Phosphorus Loading in Furrow Irrigation Tailwater

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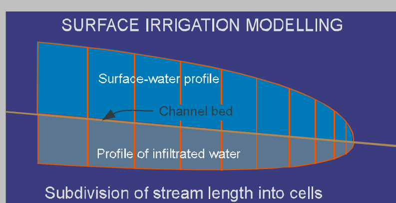
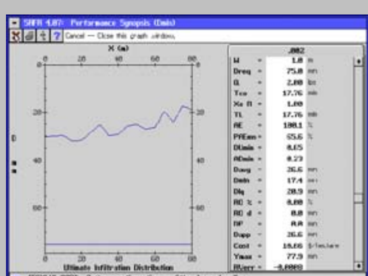
Erosion from surface irrigated fields contributes to Phosphorus load of streams

Where runoff from furrow irrigation is allowed to enter streams, high phosphorus concentrations have been measured. This is particularly a problem in the Pacific Northwest where soils are highly erodible.

Surface Irrigation Simulation Model (One-Dimensional) predicts movement of water



Shallow-water equations of continuity and momentum (Zero-inertia) are solved with a finite volume approach in the SRFR surface-irrigation simulation model.



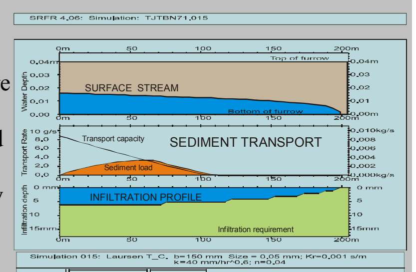
The ability to model surface irrigation systems allows us to develop design and analysis methods. These tools are used to determine expected performance levels for surface systems and how to improve them.

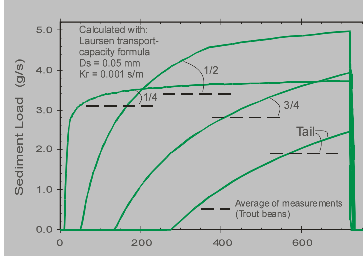
Field studies were used to measure sediment losses under furrow irrigation

In Kimberly Idaho, water flow was measured at quarter points of these furrows. Water and sediment samples are used to determine sediment and phosphorus concentrations. Samples were taken periodically during a typical irrigation. Total sediment mass and size distribution were determined.

Prediction of sediment detachment, transport, and deposition were added to SRFR

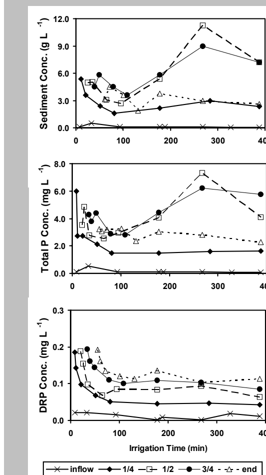
Eroded sediment concentrations are shown to grow with distance and then decline as flow and velocity decrease due to infiltration.





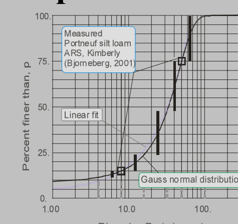
Field comparisons show reasonable results in some cases, subject to proper selection of particle size(s).

Phosphorus losses from surface-irrigated fields comes primarily from eroded sediments



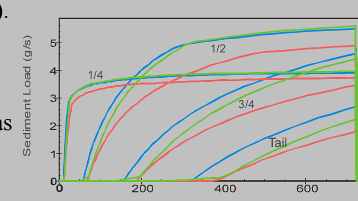
Phosphorus attached to soil particles accounts for a significant amount of the total Phosphorus runoff from fields. Notice how total P loads from field studies in Kimberly, ID track sediment concentration. Dissolved-reactive P (DRP) is an order of magnitude lower. Total P load is maximum near the middle of the field, while DRP is greatest at the end of the field.

Particle-size distribution needed for good erosion prediction

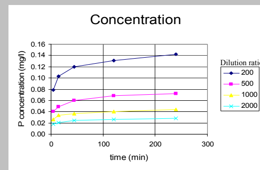


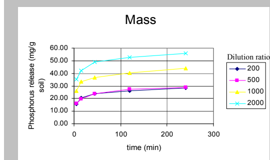
A distribution of particle sizes is needed to avoid step changes in erosion predictions.

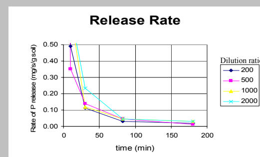
The influence of a particular mix on total transport capacity (and, hence, sediment loads at the furrow quarter points) is shown relative to that for a single representative particle size, the median, D50 (blue). Accounting for the mix as in WEPP (USDA, 1995) is shown in red, and as per Wu and Meyer (1989) in green.



Batch studies were used to determine desorption of Phosphorus from eroded soil

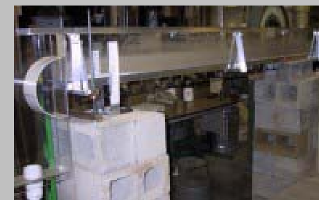


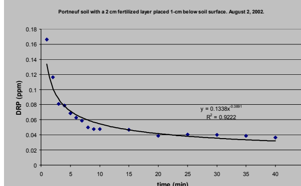




The mass of phosphorus released over time from the soil in batch studies was related to both the dilution ratio and the concentration of P in the water. This complicates estimates of release rates needed to model P desorption.

Laboratory Flume studies determine phosphorus desorption from a non-eroded soil surface



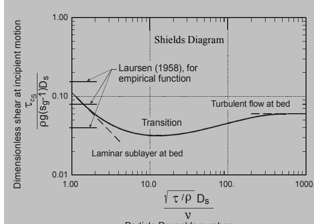


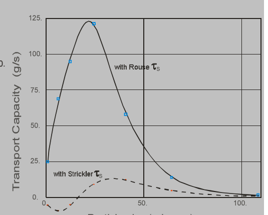
Phosphorus pick up from the soil was shown to be a function of soil P index and flow turbulence.

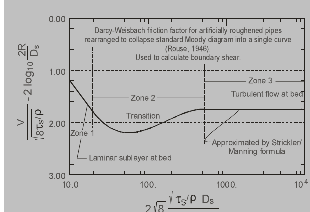
New water-measurement flume developed for furrow erosion research

Existing flume for furrow flow rate caused significant backwater effects and caused sediment to accumulate upstream from the flume. Placing these flumes low enough to avoid these problems caused sample collection problems. A new design with a wider throat avoided these problems.

Application of Laursen Formula for Soil Erosion required adaptation for small particle sizes

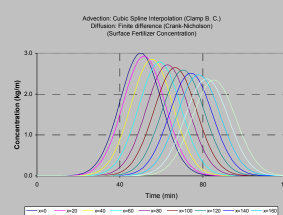






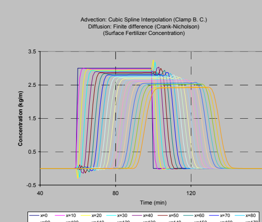
Transport capacity for silt-size particles must consider laminar sublayer. Otherwise the Laursen formula predicts negative transport capacities.

Model of chemical advection and dispersion tracks Phosphorus (DRP) movement in the stream



Addition of chemical into flowing stream: results show both advection and dispersion.

Step change in chemical concentration can cause numerical problems with calculation of advection. Dispersion actually reduces the impact of numerical spikes on solution.



Modeling of Surface Irrigation Erosion Leads to Improved Environmental Protection

Combining advection/dispersion of chemicals with SRFR model of surface flow is in progress.

Erosion from surface-irrigated fields adds phosphorus and nitrogen to receiving waters. Predictive modeling will aid mitigation and prevention efforts.