WATER QUALITY PROGRAMS IN THE TRI-BASIN NATURAL RESOURCES DISTRICT

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Tri-Basin Natural Resources District (TBNRD) began testing for groundwater nitrate in 1978. The nitrate level in wells tested at this time was relatively low -- 75 percent of the three-county area had concentrations of less than two parts per million (ppm). Test results eight years later from the same wells revealed an average increase of 4.5 ppm. Since 1986, annual testing of these wells indicates that nitrate levels have continued to climb.

As a result of this annual testing, two areas of the district were found to contain high levels of groundwater nitrate. One area (with an average of 16.5 ppm) was a four-mile wide strip along the Platte River extending from central Phelps County east to the Adams County line. The other area averaged 11.2 ppm and surrounded the towns of Holdrege, Funk and Wilcox.

The maximum contaminant level (MCL) of nitrate in a public water supply as set by the U.S. Department of Health is 10 ppm. Faced with this dilemma, the towns of Holdrege, Funk and Wilcox were forced to replace wells.

GROUNDWATER MANAGEMENT AREAS

The Nebraska Unicameral adopted legislation that enabled the NRD to approve its comprehensive groundwater quality management plan in 1986. This plan outlines the district's responsibilities in dealing with groundwater quality and quantity issues. A triple-phased groundwater quality management area was developed and came into effect in November of 1989.

The only requirement in the phase I area (0-10 ppm) is the ban on fall and winter applications of commercial nitrogen fertilizer on sandy soil. Fall application is permitted on heavier soils only after November 1. In addition to Phase I requirements, Phase II area (10-20 ppm) farmers are required to obtain annual soil samples at a depth of three feet to determine the residual nitrogen available in the soil. Irrigation water analysis to determine the nitrogen benefit from irrigation water is also required. A crop report must be submitted annually following each crop year.

The management program is basically designed to be an educational program promoting common sense application of nitrogen fertilizers on farm fields. The program enables farmers to take advantage of residual nitrogen already available in the soil and water and apply only what is needed to grow the crop.

Phase III areas contain over 20 ppm of nitrate in the ground water. There are no Phase III areas within the district at this time.

IRRIGATION MANAGEMENT CONDUCIVE TO NITROGEN MANAGEMENT

Irrigation management is also a very important part of the total nitrogen management program. Nitrate-nitrogen will not move in the soil profile unless it is carried by water. Snow melt, heavy spring rains and over-application of irrigation water are all carriers of any nitrate-nitrogen which may be in the soil profile.

The key to proper irrigation management is to apply water uniformly across the field at an application rate that does not percolate water below the crop root zone. Once below the root zone, nitrate-nitrogen proceeds directly to the underground aquifer. Properly managed, surge and pivot irrigation offer great opportunities in reducing the total amount of irrigation water applied with a more uniform distribution across the field. Irrigation scheduling, a process where irrigations are done on an "as needed" basis can also help prevent deep percolation.

Accomplishment of our goal of decreasing the amount of nitrate-nitrogen leaching below the crop root zone will happen only after a proper irrigation and fertilizer management program is in place on each piece of irrigated farm ground.

COOPERATIVE EFFORT TO PROTECT GROUNDWATER SUPPLIES

The district feels that water quality matters can best be handled on the local level rather than turned over to state and federal agencies. Best management practices must be followed by everyone to make this program effective. Fertilizer and water must be applied only as needed, whether on a lawn or on a field of corn.

The cooperative effort involves state, federal, private business, irrigation districts, the University of Nebraska and people who live in the small communities within the district. State and federal agencies are providing cost-share money to farms in Water Quality Management areas. Irrigation districts, such as Central Nebraska Public Power and Irrigation District have initiated aggressive water conservation programs. The university has been very active in providing needed research and timely programs on groundwater quality. Private businesses, such as cooperatives, private agronomists and agri-business promote practices to improve groundwater quality. The cooperative Extension Service has started a "Don't Bag It" program to promote recycling of grass clippings and utilize the nitrogen in the clippings.

All local residents - urban and rural - must accept the responsibility for protecting the quality and quantity of our water in order to continue our way of life.

IRRIGATION WATER MEASUREMENT AND MOVEMENT

Water Flow Rate:

$$Q = AV$$

where:

Q = flow in cfs (ft^3/sec)
A = area in square feet (ft^2)
V = velocity in feet per sec (ft/sec)

Example 1:

Given:

Inside diameter (I.D.) = 6.125 in
Collins gauge reading = 4.03 ft/sec
Area of a circle = pr^2

$$\text{Area} = 3.14 \times (3.062\ in)^2 = 29.4\ in^2$$

$$29.4\ in^2 \times \frac{1\ ft^2}{144\ in^2} = 0.204\ ft^2$$

$$0.204\ ft^2 \times 4.03\ ft/sec\ (\text{collins reading}) = 0.822\ ft^3/sec \text{ or cfs}$$

$$0.822\ cfs \times \frac{450\ gpm}{1\ cfs} = 369.9\ gpm$$

1 cfs = 1 ac-in/hr = 1 ac-ft/12 hrs = 2 ac-ft/day (24 hrs)

Water Application:

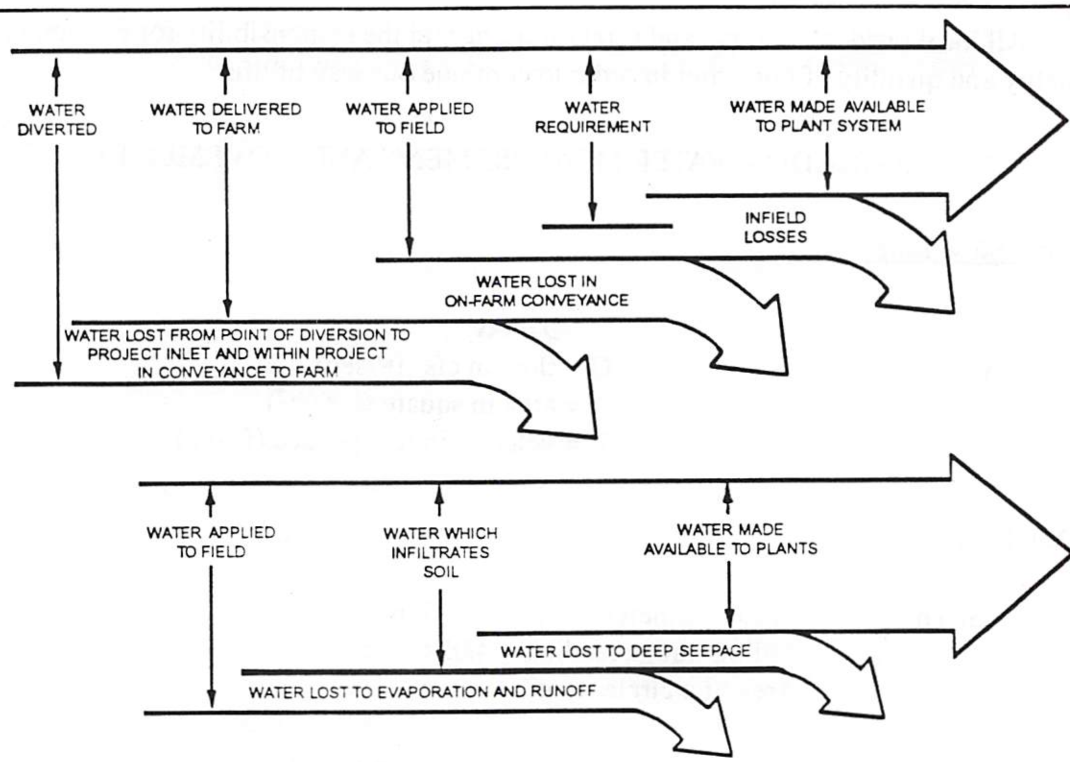
In irrigation management, we need to know water supply (Q) for a given irrigation system. If we know the water supply amount, we may determine how much time (T) it takes to replenish a known area (A) of the water removed (D).

Flow = volume relationship

$$QT = AD$$

where:

Q = flow in cfs
T = time in hours
A = acres
D = depth in inches



Water losses from source to plant.

Example 1:

For the flow rate from our collins gauge (369.9 gpm), how long (hours) would it take to apply two inches of water to 90 acres?

$$QT = AD \Rightarrow T = \frac{AD}{Q}$$

Given:
- A = 90 ac
- Q = 370 gpm
- D = 2 in.
- T = unknown

$$Q = 370 \text{ gpm} \times \frac{1 \text{ cfs}}{450 \text{ gpm}} = 0.82 \text{ cfs}$$

$$T = \frac{90 \text{ ac} \times 2 \text{ in.}}{0.82 \text{ cfs}}$$

$$T = \frac{180 \text{ ac-in}}{0.82 \text{ cfs}} \times \frac{1 \text{ cfs}}{1 \text{ ac-in/hr}}$$

$$T = 219.5 \text{ hr}$$

Example 2:

What if you wanted to apply 0.33 inches every day to 90 acres, what flow rate would you need?

$$QT = AD \Rightarrow Q = \frac{AD}{T}$$

Given :

D = 0.33 in
A = 90 ac
T = 24 hr
Q = unknown

$$Q = \frac{90 \text{ ac} \times 0.33 \text{ in}}{24 \text{ hrs.}}$$

$$Q = \frac{29.7 \text{ ac-in}}{24 \text{ hrs.}} = 1.24 \text{ ac-in/hr}$$

$$Q = 1.24 \text{ ac-in/hr} \times \frac{450 \text{ gpm}}{1 \text{ cfs}} \times \frac{1 \text{ cfs}}{1 \text{ ac-in/hr}}$$

$$Q = 585 \text{ gpm}$$

IRRIGATION EFFICIENCIES:

The QT = AD equation can be related to net application if efficiency is considered. The relation is expressed as:

$$QTE = D_n A$$

E = efficiency (season or application)
D_n = depth of net application

Application Efficiency

$$E_a = V_s/V_f$$

where:

E_a = application efficiency
V_s = the volume of water stored in the root zone usable by the plant for evapotranspiration
V_f = the gross volume of water delivered to the field for the individual irrigation.

Note: The difference between V_s and V_f are the irrigation losses from runoff and deep percolation.

Average values for application efficiency for different types of irrigation systems can be found in various publications. The value from Neb-Guide G85-753 "Irrigation Scheduling Using Crop Water Use Data" is listed in the following table:

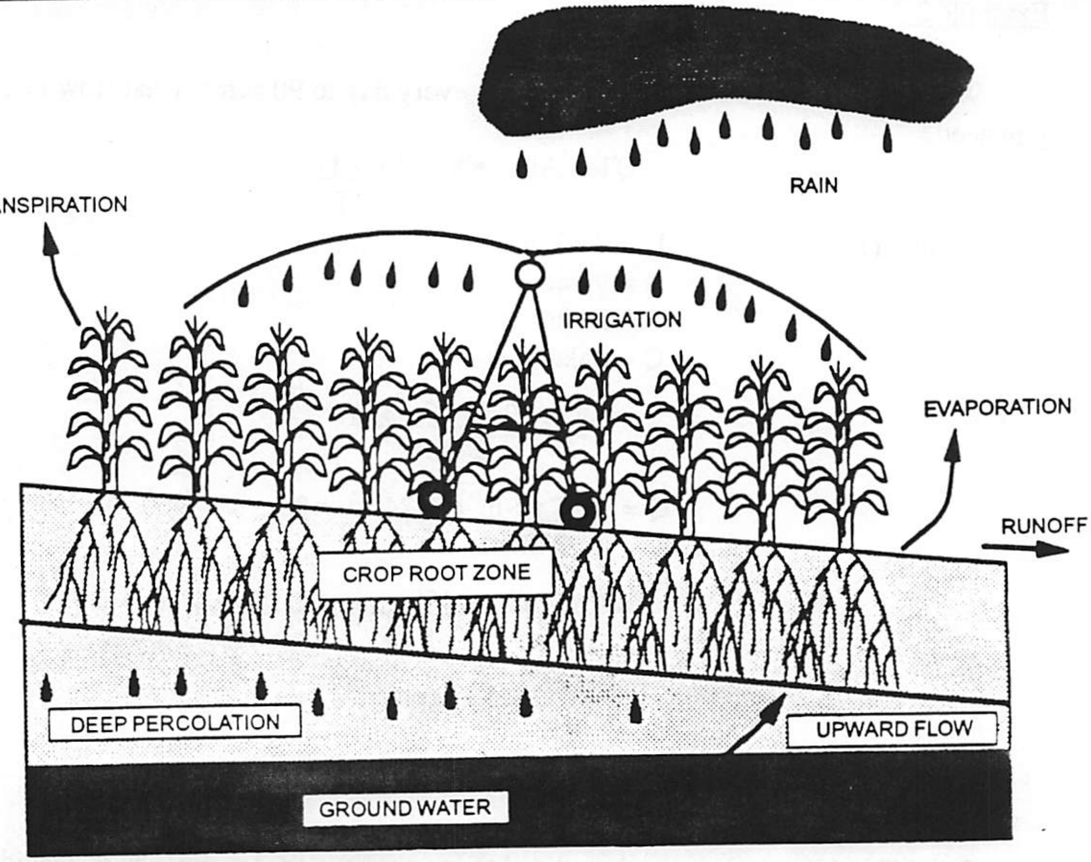


Diagram of components of the soil water balance.

Irrigation System		Efficiency (%)
Sprinkler		
	Center pivot and lateral move	80
	Skid tow	75
	Solid set	75
	Side roll	75
	Traveling big gun	70
Surface		
	Gated pipe with reuse	70
	Gated pipe without reuse	50
	Siphon tube with reuse	65
	Siphon tube without reuse	45
	Surge with reuse	80

Season Efficiency

Crop water use and irrigation for the season:

$$E_s = V_b/V_f$$

E_s = seasonal efficiency

V_b = the volume of water beneficially used over a season, defined as the net irrigation required for the season and derived as: *consumptive use + leaching required + ending stored water in effective root zone - effective precipitation - starting stored water in effective root zone.*

$$I_n = E_T + L_r + SW_e - P_e - SW_b$$

V_f = the gross volume of irrigation water delivered to the field

The differences between the gross volume delivered and the volume of water beneficially used are the irrigation losses. The losses result from deep percolation and runoff.

In determining the seasonal efficiency, the effects of application efficiency of each individual irrigation would be included on a seasonal basis. Seasonal efficiency also accounts for management efficiency. For example, do the number of irrigations meet the required crop water needs (scheduling)? Or are extra irrigations performed that cause deep percolation and runoff?

Seasonal efficiencies may or may not give the true efficiency for the season. For example, an irrigator applies water twice over the season. The first time, he over-irrigated and caused excessive deep percolation. On the second irrigation, he under-irrigates and stresses his crop. However, the seasonal efficiency would average the two irrigations and show a good job. This shows the importance of using both seasonal and application efficiency when evaluating an irrigation application and/or system.

Conveyance Efficiency

Not all water coming from the irrigation source is delivered to the irrigation set because of leaky gates, gaskets or ditches. The water lost can be estimated by using a conveyance efficiency.

$$E_c = V_f/V_t$$

E_c = conveyance efficiency

V_f = volume of water delivered to the field

V_t = volume of water diverted from the source

Farm Irrigation Efficiency

When evaluating an irrigation system, the total efficiency, also called farm irrigation efficiency, must be used. This efficiency is the product of the conveyance and irrigation efficiencies (either application or seasonal) and are expressed as ratios.

$$E_i = E_a \times E_c \quad \text{or} \quad E_i = E_s \times E_c$$

E_i = the farm irrigation efficiency

All other variables in the equation are previously defined.

Flow meters:

There are several instruments available for water measurement. Instantaneous measurements may be achieved by the use of collins gauges, flumes, impeller flow meters or ultra sonic flow meters and hour meters. The problem with using an instantaneous measurement is that the reading is for the present flow. Irrigation well and canal turn-out flows may vary during an irrigation event or throughout the irrigation season because of changes in head. These changes in flow are not reflected in an instantaneous measurement.

A more desirable method of measuring irrigation water is the cumulative method. This method uses a totalizer to provide a running account of irrigation water delivered to date. The variability in the volume being delivered is accounted for.

The cumulative method is the most reliable way of measuring water. Not all irrigators want everybody to know how much water they are using. They are skeptical about installing a flow meter for several reasons. In some cases, the instantaneous method is the only method available to use. Any method of water measurement is better than nothing. Water management begins with water measurement.