PROBLEMS OF CONJUNCTIVE USE OF SURFACE WATER AND GROUND WATER SUPPLIES

by

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In Colorado, ground water is a commodity in which no individual holds title, however, it is a commodity used (and misused) as if it were private property. In some areas of Colorado, as in many other States in the West and Southwest, we are mining or depleting this resource rather rapidly. In other areas we are polluting or contaminating supplies, and in certain situations we are using ground water to the injury of previously established surface water rights.

In Colorado, attempts to pass legislation defining ownership and rights in ground water; or legislation to help assure an orderly mining of those areas that must be depleted in order to make use of the resource; or legislation to control contamination; or legislation to protect the prior rights of surface water users, has met with failure after failure.

THE GROUND WATER-SURFACE WATER CONFLICT

One of the serious problems developing in Colorado and other areas in the West is what I will refer to here as the "ground-water-surface-water conflict." This is merely an abbreviated description of the problem which has developed along many of our Western streams. I am speaking here of the conflict of interest between surface water users from a stream which is in hydraulic connection with a ground water aquifer from which extensive withdrawals are being made. The conflict comes about when both sources are developed and used without regard to the interconnection of the two supplies.

How the Conflict Developed

As the West was settled and it became apparent that irrigation was a necessary element of agricultural development, those lands closest to the streams and rivers which required the simplest and cheapest diversion works with short conveyance ditches were developed first. As settlers continued to move into these areas, lands farther from the river requiring longer supply ditches were developed, usually through the formation of mutual ditch companies or other group financing methods. In Colorado, much of this development took place prior to 1900.

As lands adjacent to a stream were irrigated, the flow characteristics of the stream generally became quite radically changed.Part of the water diverted and spread over-land, percolated downward and raised the natural water table to the extent that ground water flowed to the river and augmented the stream flow.This resulted

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in the lower reaches of each stream obtaining a longer flow period, or in many cases, changing an emphemeral stream into a perennial stream. Because of this "return flow" phenomena it was possible for lower irrigators to take advantage of this source of water and obtain rights in it. Therefore, using Colorado as an example again, many of the lower reaches of streams such as the South Platte and the Arkansas River in Colorado depend entirely upon return flows during the latter part of the irrigation season to support their irrigation economy.

Other man-made influences generally came about soon after irrigation diversions began. Storage was seen to be needed in order to hold back spring runoff for use later in the season. In general, these storage facilities were designed for seasonal storage, not for long-term holdover storage.

Much later, principally since 1930 and more intensively in the 1950's, irrigation wells have been drilled in the alluvial aquifers beneath and adjacent to the streams.

As an example, decrees for diversions from the Arkansas River between the Rocky Mountains and the Colorado-Kansas State Line (Water Districts 14, 17 and 67) total 6200 cubic feet per second. All of these decrees are prior to 1904, however most decrees of value are prior to 1888. The "over appropriation" can be seen when the median diversion during August for the 52-year period 1911-1962 of 1770 cfs is compared with the total decrees of 6200 cfs. To complete this picture, records on file in the Colorado State Engineer's office indicate a total pumping capacity from irrigation wells (all of which have been drilled since 1904) of over 3000 cubic feet per second. All of these wells tap the alluvium of the river, and most are within two miles of the river. Since the alluvium serves as the return flow conveyance mechanism, pumping of the ground water can have a significatn effect upon the stream flow.

Not only has this problem developed as far as irrigators are concerned, but now as urban development becomes extremely important in the water picture, the problem is also affecting city water supplies. As an example the following was taken from The Denver Post of August 10, 1963. The words quoted were those of an attorney representing the city of Denver and speaking about an up-stream municipality.

> "__________________________ has been guilty of "obvious thefts of water" from supplies Denver has developed on the South Platte River by sinking wells in gravel deposits right next to the river, "and actually siphoning our water out for their use."
>
> "This sort of water-theivery cannot go unchallenged. It is intolerable, and may have to become the basis for court proceedings quite apart from this emergency."

<u>Solutions to the Problem</u>

For solutions to this problem we have looked first to case law and second to statutes to determine the thinking of the courts and State legislatures. No attempt has been made to thoroughly examine these factors; only sufficient to determine trends, precedents, and principals.

Case Law. A general rule throughout most of the West is that seepage and return flow waters tributary to a natural stream belong to that stream and are subject to appropriation in line with prior vested rights. Capture of such seepage or return flow waters and relating rights back to the date of original appropriation will generally require that the original plan should show this intention[1]. Whether or not the ground water is considered as being in a natural underground (well-defined) channel or stream or whether it is considered as the sub-flow or undercurrent of the stream, it is subject to appropriation the same as the surface flow.

As stated in an often quoted Arizona case[2], "the test is always the same: Does drawing off the sub-surface water tend to diminish appreciably and directly the flow of the surface stream? If it does, it is sub-flow, and subject to the same rules of appropriation as the surface stream itself; if it does not, then, although it may originally come from the waters of such stream, it is not, strictly speaking, a part thereof, but is subject to the rules applying to percolating waters".

From a legal standpoint, percolating waters are considered to be diffused ground waters not traveling in a well-defined channel or stream and which do not contribute to the flow of a surface stream. In most of the Western States all ground waters are considered to be percolating unless obviously contained in a natural ground water channel or stream. As a hydrologist I dislike this definition, but for the purpose of this report it suffices to say that Colorado makes exception to the universally held presumption of percolating waters of the other States. The Colorado Supreme Court has held that ground water is presumed to be tributary to a stream and the burden of proof is placed upon the one who alleges otherwise.[3]

From case law then, we see that return-flow water would normally be considered a part of the surface water flow and should be administered in the same schedule of rights as the surface water. In other words, the wells drawing this water from the aquifer would fall in the priority sequence according to their dates of drilling or production initiation. As can be seen, strict administration of such priorities on an over-appropriated stream would result in the wells seldom being able to pump. A counter-argument often heard is that because of the slow response from shutting off wells when a senior appropriator calls for the water, the administrator should not have to shut down the wells if it would not benefit the senior appropriator in time. This however does not remedy the basic problem and

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1 As an example see Fort Morgan Reservoir and Irrigation Company vs McCune, 71 Colo. 256, 206 P. 393 (1922).

2 Maricopa County Muncipal Water Conservancy District No. 1 vs Southwest Cotton Company, 39 Ariz. 65, 4 P. 2d 369, (1931).

3 See Dalpez vs Nix, 96 Colo.540, 45 P.2d 176(1935), and Safranek vs. Town of Limon, 123 Colo.330, 228 P.2d 975(1951).

it would seem that further attempts at a solution are needed.

State Statutes. A cursory look at statutes indicates at least one state[4] which forbids anyone from drawing from a ground water supply that feeds a stream if it will reduce the supply to prior appropriators of the surface water. Strict administration of such legislation would result in no ground water pumping from the alluvial materials in connection with the stream. This would appear to not provide the solution needed, in that the wells can be of great economic importance and result in a much higher beneficial use of the total water supply. Also, in many instances, the wells have been in place and used for many years. These wells and the accessory equipment represent a large investment of money and it is unlikely that legislation of this type would be enforceable once the pumping has become established.

Another State, New Mexico, requires the retirement of surface water rights according to a time schedule computed from ground-water flow theory when a well takes water from a stream-connected aquifer. This is sound from the technical standpoint and represents a scientific approach to a complex problem. This approach tends to protect the prior surface water rights, but may not go quite far enough towards obtaining maximum beneficial use.

Conjunctive Management Program

What then is the solution? The thinking we have done on this problem indicates the solution may be in the development of conjunctive management programs in which prior surface rights can be compensated, by some means, and thus allow continued ground-water pumping. As we conceive it a conjunctive management program would make use of the ground water reservoir as a part of the overall water supply, conveyance and distribution system in the basin. It would likely mean that during years of drouth the ground-water system would be called upon heavily to provide the water not available on the surface. And likewise, during more favorable run-off years, the ground-water reservoir would be replenished by artificial methods. In short, the ground-water reservoir would be a long-term storage facility used in conjunction with the seasonal storage reservoirs on the surface.

STUDY OF CONJUNCTIVE MANAGEMENT PROGRAMS

Research studies are underway to develop techniques for determining optimum conjunctive management programs. Initially we are working with mathematical models simulating typical field conditions. Programs are being prepared

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[4] Kansas Annotated Statutes, Sec. 42-306: "No person shall be permitted to take or appropriate the waters of any subterranean supply which naturally discharge into any superficial stream, to the prejudice of any prior appropriator of the water of such superficial channel". (Laws of 1891, Ch. 133, Art. 1, Sec. 6).

for use on digita computers which will allow the following factors to be varied as desired:

(1) Surface inflow into the system
(2) Number and location of diversions
(3) Priority and amount of decrees
(4) Consumptive use demand
(5) Aquifer characteristics pertinent to the pattern of return flow and effect of pumping on the stream flow
(6) Ground water pumping

Relationships of return flow patterns and effects of pumping on stream flow that have already been developed[5] are being utilized in the mathematical models. Results obtained from the models include the amount of water available to each diversion and the deficiencies of supply.

It is readily admitted that these preliminary models are somewhat idealized compared to field situations. However, we feel this step is necessary to work out techniques and to test general solutions which may be worthy of more detailed study. For instance, two management solutions being looked into are the use of "public" pumps to supply either senior or junior rights, and use of low-flow lined channels to increase delivery efficiencies in areas where ground water levels may be lowered significantly for extended periods. These and other techniques are being coupled with artificial recharge.

Physical Models

When general techniques and solutions have been developed, it may be desirable to use physical models to further refine the management programs. Such models may include electric analog, sand tank and viscous analogy models. Simulation of aquifer geometry, and permeability, as well as a less than 100% free connection with the stream flow can be obtained more realistically with physical models.

Econometric Models

As is often the case, the optimum management program from the physical standpoint may not necessarily be the most optimum from the economic standpoint. Thus, a further step in this will necessarily involve economic analyses. Optimization techniques developed in the fields of Decision Theory and Operations Research, now being applied to water allocation problems[6] will be used.

5 See: Glover, R.E., "Ground Water-Surface Water Relationships" Published with the papers of the Western Resources Conference, Ground Water Section, by the Colorado Ground Water Commission, Aug. 1960, and,

Hurley, Patrick A., "Predicting Return Flow From Irrigation" U.S. Bureau of Reclamation Tech. Memo 660, Denver, Colo., Aug. 1961.

6 Buras, Nathan and Hall, Warren A., "An Analysis of Reservoir Capacity Requirements for Conjunctive Use of Surface and Ground Water Storage, I.A.S.H. Publication No.57, Ground Water in Arid Zones, pp. 556-563, 1962.

Buras, Nathan, "Dynamic Programming Methods Applied To Watershed Management Problems, Trans. ASAE, U5, N1, pp.3-5, 1962.