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IRRIGATION WATER CONSERVATION - BENEFITS AND TRADEOFFS

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ABSTRACT

Water conservation must be examined within the context of a water balance for a zone of specified boundaries. On-farm conservation may not result in basin conservation, and may actually damage water supplies within the basin, especially if groundwater supplies dwindle. Conservation must also take place with recognition of water rights, and therefore concepts such as Irrigation Efficiency and Irrigation Sagacity must be well understood. Because of the diversity of hydrology, there is no single menu of water management improvements which are applicable in all cases. In the future, more emphasis will be placed upon improving crop yields with a given amount of water consumed, thereby maximizing the utilization of the scarce water resources.

BACKGROUND

Water conservation has been the topic of numerous conferences over the years, and there is little "new knowledge" to be delivered. However, it is very clear that considerable confusion still remains. Therefore, this paper will attempt to address some of the aspects of confusion by pointing out facts from "old knowledge". These facts must be clearly understood in order to have meaningful conversations regarding water conservation.

WATER BALANCES AND WATER CONSERVATION

"Water Conservation" implies that less water will be "consumed". The following points are essential :

1. Before considering the possibility of water conservation, a water balance must be developed. A first step in making a water balance is to define the horizontal and vertical boundaries of the area to be considered.
2. A farm water balance will give a different perspective than a district water balance. By going as far as a hydrologic basin, one gets even a different perspective.

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3. Reducing "water applied" is not necessarily synonymous with "true water conservation", because in many cases excessive applications are reused within the hydrologic basin (in streams or aquifers).
4. "Consumption" of water implies that the "consumed" water cannot be retrieved or used until it returns to the earth's surface in the form of rainfall. The most important form of consumption is conversion of liquid water into vapor, which is the process of Evapotranspiration (ET), including ET from crops, phreatophytes, wet soil surfaces, weeds, etc.
5. An increasingly important type of consumption is degradation of water quality. The degradation in quality can either restrict or eliminate the reuse of the water, or require additional "fresh" water supplies be used to dilute the degraded water.
   • We clearly understand the situation of water flowing into a surface saline body, such as the Salton Sea or the ocean.
   • We less clearly understand the situation of deep percolation into saline aquifers.
   • We poorly understand the "equivalent amount of water" lost when our "good" aquifers have a slow degradation in quality.
6. "Traditional" water conservation practices such as lining of canals may result in no water conservation at all in some areas which depend upon groundwater supplies during dry years.

IRRIGATION EFFICIENCY AND RATIOS

It has recently been pointed out (Allen, et al. 1995 and others) that the definition of Irrigation Efficiency is frequently confused and misinterpreted. Therefore, it has been recommended that fractions or ratios, such as the "reusable fraction" of water, be used instead of efficiency.

This author strongly agrees that Efficiency terms have been confusing and that the concept of using certain ratios is a helpful idea. However, the following points must be made:

1. Much of the problem is within the irrigation profession itself. There have been numerous instances of technically flawed papers dealing with the concept of efficiency which have been generated from within. There is no shortcut to understanding the technical concepts of water balances, reuse of water, the difference between actual crop water use versus crop water requirements, and many other items. Unfortunately, we have often substituted "experience" of irrigation specialists for technical correctness when discussing concepts of efficiency. Fortunately, the concepts are now becoming better understood.
2. We cannot ignore the concept and definition of Irrigation Efficiency, because it deals with the concept of the portion of the water which is Beneficially Used. Our water laws address the issue of this need for defining Beneficial

Use. Therefore, we must get very serious about educating ourselves and the irrigation profession about the complexities of determining Beneficial Use.

3. Our water laws include the concept of Reasonable Use, which is different from Beneficial Use. This must also be considered when discussing water conservation. It is unreasonable to expect that all non-beneficial uses be eliminated.
4. The American Society of Civil Engineers, Water Resources Division, has a Task Committee on Describing Irrigation Efficiency and Uniformity. The 44 page report of that committee is in its final draft stages, and will be submitted to the ASCE Irrigation and Drainage Journal by November, 1995 (Burt et al, 1995a). The Task Committee spent over two years of serious effort on the product. The committee has developed a comprehensive explanation of efficiency and uniformity. The length of the document indicates the complexity involved. A few of the concepts and terms are as follows:

Irrigation Efficiency, IE is defined as

$$IE = \frac{\text{volume of irrigation water beneficially used}}{\text{volume of irrigation water applied - } \Delta \text{ storage}} \times 100\% \quad \textbf{(1)}$$

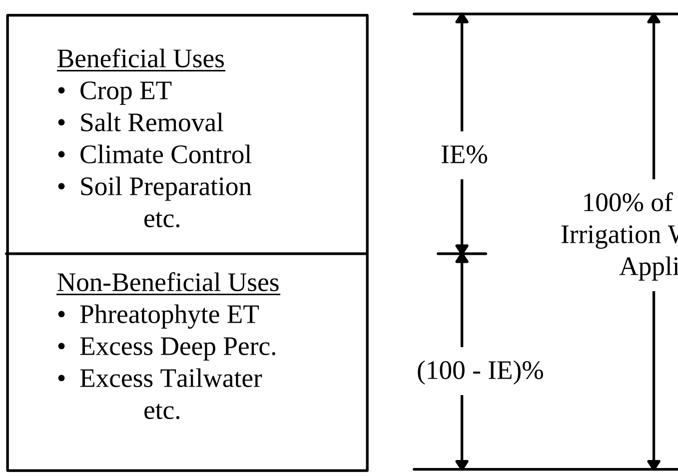

Figure 1. Irrigation Efficiency (IE) quantifies the division of applied irrigation water into beneficial and non-beneficial uses (Burt et al, 1995a).

The Irrigation Consumptive Use Coefficient (introduced by Jensen, 1993) is now defined as:

$$ICUC = \frac{\text{volume of irrigation water consumptively used}}{\text{volume of irrigation water applied - } \Delta \text{ storage}} \times 100\% \quad \textbf{(2)}$$

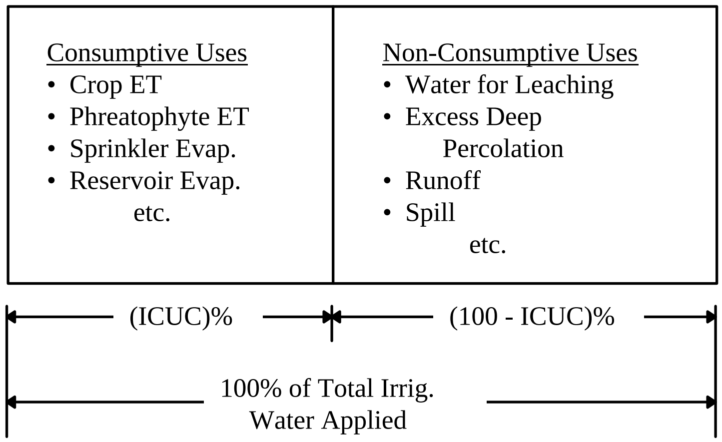

Figure 2. Irrigation Consumptive Use Coefficient (ICUC) quantifies the division of irrigation water into consumptive and non consumptive uses (Burt et al, 1995a).

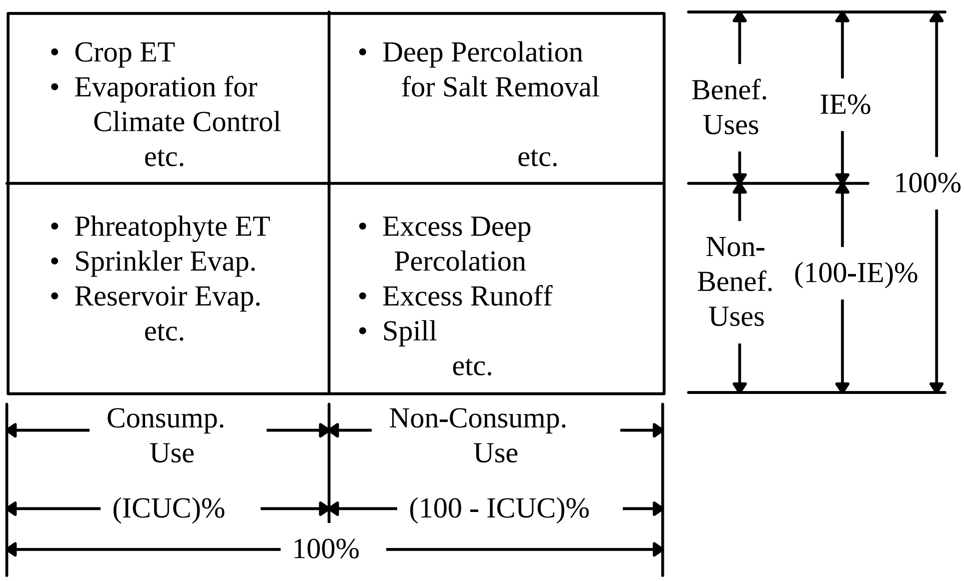

Figure 3. The division between consumptive and non consumptive uses is distinct from the division between beneficial and non-beneficial uses (Burt et al, 1995a).

These concepts of *reasonable use* suggest a new term to complement Irrigation Efficiency, namely, *Irrigation Sagacity, IS*, introduced by Solomon (1993) and now defined as,

$$IS = \frac{\text{volume of irrigation water beneficially and reasonably used}}{\text{volume of irrigation water applied - }\Delta\text{ storage}} \times 100\% \tag{3}$$

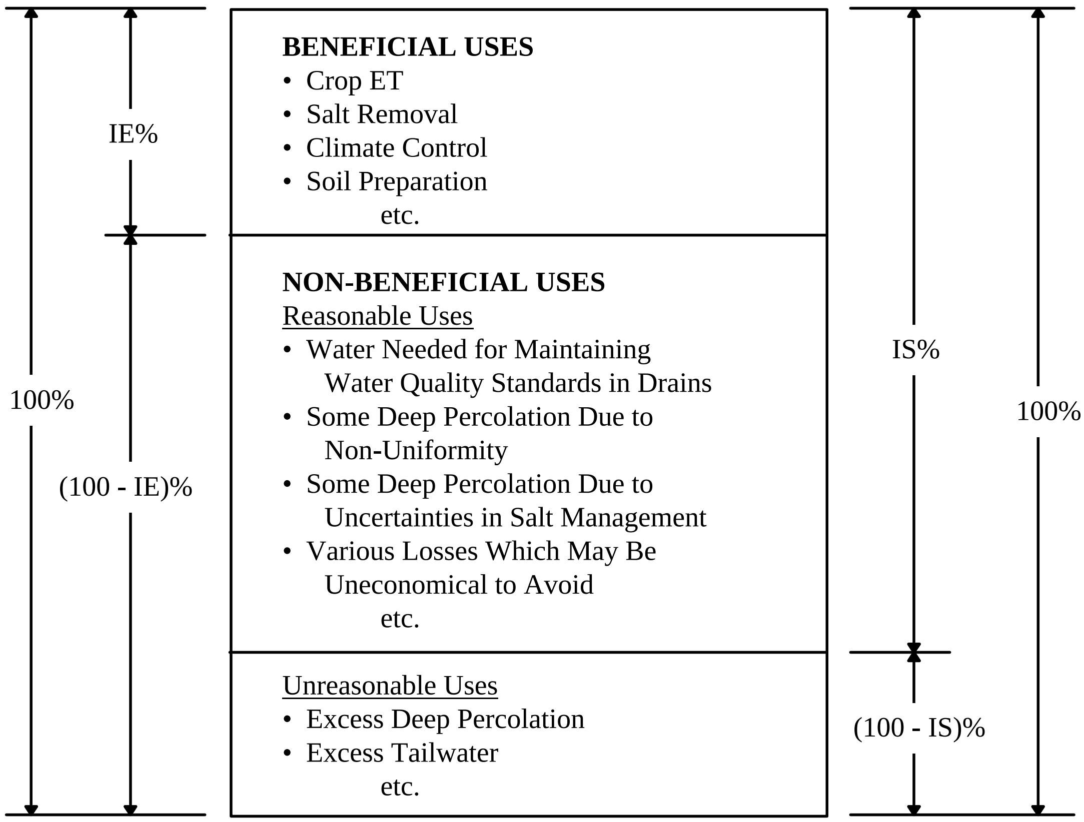

Figure 4. Irrigation Sagacity (IS) is a better measure of prudent water use than Irrigation Efficiency (IE) (Burt et al, 1995a).

WATER USE EFFICIENCY

An interesting point is that a table grape vineyard that is irrigated for "full ET" may actually have lower harvestable production than one that irrigates for 80-90% of "full ET". This is because if there is no stress on the vines, the vegetative growth can be excessive, reducing the quantity and quality of the grape berries. Likewise, for wine grapes a very high ET can reduce the sugar percentage, plus increase the incidence of rot because the grapes get too large and burst, ruining the bunches.

The ET of a cotton crop with 100% canopy cover can be about the same whether or the yield is 2.5 bales/acre or 4.0 bales/acre. The difference in yield may be due to insect control, supply of nutrients, or variations in vegetative growth. Differences in the use of growth regulators can have large impact on yield. A large, well watered cotton crop may become "rank" under certain conditions, and produce mostly leaves instead of squares.

The concept of Water Use Efficiency addresses this. It is sometimes defined as:

$$WUE = \frac{\text{Crop Yield}}{ET}$$

We need to pay much more attention to this aspect of "water conservation". For example, Fertigation (application of fertilizers through water) is still in its infancy in terms of sophisticated usage in California. To help address this gap, the Cal Poly ITRC has recently published a new comprehensive guide to Fertigation (Burt et al, 1995b) on behalf of the California Energy Commission.

The bottom line is that in two conditions of the same Irrigation Efficiency, the Water Use Efficiency can be entirely different.

WATER CONSERVATION IN CALIFORNIA

California's water conditions are tremendously diverse. There is no single satisfactory list of recommended water conservation measures. In fact, in many areas it appears that there is little or no "conservable" water, because those areas are presently in a deficit mode (overdraft of groundwater resources). It was also pointed out earlier that on-farm water conservation may or may not result in true water conservation for a hydrological basin.

Of course, there are substantial reasons to have good water management. In many cases, improved water management can enhance the profit for farmers. Yet in other cases, recommended water management practices have little or no direct benefit for an individual farmer. A question to address is this: should the farmers pay for improvements which only benefit others? We really need to do a better job of examining which "water conservation" recommendations are <u>reasonable</u>, just as reasonableness is a criteria for water rights. In many cases, specific water conservation practices are unreasonable, when considering the benefits and costs.

GROUNDWATER AND WATER CONSERVATION IN CALIFORNIA

Groundwater levels and quality are excellent indicators of the potential for water conservation in various areas of California. It is quite simple in principle - if the groundwater quality and quantities are decreasing, any efforts to conserve surface runoff losses from the study boundaries should first concentrate on stabilization of the groundwater supplies. In other words, the water must be re-distributed within the unit boundaries before it is taken outside the boundaries. It is more difficult in practice, because groundwater moves across traditional irrigation district boundaries. We also do not know exactly how to deal with questions such as the sustainability of groundwater pumping in Kern County, since the groundwater quality will inevitably decrease with time.

As a simplistic guideline, it is a good idea to minimize on-farm deep percolation of irrigation water, simply because water which deep percolates always suffers from water quality degradation. However, the primary immediate benefits are generally reduction in power consumption, reduction in fertilizer usage, reduced drainage problems in some areas, and possible increased yield. These are important, but they are not the same as water conservation in the hydrologic system.

A second simplistic guideline is that lining of canals will result in water conservation if the present deep percolation is destined for a salt sink. Deep percolation from unlined canals is "desirable" on much of the east side of the San Joaquin Valley of California because it does not pick up fertilizers or pesticides (i.e., is not degraded). In addition, it provides important groundwater recharge and does not contribute to high water table problems. It would be senseless in most cases to require a district to line canals, only to make the irrigation district purchase land to install recharge basins. Of course, there are some benefits to lining in those cases, such as the ability to make more surface deliveries during a dry year, thereby reducing the power consumption involved with groundwater pumping.

Canal seepage in other areas, such as in the Grand Valley of Colorado, has a totally different impact. In that area, all seepage picks up salinity from the soil, which eventually goes into the Colorado River.

MEASURING WATER - DOES IT CONSERVE?

Most irrigation specialists recognize that on the average, volumetrically measured and allocated water results in better on-farm and district-level control of water. But does it conserve water, especially in light of our knowledge of reuse of water? If water consumption is reduced in one area, we know that the reduced return flows or deep percolation can have impacts on downstream users.

Then why worry about metering water deliveries? Having been involved in various water balance studies over the years, and having seen the complexities of irrigation water transfers, this author believes that even if measurement does not of itself conserve water, we will develop a much better understanding of the complex hydrology in California. We are to the point in water development and scarcity that we need to have a much better idea of how much water is going where. California's Public Trust Doctrine states that any single entity can no longer manage water in isolation from others, and our complex groundwater and surface water hydrology proves the point.

Right now we have quite a few "black holes" in which significant assumptions are made in various ground/surface water models. It is important, for the sustainability of agriculture and the use of water in general, that we know exactly how much water we have, where it came from, where it is going, and the consequences of using it in various ways (i.e., we need to have better definition of our regional water balances).

CONCLUSIONS

In order to understand the pros and cons of water conservation programs, it is essential to have a common, technically competent vocabulary and set of definitions. The ASCE Task Committee on Defining Irrigation Efficiency and Uniformity has made important steps toward this goal.

Good water management has benefits for individual farmers and society. Questions remain regarding how much good water management is worth to various parties, and how much farmers should be expected to pay for benefits which are only realized by others.

Meaningful water conservation programs are quite diverse in California due to the complex and varied hydrology. No single program of improved water management practices is applicable for all regions. However, it is important to get a better handle on water balances throughout the state.

Finally, the next big frontier will be to increase Water Use Efficiency, especially through improved fertigation practices, combined with good irrigation efficiencies.

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