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### Sustainable Use of the Denver Basin

Charles B. White

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# **SUSTAINABLE USE OF THE DENVER BASIN**

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**Sustainable Use of the West's Water  
Natural Resources Law Center  
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## SUSTAINABLE USE OF THE DENVER BASIN

This paper addresses the question of whether it is possible to achieve sustainable use of a largely non-renewable resource: the nontributary ground water in the four Denver Basin aquifers which underlie the metropolitan area from Greeley to Colorado Springs. The law of nontributary ground water has evolved during the last 15 years in the context of epic litigation to adjudicate ground water rights. Not to be outdone by lawyers, the engineering community has launched a new era of research and demonstration projects to determine whether the Denver Basin aquifers can be used in conjunction with surface water and tributary ground water sources to provide a permanent municipal water supply.

### I. A Primer on Nontributary Ground Water Law.

A. Pre-1973 appropriations. Prior to 1973, it was generally assumed that ground water which was not tributary to a surface stream was not subject to the doctrine of prior appropriation, and was available only to the overlying landowner for his or her reasonable use. This view was supported by the Supreme Court's decision in Whitten v. Coit, 153 Colo. 157, 385 P.2d 131 (1963). The Court applied the common-law rule of reasonable use to water "in the soil" which is not "tributary to a natural stream or part of a stream water table."

In 1965, the General Assembly adopted the Ground Water Management Act (now codified at §§ 37-90-101, et seq., 15 C.R.S. (1990 Repl. Vol.)), which imposed a modified version of the appropriation doctrine on nontributary ground water in certain designated basins. In Fundingsland v. Colorado Ground Water Commission, 171 Colo. 487, 468 P.2d 835 (1970), the Supreme Court upheld the application of the modified appropriation doctrine to nontributary ground water within these designated basins. See also Kuiper v. Lundvall, 187 Colo. 40, 529 P.2d 1328 (1975) (Article XVI of Colorado Constitution does not prohibit regulation of use of water taking over 100 years to reach the stream).

The practice of adjudicating appropriative rights to nontributary water outside of designated ground water basins appeared to be supported by the 1969 Water Right Determination and Administration Act, C.R.S. §§37-92-101, et seq., which declared that all waters originating

in the state, "whether found on the surface or underground," were dedicated to the use of the people of the state, "subject to appropriation and use in accordance with law."

In Preisser v. Smith Cattle, Inc., 545 P.2d 711 (Colo. 1976), the Supreme Court upheld a decree awarding a priority to nontributary ground water outside of a designated basin on the theory that an appropriated water was available. The wells involved in the Preisser case were actually shallow alluvial wells tributary to an intermittent stream, which were more appropriately protected from downstream calls by the futile call doctrine—a fact which was lost on the Supreme Court. See State Engineer v. Smith Cattle, Inc., 780 P.2d 546 (Colo. 1989) (Arkansas River rules not applicable to Preisser wells). Prior to 1973, the water courts entered numerous decrees for appropriative rights to non-designated nontributary groundwater.

B. Senate Bill 213. The General Assembly first addressed rights to nontributary ground water outside of designated ground water basins in Senate Bill 213, which was adopted in 1973. This Act allowed the State Engineer to issue well permits only for "that quantity of water underlying the land owned by the applicant or by the owners of the area, by their consent, to be served." This was a rule of allocation which allowed landowners to control the development of underlying nontributary ground water. The bill did not address the ownership of that water.

S.B. 213 also imposed a management criterion on the use of nontributary ground water by specifying that "the minimum useful life of the aquifer is 100 years, assuming that there is no substantial artificial recharge within said period." Post-1973 well permits for nontributary ground water were based on a quantification of the unappropriated ground water underlying the property of the applicant, and restricted annual withdrawals to a maximum of 1 percent of that volume of water.

C. Definition of Nontributary Groundwater. S.B. 213 did not establish criteria to determine which wells were nontributary. In Hall v. Kuiper, 181 Colo. 130, 510 P.2d 329 (1973), the Court held that underground flow which would reach the surface stream within 40 years was tributary to the stream and subject to appropriation. In Kuiper v. Lundvall, 187 Colo. 40, 529 P.2d 1328 (1975), the Court held that water which would take more than 100 years to reach a surface stream was nontributary as a matter of law. In District 10 Water Users Association v. Barnett, 198 Colo. 291, 599 P.2d 894 (1979), the Court defined the standard to

be whether ground water pumping will affect the surface stream within 100 years, rather than whether the water would contribute to the flow of the stream under natural conditions.

D. The Huston Case. In 1978, an investment group led by John Huston attempted to appropriate vast quantities of nontributary Denver Basin ground water without regard to land ownership. The premise of these applications was that S.B. 213 unconstitutionally restricted the right of non-landowners to appropriate waters of the state. Four and one half years later, the Colorado Supreme Court issued its decision in State of Colorado, Department of Natural Resources v. Southwestern Colorado Water Conservation District, 671 P.2d 1294 (Colo. 1983), which established the present constitutional framework for the development of Denver Basin ground water. The Court held that nontributary ground water is not subject to appropriation under the Colorado Constitution, and that rights to such water could not be adjudicated under the provisions of the 1969 Act. However, the Court also repudiated the rule of Whitten v. Coit that nontributary ground water is the property of the overlying landowner. The Court held that nondesignated, nontributary ground water is publici juris, subject to regulation by the General Assembly. The Court affirmed the allocation provisions of S.B. 213 and invited the Legislature to establish further criteria for the use and adjudication of rights to this water.<sup>1</sup>

E. Senate Bill 5. In 1985, the General Assembly accepted the Supreme Court's invitation to establish a comprehensive scheme for the adjudication and administration of nontributary ground water. Like S.B. 213, S.B. 5 addresses both the allocation and the management of the resource.

1. Policy Statement. S.B. 5 "recognizes the unique, finite nature of nontributary ground water resources" and declares that such water "shall be devoted to beneficial use in amounts based upon conservation of the resource." The Act adopted a policy of

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<sup>1</sup>Following the Huston decision, the Legislature adopted S.B. 439, amending C.R.S. §37-92-203(1) and §37-90-137(6) to provide that rights to nontributary ground water outside of designated ground water basins could be adjudicated under the procedures of the 1969 Act and to validate prior decrees for nontributary ground water. House Bill 1440 added §37-90-137(5) to grandfather pre-S.B. 213 wells which were permitted or adjudicated under the appropriation doctrine without regard to the quantity of water underlying the land of the appropriator.

"economic development" of the resource which allows for a reduction of hydrostatic pressure levels and aquifer water levels "consistent with the protection of appropriative rights in the natural stream system."

2. Nontributary Definition. If pumping of ground water does not deplete a surface stream or its alluvium at an annual rate greater than 1/10 of 1 percent of the annual rate of withdrawal within 100 years, it is declared to be nontributary. In recognition of the "great economic importance" of the ground water in the Denver Basin aquifers, the Act adopted a special standard which allows nontributariness to be determined on the assumption that the hydrostatic pressure level in each aquifer has been lowered at least to the top of the aquifer throughout the aquifer. This provision significantly modified the application of the District 10 Water Users standard in the Denver Basin, increasing the amount of water which is considered to be nontributary.

3. Useful Life. S.B. 5 maintained the 100-year useful life principle of S.B. 213, allowing landowners or those acting with their consent to withdraw 1 percent of the underlying ground water each year.

4. "Not-nontributary" Ground Water. S.B. 5 applied the same land ownership allocation and 100-year useful life rule to ground water in the Dawson, Denver, Arapahoe, Laramie-Fox Hills and Dakota aquifers which does not meet the new .1 percent definition of nontributariness. Owners of land overlying these aquifers were, therefore, granted the right to control development of water which might otherwise have been subject to appropriation.

5. Implied Consent. In recognition of the fact that economic considerations generally make it impractical for small landowners to develop Denver Basin water, S.B. 5 allowed municipal or quasi-municipal water suppliers to obtain rights to develop nontributary ground water within their service areas. By adopting an ordinance or resolution, a district or other public water supplier may obtain the "implied consent" of landowners who are provided with water service by the district to develop underlying ground water which has not previously been adjudicated or permitted to another person or entity. This provision is the foundation of nontributary ground water development by municipal water providers in several portions of the Denver metropolitan area.



6. Material Injury. The requirement of demonstrating lack of material injury and the availability of unappropriated water still applies, but drawdown of pressure or water level does not constitute injury to other ground water users.

7. Augmentation. S.B. 5 adopted arbitrary provisions for replacement of withdrawals from Denver Basin wells. Nontributary wells need not have a court-approved plan for augmentation, that may nevertheless be required to relinquish 2 percent of the amount withdrawn. This may be accomplished by foregoing rights of reuse or successive use of 2 percent of the amount pumped.

Court-approved plans for augmentation are required prior to the use of "not-nontributary" wells in the Denver Basin. In the Dawson aquifer, replacement of all depletions is required to be made based on actual aquifer conditions, including any artesian head. For wells in the Denver, Arapahoe, and Laramie-Fox Hills aquifers located more than one mile from the point of contact between the aquifer and the stream including its alluvium, 4 percent of the amount withdrawn on an annual basis must be replaced to the affected stream system. As to wells completed in these aquifers within one mile of this point of contact, actual depletions must be replaced using the assumption that the hydrostatic pressure level in each aquifer has been lowered at least to the top of the aquifer throughout the aquifer. These decrees "may" also require the continuation of replacement after withdrawal ceases "if necessary to compensate for injurious stream depletions caused by prior withdrawals." This requirement of post-pumping augmentation has given rise to several Supreme Court opinions and creative engineering theories as to the absence of injury in the 22nd century. See Danielson v. Castle Meadows, Inc., 791 P.2d 1106 (1990); State Engineer v. Castle Meadows, Inc., 856 P.2d 496 (Colo. 1993); and Simpson v. Yale Investments, Inc., 886 P.2d 689 (1994).

8. Vested Rights. S.B. 5 declared that the rights to the use of nontributary Denver Basin and Dakota formation ground water pursuant to court decree are vested property rights, subject to future police power enactments concerning waste, beneficial use and reasonable conservation. C.R.S. § 37-92-305(11). It is questionable how much room the General Assembly left future generations to ensure the sustainable use of these aquifers, in view of the 100-year useful life standard which was enshrined in the Act and which has been incorporated into hundreds of decrees for nontributary ground water entered by the water court

in the last 10 years. While the Act adopted a policy of conservation and conjunctive use, it anticipated that this would occur only on a voluntary basis as dictated by market economics.

9. State Engineer Regulations. S.B. 5 directed the Colorado State Engineer to adopt certain regulations to implement the Act. The Denver Basin Rules were initially adopted on November 25, 1985, and amended December 9, 1986, 2 C.C.R. 402-6. These Rules define the location of nontributary and not nontributary ground water in the four Denver Basin aquifers, identify the top and bottom elevations of each aquifer, establish presumptive specific yields and saturated thickness of aquifer material for the purpose of issuing well permits, and prescribe limits on water consumption to ensure that 2 percent of nontributary ground water withdrawals are returned to the stream.

Further criteria for the issuance of well permits in the Denver Basin are contained in the Statewide Nontributary Ground Water Rules, adopted January 24, 1986, 2 C.C.R. 402-7. These Rules provide guidance on the State Engineer's determination of the amount of water underlying the land owned by the applicant or having the landowner's consent. In accordance with S.B. 5, the Rules specify that the maximum annual withdrawal is 1 percent of the total volume of unappropriated water underlying the applicant's land. However, Rule 8A contains an important provision allowing banking of water if the permittee does not withdraw the maximum amount each year. This provides a foundation for conservation of the resource by treating the statutory standard of 1 percent annual withdrawals as a rolling average calculated from the date of permit or decree.

The Statewide Rules also contain important limitations on well location, additional wells, and well fields. Rule 11 allows withdrawal of ground water attributable to a non-contiguous parcel of land, provided that the cylinder of appropriation underlies, at least in part, the non-contiguous parcel. Rule 12 allows for the issuance of permits to construct additional wells, which will certainly be required over time to sustain production levels. Rule 14 allows for the aggregate amount of water allowed to a permittee to be withdrawn from any combination of wells in a well field on contiguous or non-contiguous parcels of land. This provides for some flexibility in managing the resource, although the rules may be applied only to a single permittee.

## II. Artificial Recharge.

The useful life of the Denver Basin could be extended considerably if it were physically and legally feasible to manage the storage capacity of the aquifers through artificial recharge. Colorado law on artificial recharge is still in an embryonic state.

A. Statutory Provisions. As early as 1973, the General Assembly anticipated conjunctive use of nontributary aquifers through artificial recharge. S.B. 213 established the minimum useful life of the aquifer as 100 years, "assuming that there is no substantial artificial recharge within said period." This concept was continued in S.B. 5, which allocated to the overlying landowner "that quantity of water, exclusive of artificial recharge, underlying the land owned by the applicant." Note that the focus of S.B. 5 is on the amount of water which is available to the overlying landowner, rather than the useful aquifer life. Arguably, S.B. 5 denied to the overlying landowner, solely as an incident of land ownership, any rights to water artificially recharged by others. This reading of the Act raises significant questions as to competing rights in underground storage facilities, as discussed in section D below.

In 1994, the General Assembly adopted C.R.S. §37-90-137(9)(d), which required the State Engineer to promulgate rules for the permitting and use of waters artificially recharged in the Denver Basin aquifers. "The rules shall effectuate the maximum utilization of these aquifers through the conjunctive use of surface and ground water resources." This new section expands on earlier legislative declarations, dating back to 1969, which encouraged the conjunctive use of surface and ground water. See, e.g., C.R.S. §37-92-102(2).

B. Proposed Regulations. On December 20, 1994, the State Engineer issued the proposed Denver Basin Artificial Recharge Extraction Rules. Final rules will be issued in June, 1995. Proposed rule 3.2 recognizes that artificial recharge of the Denver Basin aquifers by injection of surface and/or groundwater can maintain historic water levels and extend the life of the resource. Under Rule 5.1, water artificially recharged into a Denver Basin aquifer must, at the time of injection, be fully consumable and/or reusable as determined by a decree, statute, or regulation, or shall be decreed by the water court as usable for artificial recharge. A permit is required to extract artificially recharged water. Extraction may be accomplished through an existing well or a specifically designed extraction well. Water recharged into confined and unconfined portions of the aquifer may be withdrawn from the injection well or a remote

extraction site located within certain prescribed distances from the nearest injection well. In order to allow banking of recharged water, the maximum amount which may be extracted in any one year shall not exceed five times the maximum amount of water injected into the aquifer in any one year, but in no case more than the total amount of water injected into that aquifer (presumably by the permittee). Proposed Rule 6.5 provides, significantly, that a permit to extract recharge water "does not grant a right for the owner of recharged water to enter upon lands not owned by him." The Rules do not address the right to recharge water into an aquifer underlying land owned by another party.

C. Water Quality Constraints. Recharge of the Denver Basin aquifers must occur in a manner which is consistent with applicable water quality standards and regulations. See 5 C.C.R. 1002-2, §6.4.0, et seq.; 40 C.F.R. Part 144. Under S.B. 181, the State Engineer is responsible for ensuring compliance with applicable water quality standards at the time of issuance of a well permit. See §25-8-202(7), 11 C.R.S. (1989), and 2 C.C.R. 402-8, Rule 5. Water quality and temperature have proven to be important factors in the success of demonstration recharge projects. The cost of treating water withdrawn from underground storage, and concerns about commingling with treated surface water supplies, are also significant considerations.

D. Underground Storage Law. The statutory recognition of the right to recharge the Denver Basin aquifers is consistent with Colorado's primitive law on ground water storage. In the Huston case, the Supreme Court acknowledged that Colorado law did not then prohibit the underground storage of water by means of regulating water levels within an aquifer, although it did not pass on the sufficiency of the applications then before it. 671 P.2d at 1321. However, in response to Huston's applications, the Legislature adopted §§37-87-101(2), 37-92-103(10.5) and 37-92-305(9)(c), which provide that waters in underground aquifers are not in storage or stored except to the extent that the waters are placed there by other than natural means by a person having a conditional or a decreed right to such water. These statutes arguably preclude a claim of right to water in the Denver Basin resulting either from induced recharge or non-use of ground water by one who has acquired, or been provided with, an alternate water supply.

Other states have developed the law of aquifer recharge to a much greater extent than has Colorado:

1. Utah. Utah Code Ann §73-3b-202 (1994) allows the State Engineer to issue a ground water recharge permit if, inter alia, a water right exists for the use of the water proposed to be stored underground and the project is hydrologically feasible, "will not cause unreasonable harm to land", and will not impair any existing water right within the area of impact. Approval may be conditioned on the applicant's acquisition of applicable water quality permits.

2. Nebraska. Nebraska allows both intentional aquifer recharge as well as claims for the recovery of ground water resulting from "incidental underground water storage" associated with ditch seepage, irrigation, and other activities which result in ground water percolation. See R.R.S. Neb. §§46-226.01 et seq., 46-233, 46-240, et seq., and 46-295, et seq. (1994). Public water suppliers are further allowed to make application to appropriate public waters for "induced ground water recharge," which is defined as "the process by which ground water withdrawn from wells near a natural stream is replaced by surface water flowing in the stream." R.R.S. Neb. §46-233(1) (1994). Significantly, Nebraska law provides that "an application for recovery of water intentionally stored underground may be made only by an appropriator of record who shows, by documentary evidence, sufficient interest in the underground water storage facility to entitle the applicant to the water requested." R.R.S. Neb. §§46-240, 241(3) (1994).

3. Idaho. Idaho Code §42-4201, et seq. (1994), authorizes certain water recharge projects for a number of purposes, such as increasing spring flow, making additional water available for withdrawal from ground water basins, and providing additional streamflow for aquatic habitat, recreation, and power generation. Idaho has authorized the formation of an aquifer recharge district for the purpose of financing the project through various means, including assessments against water users in the district.

4. Washington. Rev. Code Wash. §90.44.130 (1994) allows the filing of declarations by claimants of artificially-stored ground water within a designated ground water area. Washington Administrative Code §173-134A-080 (1994) requires a permit to be obtained from the Department of Ecology for the withdrawal of artificially stored ground waters.

5. Oregon. Oregon Rev. Stat. §537.135 (1994) authorizes permits for the appropriation of water for the purpose of recharging groundwater basins or reservoirs. The Water Resources Commission is precluded from issuing a permit unless the supplying stream "has a minimum perennial streamflow established for the protection of aquatic and fish life."

E. Entitlement to Use Underground Storage Space. The Colorado courts have not yet resolved the question of who is entitled to use empty underground storage space in the Denver Basin or other underground formations. Except for the oblique reference to artificial recharge in S.B. 5, §37-90-137(4)(b)(II), this topic has not been directly addressed by the legislature or the State Engineer in his proposed recharge rules. Colorado has a strong tradition and explicit statutory authority for the owner of water rights to use natural streams to convey appropriated water from one location to another. C.R.S. §§37-83-101, 37-87-104. It is uncertain whether the courts would impose a similar servitude on underground storage basins, particularly if water was not flowing in a defined channel beneath the land.<sup>2</sup>

Landowners may prevent the construction of surface storage reservoirs on their property unless just compensation is paid for the rights taken. C.R.S. §37-87-101(1). Arguably, a ground water recharger would also have to pay compensation for the right to use a natural underground reservoir. The Colorado Supreme Court has upheld, in a closely divided opinion, the land owner's exclusive ownership of the bed of a non-navigable stream and the owner's right to exclude others from the surface of the water, even though the water itself belongs to the people of the state. People v. Emmert, 198 Colo. 137, 597 P.2d 1025 (1979). The common-law principles underlying this decision could support an argument that a land owner can prevent others from storing water in aquifers beneath the land without his or her consent. See 5 Powell On Real Property, ¶706[5] (1994) (landowner has cause of action in trespass for intrusion into subsurface of land).

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<sup>2</sup>If the aquifer is viewed as a means of "transporting" water from one point to another, statutory provisions for obtaining rights of way may come into play. See C.R.S. §§37-86-102, 104 (owner of water right may condemn rights of way "through the lands which lie between the point of diversion and point of use or proposed use for the purpose of transporting water for beneficial use.").

Other states with a more evolved jurisprudence on aquifer recharge have developed several solutions to this problem. For example, in Niles Sand and Gravel Co. v. Alameda County Water District, 37 Cal. App. 3d 924, 112 Cal. Rptr. 846 (1974), cert. den., 419 U.S. 869 (1974), a California court ruled that the restrictions of California's correlative rights doctrine imposed a public servitude on land which allowed the underlying aquifer to be recharged by a county water district so long as the recharge did not raise the water table above the natural level that would have existed without diversions from the watershed or extractions from the basin.

In Central Nebraska Public Power and Irrigation District v. Abrahamson, 226 Neb. 594, 413 NW.2d 290 (1987), the Nebraska Supreme Court rejected a takings challenge by landowners who claimed that a statute allowing artificial recharge beneath their land unconstitutionally took their exclusive right to the storage capacity of the underlying aquifer. The court held that no constitutional claim would lie unless the recharge caused actual damage to the property. This holding, however, was based on Article XV, Section 4 of the Nebraska Constitution and the correlative rights doctrine, which allows a landowner to make a reasonable beneficial use of water on the land which he owns. The Court held that the statute would not deprive a landowner of protected property rights unless it "prevents him from doing an act which he desires to do or diminishes the enjoyment or profit which he would otherwise derive from his property." 413 NW.2d at 299. Query whether the landowner would have a claim if he sought to make a competing use of the vacant storage space for his own recharge project.

F. Control of Stored Water. C.R.S. §37-90-137(9)(d) and the State Engineer's proposed recharge rules allow a recharger to recapture the stored water without having to maintain dominion and control over the particular molecules which are placed in underground storage. Questions surrounding the right to withdraw stored water have resulted in extensive litigation in California. See, e.g., City of Los Angeles v. City of Glendale, 23 Cal. 2d 68, 142 P.2d 289 (1943);

It would be as harsh to compel plaintiff [Los Angeles] to build reservoirs when natural ones were available as to compel the construction of an artificial ditch beside a stream bed. . . . [I]n selling water to the farms, as in spreading water, plaintiff was interested in its economical transportation and storage. . . . The use by others of this water as it flowed to the subterranean basin does not cut off

plaintiff's rights. . . . Once within the basin, en route to plaintiff's diversion works, [the water] was in effect within plaintiff's reservoir.

This holding was reaffirmed by the subsequent case of City of Los Angeles v. City of San Fernando, 14 Cal. 3d 199, 537 P.2d 1250 (1975). The San Fernando decision allowed the appropriation of a "temporary surplus" of water which, when withdrawn, could create storage space which could subsequently be recharged without adverse effect on the basin's long-term supply. See Victor E. Gleason, Water Projects Go Underground, 5 Ecology L.Q. 625 (1976); Norman W. Thorson, Storing Water Underground: What's the Aqui-Fer?, 57 Neb. L. Rev. 581 (1978).

A recent California case presented the question of whether a water district which delivers imported surface water to ground water users within the district may prevent individuals from pumping the groundwater which remains in storage as a result of the availability of an alternate supply. San Benito County Water District v. Del Piero, No. H010428 (Ct. App. 6th Dist., August 19, 1994). The Court of Appeals did not reach this issue in its unpublished opinion. This so-called "in lieu" storage concept would not appear to be viable in Colorado in view of §37-92-305(9)(c), which requires a claimant of underground storage to have a decreed right to that water.

### III. Models of Sustainable Use of the Denver Basin.

Whether the water in the four Denver Basin aquifers could be considered to be a "sustainable" municipal water supply depends, in part, on the definition of "sustainability," the extent of development, the rate allowed of withdrawal, the implementation of conservation and recycling technologies, and the planning horizon which the present generation imposes on itself. Any plan for the development of a sustainable municipal water supply must recognize that there are limits on the ability of technology to meet an ever-increasing demand with a finite supply. To date, water resources planning in certain portions of the Denver Basin has been premised on the eventual availability of a permanent renewable supply from other sources.

The challenge of planning for sustainable use of the Denver Basin aquifers is to use the available resource in a way which:

- \* extends the useful life of the aquifers as long as possible;



- \* minimizes the capital and operating cost of pumping and distribution facilities;
- \* allows for conjunctive use with tributary ground and surface water in manner which optimizes the benefits of each source; and
- \* maximizes the use of the storage capacity of the aquifers through recharge.

With this in mind, there are five general models of "sustainable use" of the Denver Basin. As operating experience and new technologies improve the economics of conjunctive use of surface and ground water, elements of these models will be adapted in various combinations to meet local water supply requirements.

A. Sole Source of Supply With Restrictions. This represents the current practice in many portions of the metropolitan area. By definition, use of nontributary ground water as a sole municipal supply is sustainable only for a limited time, and the capital and operating costs will increase over time as additional wells are required to maintain yield from declining water levels. The supply can be extended through a number of regulatory mechanisms, none of which will itself achieve sustainability. However, these steps can be implemented as part of an overall conjunctive use program:

1. Water Conservation. Rate structures which encourage conservation and non-consumptive uses can slow the rate of growth in demand.

2. Use restrictions. In theory, future irrigation from Denver Basin wells could be prohibited in order to extend their life as a household use only supply. Precedent exists for such restrictions in the case of exempt small capacity wells on unsubdivided lots less than 35 acres. C.R.S. §37-92-602(3)(b)(II).

3. Pumping Restrictions. S.B. 5 could be amended to extend the minimum useful life of the aquifer. Governor Romer has suggested a standard of 300 years, which would allow withdrawals of only .033 percent of the available supply each year. However, in view of the numerous pre-S.B. 213 appropriations and "vested rights" which have been adjudicated under S.B. 213 and S.B. 5, such an approach would present potential constitutional obstacles if it were to be implemented on an effective scale.

4. Land Use Restrictions. A possible solution to the constitutional problem of restricting the use of existing decreed Denver Basin rights is for local governments

to impose land use restrictions on new residential development which require a proven water supply longer than 100 years. This was done in El Paso County, which in 1986 required new subdivisions to demonstrate, at a minimum, a 300-year supply of water. The legality of this provision was upheld by the Colorado Court of Appeals in Cherokee Water and Sanitation District v. El Paso County, 770 P.2d 1339 (Colo. App. 1988). In practice, such a requirement either triples the capital and operating costs of using Denver Basin wells, or forces the developer to rely on conjunctive use and/or renewable water sources.

B. Recycling. Proven technology exists to recycle both individual household and general municipal waste by treating it to potable quality. If implemented on a large scale in areas provided with Denver Basin supplies, recycling could reduce the draft on the Basin to the extent of water consumed through use and treatment—perhaps 5 percent of gross water requirements, exclusive of irrigation. Water consumed could be supplied by additional diversions from the aquifer or with tributary ground or surface water.

Two obstacles exist to the widespread implementation of recycling technology. The first is cost. Depending on economies of scale, recycling costs somewhere in the neighborhood of five times as much as conventional treatment of raw surface water supplies. However, after factoring in the cost of treating effluent to a level suitable for discharge to surface streams, the cost is about twice that of conventional treatment combined with wastewater disposal. As wastewater treatment costs increase to meet Safe Drinking Water Act and Clean Water Act requirements and recycling technology improves, recycling may become a viable option.

The second obstacle is public acceptance of the technology. A direct connection between the sewer and the faucet presents a psychological barrier which has yet to be overcome. One solution is to inject the treated water into local aquifers and subsequently extract it for municipal use. Of course, this increases operating costs dramatically in relation to alternatives, particularly if the water must be treated again before use to meet SDWA standards.

C. Use for Augmentation Purposes. The useful life of the Denver Basin aquifers can be extended considerably if they are used, not as a direct physical water supply, but as a source of augmentation water to replace depletions resulting from the use of tributary ground or surface water sources. Colorado law provides for the adjudication of "plans for augmentation" which enable water to be diverted out of priority if the resulting depletions are

replaced to the stream at a time and location to meet the demands of senior appropriators. See C.R.S. §37-92-305(8). The use of nontributary Denver Basin water as an augmentation source is common in areas where alluvial ground water or surface water supplies are available. However, the cost of extending raw water lines to more remote locations can be significant.

D. Dry-year Supply. A variant of conjunctive use which is currently being studied in a state-sponsored investigation of metropolitan water supply alternatives is the use of nontributary ground water in dry years to supplement the surplus yield of surface water supplies in average and above-average water years. Under one hypothetical scenario, a major metropolitan provider such as the Denver Water Department could agree to make available new residential water taps to municipal providers outside of the board's present service area, in exchange for commitments from those providers to allow Denver to call nontributary ground water into its system during dry years which meet certain hydrologic criteria. In this way, the new municipal providers would benefit from the surplus yield of Denver's system during above-average years, and the availability of Denver Basin ground water in dry years would provide assurance to Denver that the new municipal demands would not exceed the firm yield of its system. This alternative could be paired with recharging of the Denver Basin aquifers during wet years, as discussed below, in order to further extend the life of the Basin.

This alternative presents a number of significant institutional issues which would have to be resolved before implementation could be considered. Among these are: established policies against commingling of water from different sources within Denver's system; an unwillingness to rely on non-renewable sources, even in part, as a long-term domestic water supply; constraints imposed by the charter of the City and County of Denver on the leasing of water to areas outside of the City; and an unwillingness to commit "surplus" water above the firm yield of the system in reliance on supplemental supplies with an uncertain long-term yield and cost.

This model of conjunctive use also will require a significant investment in water distribution facilities to extend treated water supplies to areas which presently rely solely on ground water. However, the trend toward cooperation among water providers in the southern metropolitan area will likely result in further system interconnections which will increase the economic feasibility of wheeling both ground and surface water between different providers.

The results of the current metropolitan water supply investigation will provide further insight into these alternatives as well as potential non-structural means to meet future demands.

E. Recharge of the Denver Basin. The metropolitan water supply investigation is also considering the potential for recharging the Denver Basin aquifers with surplus surface water as a means of regulating the storage capacity of the aquifers to achieve a long-term sustainable supply. If recharge is physically, legally, and institutionally feasible, it would allow flexible conjunctive use of the ground and surface water systems and largely eliminate the need for major new surface water storage facilities, such as Two Forks, to serve the Denver metropolitan area.

Although deep-well injection of ground water and recharge of alluvial aquifers are relatively common practices, there is little information concerning the feasibility of recharging the Denver Basin formations. To date, only two demonstration projects have been operated, by Willows Water District and Centennial Water and Sanitation District, with mixed results being reported. Until more is learned about the technical feasibility of recharge in different portions of the Basin, one cannot predict the ultimate success of such a program.

Furthermore, the cost of groundwater recharge must be compared to that of available alternatives. Treatment of the water prior to injection and after recovery, pumping costs associated with both recharge and withdrawal, capital costs for injection and withdrawal wells, and water supply pipelines to connect recharge areas with surplus surface water sources must all be evaluated against the cost of alternatives, such as continued conversion of agricultural land, additional diversions from the west slope, recycling, and new surface storage facilities. However, as pressure mounts for preservation of agricultural lands, protection of basins of origin, and maintenance of minimum streamflows, recharge and recovery may eventually become a cost-effective alternative. A number of legal and institutional questions will also need to be addressed. For example:

1. Do landowners who have been granted the exclusive right to control the development of water which naturally occurs in the Denver Basin aquifer also have the right to control the use of the empty storage space in these formations? As discussed above, there is no clear answer to this question in Colorado.

2. How will the State allocate the storage space of the aquifers as between competing rechargers? Will landowners or public water suppliers who have the implied consent to develop ground water within their service area be allowed first priority? Will priority of appropriation of storage space govern? Will the relative priority of the appropriative right to the water being recharged be the determining factor?

3. What showing must the recharger make of an actual increase in the artesian head or water table in order to maintain a right to extract recharged water? At what distance from the recharge site may extraction occur, and how remote in time? May the recharger prevent other well owners within the "area of impact" from enjoying the benefits of the recharge ground water, at least without their financial participation in the project? These are questions which have been addressed in other states, as noted in section II.D above, and may to some extent be resolved in the context of the State Engineer's new Denver Basin recharge rules.

4. What is the liability of a recharger to adjacent ground water users for declines in artesian pressure or the water table in a particular aquifer? Can the rights of the recharger under §37-90-137(9)(d) and the proposed recharge rules be exercised in a manner consistent with the "vested property rights" of pre-1973 appropriators and land owners under S.B. 213 and S.B. 5 adjudications?

5. What new institutional arrangements need to be made in order to finance recharge projects, properly allocate costs and benefits, and administer recharge programs? Should recharge occur on a local or regional basis, and with or without the authority to levy assessments on property and/or water use which benefit from the program? Should existing water suppliers be allowed to participate if they contribute recharge water, facilities, funds, or a combination of these resources? It is noteworthy that several other states have established separate ground water recharge districts to administer these programs.

6. What external effects on other water resources of the state will occur? For example, if conjunctive use of ground and surface water provides a mechanism for Denver to fully utilize its west slope water rights, there will be impacts on streamflows and reservoir levels in the Colorado River Basin analogous to those which were anticipated to occur as a result of Two Forks Reservoir. What measures, if any, need be taken in order to mitigate

the impacts of additional transbasin diversions on the availability of water for municipal, snowmaking, agricultural, and recreational water users as well as fisheries and wildlife?

#### IV. Conclusion.

Sustainable use of the Denver Basin aquifers will require an unprecedented level of cooperation among front-range municipal water suppliers, the development of new institutions to finance and manage conjunctive use programs, substantial investment in infrastructure to interconnect ground and surface water supplies, and strong advances in technology in the areas of wastewater recycling and deep-well injection. While conjunctive use raises a number of unresolved legal issues, changes in law and policy will be driven by the market for economically viable uses of the Denver Basin formations.