Drip Systems and the Use of Various P Fertilizers

An Irrigator's Perspective

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According to "the book"

(The Nature and Properties of Soils by Brady and Weil)

The Phosphorus problem in soil fertility is threefold:

1. The total phosphorus of soils is relatively low in the upper layers of the soil profile where roots are active.
2. The phosphorus compounds commonly found in soils are mostly unavailable for plant uptake, usually because they are highly insoluble.
3. When soluble sources of phosphorus, such as those in fertilizers and manures, are added to soils, they are fixed (changed to unavailable forms) and in time form highly insoluble compounds.

Other than these problems, P fertility is easy.

P is not N

- Nitrogen fertilizers:
  - Are generally soluble and will move with irrigation water.
  - Must be applied carefully to avoid leaching losses.
  - Do not precipitate with cations commonly found in soils.
  - Do not change form or solubility at different soil pH's.

  Plants must capture N as it moves past the roots.
- Phosphorus fertilizers:
  - Have very limited solubility.
  - Do not move much in the soil.
  - Are tied up with Ca in basic soils
  - Are tied up with Fe and Al in acid soils

  Plants must "mine" P from "deposits" of fertilizer P

The problem with traditional P fertility is:

"Availability"

- P fertilizer applied to a moderately alkaline soil, common in CA irrigated agriculture, may only have 1%-3% of the nutrient in a form available to the plant at any one time.
- Availability can be expressed chemically as an "equilibrium" reaction:

Unavailable mineral form $\rightleftharpoons$ Plant available form

$Ca_3(PO_4)_2 \rightleftharpoons Ca^{+2} + PO_4^{-3}$

- How can the plant acquire sufficient P when so much of it is unavailable?
  - One can live on a small interest rate (3%); if one has a large enough bank account ($10,000,000).
  - The problem is to provide the plant with a large enough bank account so that the available funds are sufficient.

There are two basic problems:

- Getting the P fertilizer into the active root zone:
  - Banding is necessary because surface applications only work when followed by complete incorporation such as plowing,
  - Fertigation:
    - enhances movement of soluble forms
    - Placed directly in the root zone through buried drip lines
- Dispersing the P fertilizer within the root zone
  - Increase solubility of traditional forms of P
    - Maintain optimum pH = 6.5
    - Acidification of irrigation water
    - High frequency irrigations to maintain high water content
  - Application of more soluble forms of P
    - Poly Phosphates
    - Organic complex Phosphates

Two Studies at CSU Fresno

1. A graduate student's project to evaluate the movement of acid, and polyphosphate vs. an organic-P complex material applied through surface drip tape to a sandy loam soil.
2. A lab test of various combinations of P fertilizers and irrigation waters to evaluate the potential for plugging drip tape and recovering from the problem.

From:
Applying Nutrients to Trickle Irrigated Crops. UCCE Bulletin 1893.
Roy Rauschkolb; Extension Soils Specialist, UCD

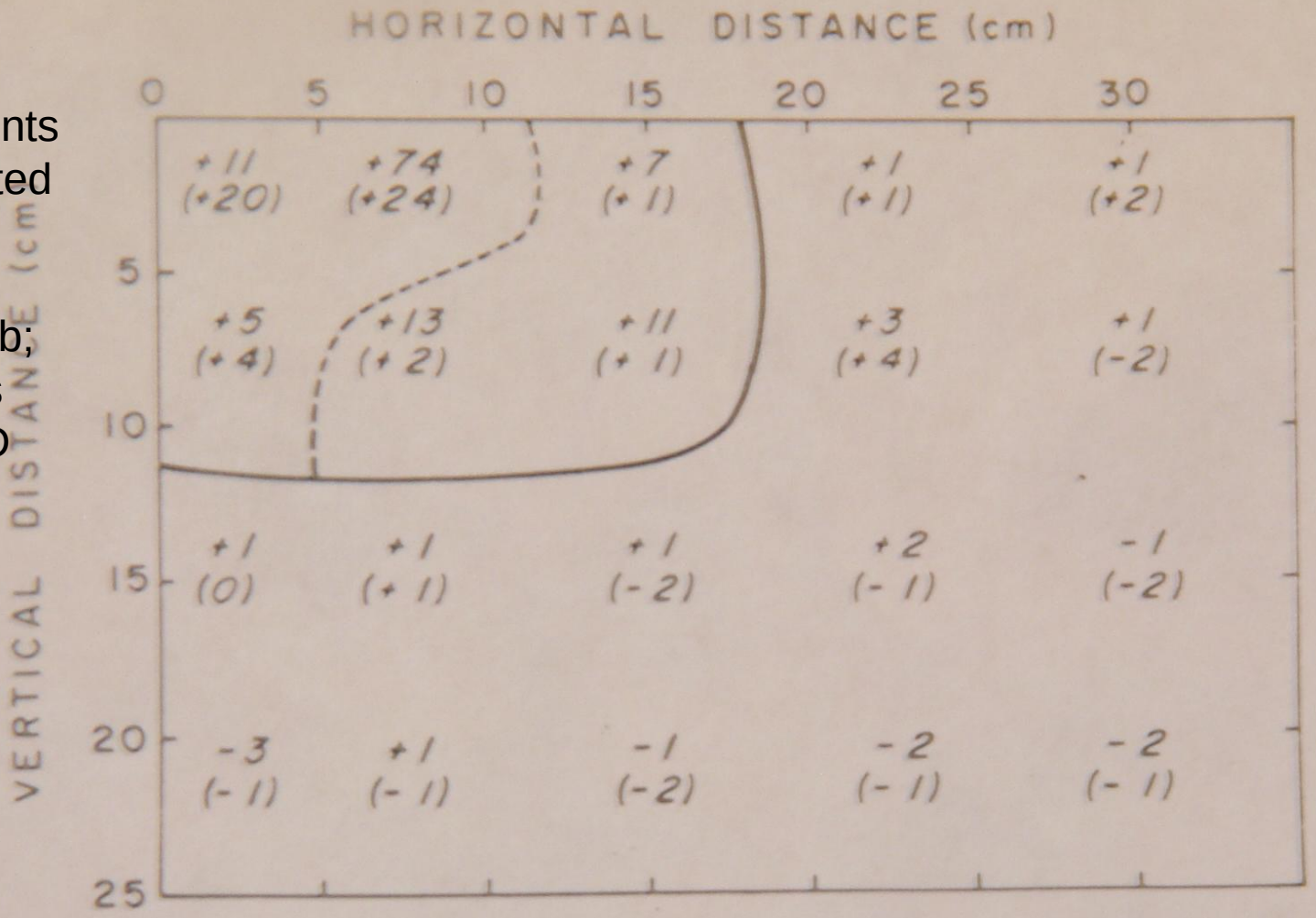

Fig. 7. Comparison of phosphorus distribution beneath a simulated emitter in the field on a Panoche clay loam soil for two sources of phosphorus. Broken and solid curves are approximate maxima for bicarbonate-soluble phosphorus movement for orthophosphoric acid (values in parentheses) and glycerophosphate (values not in parentheses) applications, respectively.

cation rate for

Injecting P fertilizers into drip tape

Selecting location for soil sample

Driving soil sampler into the profile

Extracting 3” square sub-samples

Results from the CSU Fresno trial

Three P fertilizers were injected through drip tape. Soils were sampled in a 12” grid. Change in P values over a period of 29 days is indicated in each 3” square. The drip tape location is at the upper left corner of each grid.

Check

Depth	O	1	2	3	4
A		-5.4	-19.6	-7.5	-3.5
B		-2.3	-5.8	-3.6	-2.1
C		0.9	4.3	1.8	-3.7
D		0.9	-0.8	0.4	-3.8
					-3.1

Un-Treated Check Random changes with some indication of leaching near drip line

high rate Phos acid

Depth	O	1	2	3	4
A		-21.3	-28.7	0.2	-0.1
B		-21.2	-21.9	-6.4	3.1
C		-7.6	-3.4	4.5	5.1
D		3.8	-2.0	5.4	2.2
					-5.5

Green Acid Increased leaching near drip line consistent with acidification of the soil

Results from this test were not statistically significant and are shown here as examples only

high rate 10-34-0

Depth	O	1	2	3	4
A		-3.1	-18.2	-22.1	2.7
B		-3.1	5.8	-2.0	-1.3
C		4.5	0.3	-1.7	0.2
D		4.3	1.6	0.2	1.9
					-1.9

PolyPhos Predominant movement was downward with little lateral dispersion

high rate organic P

Depth	O	1	2	3	4
A		-7.9	13.1	6.8	0.0
B		-9.7	11.3	6.5	8.0
C		6.5	9.3	11.1	6.4
D		9.8	6.7	10.5	3.8
					5.8

Organic Phos (Actagro Structure) Best combination of lateral and vertical dispersion.

Evaluation of Phosphate Fertilizer Type for Plugging of Drip Irrigation Tape

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Phoenix, AZ, November, 2007

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Testing to Evaluate Phosphate Plugging

- Initiated by the manufacturer of an organically complexed phosphate fertilizer to test its potential for precipitation with Ca^{+2} compared to traditional, inorganic phosphate materials.
- Tests were conducted at the hydraulics lab of the CSU Fresno Center for Irrigation Technology during the spring of 2005.
- A drip tape commonly used in the San Joaquin Valley for vegetable production was tested using water from a tile drainage system. Both the water and the tape were provided by the grower. Both new and used tape (3 seasons) were tested.
- A second tape commonly used in the Salinas Valley for vegetable production was tested with a high Ca^{+2} well water that had caused plugging problems in the past. Tape and water were supplied by the grower.

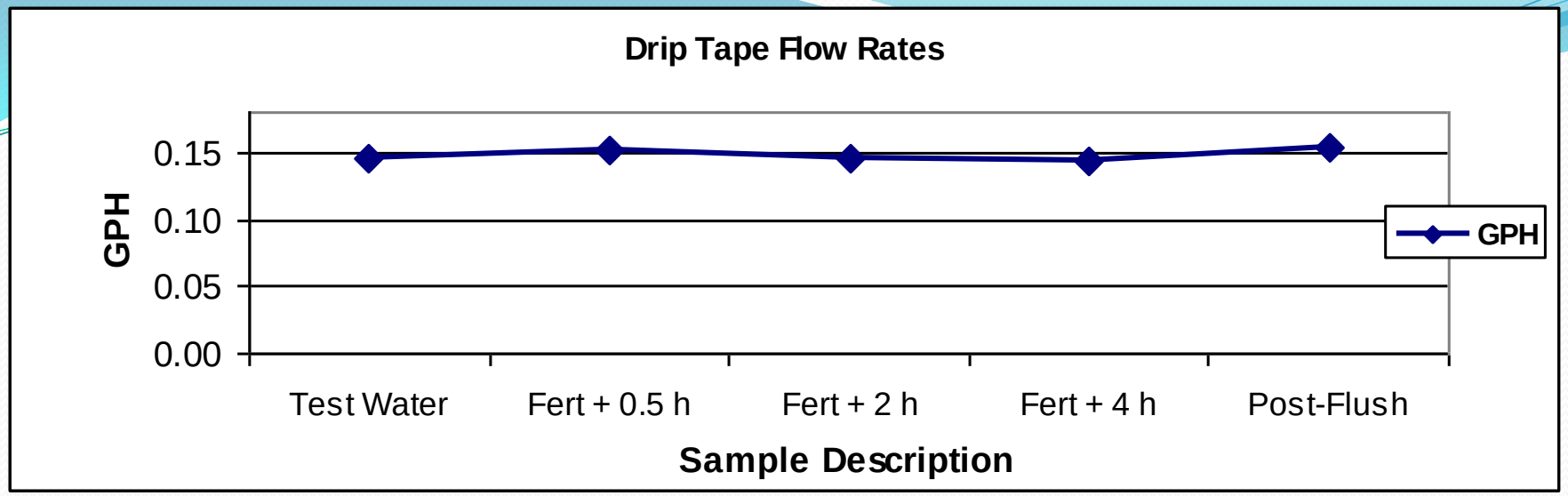
Drip Tape Testing System

- A testing bench designed to evaluate plugging of drip tape with particles was modified to test the effects of phosphate fertilizers.
- Two lengths of tape (25 feet) were connected to a circulation pump through a pressure regulator (8 psi.) and suspended over a trough to catch the emitter flow for recirculation.
- The system operated to simulate a chemigation event under extreme conditions.
  - Test water was used for the initial 30 minutes and flow rates were measured
  - Phosphate fertilizer was introduced into the system reservoir at a rate of 150#/acre (as P_2O_5) simulated for a single line on a 40" bed.
  - Flow rates were measured 0.5, 2 and 4 hours after phosphate introduction using graduated cylinders for 2 minutes at each emission point on the two tape samples.
  - The system was flushed with test water after 4 hours and the post application flow rate was measured.


Drip tape samples (2 lengths of 25 feet each)
Catch trough
Reservoir of test water (25 liters)
Circulation pump


KLENZADE
BEVRO-SHEEN

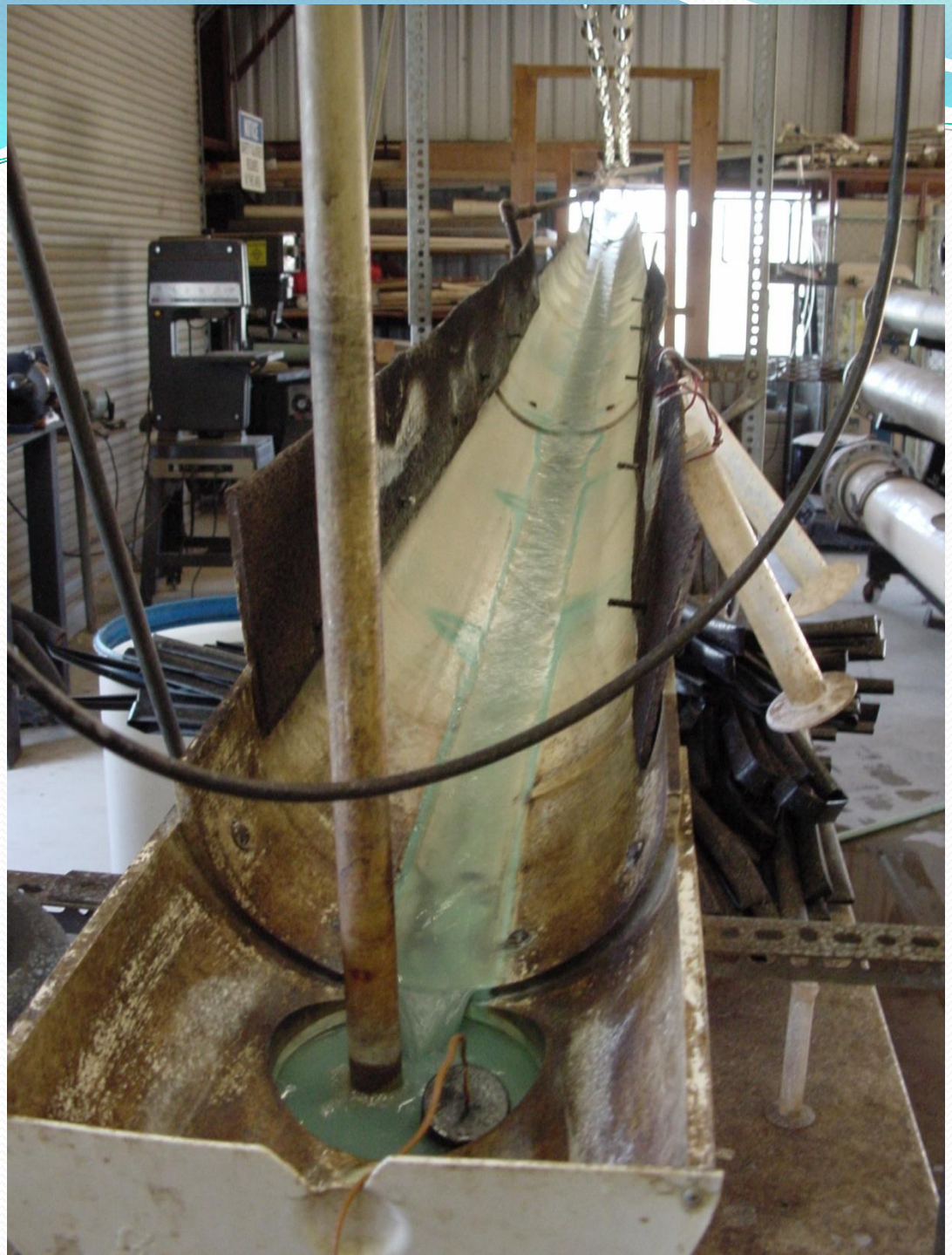

7
8
9
10



Drip Tape Plugging Test Results - Drip Tape Flow Rates					
Date 04/01/05	Fertilizer Structure		Test Water Drainage		Drip Tape T-Tape
Sample Time	900	940	1110	1310	1400
Sample Description	Test Water	Fert + 0.5 h	Fert + 2 h	Fert + 4 h	Post-Flush
Reading #	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5
GPH/Emitter	0.15	0.15	0.15	0.14	0.15
% of Initial Flow Rate	100%	105%	101%	99%	106%

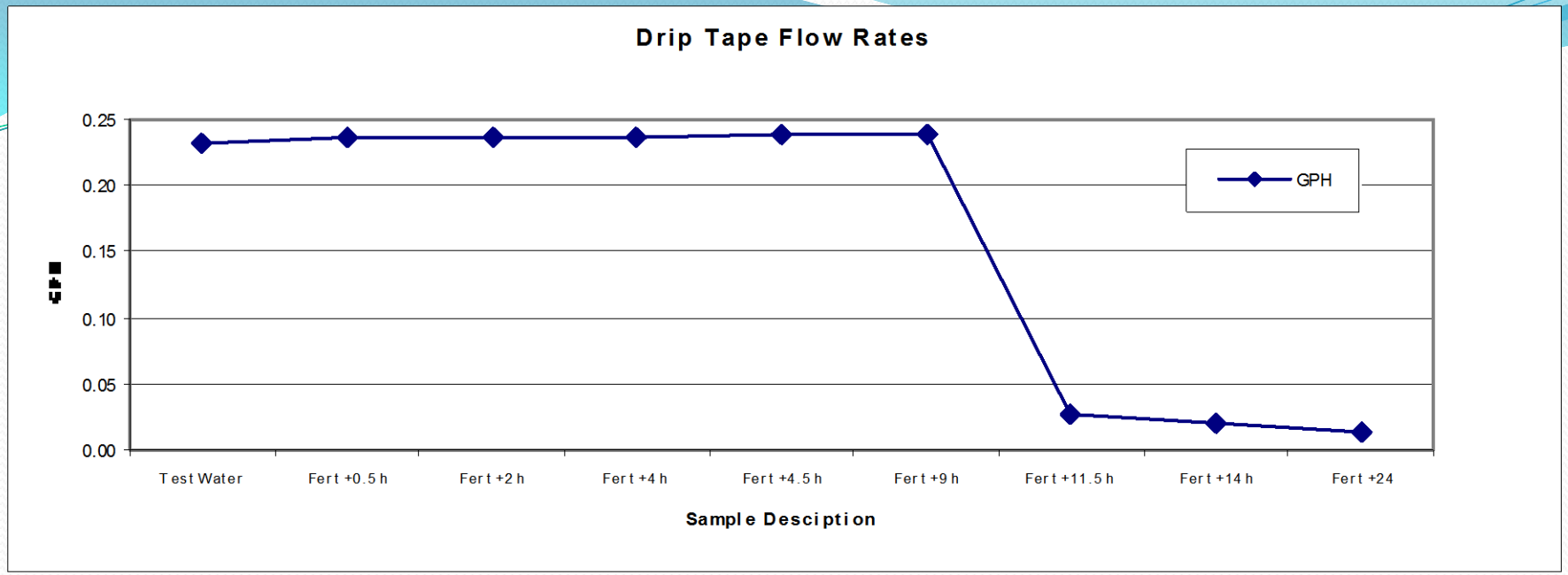
Initial Results

- No significant plugging with any combination of tape, water and fertilizer material in the 4 hour simulated chemigation event.
- The testing procedure was modified to simulate a longer period of chemigation by extending the running time to exceed 12 hours and including a shutdown and restart with the fertilizer material remaining in the tape.
- The new procedure did result in significant plugging after 10 to 12 hours of operation.
- The post-application flushing was usually, but not always successful in restoring the flow rate after plugging.
- The organic-Phosphate fertilizer was consistently better than the inorganic materials with respect to both flow reduction and recovery after flushing.

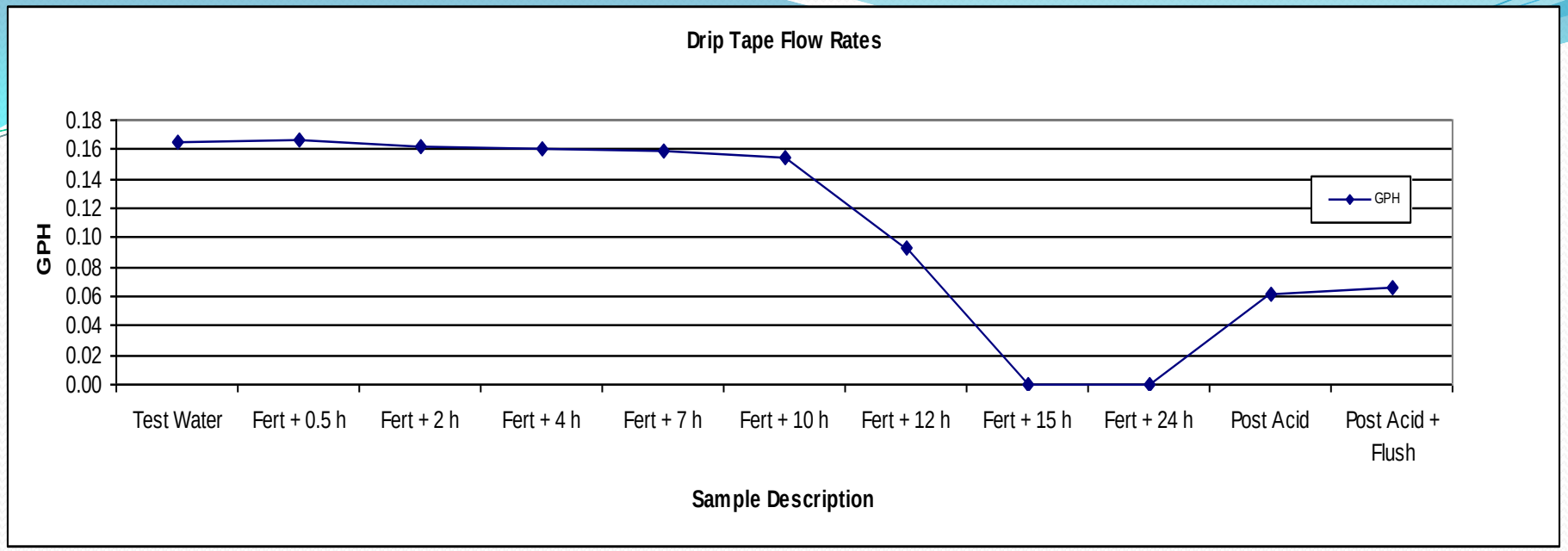


Drip tape using a Salinas Valley well water, high in Calcium with Ammonium Phosphate (10-34-0) at a rate of 150#/acre.

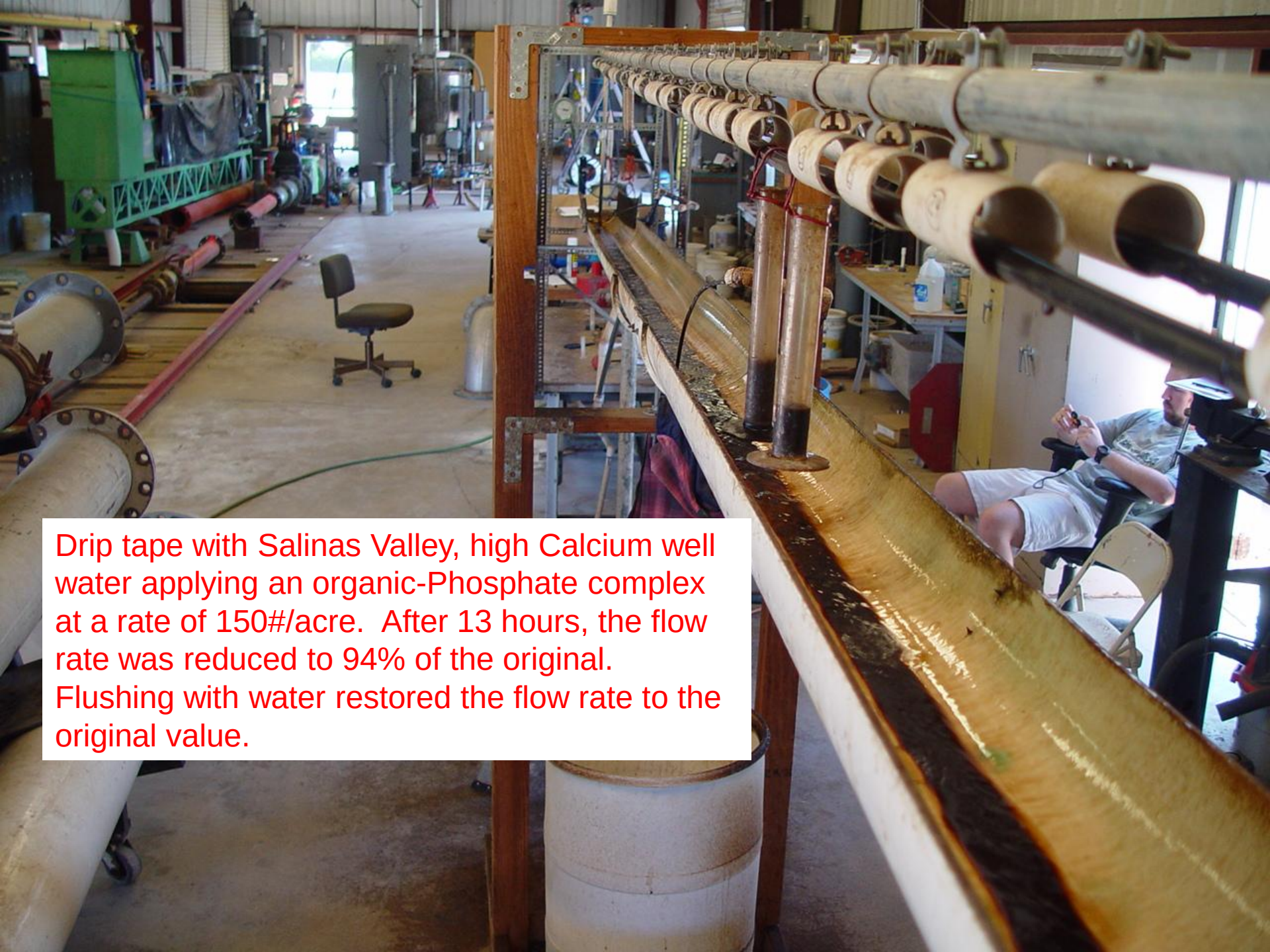
After 10 hours of running, the Calcium Phosphate precipitate has formed to a degree that the flow rate from the drip tape has been reduced. After 12 hours, the flow rate was down to about 10% of the original.



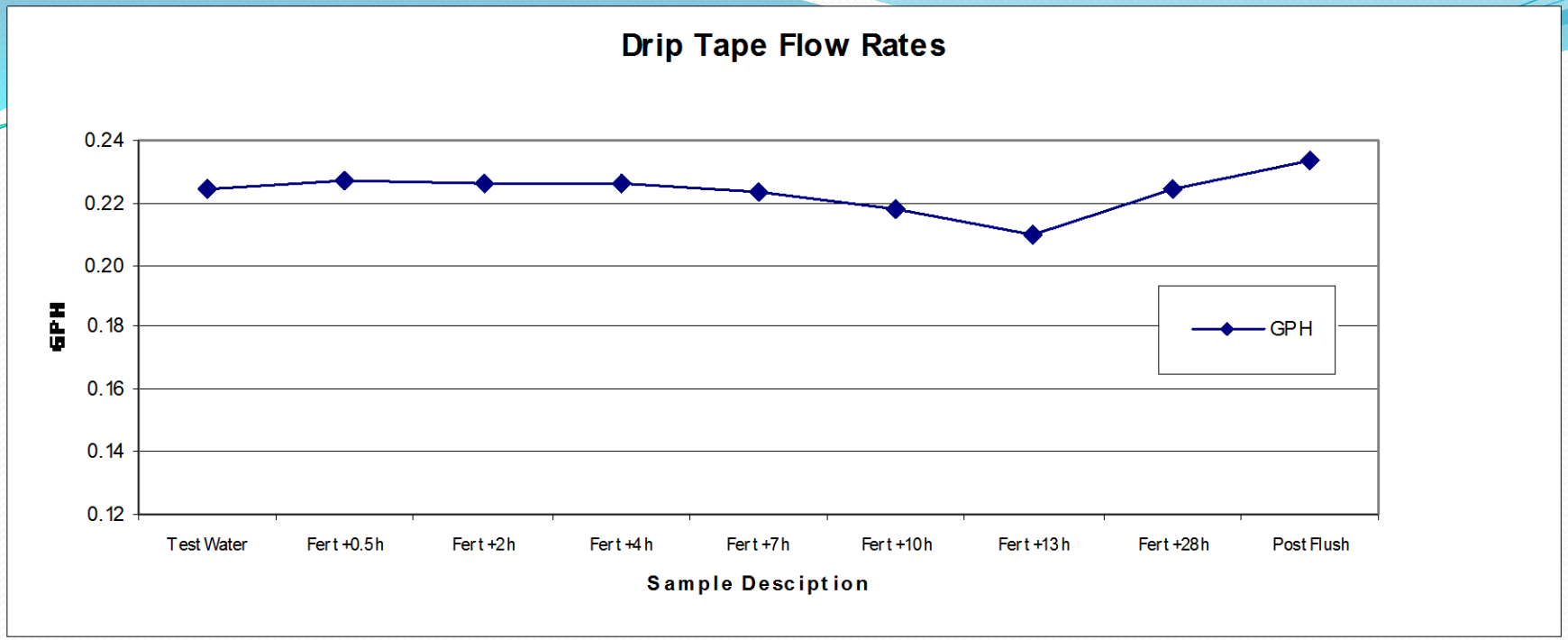
Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
10-34-0	Coastal	Salinas Valley	
Sample Time	715	2200	800
Sample Description	Test Water	Fert + 14 h	Fert + 24 h
Reading #	Reading 1	Reading 8	Reading 9
GPH/Emitter	0.23	0.02	0.01
% of Initial Flow Rate	100%	9%	6%



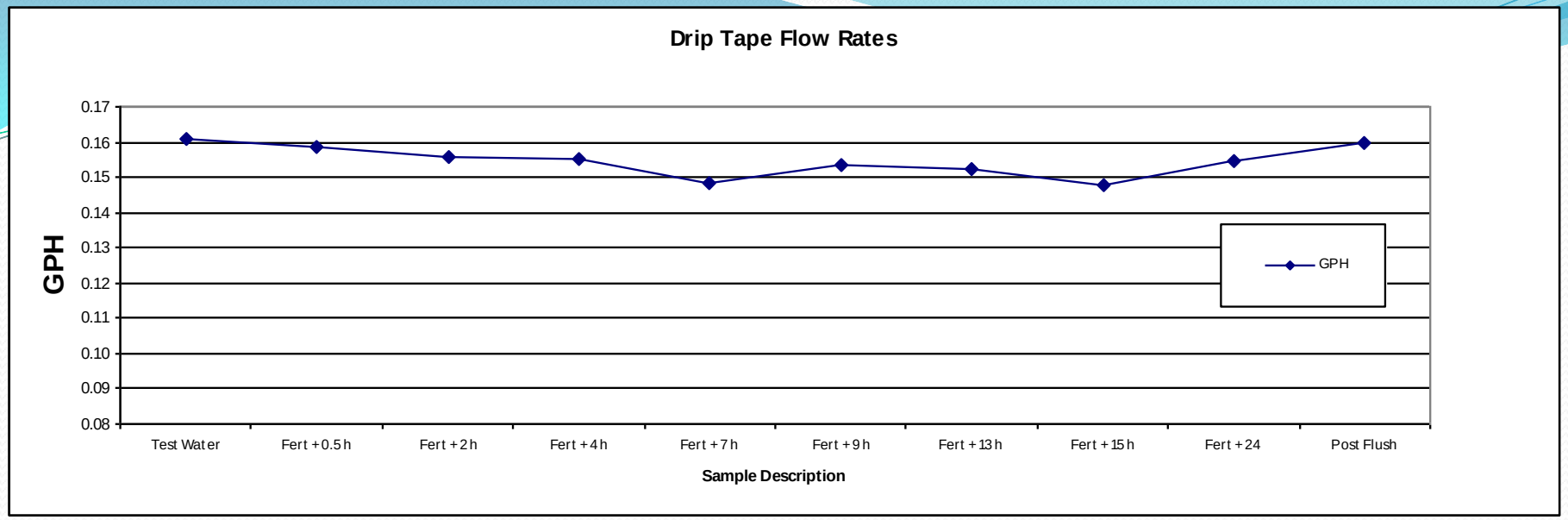
Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
10-34-0	Campus	Central Valley	
Sample Time	640	2200	850
Sample Description	Test Water	Fert + 15 h	Post Acid + Flush
Reading #	Reading 1	Reading 8	Reading 11
GPH/Emitter	0.17	0.00	0.07
% of Initial Flow Rate	100%	0%	40%



Drip tape with Salinas Valley, high Calcium well water applying an organic-Phosphate complex at a rate of 150#/acre. After 13 hours, the flow rate was reduced to 94% of the original. Flushing with water restored the flow rate to the original value.



Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
Organic	Coastal	Salinas Valley	
Sample Time	745	2130	1400
Sample Description	Test Water	Fert + 13 h	Post Flush
Reading #	Reading 1	Reading 7	Reading 9
GPH/Emitter	0.22	0.21	0.23
% of Initial Flow Rate	100%	94%	104%



Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
Organic	Drainage	Central Valley	
Sample Time	640	2200	900
Sample Description	Test Water	Fert + 15 h	Post Flush
Reading #	Reading 1	Reading 8	Reading 10
GPH/Emitter	0.16	0.15	0.16
% of Initial Flow Rate	100%	92%	99%

These simulations, while intentionally extreme, are not to be construed as proof that phosphate fertilizers can be safely applied through drip tape. The chemical precipitates can still form and plug the tape under field conditions similar to these. The interesting results found in the tests were:

1. The chemical precipitation may require several hours to form and cause plugging. Short irrigation periods and short chemical applications within those short irrigations may be safer than long runs.
2. Phosphate fertilizer remaining in the tape because of insufficient post-application flushing can be responsible for additional plugging problems.
3. Some forms of phosphate fertilizers may produce significantly less chemical precipitate than other forms.
4. Some irrigation water sources (i.e. wells) may be more likely to precipitate phosphates than other sources such as district surface water.
5. Tapes in current use are capable of being flushed after partial plugging with phosphate fertilizers to restore some, and perhaps all of the original performance.


QUESTIONS?