Economic Evaluation of Water Sources for Waterflooding Programs

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The practice of secondary recovery of oil by means of water flooding is of relatively recent application in the West Texas-Southeastern New Mexico area. More particularly, the idea of developing sources of water for such purpose is of even more recent vintage.

Early efforts at water flooding were confined to the re-injection of produced water such as was employed in the Cedar Lake Field in Gaines County in the middle to late forties. Occasionally off-structure wells were utilized to provide additional sources of water. These efforts were generally successful where the waterflooding principle was involved. However, with the advent of pressure maintenance schemes, additional sources of water were required, and gradually over the years the practice of developing water supply sources, specifically dedicated to secondary recovery operations has developed. One of the early projects of this type involved contracts between the operating companies and the Colorado River Municipal Water District for the purpose of securing a steady supply of surface water from Lake J. B. Thomas to supply the needs of secondary recovery in the Scurry County oil fields. At about the same time pilot waterflooding projects in portions of the Spraberry Oil Field were commenced utilizing water obtained from wells drilled into the Trinity (basal Cretaceous) sands for that specific purpose and small areas in the South Ward and adjacent oil fields in Ward County were put under flood with water obtained from shallow Quaternary alluvium wells.

Based upon early successes in secondary recovery by water injection an increasing number of full scale operations were instituted toward the latter part of the 1950's and the practice has been expanded materially during the past five years. Such fields as North Cowden, Fullerton, large portions of Wasson and Slaughter, and substantial portions of the Spraberry Field have been put into secondary recovery utilizing water specifically developed for such purpose. Likewise, many of the fields in Northern Crane County and on the eastern shelf in Howard, Glasscock, Nolan and Coke Counties have received attention in recent years.

Widespread activity in secondary recovery operations has brought into sharp focus the question of water supply sources for such operations and, together with increasing requirements of municipalities in the western part of the state, has resulted in the development of a royalty concept in the acquisition of vested rights in such water sources. Since in many areas the deeper brackish and saline water zones are incapable, because of low permeabilities, to deliver required volumes of water on a continuous basis and further, since some of the deeper sources provide almost insurmountable problems of corrosion, the practice of developing potable to slightly brackish water sources has received much impetus in recent years. This practice has resulted in problems not only connected with the acquisition of water rights, but also some serious problems of public relations.

The first contracts of which the writer is aware, involving the acquisition of water rights on a royalty basis, were those made by the oil companies with the Board of Regents of the the University of Texas lands in the middle to late forties. The general form of this early contract involved a small cash bonus per acre plus a royalty of ten cents per 1000 gallons of water produced from the lease. Most of these contracts were for plant purposes rather than for secondary recovery, but the principle of royalty acquisition was thus established. In the early fifties municipal contracts were drawn with the University of Texas with the royalty being tied to the annual production rate, decreasing as production increased.

In 1957 the first royalty contract to the writer's knowledge which attempted to relate the royalty payment to the market value of water was drafted between the City of Midland and the University of Texas. This contract states that the royalty to be paid to the University will amount to one-eighth of the wholesale cost of water within the Midland municipal system, and further states that as the wholesale rate increases, the royalty will increase accordingly. At this time the City of Midland is paying a royalty of 4⅜ cents per 1000 gallons based upon a wholesale consumer rate of 35 cents per 1000 gallons. At about the same time the City of Andrews signed a similar contract with the University, paying a royalty of three cents per 1000 gallons being one-eighth of their wholesale rate of 24 cents per 1000 gallons.

Since these early attempts at relating the royalty base to the market value of water a number of municipal, industrial, and secondary recovery contracts have been executed following the same general pattern. The present delivered price range of water for secondary recovery purposes, when related to the customary one-eighth value for royalty calculations, yields royalty figures in line with similar royalties being paid by municipalities. For example, the royalty due to the landowner of a one-eighth basis where the delivered price is 1.15 cents per barrel amounts to 3.4 cents per 1000 gallons. At a delivered price of 1.5 cents per barrel the royalty on the same basis would amount to 4.46 cents per 1000 gallons. From this it can be seen that under present circumstances the range in royalty is generally between three and five cents per 1000 gallons, whether based upon the delivered price of water in secondary recovery operations or whether based upon the wholesale rate of a municipal water supply.

There is also a correlation between present royalty rates and other costs of developing, producing, and transporting ground water for secondary recovery operations. It is obviously impossible to talk about the average overall cost of delivering a barrel of water to a consumer since so many critical variable factors are involved; for example, the pumping lift and the length of the transmission line. However, it is probably safe to say that a minimum amortized cost of producing water is in the range of one cent per barrel and increases as drilling depths, pumping lifts, transmission line lengths and variations in pumping rates increase.

Each water supply project must be carefully considered as to all of the facts before a realistic cost figure can be developed. Power costs, labor, replacement and repair, administrative overhead, taxes, and debt service requirements must be carefully and realistically appraised for each individual project. Repair and replacement costs must include provision for resizing of the pumps to fit the changing deliverability of the wells in most ground water reservoirs in West Texas. Royalty costs or capital expenditure in purchasing water rights prorated over the life of the project must be fitted into the operational budget to assure an adequate spread between operating costs and income. The installation and maintenance of an adequate control system to provide automatic or semi-automatic operation of the supply project geared to the requirement of the injection operation must be provided. It is also important to take into consideration the widely varying demand curve typical of many secondary recovery operations in examining the amortization and operational costs of a water supply project.

Although perhaps not directly related to the subject matter, the writer would like to take this opportunity to emphasize the need for thorough engineering studies of a proposed water supply project as a prerequisite to the development and operation of such a project. The emphasis today is upon the requirement that ground water be utilized in the most efficient manner possible with the least amount of waste. To accomplish this objective it is imperative that the hydraulic characteristics of the reservoir be thoroughly understood to the end that both development and production operations will be dictated by the nature of the reservoir.

The day of haphazard well spacing and construction methods, and uncontrolled pumping rates is rapidly coming to an end. The industry might do well to follow the lead of the ground water conservation districts in promoting orderly and efficient development of our ground water resources.

Ground water under most of West Texas is a depletable resource. The sole recharge to these reservoirs is from rainfall upon the land overlying the reservoir and, except in very few instances, there is no rejected recharge. Because of the extremely small proportion of the annual rainfall reaching the reservoir each year, there is also very little natural discharge in terms of annual withdrawal from the reservoirs by pumps. For this reason an area developed with wells operating on a continuous basis will experience a steady decline in the pumping level. In highly permeable reservoirs this decline may be rather small from month to month, but unless or until the cone of depression intercepts an area of natural discharge or an area of rejected recharge the levels must continue to decline. This is an important consideration in considering secondary recovery sources since in most cases the need for source water is on a continuing basis.

It is essential to determine such characteristics of a ground water reservoir as the permeability, the porosity, the thickness of the saturated portion of the sediments, the direction and degree of slope of the water table, and the specific capacity of the reservoir at varying production rates. The development of the well field supplying a secondary recovery project must be based upon an adequate knowledge of these factors if the industry is to discharge its responsibility in providing the most efficient utilization of this declining resource.

No attempt has been made here to relate the delivered cost of a water supply in a secondary recovery operation to its value in terms of the additional oil produced in the scheme. Many variables enter into this relationship; and the writer does not feel qualified to analyze this matter. However, it is hoped that this discussion will provide a basis upon which such economic analysis can be projected.