# Irrigation Water Quality Alters Furrow Erosion and Infiltration

*By Rick Lentz and Bob Sojka*

Furrow-irrigated crops can be damaged if the irrigation water contains large amounts of dissolved salts and/or sodium. But do the same water quality characteristics influence water infiltration, runoff and erosion? Studies conducted by the USDA Agricultural Research Service in Kimberly, ID, shine new light on exactly this question.

Water quality is often described in terms of the water's dissolved salt concentration and the proportion of sodium salts present in comparison to calcium and magnesium salts. Salt concentration is expressed in units of electrical conductivity (EC) or total dissolved solids (TDS). The dissolved sodium content is described in terms of its sodium adsorption ratio (SAR). The EC or TDS of a water sample increases with salt concentration, and its SAR increases as the proportion of sodium in those salts increases. Note in this article that references to high/low EC or SAR are relative terms and do not denote water classifications.

Irrigation water quality can vary depending on water source and season of use. For example, in south-central Idaho some irrigators have a choice of three water sources with varying dissolved salt content. The Rock Creek source contains little salt or sodium because its source is snow-melt runoff from nearby hills.

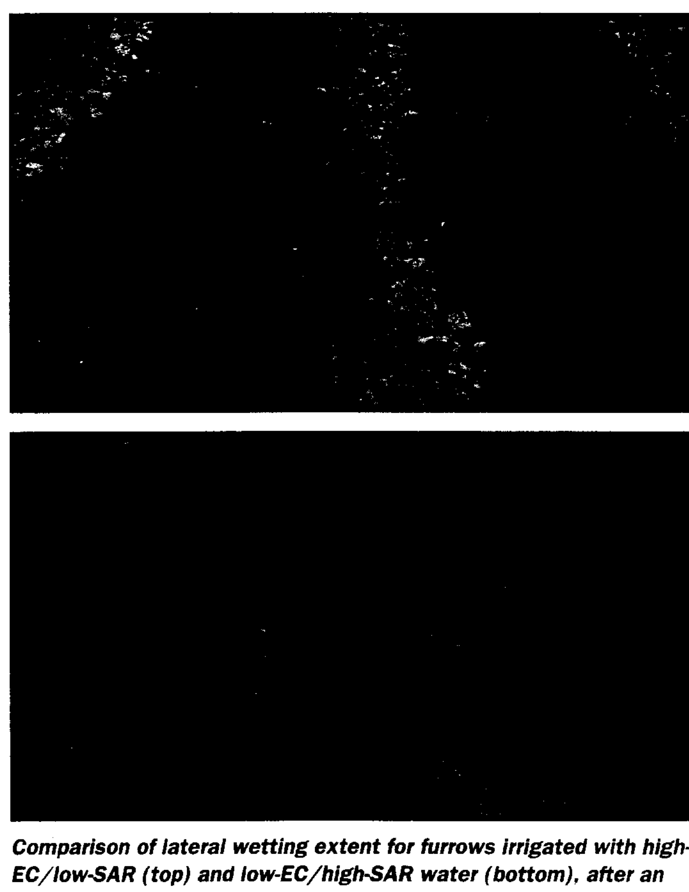
In contrast, well water contains six to ten times more salts than Rock Creek water. Since Snake River water is derived from snow-melt, groundwater, and return irrigation flows, its salt content is in between that of the others. Similarly, salt contents rise from spring to late fall, in these waters, nearly doubling in Rock Creek and Snake River sources over this period.

How do different water sources influence furrow infiltration and erosion processes? Water quality alters both the stability of soil aggregates, and the dispersed state of transported soil particles, in the furrow stream. These, in turn, influence depositional seal formation in the furrows.

### Furrow Erosion and Infiltration

Erosion results when the furrow stream detaches surface soil aggregates or particles, and transports them downstream. The extent to which erosion occurs depends upon the stream-flow characteristics and surface soil attributes. Erosion increases with increasing stream velocity. It is





***Comparison of lateral wetting extent for furrows irrigated with high-EC/low-SAR (top) and low-EC/high-SAR water (bottom), after an eight-hour irrigation. Lateral wetting was greater for high-EC/low-SAR furrows because these furrows had the greatest infiltration and least erosion (channel incision).***

greater for soils that have weak interparticle bonding, poor structure, and unstable aggregates.

Irrigated furrow infiltration-rate is strongly influenced by soil characteristics such as texture, chemistry, and organic matter content. In many irrigated soils, infiltration is controlled by the formation (deposition) of slowly permeable surface seals along the furrow wetted perimeters.

Typically, the aggregates of such soils are weak and unstable, especially when wetted quickly. When the dry, cloddy surfaces of newly cultivated furrows are irrigated, the initial advance of water quickly submerges soil aggregates. This rapid wetting causes saturated clods to slake and collapse into smaller fragments and individual soil particles. These smaller soil materials are especially susceptible to the shearing action of the flowing water. The furrow stream detaches the soil from the surface and either pushes it along the channel bottom as bed load, or carries it along as suspended load.

Within two hours, depositional seal formation can reduce water infiltration into irrigated furrows by 80-90 percent. Shortly after the irrigation begins, soil aggregates and particles are introduced into the furrow stream by rapid wetting and shear/detachment processes. Some of the stream's bed and suspended loads are carried toward the soil/water interface with infiltrating water.

The surface soil acts like a sieve. The larger-diameter bed-load materials soon clog the large surface pores and cracks, reducing water flow through the soil/water interface. Yet a plug made of somewhat large soil chunks is relatively leaky because water can flow through small gaps left between the ill-fitting large particles. But, if dispersed clay particles are suspended in the furrow stream, they will clog most of the remaining small pores, and produce more drastic infiltration-rate reduction.

Irrigation water with few salts (low EC) or a large proportion of dissolved sodium salts (high SAR) weakens the bonds that bind soil particles together. Soil aggregates are more likely to break down and separate into their smaller-sized constituents, i.e., small aggregates and individual clay, silt, and sand-sized particles. This makes soils more erodible. These water chemistries also cause fine particles in the furrow stream to disperse, giving the water a brown cloudy appearance.

Alternatively, water high in dissolved solids (high EC) with low dissolved sodium content (low SAR) actually strengthens soil bonds, and helps maintain soil aggregate integrity. The more stable aggregates resist stream shear forces better, making the soil less erodible.

When submerged in high-EC/low-SAR water, clods are less likely to slake and collapse. Instead of dispersing fine soil particles, this water chemistry causes them to flocculate, or clump together. Many of these clumps are heavy enough to settle out of the water, forming a thin mantle over the furrow bottom. This depositional layer formed along the wetted perimeter is more porous than the seals formed from finely dispersed clays.

### Examples of Water Quality Effects on Furrow Processes

The Kimberly ARS team conducted field experiments to compare the effect of four different source waters on furrow irrigation-induced erosion and infiltration. Water-source EC and SAR were adjusted so that each represented a different combination of either low or high EC levels, and low or high SAR levels. The EC and

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**Furrows**
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| Irrigation Water Treatment | EC dS/m | SAR (m molc/L)0.5 |
|---|---|---|
| Low-EC/Low-SAR (Snake R.) | 0.5 | 0.9 |
| High-EC/Low-SAR† | 2.1 | 0.5 |
| Low-EC/High-SAR† | 0.7 | 9.1 |
| High-EC/High-SAR† | 1.8 | 9.3 |

†Snake River water was chemically altered to create these water chemistries

***Table 1. Source water-quality treatments.***

SAR of the four water-quality treatments are presented in Table 1. Irrigation inflows were held constant across all furrows.

Source water quality had a pronounced effect on both furrow erosion and infiltration. The smallest soil-loss occurred in furrows irrigated with high-EC/low-SAR water. The greatest soil loss occurred in furrows irrigated with low EC/high SAR, and was 2.5 times that of the least erosive water. Net infiltration in low-EC/high-SAR watered furrows was 2.3 inches, compared to 2.8 inches for high-EC/low-SAR watered furrows.

Compared to low-SAR source-water, high-SAR waters produced 73 percent greater furrow soil losses and 15 percent lower net furrow infiltration. The decline in net infiltration and increased erosion resulting from higher-water SAR could also be observed in the extent of lateral wetting seen at the soil surface. Lateral wetting was noticeably reduced in the high-SAR watered furrows.

Increasing source-water EC had the opposite set of effects. Compared to low-EC source water, high-EC waters reduced furrow soil losses by 31 percent and had an inconsistent effect on net furrow infiltration. The detrimental impacts of high-SAR source-water on soil loss and infiltration could be improved by increasing the water's EC, e.g., by adding gypsum. This has been done in sugar beet-producing areas in Australia.

This new information concerning water-quality effects on furrow processes is particularly useful for explaining why some irrigation districts may have more irrigation-related infiltration and erosion problems than others. Current computer models designed to predict furrow irrigation processes do not account for source water quality influences.

Such models need to consider water quality effects in order to make the software sufficiently accurate and more broadly applicable. Irrigators can use this knowledge to increase infiltration and reduce erosion during surface irrigations, particularly where conjunctive use can be managed.

Some irrigators, like those near Twin Falls, ID, may have several water sources from which to choose. Or, it may be feasible to adjust the water quality of a particularly pure irrigation water source by adding gypsum or other economically available calcium salts, and thus improve net infiltration during surface irrigations. This strategy has been successfully applied in parts of California.

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