underlying land not owned by the storer?
8) What are the goals of ground water management?

The issues of ground water mining raised by Corker are discussed at length in an important paper by Hoskin (1965). Hoskin develops the idea

that ground water resources consist of a "stock" component of stored water and a "flow" component equivalent to the annual rate of recharge. Perpetual use of ground water may be possible if only the flow component of the resource is used. Hoskin demonstrates that many states which attempt to limit ground water pumpage to the flow component volume have conflicting statutes which defeat their purpose. Ralston (1973) refines the views of Hoskin. He demonstrates that the attempts to limit use to the "flow" component must also recognize the time dependency of ground water flow. Once total discharge is balanced with recharge a tremendous amount of time may be required for the system to re-equilibrate. Undesirable effects of pumpage may continue and worsen during this re-equilibration period.

Management Options Under Prior Appropriation

A number of authors have focused on a central issue in ground water management: when and how should priority be asserted? Many appropriation doctrine states deal with priority through the concept of impairment. A senior appropriator can only have junior water use shut down if the junior pumpage legally "impairs" the senior's water right. Schaab (1983) discusses the statutory and case law which has developed around the concept of impairment. Some key issues raised in this paper include:

1) Does water level decline constitute impairment?
2) Can a senior appropriator be impaired if he has not fully developed the aquifer or has a poorly constructed well?
3) If a senior water user is impaired, which of the surrounding junior water users should be shut down?
4) Who has the burden of proof in impairment contests?

5) Should junior users be shut down if the senior user will not benefit from the stoppage until after the given irrigation season, due to time lag effects?

Kelly (1983) analyzes many of the same issues as Schaab, and concludes that the best solution is mandatory conservation, with ground water allocated on the basis of need. He also demonstrates that mandatory conservation would not be a "taking" under the fifth amendment to the Constitution.

The economic aspects of impairment issues are discussed in detail by Lotterman and Waelti (1983). They find that equity transfers between pumpers are inevitable, but can be minimized by bargaining which is based on technical fact. Efficiency can be increased further by consciously avoiding "dead weight losses" - pumpage which benefits no one but costs society. Lastly, they note that the major inefficiency in the appropriation system is "transaction costs," i.e., the high cost of litigation. They recommend that litigation be removed from the management system to as great an extent as possible. These recommendations, if followed, would significantly modify prior appropriation as it is practiced today in most states. The economics of water use are given more radical treatment in Anderson (1985). Anderson demonstrates that the allocation of ground and surface water would be much more efficient if water markets were developed. In such a system, the quantity and priority of water rights could be sold in a relatively unrestricted market. The primary role of the state would be to enhance the recognition of water rights as real property and manage externalities.

Grant (1981 and 1983) analyzes the economic and social goals underlying reasonable ground water pumping levels (RGPL). Reasonable

ground water pumping levels are used by several appropriation doctrine states as criteria for managing ground water. In the 1981 paper, Grant identifies a tension in reasonable ground water pumping levels statutes between protecting the investments of senior appropriators and the overall maximum economic development of ground water. By using reasonable ground water pumping levels, states walk a line between totally protecting senior appropriators and conversely forcing each appropriator to pay whatever costs occur as a result of water level decline. In the 1983 paper, Grant notes that reasonable ground water pumping levels raise not only the issue of economic efficiency, but also the issue of proper wealth distribution between junior and senior appropriators. The reasonable ground water pumping levels "statutes narrow the wealth inequality between seniors and juniors by allowing juniors to pump down to a reasonable level and requiring seniors to pay their own increased pumping costs down to that level" (p. 61).

Some authors have addressed the effectiveness of management decision making at the state (centralized) versus local (decentralized) level. Keller (1981) demonstrates that the ground water management policy developed on the local scale in western Kansas is ineffective. Economic pressures on water users make it difficult for them to make decisions in the interest of long term conservation. Daubert and Young (1982) show that the same local management system in Kansas also is economically inefficient. Smith (1984) examines water user attitudes toward centralized (state level) management and decentralized (local level) management. Predictably, ground water appropriators are generally distrustful of centralized management.

Conjunctive Use

The integration of surface water and ground water management is commonly referred to as "conjunctive use." Conjunctive use is desirable from a technical standpoint, but has been difficult to achieve because of legal and institutional barriers. Trelease (1982) offers a complete analysis of the legal issues which surround conjunctive use. Through a comparison of different states, Trelease identifies seven concepts which can contribute to effective conjunctive use. These concepts can be summarized as follows:

1) The same laws are applied to surface and ground water.
2) All rights to both water sources are placed in the same framework of priorities.
3) A right to one of the interconnected sources may give a right in the other source as well.
4) Supply adjustment: delivering to the senior appropriator water from a new source and thus freeing the seniors original supply for a new use by a junior appropriator.
5) Surface water is imported to replenish or replace overdrawn supplies of ground water.
6) Ground water can be thought of as an underground reservoir to be used when surface water supplies are inadequate.
7) Individual water users can have their water delivered by service entities whose large scale diversions can be more easily managed.

Grant (1987) considers the legal and technical complexities encountered by states in their attempts to conjunctively use water under prior appropriation. He concludes that water management objectives under prior appropriation have become conflicting and vague. He points out that

the conflicts are caused by the technical difficulty of integrating surface and ground water management. The technical problems identified by Grant correspond to the issues raised by Corker (1971) and Schaab (1983). Ralston et al. (1984) summarizes the complexities of conjunctive use in the Snake River Basin, Idaho. They demonstrate that lag times of water level decline effects are significant. In some instances pumpage may produce decreased stream flow decades later at distances of tens and hundreds of miles. They establish that the lag in pumpage impacts on streams is a significant criteria for conjunctive use management of large basins.

Several conjunctive use computer models have recently been published in the literature. Illangaskare et al. (1984) presents a model for maximizing use of aquifers in arid zones by storing excess flood water artificially. Illangaskare and Morel-Seytoux (1985) present a model for conjunctive use allocation under the statutes of Colorado. Gupta et al. (1985) developed a model which optimizes use of ground water conjuntively with irrigation canal water in India.

Articles which address management issues in specific states are discussed in the respective state chapters of this report. Several articles compare management activities in different states. Wickersham (1981) presents a tabular comparison of ground water statutes in the contiguous 48 states. Aiken (1983) summarizes the ground water statutes of the Missouri River Basin states. Many articles previously discussed also utilize examples from various western states. An in-depth analysis of ground water management activities in appropriation doctrine states is not available in the literature.

Sources of Information

All statutory information contained in this thesis is consistent with laws published in 1986 supplements. Supplements from 1987 were used during the preparation of the Idaho and Utah chapters. Unless otherwise cited, all information contained under the "Administration" subheadings was obtained from personal interviews by the author with the following state water officials: Richard Brasch, Montana Department of Natural Resources; Harold Donaldson and Stan Green, Utah Department of Natural Resources; Ted Olson, Washington State Department of Water Resources; Fred Lissner and Marc Norton, Oregon Department of Water Resources; Roger Longenbough and Keith Kepler, Colorado Department of Water Resources; Bill Fleming, Deborah Hathaway, and Ann Wright, New Mexico State Engineer's Office; Phil Briggs and Kim Mitchell, Arizona Department of Water Resources.

MONTANA

Introduction

The appropriation doctrine has a long history in Montana, and was recognized in the state constitution of 1889. The current water code includes both surface and ground water, and dates from 1947 with a major revision in 1979.

Ground water use in Montana is relatively small, accounting for approximately 2% of all water use in the state. Ground water is nevertheless important in Montana because it is the only source of water in many areas of the state. Irrigation use of ground water has begun to expand in recent years, and currently supplies 14% of agricultural water use (Montana Governor's Ground Water Advisory Council, 1985). Unless otherwise noted, all information under administration is from personal interviews with Richard Brasch, Hydrosciences Section Supervisor, Montana Department of Natural Resources.

Appropriation Doctrine

Appropriative water rights are the core of Montana ground water management. The appropriation doctrine is explicitly recognized in the state constitution (table 1, part A). The doctrine is evident in the requirement of beneficial use (table 1, part B) and the use of relative priorities (table 1, part E). Rights may be forfeited through non use (Montana Code (M.C.) §85-2-404) and water rights are considered appurtenant to the land on which they are established (M.C. §85-2-403). Ground water waste is prohibited (table 1, part D).

Table 1. Ground Water Statutes in Montana.

A. Appropriation Doctrine Statement for Ground Water

Montana Constitution, Article IX, part 3. "All surface, underground, flood, and atmospheric waters within the boundaries of the state are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law."

B. Administration of Ground Water Rights

M.C. §85-2-101 (2) "...provide for the administration, control, and regulation of water rights and establish a system of centralized records of all water rights...this system...is essential for the documentation, protection, preservation, and future beneficial use and development of Montana's water."

C. Limit on Use of Ground Water

M.C. §82-2-101 (3) "It is the policy of this state...to encourage the wise use of the state's water resources by making them available for appropriation...and to provide for the wise utilization, development, and conservation of the waters of the state for the maximum benefit of its people with the least possible degradation..."

M.C. §85-2-317 (1) "After May 7, 1979, no application for a permit to appropriate groundwater in excess of 3,000 acre-feet per year may be granted, except pursuant to an act of the legislature permitting the specific appropriation."

D. Prevention of Ground Water Waste

M.C. §85-2-505 "Waste and contamination of groundwater prohibited. (1) No groundwater may be wasted...both flowing and nonflowing wells shall be so constructed and maintained as to prevent the waste, contamination, or pollution of groundwater..."

E. Definition of Impairment

M.C. §85-2-401 (1) "As between appropriators, the first in time is the first in right. Priority of appropriation does not include the right to prevent changes by later appropriators in the condition of water occurrence, such as the increase or decrease of streamflow or the lowering of a water table, artesian pressure, or water level, if the prior appropriator can reasonably exercise his water right under the changed conditions."

F. Adjudication of Ground Water Rights

M.C. §85-2-101 (4) "...it is further the policy of this state and a purpose of this chapter to recognize and confirm all existing rights to the use of any waters for any useful or beneficial purpose."

Table 1. Continued.

M.C. §85-2-211 "Within 20 days after May 11, 1979, the state of Montana upon relation of the attorney general shall petition to Montana supreme court to require all persons claiming a right within a water division to file a claim of the right as provided in §85-2-221."

G. Controlled Ground Water Areas

M.C. §85-2-506 (2) "Designation or modification of an area of controlled groundwater use may be proposed to the board by the department on its own motion or by petition signed by at least 20 or one-fourth of the users (whichever is the lesser number) of groundwater in a groundwater area wherein there are alleged to be facts showing:
(a) that groundwater withdrawals are in excess of recharge to the aquifer or aquifers within such groundwater area;
(b) that excessive groundwater withdrawals are very likely to occur in the near future because of consistent and significant increases in withdrawals from within the groundwater area;
(c) that significant disputes regarding priority of rights, amounts of groundwater in use by appropriators, or priority of type of use are in progress within the groundwater area;
(d) that groundwater levels or pressures in the area in question are declining or have declined excessively; or
(e) that excessive groundwater withdrawals would cause contaminant migration and a degradation of groundwater quality within the groundwater area."

H. Controlled Area Boundaries

M.C. §85-2-501 (4) "...an area which, as nearly as known facts permit, may be designated so as to enclose a single and distinct body of groundwater, which shall be described horizontally by surface description in all cases and which may be limited vertically by describing known geological formations should conditions dictate this to be desirable."

I. Controlled Area: Management Tools

M.C. §85-2-507 (in summary)
(1) Establishing the CGWA boundary, which consists of both the surface description and the aquifers(s) included.
(2) Closing the CGWA to all further ground water appropriations.
(3) Establishing a permissible total withdrawal within the area and reapportioning individual withdrawals based on priority.
(4) Reassigning withdrawal preference without reference to relative priorities, and assigning priority to domestic and livestock uses.
(5) Reducing the withdrawal of ground water by any appropriator or well in the CGWA.
(6) Requiring and specifying a system of rotation of use of ground water in the controlled area.

Table 1. Continued.

(7) Any additional requirements necessary. (8) Enforcing the CGWA order through an injunction in a district court.

Ground water management is administrated by the Department of Natural Resources and Conservation (DNRC), and by the board of directors of the Department of Natural Resources and Conservation (board). The primary goals of the Department of Natural Resources and Conservation are to provide a centralized record of all water rights (table 1, part B), and to evaluate permit applications in the context of wise utilization, development, and conservation (table 1, part C). Large scale diversions of ground water must be approved by the state legislature (table 1, part C).

Administration of Ground Water Rights

Statutory Framework

The goal of water rights administration in Montana is formal certification of each water right. All appropriations made after 1973 must be submitted for permitting to the Department of Natural Resources and Conservation. Water rights established prior to 1973 are permitted through the adjudication process. Applications are processed using a three tier system of criteria based on volume of water diverted (fig. 1). Note that applicants desiring 100 gpm or less may construct their well before the permit is issued. The applicant must satisfy additional criteria if the diversion is greater than 4,000 acre-feet per year (see fig. 1). The Department of Natural Resources and Conservation may approve, reject, or modify a proposed appropriation based on evidence presented in hearings and on its own investigation. All permits issued for appropriations greater than 100 gpm are provisional and may be modified as a result of the current state wide adjudication.

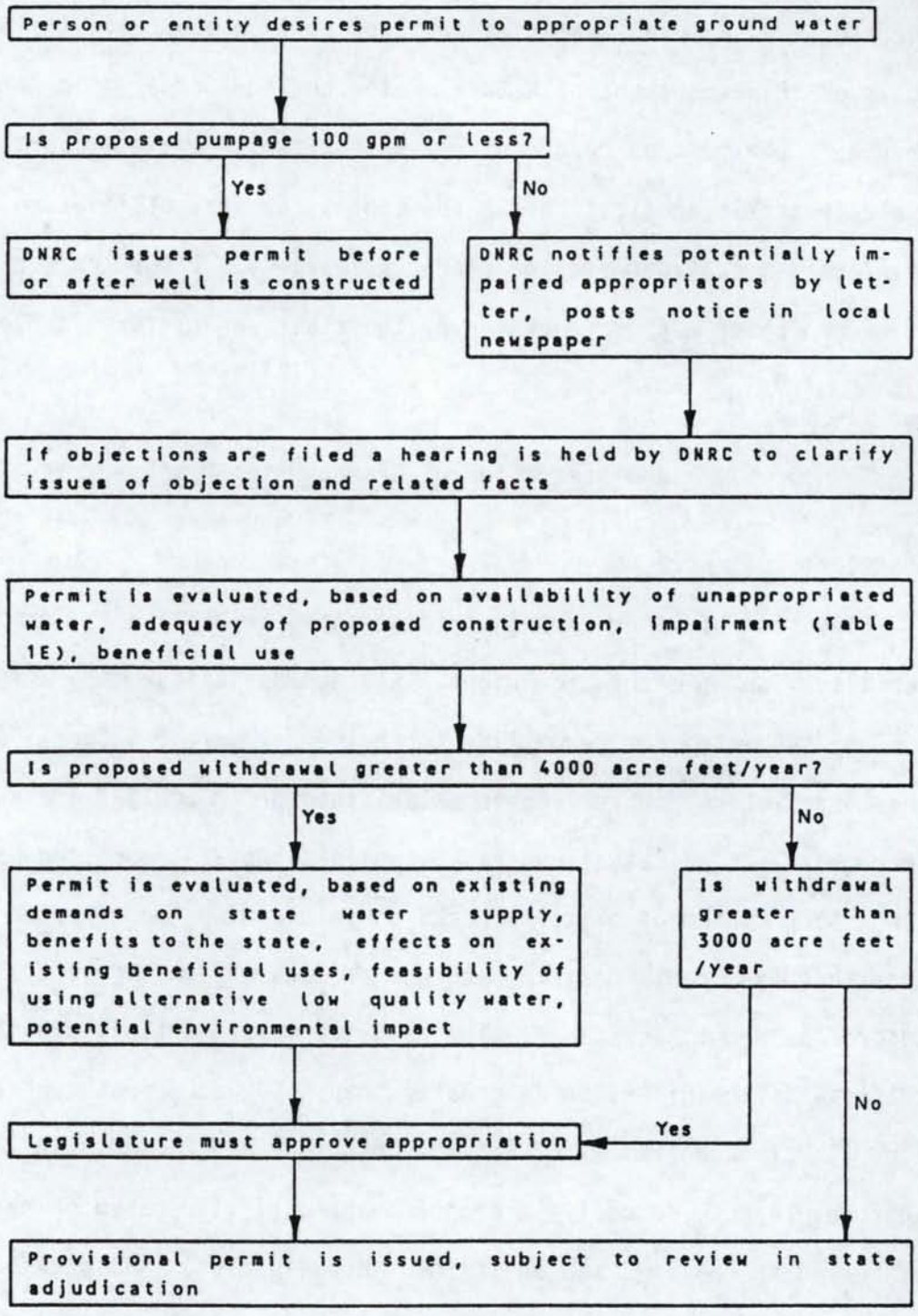

Figure 1. Montana Statutory Procedure for Acquiring Permits to Appropriate Ground Water.

Impairment of senior appropriators is defined by statute (table 1, part E). Senior appropriators are not protected with respect to the "condition of water occurrence." The senior appropriator must be able to "reasonably exercise his water right under the changed conditions." Priorities may be enforced through private litigation, including the resolution of surface-ground water conflicts.

Administration

The primary responsibility for ground water rights administration falls on the Department of Natural Resources and Conservation. Recent legislation (House Bill 859, 1985) shifts some of the permit hearings administration to district courts. An average of 3,800 ground water permit applications are submitted to the Department of Natural Resources and Conservation every year (Montana Governor's Ground Water Advisory Council, 1985). Eighty to ninety percent of these applications are for less than 100 gpm. Objections are common on applications for more than 100 gpm. The Department of Natural Resources and Conservation evaluates all applications primarily with respect to objections. If objections are found to be invalid, the application is almost always approved. The objections usually focus on adverse hydrologic effects to senior appropriators (well interference). Evaluation of these objections converges on the statutory definition of priority (table 1, part E). The Department of Natural Resources and Conservation has not established a standard for evaluating the "reasonable exercise" of senior appropriations, and this criteria is evaluated on a case by case basis. Two hydrologists are employed full time by the Department of Natural Resources and Conservation in evaluating objections to ground water applications. Funds are usually not available for technical

investigations and the "availability of unappropriated waters in the source of supply" is a functionally ignored criteria.

Adjudication of Water Rights

Statutory Framework

In 1979, Montana began a statewide adjudication of all water rights holding priority dates prior to 1973. Appropriators were required to file claims with the Dept. of Natural Resources by 1983; unfiled claims were considered abandoned (M.C. §85-2-212).

The Montana adjudication process consists of three parts. The first stage is the issuance of a preliminary decree (M.C. §85-2-231). The preliminary decree is issued on a hydrologic scale which varies in size from streams to entire basins. The adjudication is based on all claims filed within the decree area. Indian and federal reserved rights are negotiated separately through the Reserve Water Rights Compact Commission (RWRCC).

The second stage in the adjudication process consists of hearings on the preliminary decree (M.C. §85-2-233). Any person named in the decree, or the Department of Natural Resources and Conservation, may request a hearing. The hearing is conducted as for a civil action, and may change findings of the preliminary decree.

A final decree is the last stage in the adjudication process. The final decree includes any considerations resulting from preliminary decree hearings and all Indian and federal reserved rights. The final decree lists the volume, use, and priority of each water right in the state. Following the final decree, the Department of Natural Resources

and Conservation will issue a certificate of water right to each right holder.

Administration

The primary administration of Montana's adjudication is handled by a system of water courts and water judges. The water judges are elected by district judicial judges (M.C. §3-7-201). The judges coordinate adjudication proceedings and hearings. The water court system is supervised by the state supreme court (M.C. §3-7-204).

Indian and federal reserved rights are not adjudicated initially by the water courts. A Reserved Water Rights Compact Commission is established to negotiate a preliminary adjudication with tribes and federal agencies (M.C. §85-2-701). The commission consists of three state senators, three state house representatives, and three governor appointees. The water courts incorporate compacts from the Reserved Water Rights Compact Commission in the adjudication final decree.

The statutory process of adjudication has been modified somewhat in its application by water courts. The courts have utilized temporary decrees (a provision of M.C. §85-2-231) to resolve objections and conflicts prior to issuance of preliminary decrees. This may shorten or eliminate hearings on preliminary decrees.

Currently the adjudication in Montana is in the "preliminary decree" stage. The Reserved Water Rights Compact Commission negotiations are proceeding very slowly. Currently, the Commission has only made one compact. This compact agreement is with the Fort Peck Tribe. Compacts with the Forest Service are close to settlement at this time (1987).

Controlled Ground Water Areas

Statutory Framework

The primary ground water conservation activity in Montana involves the establishment of Controlled Ground Water Areas (CGWA). The designation and administration of Controlled Ground Water Areas are delegated to the board of the Department of Natural Resources and Conservation. Controlled Ground Water Area designations may be proposed by the Department of Natural Resources and Conservation, or by a petition of affected water users (table 1, part G). Table 1, part G also lists the five criteria for designating a Controlled Ground Water Area. The designation is designed to deal with a wide variety of ground water management problems, including ground water mining, water rights conflicts, water level declines, and contaminant migration. Boundaries of the Controlled Ground Water Areas are hydrogeologic, and may be defined horizontally and vertically (table 1, part H). Sub-area boundaries may be established which are not hydrogeologic (M.C. §85-2-503).

Establishment of a Controlled Ground Water Area or a temporary Controlled Ground Water Area (two years) is determined at a hearing administrated by the board. The board has broad powers in creating a Controlled Ground Water Area (table 1, part I). Note that domestic use may be assigned senior priority, and the enforcement of the provisions may utilize district court injunctions. Rotational use is an included option in addition to the closure of the area to further appropriation and establishment of a total permissible withdrawal.

Administration

The Department of Natural Resources and Conservation board is appointed by the governor. The terms of board members are staggered. The board may issue new or revised orders for Controlled Ground Water Area designations. Revised Controlled Ground Water Area orders are considered at a hearing after petition by the affected users or the Department of Natural Resources and Conservation.

Two Controlled Ground Water Areas are designated currently in Montana (fig. 2). The boundaries of both Larson Creek and South Pine Controlled Ground Water Areas are not hydrogeologic. Both areas were designated because of significant water rights disputes and water level declines. "Withdrawals in excess of recharge" have not been an actively used criteria in the creation of Controlled Ground Water Areas to date. Both areas were created through local petitioning efforts. The Department of Natural Resources and Conservation currently maintains an internal policy of not petitioning the Department of Natural Resources and Conservation board for Controlled Ground Water Area designations.

The Department of Natural Resources and Conservation board has exercised its administrative options with restraint. The Larson Creek order placed a moritorium on additional appropriations within 263 feet of existing wells. The South Pine order originally limited oil company water withdrawals because they were causing water level declines of several hundred feet. Eventually Shell Oil was required (by a revised order) to pay the additional pumping costs incurred by other appropriators.

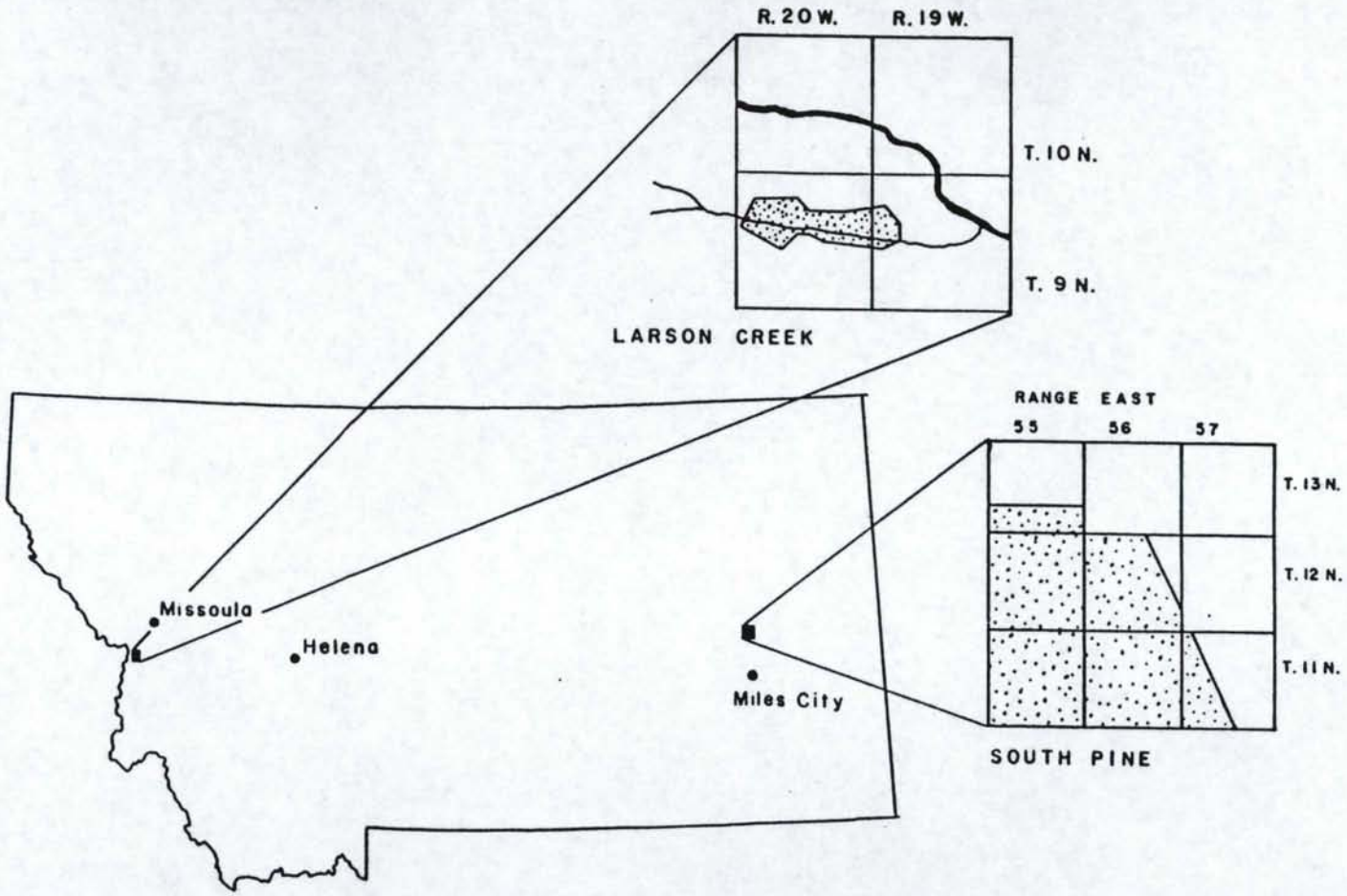

Figure 2. Critical Ground Water Areas in Montana, 1986 (Brasch, 1986).

Management Case Study: Larson Creek Controlled Ground Water Area

Development History

The physical characteristics of the Larson Creek area are summarized in table 2. Housing development in the study area has required the use of shallow wells to provide domestic water supplies. Well interference conflicts between domestic water users became significant in the early 1980's.

Management History

1984. The board received a formal petition to establish a Controlled Ground Water Area from seven water users in the Larson Creek area. One opposition to the designation was filed by a local well driller.

1985. A temporary (two year) Controlled Ground Water Area was established in the Larson Creek area (see fig. 2). The boundaries of the area were drawn to surround the petitioning water users and extend to a depth of 70 feet. Within the boundary, no new well may be drilled within 263 feet of any existing wells. Wells perforated below 70 feet are permitted. The Department of Natural Resources and Conservation is required to conduct further studies on the aquifer at the petitioner's expense. The studies are to be used in reevaluating the Controlled Ground Water Area designation in 1987.

Table 2. Physical Description of the Geography, Geology, and Hydrogeology of the Larson Creek Controlled Ground Water Area in Montana (Dept. of Natural Resources and Conservation).

Geography	
Location (see fig. 2)	Located in southwestern Montana, west of Stevensville, 150-200 acres in size.
Drainage	Larson Creek (perennial stream).
Land Use	Domestic.
Climate	Temperate.
Geology	
Stratigraphy	Alluvial valley fill to a depth exceeding 80 feet.
Hydrogeology	
Aquifers	An alluvial, unconfined aquifer exists to a depth of 70 feet.
Discharge	Relationship between aquifer and Larson Creek is unknown.
Ground Water Use	Domestic.

UTAH

Introduction

Water law in Utah currently is based on the prior appropriation doctrine. Prior to the 20th century, however, the management of water in the Utah territory was characterized by conflicts over water ownership between Mormon and gentile settlers (Swenson, 1984). The state constitution of 1896 and the 1897 Water Act settled the controversy over water ownership, recognizing the validity of existing water uses and codifying the use of the appropriation doctrine. Ground water was explicitly included in Utah water statutes in 1935.

Ground water management in Utah is administrated by the Division of Water Rights of the Department of Natural Resources (DWR). The Division of Water Rights is supervised by the state engineer who is appointed by the governor. All information contained in the administration sections of this chapter, except where cited otherwise, is drawn from personal interviews with Stanley Green and Harold Donaldson, Utah Department of Natural Resources.

Appropriation Doctrine

The appropriation doctrine governs the use and distribution of all water in the state of Utah. Ground and surface water are treated in a single water code (table 3, part A). The Division of Water Rights, under the state engineer, administrates appropriative water rights through a system of permits. Utah statutes include beneficial use requirements and criteria (table 3, part C), land appurtenance requirements (Utah Code

Table 3. Ground Water Statutes in Utah.

A. Appropriation Doctrine Statement for Ground Water

U.C. §73-1-1 "All waters in this state, whether above or under the ground are hereby declared to be the property of the public, subject to all existing rights to the use thereof."

B. Administration of Ground Water Rights

U.C. §73-3-1 "...No appropriation of water may be made and no rights to the use thereof initiated and no notice f intent to appropriate shall be recognized except application for such appropriation first be made to the state engineer...The appropriation must be for some useful and beneficial purpose, and, as between appropriators, the one first in time shall be first in rights..."

C. Limit on Use of Ground Water

U.C. §73-1-3 "Beneficial use shall be the basis, the measure and the limit of all rights to the use of water in this state."

D. Impairment of Senior Appropriators

U.C. §73-3-21 "Appropriators shall have priority among themselves according to the dates of their respective appropriations, so that each appropriator shall be entitled to receive his whole supply before any subsequent appropriator shall have any right; provided, in times of scarcity, while priority of appropriation shall give the better right as between those using water for the same purpose, the use for domestic purposes, without unnecessary waste, shall have preference over use for all other purposes, and use for agricultural purposes shall have preference over use for any other purpose except domestic use."

E. Adjudication of Ground Water Rights

U.C. §73-4-1 "Upon a verified petition to the state engineer, signed by five or more or a majority of water users upon any stream or water source, requesting the investigation of the relative rights of the various claimants to the waters of such stream or water source, it shall be the duty of the state engineer, if upon such investigation he finds the facts and conditions are such as to justify a determination of said rights, to file in the district court an action to determine the various rights...the court may order an investigation and survey by the state engineer of all the water rights on the source or system involved."

Table 3. Continued.

F. Ground Water Management Area

U.C. §73-5-1 "...In addition to the power granted the state engineer to appoint water commissioners for the distribution of water as provided herein, the state engineer is hereby authorized upon his own motion at any time to hold a hearing, or upon a petition signed by not less than one-third of the users of underground waters in any area as shall be defined by the state engineer, he shall hold such hearing, to determine whether the underground water supply within such area is adequate for the existing claims. Notice of such hearing shall be given in a form and manner which in the judgment of the state engineer will best suit local conditions. Upon such hearing the state engineer is authorized to make full investigation and findings thereon. If it be found the water supply is inadequate for existing claims, he shall divide, or cause to be divided, by the water commissioners as provided in this section, the waters within such area among the several claimants entitled thereto in accordance with the rights of each respectively."

(U.C.) §73-1-10, §73-1-11), and criteria for the abandonment and forfeiture of rights through non-use (U.C. §73-1-4).

Utah's application of the appropriation doctrine is distinctive in several respects. First, a water right may or may not be appurtenant to land. If the right is not intended for the exclusive benefit of particular land, as stated in a permit, it may be severed from the land and sold by itself (see Roberts v. Roberts 584 P2d. 378 (1978)). Second, some beneficial uses are considered more beneficial than others, and are given preference over priority allocation in times of scarcity (table 3, part D). Specifically, preference is given to domestic and agricultural uses. This preference has its source in the territorial water laws of the 1800's (Swenson, 1984).

The Utah water statutes are relatively brief and general, by comparison with other states. The water law of this state is determined to a significant degree by the discretionary authority of the state engineer and the determinations of the courts. Specific goals for ground water management are not outlined in the statutes. The general goals of water management outlined by the statutes include the administration of a permit system of appropriative rights by the Division of Water Rights, adjudication of rights, and the optimum utilization of available water resources.

Administration of Ground Water Rights

Statutory Framework

The appropriation of ground water in Utah requires the application to the Division of Water Rights for a permit (table 3, part B). The permitting process is illustrated in figure 3. Note that the criteria for

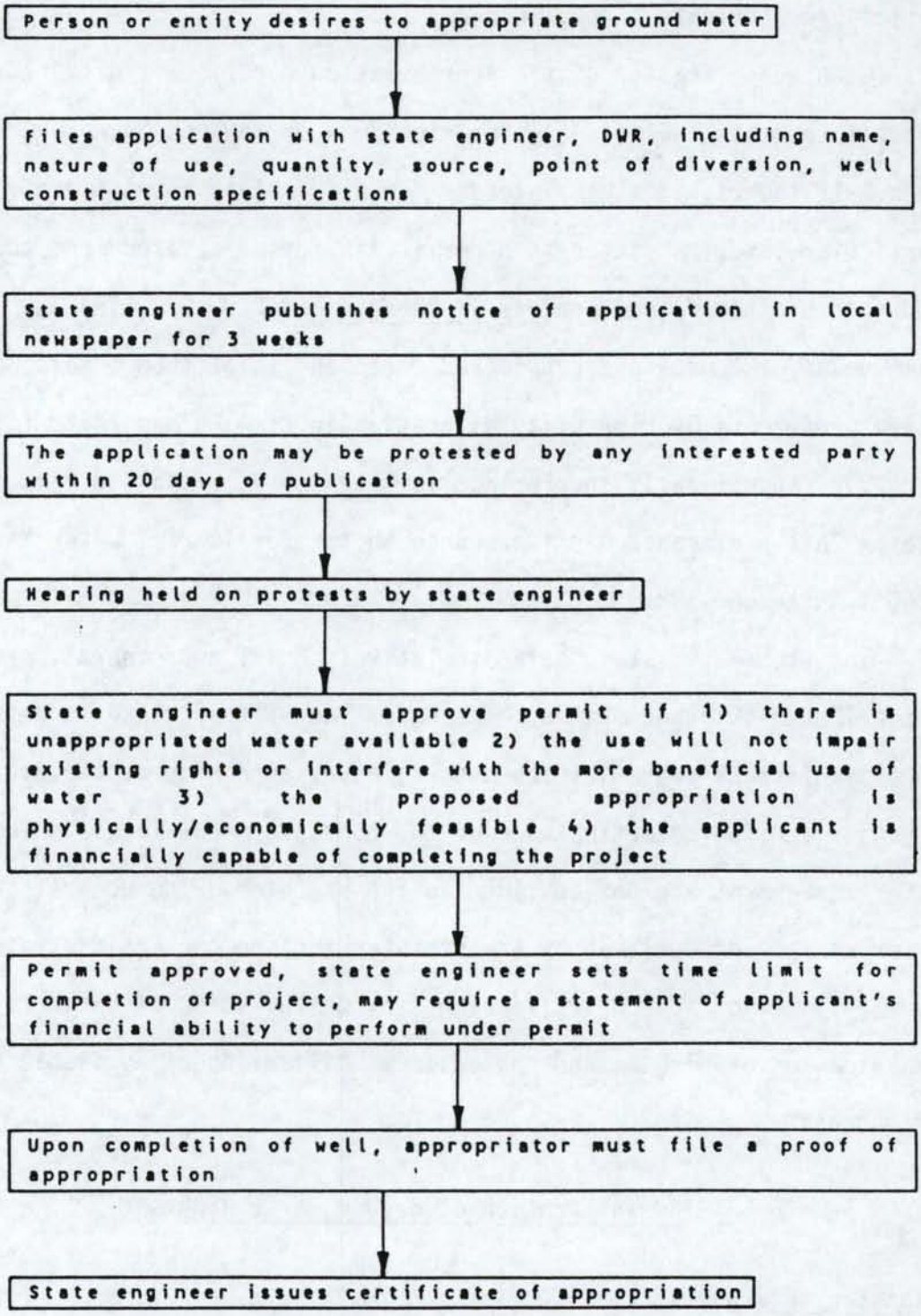

Figure 3. Utah Statutory Procedure for the Appropriation of Ground Water.

permit approval include the financial ability to complete the project. The time limit specified by the state engineer in the construction permit must be less than 50 years. The statutes are unusually explicit in their requirements for diligent completion of the project in the specified time. Water users who feel that construction is not adequately diligent may protest. These diligence protests are resolved in a hearing held by the state engineer.

The impairment of senior appropriators is defined generally to be an inability to obtain the entire quantity of the senior right (table 3, part D). Note that in times of scarcity preference is given to domestic and agricultural use. The enforcement of relative priorities requires filing of a suit in district court.

Administration

In 1986 the Division of Water Rights received 1,389 applications for new or changed water rights. The percentage of these applications which were for ground water was not obtainable from the Division of Water Rights. The total number of applications has dropped an average of 13% each year since 1984. The Division of Water Rights estimates that they receive protests for 10% of the applications which are processed. A substantial number of appropriators have attempted to change their water rights by expanding their irrigated acreage, i.e., spreading the same total quantity of water over a larger area. The Division of Water Rights maintains a firm policy of rejecting irrigation expansion proposals.

Issues of priority between appropriators are settled in court. Several cases are noteworthy. Peterson v. Wood 262 P. 828 (1927) established that ground water developers near an appropriated stream must demonstrate that they will not impair surface water users. Current Creek

Irrigation Co. v. Andrews 344 P2d. 528 (1959) established that ground water appropriators are protected in the maintenance of artesian pressure. The court held that the later appropriator must restore the pressure or bear the expense of installing pumping devices for the first well (Swenson, 1985). Wayman v. Murray City Corp. 458 P2d. 861 (1969) revised the "Current Creek" option, saying that issues of protecting artesian pressure must be decided on an ad hoc basis by the state engineer, based on the technical merits of each particular case. Currently the Division of Water Rights does give tacit protection to artesian conditions in the southern Utah Valley and western Davis and Weber counties.

Significant attention has been directed by the courts to issues of ground water rights for the purposes of dewatering. This issue is very important in Utah, because the reclamation of land near playa lakes is a common practice.

Adjudication of Water Rights

Statutory Framework

The statutes of Utah delegate the adjudication of water rights to the state engineer and Division of Water Rights in conjunction with the courts (table 3, part E). The adjudication procedure is displayed in figure 4. The procedure provides for determination of an Interlocutory Decree which may be updated in the future. The process economizes the use of court time by utilizing a "proposed determination" which is compiled by the state engineer and the Division of Water Rights.

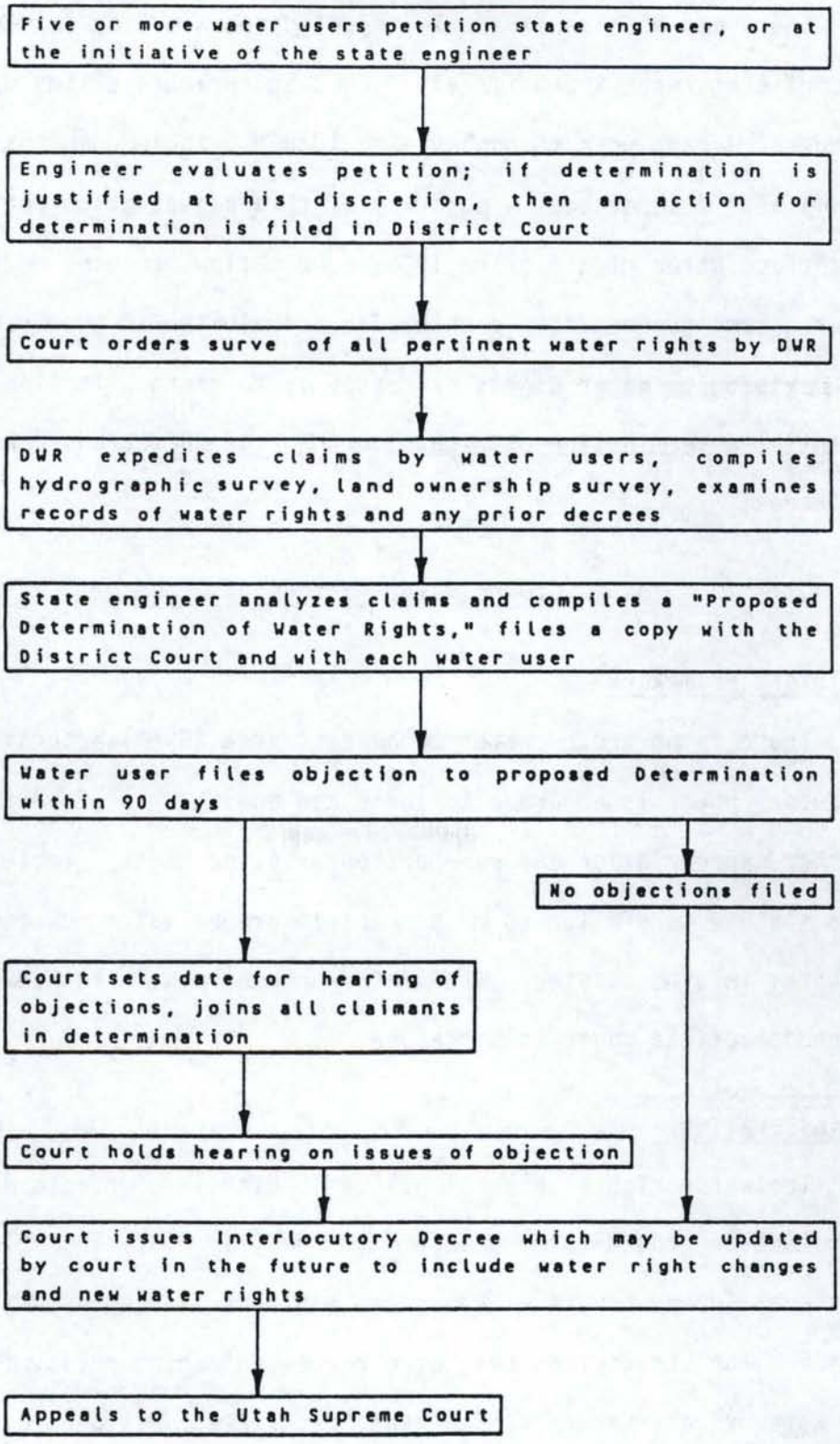

Figure 4. Adjudication Procedure in Utah.

Administration

There has been considerable adjudication activity in Utah under the present statutes. Approximately 6,000 water rights claims were adjudicated each year throughout the 1970's. In 1986 approximately 4,000 claims were determined. A majority of this adjudication activity focused on surface water rights. The 1986 adjudications focused on the San Rafael River. Some ground water rights were adjudicated in the Bosheu Valley. The Division of Water Rights currently is focusing attention on the future potential determination of rights on the Provo River and Jordan River drainages.

Ground Water Management Areas

Statutory Framework

There is no ground water management area (GWMA) program in Utah. A statutory power is accorded to the state engineer to withdraw areas from further appropriation and reapportion existing rights (table 3, part F). This statute is similar to more specific ground water management area statutes in other states. The state engineer must hold hearings on his intended actions under this statute.

Administration

The water rights approval policy in Utah is a defacto designation of a state-wide ground water management area (fig. 5). The policy is based on the statutory powers of the state engineer as displayed in table 3, part F. The statute has been used for establishing policy for approval of new water rights under "closed" and "restricted" designations. In closed areas the Division of Water Rights will not approve any new appropriations of ground water for any volume. In restricted areas the Division of Water

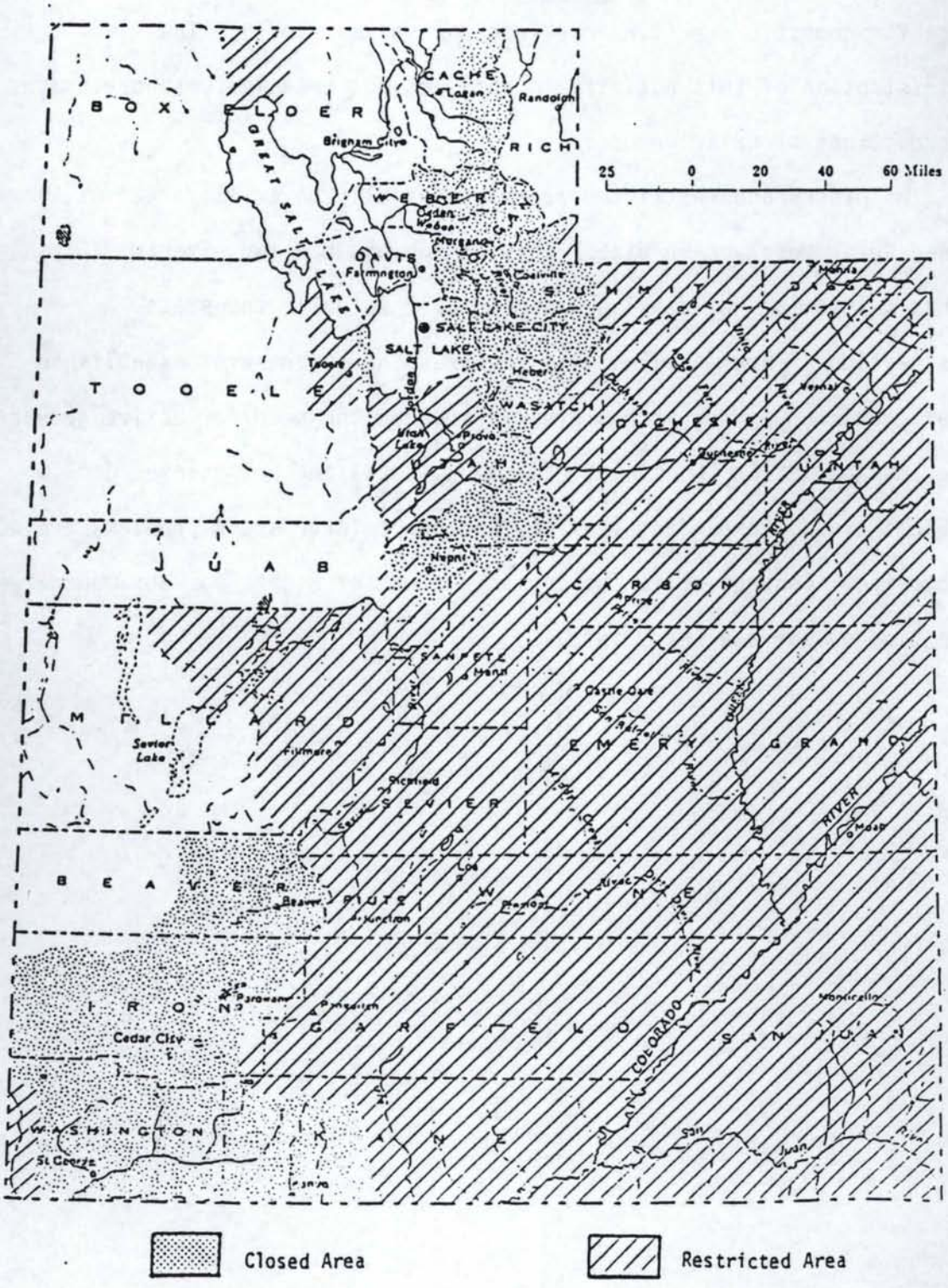

Figure 5. Utah Ground Water Permit Approval Status (Donaldson, 1986).

Rights will approve new appropriations only for very small quantities of water for domestic use (1.6 acre-feet per year or less). The administration of this activity to date has not entailed reapportionment or reductions of existing use.

The closed and restricted areas essentially cover all areas of known ground water reserves in Utah. This action has had two effects. First, it has halted further development of ground water in the state. Construction of new wells usually requires the purchase of established water rights. Second, it has greatly reduced the need for active ground water management in the state. Existing, localized water level decline problems are not expanding in size, and newer large scale problems are not developing. Consequently, the Division of Water Rights focuses management attention on surface water issues.

WASHINGTON

Introduction

Washington's water resources have always been managed under the doctrine of prior appropriation. Surface water statutes were established by the state in 1917. Ground water statutes were enacted in 1945. The state's ground water laws currently are administrated and enforced by the Division of Water Resources (DWR) of the Washington Department of Ecology (DOE). All information contained in the administration and management history sections of this chapter, except where otherwise cited, is drawn from personal interviews with Ted Olson and David Peeler, Division of Water Resources, Washington Department of Ecology.

Appropriation Doctrine

The appropriation doctrine is the basis for all water management activities in Washington (table 4, part A); however, ground water and surface water are addressed in separate statutes. Beneficial use is an important component of every ground water right (table 4, part B), but is not the limiting criteria on ground water use. Instead, a safe sustaining yield from all ground water sources limits the development of ground water (table 4, part C). Statutes prohibit the waste of ground water (table 4, part D), and include criteria for forfeiture through non-use.

The Washington ground water code outlines four broad objectives for the administrative activities of the Division of Water Resources:

1) administrating a system of water rights (table 4, part B).
2) adjudicating ground water rights (table 4, part H).

Table 4. Ground Water Statutes in Washington.

A. Appropriation Doctrine Statement for Ground Water

Revised Code of Washington (R.C.W.) §90.03.010 "...all waters within the state belong to the public, and any right thereto, or the use thereof, shall be hereafter acquired only by appropriation for a beneficial use and in the manner provided and not otherwise; and, as between appropriations, the first in time shall be the first in right."

B. Administration of Ground Water Rights

R.C.W. §90.44.130 "As between appropriators of public ground water, the prior appropriator shall as against subsequent appropriators from the same ground water body be entitled to the preferred use of such ground water to the extent of this appropriation and beneficial use... Water resources shall have jurisdiction over the withdrawals of ground water and shall administer the ground water rights under the principle just set forth..."

C. Limit on Use of Ground Water

R.C.W. §90.44-130 "...the jurisdiction to limit withdrawals by appropriators of ground water so as to enforce the maintenance of a safe sustaining yield from the ground water body..."

D. The Prevention of Ground Water Waste

R.C.W. §90.44.110 "No public ground waters that have been withdrawn shall be wasted..."

E. Reasonable or Feasible Pumping Lift

Washington Administrative Code (WAC) 173-150-040 "...reasonable or feasible pumping lift shall be determined by the department taking into account the following factors, among others:
(1) The geohydraulic characteristics of the aquifer;
(2) The state of construction technology of water withdrawal facilities;
(3) Historic considerations in regards to the construction, maintenance and use of water withdrawal facilities within the vicinity;
(4) The ground water area or subarea management program for the vicinity, if one exists."

F. Impairment of Senior Appropriators

WAC 173-150-050 "...If the department determines that a proposed appropriation of ground water would cause a lowering of the water levels below a reasonable or feasible pumping lift in any withdrawal facilities of an existing ground water right holder or that approval

Table 4. Continued.

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of the proposed appropriation would impair any existing water rights or would otherwise be detrimental to the public welfare, the application shall be rejected."

G. Definition of Impairment

WAC 173-150-060 "Impairment of water right. For the purposes of this chapter, a ground water right which pertains to qualifying withdrawal facilities, shall be deemed to be impaired whenever:
(1) There is an interruption or an interference in the availability of water to said facilities, or a contamination of such water, caused by the withdrawal of ground water by a junior water right holder or holders; and
(2) Significant modification is required to be made to said facilities in order to allow the senior ground water right to be exercised."

H. Adjudication of Ground Water Rights

R.C.W. §90.03.110 "...govern and apply to the adjudication and determination of such ground water body and to the ownership thereof... (90.44.220) ...the interest of the public will be subserved by a determination of the rights thereto...

I. Ground Water Management Areas (1945)

R.C.W. §90.44.180 ...The supervisor of water resources may hold a hearing on his own motion, and shall hold a hearing upon petition of at least fifty or one fourth, whichever is the lesser number, of the holders of valid rights to withdraw public ground waters...to determine whether the water supply...is adequate for the current needs of all such holders... If such hearing finds that the total available supply is inadequate...the supervisor shall order the aggregate withdrawal from such area...decreased so that it shall not exceed such available supply. Such decrease shall conform to the priority of the pertinent valid rights... (§90.44.130) in order that overdraft of public ground waters may be prevented so far as is feasible."

J. Ground Water Management Areas (1985)

R.C.W. §90.44.400 "...In recognition of existing water rights and the need to manage ground water aquifers for future use, the Department of Ecology shall, by rule, establish standards, criteria, and a process for the designation of specific ground water areas or sub-areas, or separate depth zones...and provide for either the Department of Ecology, local governments, or ground water users of the area to initiate development of a ground water management program for each area or sub-area, consistent with sate and local government objectives, policies, and authorities."

Table 4. Continued.

K.	Management Area Boundaries
	R.C.W. §90.44.130 "...to designate separate depth zones within any such area or sub-area, or to modify the boundaries of such existing area, or sub-area, or zones to the end that the withdrawals therefrom may be administratively controlled...Each such area or zone shall... enclose a single and distinct body of ground water...Each such sub-area...[shall] enclose all or any part of a distinct body of public ground water."

3) maintaining a safe sustaining yield from all ground water systems (table 4, part C).

4) preventing the waste of ground water (table 4, part D).

The first two objectives are standard components of prior appropriation management. The third and fourth objectives express an intent to manage ground water as a renewable resource.

Administration of Ground Water Rights

Statutory Framework

Ground water rights in Washington are administrated by the Division of Water Resources. The statutory procedure used by the Division of Water Resources in issuing new ground water rights is illustrated in figure 6. Key management criteria are established by the phrases "reasonable or feasible pumping lift," "reasonable or feasible reduction in pressure," and "potential impairment of senior appropriators." These criteria are applied within the context of the "safe sustaining yield" objective (Wallace, 1986, p. 2).

Administration

The focus of Washington's ground water management activities is the maintenance of a water rights system. In its Seventh Biennial Report to the Legislature, the Division of Water Resources clearly states its regulatory stance:

> The ground water code provides a means for regulating, controlling, and managing ground water through the issuance of water rights (Washington State Department of Ecology, 1985, p. 35).

The management activities of the Division of Water Resources are based largely on the "reasonable or feasible pumping lift" criteria. The

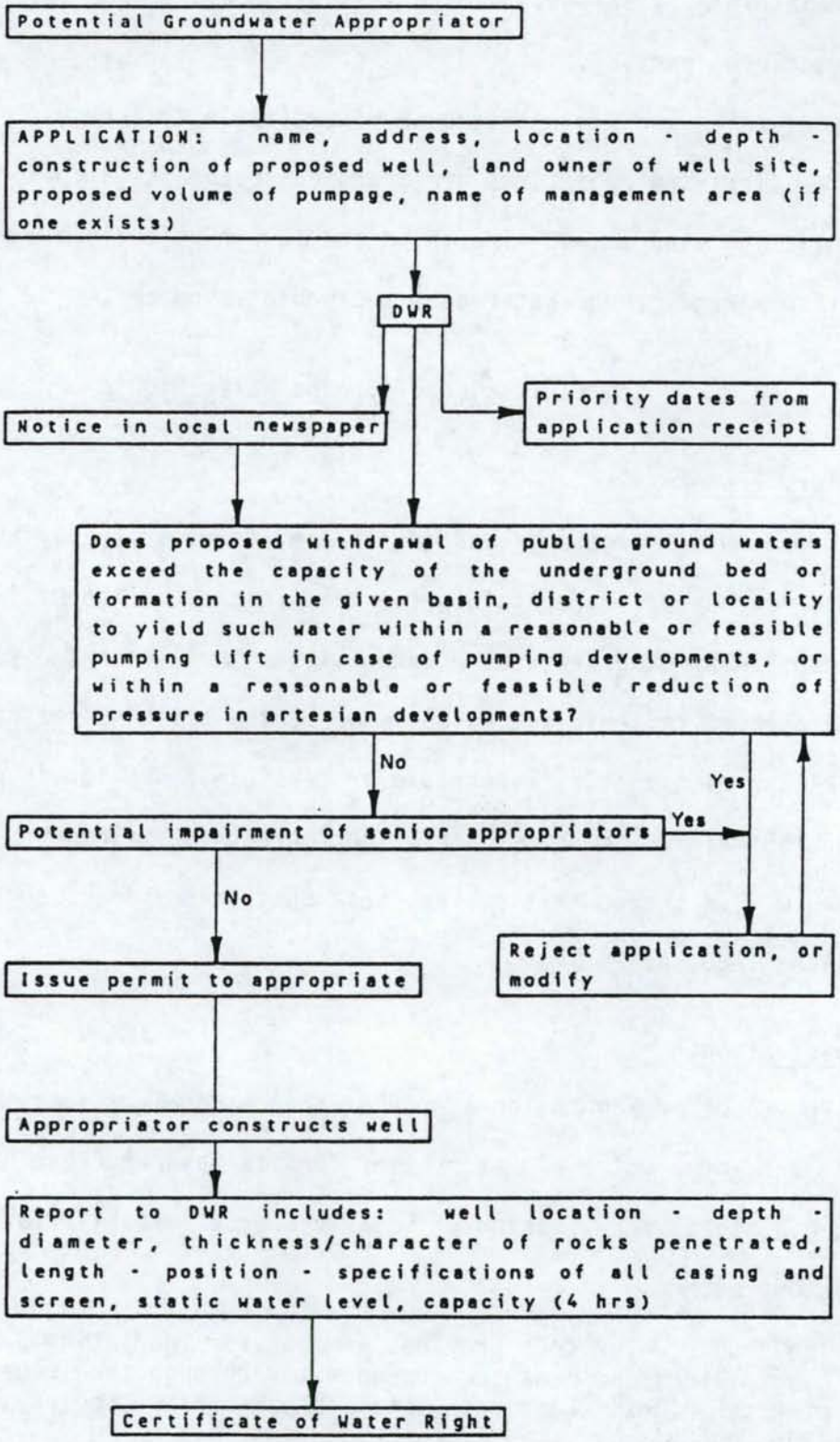

Figure 6. Washington Statutory Procedure of Acquiring Ground Water Certificate of Water Right.

considerable regulatory discretion delegated to the Division of Water Resources by this criteria has been challenged in court many times. The authority has been upheld, and the Division of Water Resources has responded with regulations which describe how reasonable or feasible pumping lift is determined (table 4, part E). The "safe sustaining yield" criteria is conspicuously absent in the factors which are listed in table 4, part E. Nevertheless, the Division of Water Resources maintains that the safe yield concept is considered in defining the pumping lift.

The reasonable pumping lift is also important in resolving water rights conflicts. The Division of Water Resources regulations define impairment of senior appropriators in terms of pumping lift (table 4, part F). The regulations also define impairment in terms of water availability and the economics of well rehabilitation (table 4, part G). As a result, it is not clear from the regulations whether impairment is defined by pumping lift, availability, or both. In fact, the availability criteria (table 4, part G) are applied most often, perhaps because they are easier to assess.

Surface water rights are not actively administrated in conjunction with ground water rights. The interference with surface water appropriators is not a widespread problem, according to the Division of Water Resources, because most serious water level declines are in the arid, eastern portion of the state. Where interference does occur, the ground water code specifically states that the surface water appropriator shall hold the better (senior) right (R.C.W. §90.44.130). The rationale for this statement is unclear.

Adjudication of Water Rights

Statutory Framework

Ground water is adjudicated in Washington under the same statutory procedures mandated by the surface water code. This procedure is displayed in figure 7. Note that the adjudication may be initiated by the Division of Water Resources or by petition of the water users. Both surface and ground water users may be included in the adjudication as is "pertinent."

Administration

To date, all adjudications in Washington have been surface water rights determinations only. The majority of adjudications have been initiated by water users rather than the Division of Water Resources. There is no adjudication of ground water rights as part of the Ground Water Management Area Program. The state has completed 76 determinations of surface rights, an additional 7 are "incomplete/active," 5 are "incomplete/inactive," and 20 petitions currently are filed pending action (1987). A combined surface-ground water adjudication was initiated by the Division of Water Resources in Pend O'rielle County in the spring of 1987.

Ground Water Management Areas

Statutory Framework

Two 1945 statutes provide for the creation of Ground Water Management Areas (GWMA) in Washington (table 4, part I). These statutes list specific criteria for establishment of Ground Water Management Areas. The statutes also describe an administrative procedure for declaring the

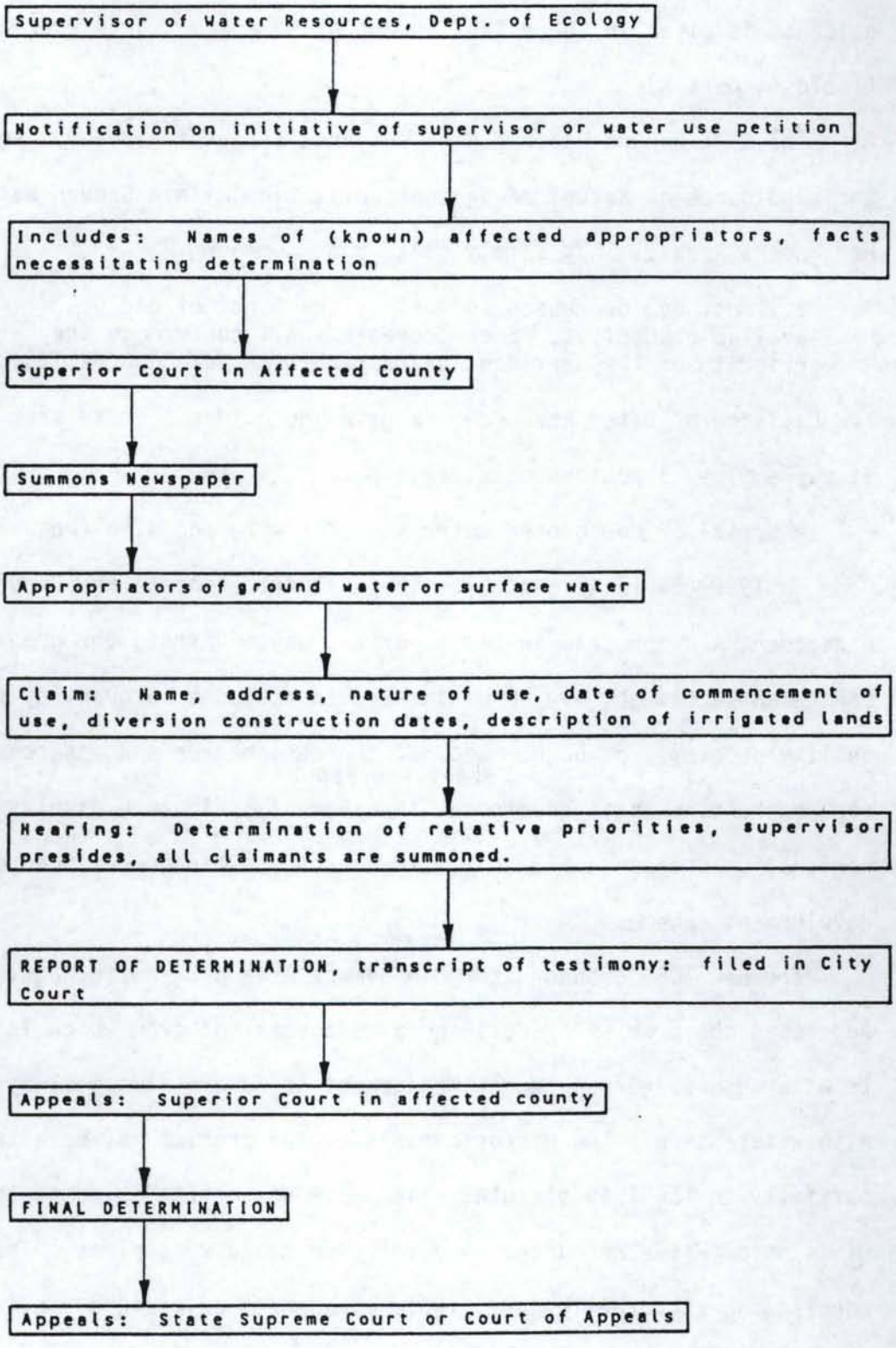

Figure 7. Adjudication Procedure in Washington.

Ground Water Management Areas which includes a hearings process. Concise guidance is given in the establishment of management area boundaries (table 4, part K).

The 1945 Ground Water Management Area statutes are very general in their guidance of actual management activities within Ground Water Management Areas. They simply state that pumpage

> ...[must be] decreased so that it shall not exceed... available supply... Such decrease shall conform to the priority of the pertinent valid rights (R.C.W. §90.44.180).

The Division of Water Resources is given no guidance as to what measures it may employ to achieve this mandate.

A series of new ground water statutes were added to the Washington Code in 1985 (table 4, part J). These statutes change the Ground Water Management Area program in two important ways. First, the ground water management areas now may be designated in response to quantity problems, quality problems, or both. Second, the designation and management of an area emphasizes local government involvement. Figure 8 displays the designation process. Figure 9 illustrates the management program development scheme.

The new 1985 Ground Water Management Area program in Washington addresses the problem of defining a management program which is acceptable to water users. Ground Water Management Areas are almost always unpopular with water users. The historic basis of the problem may be attributed partially to the 1945 statutes which give unspecific guidance to the Division of Water Resources in developing management plans. The lack of concise and statutorily justifiable management criteria are evident in the Management Case Study which concludes this chapter. The 1985 statutes do not confront this issue. Instead they shift the burden of developing

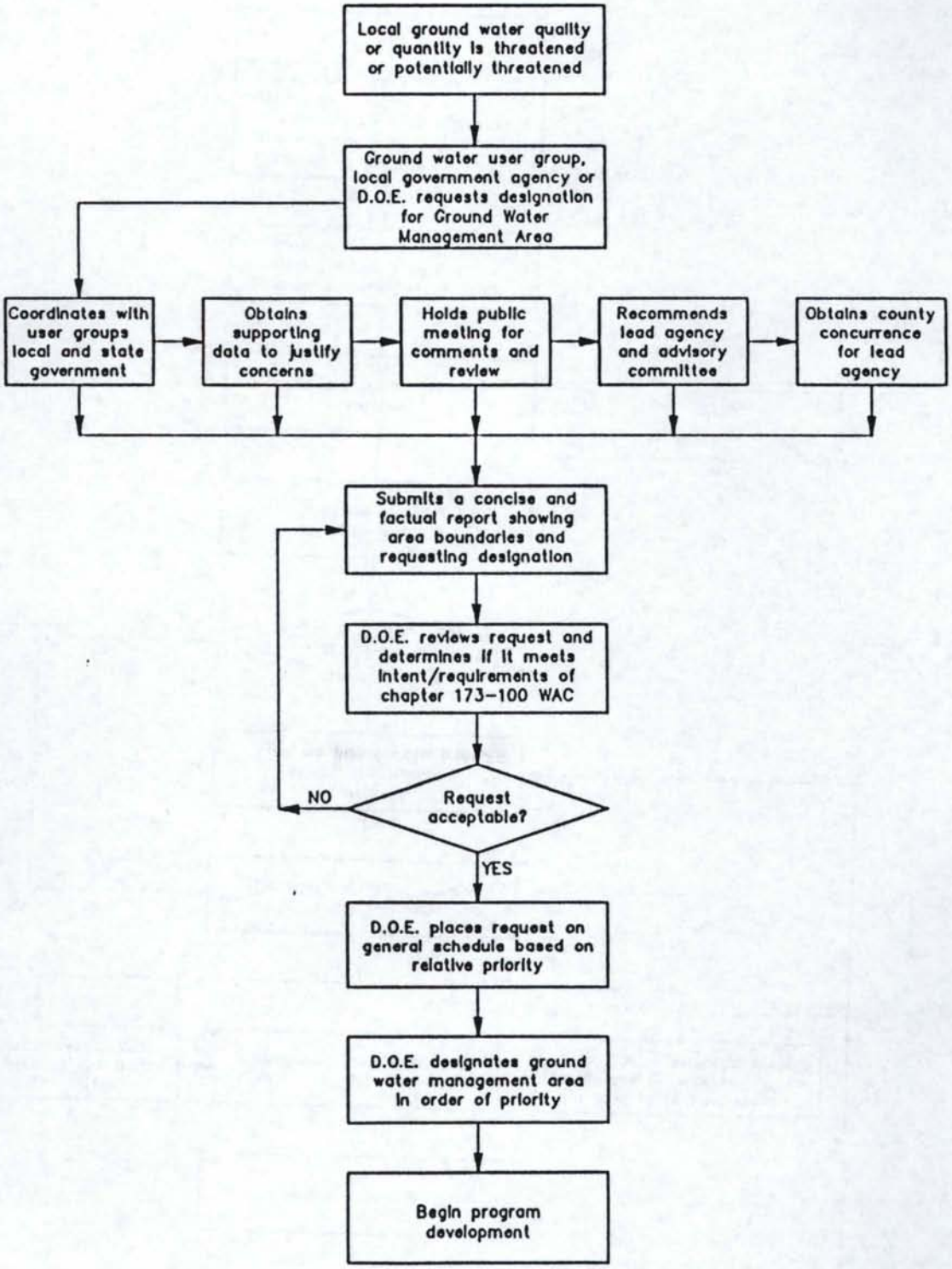

Figure 8. Request for Ground Water Management Area Designation (Peeler, 1986).

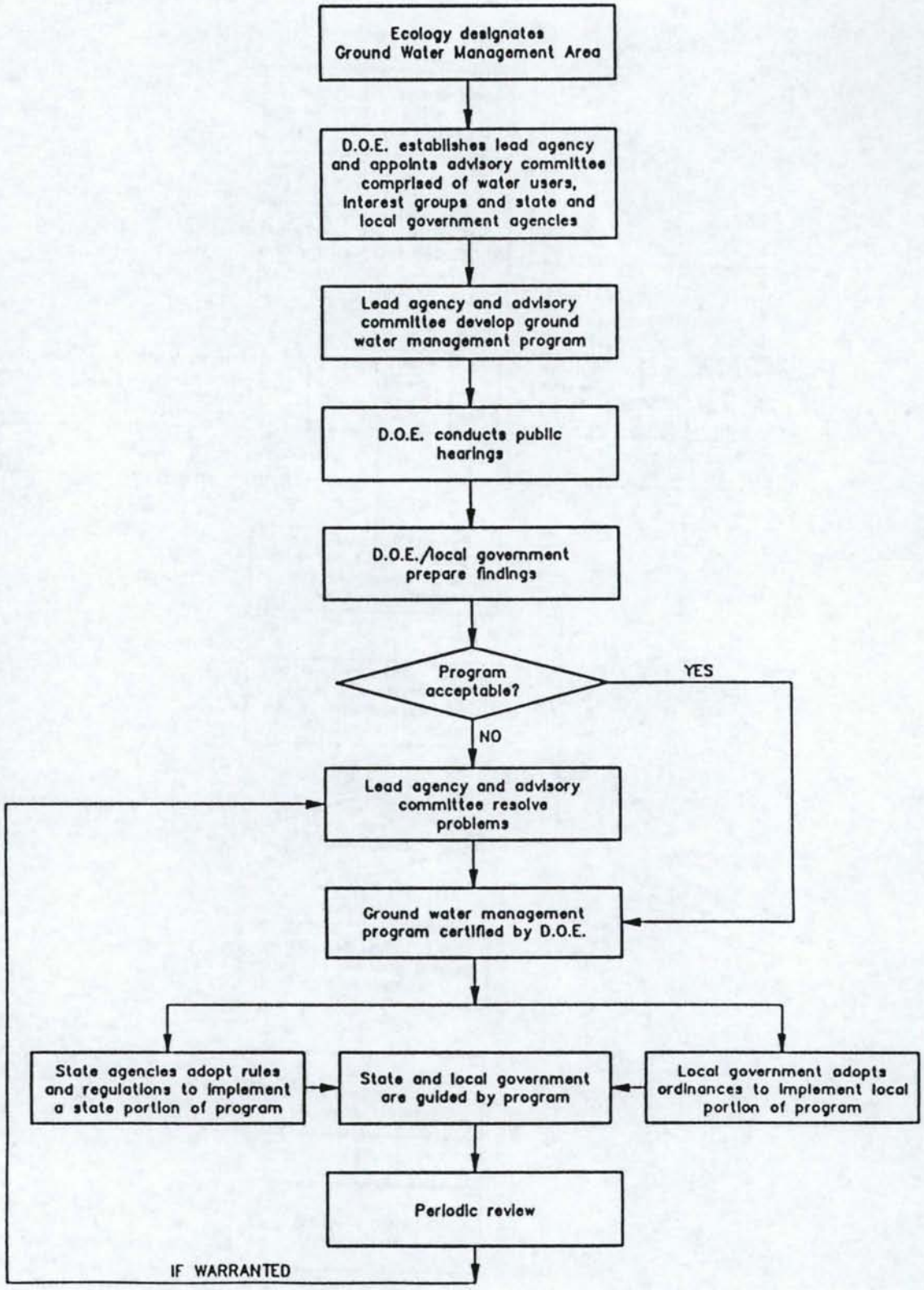

Figure 9. Ground Water Management Program Development (Peeler, 1986).

management plans to the water users and local entities. The Washington statutes remain unspecific as to what the management plans should or may contain.

Administration

The Division of Water Resources has established three Ground Water Management Areas under the 1945 authority (fig. 10). Ground water management regulations have been adopted by the Division of Water Resources for the Quincy subarea and the Odessa subarea. The Quincy designation was made to protect private ownership of irrigation return flows. The Duck Lake subarea also was designated for the purpose of administrating irrigation return flows. A management program will be developed for Duck Lake when adjudication of the Okanogan Irrigation District is completed. The Odessa designation was made to manage water level decline problems, and is discussed further in the Management Case History section.

The designation of Ground Water Management Areas under the 1985 statutes is still in its formative stages. Eight management area designations have been initiated under the 1985 statutes (fig. 10).

Management Case Study: Odessa Ground Water Management Subarea

Development History

The Odessa Ground Water Management Area is located in east central Washington (fig. 10). Table 5 summarizes the geography, geology, and hydrogeology of the area.

Early settlers in the Odessa area drilled wells for domestic and stock watering purposes (Garrett, 1968). Dry land rotation farming of wheat was the primary agricultural practice prior to 1960. The

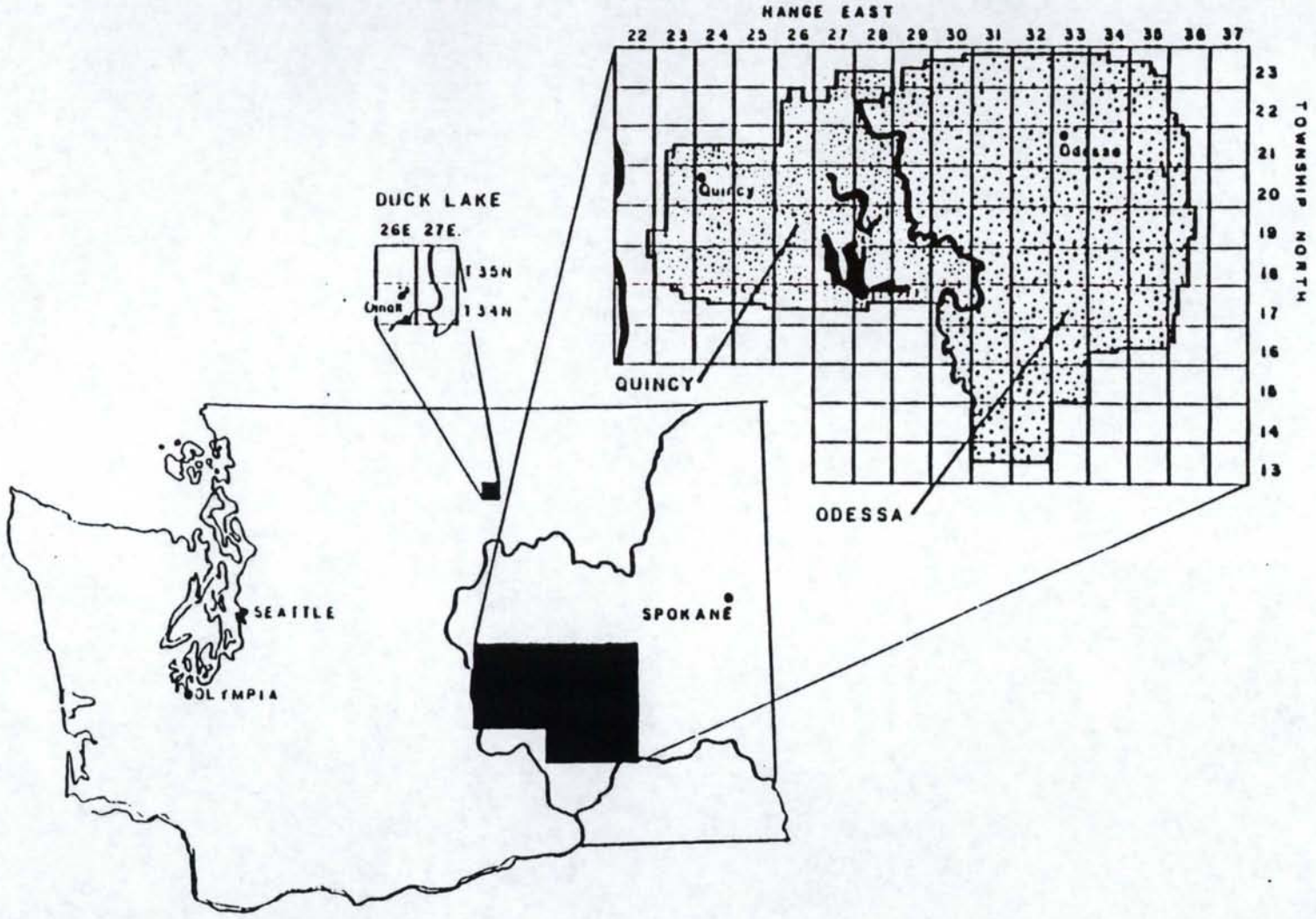

Figure 10. Ground Water Areas (Critical) in Washington, 1986 (Olson, 1986; Peeler, 1986).

Table 5. Physical Description of the Geography, Geology, and Hydrogeology of the Odessa Ground Water Management Area, Washington (Luzier and Burt, 1974; Olson, 1983; Olson, personal communication, 1986).

Geography	
Location (see fig. 5)	Located in east central Washington, approximately 1200 miles^2 in size, bounded by east low canal to west (Columbia Basin Project), political boundaries to north, east, and south.
Drainage	Crab Creek (ephemeral stream).
Land Use	Agriculture, primary crop is wheat.
Climate	Semi-arid, receiving an average of 6 to 10 inches of rainfall per year.
Geology	
Stratigraphy	Approximately 4,400 feet of Tertiary Columbia River Basalt, overlain locally by Pleistocene eolian silts and sand.
Structure	Basalt dips gently ($<5^o$) to east, and is fractured, locally faulted.
Hydrogeology	
Aquifers	Zone A: aquifers found in interflow zones of the Saddle Mountains and Wanapum Basalt formations. Zone B: aquifers found in the interflow zones of the underlying Grande Ronde Basalt formation.
Transmissivity	10^3 to $3x10^4$ ft^2/day.
Storativity	Bulk value: 10^{-3}.
Recharge	Unknown.
Discharge	Columbia and Snake Rivers are regional discharge areas.
Water Use	Primarily irrigation; also municipal and domestic.

supplemental irrigation of wheat was first attempted in the late 1950's. Yields were doubled and tripled with the addition of 6 to 8 inches of irrigation water. Wheat prices were high, and the switch to irrigated agriculture occurred rapidly. Irrigation expansion in the 1960's was based on large diameter wells which were uncased (open hole) in both upper (zone A) and lower (zone B) aquifers, providing maximum production. Luzier and Skrivan (1975) report that pumpage quadrupled in the Odessa area during the 1960's. Olson (1983) reports that the number of wells in the area doubled during the same time period.

The development of ground water for irrigation in the 1960's had two primary physical impacts. First, the many open holes connecting the upper and lower aquifers have allowed drainage of water from the shallow aquifer (zone A) into the lower aquifer (zone B). Secondly, water level in the lower zone B aquifer has declined at rates of 8 to 18 feet per year (Luzier and Burt, 1974).

Management History

1967. The Division of Water Resources designated the "Odessa Hold Area," placing a moratorium on the issuance of additional permits (Luzier and Skrivan, 1975). The moratorium gave the Division of Water Resources time to evaluate the effects of high volume pumpage in the area (Olson, 1983). The Division of Water Resources evaluation included three components:

1) development of a three dimensional finite-difference model of the aquifer system in conjunction with the U.S. Geological Survey.
2) a feasibility study of flow meter requirements.
3) an economic study of the water pumpage/use to determine a reasonable, feasible pumping lift.

1973. The Odessa Ground Water Management Subarea was established by the Division of Water Resources. The "Sub-Area" designation was based on the statutory distinction that the management area did not comprise an entire basin (table 4, part K). The Subarea boundary was drawn with the idea that withdrawals within the boundary would not affect water levels outside the area. Management regulations were drafted and hearings were held.

1974. The revised regulations were adopted and codified as WAC 173.128A and WAC 173.130. These regulations:

1) define the Subarea boundary.
2) define a maximum allowable rate of water level decline of 30 feet in three years.
3) define a maximum allowable pumping lift of 700 feet.
4) define aquifer zones A and B (as in table 5) and zone C from 300 feet below mean sea level downward for use in permitting new water users.
5) define an irrigation season (March 1 to Sept. 30).
6) define a water duty (2.5 feet/acre).
7) require that totalizing flow meters be installed on each well.
8) require that static water levels be measured each spring in each well.
9) require an annual review of the regulations for five years.
10) require that new permits be evaluated with respect to the above rules.

The Division of Water Resources evaluated the many permit applications which were still on "hold" based on the new regulations. The finite difference model was used to predict water level impacts from the proposed

pumpage. A small number of new permits were issued. The intent of the management program was to ensure "the maintenance of a safe sustaining yield by defining a reasonable and feasible pumping lift" (Olson, 1983, p. 131).

1975. The regulations were revised so that new or reworked wells would be required to case off (seal) zone A and prevent drainage into aquifer B. The irrigation season also was lengthened by three months.

1982. Four important revisions were made in the regulations. First, the flow meter requirement was eliminated. Many flow meters had failed and the water users found them expensive to replace. Second, the aquifer designations were lifted, essentially allowing the interconnection of aquifers. This change helped farmers who were experiencing high electricity (pump) costs. Third, the boundary of the area was extended southward. Lastly, an acreage expansion program was established. The program allowed irrigators to alter their water duty without increasing their pumpage, i.e., spreading the same total volume of water over a larger land area.

During the same year, the Division of Water Resources evaluated an additional 129 new permit applications. It was decided that the 1974 aquifer model was not sufficiently accurate in its predictions to evaluate the impacts from the proposed new pumpage. Therefore a new two-dimensional finite-difference model was utilized. Ten new permits were approved (1500 acre-feet total) based on operation of this model (Olson, 1983).

Post 1982. Water levels have continued to decline, but at a reduced rate. Areas where decline rates were 10 to 18 feet/year during the mid 1970's have experienced a 5 to 6 feet/year drop during the early 1980's.

Flow meters are not in place so that current total pumpage is unknown. A cooperative Division of Water Resources-U.S. Geological Survey program is underway to estimate pumpage using power consumption records and Landsat images. Participation in the acreage expansion program is small.

Currently (1987), pumpage in the Odessa subarea is decreasing because of factors beyond the control of state management activities. Many irrigators have reduced their pumpage because of power costs. Some farmers have returned to dry land farming because of general economic conditions. Olson (personal communication, 1986) believes that the high cost of power and low wheat prices ultimately will limit use of the ground water in the subarea.

OREGON

Introduction

The management of ground water in Oregon is based on the prior appropriation doctrine. The state has a long history of adherence to this doctrine, and has followed an appropriative water rights system since 1909 (Glick, 1986). A ground water code was established for the eastern portion of the state in 1927. Statewide ground water laws were enacted in 1955, and since that time the management of ground water has been isolated by the statutes from the management of surface water (Huffman, 1986).

The ground water code of Oregon is administrated by the Department of Water Resources (DWR). The policies of the Department of Water Resources are established by the Water Resources Commission, which consists of seven members appointed by the Governor to staggered four year terms. The Director of the Department of Water Resources serves as liaison to the Commission, and is a central figure in the Department of Water Resources' administrative activities. All information contained in the administration and management history sections of this chapter, except where otherwise cited, is drawn from personal interviews with William Young, Fred Lissner, Marc Norton, Larry Jebousek, and Mike Zwart, Oregon Department of Water Resources.

Appropriation Doctrine

The Oregon ground water code incorporates the major tenants of the prior appropriation doctrine. Beneficial use is stated clearly as the basis of ground water rights (table 6, part A), and is defined further in other sections of the statutes (Oregon Revised Statutes (O.R.S.))

Table 6. Ground Water Statutes in Oregon.

A. Appropriation Doctrine Statement for Ground Water

O.R.S. §537.525 (2), (3), (4) "Rights to appropriate ground water and priority thereof be acknowledged and protected...Beneficial use without waste, within the capacity of available sources, be the basis measure and extent of the right to appropriate ground water...All claims to rights to appropriate ground water be made a matter of public record..."

B. Administration of Ground Water Rights

O.R.S. §537.605 "...Any person or public agency claiming any right to appropriate ground water...is entitled to receive from the Water Resources Commission...a certificate of registration as evidence of a right to appropriate ground water."

C. Limit on Use of Ground Water

O.R.S. §537.525 (5) "Adequate and safe supplies of ground water for human consumption be assured, while conserving maximum supplies of ground water for agricultural, commercial, industrial, recreational and other beneficial uses."

D. Prevention of Ground Water Waste

O.R.S. §537.525 (9) (10) "...Wasteful use of ground water, impairment of or interference with existing rights to appropriate surface water, declining ground water levels, interference among wells, overdrawing of ground water supplies...controlled use of the ground water concerned be authorized and imposed...Location, construction, depth, capacity, yield, and other characteristics of and matters in connection with wells be controlled..."

E. Reasonable Feasible Pumping Lift

O.R.S. §537.525 (7) (8) "Reasonably stable ground water levels be determined and maintained...Depletion of ground water supplies below economic levels, impairment of natural quality by pollution and wasteful practices in connection with ground water be prevented or controlled within practicable limits."

F. Impairment of Senior Appropriators

O.R.S. §537.620 (3) "When an application [to appropriate] discloses the probability of wasteful use or undue interference with existing wells or...will impair or substantially interfere with existing rights to appropriate surface waters...the commission may impose conditions or limitations in the permit...or reject the same after hearing."

Table 6. Continued.

G. Definition of Impairment

The Department of Water Resources has defined undue interference as an inability of the senior appropriator to exercise is right. Water levels are not protected, and a senior appropriator may need to rework his well to exercise the water right (Lissner, 1986).

H. Adjudication of Ground Water Rights

O.R.S. §537.670 (1) "The Water Resources Director upon the motion of the director or, in the discretion of the director, upon receipt of a petition therefor by any one or more appropriators of ground water... may proceed to make a final determination of the rights to appropriate the ground water of any ground water reservoir in this state."

I. Ground Water Management Areas

O.R.S. §537.730 "The Water Resources Commission upon the commission's own motion or...upon receipt of a petition...may initiate a proceeding [for determination of a critical ground water area] if the commission has reason to believe that: a) ground water levels in the area in question are declining or have declined excessively; b) [substantial well interference problems exist]; c) [ground water pumpage]... interferes with the production of geothermal resources; d) the available ground water supply in the area in question is being or is about to be overdrawn; e) [ground water pollution problems are occurring or will occur]."

J. O.R.S. §537.735 (2) "The order of the commission shall define the boundaries of the critical ground water area and shall indicate which of the ground water reservoirs located within the area in question are included within the critical ground water area. Any number of ground water reservoirs which either wholly or partially overlie one another may be included within the same critical ground water area."

K. Critical Area: Management Tools

O.R.S. §537.735: (4) "a) A provision closing the critical ground water area to any further appropriation of ground water. b) A provision determining the permissible total withdrawal of ground water in the critical area each day, month, or year, and...apportion such withdrawal among the appropriators...in accordance with the relative dates of priority... c) A provision according preference, without reference to relative priorities, to withdrawals of ground water in the critical area for residential and livestock watering purposes first. d) A provision reducing the permissible withdrawal of ground water by any one or more appropriators or wells in the critical area... g) A provision requiring and specifying a system of rotation of use of ground water in the critical area."

§537.160). The appropriation system also is evident in the use of water right priority dates (O.R.S. §537.250), land appurtenance requirements (O.R.S. §537.705), and forfeiture through non use criteria (O.R.S. §537.450).

The ground water statutes of Oregon define five broad management goals. The first two of these goals involve activities which are central to prior appropriation systems:

1) The administration of ground water rights by the Department of Water Resources (table 6, part B).
2) The adjudication of ground water rights (table 6, part H).

The remaining three goals reach beyond the basic components of the appropriation system and are based on broader concepts of resource use and social responsibility:

3) The equitable distribution of ground water with preference given to human consumption (table 6, part C).
4) The control of ground water use in instances of waste, interference with existing rights, or overdraft (table 6, part D).
5) The maintenance of reasonably stable ground water levels (table 6, part E).

Administration of Ground Water Rights

Statutory Framework

The Oregon Ground Water Act of 1955 altered water rights administration. The act established a two tier system of water rights permits. Appropriations established prior to August 3, 1955, are recognized as the first type of valid water rights. The second type of permit applies to new or modified appropriations. Water users under the

second category must apply for permits prior to constructing or modifying their well. Figure 11 illustrates the permitting process defined by the Oregon statutes.

The permitting process displayed in figure 11 is the core of ground water management in Oregon. Note that de minimus uses of water are excluded from the permitting process. The evaluation criteria shown in the figure are significant, particularly the potential impairment of surface water rights. This is the only point in Oregon's management system where ground water-surface water interference may be examined by the Department of Water Resources. Once a ground water appropriation is permitted, the separation of surface and ground water codes effectively prevents curtailment of ground water pumpage in the interest of surface water rights. Additional criteria for permit approval are found in statutes pertinent to the prevention of "overdraft" (table 6, part D), and the maintenance of "reasonably stable" and "economic" water levels (table 6, part E).

The Department of Water Resources may take one of three actions on a permit, based on the evaluation criteria. First, the Department of Water Resources may impose conditions or limitations on the permit. These may include any or all of the following: reducing the quantity pumped, specifying the well location, or limiting the time of use. The second option is the holding of a hearing to determine the facts and opinions of affected water users which pertain to the permit. This hearing may be initiated by the department or by a protest of the permit by other potentially affected appropriators. These first two options are illustrated in figure 11. The third option available to the Department of

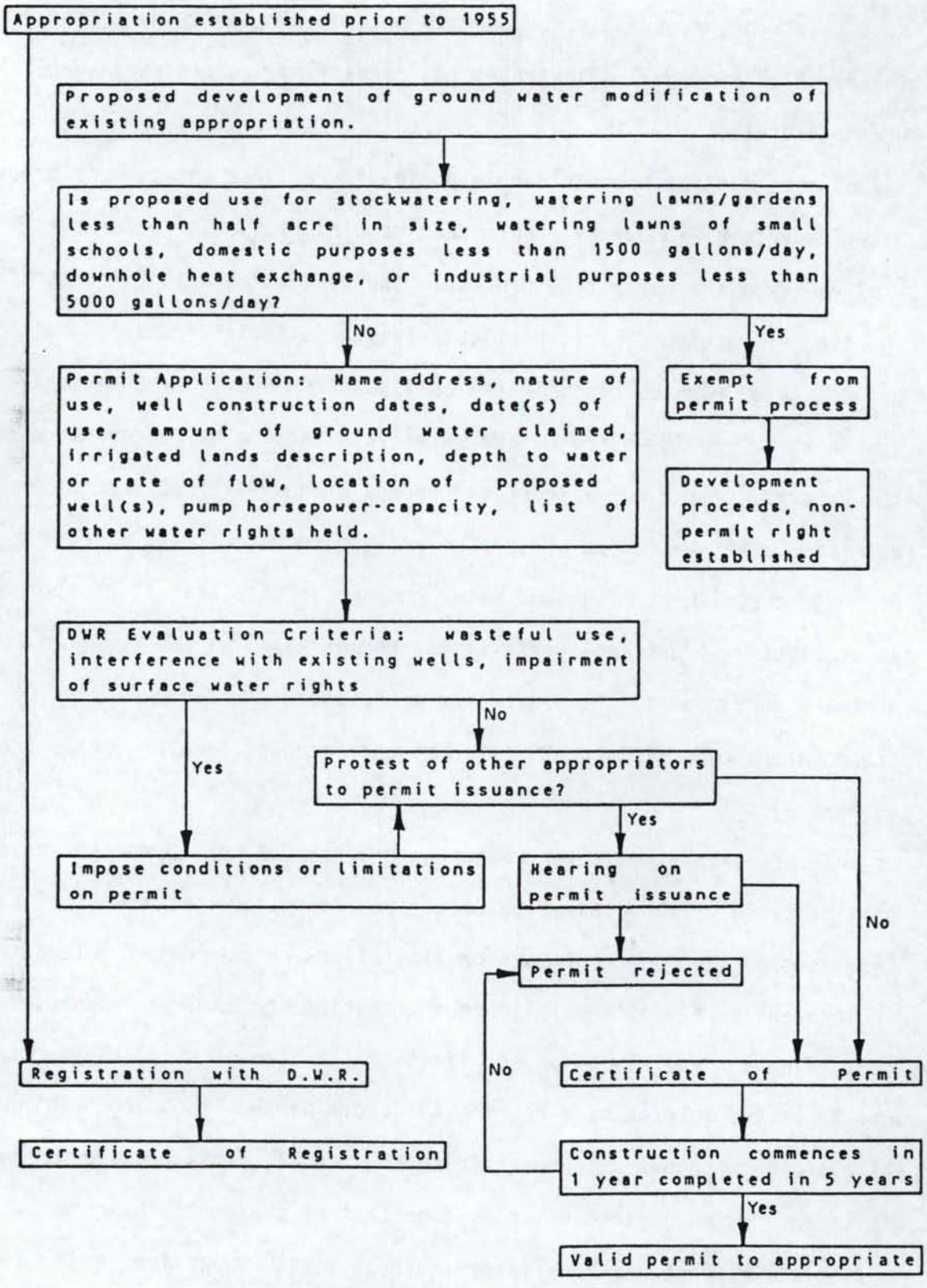

Figure 11. Oregon Statutory Procedure for Acquiring Permits to Appropriate Ground Water.

Water Resources is initiation of proceedings to designate a Critical Ground Water Area.

Administration

The Department of Water Resources engages in two types of activity in administering the system of ground water rights. The first activity is reviewing permit applications. The second involves the enforcement of relative priorities in instances of water user conflicts.

There are many criteria which must be evaluated by the Department of Water Resources in review of a permit application. The Department of Water Resources places an emphasis on evaluating potential interference with existing surface or ground water rights. The wasteful use criteria (table 6, part D) and stable water level criteria (table 6, part E) are not applied vigorously. The Department of Water Resources attempts to utilize these two criteria more fully in hearings on permit applications and in the Critical Ground Water Area activities.

The Department of Water Resources routinely modifies permit applications prior to approval. Common modifications include changes in the rate of diversion, the duty of water, and the time of use. The Department of Water Resources commonly enforces such modifications through the use of totalizing meters on wells. Additionally, some proposed shallow wells in direct proximity to streams may be reclassified completely as surface appropriations.

Objections to proposed ground water appropriations are uncommon. They occur for less than 1% of the applications. In cases where hearings are necessary, the Department of Water Resources Hearings officer presides. Protests against new appropriations occur more commonly after the permit is exercised. The Department of Water Resources responds to

conflicts between permitted appropriators by sending personnel into the field to work out cooperative agreements with the respective users.

The resolution of water rights conflicts frequently hinges on the definition of "undue interference." To define "undue interference" the Department of Water Resources examines the answers to three questions:

1) Can hydraulic connection be established between the wells?
2) Can the senior appropriator continue to exercise his right?
3) If the answer to either question is negative, does the well construction of the senior appropriator contribute to the problem?

In the view of the Department of Water Resources, well interference is not "undue" if the senior appropriator has failed to develop fully the aquifer (e.g. poor well construction, partial penetration). The activities of the Department of Water Resources to resolve conflicts through cooperative agreements frequently are successful. Where conflicts remain unresolved, the water users may resort to litigation; the Department of Water Resources may initiate proceedings to designate a Critical Ground Water Area.

Adjudication of Water Rights

Statutory Framework

The adjudication of ground water rights in Oregon may be initiated by the Director of the Department of Water Resources, or by water users via petitions. The adjudication process then proceeds in two phases, as illustrated in figure 12. The first phase involves a determination of priorities and volumes by the Department of Water Resources. This determination then is subject to a review by the state circuit courts. The adjudication statutes protect water users by allowing determinations

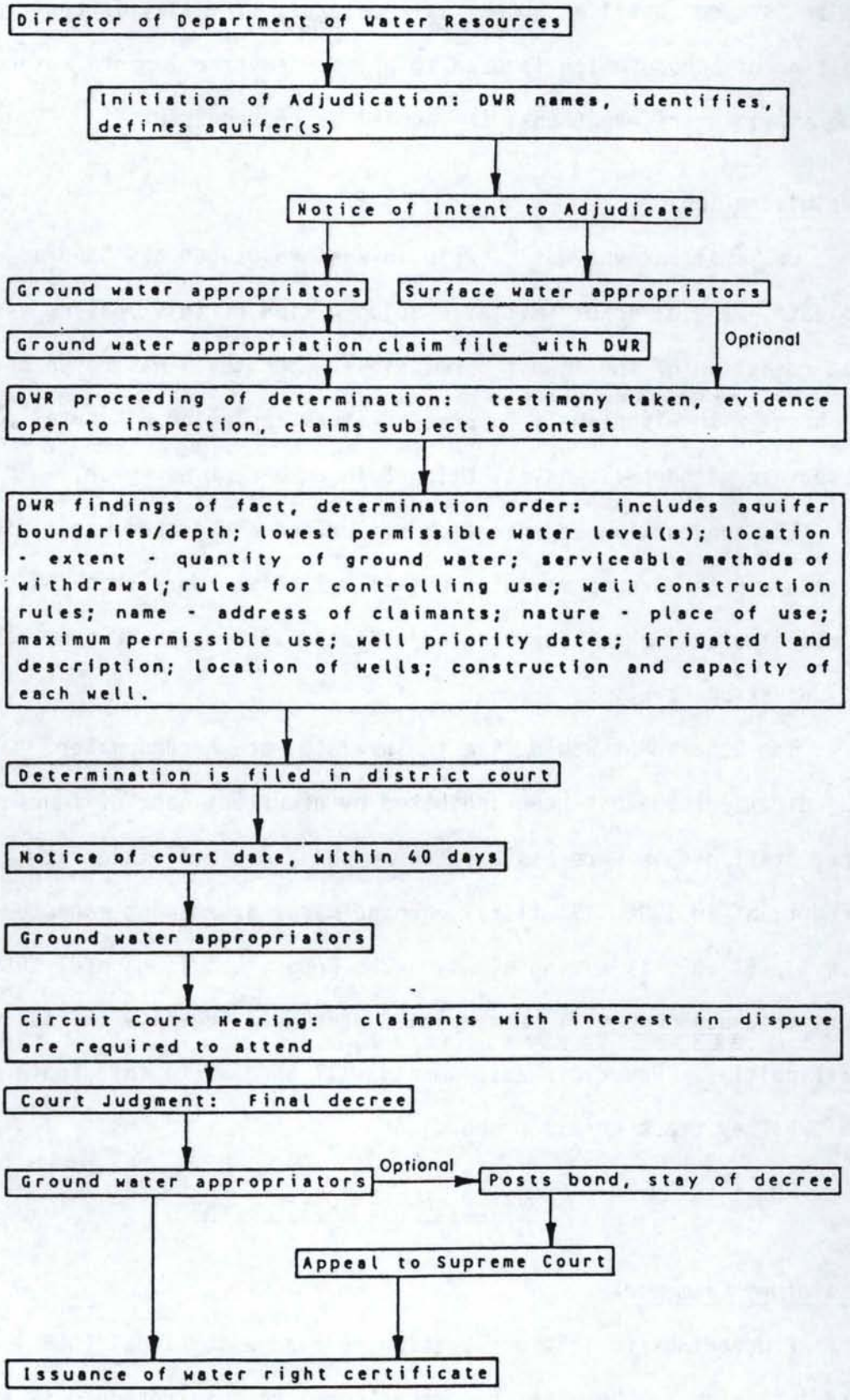

Figure 12. Adjudication Procedure in Oregon.

to be "stayed" until an appeal is completed. The stay is based on the posting of a bond which is used to pay for adverse impacts associated with the stay, in the event that the appeal is unsuccessful.

Administration

One small ground water basin in western Oregon has been adjudicated to date. The director initiated adjudication of this shallow system. Determination of the lowest permissible water level was based on balancing recharge with withdrawals to prevent stock depletion. A total allowable reservoir withdrawal was established in acre-feet per year.

The conjunctive adjudication of surface and ground water rights is possible under Oregon statutes but is unlikely. More than 70% of all surface water rights have been adjudicated in Oregon. Ground water adjudication barely has begun.

The Department would like to initiate more ground water adjudications but has been inhibited by a current lack of funding. Only four staff people were assigned to adjudication activities at the Department in 1986. Similarly, ground water assessment mandated under O.R.S. §537.665 is moving slowly. The Department is hopeful that one aquifer assessment will be completed each year, despite the budget difficulties. Reservoir assessments will be used to anticipate problems before they reach crisis proportions.

Critical Ground Water Areas

Statutory Framework

Proceedings to initiate Critical Ground Water Areas (CGWA) in Oregon are initiated by the Water Resources Commission in response to a variety of conditions which are specified by statute. These conditions are listed

in table 6, part I. Note that the conditions listed basically define two ground water management problems: "excessive" or persistent water level declines and basin overdraft. Water level decline problems also are defined by the wasteful use and reasonably stable ground water levels criteria listed in table 6, part D and part E. It is interesting to note that the statutes list basin overdraft as a criteria for designating Critical Ground Water Areas, but do not require a determination of recharge and discharge to areas once they are designated.

The Commission may obtain the information necessary to initiate a Critical Ground Water Area upon its own motion, or from investigations related to permit applications or adjudications. Appropriators may petition the Commission to initiate Critical Ground Water Area proceedings.

When the Commission initiates Critical Ground Water Area proceedings, a public hearing is held to determine the necessity of the designation. A variety of corrective measures are available for use in dealing with management problems in areas which are designated. These corrective measures are listed in table 6, part K. The boundaries which may be designated for Critical Ground Water Areas are discussed in the statutes which are displayed in table 6, part J.

Administration

Five Critical Ground Water Areas have been established in Oregon and three additional areas currently are pending hearings and designation (fig. 13). Many of these Critical Ground Water Areas are located near the Columbia River. Two of the three proposed Critical Ground Water Areas, Stage Gulch and Ella Butte, are located in the Umatilla Basin where the Ordinance and Butter Creek areas already have been designated.

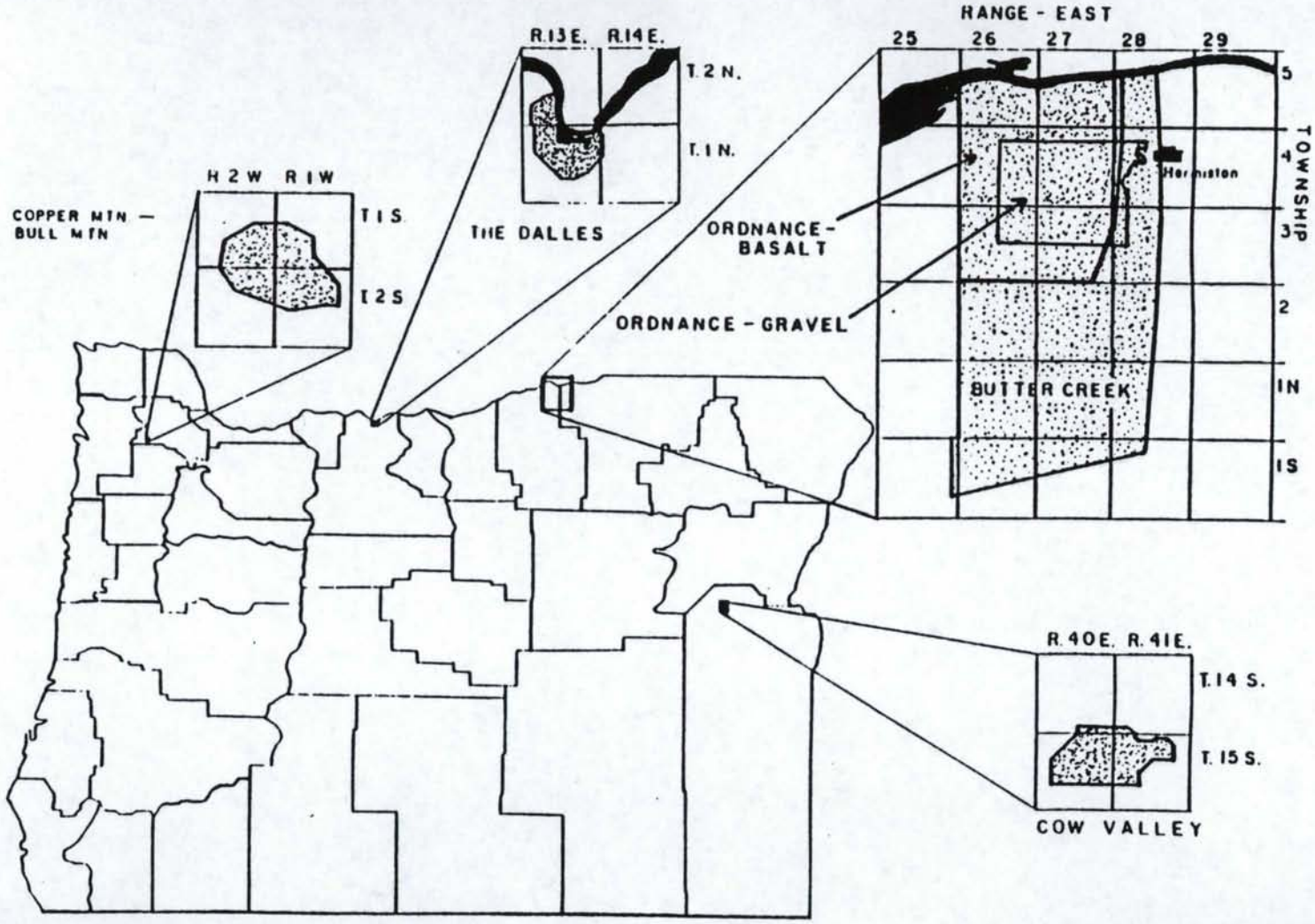

Figure 13. Critical Ground Water Areas in Oregon, 1986 (Lissner, 1986).

Most of Oregon's Critical Ground Water Areas have been designated in areas where irrigated agriculture is the predominant water use. Declines in The Dalles area, however, are associated with competitive use by both municipal and irrigation interests. The Cooper-Bull Mountain area has been designed in a Portland suburb where domestic wells tap a fractured basalt aquifer. In all instances the Critical Ground Water Area designation has been made in areas where:

1) significant water level declines are occurring annually (e.g. 10 feet per year or more).
2) well interference conflicts require the constant and repeated attention of the Department of Water Resources.
3) applications for new permits to appropriate ground water are being filed in significant numbers.

In the words of Fred Lissner, "the Critical Ground Water Area designation has been a response to crisis situations" (Lissner, 1987).

One of the proposed Critical Ground Water Areas, Fort Rock Christmas Valley, is being designated in anticipation of a potential water management "crisis." The Department of Water Resources has determined that pumpage in the area has approached the determined recharge to the aquifer (80,000 acre-feet annually). It is hoped that the current designation will prevent overdraft of the aquifer as well as the divisive well interference conflicts which have occurred in other Critical Ground Water Areas. If successful, this designation will represent a significant step in Oregon ground water management. Currently the management effort has been frustrated by the courts approval of the designation for only a two-year temporary period.

The temporary designation of the Fort Rock area illustrates a significant problem in the Oregon Critical Ground Water Area program. The Department of Water Resources has experienced significant problems in designating Critical Ground Water Areas permanently, particularly where the designations are opposed by appropriators. Affected water users are entitled to judicial review of a critical designation, stalling the management effort. The Butter Creek designation has undergone ten years of litigation to date (1987) and currently is being challenged in the courts for a third time.

Management Case Study: The Umatilla Basin

Development History

The most pervasive ground water management problems in Oregon have occurred in the Umatilla Basin. The basin is located in northeastern Oregon and covers an area of 4,500 square miles (fig. 13). The geography, geology, and hydrogeology of the basin are summarized in table 7.

Development of ground water in the Umatilla Basin has occurred in two aquifer systems. An alluvial aquifer system overlies the Columbia River Basalts in the northwestern portion of the basin. Wells in the alluvium produce from 400 to 3000 gallons per minute (gpm). Basalt interflow zones and interbeds constitute a second aquifer system. Wells in the basalt produce from 500 to 4000 gpm.

Wells were drilled in the alluvium starting in 1950 to produce water for irrigation and domestic purposes. Wells were constructed at a rate of two and three per year up until 1966. Sixty-seven wells were constructed in the alluvium in the subsequent five year period. This large increase in pumpage resulted in water level declines averaging 1.6 feet per year.

Table 7. Physical Description of the Geography, Geology and Hydrogeology of the Umatilla Basin, Oregon (Oregon Department of Water Resources, 1976, 1980; Norton, 1987; Lissner, 1987).

Geography	
Location (see fig. 13)	Located in northeastern Oregon, 4500 miles^2, bounded by Blue Mountains to east and south, John Day Basin to west, Columbia River to north.
Drainage	Umatilla River watershed and Willow Creek drainage.
Land Use	Agricultural; principal crops include wheat, potatoes, alfalfa, peas, and fruit.
Climate	Semiarid in lowlands (7 inches annual rainfall), temperate in Blue Mountains (35 inches annual rainfall).
Geology	
Stratigraphy	Low permeability Cretaceous metasediments, granitic and ultramafic rocks overlain by Columbia River Basalts. Basalts are covered locally by lacustrine and fluvial deposits.
Structure	Regional, westward plunging syncline in Columbia River Basalts with associated faults.
Hydrogeology	
Alluvial Aquifers	Sand and gravel aquifers found in flood plains of major rivers, 150 feet thick.
Basalt Aquifers	Columbia River Basalts, flow tops and interbeds.
Transmissivity	Basalt: ranges from 1,100 to 67,000 ft^2/day.
Storativity	Basalt: 10^{-2}.
Recharge	USGS model estimate: 50,000 ac-ft/year.
Natural Discharge	Columbia River is regional discharge area.
Pumpage	Estimated presently: 180,000 ac-ft/year. Permitted withdrawal is approximately 300,000 ac-ft/year.
Water Use	Irrigation, industrial, municipal, domestic.

By 1976 a loss of more than 50% of the predevelopment saturated thickness had occurred. The Department of Water Resources concluded that "artificial" discharge from the alluvial aquifer system by withdrawals of groundwater by wells is exceeding natural recharge to the aquifer (Oregon Department of Water Resources, 1976, p. 19-25).

The development of the basalt aquifers of the Umatilla Basin began in 1941 with the construction of three wells at the Umatilla Army Depot at Ordnance (Oregon Department of Water Resources, 1976, p. 16). Throughout the late 1940's and early 1950's a number of deep wells were constructed for municipal and industrial use at the Army Depot, and in the towns of Umatilla, Irrigon and Boardman. The development of the basalt aquifer system parallels that of the alluvium; a tremendous growth in irrigation pumpage during the 1960's and 1970's. By 1980 the permitted annual withdrawal of water approached 300,000 acre-feet per year. Current estimates of the actual pumpage are approximately 60% of the permitted amount.

The pumpage from the basalt aquifers has produced dramatic water level declines. Water levels have dropped an average of 50 feet since 1940 in the central portion of the basin. In some instances the declines have been as great as 350 feet in 25 years. The Department of Water Resources has concluded that pumpage exceeds recharge to the basalt aquifers.

Management History

1976. The Department of Water Resources designated two Ordnance Critical Ground Water Areas in 1976 (fig. 13). The designations cover the alluvial aquifer and the basalt aquifer separately. The designations were based on the conclusion that pumpage exceeded recharge to both

aquifer systems. The evidence of overdraft was the continual decline of water levels.

The Department of Water Resources cites specific sections of the statutes in the single designation order. In addition to noting the Critical Ground Water Area statutes, the hearings order notes the necessity of maintaining stable water levels (table 6, part E).

The alluvial Critical Ground Water Area was closed to further appropriation and a number of pending appropriation permits were rejected. A maximum cumulative annual withdrawal of 9,000 acre-feet per year was established for the area, and the local water master was designated to enforce the withdrawal based on priority of existing rights.

The designation also established a Critical Ground Water Area in the Ordance basalt aquifer system. The area was closed to future appropriations and the pending new appropriations were rejected. Several applications to change point of diversion were approved. An irrigation season was established and all existing water users were required to equip their wells with totalizing meters.

In 1976 the Department of Water Resources also designated the Butter Creek Critical Ground Water Area (fig. 13). The designation was challenged immediately in court, as the statutes provide for judicial review of all Critical Ground Water Area designations.

1977. The Butter Creek designation was remanded by court order, based on a procedural error by the Department of Water Resources. The Director of Water Resources had failed to read the entire transcript at the hearing. The area was designated again in late 1977.

1979. The Butter Creek designation was remanded again when challenged in court. The Department of Water Resources had failed to mail notices of the hearing and designation by certified mail.

1985. The Department of Water Resources issued two proclamations of intent to designate Critical Ground Water Areas in the Stage Gulch and Ella Butte areas (fig. 13). In both areas the Department of Water Resources indicated that "recharge is being exceeded by pumping demand" (Oregon Department of Water Resources, 1985a, 1985b, p. 2). The proclamations suspend actions on all pending permits to appropriate ground water from basalt aquifers.

1986. The Department of Water Resources designated the Butter Creek Critical Ground Water Area for a third time. The designation was based on "excessive" water level declines since 1940, which averaged 50 feet per well, and have been as great as 400 feet in some instances. The continual water level decline in the management area was determined to indicate an overdraft of the basalt aquifers, although recharge to the basalt aquifers was not determined. Calibration of a USGS model provides an estimate of recharge of 50,000 acre-feet per year (Lissner, 1987). Pumpage in the Butter Creek area from 1976 to 1983 ranged from a peak of 27,000 acre-feet in 1977 to a low of 15,000 acre-feet in 1983. In the 1986 hearing order the Department of Water Resources concludes that

> "the average annual withdrawal of water from the proposed Butter Creek CGWA basalt ground water reservoir for the period of record, together with any natural discharge from the said ground water reservoir, has been in excess of the average annual natural recharge to the said ground water reservoir" (Oregon Department of Water Resources, 1986, p. 11).

The Butter Creek hearing order cites specific statutory sections in justifying the designation. The order notes the necessity of control

where overdraft is occurring (table 6, part D), and the necessity of maintaining stable ground water levels (table 6, part E).

The Butter Creek hearing order divides the Critical Ground Water Area into six management subareas and lists water rights priorities in each area. The designation closes the Critical Ground Water Area from further appropriations of ground water and rejects nine applications for new appropriation permits. Total annual withdrawals are established for each management subarea and are to be enforced based on priority dates listed for each subarea. Local water masters enforce the quotas, and totalizing flow meters are required on each well.

1987. The Butter Creek designation is being challenged in the courts for a third time. The current challenge is based on nine objections, four of which are hydrologically based:

1) The fact that the Critical Ground Water Area boundaries are not hydrogeologic boundaries.
2) The adjudication of rights in six subareas does not reflect the actual relative priorities of rights.
3) The Department of Water Resources has not established rules defining excessive decline, overdraft, and public health and safety.
4) The Department of Water Resources failed to adequately substantiate the conclusion that the aquifer is being overdrawn.

Hearing orders for the determination of Critical Ground Water Areas in Stage Gulch and Ella Butte are not available at this time (1987).

IDAHO

Introduction

The prior appropriation doctrine has governed Idaho water management throughout the state's history. Appropriative water rights were incorporated in the state statutes by the territorial legislature in 1881 (Ralston et al., 1984). There was some debate in the courts concerning the applicability of prior appropriation to ground water until 1931, when the doctrine was affirmed by several court cases (Ralston et al., 1984). Appropriation of ground water was incorporated in the Idaho statutes in 1951. Ground water management is administrated by the Idaho Department of Water Resources (DWR).

Ground water supplies a large portion of the water used in Idaho. Idaho currently pumps more ground water than all of its neighboring states combined (Ralston, personal communication, 1986). A majority of this water is pumped from the basalts of the Snake River Basin to supply the agricultural, industrial, and municipal needs of southern Idaho.

Appropriation Doctrine

Surface and ground water are managed under the appropriation doctrine in Idaho (table 8, part A). Idaho statutes clearly declare beneficial use as the basis for all water rights (Idaho Code (I.C.) §42-104). Priority between appropriators is based on the principal of "first in time is first in right," (I.C. §42-106). Surface and ground water rights are incorporated in a single system of relative priorities, and are treated in a single section of the Idaho Code.

Table 8. Ground Water Statutes in Idaho.

A. Appropriation Doctrine Statement for Ground Water

Idaho Code (I.C.) §42-103 "The right to the use of the unappropriated waters of rivers, streams, lakes, springs, and of subterranean waters or other sources within this state shall hereafter be acquired only by appropriation under the application, permit and license procedure..."

B. Administration of Ground Water Rights

I.C. §42-201 "All rights to divert and use the waters of this state for beneficial purposes shall hereafter be acquired and confirmed under the provisions of the Chapter and not otherwise...Such appropriation shall be perfected only by means of the application, permit and license procedure as provided in this title..."

C. Limit on Use of Ground Water

I.C. §42-237a g. "Water in a well shall not be deemed available to fill a water right therein if withdrawal therefrom of the amount called for by such right would affect, contrary to the declared policy of this act, the present or future use of any prior surface or ground water right or result in the withdrawing of the ground water supply at a rate beyond the reasonably anticipated average rate of future natural recharge..."

D. The Prevention of Ground Water Waste

I.C. §42-237a b. "To require both flowing and nonflowing wells to be so constructed and maintained as to prevent the waste of ground waters through leaky wells, casings, pipes, fittings, valves, or pumps either above or below the land surface."

E. Reasonable Pumping Levels

I.C. §42-226 "...Prior appropriators of underground water shall be protected in the maintenance of reasonable ground water pumping levels as may be established by the director of the department of water resources..."

F. Impairment of Senior Appropriators

I.C. §42-226 "The traditional policy of the state of Idaho, requiring the water resources of this state to be devoted to beneficial use in reasonable amounts through appropriation, is affirmed with respect to the ground water resources of this state as said term is hereinafter defined and, while the doctrine of "first in time is first in right" is recognized, a reasonable exercise of this right shall not block full economic development of underground water resources."

Table 8. Continued.

G. Adjudication of Ground Water Rights

I.C. §42-1406 (1) "Upon petition signed by five (5) or more or a majority of the users from any water system requesting a determination of the rights of the various claimants of water from that system, if the director deems that the public interest and necessity will be served by a determination of the water rights of that water system, the director shall petition the court for an order commencing a general adjudication of the rights of the claimants from the water system... (2) If the director deems that the public interest and necessity will be served by a determination of the water rights of any water system, the director, upon his own initiative, may file a petition for entry of an order commencing a general adjudication."

H. Snake River Basin Adjudication

I.C. §42-1406A (1) "Effective management in the public interest of the waters of the Snake River basin requires that a comprehensive determination of the nature, extent and priority of the rights of all users of surface and ground water from that system be determined."

I. Critical Ground Water Areas

I.C. §42-233a " 'Critical ground water area' is defined as any ground water basin, or designated part thereof, not having sufficient ground water to provide a reasonably safe supply for irrigation of cultivated lands, or other uses in the basin at the then current rates of withdrawal, or at rates of withdrawal projected by consideration of valid and outstanding applications and permits, as may be determined and designated, from time to time, by the director of the department of water resources...In the event the application for permit is made in an area which has been designated as a critical ground water area, if the director of the department of water resources...has reason to believe that there is insufficient water available subject to appropriation at the location of the proposed well described in the application, the director of the department of water resources may forthwith deny said application..."

J. Ground Water Management Areas

I.C. §42-233b " 'Ground water management area' is defined as any ground water basin or designated part thereof which the director of the department of water resources has determined may be approaching the conditions of a critical ground water area...Applications for permits made within a ground water management area shall be approved by the director only after he has determined on an individual basis that sufficient water is available and that other prior water rights will not be injured...The director, upon determination that the ground water supply is insufficient to meet the demands of water rights within all or portions of a water management area, shall order those

Table 8. Continued.

water right holders on a time priority basis, within the area determined by the director, to cease or reduce withdrawal of water until such time as the director determines there is sufficient ground water..."

K. Ground Water Recharge Districts

I.C. §42-4201A (1) "...The legislature hereby acknowledges that proposed projects to recharge water basins in the state by means of storage of unappropriated waters of the public waters of the state in underground aquifers represents a unique and innovative endeavor to further water conservation and increase the water available for beneficial use. (§42-4202) For purposes of formation of the aquifer recharge district, a petition shall be presented to the Department of Water Resources which shall set forth the object of the organization of the district and the benefits to be provided by the district. The petition shall be accompanied by a map of the proposed district which shall indicate the proposed boundaries of the district, the nature and location of the proposed diversion works and other facilities by means of which water is to be diverted into the recharge area. Shall delineate the underground water basin or basins to be affected by the recharge, and shall designate the location of any streams or springs which shall be affected by the recharge..."

Ground water development under the appropriation doctrine is managed with respect to three criteria. First, development must not exceed the "anticipated average rate of future natural recharge" (table 8, part C). Second, ground water appropriators are "protected in the maintenance of reasonable ground water pumping levels" (table 8, part E). Lastly, the enforcement of relative priorities between appropriators "shall not block full economic development of underground water resources" (table 8, part F). Taken as a whole, these criteria establish the policy in Idaho of managing ground water as a renewable resource. Additionally, the statutes declare the policy objectives of: (1) administrating a system of water rights, (2) adjudicating ground water rights, (3) preventing ground water waste (table 8, part D), and (4) encouraging artificial recharge of ground water.

Administration of Ground Water Rights

Statutory Framework

Appropriators of ground water must obtain a permit to construct a well, and are issued a license when the diversion is complete (table 8, part B). Prior to 1963 the permitting process was optional, and ground water users could establish a "constitutional method" water right simply by constructing their well and putting the water to a beneficial use (Ralston et al., 1984). The licensing process is now mandatory, and is illustrated in figure 14. The Idaho Department of Water Resources examination step of the process lists several criteria. The reasonable pumping lift and recharge limit criteria (table 8, part E and part C) could be used to determine the sufficiency of water supply in the application evaluation process. The information included in the permit

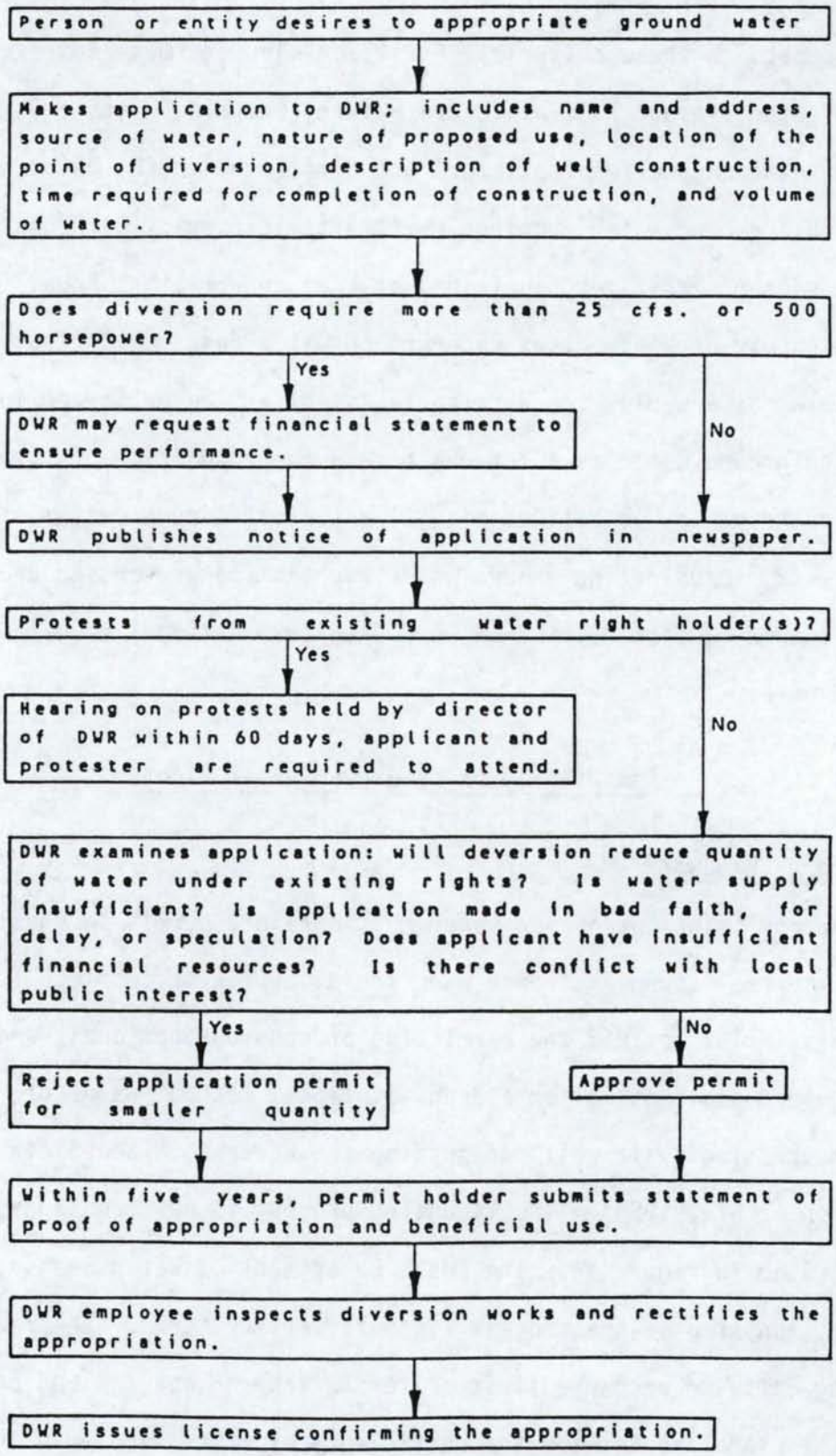

Figure 14. Ground Water Appropriation Process in Idaho.

application (i.e., volume of water, point of diversion, nature of use, and period of use) all become part of the licensed water right, and application must be made to the Idaho Department of Water Resources to change any of these characteristics of the right (Ralston et al., 1984).

Administration

The practical administration of surface water rights is discussed in Ralston et al. (1984); the following discussion is based on this source. For the purpose of administrating water rights, large parts of the state of Idaho are divided into water districts. Each water district is managed by a water master who is elected by district water users and supervised by the Idaho Department of Water Resources. The water master allocates surface water on the basis of priority; however, all adjudicated and licensed rights are treated as senior to all unadjudicated and "constitutional method" rights. Water masters report to the Idaho Department of Water Resources, and the Idaho Department of Water Resources coordinates priorities between districts for the entire water division. The water masters, however, are not actively involved in the administration of priorities related to ground water rights.

The director of the Idaho Department of Water Resources may restrain any ground water appropriator in accordance with the "reasonable pumping lift" criteria (table 8, part E). A "ground water board" may be created to hear objections and disputes arising from the administration policies or disputes between appropriators. The board consists of the director, a licensed engineer, and a local appropriator. As in other appropriation doctrine states, appropriators may also assert their priorities through litigation.

Adjudication of Water Right

Statutory Framework

The statutes of Idaho delineate three adjudicatory processes. The first is a private action adjudication, and may be initiated by a single water user. In this instance, the adjudicatory process is used to resolve a water rights dispute of limited size, and the determination joins only those water users directly involved in the disagreement. The second process is a general adjudication, and involves the determination of all water rights in a given water system. The third process is a supplemental adjudication, and is designed to update a general adjudication.

The general adjudication process is currently of great importance in Idaho, and is the most comparable of the three types to the processes of other states. A general adjudication may be initiated by a petition of water users or by the director of the Idaho Department of Water Resources (table 8, part G). Recent legislation demonstrates that a general adjudication may also be initiated by the state legislature. Via statute §42-1406A (1985), the legislature ordered the director to initiate a general adjudication of the Snake River Basin.

The general adjudication procedure is very complex (figure 15). It includes a hearing process to determine the appropriate boundaries of the determination. A special judge is appointed by the supreme court to preside over the adjudication.

The general adjudication process is designed to deal with federal reserved water rights in a special way. The McCarran Amendment (federal statute) waives United States sovereign immunity in an adjudication and is a source of potential difficulty. The federal government has been

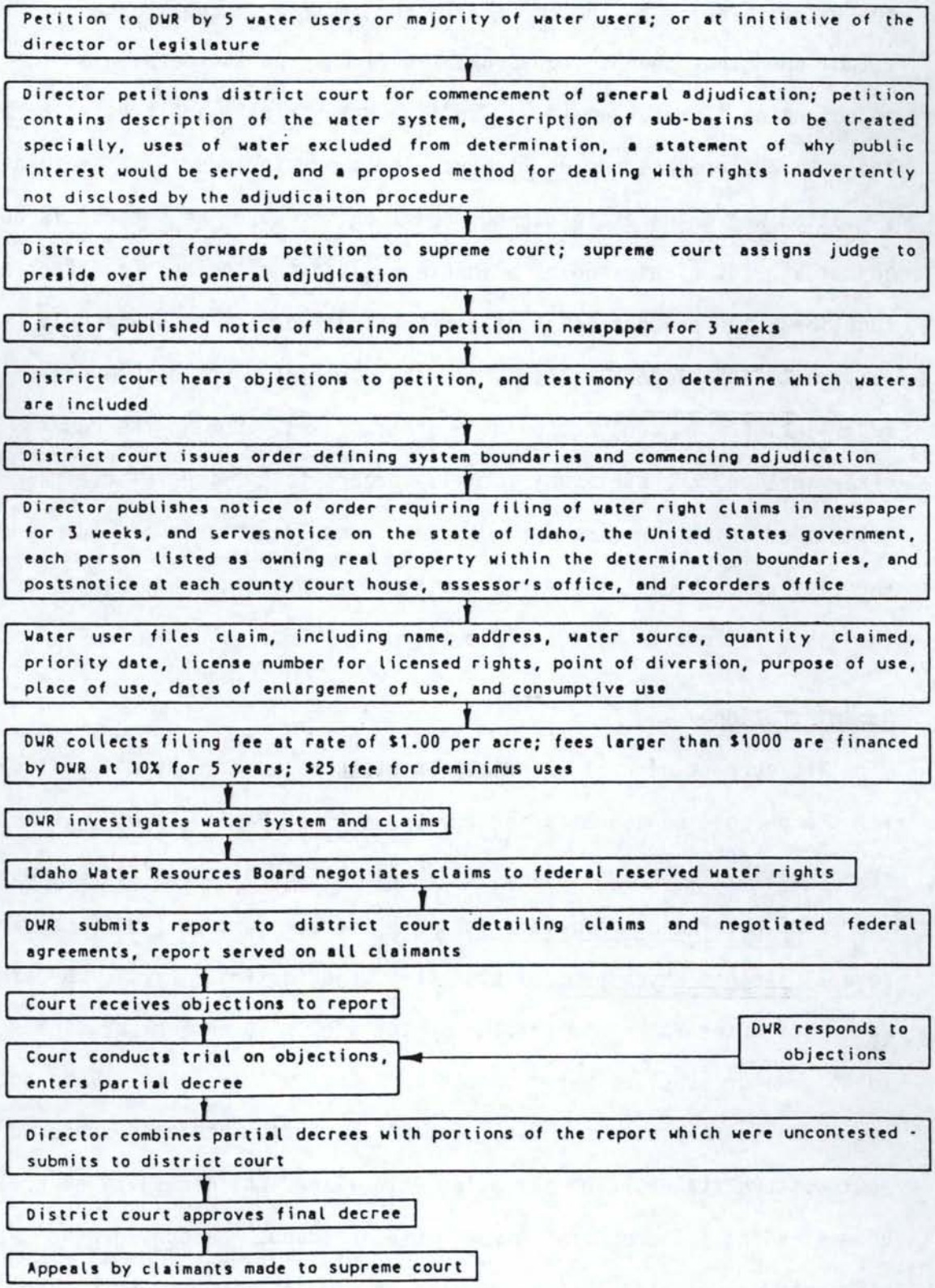

Figure 15. General Adjudication Procedure in Idaho.

reluctant to abide by the amendment, and in several court cases has established that the U.S. government will only participate in an adjudication if reserved (e.g., Indian) water rights are treated with adequate due process and de minimus rights are included. To avoid a situation where the state (Idaho Department of Water Resources) is both an adjudicator of rights and an advocate against the Indians (conflict of function), the process splits these two functions. The state only "abstracts" the federal claims, and the district court determines the federal rights in conjunction with other claims. During the court determination, the state may formally object to the federal claims. The general adjudication also includes de minimus rights, in accordance with the requirements of the federal government, however, these rights are not lost by a failure to file a claim (Strong, 1986).

Administration

The current general adjudication statutes were created specifically for the purpose of adjudicating the Snake River Basin (Strong, 1986). The necessity for adjudicating this basin has been recognized by water users and government officials for many years. Carlson (1986) describes several factors which precipitated this adjudication. First, the state Water Resources Board was created in the 1960's to demonstrate that all of Idaho's water supplies were committed to uses within Idaho. This action was taken in response to a fear of major diversion projects proposed by southwestern states. The situation established the necessity of fully understanding and quantifying water use in Idaho. Second, ground water use expanded dramatically in the basin during the 1950's, 60's, and 70's. This expansion required the establishment of many new water rights, and greatly increased the number of disputes over priority. The increased

power demands for irrigation pumps also necessitated the construction of hydropower facilities on the Snake River, which further complicated the priority system. Carlson states that ground water development was the single most important factor in precipitating the adjudication. Third, a state water plan was devised in 1976 which called for a determination of "constitutional method" rights, federal reserved rights, and in-stream flow rights. Fourth, a series of court cases, most notably Olson v. Idaho Department of Water Resources et al., demonstrated that previous adjudications in the basin were inadequate and not valid because they contained incomplete information. Lastly, the adjudication was initiated by an agreement between the state and a hydropower entity to settle a dispute over a power right on the Snake River at Swan Falls. The Swan Falls dispute concerned the priority and validity of an in-stream flow right.

The adjudication of the Snake River Basin will be the largest single water right determination in the country's history, and will involve over 40,000 individual water rights claims (Shaw, 1986). The adjudication will be funded by claim fees, and will probably join all water users upstream from the Oregon border (Shaw, 1986). There is some question as to whether the determination should include all claims upstream of Lewiston, Idaho (Shaw, 1986).

The historical expansion of water usage will be an important issue in the adjudication. Under Idaho law, any change in water use requires approval of the Idaho Department of Water Resources. In administering the Snake River Basin adjudication, the Idaho Department of Water Resources will accept all previous expansions of water rights as valid, including expansions which were made illegally (I.C. §42-1416). One exception to

this policy pertains to ground water rights in Critical Ground Water Areas. Expansion of these rights will not be recognized as valid (I.C. §42-1416). One additional problem anticipated by the Idaho Department of Water Resources is accurately determining irrigated acreage. The Idaho Department of Water Resources plans to utilize landsat images to make the determination of acreages.

Ground Water Management Areas

Statutory Framework

The statutes of Idaho provide a two-tier system of ground water management areas. The first type of area is a Critical Ground Water Area (CGWA) and is established by the director of the Idaho Department of Water Resources. Critical Ground Water Areas are established in areas "not having sufficient ground water to provide a reasonably safe supply for irrigation of cultivated lands," (table 8, part I). Within Critical Ground Water Areas the director may reject applications for new appropriations of ground water or require appropriators to artificially recharge the basin to offset their withdrawal. The second type of area is a Ground Water Management Area (GWMA). Ground Water Management Areas are established by decree of the director (there is no hearing). Ground Water Management Areas are established in areas determined to be approaching the conditions of a Critical Ground Water Area (table 8, part J). Within Ground Water Management Areas, the director may require appropriators to measure their annual withdrawal of ground water and report the quantity to the Idaho Department of Water Resources. The director may also cease or reduce pumpage in a Ground Water Management Area in accordance with priority dates. The statutory recharge-discharge balance criteria (table

8, part C), and the reasonable pumping lift criteria (table 8, part E), are both applicable to the decision to designate Critical Ground Water Areas and Ground Water Management Areas.

The statutes of Idaho also provide for the formation of Ground Water Recharge Districts (GWRD). The Ground Water Recharge Districts are economic entities formed at the initiative of water users. The Districts are subject to the approval and supervision of the Idaho Department of Water Resources. The statutes do not address the issue of ownership or appropriability of recharge waters; however, any water user who believes he has not benefited from the project may petition for exclusion from the district. Exclusion releases the appropriator from payment of District fees. New ground water appropriations which are made within a Ground Water Recharge District are required to join the District.

Administration

As of 1986, four Ground Water Management Areas and eight Critical Ground Water Areas have been established in Idaho. Most of these areas are located in the southern portion of the Snake River Basin (fig. 16). Higginson (1986) reports that these areas were all closed primarily because of the criteria pertaining to insufficiency of ground water supply. He further states that within all of these areas the Idaho Department of Water Resources has not allowed the issuance of any new ground water appropriation licenses. The Idaho Department of Water Resources has allowed continued exercise of existing water rights in almost all of the areas. An adjudication of ground water rights in the Cottonwood area was followed by a reduction of pumpage in accordance with priorities (Ralston, personal communication, 1986). The Idaho Department of Water Resources attempted to adjudicate the Blue Gulch area in 1985 for

similar purposes. Despite continuing water level declines, the Blue Gulch water users were unanimously opposed to the adjudication. The water users in this area preferred the water level declines to the prospect of reduced pumpage. The Idaho Department of Water Resources did not proceed with the Blue Gulch adjudication.

Management Case Study: The Raft River Basin Critical Ground Water Area

Development History

The Raft River Basin, located in southeastern Idaho, is a north-south trending valley bounded by mountains (fig. 16). The geography, geology, and hydrogeology of the basin is summarized in table 9. Two primary alluvial aquifers of considerable thickness underlie most of the valley floor. The relationship between the Raft River and the ground water is complex. The river gains and loses water in different reaches during different times (Ralston et al., 1984).

Pumpage in the Raft River Basin increased dramatically during the early 1960's. Ralston (1973) reports that the number of irrigation wells in the basin expanded from 290 in 1963 to 330 by 1966. Higginson (1986) reports that no new appropriations of ground water have been approved since 1966; the distribution of wells in the valley has been essentially constant since that time. Water levels have declined considerably in response to the pumpage. The declines have generally occurred throughout the northern portion of the valley and have been as large as 100 feet in some areas (Ralston et al., 1984). Areas of extreme decline are localized in areas of well concentrations, owing to the unconfined nature of the aquifers.

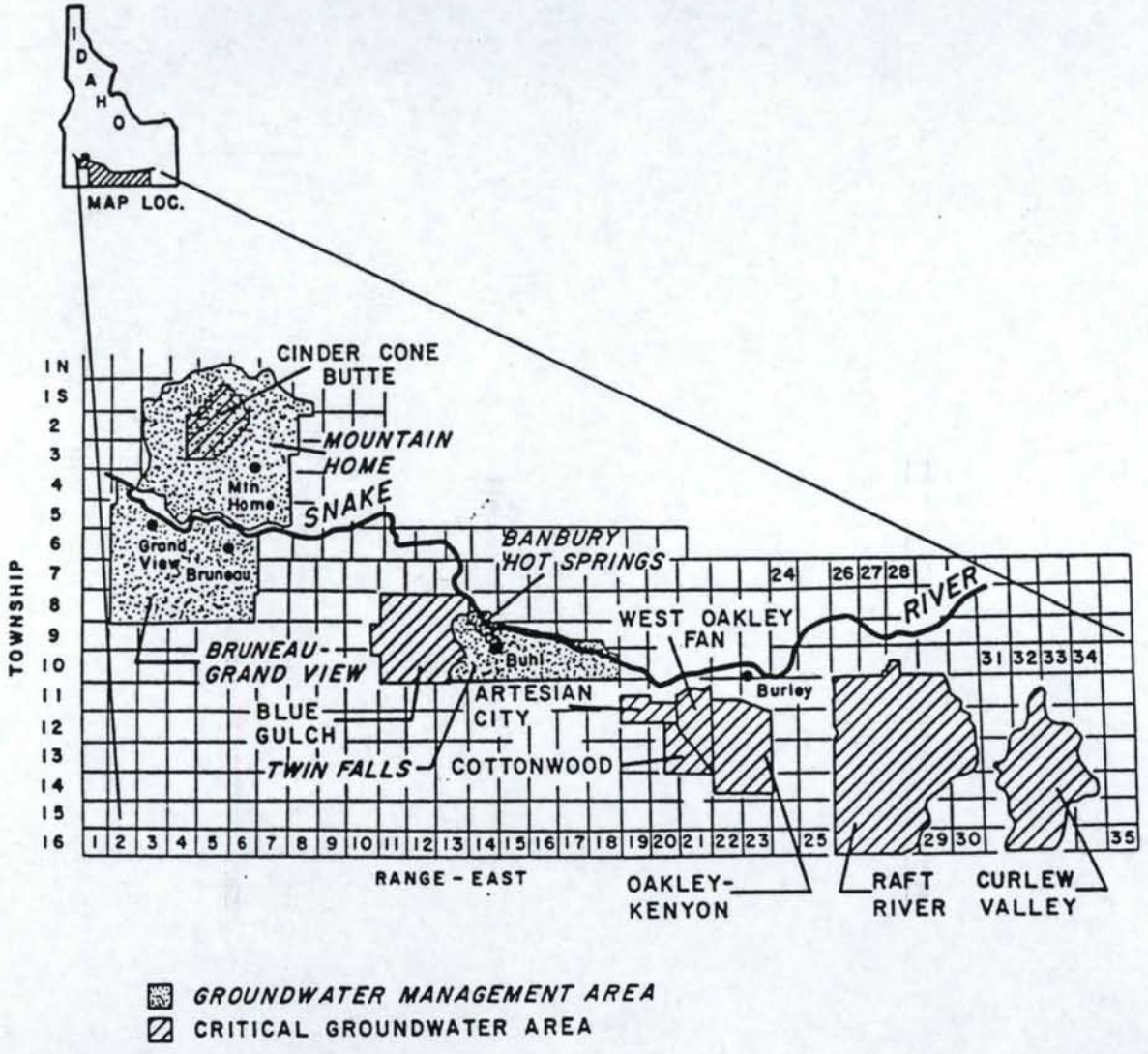

Figure 16. Critical Ground Water Management Areas in Idaho, 1986.

Table 9. Physical Description of the Geography, Geology, and Hydrogeology of the Raft River Critical Ground Water Area (Ralston, 1973; Ralston et al., 1982; Ralston et al., 1984).

Geography	
Location (see fig. 16)	Located on the south side of the Snake River Plain, approximately 1,530 miles^2, bounded by the Albion, Goose Creek, Black Pine and Sublett Ranges and Raft River Mountains.
Drainage	Raft River and Cassia Creek and tributaries.
Land Use	Irrigated agriculture.
Climate	Humid and subhumid in mountains (up to 30 inches of precipitation annually), semiarid on valley floor (less than 10 inches).
Geology	
Stratigraphy	Alluvial valley fill in the valley floor, Snake River basalts in northern portion of valley.
Structure	Basin and range style fault block mountains of consolidated pre-Tertiary sediments.
Hydrogeology	
Aquifers	Primarily unconfined aquifers in the Salt Lake and Raft River Formations and basalts of the Snake River Group, base of aquifers range from 700 to 1,400 ft below land surface.
Depth to Water	Ranges from near land surface to 400 ft.
Transmissivity	1,000 to 12,000 ft^2/day (Nichols, 1979).
Storativity	10^{-1} to 10^{-2}.
Recharge	Estimates range from 140,000 to 320,000 ac-ft/year.
Discharge	Northward gradient of approximately 15 ft/mile, ground water discharges to Snake River Plain aquifers and Raft River, pumpage was 141,000 ac-ft in 1966.
Water Use	Primarily irrigated agriculture; also domestic/stock.

Management History

The Raft River Basin was designated as a Critical Ground Water Area in 1963. Under this designation the Idaho Department of Water Resources would not accept new applications to appropriate ground water, but would allow 40 permits to mature into licenses (Ralston et al., 1982). Pumpage increases have been prohibited by the Idaho Department of Water Resources since 1966 (Higginson, 1986). The results of these management actions reflect the complex nature of the aquifer system. Water level declines have continued in the northern portion of the valley where pumpage is concentrated. Water levels have risen in the southern portion of the valley in response to recharge events. Ralston (1973) suggests that this situation highlights the time lag aspects of ground water flow in an unconfined aquifer, particularly:

> The concepts of stock and flow ground water are time dependent and are dependent on the hydrologic characteristics of the system in question. The ground water in the Raft River basin acts as a flow resource only if a very long time frame is considered. During any short period the stock aspects of the resource predominate. This is shown vividly by the local effects from points of recharge or discharge. The temporal characteristics of stock or flow ground water are dependent on the confined or unconfined nature of the resource. An artesian aquifer of similar dimensions and permeability as that in the Raft River basin would assume the characteristics of a flow resource in a much shorter period of time than the existing unconfined system.
>
> Administration of ground water under the appropriation doctrine of water rights as applied in Idaho does not recognize the time dependency of the stock aspect of the resource. Designation of the entire basin as critical ground-water area is based on the assumption that the area acts as a single hydrologic unit; and additional well at any point in the system is assumed to reduce the total supply to all other users. A considerable lag in this cause-effect relationship is present because of the stock aspects of the resource. Designation of smaller critical areas in the locations of excessive decline would allow administration of the resource under a shorter management period. (p. 916)

As Ralston points out, the management objectives of the statutes are not being met. Full economic benefits of the resource are unrealized: large areas of land are uncultivated where water levels have risen.

COLORADO

Introduction

The Colorado doctrine of appropriation has been labeled the "West's appropriation doctrine in its purest form" (Carlson, 1973, p. 295); however, prior appropriation has been modified substantially in its application to ground water. Under Colorado Law, ground water is classified as tributary, nontributary, and designated. Each class of ground water is subjected to a different system of management criteria which modify the appropriation doctrine in some instances. Nontributary ground water is not subject to prior appropriation management. This was established recently by the Colorado Supreme Court in Huston, 641 P2d. 1294 (1983). The decision illustrates that ground water law in Colorado is dominated by the state's courts, and is unusually complex.

Ground Water Classification

The principal distinguishing factor in Colorado ground water law is its system of classification. Ground water is classified as tributary, nontributary, and designated. The classification of ground water types facilitates use of different management objectives in different hydrologic and economic settings.

Tributary Ground Water

Tributary ground water is defined as ground water which is hydraulically connected to surface waters (table 10, part B). A significant statutory component of this definition is the requirement that tributary ground water must influence the rate/direction of surface discharge. This definition has been refined substantially by the courts.

Table 10. Ground Water Law in Colorado.

A. Appropriation Doctrine Statement for Ground Water

C.R.S. §37-90-102 (1) "It is declared that the traditional policy of the state of Colorado, requiring the water resources of this state to be devoted to beneficial use in reasonable amounts through appropriation, is affirmed with respect to the designated ground waters of this state... While the doctrine of prior appropriation is recognized, such doctrine should be modified to permit the full economic development of designated ground water resources. Prior appropriations of ground water should be protected and reasonable ground water pumping levels maintained, but not to include the maintenance of historical water levels... (2) ...nontributary ground water shall be devoted to beneficial use in amounts based upon conservation of the resource and protection of vested water rights."

B. Definition of Tributary Ground Water

C.R.S. §37-92-103 (11) "...that water in the unconsolidated alluvial aquifer or sand, gravel, and other sedimentary material, and all other waters hydraulically connected thereto which can influence the rate or direction of movement of the water in that alluvial aquifer or natural stream."

C. Administration of Tributary Ground Water

C.R.S. §37-92-102 (1) (a) "...all water in or tributary to natural surface streams...have always been and are hereby declared to be the property of the public, dedicated to the use of people of the state, subject to appropriation...it is the policy of this state to integrate the appropriation, use, and administration of underground water tributary to a stream with the use of surface water in such a way as to maximize the beneficial use of all of the waters of this state..."

D. Definition of Designated Ground Water

C.R.S. §37-90-103 (6) (a) "Designated ground water" means that ground water which in its natural course would not be available to and required for the fulfillment of decreed surface rights, or ground water in areas not adjacent to a continuously flowing natural stream wherein ground water withdrawals have constituted the principal water usage for at least fifteen years preceding the date of the first hearing on the proposed designation of the basin, and which in both cases is within the geographic boundaries of a designated ground water basin..."

E. Administration of Designated Ground Water

C.R.S. §37-90-107 (1) "Any person desiring to appropriate ground water for beneficial use in a designated ground water basin shall

Table 10. Continued.

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make application to the commission in a form to be prescribed by the commission..."

F. Definition of Nontributary Ground Water

C.R.S. §37-90-103 (10.5) " 'Nontributary ground water' means that ground water, located outside the boundaries of any designated ground water basins in existence on January 1, 1985, the withdrawal of which will not, within one hundred years, deplete the flow of a natural stream...at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal."

G. Administration of Nontributary Ground Water

C.R.S. §37-90-137 (4) "In the issuance of a permit to construct a well outside a designated ground water basin... (1) the user [shall make] an application in writing to the state engineer for a permit to construct a well, in a form to be prescribed by the state engineer... (b) (I) [who] shall allow withdrawals on the basis of an aquifer life of one hundred years... (b) (II) ...the amount of such ground water available for withdrawal shall be that quantity of water, exclusive of artificial recharge, underlying the land owned by the applicant..."

H. Prevention of Waste

C.R.S. §37-90-138 "The state engineer in cooperation with the commission has power to regulate the drilling and construction of all wells in the state of Colorado to the extent necessary to prevent the waste of water..."

I. Definition of Impairment: Tributary Ground Water

C.R.S. §37-90-137 (2) "...make a determination as to whether or not the exercise of the requested permit will materially injure the vested water rights of others...no permit shall be issued unless the location of the proposed well will be at a distance of more than six hundred feet from an existing well..."

J. Definition of Impairment: Designated Ground Water

C.R.S. §37-90-107 (3) "...the commission shall, if it finds that the proposed appropriation will not unreasonably impair existing water rights from the same source, and will not create unreasonable waste, grant the said application... (5) ...With regard to whether a proposed use will impair uses under existing water rights, impairment shall include the unreasonable lowering of the water level, or the unreasonable deterioration of water quality, beyond reasonable economic limits of withdrawal or use."

Table 10. Continued.

K. Definition of Impairment: Nontributary Ground Water

C.R.S. §37-90-137 (4) (c) "Material injury to vested nontributary ground water rights shall not be deemed to result from the reduction of either hydrostatic pressure or water level in the aquifer."

L. Adjudication: Designated Ground Water

C.R.S. §37-90-106 (1) "The commission shall...determine designated ground water basins and subdivisions thereof by geographic description...In making such determinations the commission shall make the following findings:
(a) The name of the aquifer within the proposed designated basin;
(b) The boundaries of each aquifer being considered;
(c) The estimated quantity of water stored in each aquifer;
(d) The estimated use of ground water in the area;
(f) If the source is an area of use exceeding fifteen years as defined in section §37-90-103 (6), the commission shall list those users who have been withdrawing water during the fifteen-year period, the use made of the water, the average annual quantity of water withdrawn, and the year in which the user began to withdraw water."

M. Adjudication: Ground Water Outside Designated Basins

C.R.S. §37-90-137 (6) "Rights to nontributary ground water outside of designated ground water basins may be determined in accordance with procedures of sections 37-92-302 to 37-92-305 [by Water Courts]..."

N. Management Tools Available to Management Districts

C.R.S. §37-90-130) (2)
"(a) To provide for the spacing of wells producing from the ground water aquifer or subdivision thereof, and to regulate the production therefrom so as to minimize as far as practicable the lowering of the water table or the reduction of the artesian pressure;
(b) To acquire lands for the erection of dams and for the purpose of draining lakes, draws, and depressions, and to construct dams, drain lakes, depressions, draws, and creeks, and to install pumps and other equipment necessary to recharge the ground water reservoir or subdivision thereof;
(c) To develop comprehensive plans for the most efficient use of the water of the ground water aquifer or subdivision thereof, and for the control and prevention of waste of such water, which plans shall specify in such detail as may be preacticable the acts, procedure, performance, and avoidance which are or may be necessary to effect such plans, including specifications therefor; to carry out research projects, develop information, and determine limitations, if any, which should be made on the withdrawal of

Table 10. Continued.

water from the ground water aquifer or subdivision thereof; to collect and preserve information regarding the use of such water and the practicability of recharge of the ground water aquifer; to publish such plans and information, bring them to the notice and attention of the users of such ground water within the district, and to encourage their adoption and execution;

(d) To require the owner or operator of any land in the district upon which is located any open or uncovered well to close or cap the same permanently...

(e) To promulgate reasonable rules and regulations for the purpose of conserving, preserving, protecting, and recharging the ground water of the ground water aquifer or subdivision thereof; in conformity with the provisions of this article;

(f) To prohibit, after affording an opportunity for a hearing before the board of the local district and presentation of evidence, the use of ground water outside the boundaries of the district where such use materially affects the rights acquired by permit by any owner or operator of land within the district;

(g) In the control and administration of the quantity of ground water extracted from the aquifer, to adopt such devices, procedures, measures, or methods as it deems appropriate to effectuate this purpose.

(h) To promulgate reasonable rules and regulations with respect to the protection and compensation of the owners of any small capacity wells as defined in section §37-90-105 which may be injured by irrigation wells;

(i) To represent the district at any hearings or proceedings conducted or authorized by the commission affecting any water rights, either actual or potential, within the district;

(j) To exercise such other administrative and regulatory authority concerning the ground waters of the district as, without the existence of the district, would otherwise be exercised by the ground water commission."

Hall v. Kuiper 510 P2d. 329 (1973) established that ground water which would reach the stream in 40 years is tributary. Kuiper v. Lunduall 529 P2d. 1328 (1974) established that ground water which would require more than 100 years to reach the stream is not tributary. This "at least 40 and less than 100 years" rule was clarified further in District 10 Water Users Association v. Barnett 599 P2d. 894 (1979). In general, the court said that if pumping would affect the stream flow in 40 years the ground water is tributary; if pumping does not affect stream flow in 100 years it is not tributary.

Nontributary Ground Water

The definition of tributary ground water defines nontributary ground water by default (table 10, part F). The District 10 Water Users Association decision was incorporated in the statute to define nontributary ground water. This statute further clarifies the line between tributary and nontributary ground water based on the 100 year pumping impact rule. The calculated 100 year depletion of streams cannot exceed one-tenth of one percent of the annual rate of withdrawal (pumpage) in nontributary ground water settings.

Designated Ground Water

Certain nontributary ground water may be "designated" by the Colorado Ground Water Commission (table 10, part D). Nontributary ground water in a designated area is subject to appropriation doctrine management which is supervised by the Colorado Ground Water Commission (table 10, part A). Some 1985 additions to the statutes justify the "designation" of some tributary ground waters as well. These are areas where ground water has been a principal source of water supply for at least 15 years (table 10,

part D). The additions essentially legitimize the Colorado Ground Water Commission's management of areas east of Denver which are near surface water sources.

Applicability of the Appropriation Doctrine

Considerable controversy has occurred recently over what types of ground water are subject to management under the appropriation doctrine in Colorado. The controversy is based, at least in part, on the ambiguity of the statutes. Statute §37-82-101 states that "all waters" are subject to appropriation; §37-92-102 says "all water in or tributary to natural surface streams" is subject to appropriation. The situation has been clarified by the Houston decision: tributary and designated ground water is subject to appropriation, all other nontributary ground water is not.

In practice, some components of the appropriation doctrine apply to all three classes of ground water. Tributary ground water is managed in conjunction with surface water through decentralized, court enforced assertions of priorities. The appropriation doctrine also is used to manage designated ground water, but management decisions are centralized with the State engineer (table 10, part A). Nontributary ground water is not subject to appropriation; however, ownership of this ground water is based partially on beneficial use and the protection of vested rights, both of which are components of the doctrine (table 10, part A). The primary requirement of nontributary ground water ownership is land ownership, which departs radically from the doctrine.

The appropriation doctrine commonly is applied to ground water in Colorado, in the areas where it is pertinent. Permits are required for all wells (Colorado Revised Statutes (C.R.S.) §37-90-105, 107, 137;

§37-92-602), and beneficial use is a central criteria in issuance of the permits. Impairment of senior appropriators is examined in permit issuance (C.R.S. §37-90-107, 137), and prohibited in the exercise of existing tributary ground water rights (C.R.S. §37-92-501). Waste of ground water is prohibited (table 10, part H), and ground water rights may be forfeited through nonuse (C.R.S. §37-92-402).

Administration of Ground Water Rights

Tributary

The water courts play an important role in establishing tributary ground water rights (fig. 17). The appropriator must apply to the state engineer to obtain a permit to construct a well, but he must go to court to establish the actual right to appropriate.

The state engineer administrates management of tributary ground water in conjunction with the courts. The primary goal of this administration is management of the surface and ground water under a single system of strict priority which will "maximize beneficial use" and protect senior rights (table 10, part C) and (C.R.S. §37-92-501). This has resulted in significant efforts to define impairment in tributary settings. The statutes state that impairment consists of "material injury" to vested rights (table 10, part I). Case law has refined the definition to say that the impairment does not have to occur from a specific well, but can be determined generally. Fellhauer v. People 447 P2d. 986 (1968) upheld the right of the state engineer to curtail groups of ground water appropriations which, in aggregate, were impairing senior surface rights on an adjacent fully appropriated stream. To solve these impairment problems the water courts also have statutory authority to require that

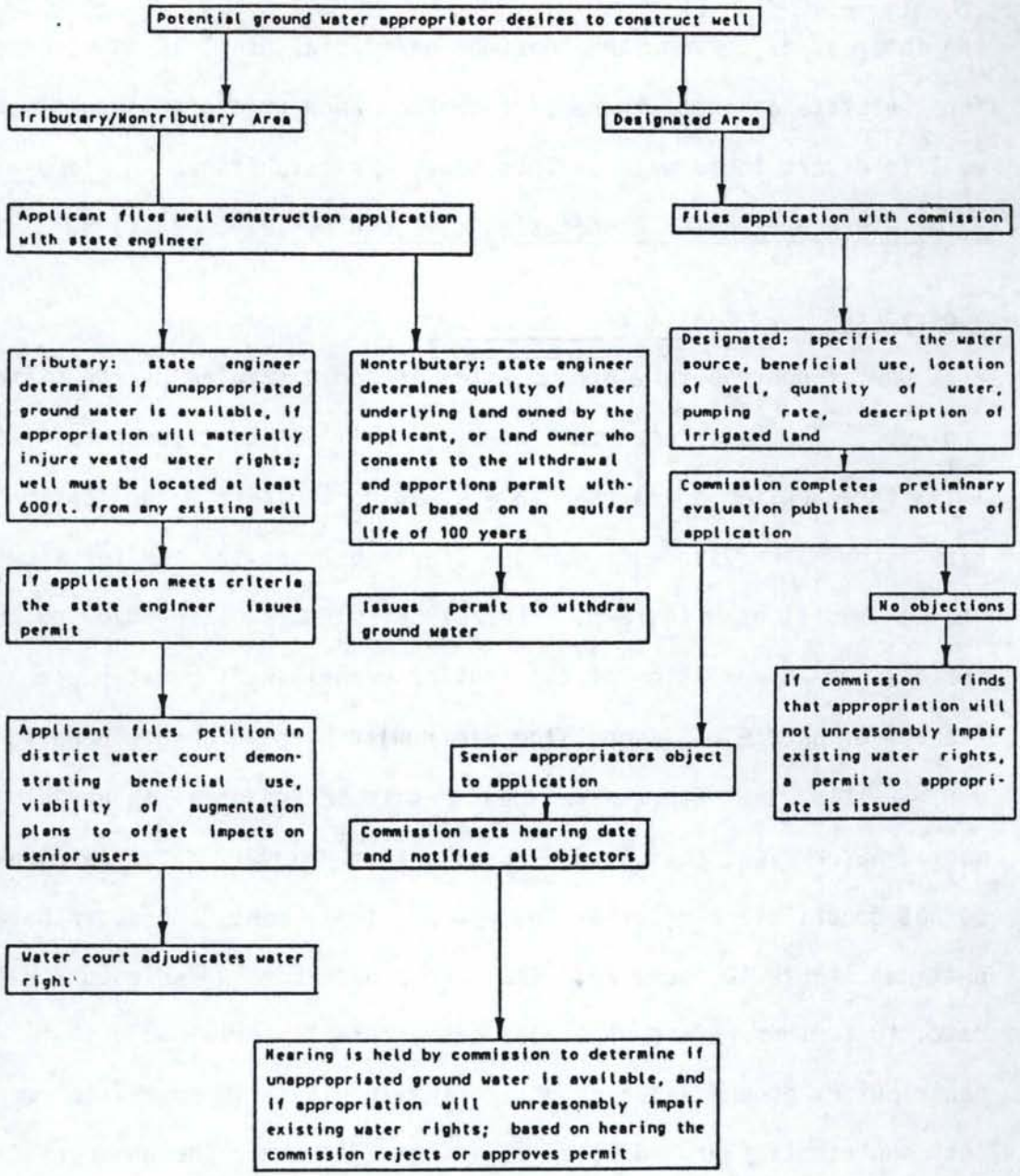


Figure 17. The Three Tier System for Ground Water Appropriation or Permitted Use Under Colorado Statutes.

tributary ground water users either purchase surface water rights to offset stream depletion or augment the water supply of surface appropriators (C.R.S. §37-92-302). Recently it has been found that, in the interest of serving the "maximum beneficial use," it is also possible for the state engineer to require surface appropriators to construct a well to divert their water. This power was established in Alamosa-LaJara Water Users Protection Association v. Gould 694 P2d. 914 (1983).

Nontributary

Use of nontributary ground water is administrated by the state engineer. The water user must obtain a well construction permit (fig. 17). Three criteria are used in evaluating the permit application. First, the water user must own the land overlying the aquifer from which the water will be withdrawn. The rate of withdrawal is adjusted to allow for a 100 year depletion of the aquifer underlying the water user's land (table 10, part G). Second, the water must be put to some beneficial use. Lastly, the water use may not result in "material injury" to any vested water right (C.R.S. §37-90-137) (4); however, water level declines do not constitute a material injury, or "impairment," in nontributary settings (table 10, part K). The courts have not had an opportunity, to date, to further refine what does constitute "material injury" to nontributary ground water rights. Finally, it is important to emphasize that nontributary ground water is not managed under the appropriation doctrine, but is allocated instead under a common law doctrine based on overlying land ownership. The location of nontributary and designated nontributary ground water areas in Colorado is shown in figure 18.

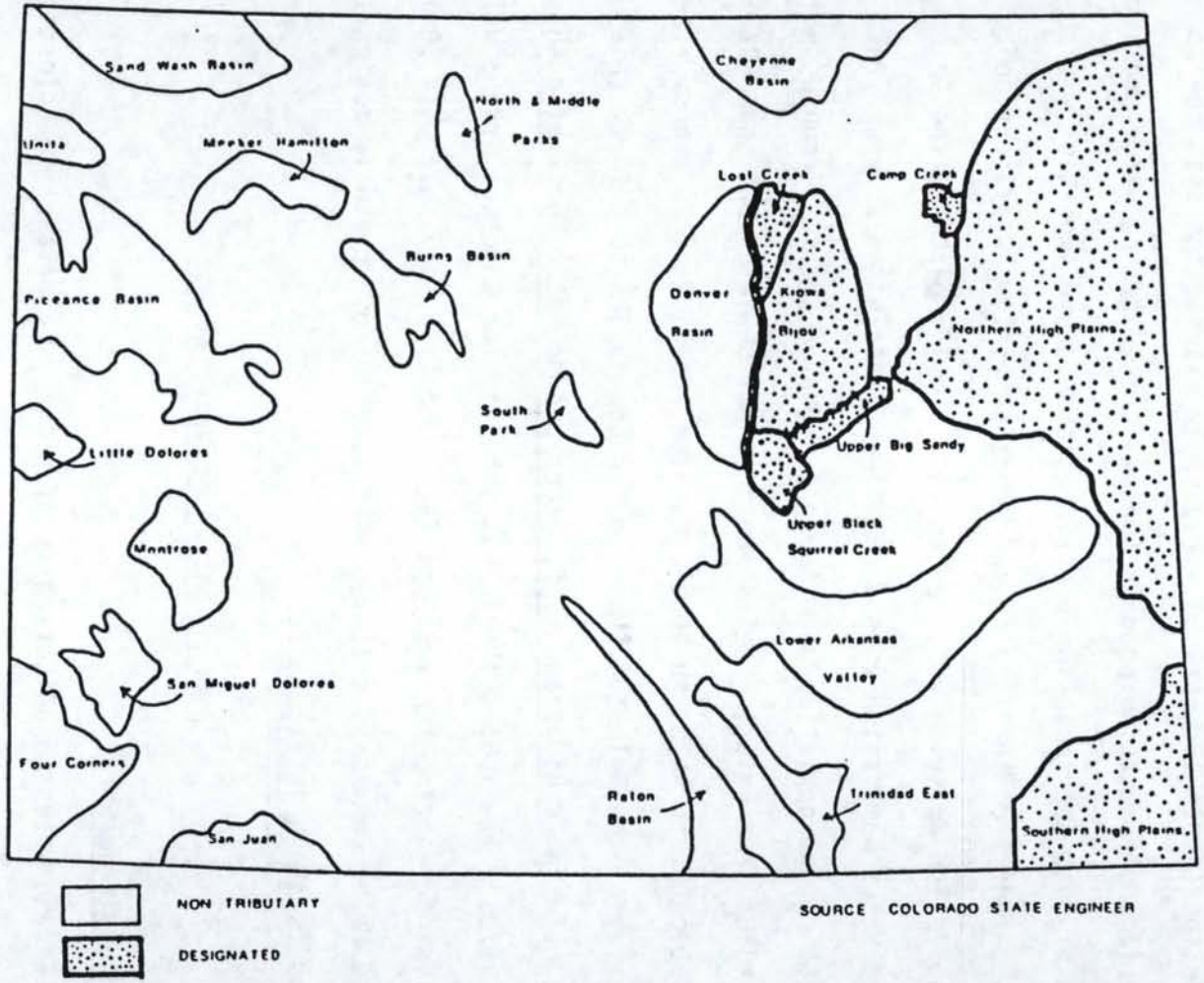


Figure 18. Colorado Nontributary and Designated Ground Water Basins (Longenbough, 1986).

Designated

Ground water management in designated basins or areas is administrated by the Colorado Ground Water Commission. A permit to appropriate ground water is obtained from the Colorado Ground Water Commission (table 10, part E). Figure 17 illustrates that the permit criteria and permitting process for designated ground water are similar to those of most appropriation doctrine states. One important difference is not apparent from the figure, and constitutes the "modification" of the appropriation doctrine referred to in table 10, part A. The Colorado Ground Water Commission uses a "3 mile-40% depletion-25 year" rule in evaluating appropriation permits in designated areas. Proposed wells must be 3 miles from existing wells and must not deplete more than 40% of the available ground water in that area over a period of 25 years. The authority of the Colorado Ground Water Commission to enforce this criteria was upheld in Fundingsland v. Colorado Ground Water Commission 468 P2d. 835 (1970). The 1985 criteria published by the Colorado Ground Water Commission redefine the well spacing criteria as one-half mile (Colorado Ground Water Commission, 1985). The location of currently designated basins is shown in figure 18.

Adjudication of Water Rights

Statutory Framework

Ground water adjudication is of primary importance in Colorado's system of management. Management of tributary ground water, in particular, is based on strict enforcement of priorities which requires a continual determination of rights. Nontributary ground water is used on the basis of land ownership and therefore priorities are not recognized;

adjudication is unnecessary. Designated basins are adjudicated in conjunction with the designation process by the Colorado Ground Water Commission.

Tributary ground water is adjudicated by the water courts (table 10, part M). The water court is a district judge designated by the Colorado Supreme Court in each of seven state water divisions. The water judge is assisted by a water clerk and a water court referee (Aiken, 1983, p. 15). The adjudication process for tributary ground water areas is illustrated in figure 19. This process is used as a central part of water management in tributary areas, and is the core of the process required to establish new appropriations.

Adjudication of ground water rights in designated basins is administrated by the Colorado Ground Water Commission. Table 10, part L shows that the determination of ground water rights occurs as an integral part of designating the basin. Management of designated ground water through "management districts" provides procedures for resolving water rights conflicts, and is described in the next portion of this chapter.

Administration

A description of past and current adjudications is not provided. A significant portion of the state is outside nontributary and designated areas (fig. 18), and the adjudicatory process essentially is continuous in these tributary areas.

Ground Water Management Areas

There is no ground water management area program in Colorado. The management of designated ground water basins parallels the management

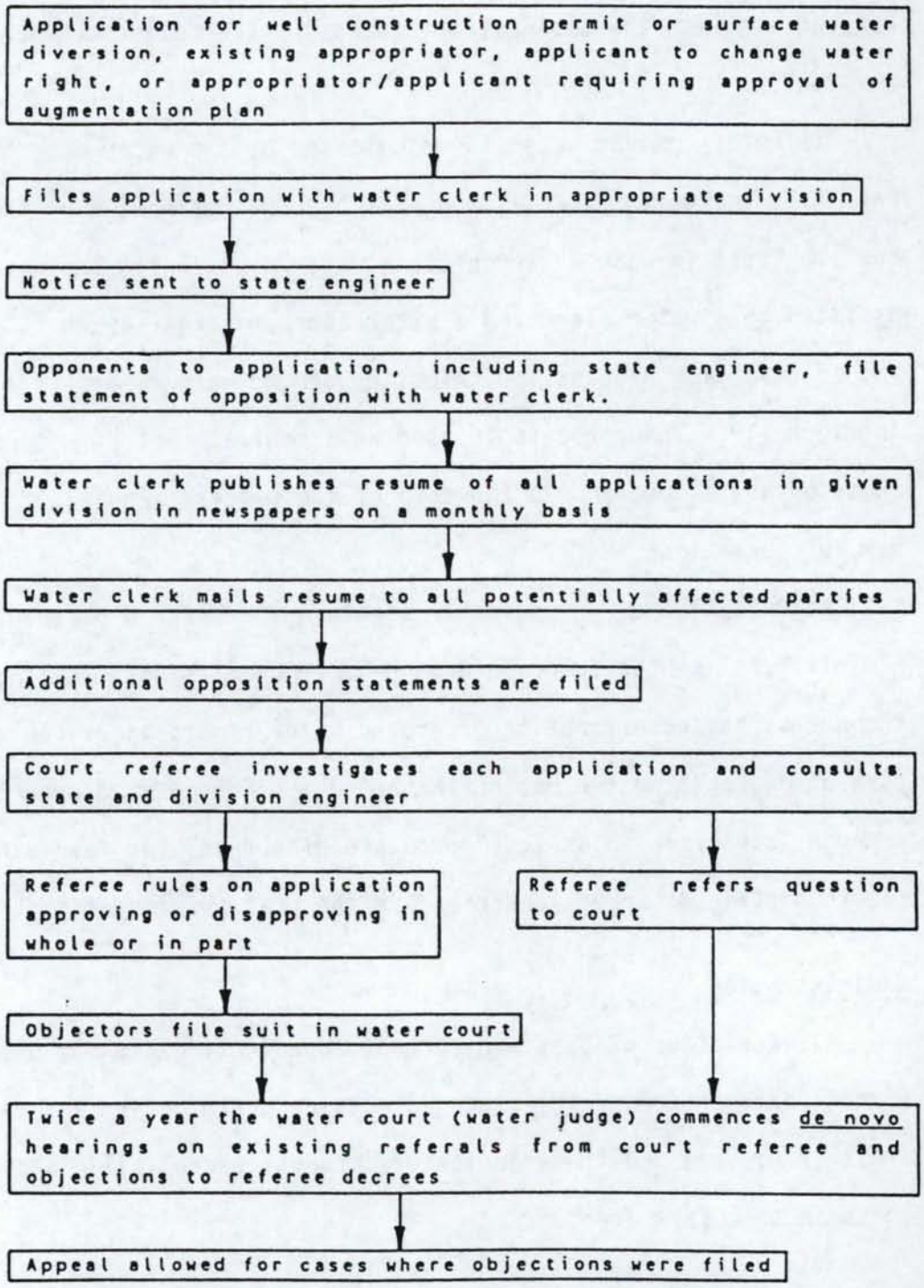


Figure 19. Adjudication Procedures for Colorado Tributary Ground Water.

area programs of other states in many respects, and is treated in further detail in this section of this chapter.

Statutory Framework

The management of ground water within designated basins is achieved through the collaborative efforts of the Colorado Ground Water Commission and ground water management districts. "Management districts" are political and economic entities established by petition and referendum of taxpaying voters in a designated basin. The board of directors of a management district (board), consists of five to fifteen members of the district community who are elected to terms of four years, and are not compensated for their service (C.R.S. §37-90-118, 129). The board may promulgate rules and regulations to control and regulate the use of ground water within the district, subject to consultation and approval of the Colorado Ground Water Commission (C.R.S. §37-90-130). The board may exercise a broad range of options in their management activities, which are listed in table 10, part N. Hearings must be held on proposed rules, or any complaint by a water user about the enforcement of rules. The board holds all hearings, and the decisions of the board may be appealed to the Colorado Ground Water Commission. Conflicts between water users are also resolved through this hearings process (C.R.S. §37-90-131). The board may levy taxes and issue bonds to finance the district management activities.

Administration

The Colorado Ground Water Commission has found the management district program to be very effective in the management of designated ground water because of the direct involvement of water users in the

promulgation and enforcement of management regulations. Thirteen management districts are currently incorporated in the seven designated ground water basins (fig. 20). Management districts may encompass all or part of a designated basin. The Northern High Plains designated basin currently is covered completely by a patchwork of eight management districts. Camp Creek contains no management district, and therefore is managed entirely by the Colorado Ground Water Commission. Kowa-Bijou Basin contains one management district in its northern section, and Lost Creek Basin is situated similarly with one district in the south. Upper Big Sandy and Upper Black Squirrel Creek, both contain one district which is contiguous with the basin boundaries.

Problems are experienced by the Colorado Ground Water Commission in overseeing the complex interrelationships of different districts within the same basin. The Colorado Ground Water Commission has dealt with this situation by subjecting all districts within a basin to a single set of general criteria, within which the districts are given latitude. By far the most persistent problem has been ensuring stream flows out of the state which are required by interstate compacts. The North Fork of Republican River which flows out of the Northern High Plains Basin into Nebraska has been particularly difficult to deal with in this respect. The Colorado Ground Water Commission has required the Central Yuma District to use a three mile well spacing policy to aid in ensuring stream flows in the river.

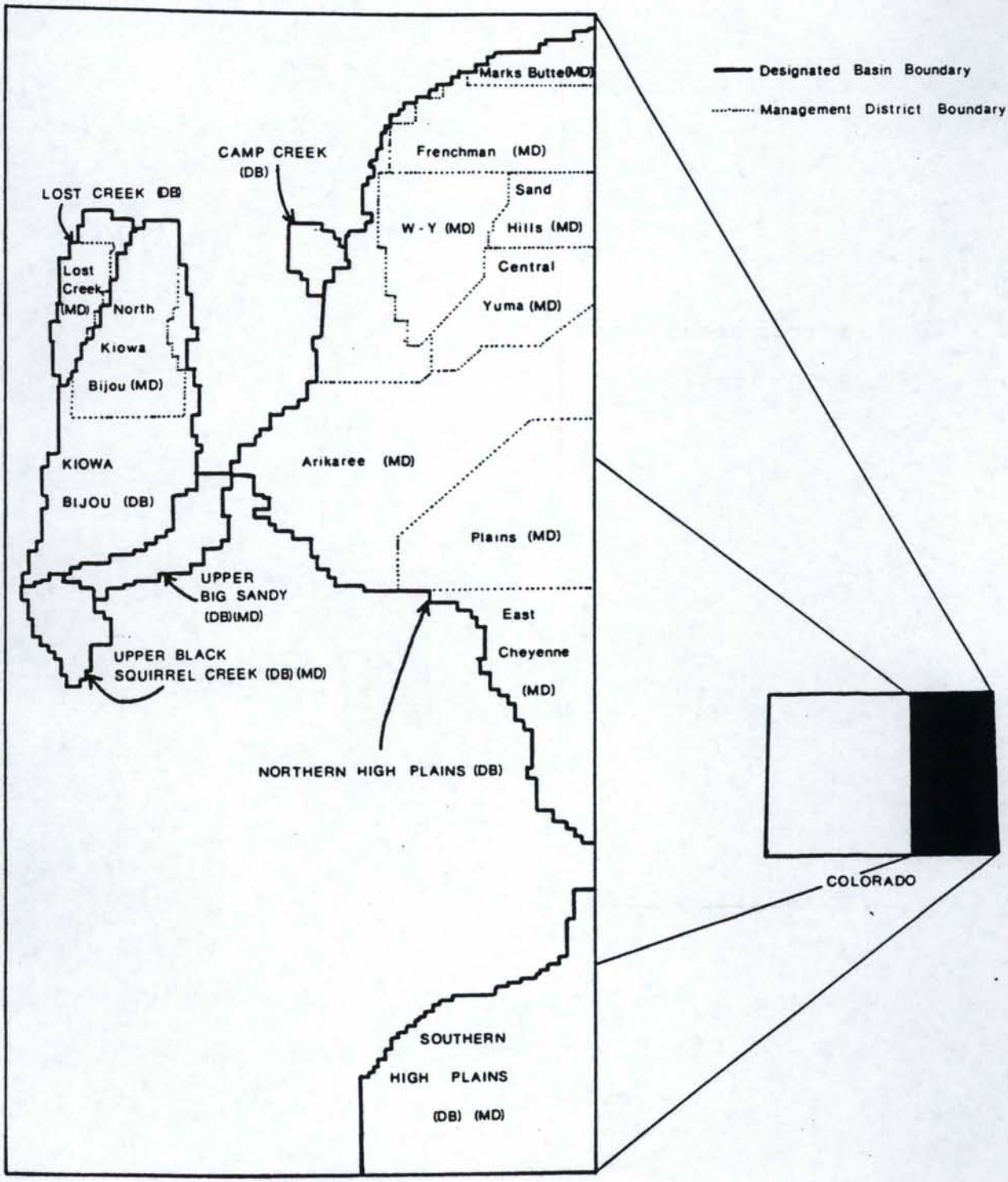


Figure 20. Colorado Designated Basins (DB) and Management Districts (MD) (Longenbough, 1986).

Management Case Study: Northern High Plains Designated Basin

Development History

The Northern High Plains Basin is located in the northeastern portion of the state (figs. 19 and 20). The physical description of the basin geography, geology, and hydrogeology is found in table 11. The surface streams listed in table 11 were all fully appropriated during the 1800's and early 1900's.

The development of the Ogallala aquifer for irrigation purposes occurred primarily during the 1960's and 1970's. The number of irrigation wells in the high plains of Colorado increased from 366 in 1960 to 2,200 in 1969 (Radosevich et al., 1973, p. 39). This number increased to 4,400 by the mid 1970's, and has remained relatively stable since that time. The volume of pumpage in the basin is unknown. The increased cost of power and lower crop prices have resulted in most appropriators using less than their fully permitted withdrawal during the 1980's (Longenbough, 1986).

Observation wells maintained by the United States Geological Survey provide some measure of water level declines resulting from aquifer development. The 1985 Water Use Summary for Colorado reports water level declines in the Ogallala aquifer which average 1 foot per year from 1955 to the present. The same report shows a range in depth to water of 45 to 133 feet in the Ogallala aquifer at the end of the irrigation season. Water levels may decline as much as 10 feet during the irrigation season (Boettcher, 1966). The saturated thickness of the Ogallala in 1966 was 340 feet on the Nebraska border, and decreased towards the west (Boettcher, 1966, p. 7).

Table 11. Physical Description of the Geography, Geology, and Hydrogeology of the Northern High Plains Designated Basin (Boettcher, 1966; Longenbaum, 1987).

Geography	
Location (see figs. 19, 20)	Located in northeastern Colorado, approximately 9,500 miles^2, encompasses upland, eastward draining watersheds between the South Platte and Arkansas Rivers.
Drainage	Frenchman, North Fork of the Republican, Arikaree, South Fork of the Republican, and Smoky Hill River drainages.
Land Use	Agriculture; principal crops include corn, sorghum, alfalfa, and sugar beets.
Climate	Semiarid, mean annual precipitation ranges from 14.2 inches to 17.2 inches.
Geology	
Stratigraphy	Pliocene Ogallala Formation (semi-consolidated sands, silts, clays, gravel) exposed over most of the area, thickens eastward from a few feet on west to 400 feet on east; locally covered by dune sand, loess, and alluvial deposits of Pleistocene and Recent age.
Hydrogeology	
Aquifers	Ogallala: Primary aquifer, unconfined, irrigation well yields commonly greater than 1,000 gpm. Alluvial: Locally important sources of domestic and irrigation water - especially near streams.
Transmissivity	Ogallala: 2,500 ft^2/day to 34,000 ft^2/day.
Storativity	Ogallala: 0.01 to 0.20.
Recharge	EStimated average 430,000 ac-ft/year.
Natural Discharge	South Platte River.
Pumpage	Unknown, currently 4,400 wells permitted.
Water Use	Irrigation, domestic, stock watering.

Management History

The Northern High Plains Basin was designated by the Colorado Ground Water Commission in 1966. The designation was based on two related problems of over-development. First, the Division of Water Resources recognized that the demand for well permits, if satisfied, would lead to a rapid depletion of the aquifer. Second, financial institutions had invested heavily in the irrigation development of the area, and demanded control of the aquifer depletion to ensure full returns on their loans.

In December of 1966, four months after the basin was designated, the Sand Hills management district was incorporated (fig. 20). Five additional management districts were formed in 1967: Plains, Arikaree, Frenchman, Central Yuma, and W-Y. The East Cheyenne district lies at the very southern end of the basin and wasn't formed until 1973. Marks Butte management district was formed in 1977.

The districts formed in the 1960's began establishing aquifer regulations in 1971 and 1972. All of the district regulations have certain rules in common. The first rule always recapitulates statute §37-90-130 (table 10, part N). Secondly, they all prohibit the export of water from the district without the approval of the district board of directors. All the districts require a half mile well spacing, and reserve the right to require a flow meter on any well. The Colorado Ground Water Commission requires flow meters on irrigation wells drilled in the alluvium of stream valleys. Finally, all districts require that replacement or substitute wells are drilled within 300 feet of the original well head and prohibit construction of supplemental wells.

The district management plans are different in some respects. The Central Yuma District bans construction of new wells within three miles

of the North Fork of the Republican River. Some districts prohibit the expansion of irrigated acreage.

District administration is also variable. The Plains District is managed very carefully; aquifer depletion in the district has reached 60%. Just south of the Plains District is East Cheyenne, where administration has been permissive and the board of directors has attempted to circumvent the regulations. Four districts, Sand Hills, Frenchman, W-Y, and Marks Butte, are administrated by the same individual (Longenbough, 1986).

The Colorado Ground Water Commission has found the management district program to be very successful in the Northern High Plains Basin. The success results from water users monitoring and policing their own actions, and the actions of their neighbors. Interdistrict conflicts have not been a problem to date (1987). This may change in the future, however, because the districts soon will be given more autonomous control of district management. The Colorado Ground Water Commission has recently adjudicated 1,100 rights in the basin which existed prior to 1965. The remaining 3,300 rights soon will be determined. The management districts will be given autonomy from the Colorado Ground Water Commission in their management activities when the adjudication is complete.

NEW MEXICO

Introduction

New Mexico was the first state to codify ground water management under the prior appropriation doctrine (1927) (Corker, 1971). The current statutes date from 1931 and define a system of ground water management in broad terms. This differs sharply from statutes of most appropriation doctrine states which are very explicit in defining management criteria.

The establishment of specific ground water management criteria in New Mexico is delegated to the state engineer. The broad discretionary authority accorded to the state engineer has resulted in a degree of flexibility in management which is unprecedented in other appropriation doctrine states. Management flexibility has facilitated conjunctive use of surface and ground water throughout the state. Surveys of water users also indicate that the flexibility of New Mexico's management system is popular. Water user groups are unanimous in their support for the centralized decision making of the current and long term state engineer, Mr. Steve Reynolds (Smith, 1984).

Appropriation Doctrine

The prior appropriation doctrine applies to all uses of ground water in the state of New Mexico. The state engineer has jurisdictional authority over the appropriation doctrine in areas of the state which he "declares" (table 12, part J). Declared ground water basins must have reasonably ascertainable hydrogeologic boundaries (table 12, parts A and I).

Table 12. Summary of New Mexico Ground Water Management Statutes.

A. Appropriation Doctrine Statement for Ground Water

New Mexico Statutes (N.M.S.) §72-12-1 "The water of underground streams, channels, artesian basins, reservoirs or lakes, having reasonably ascertainable boundaries, are hereby declared to be public and to be subject to appropriation for beneficial use..."

B. Administration of Ground Water Rights

N.M.S. §72-12-1 "...Any person, firm, or corporation desiring to use [ground water]...shall make application...to the state engineer...the state engineer shall issue a permit to the applicant to so use the waters applied for..."

C. Limit on Use of Ground Water

N.M.S. §72-12-2 "Beneficial use is the basis, the measure, and the limit to the right to the use of [ground water]."

D. The Prevention of Ground Water Waste

State ex rel. Erickson v. McLean, 62 N.M. 264, 308 P2d. 983 (1957) "Law will not countenance diversion of volume of water from artesian well which, by reason of waste...is many times that which is actually consumed for useful or beneficial use."

State ex rel. Reynolds v. Mears, 86 N.M. 510, 525 P2d. 870 (1974) "Public waters of this state are owned by state as trustee for the people, and it is authorized to institute suits to protect public waters against unlawful use or to bring any other action required by its pecuniary interests or for general public welfare."

E. Reasonable or Feasible Pumping Lift

N.M.S. §72-12-3 "[The state engineer shall issue a permit to appropriate ground water if the proposed appropriation]...is not contrary to conservation of water within the state and is not detrimental to the public welfare of the state..."

F. Impairment of Senior Appropriator

N.M.S. §72-12-3 "...the state engineer shall, if he finds that there are in the underground stream, channel, artesian basin, reservoir, or lake unappropriated waters or that the proposed appropriation would not impair existing water rights from the source...grant the application and issue a permit to the applicant to appropriate..."

Table 12. Continued.

G. Definition of Impairment

Impairment is defined by the state engineer on a case by case basis (Wright, 1987).

H. Adjudication of Ground Water Rights

N.M.S. §72-4-15 "Upon the completion of the hydrographic survey of any stream system, the state engineer shall deliver a copy of so much thereof as may be necessary for the determination of all rights to the use of the waters of such system together with all other data in his possession necessary for such determination, to the attorney general of the state who shall, at the request of the state engineer, enter suit on behalf of the state for the determination of all rights to the use of such water, in order that the amount of unappropriated water subject to disposition by the state under the terms of this chapter may become know, and shall diligently prosecute the same to a final adjudication..."

I. Ground Water Management Areas

"When the state engineer finds that the waters of an underground source have reasonably ascertainable boundaries, and he so proclaims, or "declares," by describing the administrative boundaries of the basin, he asserts jurisdiction over appropriations from the source for beneficial use." (Reynolds, 1986, p. 2)

J. Management Tools Available for Use in Ground Water Management Areas

All management activities of the state engineer described in the statutes are applicable only to "declared" areas of the state. N.M.S. §72-12-20 "No permit and license to appropriate underground waters for in-state use shall be required except in basins declared by the state engineer..."

The traditional components of the appropriation doctrine are incorporated in the New Mexico statutes. Beneficial use is established as an important management criteria (table 12, part C). Forfeiture through non-use also is included in New Mexico statutes (NMS §72-12-8).

Two ground water management criteria, or goals, are broadly defined by the statutes. Management activities must be consistent with (1) "conservation of water within the state," and (2) the "public welfare" (table 12, part E).

Administration of Ground Water Rights

Statutory Framework

Water rights in New Mexico are not administrated by the state engineer in areas of the state which are undeclared. Appropriators in these areas of the state establish and monitor the local system of appropriative water rights by themselves. In instances of water right conflicts the appropriators must resort to litigation when mutual agreements on water use cannot be reached.

In declared basins the system of appropriative water rights is administrated by the state engineer. Appropriators are required to obtain permits to make new appropriations, or to change the location of existing wells (table 12, part B). Figure 21 illustrates the process of obtaining a ground water appropriation permit in New Mexico. It is important to note that anyone in the declared basin may protest a proposed appropriation, including people/entities which are not appropriators. Additionally, the statutes do not define "impairment" of senior appropriators, or a reasonable/feasible pumping lift. Impairment and pumping lifts are defined on a case by case basis by the state

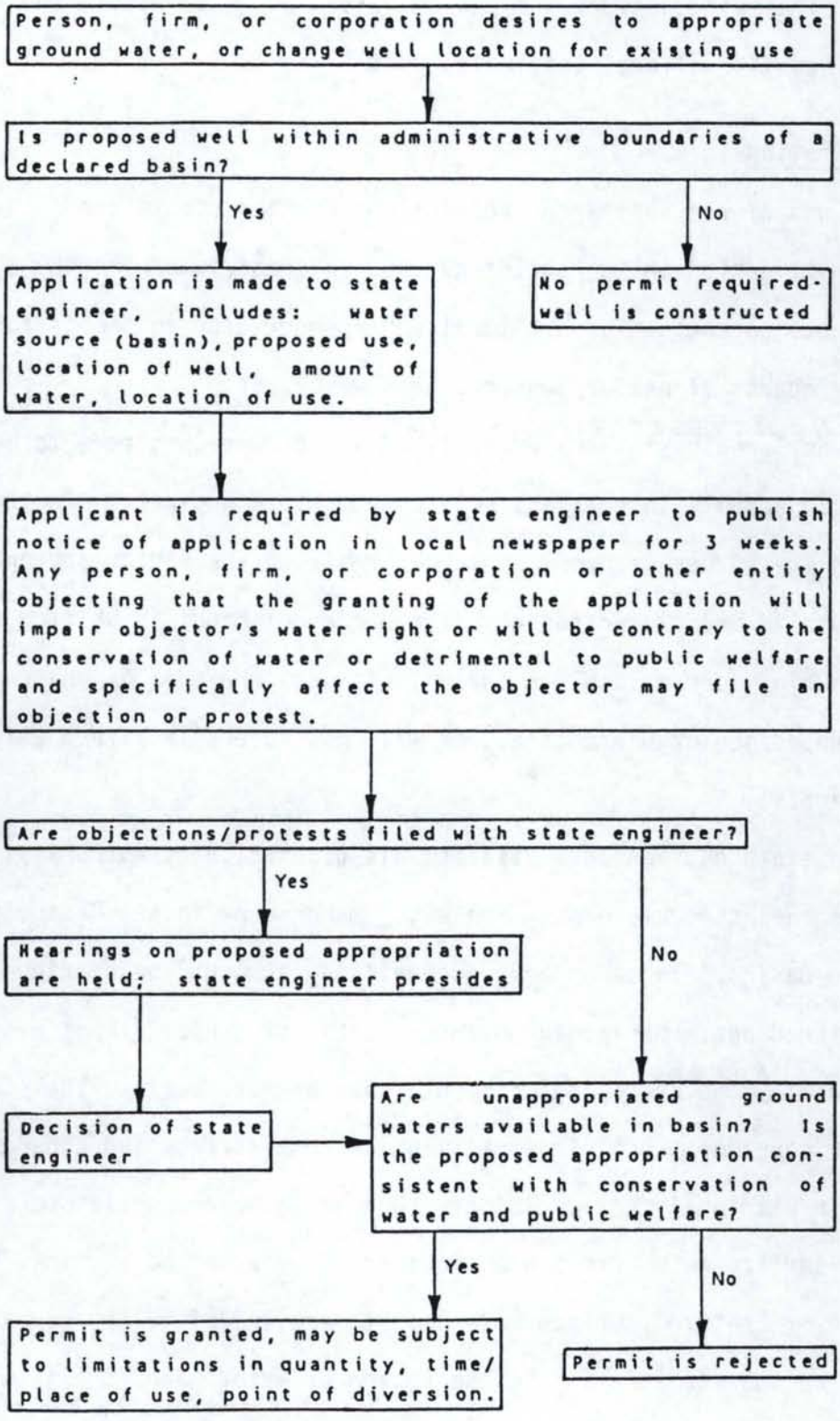


Figure 21. The Process of Acquiring a New Appropriative Ground Water Right in New Mexico.

engineer who must consider the "conservation of water within the state" and the "public welfare" (table 12, part E).

Administration

In undeclared basins the resolution of water rights conflicts may require litigation in the state courts. In these instances the burden of proof rests on the senior or "impaired" appropriator to demonstrate the adverse impacts of new or junior ground water use.

In declared basins the protests of senior appropriators to new or junior use results in hearings held by the state engineer. In these hearings the burden of proof no longer rests on the senior appropriator as it does in undeclared basins. The burden of proof is shifted to the new or junior appropriator in these instances, who must demonstrate that the proposed/junior use does not or will not adversely affect existing water rights.

The state engineer has utilized his discretionary authority to establish a system of conjunctive water management in New Mexico's declared basins. This has been accomplished through the hearings process and declared basin management plans. Issues of senior "impairment" are determined by the state engineer on a case by case basis. The state engineer considers possible impairment of both surface and ground water rights in his impairment decisions. Ground water appropriators who deplete surface water flows are required, over a period of time, to purchase or "retire" surface water rights equivalent to the pumpage effects on the stream. The "conservation of water" and "public welfare" (table 12, part E) are the state engineer's statutory guidelines in these determinations.

The discretionary authority of the state engineer to manage ground and surface waters conjunctively has been challenged in the New Mexico courts. The case of City of Albuquerque v. Reynolds 379 P2d. 73 (1962) affirmed this authority. On appeal, the New Mexico Supreme Court upheld the state engineer's three conditions on the withdrawal of ground water:

1) That the amount of water pumped be measured.
2) That the amount of return flow be measured.
3) That existing rights to the consumptive use of surface water would be retired to the extent necessary to offset the effects of the appropriation by Albuquerque on the Rio Grande River (DuMars, 1982).

Two other court cases (table 12, part D) affirm the state engineer's authority to prevent waste of the ground water resource.

New Mexico law does allow the sale of ground water rights (NMS §72-12-7) "To make such a transfer, the transferer has the burden of showing that other users' water rights will not be impaired" (DuMars, 1982, p. 1052). The process of transferring a water right is essentially identical to that used in permitting a new appropriation (fig. 21). The state engineer has allowed some transfers of surface rights to ground water rights (DuMars, 1982).

Adjudication of Water Rights

Statutory Framework

The adjudication of ground water rights in New Mexico usually is done conjunctively with surface water rights (table 12, part H). The adjudication takes the form of a suit filed in U.S. district court or a state district court by the attorney general at the request of the state engineer (fig. 22). Adjudication suits may also be brought by water

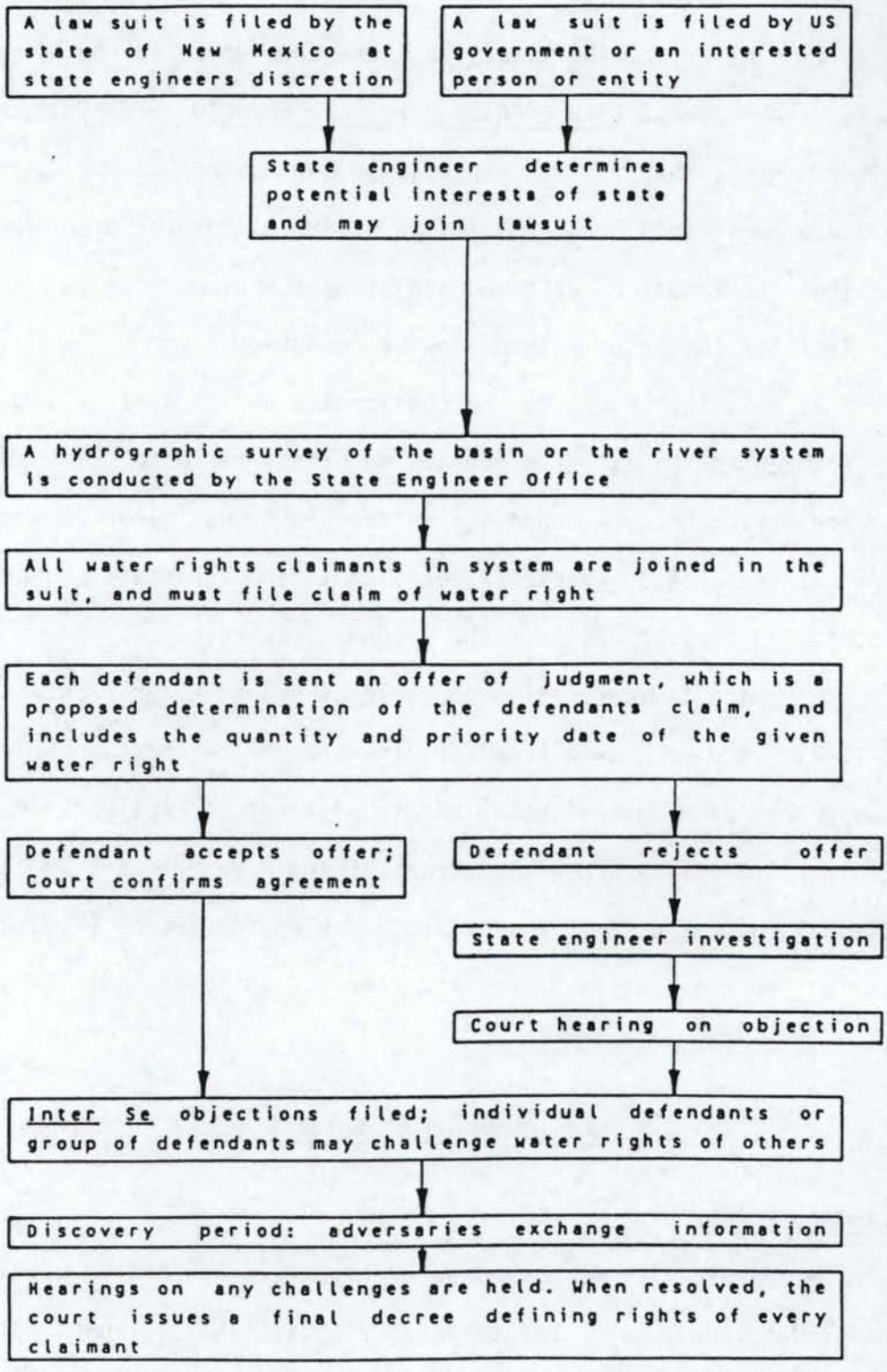


Figure 22. Generalized Procedure for the Adjudication of Water Rights in New Mexico.

users, and are joined by the state at the discretion of the state engineer. Unlike many states, the New Mexico adjudication statutes do not mandate a specific process; however, most adjudications follow the scheme presented in figure 22. In all cases a complete hydrographic survey of the basin is completed by the engineer, and all water rights claimants in the water system are joined to the suit.

Administration

Adjudication of water rights has been active in New Mexico. Many of the declared ground water basins in the state have been adjudicated in conjunction with hydraulically connected surface waters. Adjudications are currently (1987) underway in the Rio Grande Basin, Pecose River Basin, San Juan River Basin, Lower Colorado River Basin, and the Southwestern Closed Basins (Mimbras River Valley).

Ground Water Management Areas

Statutory Framework

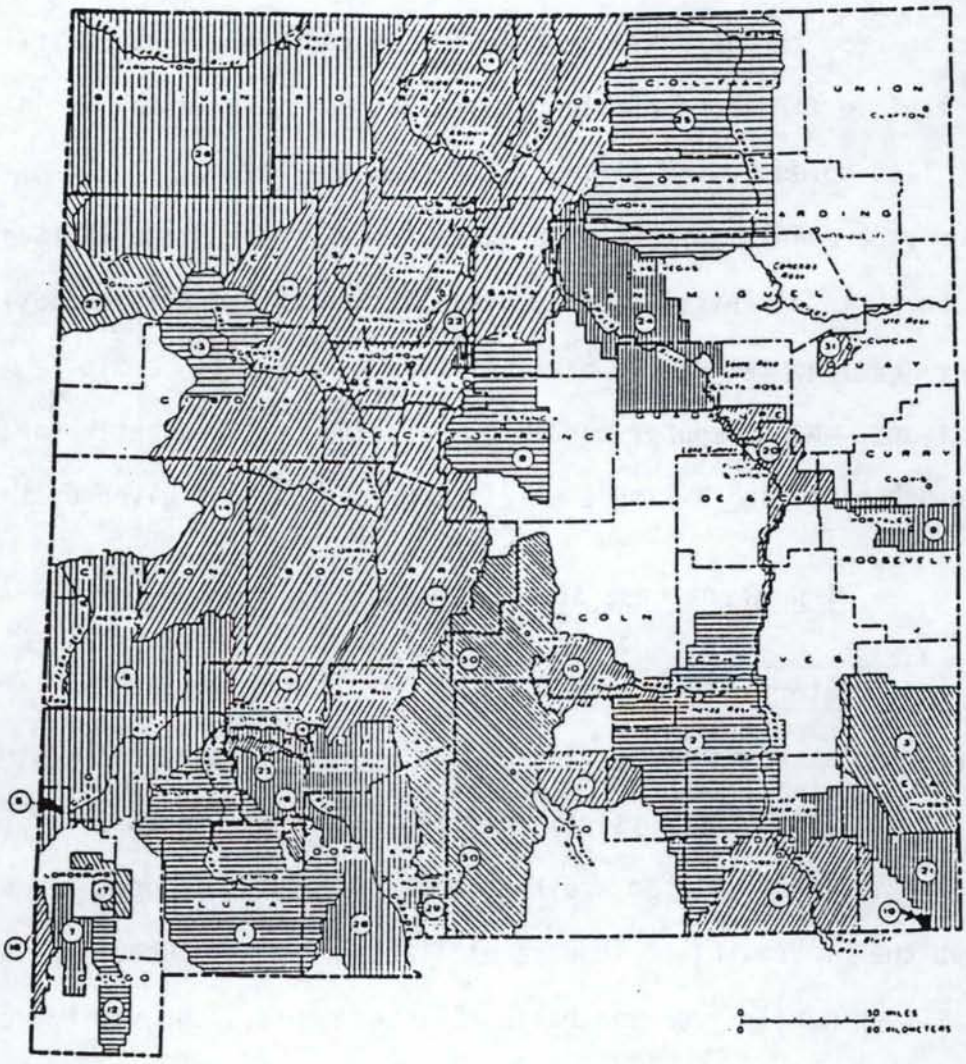
No statutory framework exists in New Mexico for ground water management areas in the sense that this designation is used by other appropriation doctrine states. The "declaration" of ground water basins in New Mexico is similar to critical management area designations in other states (table 12, parts I and J). The declaration of a basin entails the development of a basin management plan. The powers of the state engineer to develop and enforce basin management plans are broad, and have been affirmed in numerous court cases. These powers include the determination of a basin yield objective and curtailment of new and transferred water rights to conform with the plan.

Basin management plans frequently are based on a mining yield objective. The authority of the state engineer to plan ground water mining was affirmed in Mathers v. Texaco 421 P2d. 771 (1966). This important case was centered around the management plan for the Lea County Basin. The plan called for a forty-year depletion of two-thirds of the aquifer's determined storage. Texaco received a water right permit under this plan for use in oil production. Mathers sued Texaco, "arguing that any appropriation from the aquifer subsequent to his necessarily impaired his right because the amount of water in the aquifer was finite" (DuMars, 1982, p. 1054). The state court of appeals ruled in favor of Texaco, and "ratified the following principles followed by the State Engineer:

> (1) The New Mexico State Engineer can and does have the power to determine the useful life of an underground water basin and allow water to be mined from that basin until agricultural and industrial use of the water is no longer economically feasible, thus practically terminating all industrial and agricultural water rights stemming from the basin on that day.
>
> (2) He can and does allow mining of that basin for the specified number of years even through this results in higher pumping costs for earlier appropriators (DuMars, 1982, p. 1056).

Administration

As of June 1986, thirty-one basins had been declared by the New Mexico state engineer (fig. 23). A mining yield management objective forms the basis of most declared basin management plans. This policy is based on the idea that it "would be physically impossible to distribute withdrawals over these basins to take only the annual recharge and thus operate the basin on a sustained yield basis" (Gray, 1975, p. 1). Mining is usually controlled by determining a management life for the basin, and planning for the maximum depletion of two-thirds of the aquifer's storage capacity during that time period. In some basins the plan is



BASIN	AREA IN SQUARE MI
1. MIMBRES VALLEY	4,279
2. ROSWELL	4,281
3. LEA COUNTY	2,180
4. HOT SPRINGS	284
5. VIRDEN VALLEY	19
6. CARLSBAD	1,965
7. ANIMAS	426
8. ESTANCIA	1,724
9. PORTALES	628
10. HONDO	901
11. PENASCO	723
12. PLAYAS VALLEY	515
13. BLUEWATER	1,318
14. RIO GRANDE	26,209
15. GILA – SAN FRANCISCO	5,659

BASIN	AREA IN SQUARE MI.
16. SAN SIMON	263
17. LORDSBURG VALLEY	329
18. NUTT-HOCKETT	133
19. JAL	15
20. FORT SUMNER	1,059
21. CAPITAN	1,550
22. SANDIA	73
23. LAS ANIMAS CREEK	131
24. UPPER PECOS	2,708
25. CANADIAN RIVER	5,825
26. SAN JUAN	9,727
27. GALLUP	1,439
28. LOWER RIO GRANDE	3,858
29. HUECO	255
30. TULAROSA	6,070
31. TUCUMCARI	177
	84,723

Figure 23. New Mexico Designated Basins.

administrated through a block system. Aquifer storage for each township or block is determined. The quantity of existing rights in each block is subtracted from the determined storage. If additional water still remains it is eligible for appropriation. Some basins employ a maximum allowable pumping lift to determine mining yield from the basin.

Computer models are utilized extensively by the State Engineer's Office in basin administration. In one instance, the Mimbras Basin, a computer model of the entire basin is used to evaluate permit applications. New computer models are constructed frequently for the purpose of evaluating a single permit application in a given basin.

Management Case Study: Mimbras Declared Basin

Development History

The Mimbras Basin is located in the southwest corner of New Mexico (figs. 23 and 24). The physical characteristics of the basin are summarized in table 13. No drainage occurs out of this desert basin, although the Mimbras River is perennial above Deming. Ground water pumpage is primarily from the basin fill sediments. Underlying volcanic sediments also contain usable aquifers.

The development of irrigated agriculture in the Mimbras Basin was based largely on ground water pumpage from the alluvial aquifers. Irrigated acreage essentially doubled every decade from 1940 to 1970. Ground water supplied 84% of irrigation requirements. Ground water is also the source of municipal water supply to the towns of Silver City, Deming, and Columbus. The copper industry in the Silver City area pumps significant quantities of ground water for dewatering and processing activities. During 1985, the minerals industry in Grant County (Silver

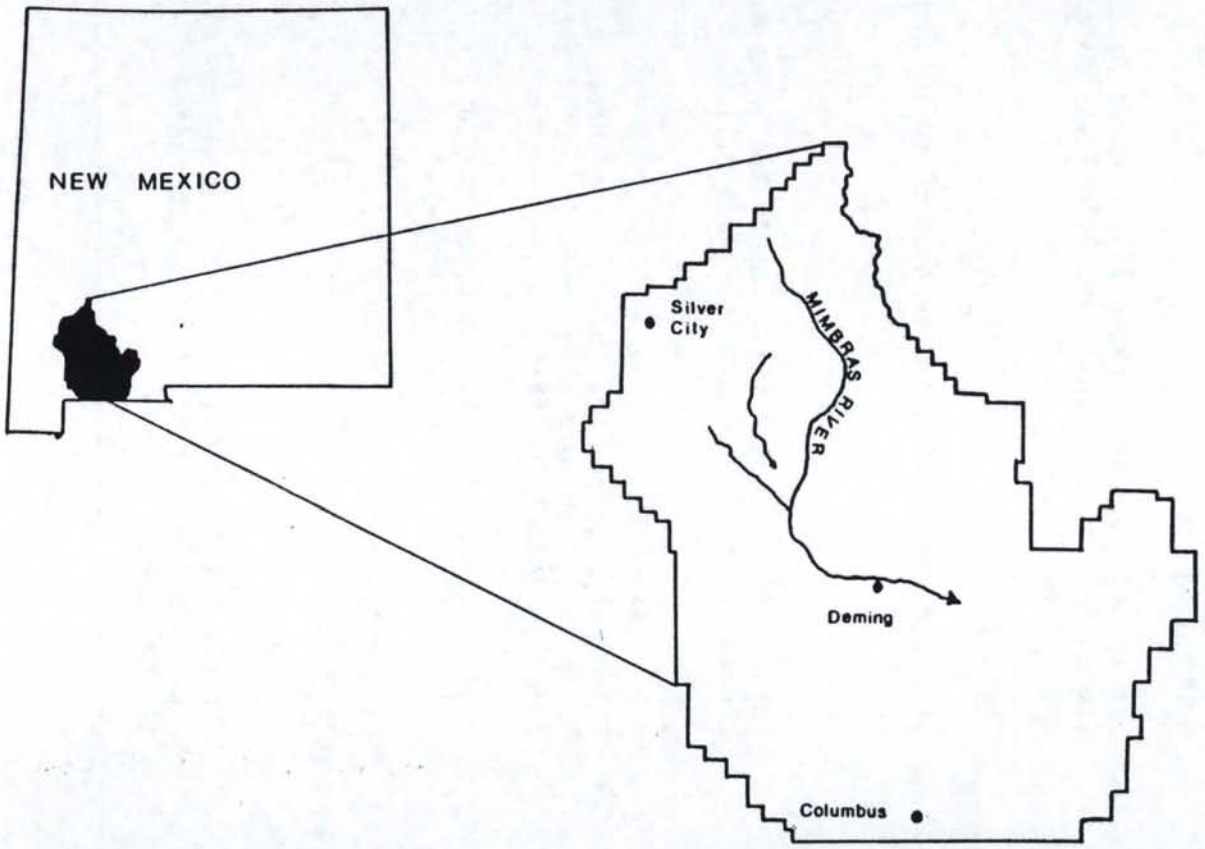


Figure 24. Mimbras Valley Declared Ground Water Basin (Fleming et al., 1987).

Table 13. Physical Description of the Geography, Geology, and Hydrogeology of the Mimbras Basin, New Mexico (Hathaway, 1987; Reynolds, 1986).

Geography	
Location (see fig. 24)	Located in southwestern New Mexico, 4,279 miles^2 in size, surrounded by fault block mountains on west, north, and east.
Drainage	San Vincente Arroyo (ephemeral), Mimbras River (perennial above Deming), and Fila River on northeastern border.
Land Use	Agriculture and copper mining.
Climate	Semiarid, precipitation averages 10 to 20 inches annually.
Geology	
Stratigraphy	Three units of basin fill: upper two units are Gila conglomerate, lower unit is Bolson fill.
Hydrogeology	
Aquifers	Principal aquifers are found in the three units of basin fill, aquifers also found in Tertiary basalt-andesite underlying the alluvium.
Transmissivity	Gila conglomerate: 500 to 3,000 ft^2/day, Bolson fill: 500 to 5,000 ft^2/day.
Storativity	Gila conglomerate: 0.04 to 0.15. Bolson fill: 0.0001 to 0.15.
Depth to Water	100 to 400 feet.
Water Use	Municipal (Silver City, Deming, and Columbus), industrial (copper mining), and irrigated agriculture.

City) used over 12,000 acre-feet of ground water -- more than half the total withdrawals for the county and the largest single water use in the Mimbras Basin (Wilson, 1986). Irrigated agriculture used approximately 11,000 acre-feet of ground water in 1985. Domestic (municipal) and stock use of ground water was less than 7,000 acre-feet.

Water levels have declined steadily in the Mimbras Basin. In the Deming area, declines averaged 50 feet during the 1913-1955 period (Citizen's Conference on Water, 1971). The same source reports accelerated declines during the 1960's, averaging 3 feet per year in the Deming area. The depth to water in 1987 ranges from 100 to 400 feet, with the greater depths occurring in the northern (Silver City) portion of the basin (Hathaway, 1987).

Management History

The Mimbras Basin was the first basin declared by the state engineer, established in 1931. Fourteen subsequent orders have been issued since that time, extending, closing and reopening areas of the basin.

> "The Mimbras Basin is a 'mined' basin, ... the state engineer allows for the development and use of the ground water resource to the extent necessary for beneficial use so long as the use does not cause unacceptable declines in water levels or unacceptable stream depletions" (Hathaway, 1987, p. 4).

The administration of the ground water mining currently is based on a set of criteria for evaluating proposed appropriations of ground water. A finite-difference computer model is used to evaluate the proposed withdrawals. The model is a projection of 1994 water levels. The 1994 projections are compared with 1969 water levels to determine average annual decline rates. The proposed withdrawal is added to the model, and

the projected results of the pumpage are evaluated using the established criteria.

The Mimbras Basin Administrative Criteria were adopted in 1982 and are used currently in the administration of the basin. The criteria are summarized below:

1) One thousand and three square miles of the basin are closed to all further appropriations of ground water.
2) The 1994 water levels projected by the computer model for a proposed appropriation may not exceed 128 feet in depth in the surrounding four block area (each "block" is one-ninth of a township).
3) Computer projected rates of water level decline for proposed appropriations may not exceed 2.5 feet per year.
4) Blocks with projected non-pumping 1994 water levels in excess of 128 feet, or with projected rates of decline in excess of 2.5 feet per year are designated as "critical," and further appropriations are prohibited.
5) In blocks with no existing irrigation rights and with projected water levels greater than 128 feet, new appropriations will be granted if the projected rate of decline is less than 2.5 feet per year.
6) Appropriations will be granted in blocks adjacent to "critical" blocks as long as the projected rate of decline in the "critical" block is less than 2 feet per year.
7) New appropriations in the "Eastern Extension" area of the basin are limited additionally to a depth of 230 feet below land surface, where a marker clay bed is encountered.
8) Because the Gila and Mimbras rivers are fully appropriated, no new ground water appropriation will be granted if the calculated effects

of any proposed appropriation of ground water on the surface flows of the Gila River exceed 0.10 acre-foot per year by 1994, or exceed 0.25 acre-foot per year on the Mimbras River by 1994, unless the effects on the stream are offset by the retirement of existing surface water rights.

9) Applications to appropriate ground water will be entertained in the following quantities:

Transmissivity	Allowable Diversion
500 ft^2/day	300 gpm/300 acre-ft per year/60 acres
1,500 ft^2/day	500 gpm/500 acre-ft per year/100 acres
2,500 ft^2/day	1,000 gpm/1,000 acre-ft per year/200 acres

10) Applications to appropriate ground water from artesian aquifers beneath the basin fill alluvium (in volcanic sediments) will be evaluated on a case by case basis.

11) In general any well for a new appropriation should be located at least one-quarter mile distance from an existing well.

12) In calculating the computer model effects on 1994 water levels, all new appropriations will be assumed to have commenced in 1975.

13) New appropriations which are granted are added permanently to the model and are utilized in evaluating subsequent applications.

ARIZONA

Introduction

The history of Arizona ground water management is characterized by complex statutory and juridical guidance which fostered unrestrained development of ground water. Ground water has served as a primary source of water in this desert state, accounting for more than 60% of the state's water resources (Connall, 1982, p. 314). The evolution of Arizona ground water law and the concurrent growth in pumpage can be divided into three stages: pre-1948, 1948 to 1980, and post-1980.

The pre-1948 period was dominated by a duality in the law which facilitated the largely unrestrained growth of ground water use. Chalmers (1974) describes this period in detail. The 1919 water code stated that ground water in clearly defined channels of underground streams was the property of the public and, like surface streams, was subject to appropriation. All other ground water was considered percolating, and through a series of court cases, was shown to belong to overlying land owners. Development of ground water grew steadily as speculators purchased land to gain ownership of ground water, and the process of establishing the existence of underground streams in the courts became nearly impossible. The Southwest Cotton Company case 4 P2d. 369 (1931) demonstrated the inability of the courts to adequately distinguish the two types of ground water during this period. The situation was one of steady development and legal ambiguity.

A new ground water code was enacted in Arizona in 1948. The political environment which produced the code was complex. Governor Osborn and others truly desired some form of management which would

curtail the development of ground water; many felt the appropriation doctrine should be applied to all water in the state (Chalmers, 1974). Political power, however, rested with those interested in overlying landownership of ground water, and the code reinforced the dual system of classifying the resource. The 1948 act also required the registration of well information with the state land commissioner, and provided for the creation of critical areas where further development would be halted. Existing uses in critical areas, however, would not be curtailed.

The critical area program under the 1948 Act was ineffective. Chalmers (1974) reports that ground water pumpage rose from 3,250,000 acre-feet in 1949 to 4,800,000 acre-feet in 1954. The news of a pending critical area designation spurred well drilling activity as water users attempted to establish a maximum pumpage before the area was closed to new development.

The period up until 1980 saw continued development of ground water, and continued legal ambiguity. The legislature refused to address the ground water issue after 1948, and the courts gave uneven guidance. The confusion reached a high point in the Bristor decisions in 1952, wherein the Arizona Supreme Court decided that all ground water was subject to appropriation, and then reversed the decision several months later. The final result firmly established the doctrine of reasonable use (overlying land ownership) for percolating ground water (Connall, 1982).

During the late 1970's the issue of ground water transport outside of critical areas prompted litigation which ultimately resulted in the Arizona Ground Water Act of 1980. Farmers Investment Co. v. Bettwy (FICO) 558 P2d. 14 (1976) generally established the illegality of transporting ground water for use outside a critical area where it is pumped. The

decision potentially affected many municipalities and mining interests who practiced such transport. This set the stage for passage of the 1980 Act (Kyl, 1982).

Reform of Arizona ground water law was difficult politically. It was recognized that without controls, the ground water supply would be exhausted and destroy the state's economy (Connall, 1982). The control was consistently delayed, however, because the political viability of legislators depended on protecting the water consumption habits of their constituency (Chalmers, 1974). After FICO, the water users were eager for reform, particularly reform which would allow transfer of agricultural ground water to the rapidly growing urban areas (Kyl, 1982). In addition, the municipalities were anxious for construction of a major diversion of Colorado River water to central Arizona: the Central Arizona Project (CAP). The federal government was withholding construction of the CAP until the ground water code was reformed (Kyl, 1982). The CAP essentially provided the legislators with the justification they needed to vote for a change.

The 1980 Arizona Ground Water Management Act is unique, and has been labeled "the most comprehensive ground water code in America" (Connall, 1982, p. 313). The act completely restructured ground water law within four Active Management Areas (AMAs) (fig. 25). The Active Management Areas contain about 80% of Arizona's population; 70% of the state's ground water overdraft occurs within their boundaries (Arizona Department of Water Resources, 1984, p. 2). The Act also established two Irrigation Non-expansion Areas. Many aspects of the 1948 code continue to apply to groundwater use outside Active Management Areas and Irrigation Non-expansion Areas. This chapter focuses on ground water management in

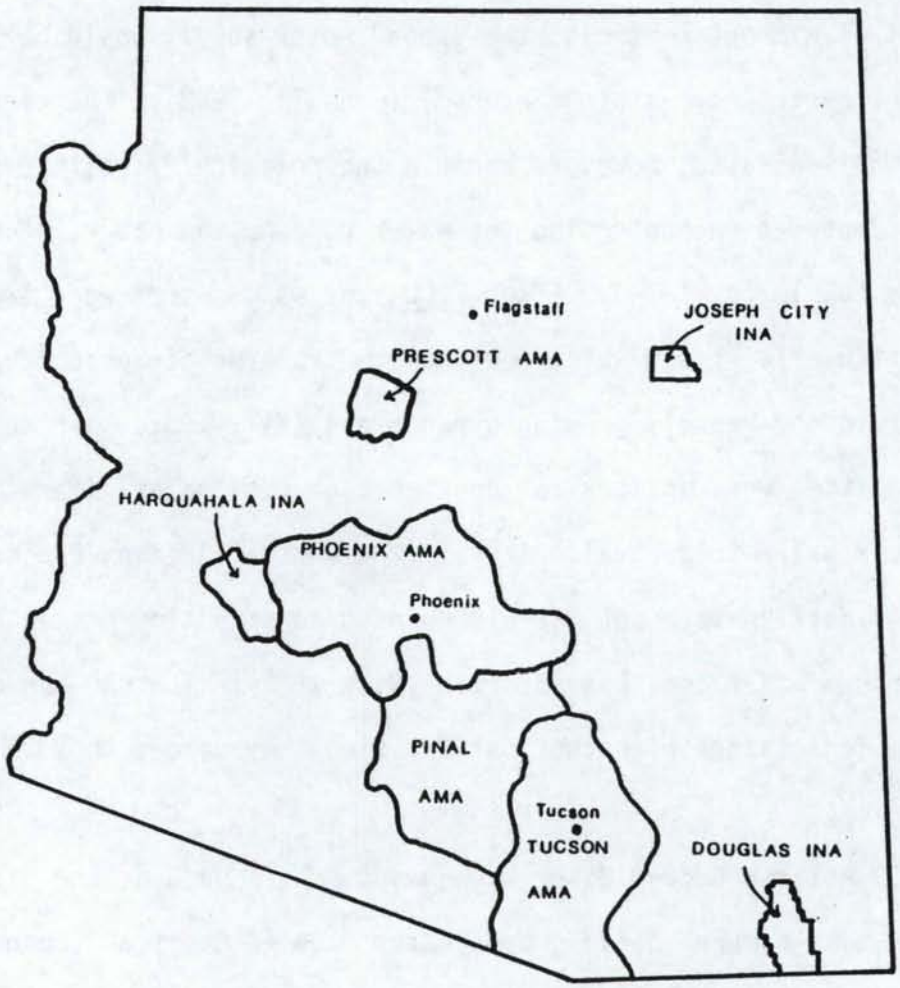


Figure 25. Arizona Active Management Areas (AMA) and Irrigation Non-Expansion Areas (INA) (Arizona Department of Water Resources, 1984).

Arizona within the Active Management Areas and Irrigation Non-expansion Areas under the 1980 Act.

Management Goals

The primary goal of ground water management under the 1980 Act is ground water conservation (table 14, part A). Table 14, part A illustrates that the conservation of ground water is recognized as a critical factor in the future economic viability of the state. The specific long-range goal of the law is to insure safe yield in three of the Active Management Areas by 2025 (table 14, part B). Note that the Final Active Management Area management goal is to provide a smooth transition of irrigation use to municipal use. Safe yield is defined by the Act in terms of a pumpage recharge balance (table 14).

Jon Kyl was an active participant in the negotiations which produced the 1980 Act. Kyl (1982) provides further insight to the Act's underlying goals. In addition to conservation, the Act was motivated by three additional factors:

1) The mining industry's pursuit of a more favorable water transportation statute.
2) The municipalities desire for a virtual monopoly on all water deliveries within and around cities.
3) A desire to restrict water usage by agriculture and eliminate (or reduce) any value of water rights acquired under reasonable and beneficial use (Kyl, 1982, p. 481).

The 1980 statutes direct Arizona ground water management under three broad categories: administration, ground water rights, and conservation.

Table 14. Ground Water Statutes in Arizona.

A. Statement of Ground Water Management Policy

Arizona Revised Statutes (A.R.S.) §45-401 "The legislature finds that the people of Arizona are dependent in whole or in part upon groundwater basins for their water supply and that in many basins and sub-basins withdrawal of groundwater is greatly in excess of the safe annual yield and that this is threatening to destroy the economy and welfare of this state and its citizens. The legislature further finds that it is in the best interest of the general economy and welfare of this state and its citizens that the legislature evoke its police power to prescribe which uses of groundwater are most beneficial and economically effective...it is necessary to conserve, protect and allocate the use of groundwater resources of the state and to provide a framework for the comprehensive management and regulation of the withdrawal, transportation, use, conservation and conveyance of rights to use the groundwater in this state."

B. Management Goals for Active Management Areas

A.R.S. §45-562) A. "The management goal of the Tucson, Phoenix and Prescott active management areas is safe-yield by January 1, 2025, or such earlier date as may be determined by the director."

B. "The management goal of the Pinal active management area is to allow development of non-irrigation uses as provided in this chapter and to preserve existing agricultural economies in the active management area for as long as feasible, consistent with the necessity to preserve future water supplies for non-irrigation uses."

C. Definition of Safe Yield

A.R.S. §45-561 6. "Safe-yield means a groundwater management goal which attempts to achieve and thereafter maintain a long-term balance between the annual amount of groundwater withdrawn in an active management area and the annual amount of natural and artificial groundwater recharge in the active management area."

D. Administration of the Department of Water Resources

A.R.S. §45-103 B "The director has general control and supervision of surface water, its appropriation and distribution, and of groundwater..."

This chapter focuses on describing the statutory framework and administrative activities under each category.

Administration

All ground and surface water management is administrated by the Department of Water Resources (DWR). State (as opposed to local) administration was ultimately determined to be the best way to bring necessary expertise and even handedness to ground water management (Kyl, 1982, p. 483). The director of the Department of Water Resources essentially runs the state water management system (table 14, part D) and has established deputy directors for each Active Management Area (Kyl, 1982). The Arizona Water Commission, which was formerly quite powerful, now only may advise the director.

The director is responsible for enforcement of the code. The director has the power to investigate all potential violations of the code, to try potential violations in a hearing before the Department of Water Resources, and to obtain court injunctions to enforce his determinations (A.R.S. §45-633-634). Penalties for violation of the code may be severe, as great as $10,000 per day (A.R.S. §45-635). A violation is classified as a felony if it involves the illegitimate withdrawal of more than 1,000 acre-feet of ground water (A.R.S. §45-636). The Phoenix Active Management Area has already imposed one $30,000 fine on a gravel company which exceeded its groundwater pumpage allotment. Several municipalities, including Scottsdale and Glendale, are facing potential fines in 1987 (Arizona Republic, 1987).

Ground Water Rights

Statutory Framework

All rights to use ground water in Active Management Areas were reorganized under the 1980 Act. Three kinds of permitted ground water use occur: grandfathered rights, use in service areas, and special permit use. Wells pumping 35 gpm and watering two acres or less are exempt from controls, but must register with the Department of Water Resources (A.R.S. §45-454).

Grandfathered Ground Water Rights. The "grandfathering" of pre-1980 ground water rights preserved the existing patterns of use in Active Management Areas. All existing users of ground water were required to file a grandfather claim in 1981 (A.R.S. §45-476). Grandfather Rights (GFR) generally do not include a right to a specific quantity because withdrawals will change and reduce with time. Three types of Grandfather Rights are: Irrigation Grandfather Rights, Type 1 Non-Irrigation Grandfather Rights, and Type 2 Non-Irrigation Grandfather Rights.

Irrigation Grandfather Rights are based on the irrigation of land from 1975 to 1980. The Irrigation Grandfather Rights is the right to continue irrigating that land,but not at the quantity used prior to 1980. The quantity associated with an Irrigation Grandfather Rights is established by the Department of Water Resources as part of the Active Management Area's ten year management plans, and is pro rated on a per acre basis with a maximum allowable acreage (A.R.S. §45-465). A water account is associated with each Irrigation Grandfather Rights and the water user may use more than the allotted amount in a given season, but must make that amount up in future seasons through conservation; each account has a debt limit of 50% of annual withdrawal (A.R.S §45-467). Use

of surface and ground water together is not prohibited, but the water duty still applies; i.e., if any ground water mixes with surface water in the irrigation system, the surface water counts towards the total allowable ground water use (Kyl, 1982, p. 487). Irrigation Grandfather Rights may only be sold with the land (A.R.S. §45-472). Other entities may buy them and continue irrigating. If Irrigation Grandfather Rights are sold for non-irrigation use of the water, the right reduces to a maximum of 3 acre-feet per acre per year (Type 1 Non-Irrigation Grandfather Rights), a quantity which may be reduced by subsequent management plans (A.R.S. §45-472). If the sale for non-irrigation use is within a "service area" of a municipality, the right disappears (A.R.S. §45-472). Type 1 Non-Irrigation Grandfather Rights are simply Irrigation Grandfather Rights which have been retired for non-irrigation use. In addition to being limited to 3 acre-feet per acre, the Type 1 Grandfather Rights may never be returned to an irrigation use (A.R.S. §45-472, F).

Type 2 Non-Irrigation Grandfather Rights are rights for non-irrigation uses which existed prior to 1980 (A.R.S. §45-464). The quantity of this right is based on the maximum withdrawal from 1975 to 1980.

Ground Water Use Within Service Areas. Cities, towns, private water companies and irrigation districts have "service area rights" to withdraw and transport ground water (Department of Water Resources, 1984, p. 5). The "service area" definition in the statutes is unclear, but generally is the area of land actually served by the given entity which provides water for non-irrigation uses (Kyl, 1982; Department of Water Resources, 1984). The quantities of ground water associated with service area rights are not

fixed, but must comply with conservation goals established in each successive ten year management plan (Department of Water Resources, 1984).

Special Permits. Permits to withdraw ground water are issued by the Department of Water Resources for uses not covered by other types of recognized rights (A.R.S. §45-512). Seven types of permits are issued:

1) Dewatering permits (A.R.S. §45-513).
2) Mineral extraction and metallurgical processing permits (A.R.S. §45-514).
3) General industrial use permits (A.R.S. §45-515).
4) Poor quality ground water permits (A.R.S. §45-516).
5) Temporary permits (A.R.S. §45-517 and 518).
6) Drainage water permits (A.R.S. §45-519).
7) Hydrologic testing permits (A.R.S. §45-519.01).

Administration

The administration of the new system of ground water rights has been received well by Arizonans. Wesley Steiner, director of the Department of Water Resources, remarked that he has been "gratified" by the general sense of cooperation exhibited by water users, citizens, and planning groups (Department of Water Resources, 1984). Within the Phoenix Active Management Area over 10,000 applications for Grandfather Rights were received by 1981. The Department of Water Resources extended the application deadline to 1983.

The retirement of Irrigation Grandfather Rights by the municipal service areas has been active. Edmonds (1986) reports that a steady reduction in irrigation resulting from sale of Irrigation Grandfather Rights to municipal service areas is occurring within the Salt River

Project (irrigation corporation). He speculates that irrigation consumption of project water will constitute less than 10% of the total by the turn of the century.

Irrigation Non-expansion Areas

The 1980 Act converted the Joseph City and Douglas critical groundwater areas into Irrigation Non-expansion Areas (INA) (A.R.S. §45-431). No formalization of water rights exists in Irrigation Non-expansion Areas. Within Irrigation Non-expansion Areas, irrigators are allowed to continue irrigating lands which were watered during the five years preceding the designation (A.R.S. §45-434). The designation halts further development of ground water in the Irrigation Non-expansion Areas. The Irrigation Non-expansion Areas may be converted to an Active Management Area by the director of the Department of Water Resources (A.R.S. §45-439). A hearings process is established by the statutes for designating future Irrigation Non-expansion Areas and Active Management Areas.

Conservation

The primary goal of ground water conservation is to achieve "safe yield" in three of the four Active Management Areas by 2025 (table 14, part B). In the final Active Management Area, irrigation will be allowed for as long as feasible, but is limited in order to preserve water for future non-irrigation uses (Kyl, 1982, p. 492).

To meet the "safe yield" goal the Department of Water Resources is required to develop a conservation plan for every ten years. The

conservation plan may curtail ground water pumpage in three ways (A.R.S. §45-564 to 45-569):

1) Reducing the per capita consumption of water in service areas by establishing quotas.
2) Reducing the water duty on irrigated lands.
3) Requiring industries to conserve water by using the "best available technology."

The conservation plans may also include the imposition of a pump tax. The tax slides on a scale from $1.00 per acre-foot during the first 10 years, up to $5.00 by 2025. The funds collected through the tax are to be used for administration of the Department of Water Resources and for purchasing and retiring irrigated lands to reduce pumpage (A.R.S. §45-611).

Case Study: Phoenix Active Management Area

Development History

The Phoenix Active Management Area, in conjunction with the Pinal Active Management Areas, contains the largest agricultural area in Arizona. The physical description of the geography, geology, and hydrogeology is shown in table 15. Agricultural activities are based on supplies of irrigation water because of the aridity of Arizona's climate. Surface water supplied irrigation needs during the late 1800's. Extensive ground water development began in the early 1900's to augment surface water supplies (Konikow, 1986) and continued slowly until 1940 (Arizona Department of Water Resources, 1984). After the late 1960's the spread of urbanization and increasing water costs caused a decline in ground water use in some areas (Arizona Department of Water Resources, 1984). The

Table 15. Physical Description of the Geography, Geology, and Hydrogeology of the Phoenix Active Management Area (Arizona Department of Water Resources, 1984; Konikow, 1986).

Geography	
Location (see fig. 25)	Located in central Arizona, 5,646 miles^2, contains Phoenix, the largest urban area in Arizona, AMA population in 1980: 1,511,000.
Drainage	Hassayampa, Salt, Agua Fria, Beardsley, New, Arizona, Grand, and Verde Rivers, all ephemeral and tributary to the Gila River.
Land Use	Urban, agriculture.
Climate	Semiarid, receiving an average of 8 inches of rainfall per year.
Geology	
	Rugged mountains composed mainly of low-permeability crystalline rocks, separated by broad alluvial valleys underlain by thousands of feet of unconsolidated to consolidated alluvial deposits.
Hydrogeology	
Aquifers	Most water is derived from the upper most unit of alluvium - highly permeable sand and gravel up to 600 feet in thickness.
Transmissivity	10,000 ft^2/day to 20,000 ft^2/day.
Storativity	0.10 to 0.20.
Recharge	1,080,000 ac-ft.
Annual Pumpage	2,450,000 ac-ft.
Water Use	Total 1980 demand from all sources was 3.41 million ac-ft, 70% agricultural, 20% municipal-industrial, 10% losses.

majority of current water demand in the Active Management Area continues to be agricultural (table 15). The Department of Water Resources projects that by 2025 agricultural demand will drop to 38% of total use.

The Department of Water Resources has determined that currently the ground water supplies in the Active Management Areas are being mined at a rate of 1.37 million acre-feet per year. Groundwater is supplying 80% of the total annual water supply (Konikow, 1986). In some areas of the Active Management Areas the water level is declining as much as 20 feet per year. Maximum declines from 1923 to 1964 were about 360 feet (Konikow, 1986, p. 174).

Management History

Chalmers (1974) provides a detailed analysis of the politics and policies of Arizona ground water management before the 1980 Act. The following discussion is based largely on this source.

Development of ground water in the Phoenix Active Management Area region was not managed prior to 1948. Use of ground water was based on overlying land ownership; the doctrine of reasonable use prevented transport of the ground water off the overlying lands.

In 1951, three critical areas were designated under the 1948 statutes in the region now designated as the Phoenix Active Management Area. These areas were the Salt River Valley, Queen Creek-Superstition, and Gila-Santa Cruz Critical Areas. Their designation was preceded by several years of intense drilling activity by users interested in establishing water use before the area was closed to new development of ground water. Existing pumpage was not restricted in the critical areas. Arizona Ground Water Commission (1953) notes that the State Land Department was under funded, and did not provide adequate supervision of critical areas.

Within the critical areas, non-irrigation wells were under no limitations except the prohibition of waste. Irrigators were prohibited from expanding their water consumption, but were allowed to expand their irrigated acreage. Ground water was prohibited from transfer out of or into critical areas, except that municipalities could violate this rule to the extent that they purchased and retired irrigated land.

The Arizona Ground Water Act of 1980 established the Phoenix Active Management Area. The boundaries of the Active Management Areas are shown on figure 25. The following discussion is based on the Department of Water Resources 1984 management plan for the Phoenix Active Management Area.

The management goal for the Phoenix Active Management Area is "safe yield" by 2025. Safe yield is defined as a discharge-recharge balance. The Department of Water Resources has identified six components of a strategy to achieve the safe yield goal:

1) Require conservation and management of all water used.
2) Regulate new ground water withdrawals to reduce, and eventually eliminate damages from water quality changes, cones of depression and land subsidence.
3) Require, when feasible, the utilization of sources of water other than ground water to meet new demands.
4) Monitoring and protection of water quality.
5) Identification and completion of projects that foster ground water recharge or reuse of all unused water or waste water available in the Active Management Areas.

6) Identification and elimination of unreasonable institutional barriers to the sound management of water resources (Department of Water Resources, 1984, p. 35).

The management plan outlines mandatory conservation measures for agricultural, municipal, and industrial users of ground water. In addition to these conservation measures, the Department of Water Resources has certified grandfathered rights, required well owners to measure and report pumpage volumes, and encouraged use of CAP water whenever possible.

Certificates of Irrigation Grandfathered Rights in the Phoenix Active Management Area permit irrigation of 350,000 acres. Twenty-six irrigation districts exist in the Active Management Areas. The agricultural conservation program establishes an irrigation water duty and a maximum annual ground water allotment for each farm. The irrigation water duty is calculated by dividing the total water requirement by the total planned acreage. This per acre water requirement is then reduced by a percentage related to irrigation efficiency. The irrigation efficiency is crop and land specific, and based on an assessment of consumptive use, soil leaching requirement, and reasonable conservation measures. The maximum allotment is determined by multiplying the water duty by the determined water duty acres for the given farm. Water duty acres are based on historical acreage irrigated by the farm from 1975 to 1979. The Department of Water Resources expects to reduce water duties during subsequent management periods.

Municipal providers of water used 184,000 acre-feet of ground water in the Phoenix Active Management Area in 1980. Conservation measures during the first management period (1980-1990) are directed towards municipal water delivery entities which provide water to more than 500

households or users. Municipal providers are separated into conservation groups based on the gallons per capita per day (GPCD) in 1980. Municipal providers which average 140 GPCD or less in 1980 have no required reduction in use. Municipal providers which average 140 to 350 GPCD are required to reduce consumption by 6% from the 1980 rate, or to 140 GPCD, whichever is less. Municipal providers which average more than 350 GPCD are required to reduce consumption by 11%. The compliance date for the conservation limits is two years after the date of the conservation plan (i.e., 1986). The municipal providers of water must implement their own conservation limits.

Industrial use requires 131,600 acre-feet of ground water in the Phoenix Active Management Area. The majority of this water (98,200 acre-feet) is associated with Type 2 Non-Irrigation Grandfathered Rights; 13,000 acre-feet of ground water has been appropriated since 1980 through acquisition of special permits.

A significant quantity of industrial use water (40,000 acre-feet) is consumed by turf-related industries: golf courses, parks, school grounds, and cemeteries. Each turf-related industry site is given a maximum annual water allotment. The allotment is computed using a complex formula which considers the size of the site, the use of the facility, the existing vegetation, and potential water savings from use of less consumptive plants.

Power plants consume 12,000 acre-feet of ground water annually in the Phoenix Active Management Area. To conserve water, the plants are required to utilize at least seven "cycles of concentration" in their steam generation process. The plants are also required to divert the greatest feasible amount of waste water to the cooling process.

Sand and gravel operations use 17,000 acre-feet of ground water in the Phoenix Active Management Area. These industries are required to reuse their wash water either by recycling water through reclamation ponds or by using "clarifiers."

An important component of the management program is enforcement. All ground water users are required to maintain flow meters and report ground water withdrawals annually. The Department of Water Resources has a statutory right to inspect all facilities and records related to ground water use. The Department of Water Resources states "when necessary, the department will utilize its full authority to ensure compliance with the provisions of the Code and Department rules, permits and management plans" (p. 126).

Most water users have complied with the management plan, according to the Department of Water Resources; however, some violations have occurred. The Arizona Republic presented an article on current violations on December 18, 1986. The Republic reported that a $30,000 fine had been levied against a sand and gravel company which had knowingly exceeded its maximum annual allotment. The article also reported that the city of Scottsdale had exceeded its GPCD limit by 48 gallons in 1986. Unless Scottsdale can rectify the situation in 1987, the city faces daily fines of $10,000.

DISCUSSION

This document provides detailed summaries of the ground water management activities in the states of Montana, Utah, Oregon, Washington, Idaho, Colorado, New Mexico, and Arizona. The state summaries illustrate the many different approaches used by western states to manage ground water resources. The first section of this discussion focuses on comparing the state management activities, highlighting important similarities and differences. This comparison raises several general questions of management effectiveness under prior appropriation which are discussed in the second section.

Comparison of State Ground Water Management Statutes and Administrative Activities

Appropriation and Permits

Most of the states considered in this report are similar in their statutory adherence to the appropriation doctrine. Part A of table 16 lists the six basic tenants of the prior appropriation. Nontributary ground water in Colorado and all ground water in Arizona are not managed under prior appropriation. Colorado nontributary management does utilize several components of the doctrine. Application of the priority principal to nontributary ground water could occur in the future if pumpage exceeds the 100 year depletion criteria. Future litigation possibly will clarify the issue of water right priority and impairment in nontributary areas of Colorado.

All states require that all uses of ground water are centrally recorded with the state through a permitting process (table 16, part B). The states not only require that new and existing uses are permitted, but

also require water users to seek permission to change the nature of their right. Changes include the well location, quantity of water, irrigated acreage, nature of use, or selling of the right separately from the land.

Management Criteria and Impairment of Senior Water Rights

A wide diversity of statutory powers exists in the states with regard to management criteria for new appropriations of ground water (table 16, part C). Only Arizona, Idaho, Washington and Oregon limit pumpage to net recharge according to their statutes. Of these four states, only Arizona has made a concerted effort to issue permits on the basis of this criterion. State management officials in the three states of Idaho, Washington, and Oregon all report that insufficient recharge data preclude effective use of a pumpage/recharge limit in evaluating applications for new permits. In contrast, New Mexico and Colorado utilize a mining yield limitation in issuing new permits (table 16, part C). The difference between a recharge limit and mining yield criterion demonstrates the different definitions of ground water availability. Note that each state requires that unappropriated ground water must be available before issuing a permit (table 16, part C).

The management criteria for new appropriations illustrate several additional differences between states which are significant (table 16, part C). First, Arizona and Montana require that alternative, poor quality sources of water are examined for potential use before approving the use of ground water. Second, Idaho, Washington, and Oregon utilize a maximum pumping lift criterion. Lastly, a minimum well spacing criterion is utilized in Arizona and for tributary and designated ground water in Colorado.

Table 16. Ground Water Management: Statutory Powers

	Arizona	New Mexico	Colorado Designated	Colorado Nontributary	Colorado Tributary	Idaho	Washington	Oregon	Utah	Montana
A. APPROPRIATION DOCTRINE										
ground water owned by public; subject to appropriation		X	X		X	X	X	X	X	X
priority principle applies to ground water		X	X		X	X	X	X	X	X
ground water must be put to some beneficial use		X	X	X	X	X	X	X	X	X
ground water rights forfeited through non-use		X	X		X	X	X	X	X	X
waste of ground water prohibited	X	X	X	X	X	X	X	X	X	X
ground water rights are appurtenant to land		X	X	X	X	X	X	X	X	X
B. GROUND WATER "PERMIT REQUIREMENTS"										
permit or certificate required for existing ground water rights	X	X	X	X	X	X	X	X	X	X
permit required prior to construction of a new well	X	X	X	X	X	X	X	X	X	X
permit required to change well location, nature or place of use	X	X	X	X	X	X	X	X	X	X
permission required to sell ground water right in severance of land	X	X	X	X	X	X	X	X	X	X
C. MANAGEMENT CRITERIA FOR NEW APPROPRIATIONS OF GROUND WATER										
unappropriated ground water must be available	X	X	X		X	X	X	X	X	X
aquifer recharge is used as criteria in limiting new appropriations	X					X	X	X		
mining yield is used as criteria in limiting new appropriations		X	X	X						
maximum pumping lift is used as criteria in limiting new appropriations						X	X	X		
minimum well spacing is used as criteria in limiting new appropriations	X		X		X					
feasibility of using alternative low quality water is examined	X									X
new appropriation may not impair senior water users		X	X		X	X	X	X	X	X
overlying land ownership is required				X						
prospective appropriator must demonstrate financial competence	X					X			X	
D. ADJUDICATION OF WATER RIGHTS										
adjudications are initiated by:										
a. the state or managing agency		X	X			X	X	X	X	X
b. petition of water users					X	X	X	X	X	X
adjudication process										
a. is mandated by statute			X			X	X	X	X	X
b. follows civil court procedures		X			X					
c. is part of permit process for new appropriations					X					
d. utilizes preliminary decrees			X			X	X	X	X	X
E. GROUND WATER MANAGEMENT AREAS										
designation may be initiated by										
a. state management agency		X	X			X	X	X	X	X
b. petition of water users							X	X		X
a hearing is required prior to designation of management area		X	X				X	X	X	X
designation boundaries										
a. must encompass entire basins		X	X							
b. may encompass parts of basins						X	X	X	X	X
goal of designation is										
a. to balance recharge with pumpage or total discharge						X	X	X		X
b. to protect reasonable ground water levels		X	X			X	X	X	X	X
management program for area is designed by										
a. state management agency		X	X			X	X	X	X	X
b. affected water users			X				X			
management alternatives for designated area										
a. close area to further ground water appropriation						X	X	X	X	X
b. establish a cumulative pumpage limit						X		X		X
c. give preference to domestic/stock use								X	X	X
d. reduce pumpage according to priority		X				X	X	X		X
e. establish system of rotational pumpage		X						X		X
f. establish minimum well spacing		X	X			X	X	X	X	X

All of the prior appropriation states included in this study utilize senior pumpage impairment as a criteria for evaluating permits (table 16, part C). The management officials interviewed indicted that the impairment of senior ground water and surface water users has been the primary criterion for issuing ground water appropriation permits. Some significant differences exist, however, in the different state definitions of impairment. Table 17, part A, illustrates that most of the states administer surface and ground water rights under a single set of priorities. Designated and nontributary areas in Colorado involve only the administration of ground water priorities, and all impairment issues in these areas are between well owners. Oregon has a unique priority system: impairment of surface water rights by pumpage is only considered when evaluating permits for new ground water appropriations. Oregon maintains separate priority lists for existing surface and ground water rights. Table 17, part A, also illustrates the different criteria which states have used in determining if senior water rights are impaired. All the appropriation doctrine states have established that senior ground water users must be able to obtain their permitted volume of water; if not, the right is considered impaired. Similarly, the states are in agreement that a senior pumper's well must fully utilize the aquifer. Utah is unique: a ground water right may be considered impaired if the water level drops below historic pumping levels.

Adjudication

All appropriation doctrine states utilize adjudications to maintain accurate lists of priorities. Each state reserves the right to initiate adjudications (table 16, part D). Colorado tributary areas are the only exception; in tributary areas adjudications are only initiated by water

Table 17. Ground Water Management Administration

	Arizona	New Mexico	Colorado Designated	Colorado Nontributary	Colorado Tributary	Idaho	Washington	Oregon	Utah	Montana
A. ADMINISTRATION OF GROUND WATER RIGHTS										
administration of ground and surface water rights under:										
a. a single set of priorities		X			X	X	X		X	X
b. separate sets of priorities			X	X				X		
administrative definition of senior water right impairment by junior ground water pumpage:										
a. protects historic senior ground water levels									X	
b. protects senior ground water volume		X	X		X	X	X	X	X	X
c. protects usefulness of senior well facilities if reasonable		X	X		X	X	X	X	X	X
d. protects senior surface water point of diversion		X			X	X	X		X	X
B. ADJUDICATION										
large scale or statewide adjudication of water rights has been initiated						X				X
adjudication activity has been primarily focused on:										
a. surface water rights							X	X	X	
b. surface and ground water rights		X	X		X	X				X
C. GROUND WATER MANAGEMENT AREAS (activities which have occurred in at least one designated area)										
designated area initiated by:										
a. state management agency		X	X			X	X	X	X	
b. petition of water users										X
designated area boundaries enclose:										
a. an entire basin		X	X						X	
b. a portion of a basin						X	X	X		
a management area designation has been successfully challenged in court								X		
management actions within a designated area have included:										
a. closing the area to further ground water appropriations						X	X	X	X	X
b. establishing a cumulative pumpage limit		X						X		X
c. giving preference to domestic/stock uses										X
d. reducing existing pumpage according to priority		X				X		X		
e. establishing a system of rotational pumpage		X								
f. establishing minimum well spacing requirements		X	X			X				X
water level declines have continued in a designated area		X	X			X	X	X	X	X
water levels have stabilized in a designated area		X	X			X			X	

users. This coincides with the fact that adjudications are an integral part of permitting new appropriations of tributary ground water (table 16, part D). New Mexico and Colorado tributary areas are unique in that the adjudication procedure is not mandated by statute, but instead is determined on a case-by-case basis by the courts. Most states utilize preliminary decrees which are compiled by the administrative agency; this economizes court costs. Only Idaho and Montana have initiated large scale or statewide adjudications (table 17, part B). Most appropriation doctrine states have adjudicated some ground water rights. Only surface water rights have been adjudicated in Washington, Oregon, and Utah (table 17, part B).

Ground Water Management Areas

The states of Idaho, Washington, Oregon, and Montana all have ground water management area programs. Utah, New Mexico, and Colorado have management area programs under different names which are included in this discussion. All seven of these states reserve a statutory right to initiate a management area designation, and in Washington, Oregon and Montana a designation may be initiated by water users (table 16, part E). Outside of Montana, all designations to date have been initiated by the state management agencies. Idaho is unique in not requiring a hearing prior to making a designation (table 16, part E).

Management area boundaries are a point of difference between the states. New Mexico and Colorado require the boundaries to include entire basins (table 16, part E). The other states allow boundaries to include both whole basins and portions of basins. In practice, only New Mexico, Colorado, and Utah have designated entire basins (table 17, part C). Oregon is unique in that a management area designation, the Butter Creek

area, has been successfully challenged by water users in court (table 17, part C).

Some differences exist between states in the goals of the management area designations. Idaho, Washington, Oregon, and Montana all have statutes which state a discharge/recharge balance as a management goal (table 16, part E). None of these states have demonstrated that this goal has been reached in any existing management area. All seven of the states have statutes expressing protection of reasonable or economic pumping levels as a management goal (table 16, part E). This goal has been met in some areas of eastern Utah, the Cottonwood area in Idaho, several districts of the Northern High Plains area in Colorado, and many of the basins in New Mexico (table 17, part C). Note that water level declines have continued in some management areas in all the states.

All seven states require the management agency to take an active role in designing the management plan for designated areas (table 16, part E). Colorado's designated areas include water users in the planning process through the water district program. Washington has recently developed a water user planning program in its management area statutes (table 16, part E).

A variety of management alternatives for designated areas are expressed in the respective state statutes (table 16, part E). Idaho, Washington, Oregon, Utah, and Montana share many of the same alternatives. All five of these states may close the designated area to further appropriations of ground water. In practice, each of these states have used this management tool in the areas which have been designated (table 17, part C). Cumulative pumpage limits are allowed by statutes in New Mexico, Idaho, Oregon, and Montana (table 16, part C), and have been

used in all of these states except Idaho (table 17, part C). Only Montana has exercised the power to assign pumpage preference to domestic/stock uses; this occurred in the South Pine Area (table 17, part C). Most of the states allow the managing agency to reduce pumpage according to priority (table 16, part E), but only New Mexico, Idaho, and Oregon have utilized this power in existing areas (table 17, part C). Rotational pumpage is a management option in New Mexico, Oregon, and Montana (table 16, part E), but has only been utilized by New Mexico (table 17, part C). Lastly, all seven of the states have the power to utilize minimum well spacing requirements (table 16, part E). New Mexico, Colorado, Idaho, and Utah have used well spacing in some of their designated areas (table 17, part C).

Ground Water Management Issues

Combining ground water administrative data obtained from management officials with the statutory information presents a unique opportunity to compare management intent with action. The following four questions and answers place the documented administrative actions within the context of the state statutes.

1. To what extent are ground water management activities consistent with the goals and powers expressed in the statutes of each state?

The ground water management activities described in this document demonstrate that management agencies rarely overstep their statutory authority. Conversely, many management problems are associated with a reluctance to utilize statutory powers which are available. In a few instances, the management agency has been unsuccessful in its actions because of insufficient statutory power, or ambiguous statutes.

Arizona stands out as a state where management actions are in almost complete agreement with the statutes. This has several probable causes. First, the statutes are unusually explicit in describing the duties of the Department of Water Resources. Very little discretionary authority is given to the Department of Water Resources; most criteria are stated in an imperative form. Second, the statutes include a lengthy and detailed enforcement section. Third, and perhaps most importantly, the Arizona system was created recently with a sense of urgency, responding to a serious water crisis. The people of Arizona are supporting the new system and the Department of Water Resources because of the seriousness of their management problems.

New Mexico statutes contrast sharply with those of Arizona; they state general goals and principals, leaving specific powers undefined. A tremendous range of discretionary authority is given to the state engineer. This situation has generated many challenges of the state engineer's power, most accusing him of over-stepping his statutory power. Although similar challenges have occurred in each state, this situation is most common in New Mexico. Generally, however, the state engineer's actions are consistent with the goals expressed in the statutes.

Colorado water law is unusually complex. Ground water is divided into three categories and many of the important water laws have been established by the courts. This has resulted in the decentralization of administrative authority. The courts manage tributary areas; the Department of Water Resources manages nontributary areas; and the commission manages designated areas. The result of this complexity is some considerable uncertainty in the law. For example, many aspects of nontributary management remain undefined. Generally, the activities of

the Department of Water Resources have included the statutory and case law powers which are available.

Idaho, Washington, and Oregon each display a similar set of inconsistencies between statutes and administration. Each of these states has a statute which limits pumpage to net discharge. None of the states have seriously attempted to incorporate the statute in their permit approval process. Each of these states has a reasonable/feasible pumping lift limitation. None of these states have managed to determine what the pumping lift should be for each aquifer system, although Idaho and Washington have made some unsuccessful attempts. Each of these states may also designate entire basins as management areas. Instead, they have all chosen to designate portions of basins as separate areas. Through time the Snake River Basin, Columbia Plateau, and Umatilla Basin have slowly been filled with a patchwork of designated areas.

Idaho, Washington, and Oregon are also different in many respects. Aside from the recharge limit, Idaho is very consistent in applying the management criteria for new permits. Idaho also has used most of its management area powers with some success. Washington has not utilized its management area statutes effectively. The Odessa case study illustrated that the only effective control of pumpage was economics. Oregon suffers from a lack of statutory power.

The Oregon Department of Water Resources has had tremendous problems simply designating a management area (Butter Creek). Similarly, the Oregon statutes do not allow the Department of Water Resources to manage ground and surface water rights under one set of priorities.

Utah ground water management largely has been suspended by the restricted designations of the state engineer. In this instance the

statutory power of the state engineer has been used to its fullest extent in the restriction of the permit approval process. The usefulness of other management statutes, such as the well spacing alternative, has been superceded by the restrictive permit approval policy.

The Montana statutes largely are utilized by the Department of Natural Resources. In approving new appropriations, the impairment criterion is nearly always the only issue of concern. The availability of unappropriated water is a functionally ignored criteria. Similarly, the management area program in Montana includes one of the most complete and detailed sets of statutes in the west. The designation is only used at the request of the water users, and has only been applied in a limited form.

2. The prior appropriation doctrine is based on the principle that during times of water shortage, those water users senior in time receive their full entitlement and junior users receive no water. How has this principal been applied to ground water use?

The application of the priority principal to ground water has been problematic at best. The problem has three components: 1) surface water seniority, 2) the difficulty of defining shortage and 3) the difficulty of determining impairment.

The development of surface water resources preceded ground water development in the west. In most areas, this has resulted in a situation where nearly all surface water users are senior in time to nearly all ground water users. In large basins, like the Snake River Basin in Idaho, the effects of pumpage on streamflows may involve significant lag time, making application of the priority principle difficult (see Ralston et al., 1984). Some authors have noted that maintaining sufficiently high

ground water levels to support stream flows is inefficient, and prevents optimum water use (see Trelease, 1982). Colorado offers the most comprehensive form of conjunctive surface and ground water management in its tributary areas. Regardless of the management system, however, the assessment of pumpage effects on stream flow remains a technically difficult problem.

The application of the priority principle is based on recognizing that a water shortage exists. States such as Idaho, Washington, and Oregon have statutes which mandate that a recharge/discharge balance be maintained in aquifers. This means that ground water is in "shortage" when total pumpage from an aquifer exceeds net discharge. In practice the application of the priority principle under these circumstances has been difficult for two reasons. First, the recharge to an aquifer is extraordinarily difficult to determine. Second, when and if the recharge limit is reached, no shortage is evident to the users - all appropriators pump the water they need from storage. Economically, it does not make sense to shut off users today to benefit other users in the future; it is very difficult for the state to justify shutting off junior users. As a result, the recharge limit has not been used in conjunction with the priority principle. Instead, all of the appropriation doctrine states included in this study use the priority principal primarily for resolving well interference conflicts.

A different problem arises when priority is used to resolve well interference conflicts. This problem is related to the spatial distribution of wells. On a stream, water use is linear; only up-stream users can impair a down-stream water user. Ground water is three dimensional. Junior and senior ground water appropriators are usually

distributed unevenly throughout a basin; the shutting down of junior pumpers may not solve a given senior's interference problem. Appropriation doctrine states have resisted the idea of turning off every junior pumper until a senior's interference problem is solved. Instead, some state management agencies identify wells which are contributing to a given interference problem and then apply the priority principle (for example, Oregon and Montana).

3. What are states attempting to achieve with ground water management area designations? What failure in the system are these designations designed to address?

The statutory goals of management area designations are the maintenance of a recharge-discharge balance and the maintenance of reasonable and economically feasible pumping levels. The recharge-discharge goal is stated in Idaho, Washington, Oregon, Utah, and Montana. The pumping level goal is pertinent to all of the states. The power to reduce pumpage according to priority is the most significant of the tools available to achieve these goals. Ground water management area designations allow the state agency to define water shortage for an entire aquifer or area based on a recharge criterion and/or a water level criterion. Once an area is designated, state agencies have the express authority to reduce pumpage according to priority.

In practice, the states have universally utilized the designations to limit the development of ground water by preventing new appropriations. With the exceptions of isolated areas in New Mexico, Idaho, and Oregon, pumpage has not been reduced in designated management areas. In fact, the discharge-recharge goal and the reasonable pumping levels goal have not been addressed in most designated areas. Examples include the Northern

High Plains area in Colorado, the Blue Gulch area in Idaho, the Odessa area in Washington, the Cow Valley area in Oregon, the entire state of Utah, and the South Pine area in Montana. The Odessa area in Washington typifies the approach. The area was closed to further appropriations but pumpage was not curtailed by application of the priority system; the economics of pumping from greater depths was allowed to control use. Several states, particularly Montana and Oregon, have used the designations to deal with water rights conflicts.

4. How has the appropriation doctrine changed as ground water development has become more intense?

A pattern of management history is evident from the examination of the eight western states. Five management stages may be identified: I) initial development, IIA) local impacts of ground water development, IIB) controlled mining, III) regional impacts of ground water development, and IV) controlled use. After Stage I the management stages branch into renewable and non-renewable management pathways (Stages IIA, III and IV versus IIB, fig. 26). The three stages of the renewable path are temporal in that each state goes through the stages in numerical order. All eight states, and individual basins within each state, are currently at some unique position on this progression of ground water management.

Stage I: Initial Development

The ground water management history of Montana typifies the initial development stage of ground water management. This stage has three distinguishing characteristics. First, water level declines are not occurring on a significant scale. Montana derives only a small portion of its water use from ground water systems. Second, ground water management

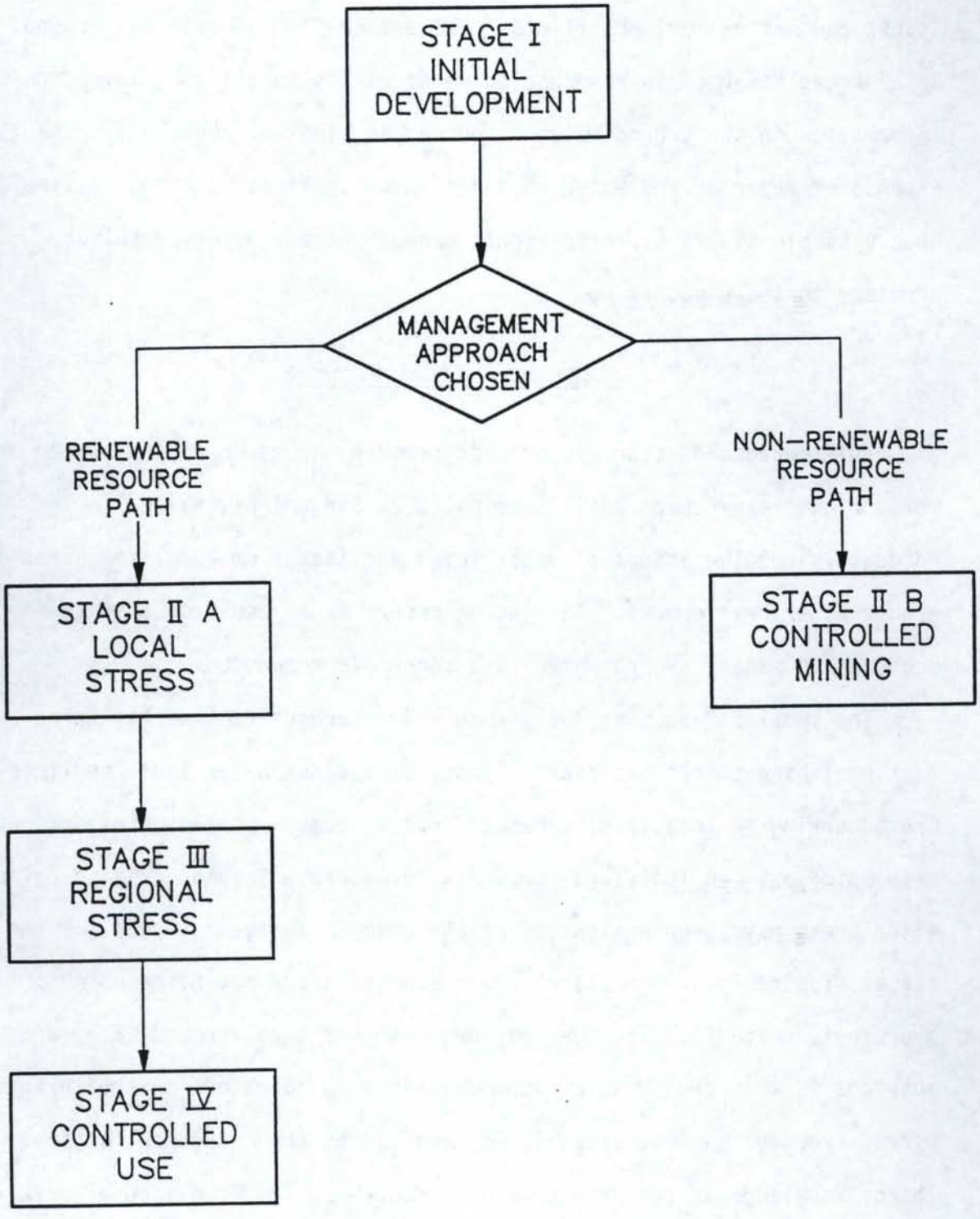


Figure 26. Stages of Ground Water Development in Appropriation Doctrine States.

activities primarily focus on the maintenance of a system of water rights. In Montana, the majority of management energy is expended on interference issues and water rights conflicts. The designation of critical ground water areas has been in response to water rights conflicts. Third, information on the ground water resources is limited. Generally, the expense of major ground water resource investigations is not justifiable when a simple system of water rights management adequately resolves problems that are occurring.

Stage IIA. Local Stress

This management stage is characterized by areas where the system of water rights management activities noted as Stage I has failed to adequately resolve issues of water level declines from localized areas of ground water development. This stage occurs as a result of a state decision to manage ground water as a renewable resource.

The local stress stage of ground water management also has three distinguishing characteristics. First, persistent water level declines are occurring in localized, sub-basin scale areas. Serious conflicts are developing between individual ground water users. Second, critical ground water areas have been designated as the primary management tool for the state. Typically, the critical area boundaries are not based on hydrologic criteria. The designation of the critical ground water area suspends further ground water appropriations but does not control existing users. Pumpage in most areas is not reduced by the management actions. Third, knowledge of the ground water resource system is gained at a fairly rapid rate as part of management activities. The Odessa-Lind area of Washington, the Fort Rock area of Oregon and the Bruneau-Grandview area of

Idaho all typify the local stress management stage. Utah possesses all three of the distinguishing characteristics of the IIA management stage. Utah is unique, however, because isolated management areas have not been designated. Instead, the entire state has been designated and further ground water development has been suspended.

Stage III. Regional Stress

The regional stress management stage represents a breakdown of the "system of water rights" approach to the management of ground water as a renewable resource. Entire basins are removed from further development and comprehensive management schemes involving conjunctive management of surface water and ground water are initiated. This stage also has three distinguishing characteristics. First, serious ground water level declines are occurring on a regional scale. In some cases, this represents the overlapping of localized areas of water level decline. Water rights controversies are widespread and include conflicts between surface water and ground water users. Management based on the administration of individual water rights lacks effectiveness because of the scope of the ground water problems. Second, the local stress type critical ground water areas are interconnected with one another and overlap in a patchwork which covers much of the basin. Third, knowledge of the hydrologic system continues to increase as management decisions become increasingly complex. Typically, large-scale numerical ground water models are involved at this stage of management.

The Snake River Basin in Idaho and the Umatilla Basin in Oregon display many aspects of this management stage. The Snake River Basin adjudication will delineate ground water and surface water rights over a

broad portion of southern Idaho. The areas presently delineated under either a critical designation or a ground water management designation include broad areas within the Snake River Basin. Similarly, the Umatilla Basin is covered by a patchwork of five designated and proposed critical areas.

Stage IV. Controlled Use

Only Arizona has reached the delineated fourth stage of management of ground water as a renewable resource. This stage of management has four distinguishing characteristics. First, ground water management problems have occurred in large portions of the state; control of water level declines is perceived as a survival issue, making dramatic water policy changes politically feasible. Second, ground water and surface water are managed as a single resource. Quantitative large-scale water resource investigations are undertaken and water code enforcement becomes much more strict, imposing criminal penalties. Third, the water rights system is reorganized. The quantities of water associated with individual rights may be reduced and many rights are placed on a scheduled reduction of use and retirement. Patterns of use are altered through the sale of water rights. Agricultural uses, in particular, are shifted to municipal and industrial uses. Fourth, long range conservation plans are devised and implemented. This step is made possible by the political importance of water management as a statewide issue.

Stage IIB. Controlled Mining

This management stage occurs in states which have decided to manage ground water in specific areas as a non-renewable resource. This

management stage has three distinguishing characteristics. First, development from Stage I has proceeded to the point where water level declines are widespread and pumpage is believed to exceed recharge. Second, the political entities of the state have determined that a reduction of pumpage to achieve a water balance is undesirable from an economic or social standpoint. Third, the managing agency has adopted a policy of determining the quantities of ground water available, assigning a resource "life" (e.g., 50 years), and restricting pumpage to sustain usage throughout the projected time period. Areas in New Mexico plus nontributary and designated areas in Colorado are characterized by Stage IIB management.

CONCLUSIONS

The history of ground water management in the states of Montana, Utah, Oregon, Washington, Idaho, Colorado, New Mexico and Arizona suggests a temporal development pattern of management stages. Different management stages may be identified depending on whether the state considers the resource as renewable or nonrenewable. For a renewable resource, the stages are: 1) initial development, 2) local impacts of development, 3) regional impacts of development and 4) controlled use. For a nonrenewable resource, only two stages may be identified: 1) initial development and 2) controlled mining. Ground water management in most states is based on consideration of ground water as a renewable resource. Arizona is the only example of the controlled use stage of management of ground water as a renewable resource. Areas in New Mexico plus nontributary and designated areas in Colorado are characterized by controlled mining of ground water. Management activities become increasingly complex and restrictive as ground water development proceeds, regardless of whether the resource is considered renewable or nonrenewable.

Similarities and differences between the management statutes and administrative activities in the eight states illustrate that management agencies often do not utilize fully the statutory powers which are available. Many of the management problems are associated with a reluctance of the state agencies to utilize powers which are available. Arizona stands out as a state where management activities are in almost complete agreement with the statutes.

The states which manage ground water under the appropriation doctrine experience difficulties in applying the priority principal because of the storage or stock aspect of the resource. The problem has

three components: 1) surface water seniority, 2) the difficulty in defining shortage and 3) the difficulty in determining impairment.

The designation of ground water management areas generally has not resulted in achievement of the statutory goals of recharge-discharge balance and the maintenance of reasonable and economically feasible pumping levels. The states have universally utilized the designations to limit the development of ground water by preventing new appropriations.

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