3rd Annual

Midwest Soil Improvement Symposium: 2013

Research and Practical Insights into Using Gypsum

March 7, 2013

Current Research Activities for Agricultural Uses on Highly Erodible Soils

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THE OHIO STATE UNIVERSITY

GYPSOIL™ BRAND GYPSUM

CTIC CONSERVATION TECHNOLOGY INFORMATION CENTER

Current Research Activities for Agricultural Uses on Highly Erodible Soils

Allen Torbert

USDA-Agriculture Research Service
National Soil Dynamics Laboratory

Benefits of Gypsum

- Improve soil properties
  - Improve water infiltration
  - Control soil erosion and crusting
  - Nutrient soil for crops (Ca and S)
  - Alleviate the effects of subsoil acidity (Al Toxicity)

- Reduce contaminates in water runoff.

ARS Multi Location Gypsum study

Use of FGD Gypsum to Improve Crop and Forage Production and reduce P loss on Erodible Soils of the South

Research Goals

- Establish rates of FGD gypsum and poultry litter
- Document improvements in water quality
- Develop guidelines for use of FGD gypsum

USDA-ARS J. Phil Campbell Sr. Natural Resource Conservation Center, Watkinsville, GA

Harry Schomberg - Pasture

USDA-ARS National Soil Dynamics Laboratory, Auburn, AL

Dexter Watts - Pasture

USDA-ARS National Sedimentation Laboratory, Oxford, MS

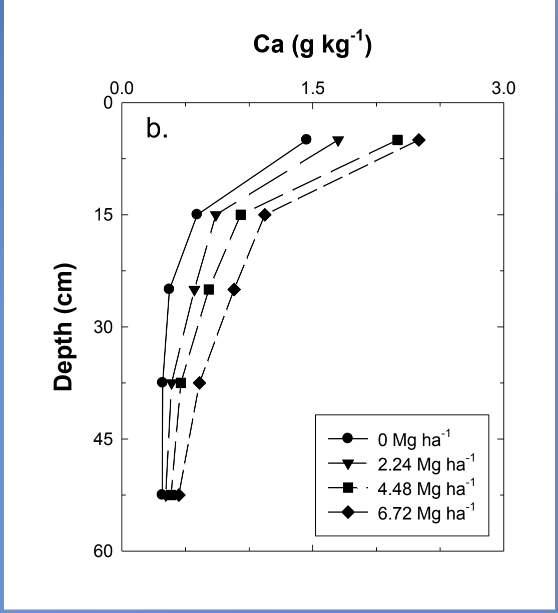
Martin Locke – Row Cropping Systems

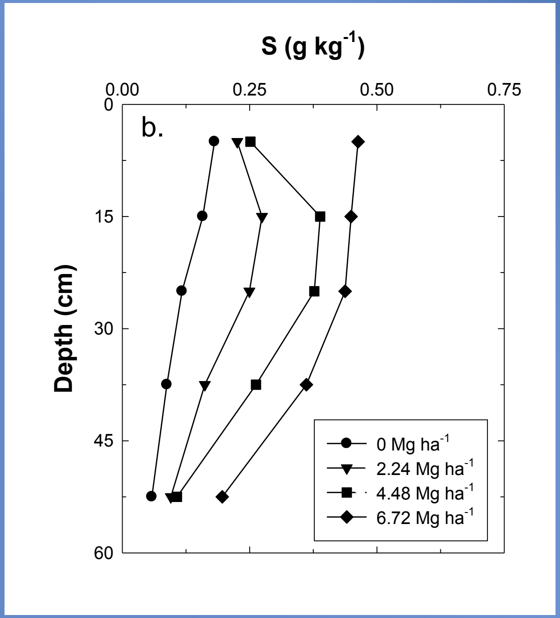
USDA-ARS
National Sedimentation Lab,
Oxford, MS

Cotton and Soybeans

Conventional tillage vs. No-tillage

Results





Comments: Calcium and sulfur distributions with soil depth indicate that three consecutive years of surface applied FGD gypsum amendments on no-till cotton have resulted in significant increases in these essential plant nutrients at depth.

Note: 0, 2.24, 4.48, and 6.72 Mg ha-1 correspond to 0, 1, 2, and 3 tons/acre.

Soil Physical Characterization

Soil penetration resistance, 2012 Milan, TN

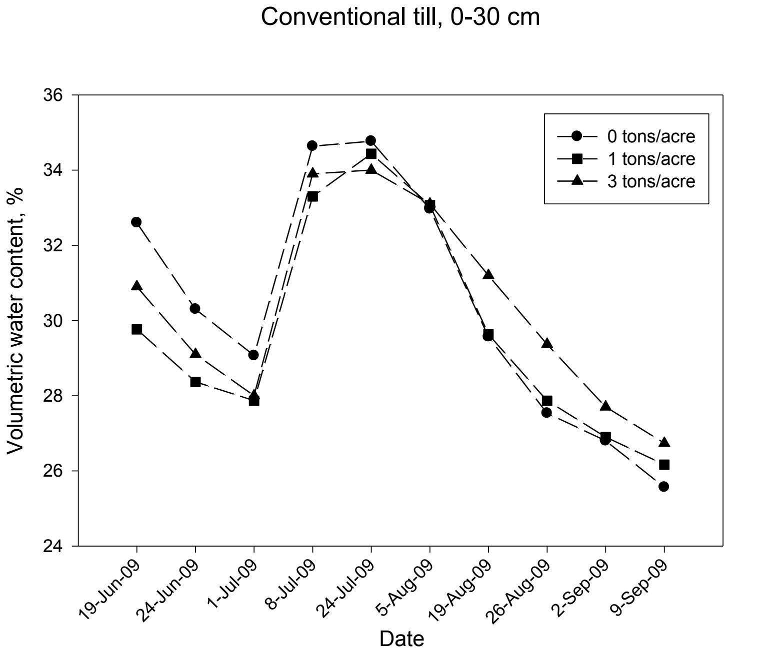
- Cone penetrometer measured integrated total force required to reach a 12-inch depth
- Crop row and middle of row (wheel track and non-wheel track)
- In all row positions, resistance tended to decrease in plots treated with FGD gypsum,

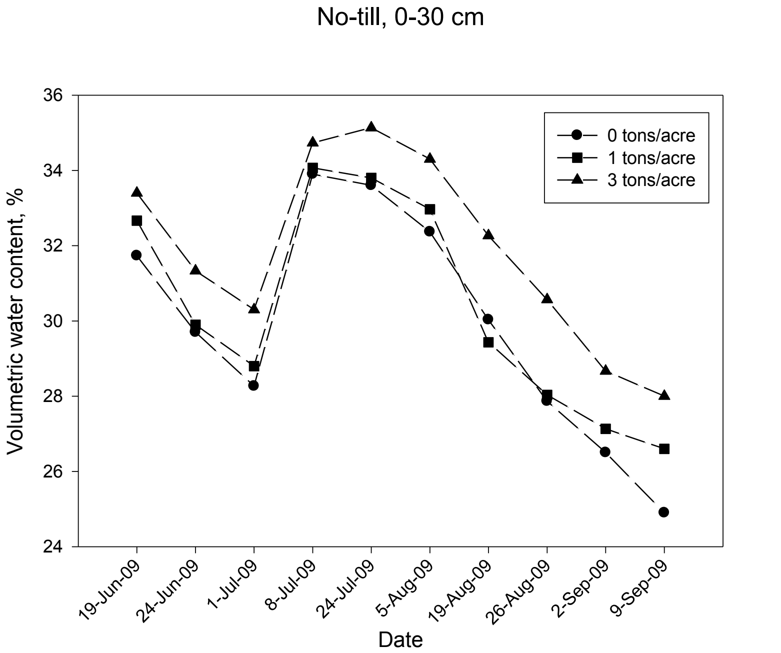
Tillage	FGD gypsum rate	Non-wheel track middle	Crop Row	Wheel track middle
	tons/acre	------------------ kPa X 10^{-3} ------------------		
Conventional	0	79.4	76.0	94.8
	1	71.2	73.3	91.3
	2	68.7	75.0	84.2
	3	72.2	71.3	89.0
	5	73.4	69.9	86.4
No-till	0	80.8	72.5	90.6
	1	68.4	68.9	83.0
	2	84.0	75.5	92.3
	3	71.4	71.4	84.3
	5	79.1	70.1	88.1

Martin Locke - unpublished data

Soil water content during the 2009 growing season Verona, MS

- Water content was measured with TDR only in 2009
- CT plots showed little difference until end of the growing season, when 3 tons/acre FGD held more water
- NT showed a more consistent advantage for the 3 tons/acre FGD treatment, with the difference starting earlier in the growing season
- Slightly higher soybean yields in NT may have resulted from the increased moisture

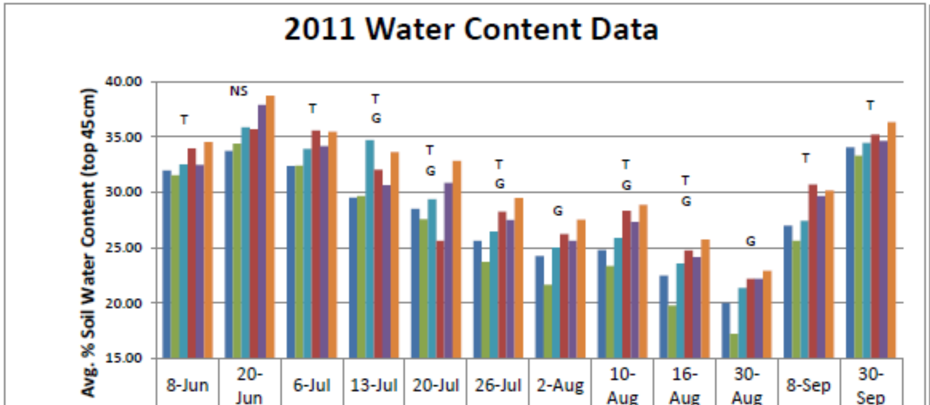




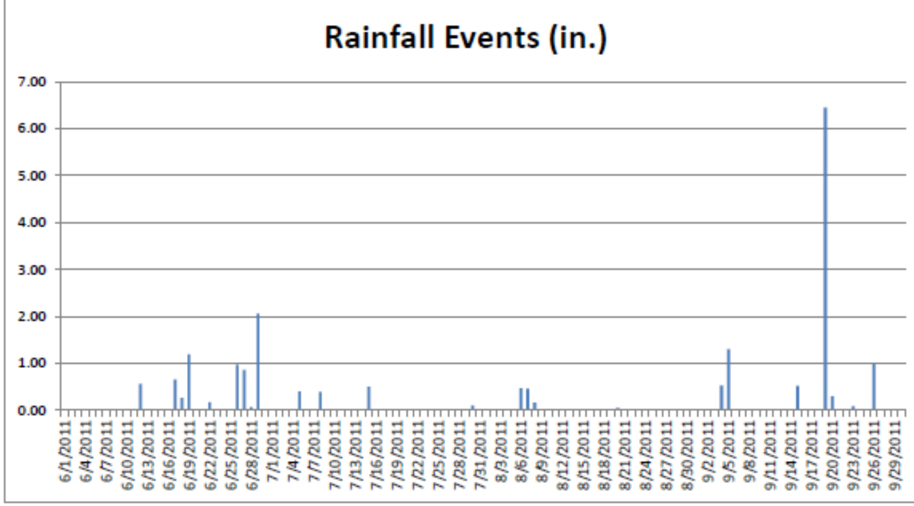
Martin Locke - unpublished data

Soil water content, Milan, TN

- TDR soil water content, 2011
- Rainfall and mean volumetric soil water content for the top 45 cm as affected by tillage and gypsum
- With exception of two dates, 3 tons/acre NT plots consistently had higher soil moisture
- NT cotton yields were higher in 2011



	8-Jun	20-Jun	6-Jul	13-Jul	20-Jul	26-Jul	2-Aug	10-Aug	16-Aug	30-Aug	8-Sep	30-Sep
0 G till	31.97	33.71	32.33	29.50	28.50	25.60	24.27	24.77	22.50	20.00	26.99	34.04
1 G till	31.53	34.37	32.37	29.67	27.54	23.70	21.67	23.37	19.77	17.23	25.60	33.27
3 G till	32.50	35.83	33.90	34.67	29.37	26.43	25.00	25.87	23.57	21.37	27.40	34.43
0 G no-till	33.93	35.63	35.57	32.00	25.60	28.23	26.23	28.30	24.73	22.20	30.70	35.20
1 G no-till	32.43	37.86	34.13	30.63	30.83	27.47	25.60	27.30	24.13	22.17	29.63	34.61
3 G no-till	34.50	38.70	35.46	33.60	32.80	29.47	27.50	28.83	25.73	22.90	30.17	36.30



Martin Locke - unpublished data

Watkinsville, Ga

Piedmont Soil

Auburn, Al

Coastal Plains Soil

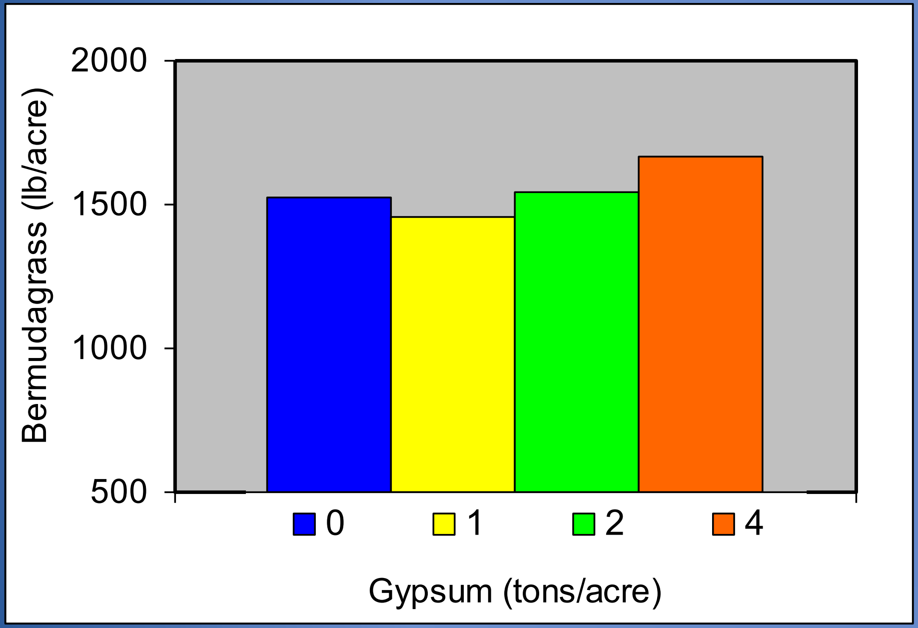
FGD-Gypsum & Poultry Litter

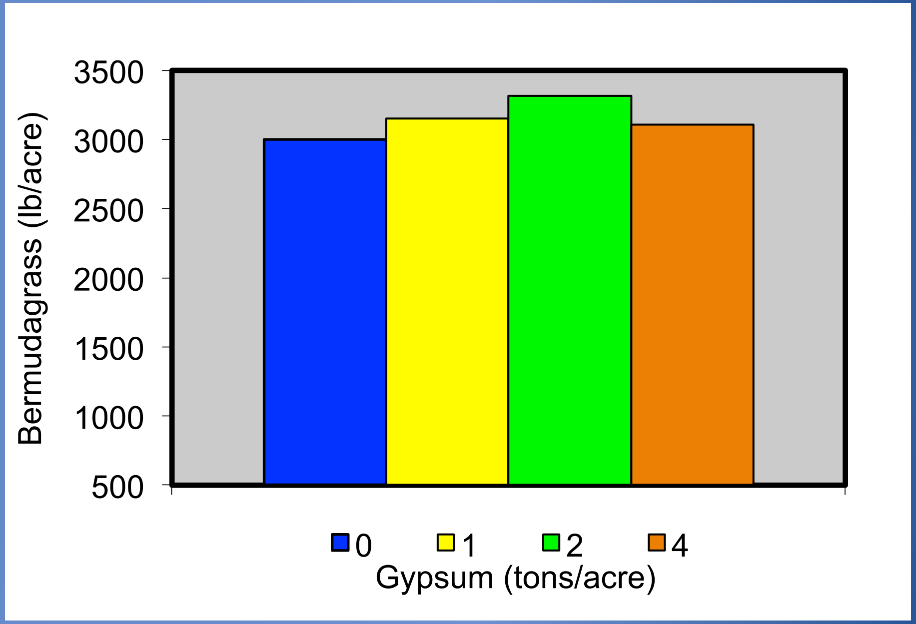
Poultry Litter (tons/acre)

Gypsum (tons/acre)

	0	2	4	6
0	0-0	0-2	0-4	0-6
1	1-0	1-2	1-4	1-6
2	2-0	2-2	2-4	2-6
4	4-0	4-2	4-4	4-6

Yield Average





Bermudagrass

Watkinsville 2011

Water Quality

- What is quality of water in the U.S.
  * 45% of river miles are impaired
  * 47% of lake acres,
  * 32% of estuarine water is impaired.
- Agriculture is considered to be one of the major contributors to water quality
- Phosphorus loss from agriculture
- Poultry Industry
  - Improper disposal of waste from poultry industry


Gypsum Interaction with Soluble P

- Formation of an insoluble Ca-phosphate complex

- Insoluble hydroxyapatite and fluorapatite

Orthophosphate PO_4^{3-} → $Ca_5(PO_4)_3(OH)$

Orthophosphate PO_4^{3-} → $Ca_5(PO_4)_3F$

Rainfall Simulations

FGD-Gypsum & Poultry Litter

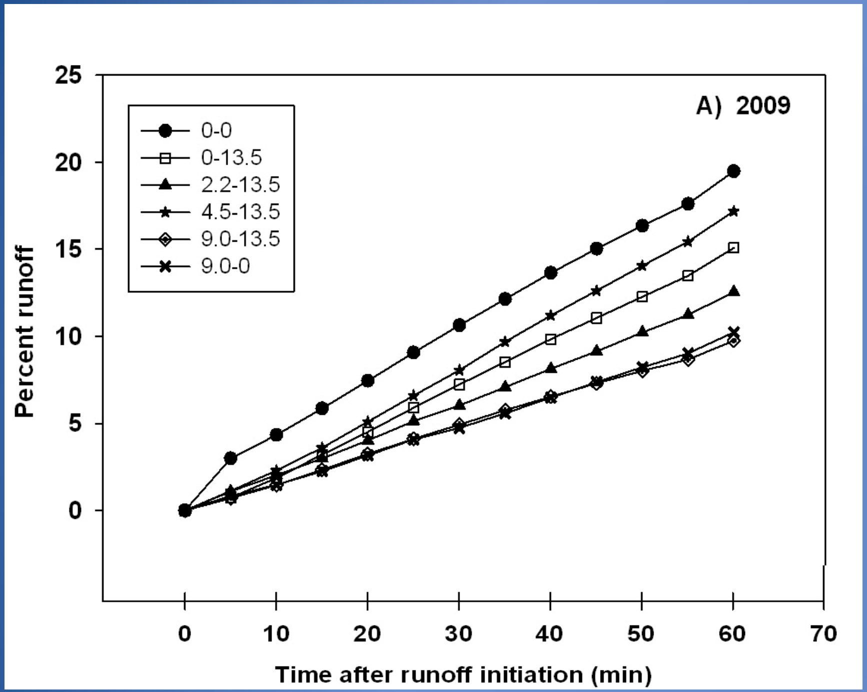
Poultry Litter (tons/acre)

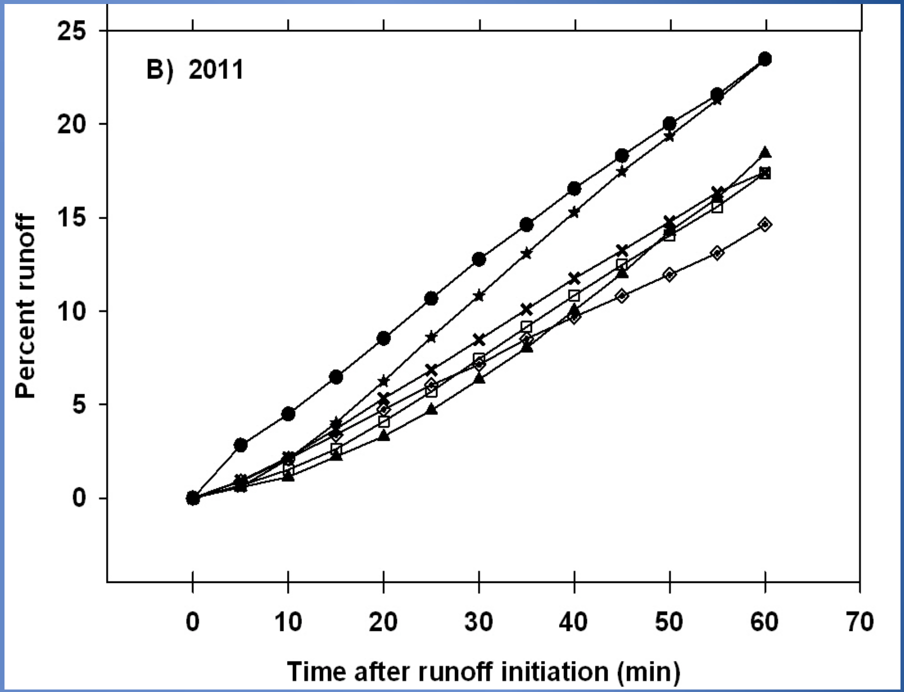
Gypsum (tons/acre)	0	2	4	6
0	0-0	0-2	0-4	0-6
1	1-0	1-2	1-4	1-6
2	2-0	2-2	2-4	2-6
4	4-0	4-2	4-4	4-6

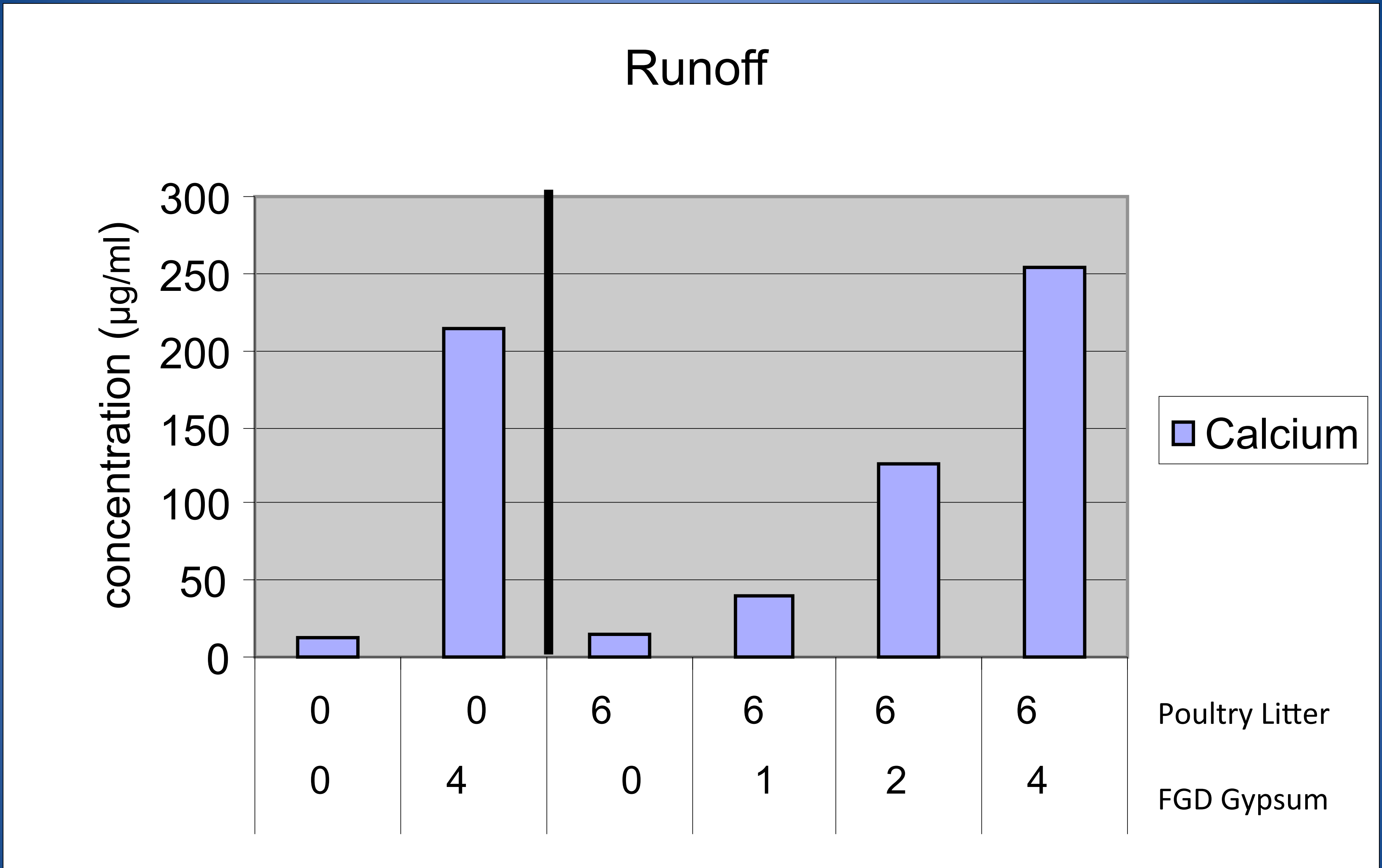
Time samples - 0, 10, 20, 30, 40, 50, 60
Cumulative samples
Unfiltered – Total nutrient
Filtered - Dissolved

Runoff

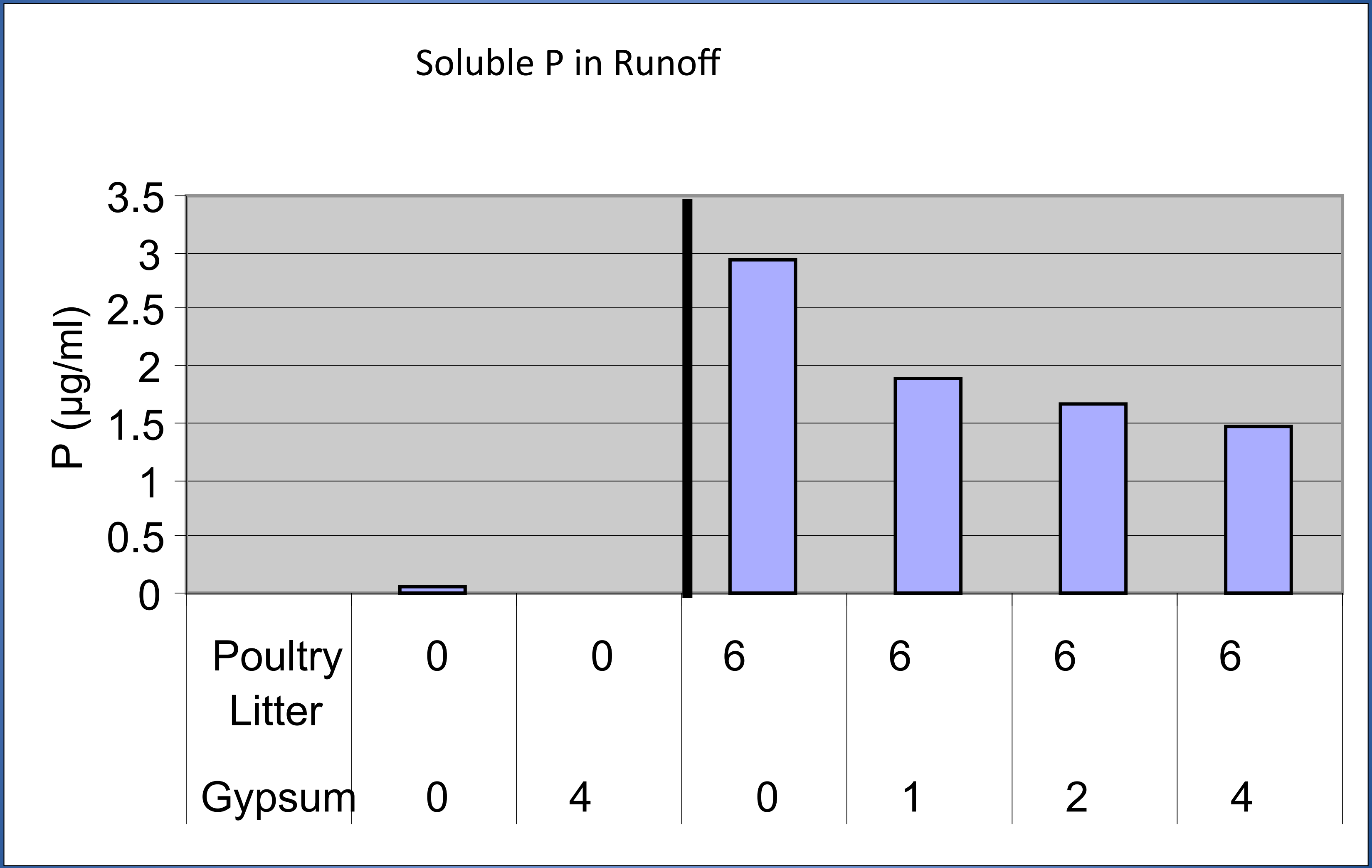
Runoff as % of Rainfall





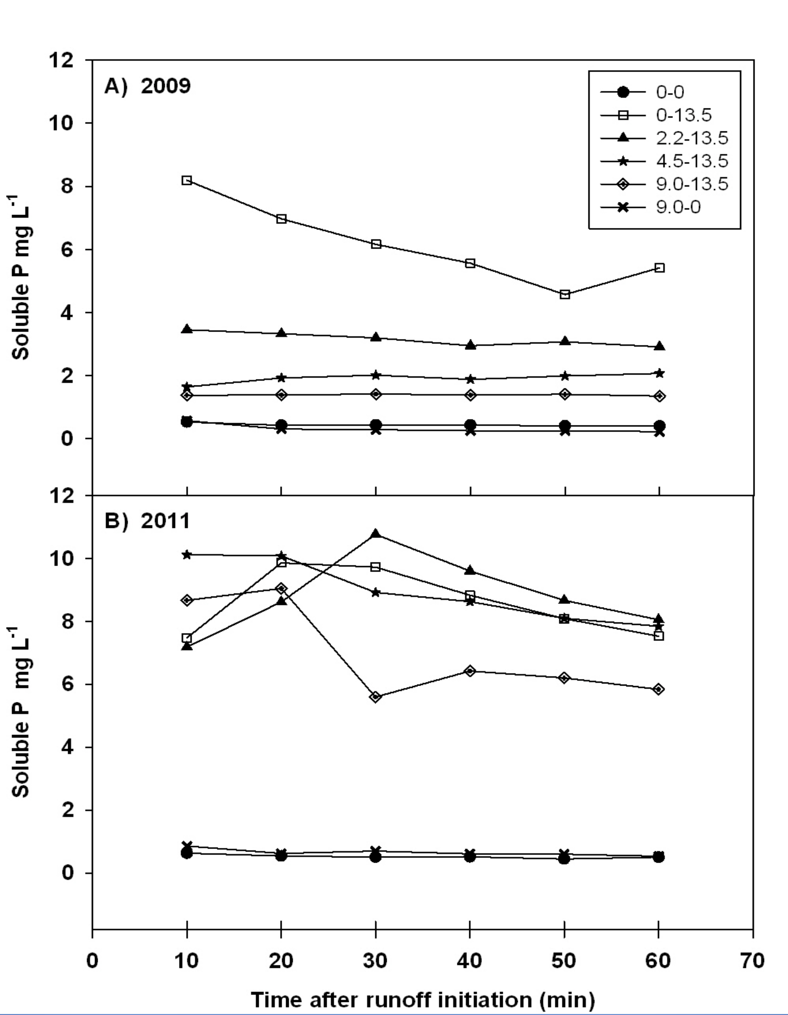


Runoff
concentration (µg/ml)
300
250
200
150
100
50
0
Calcium
0 0 6 6 6 6
Poultry Litter
0 4 0 1 2 4
FGD Gypsum



Soluble P in Runoff
P (µg/ml)
3.5
3
2.5
2
1.5
1
0.5
0
Poultry Litter
0
0
6
6
6
6
Gypsum
0
4
0
1
2
4

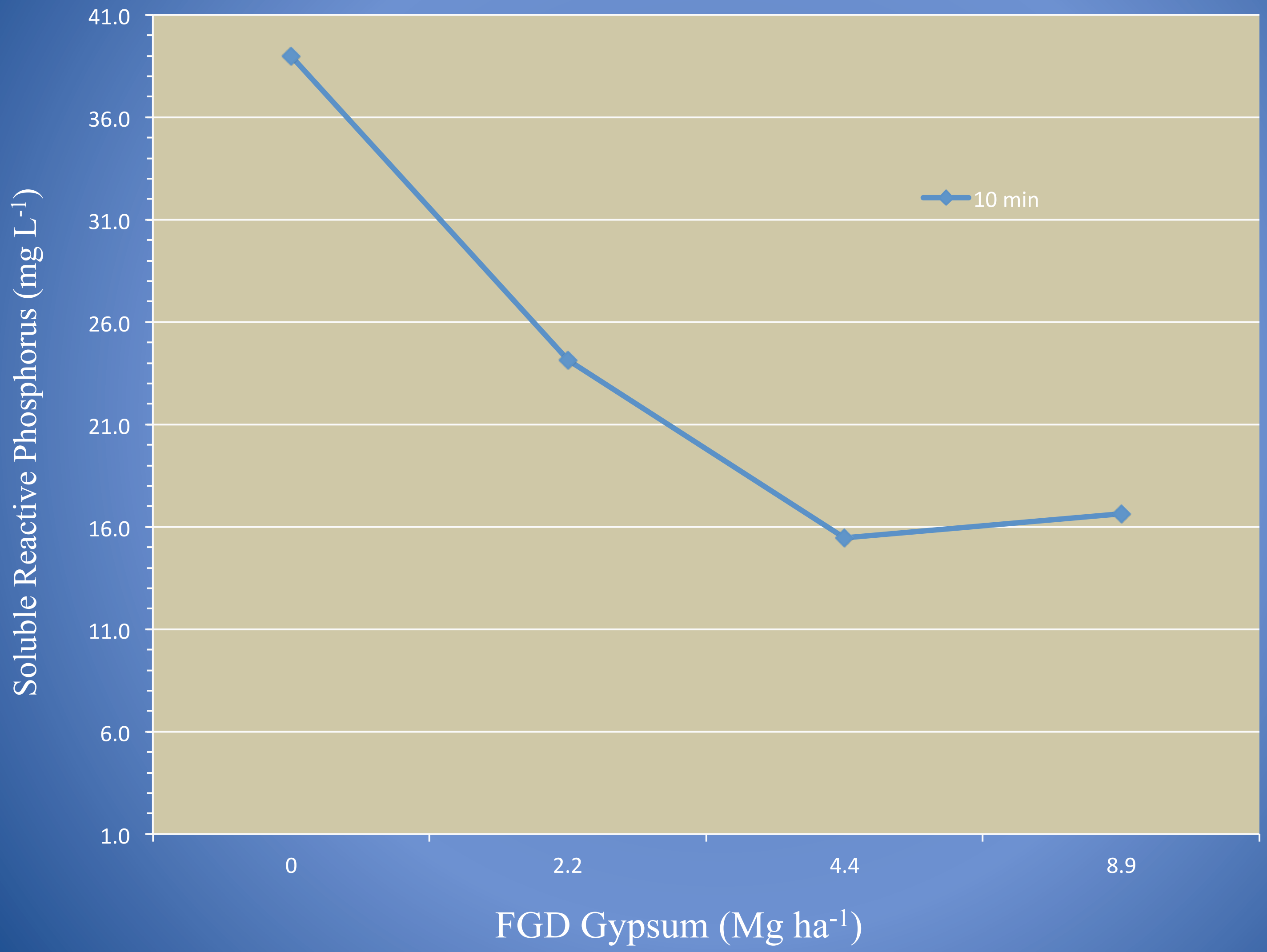
Soluble P



Watkinsville 2012

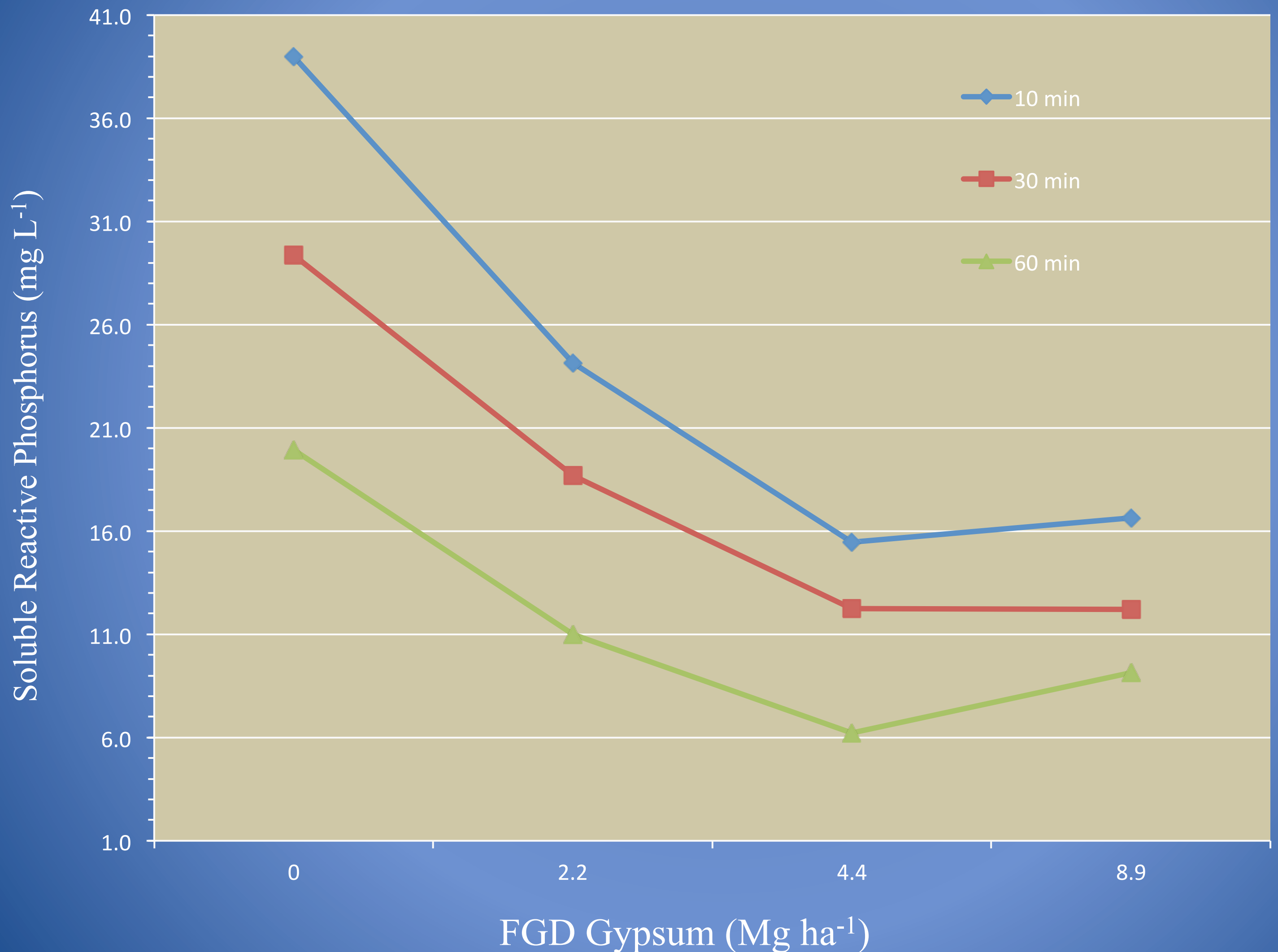
Initial Runoff

Worst Case



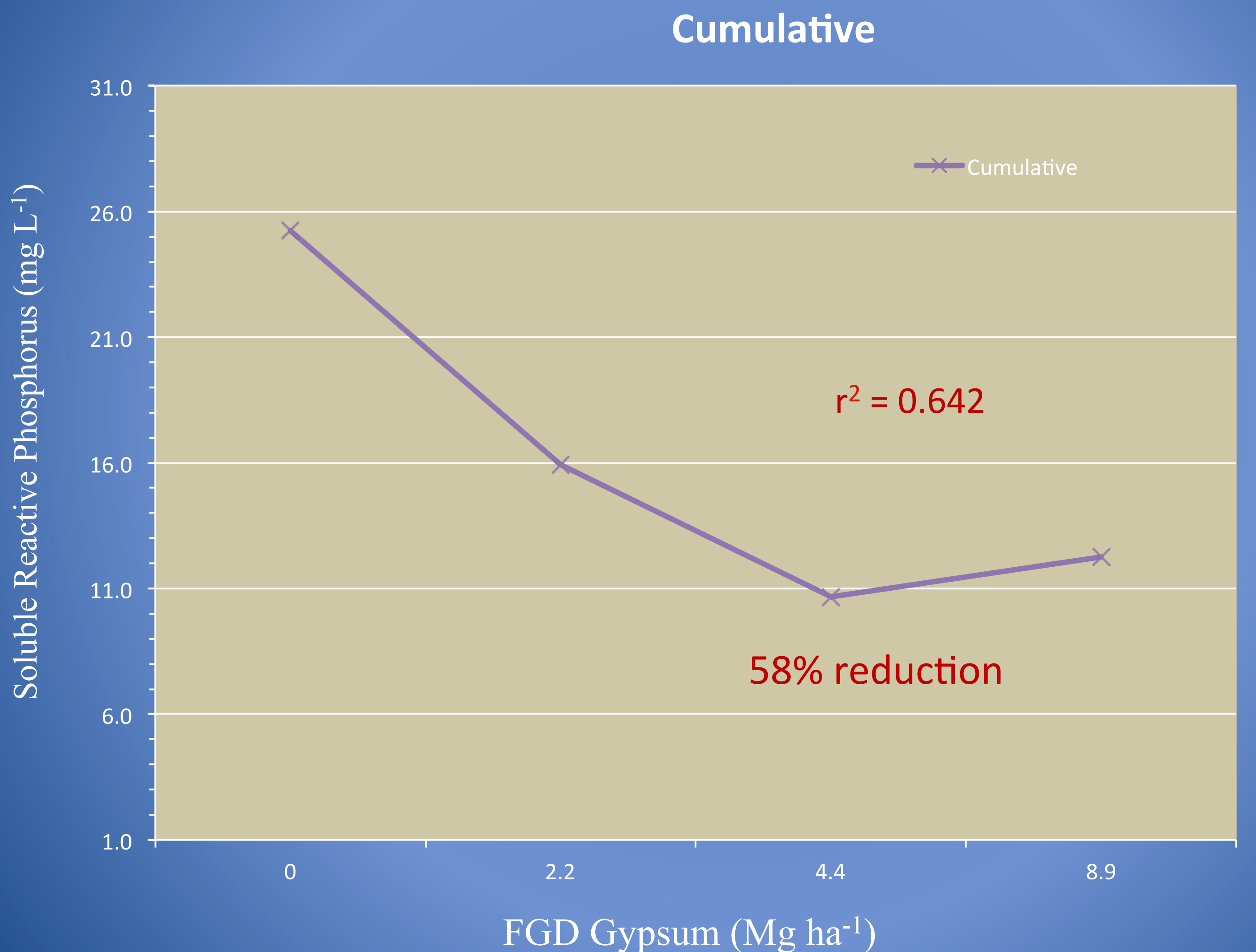
Initial Runoff

Worst Case



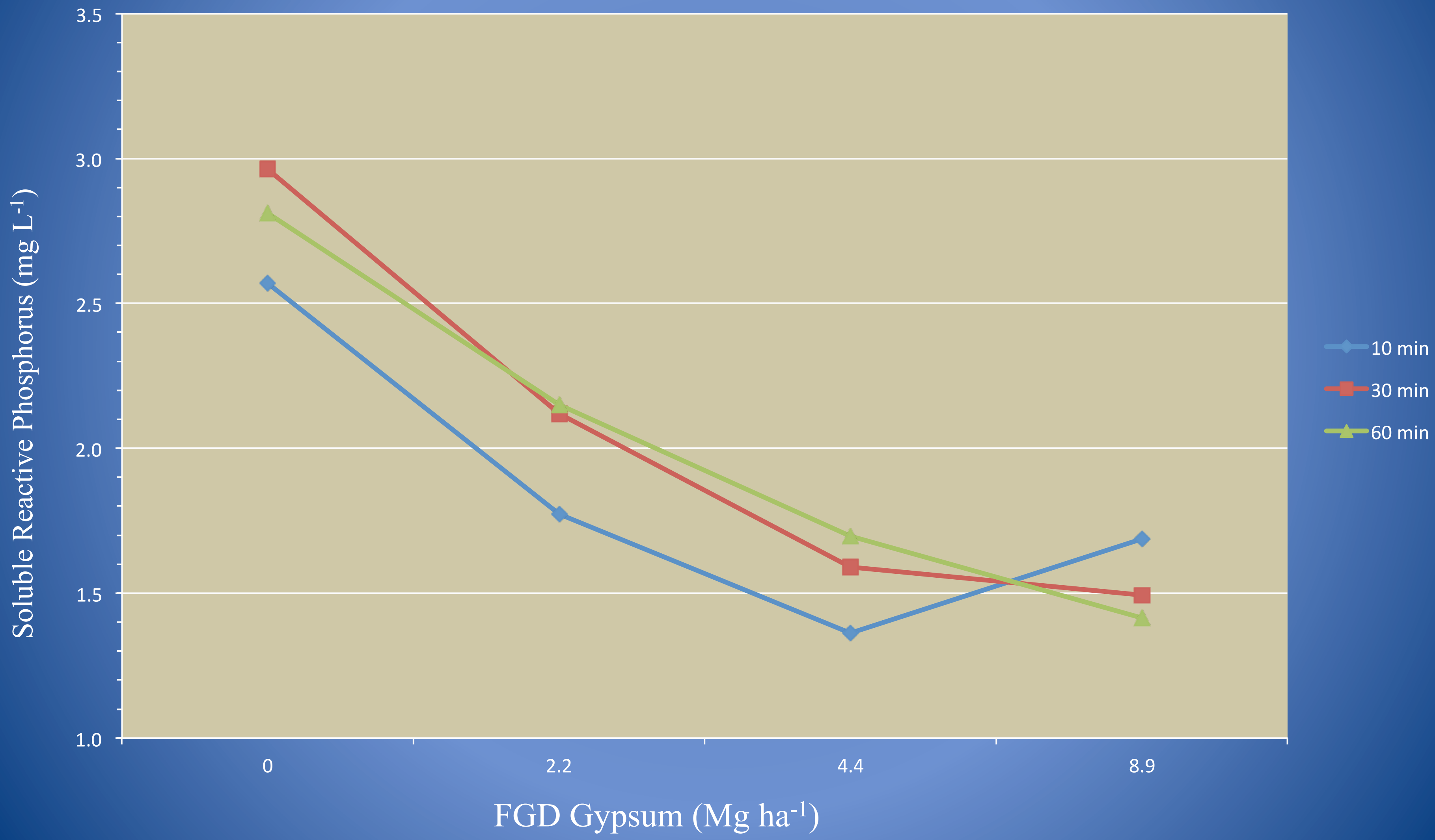
Initial Runoff

Worst Case



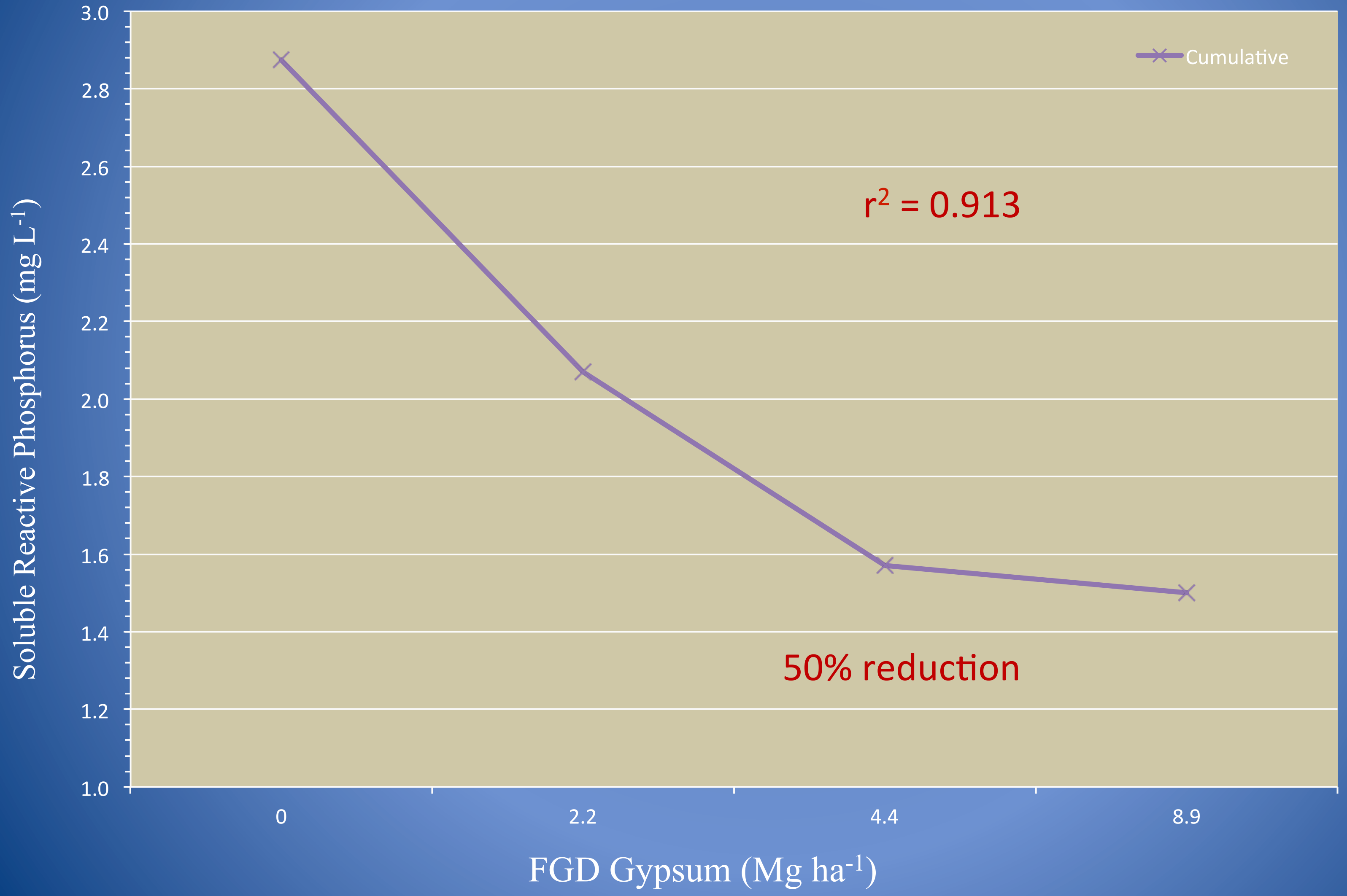
Six Weeks Runoff

After 5 inches

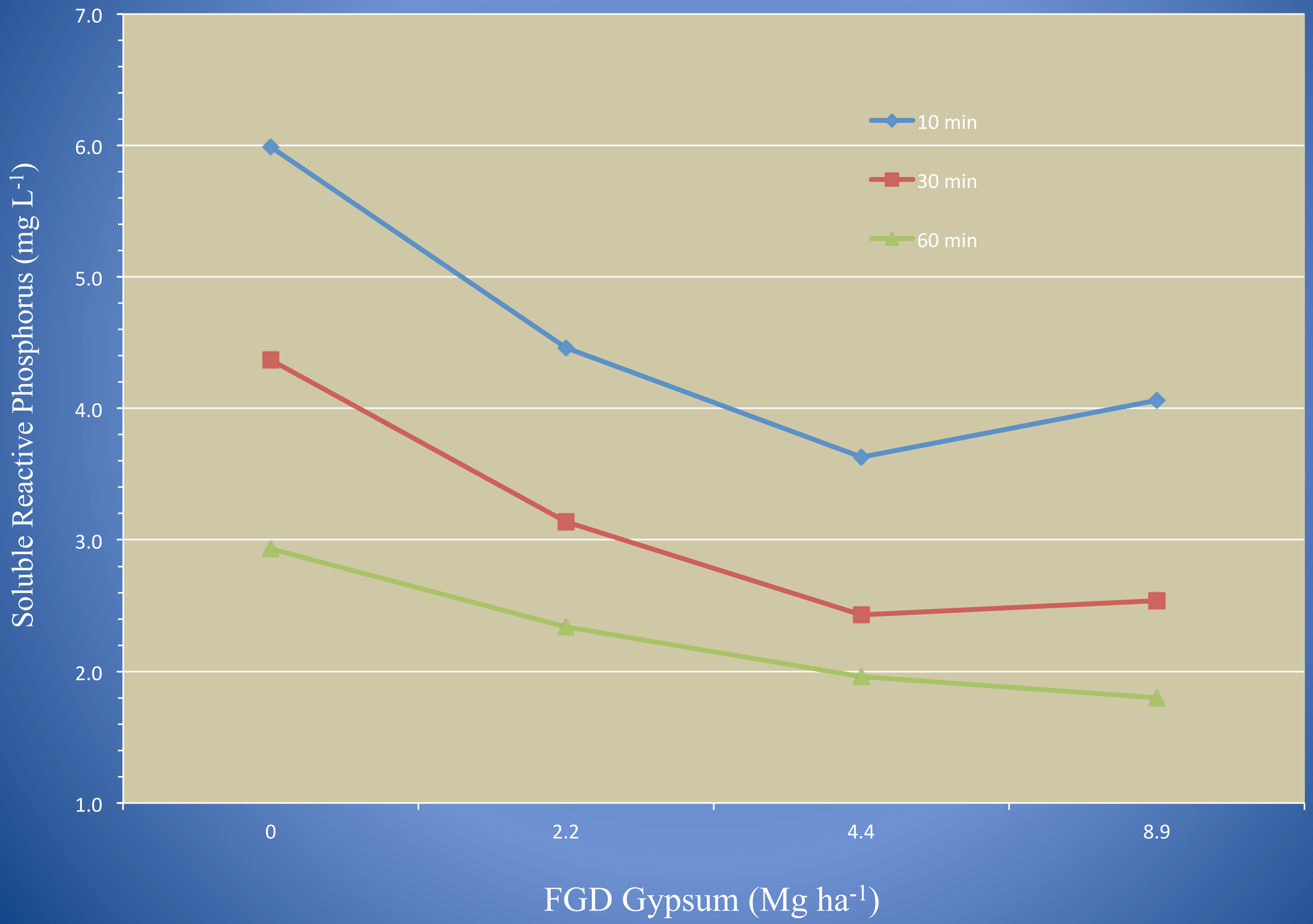


Six Weeks Runoff

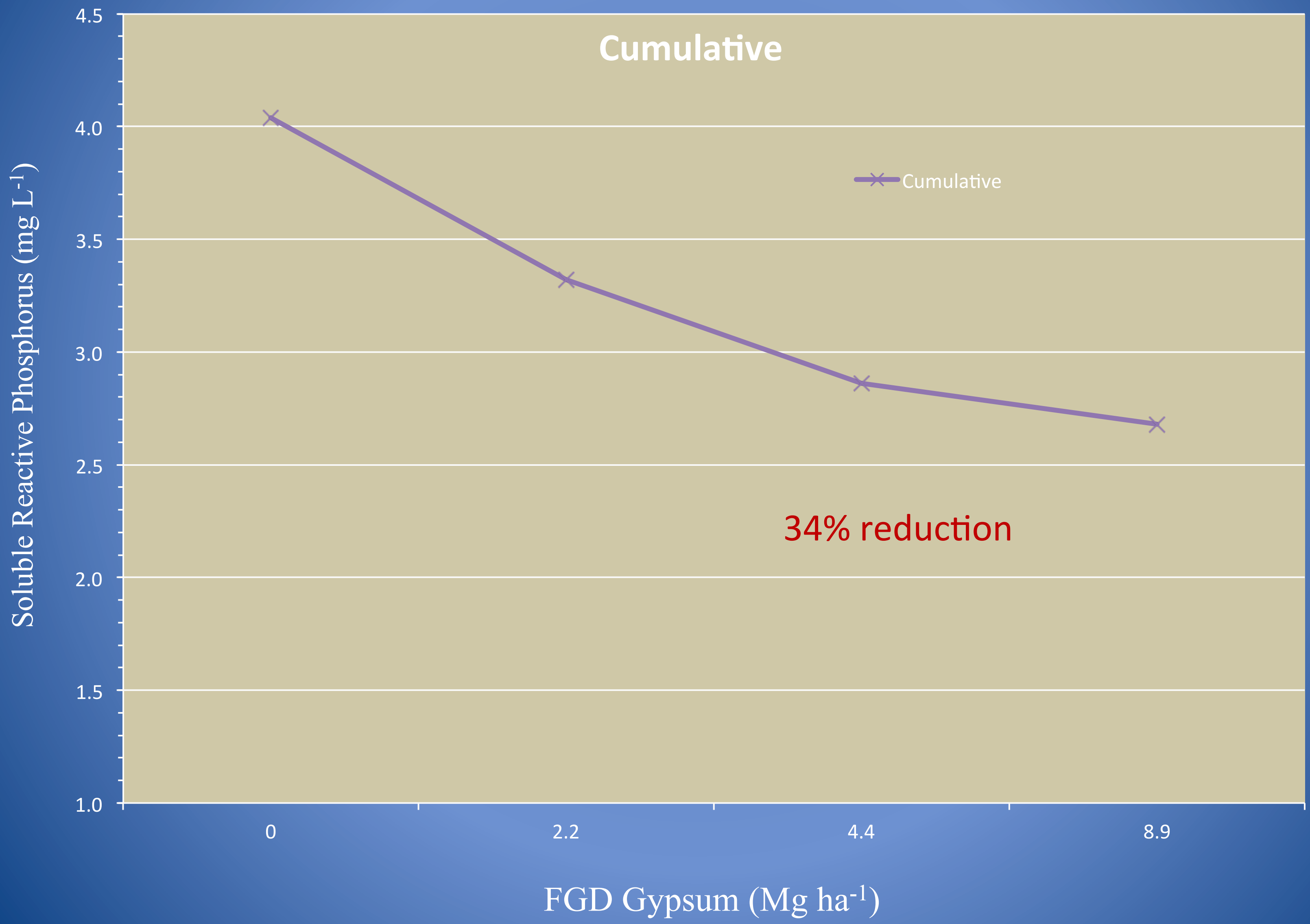
After 5 inches



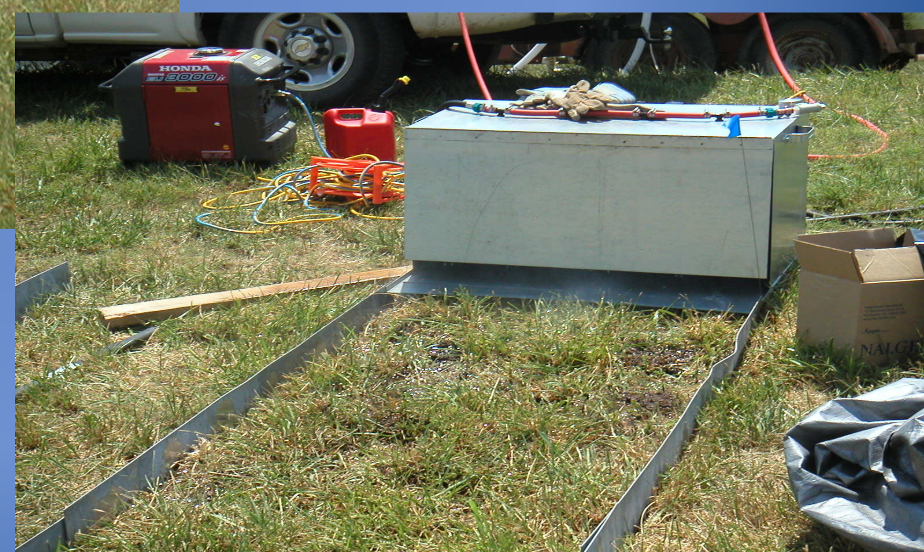
End of Season Runoff



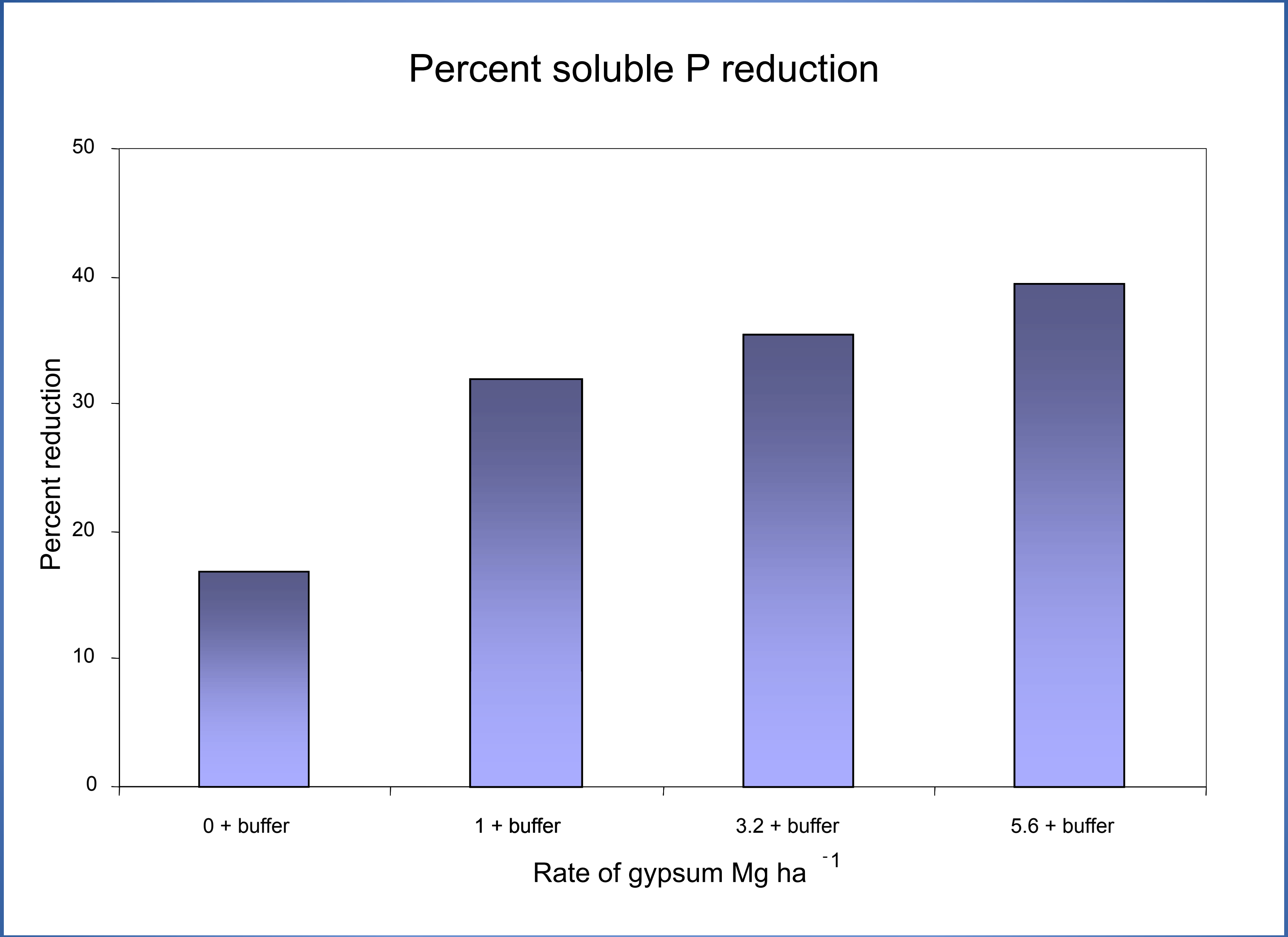
End of Season Runoff



Gypsum Run-over



Watts D.B., and H. A. Torbert. 2009. Impact of Gypsum Applied to Buffer Strips on Reducing Soluble P in Surface Water Runoff. J. Environ. Qual. 38:


Percent soluble P reduction
Percent reduction
50
40
30
20
10
0
0 + buffer
1 + buffer
3.2 + buffer
5.6 + buffer
Rate of gypsum Mg ha -1

Risk Assessment Activities in 214 CRIS

Rufus Chaney

With support from US-EPA, will analyze FGD-gypsum, poultry litter, amended soils, crops, and water/solids from runoff tests in GA and AL fields.

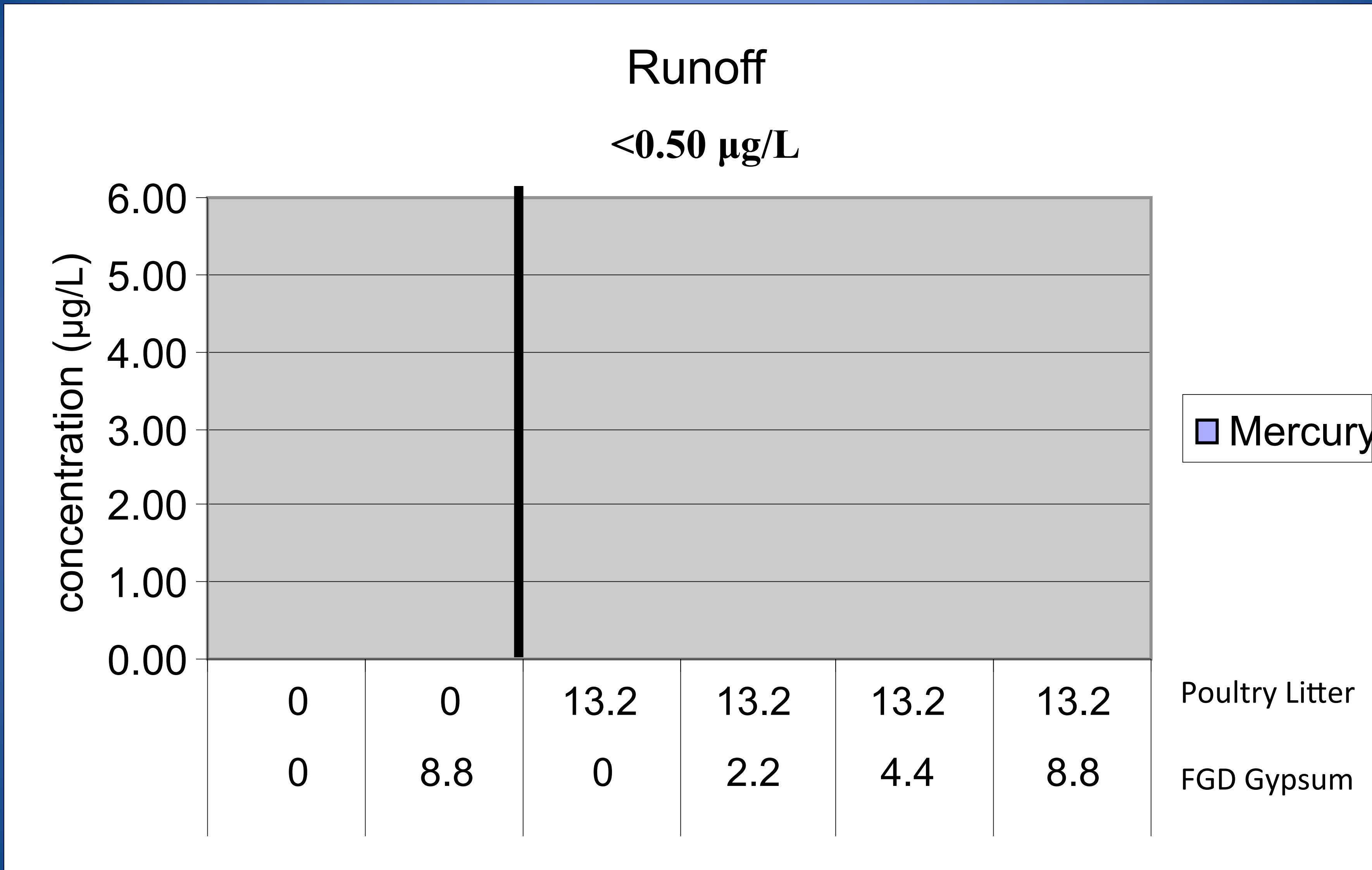
Cooperate with US-EPA, EPRI, and researchers to conduct risk assessment for contaminants in land applied FGD-Gypsum

Key issues include As, Hg, (Se).

- Assess all pathways for exposure
- Farm and garden crops
- Livestock exposure.
- Leaching and runoff from amended fields

Old vs. New FDG-Gypsum

- Old FGD-Byproduct contained fly ash element residues, such that B, As, Se, etc. were a source of concern depending on the coal source.
  - Used at limestone rate for alfalfa, FGDB supplied B, Ca, alkalinity and Se that served as fertilizers without causing excessive transfer of toxics to crops.
- New FGD-Gypsum manufactured post fly ash removal contains low levels of all trace elements.
  - Difficult to find potential adverse effects of constituents of present high quality FGD-Gypsum.



Runoff
<0.50 µg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
concentration (µg/L)
Mercury
0
0
0
8.8
13.2
0
13.2
2.2
13.2
4.4
13.2
8.8
Poultry Litter
FGD Gypsum

Not Detected

- Arsenic
- Aluminum
- Antimony
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Lead
- Nickel
- Selenium
- Silver
- Thallium
- Vanadium
- Hexavalent Chromium

≈ <50 µg/L

Not Detected

- Dissolved Arsenic
- Dissolved Aluminum
- Dissolved Antimony
- Dissolved Barium
- Dissolved Beryllium
- Dissolved Cadmium
- Dissolved Chromium
- Dissolved Cobalt
- Dissolved Copper
- Dissolved Lead
- Dissolved Potassium
- Dissolved Selenium
- Dissolved Silver
- Dissolved Sodium
- Dissolved Thallium
- Dissolved Vanadium
- Dissolved Zinc
- Kitchen Sink

≈ <50 µg/L

Conclusion

- Gypsum can improve soil physical properties
- Improve aggregation
- Increase Water Infiltration
- Reduce runoff
- Improve water holding capacity
- Reduce erosion losses and nutrient losses

Conclusion

- Gypsum should be considered as a Best Management Practice for reducing Soluble P losses.