The Role of Soil Pipes and Pipeflow in Headcut Migration Processes

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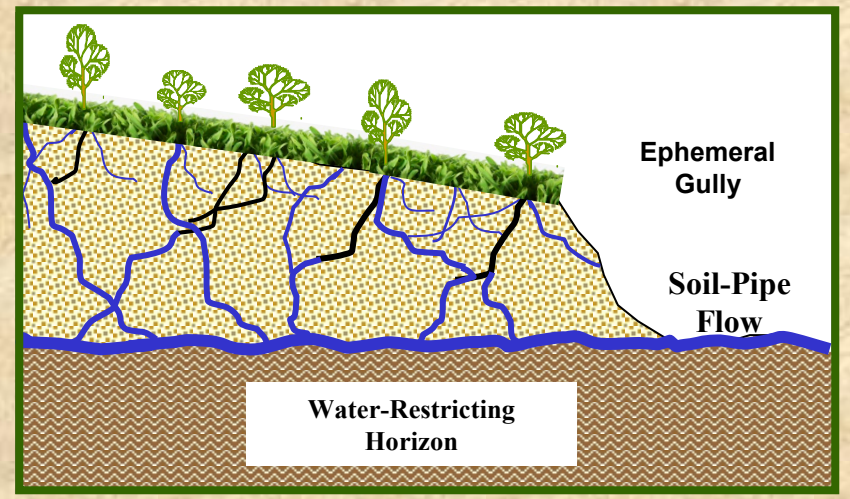
Nichols et al., 2016, Geomorphology

Geomorphic change during the ten year period was dominated by a single piping event

Pipe collapse flutehole ahead of gully headcut intercepted runoff and diverted into soil pipe

Gully advanced 7.4m (51% of the overall 10 yr advance) and removed 11.3m^3 of sediment.

Pipe Collapse Gully Formation



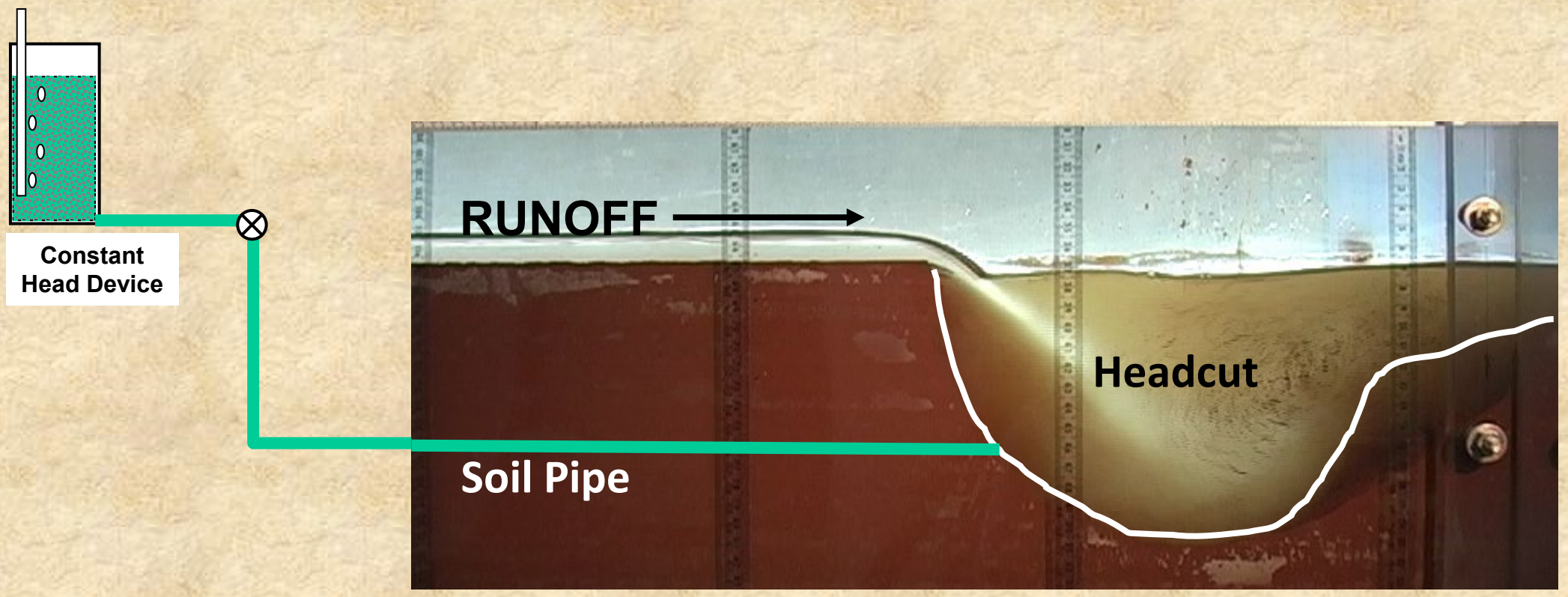
A common feature of gullies, especially ephemeral gullies, is to find a soil pipe at the headcut.

In agricultural setting, such gullies are filled-in resulting in a discontinuous soil pipe

Also common to find soil pipe above water-restrictive layers, which Faulkner (2006) termed duplex soils, that perch water and foster lateral flow or seepage into soil-pipes and gullies.

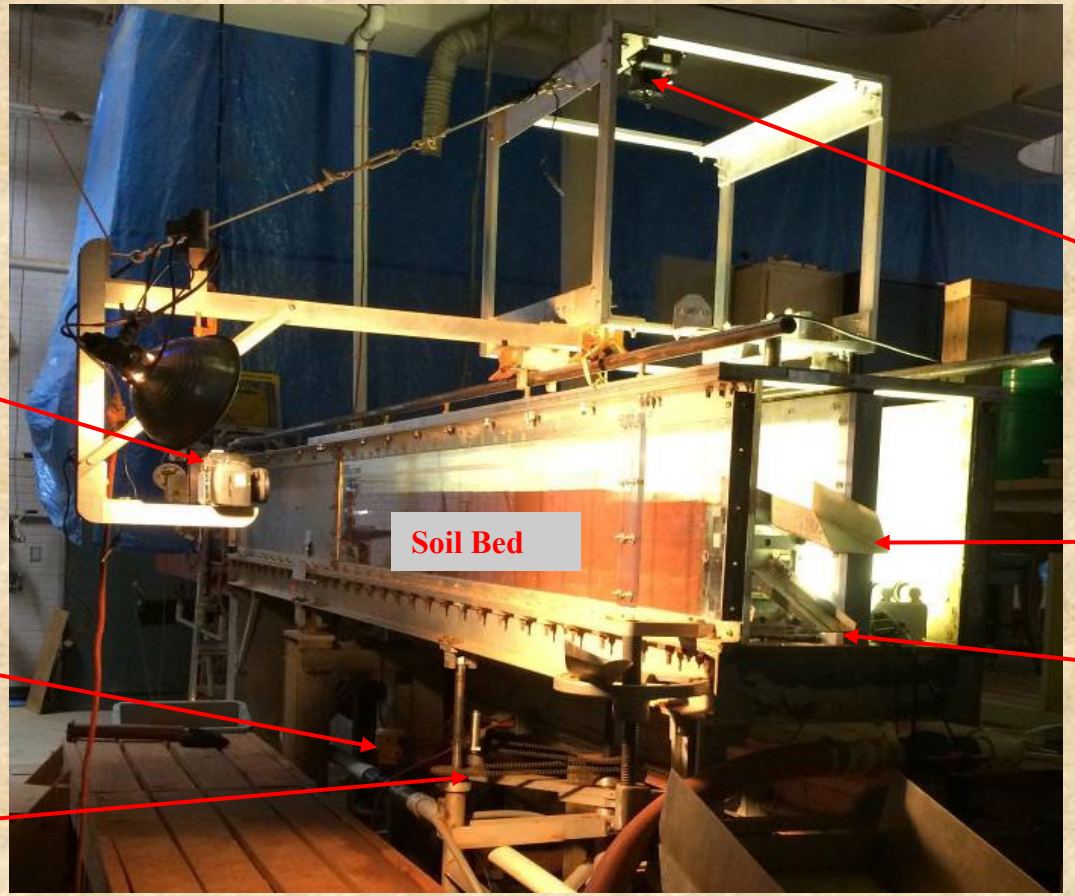
Pipeflow interactions with Gully Headcut Advance

Very little is known about the role of pipeflow or seepage on headcut advance



Xu et al. (2020, ESPL) modified the classic Bennett (1999, Geomorph.) headcut advance flume setup for investigation the role of pipeflow with and without surface flow

Xu et al. (2020, ESPL) Experimental Setup



Cameras attached to moveable cart

Flow meter

Slope adjustment

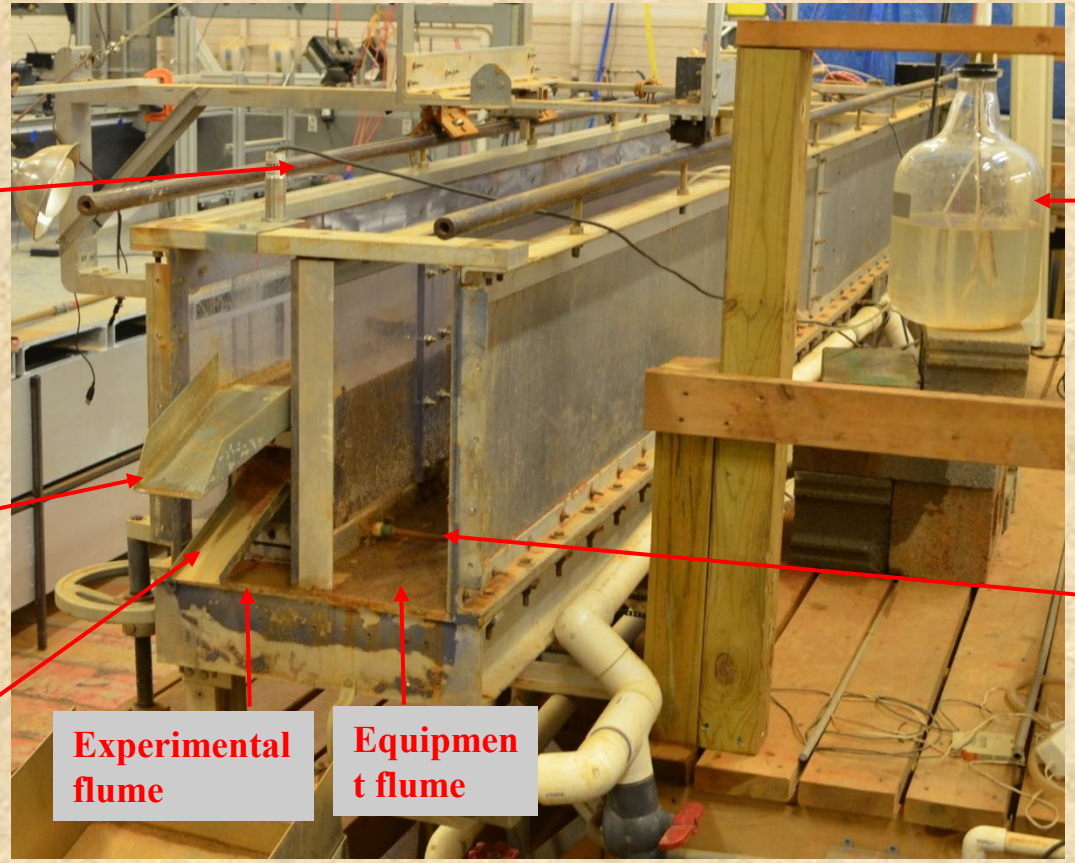
Cameras attached to moveable cart

Surface runoff collector

Subsurface runoff collector

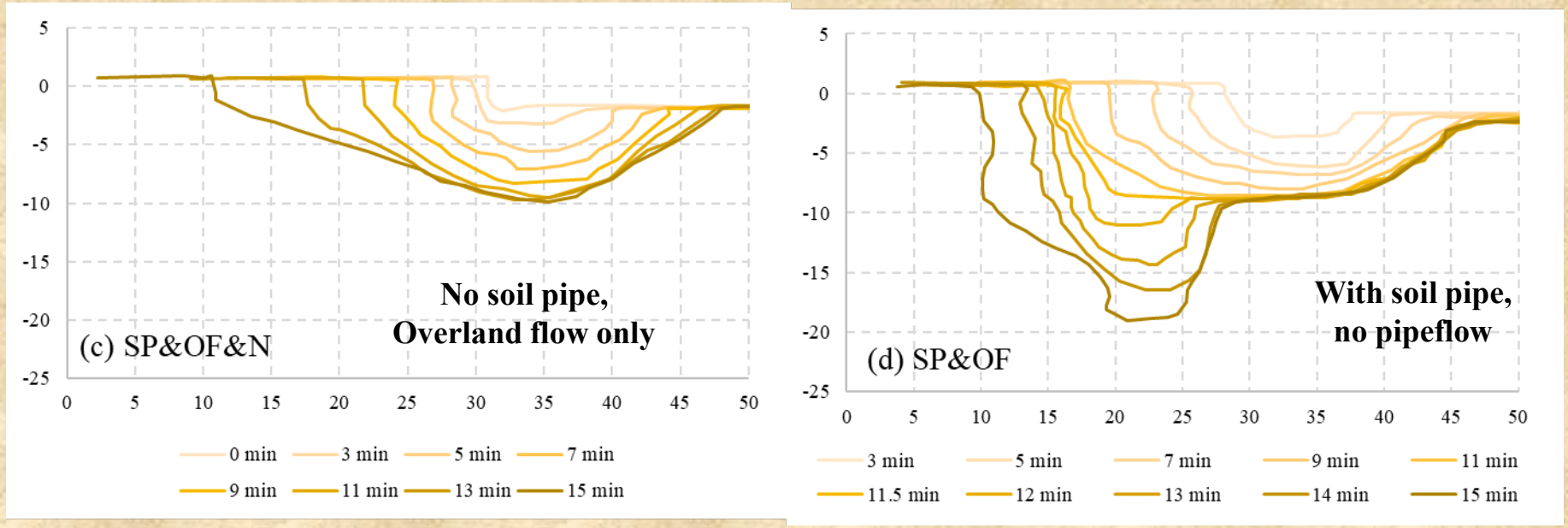
Soil pipe created below the surface and headcut on surface. Ability to track changes in headcut plunge pool morphology and headcut advance by cameras

Xu et al. (2020, ESPL) Experimental Setup



Ability to sample overland flow and pipeflow separately at outlet and to apply a perched water table or free-drainage conditions

Soil Pipe Presence Impacts on Headcut Advance

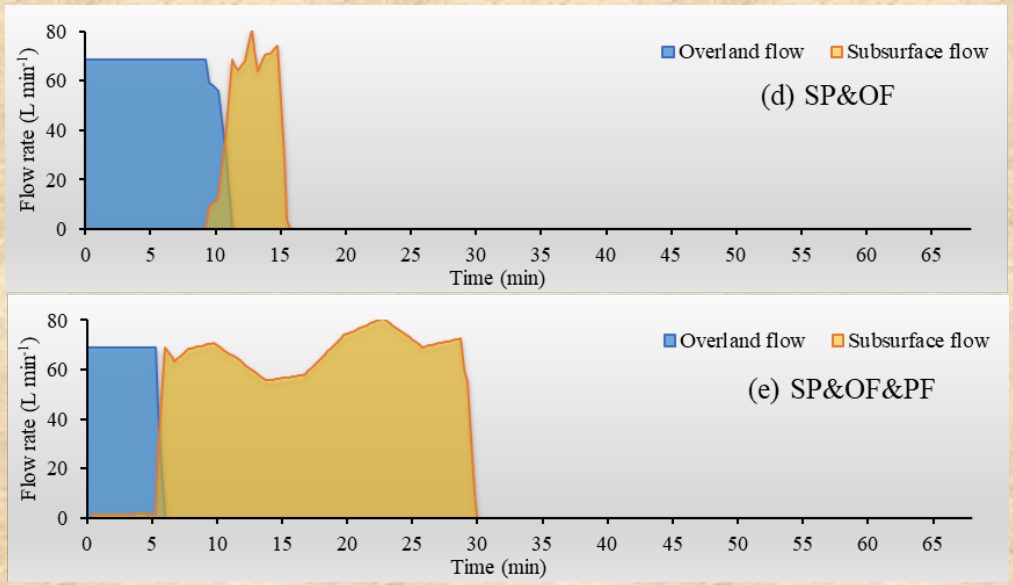


The presence of a soil pipe, even without pipe inflow, greatly changes the headcut plunge pool morphology and headcut advance.

Once the plunge pool erodes down to the soil pipe, all surface flow will be diverted into the downslope soil pipe and headcut advance will accelerate

Soil Pipeflow Impacts on Headcut Advance

Seepage from perched water table creates some pipeflow and greatly decreases the time required for the plunge pool to reach the depth of soil pipe



Upslope pipe inflow combined with perched water table seepage greatly shifts the outflow to pipeflow dominated

Upslope pipe inflow combined with surface flow increased headcut advance rate and sediment export

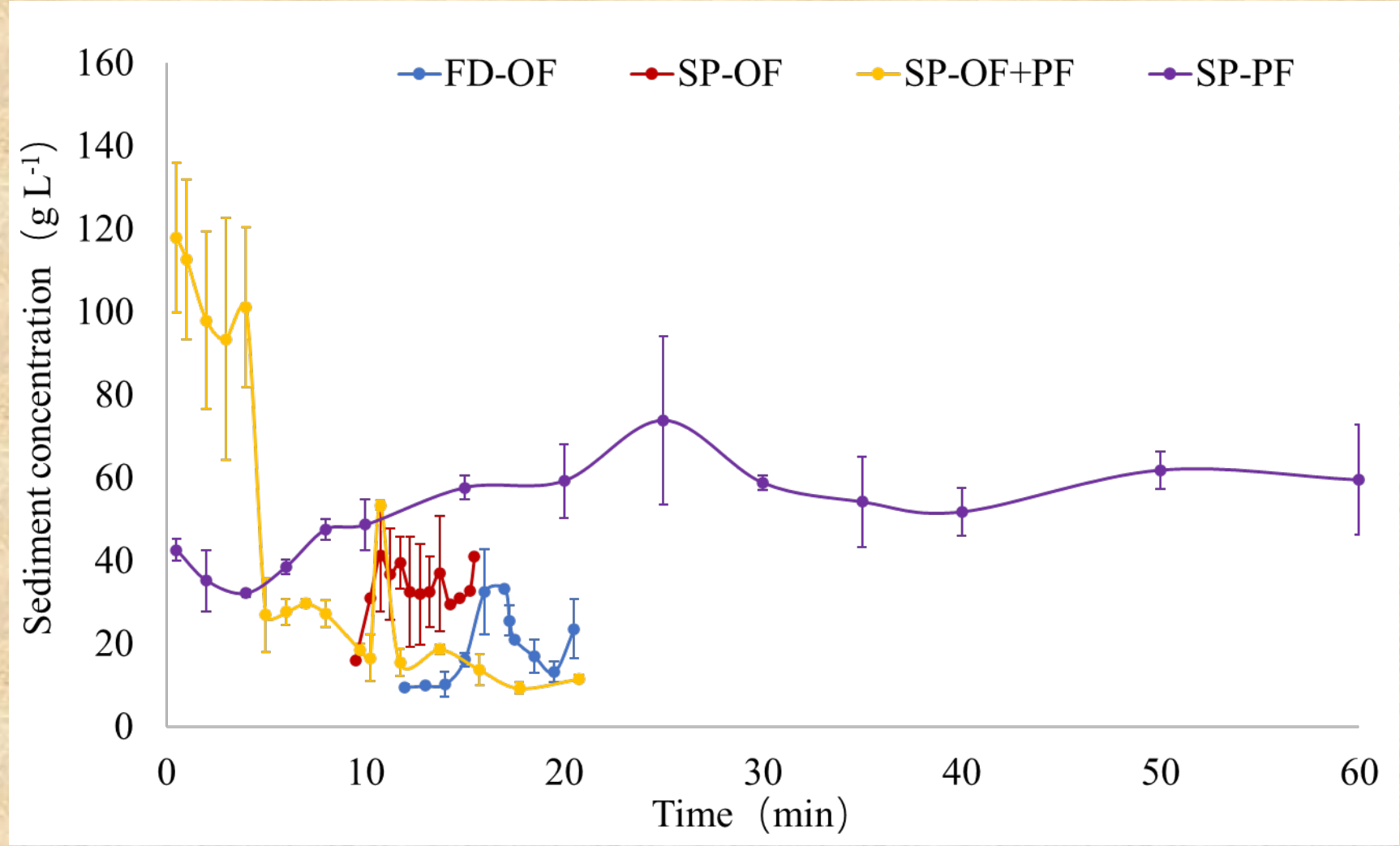
Once pipe collapse occurs upslope of headcut, surface flow is diverted to pipeflow with substantial increase in sediment export

Soil Pipeflow Impacts on Headcut Advance

Overland flow under free drainage has delayed outflow and low sediment concentrations

Addition of seepage accelerates time to outflow and increases sediment export

Addition of pipe inflow greatly increases sediment export and acceleration of outflow



Summary and Conclusions

1) For the baseline treatments without a soil pipe, seepage condition increased sediment concentration 42% and headcut migration rate 47% compared with free drainage condition.
2) When a soil pipe was present below the soil bed, once the headcut scour hole contacted the soil pipe, the scour hole depth increased and combined with the overland flow being diverted into pipeflow downslope of the headcut, these changes accelerated the headcut migration rate.
3) The process of overland flow being diverted into the soil pipe occurred sooner and resulted in higher headcut migration rates in the presence of a perched water table (seepage).
4) When soil pipes are fed by seepage and an upslope inflow whether there is overland flow through the channel or not, tunnel collapse will create surface openings for intercepting surface runoff above or in the absence of headcut.