

Measuring the Impact of Nitrogen Management on Groundwater Quality in Sandy Soils

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WPVGA



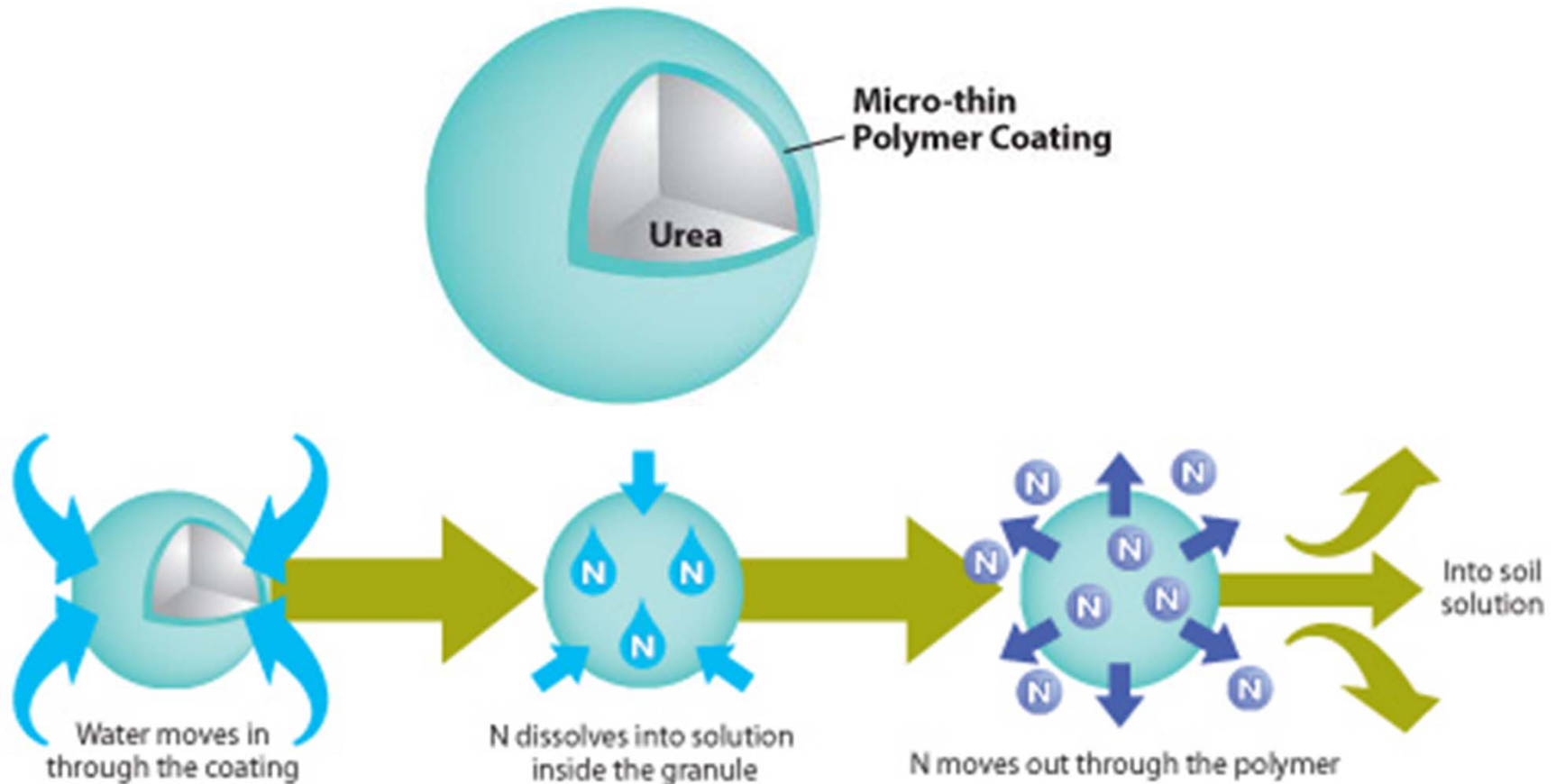
Wisconsin Groundwater
Coordinating Council
(GCC)



The Issues

- Alternative management methods
 - Controlled-Release Fertilizer as a polymer coated urea (PCU)

Environmentally Smart Nitrogen (ESN[®])

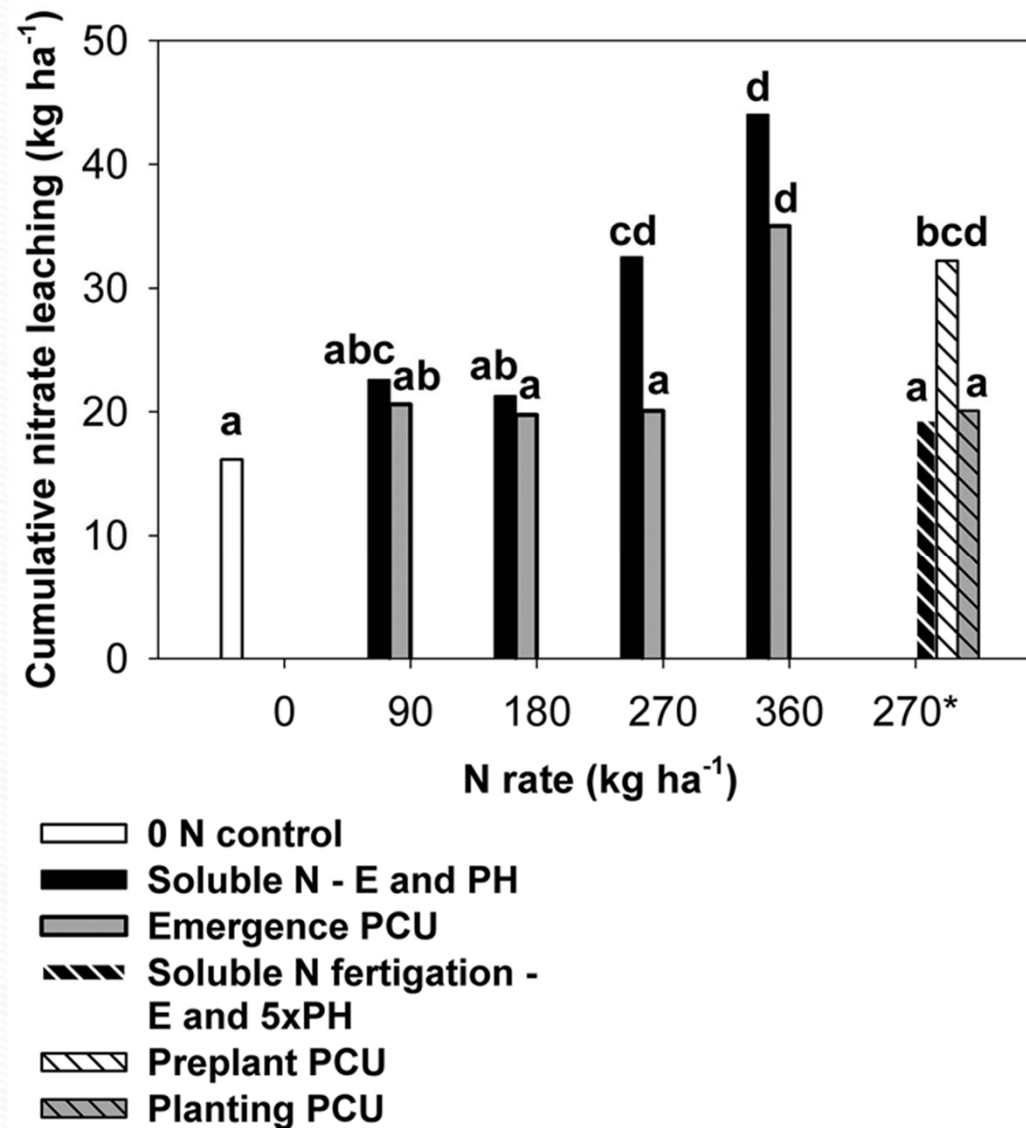


Mitigating N

- PCU has the potential to reduce the amount of N reaching the groundwater
 - Increase Nitrogen Use Efficiency
 - Increased yields with equivalent rate of application
 - Equal yields with reduced rates
 - Limit available N to leach from the root zone to groundwater
 - On sandy soil use of PCU has shown promise



Mitigating N



Graph from Wilson, Melissa L., Carl J. Rosen, and John F. Moncrief. "Effects of Polymer-coated Urea on Nitrate Leaching and Nitrogen Uptake by Potato." *Journal of Environmental Quality* 39.2 (2010): 492-99. Print.

Mitigating N

- PCU studies have focused on N leaching directly below the root zone
 - Amount of N reaching the groundwater has only been inferred from root zone data
- Few, if any studies have been conducted directly measuring groundwater N concentrations under controlled-release fertilizer at large plot sizes in this area

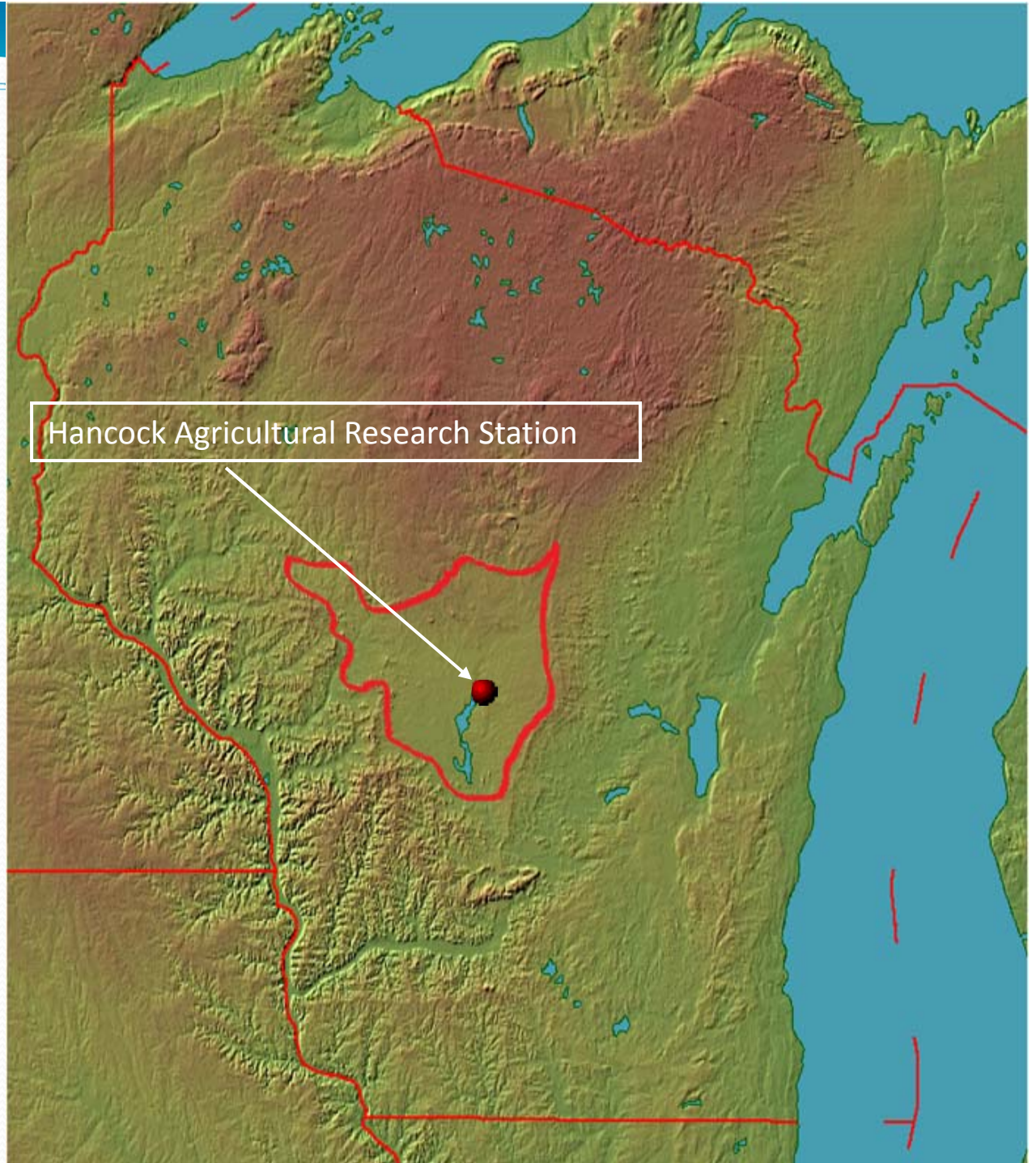


Experimental Design

- Experimental design
- Bromide-chloride tracer study
- Water quality results
- Conclusions



- Hancock, WI
 - Central Sands
- Potato as a model crop
 - High N demand
 - Difficult to manage

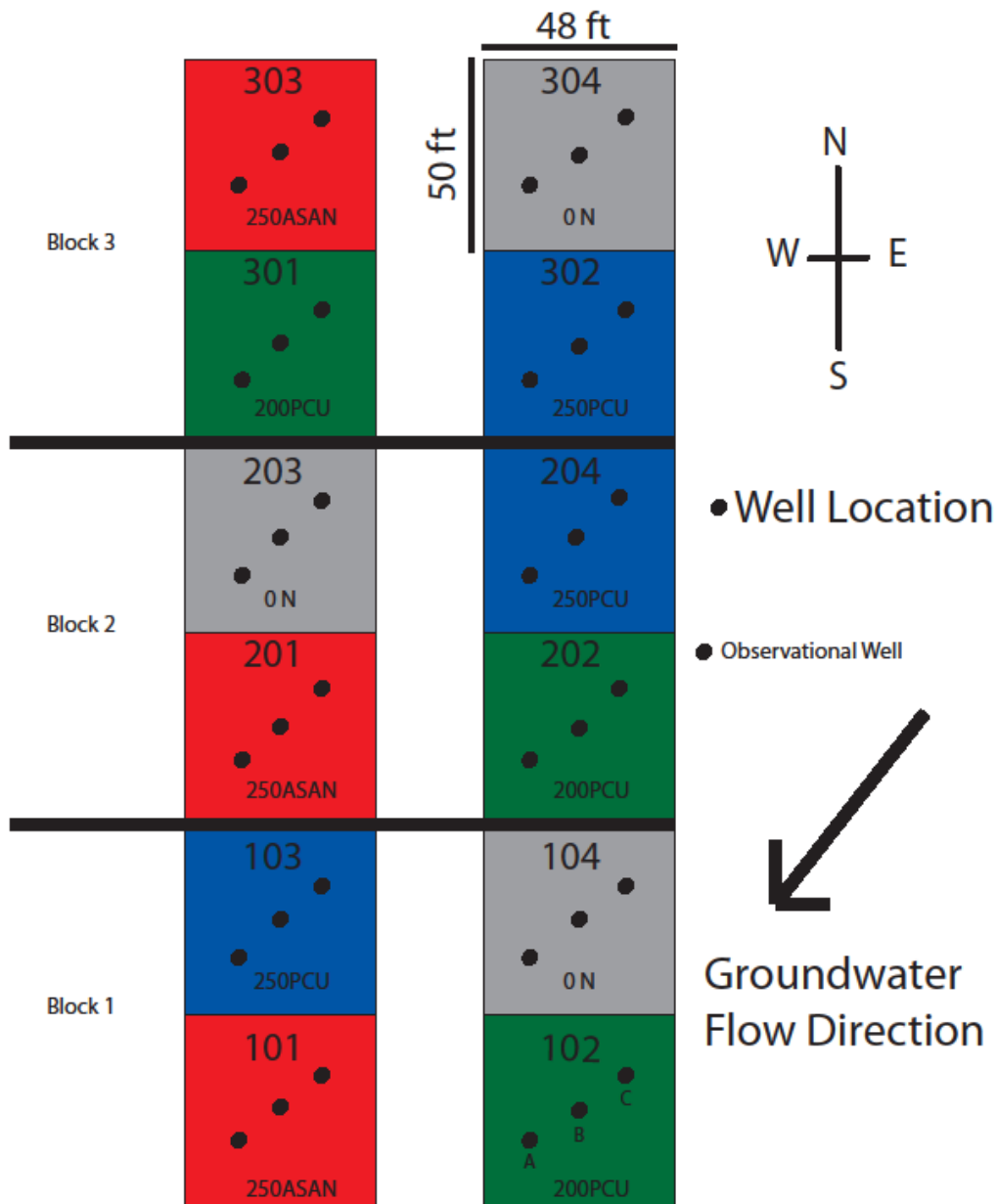


Experimental Design

Treatment Code	Treatment	N applied at emergence (~20-25 DAP)	N applied at tuber initiation (~35-45 DAP)
250ASAN	250 lbs ac⁻¹ AS-AN	83 lbs ac⁻¹ as ammonium sulfate	167 lbs ac⁻¹ as ammonium nitrate
250PCU	250 lbs ac⁻¹ PCU	250 lbs ac⁻¹ as ESN[®]	None
200PCU	200 lbs ac⁻¹ PCU	200 lbs ac⁻¹ as ESN[®]	None
0 N	0 N	None	None

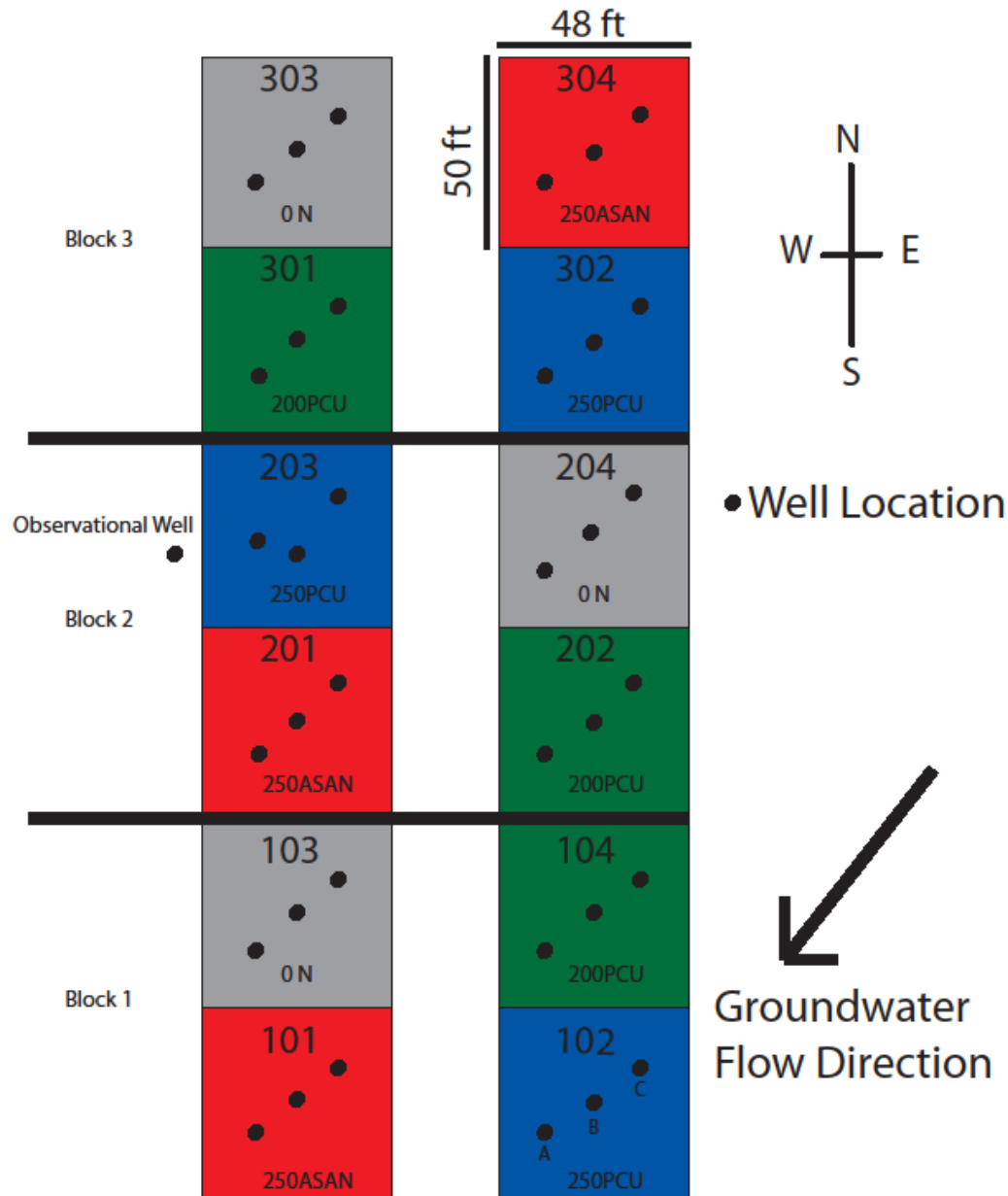
- (All plots received 30 lbs N ac⁻¹ as starter fertilizer)
- DAP – Day after planting
- Plant Date was 29 April 2010 and 25 April 2011

Experimental Design



- 4 fertilizer rates
 - 250ASAN (red)
 - 250PCU (blue)
 - 200PCU (green)
 - 0 N control (gray)
- Wells
 - Drilled to 32 ft
 - 4 ft screens (2010)
 - Water table at 22 ft

Experimental Design



- 4 fertilizer rates
 - 250ASAN (red)
 - 250PCU (blue)
 - 200PCU (green)
 - 0 N control (gray)
- Wells
 - Drilled to 30 ft
 - 7.5 ft screens (2011)
 - Water table at 24 ft

Experimental Design

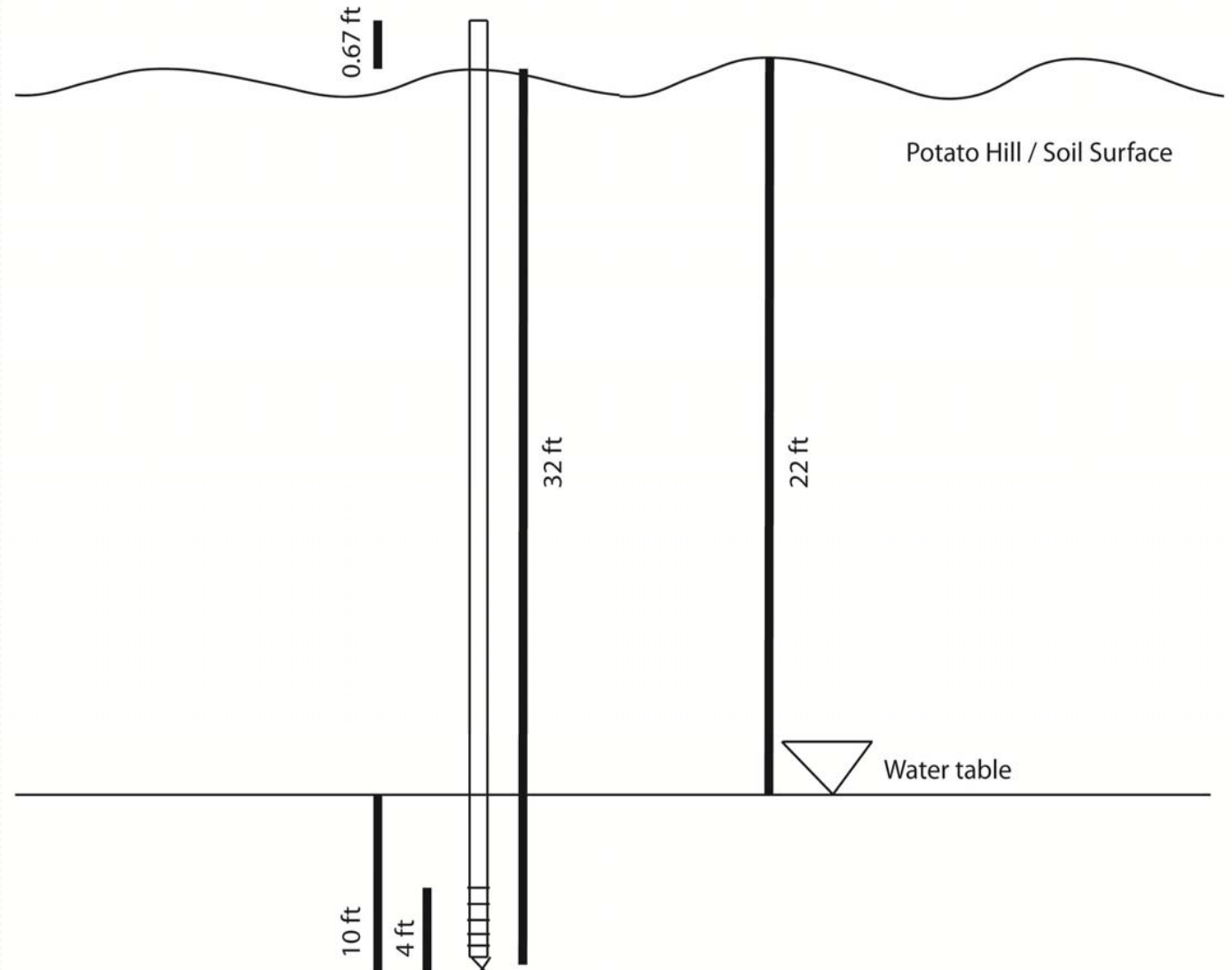
- 2010-2011 well side view diagram

Growing season
29 April – 30 August

- 540 mm precipitation
- 213 mm irrigation
- 19.4 °C

30 year averages

- 435 mm precipitation
- 17.5 °C



Experimental Design

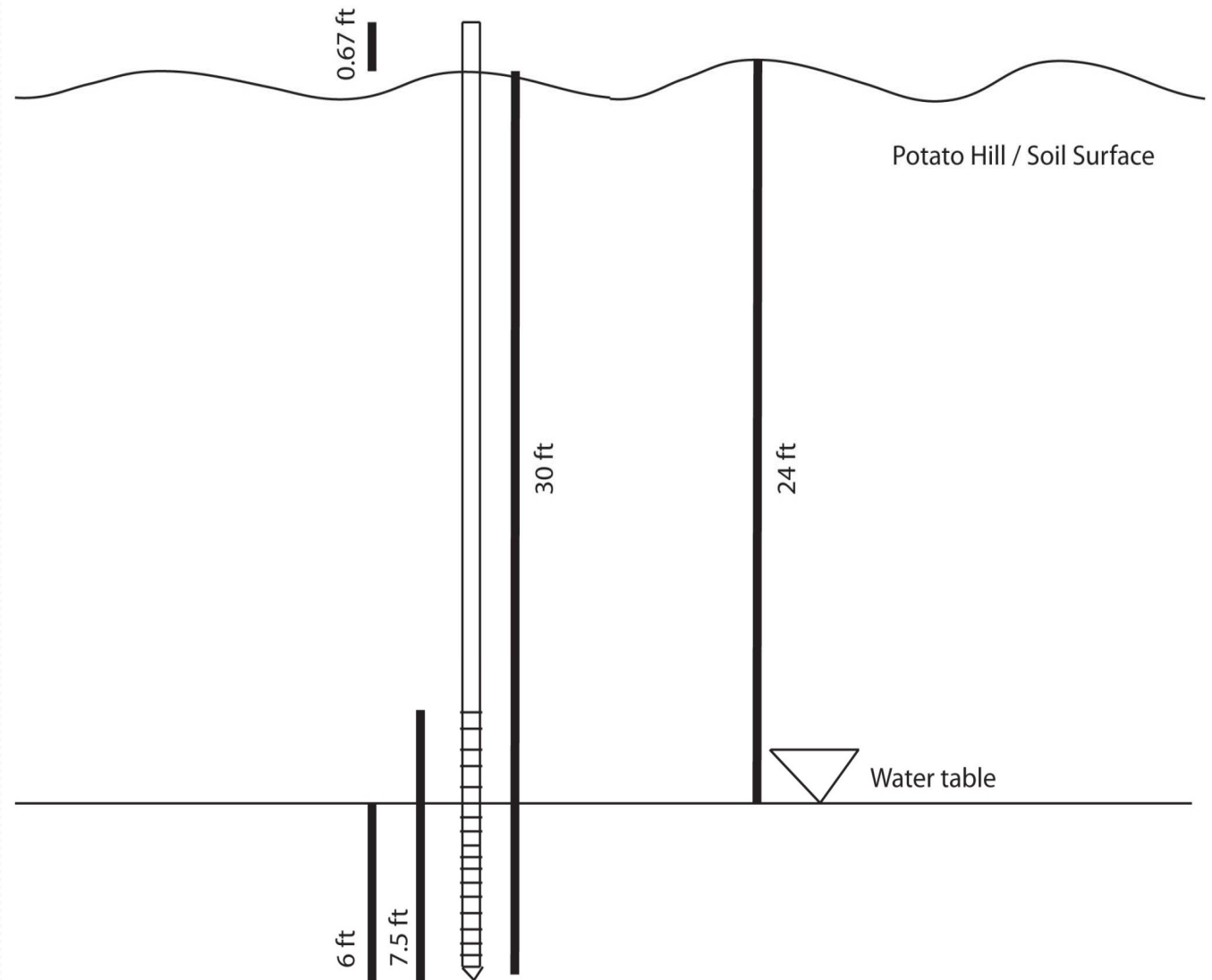
- 2011-2012 well side view diagram

Growing season
25 April – 12 September

- 217 mm precipitation
- 283 mm irrigation
- 18.2 °C

30 year averages

- 435 mm precipitation
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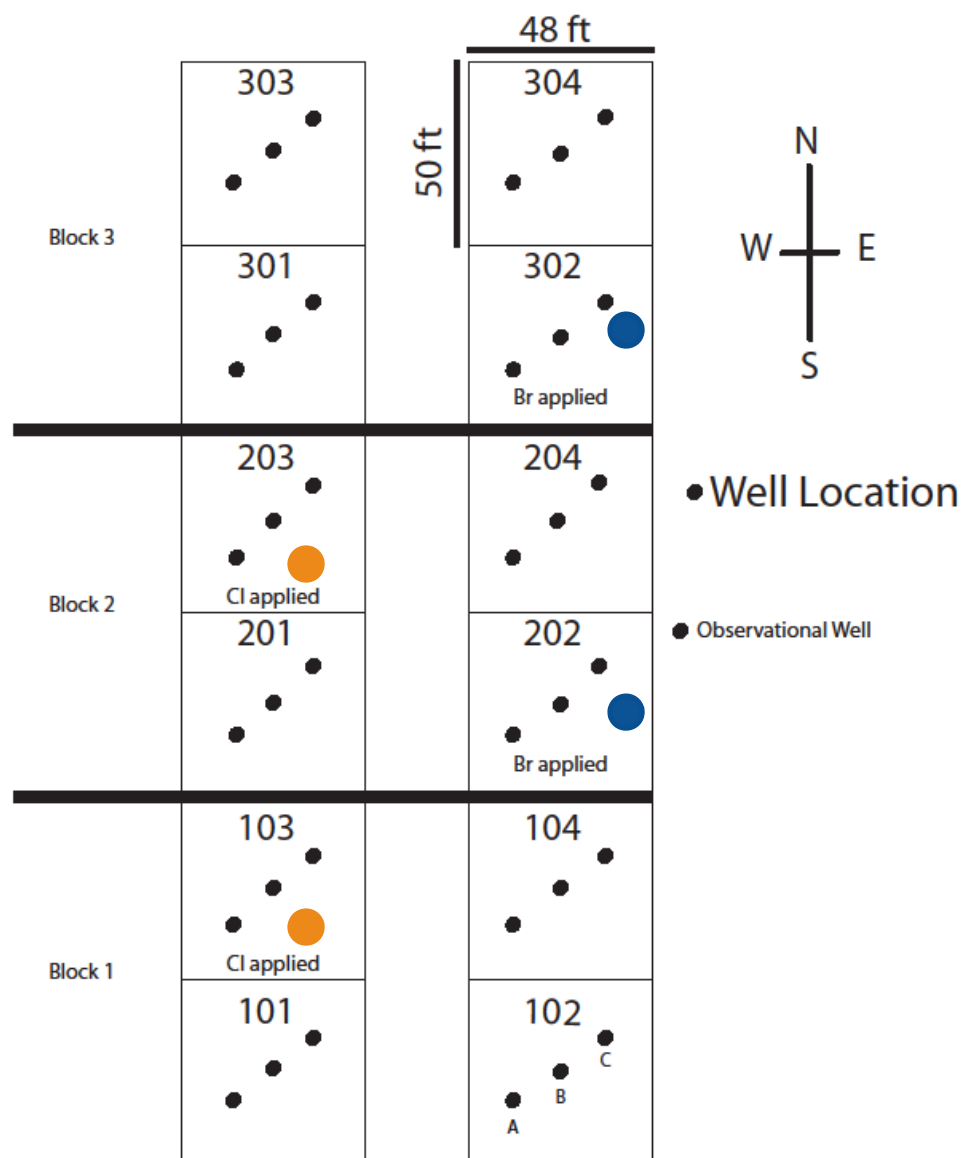


Bromide-Chloride tracer results

- Experimental design
- Bromide-chloride tracer study
- Water quality results
- Conclusions

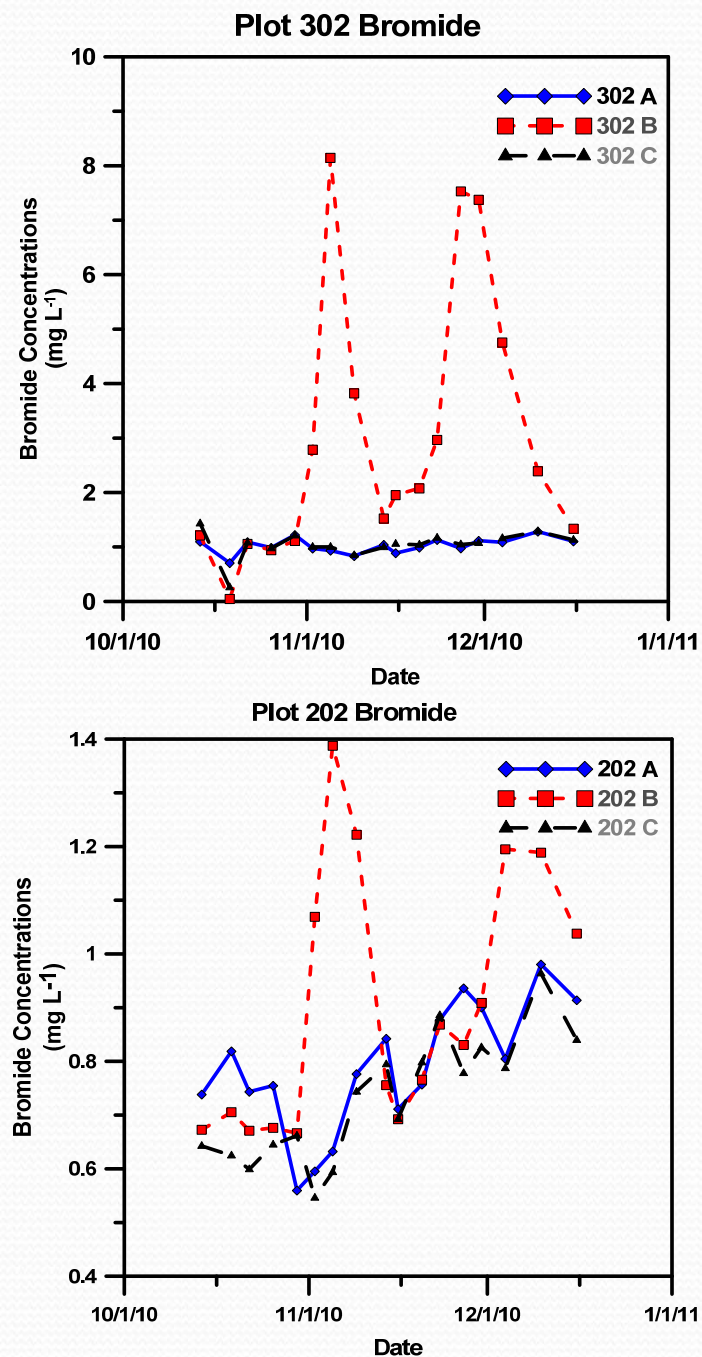
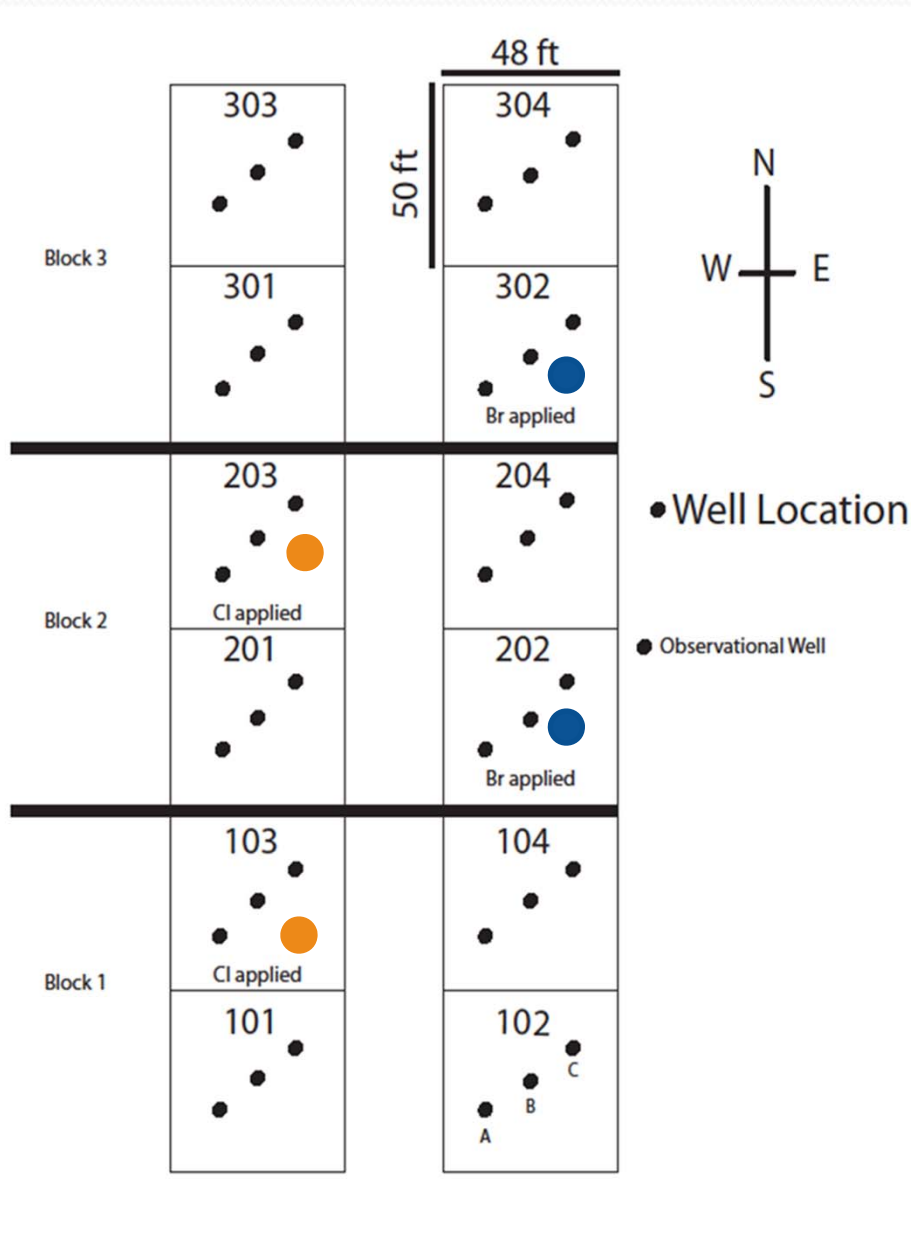


Bromide-Chloride tracer results

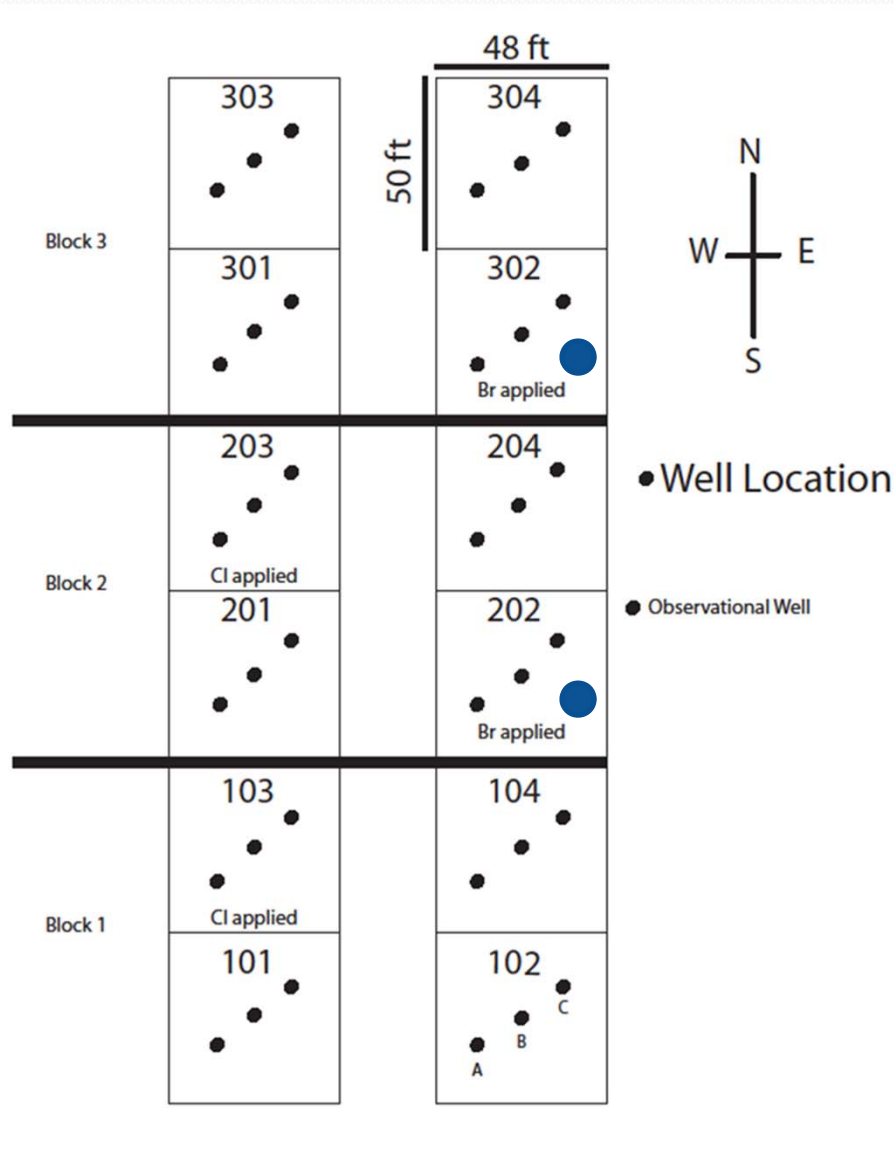


- Bromide and Chloride 2010
 - Moved center "B" well up to allow well screen to intersect water table
 - Tracers applied 14 Oct 2010
 - Irrigation provided water for leaching

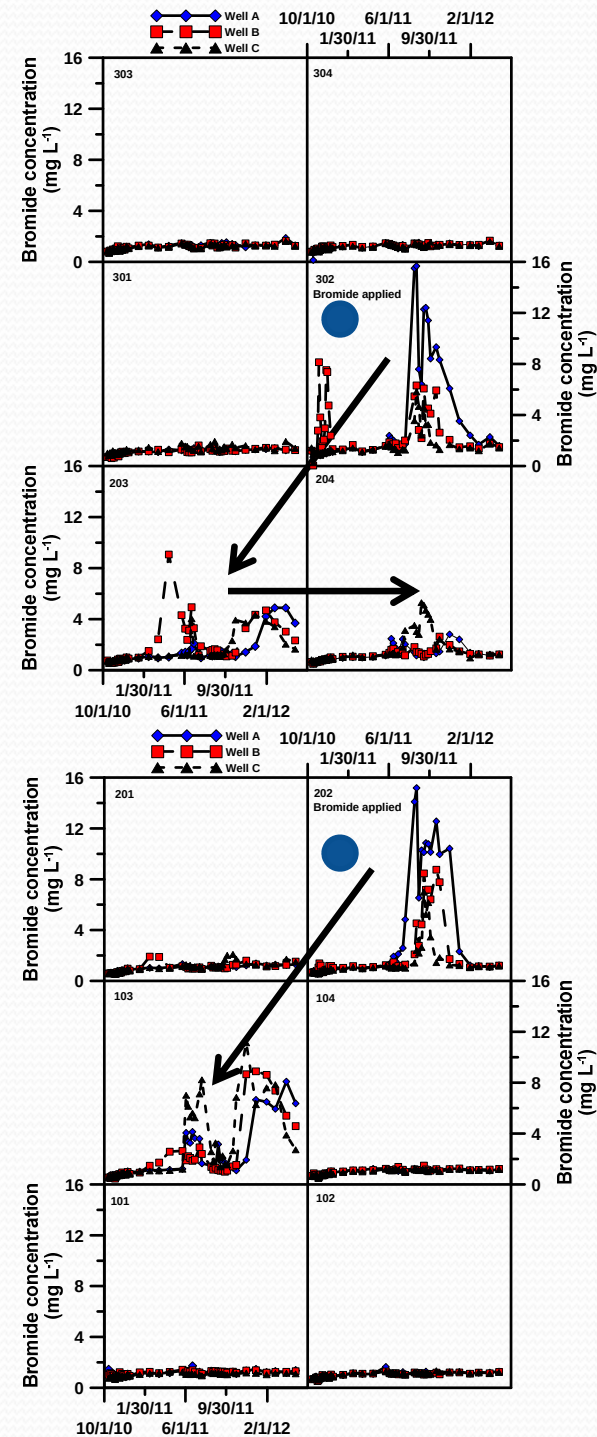
Bromide-Chloride tracer results--Bromide



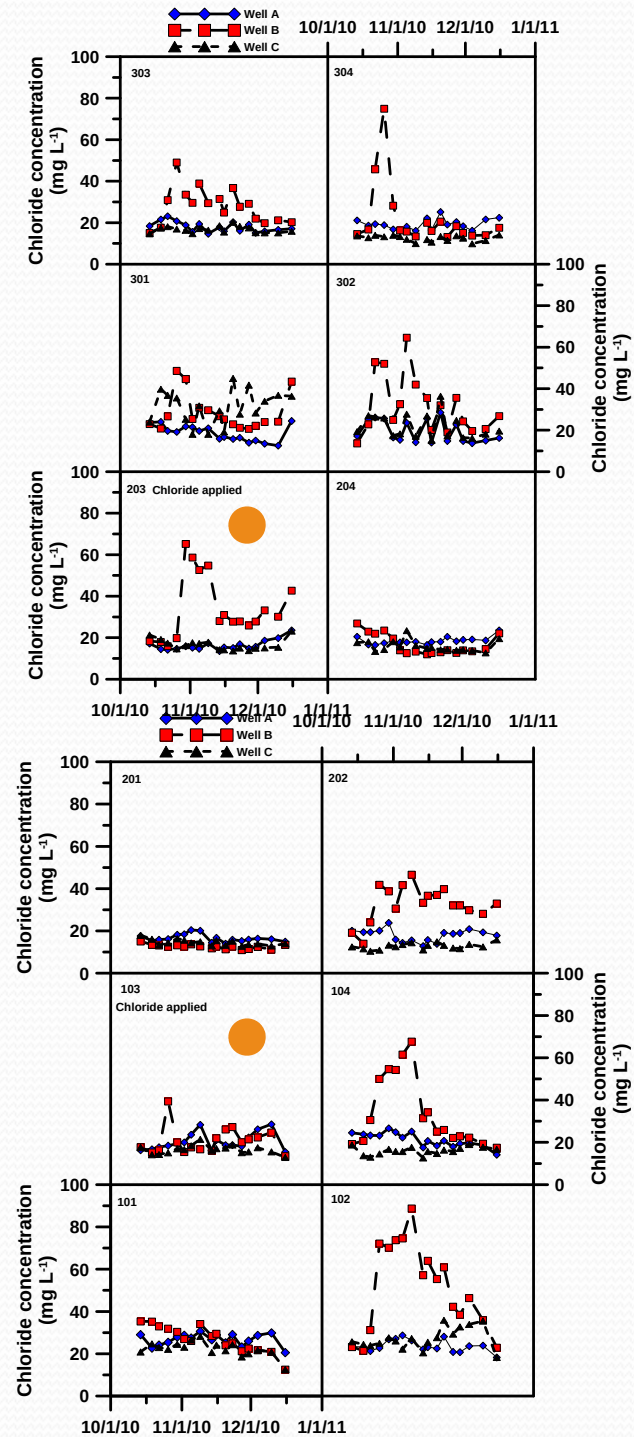
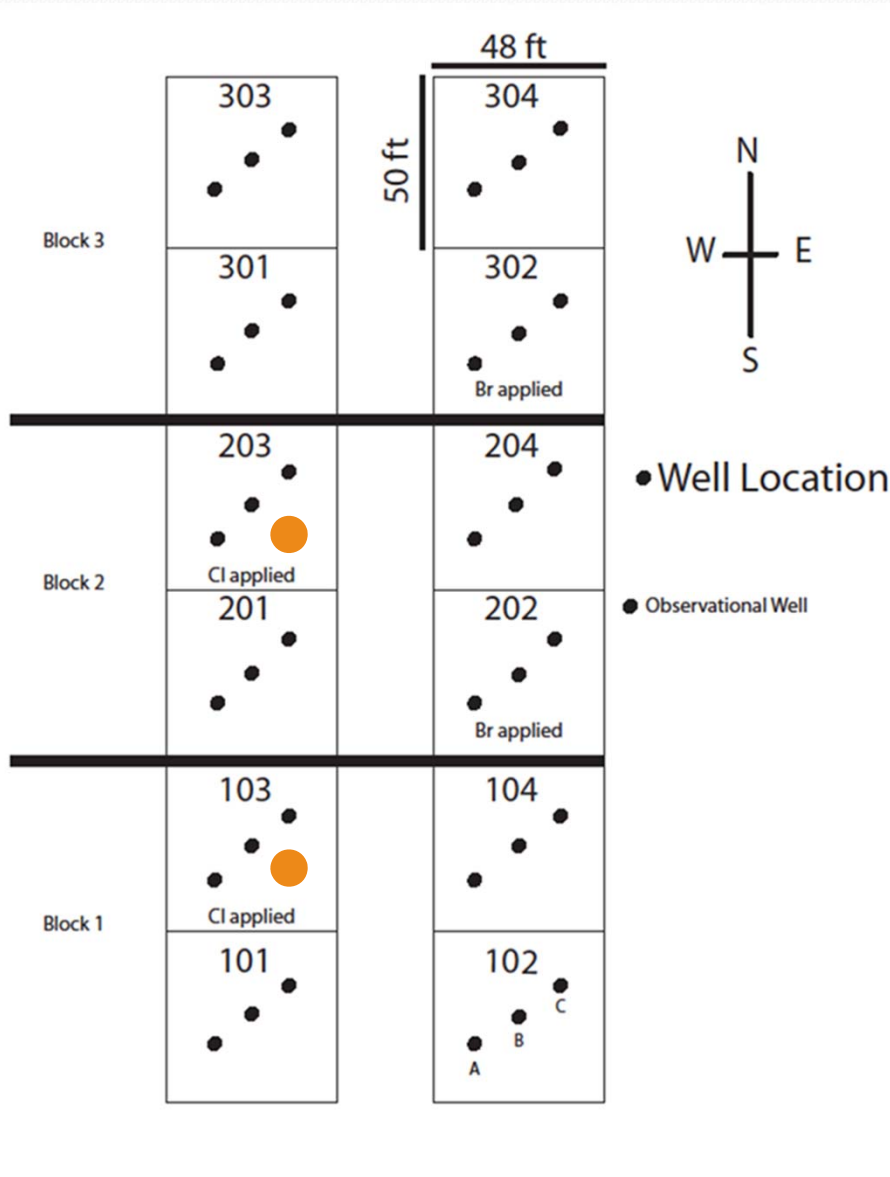
Bromide-Chloride tracer results--Bromide



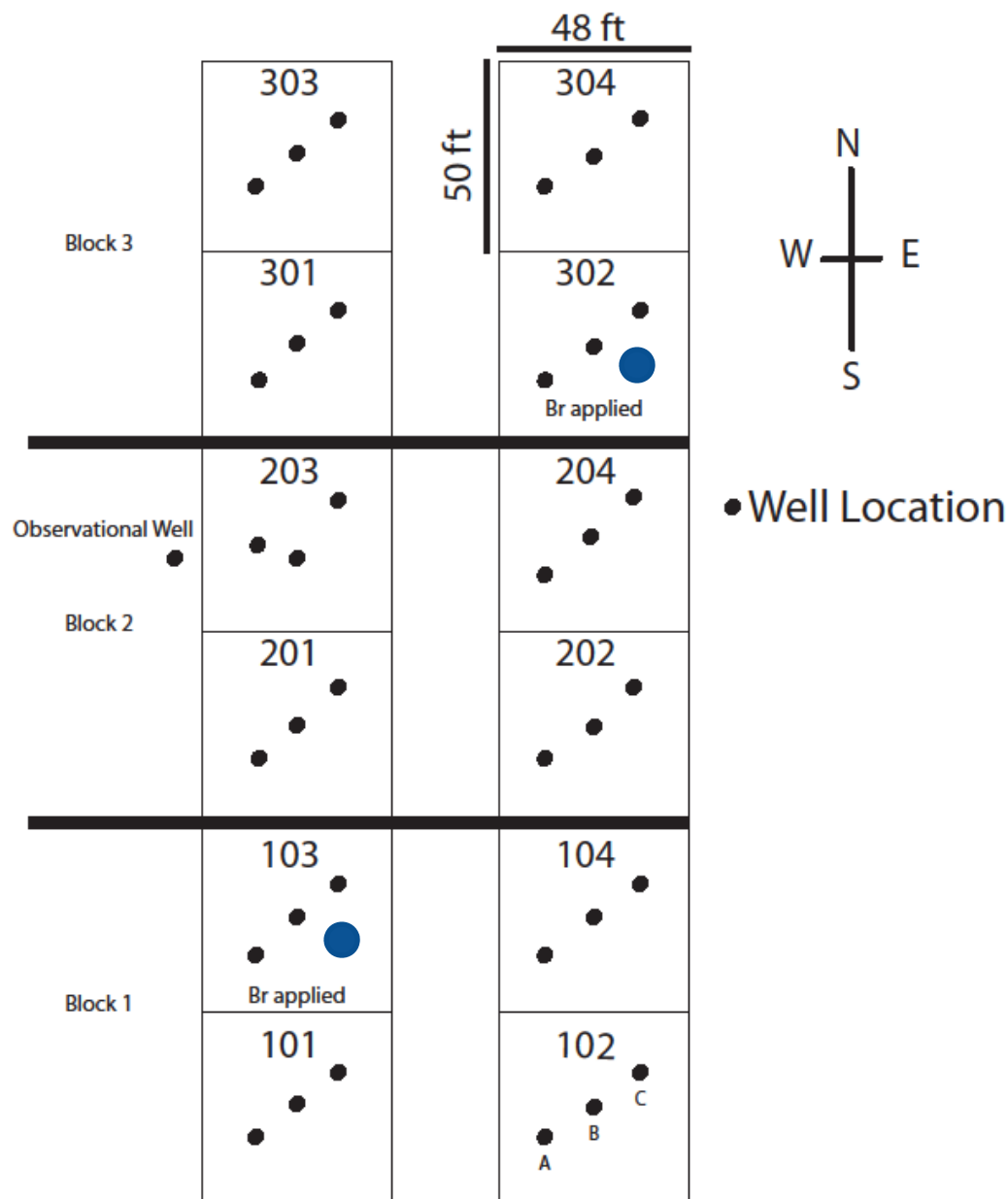
(All wells raised on 23 May 2011)



Bromide-Chloride tracer results--Chloride



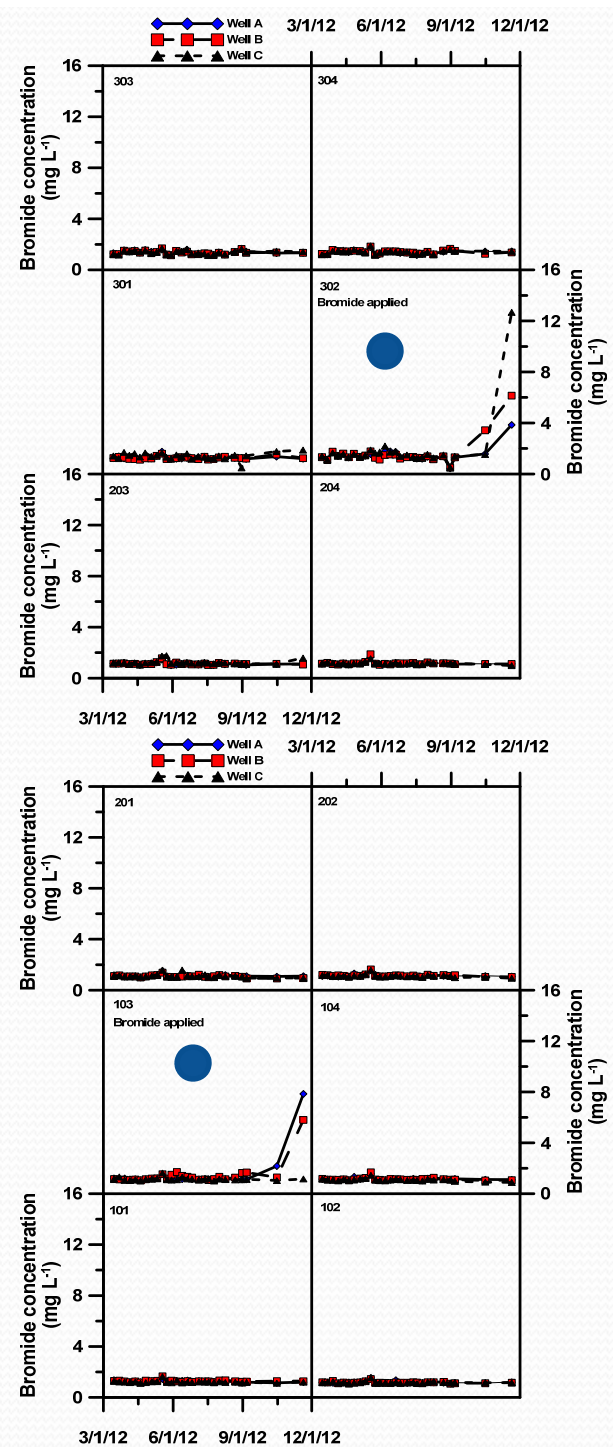
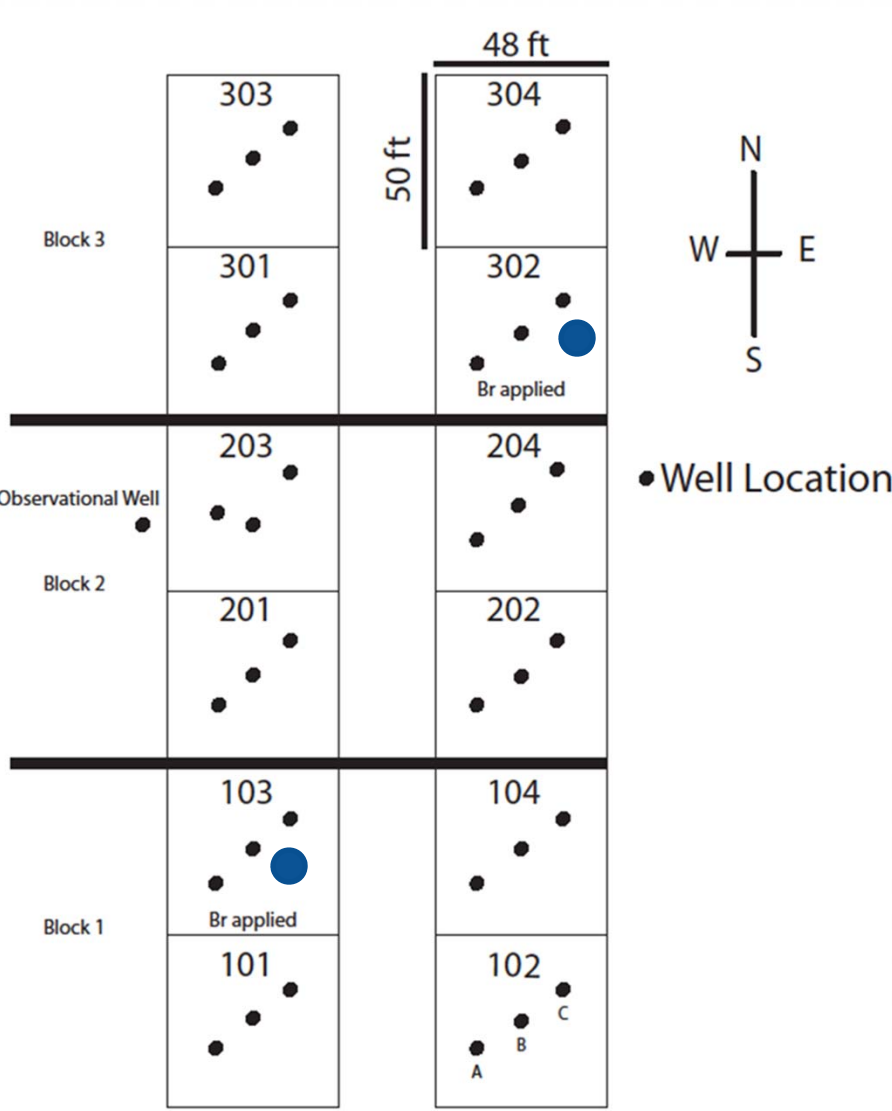
Bromide-Chloride tracer results



Bromide 2012

- All wells intersected the water table at all times during tracer study
- Bromide applied 9 March 2012
- Rainfall and crop irrigation as water source

Bromide-Chloride tracer results -- Bromide



Conclusions – Tracer study

- Bromide shows initial downward movement of solute in this area is within the 48 ft × 50 ft plot.
- While plot level monitoring wells are sufficient for initial N arrival, however plot to plot contamination will occur over time from groundwater flow
- Rainfall intensity has effect on lag time of solute leaching to the water table
- Chloride not an effective tracer in this area due to high and variable background concentrations



Water Quality Results

- Experimental design
- Bromide-chloride tracer study
- Water quality results
- Conclusions



Potato agronomic results

- Potato Yield

2010			2011	
Treatment	Marketable	Total	Marketable	Total
-----cwt ac ⁻¹ -----				
250ASAN	356 a	436 a	446 ab	487 a
250PCU	373 a	448 a	454 a	504 a
200PCU	350 a	427 a	465 a	504 a
0 N	193 b	276 b	368 b	434 a

- Harvest date was 30 August 2010 and 12 September 2011
- (C.V.)

Potato agronomic results

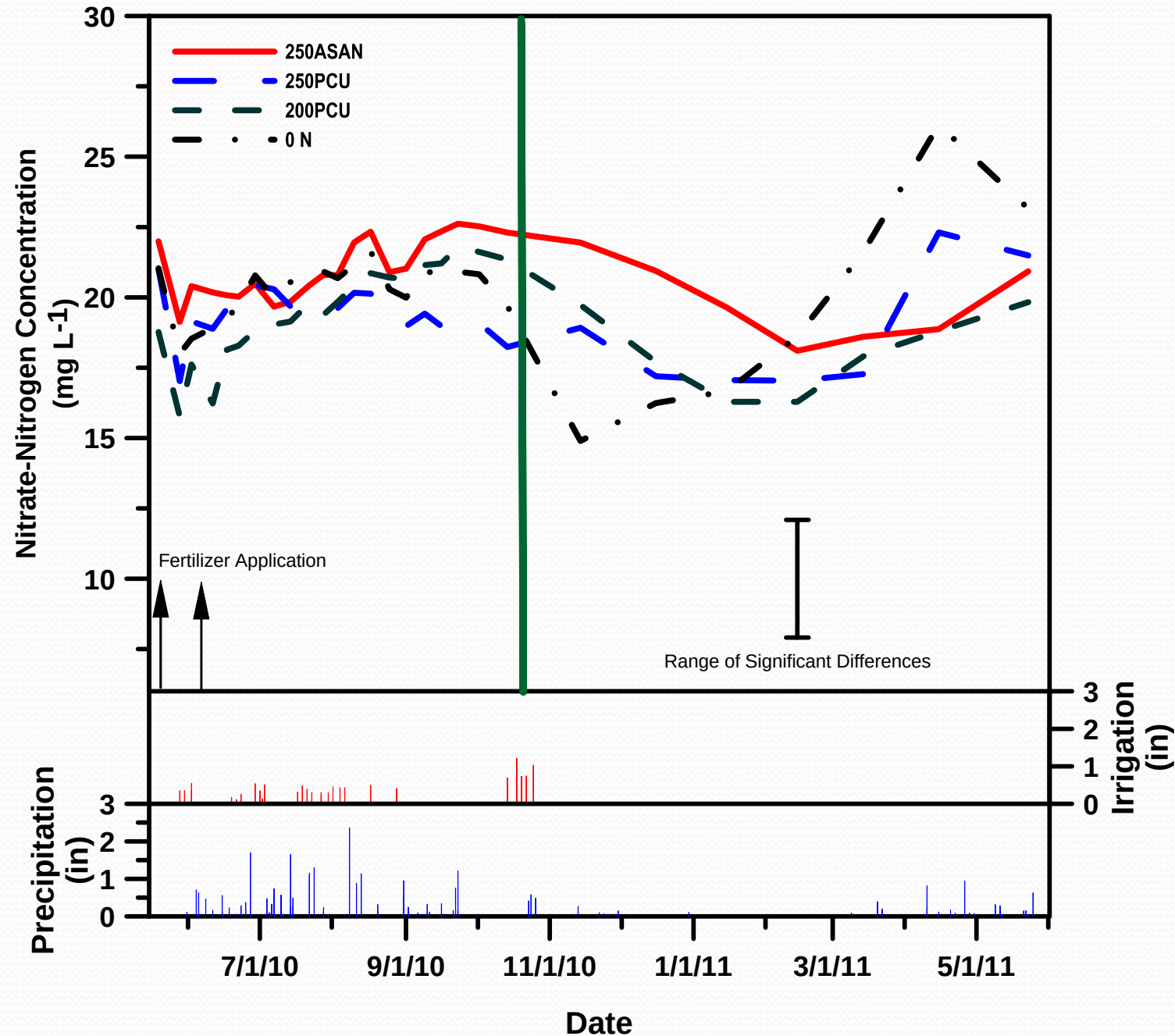
Year	Treatment	N applied (lbs ac ⁻¹)	Ave. N uptake (lbs ac ⁻¹)	Ave. System N (0 N uptake) (lbs ac ⁻¹)	Ave. N available to leach(lbs ac ⁻¹)
2010	250ASAN	250	145	56	161
	250PCU	250	129	56	177
	200PCU	200	134	56	122
2011	250ASAN	250	251	138	137
	250PCU	250	244	138	144
	200PCU	200	243	138	95

Water Quality Results

2010 Potato Groundwater Well NO₃-N Concentrations

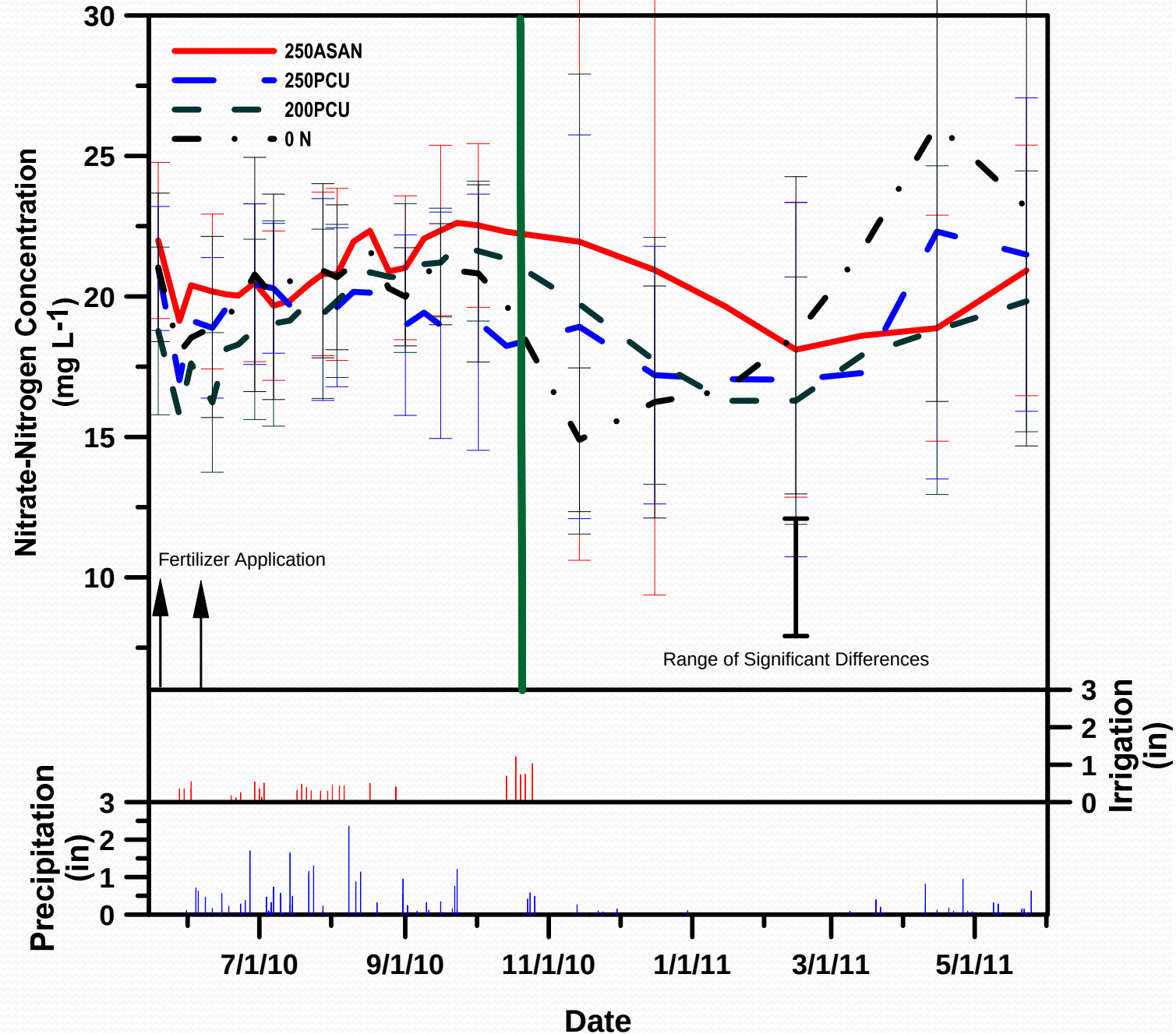
Plot averages

- 13.5 – 26.5
 - 13.1 – 29.9
- NO₃-N (mg L⁻¹)



Water Quality Results

2010 Potato Groundwater Well NO₃-N Concentrations

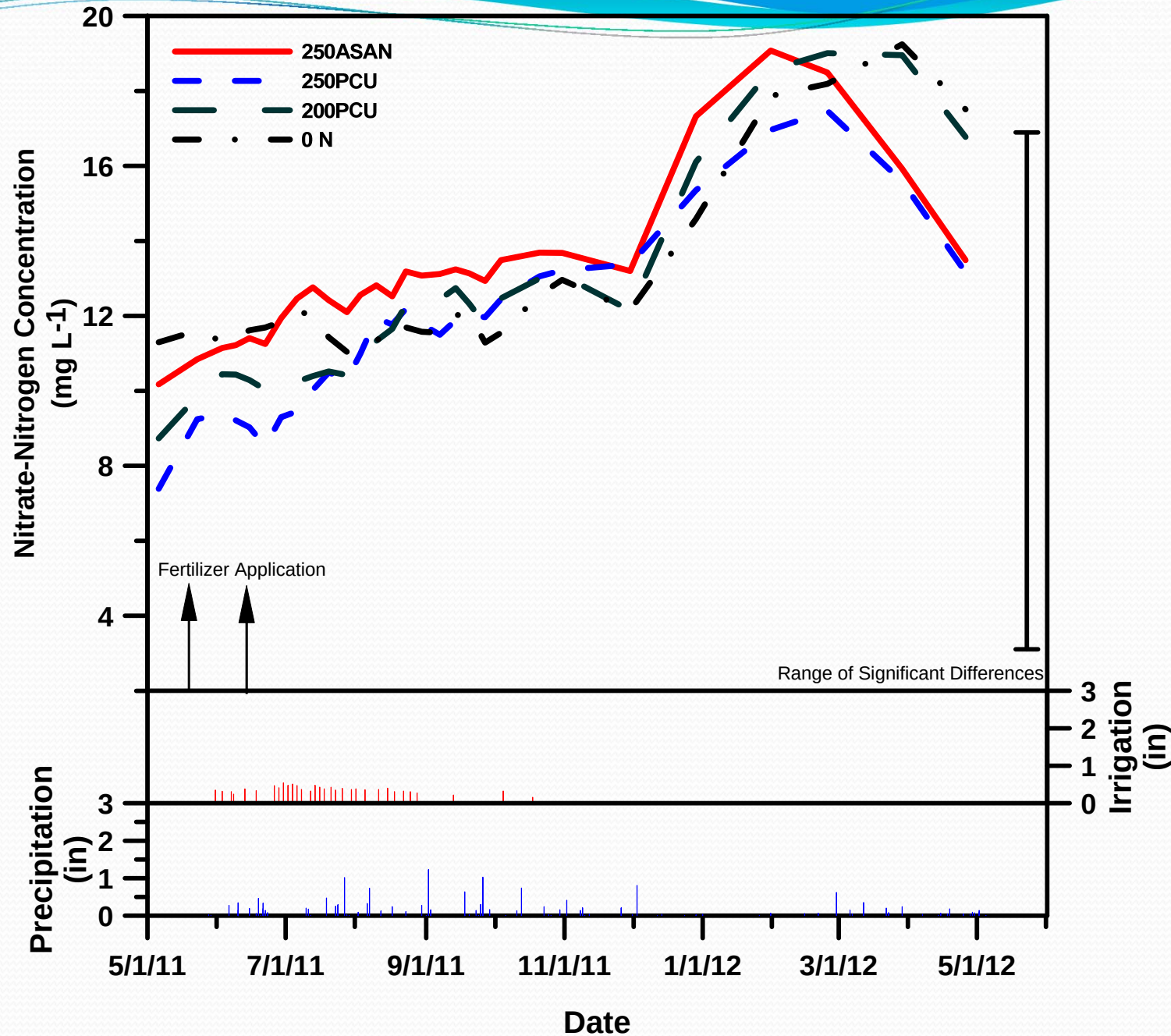


Water Quality Results

2011 Potato Groundwater Well NO₃-N Concentrations

Plot averages

- 2.0 – 37.3
NO₃-N (mg L⁻¹)

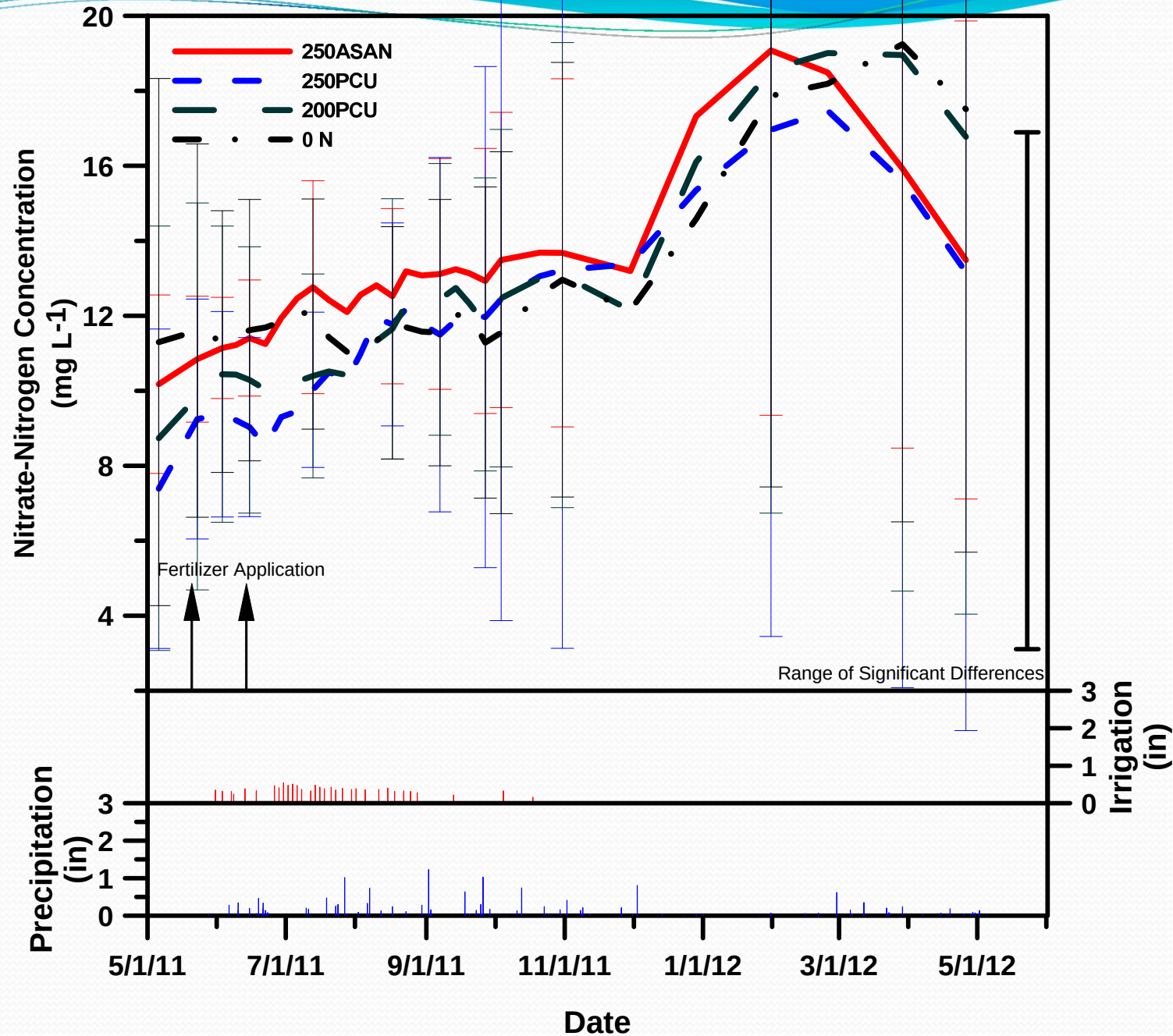


Water Quality Results

2011 Potato Groundwater Well NO₃-N Concentrations

Plot averages

- 2.0 – 37.3
NO₃-N (mg L⁻¹)



Conclusions – Water Quality

- Background and variability in groundwater N concentrations, both within and among plots resulted in no statistical difference between conventional and PCU fertilizer
- In the short term data collection should continue using root zone measurements, N balance and Nitrogen Use Efficiency
- Background and variation in groundwater N concentration addressed at field level over multiple years
 - Need field size large enough to account for movement of groundwater
 - May account for cumulative fertilizer effect on groundwater N concentrations
 - Evaluate water quality over time and agricultural systems

Questions?



2010 Water table and climate

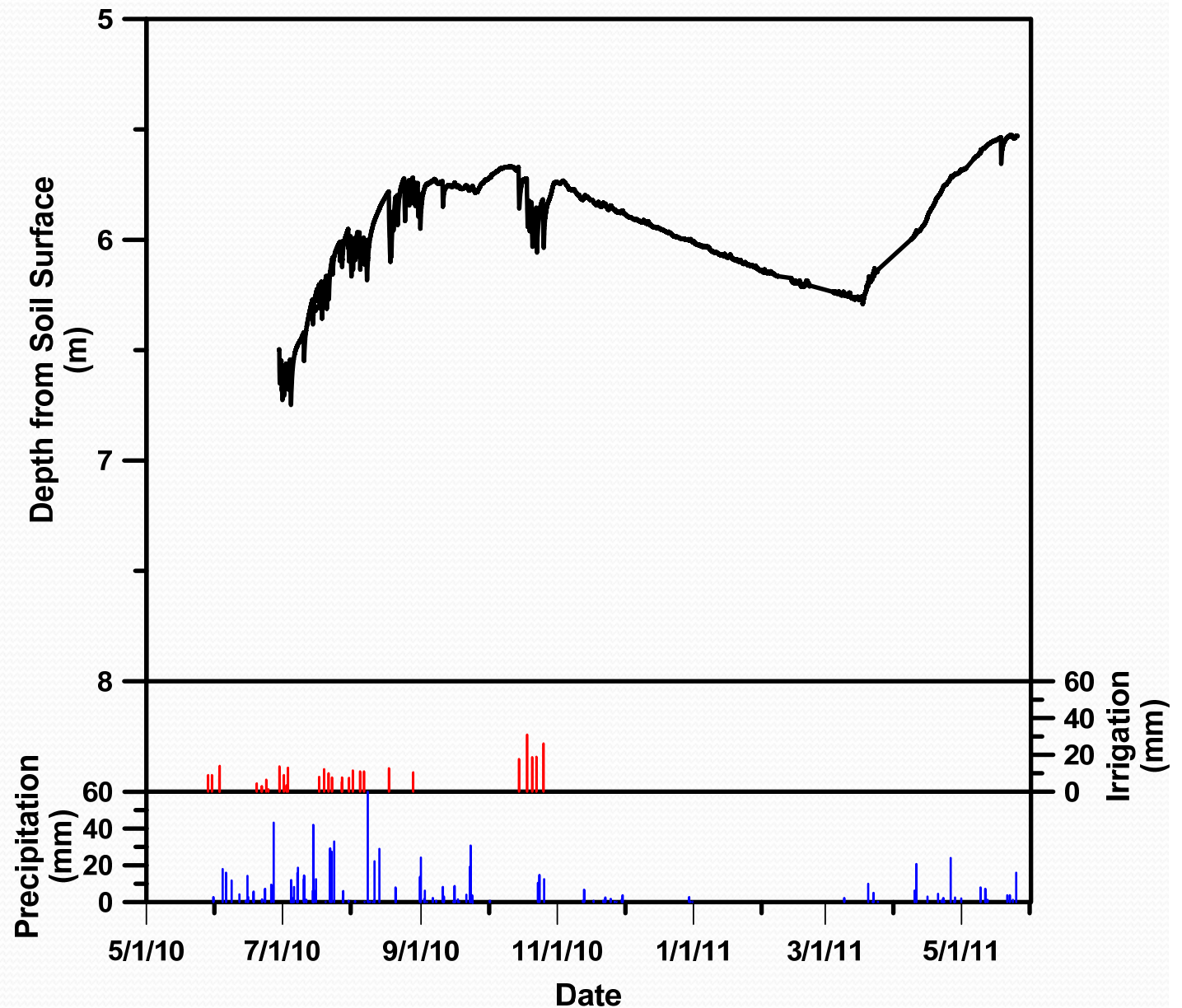
2010 Potato Depth to Water Table and Climate Data

Growing season
29 April – 30 August

- 540 mm precipitation
- 213 mm irrigation
- 19.4 °C

30 year averages

- 435 mm precipitation
- 17.5 °C



2011 Water table and climate

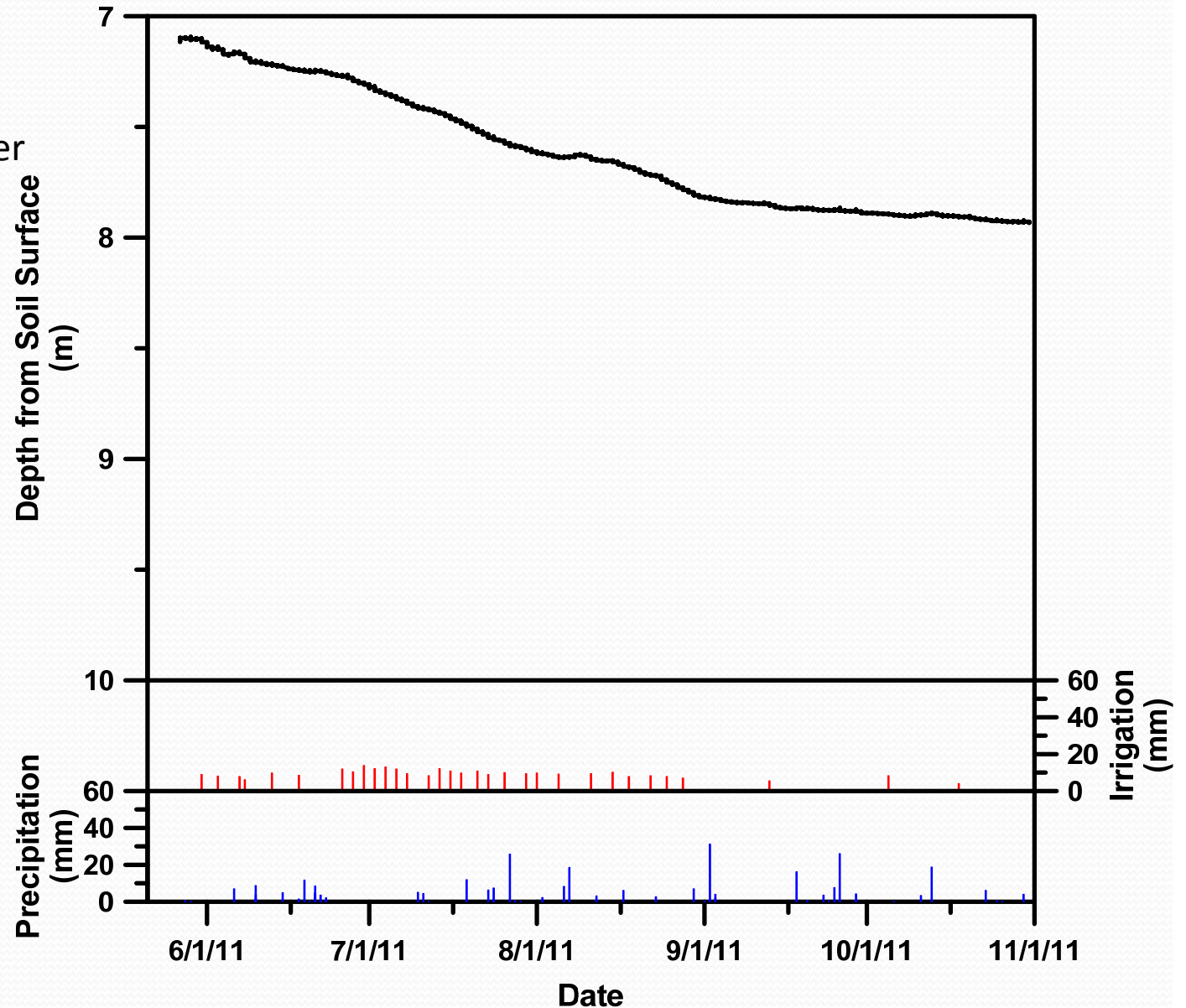
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2011 Potato Depth to Water Table and Climate Data



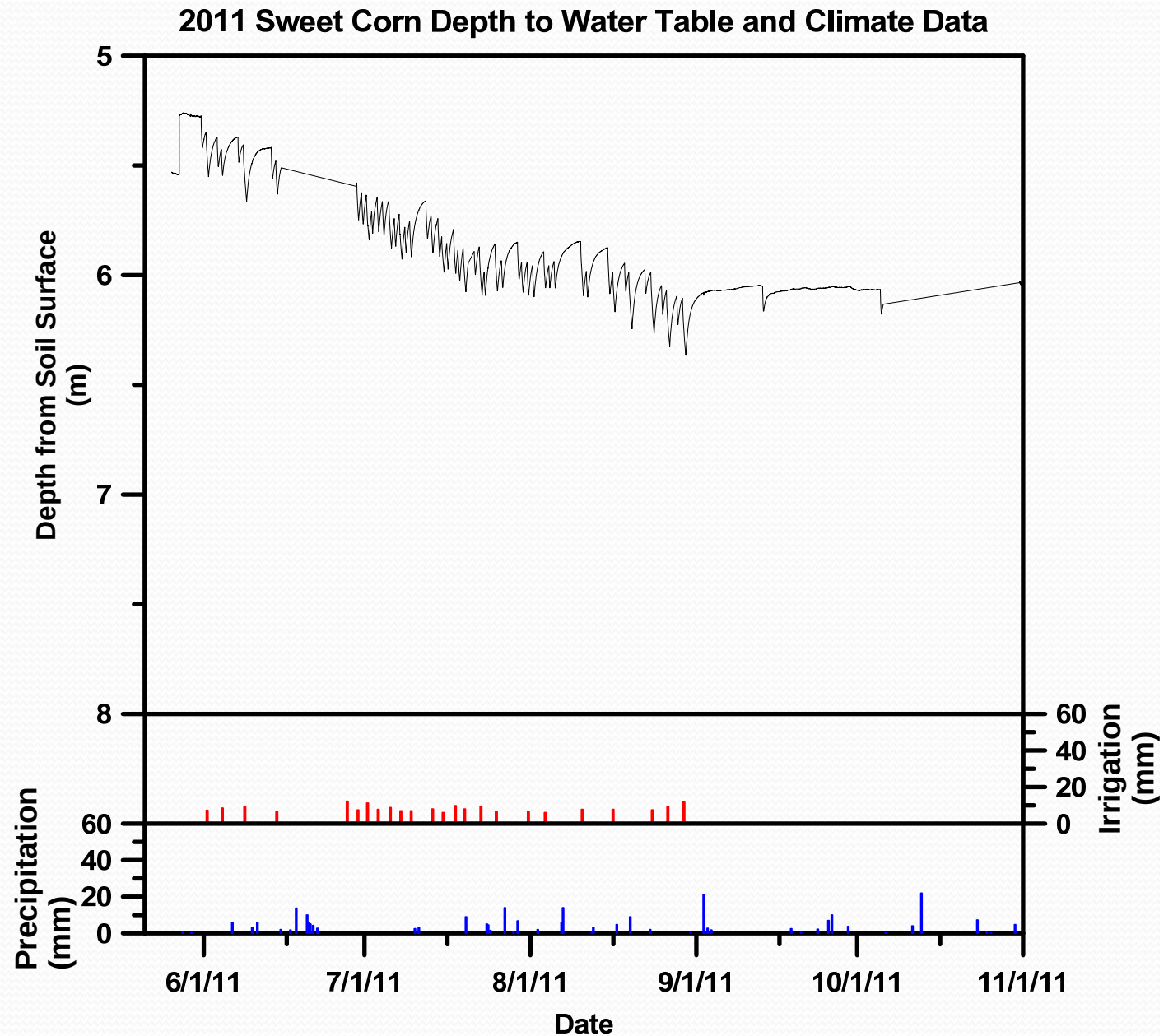
2011 Water table and climate

Growing season
25 May – 25 August

- 150 mm precipitation
- 176 mm irrigation
- 20.6 °C

30 year averages

- 312 mm precipitation
- 19.7 °C



2011 Water table and climate

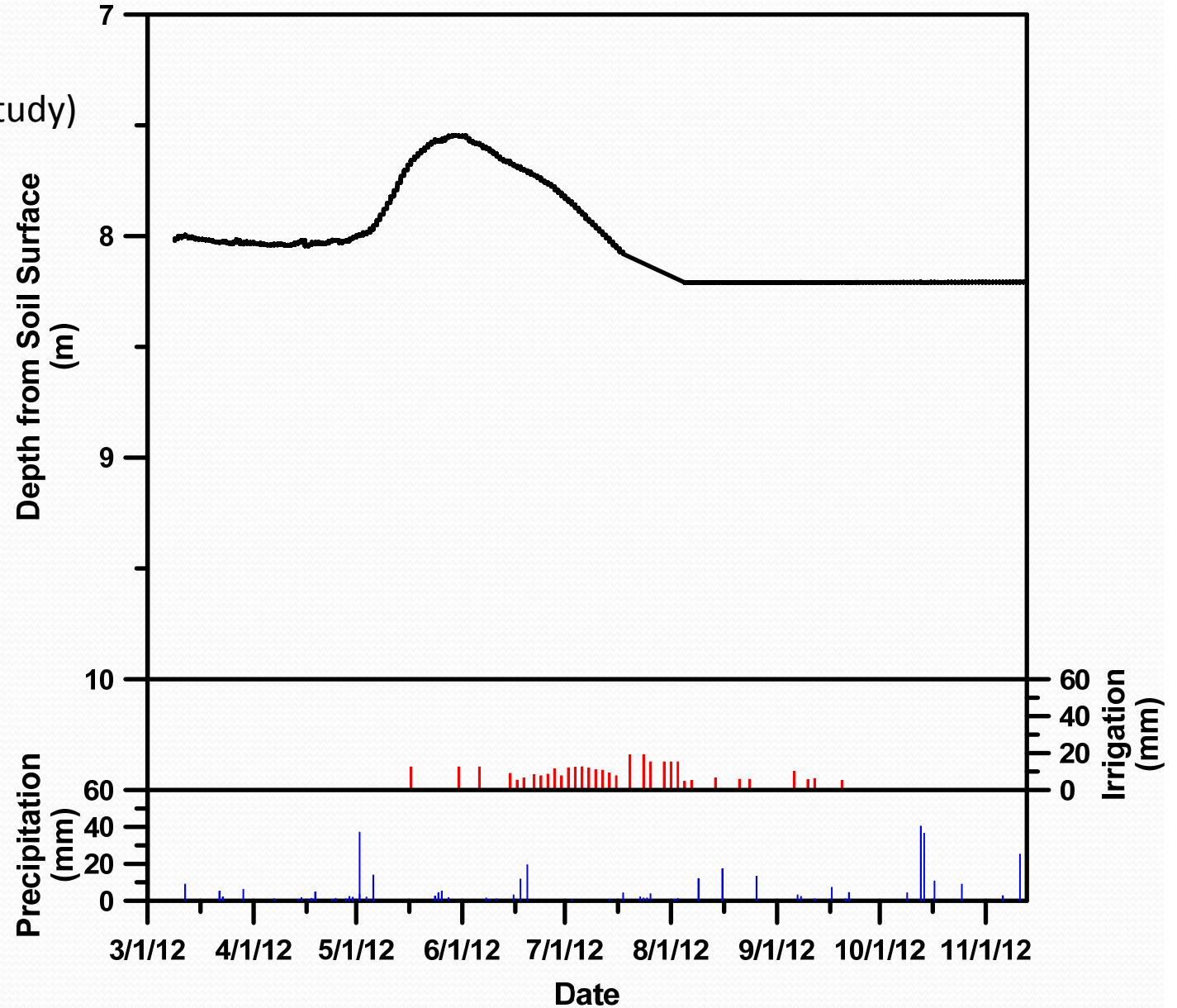
2012 Sweet Corn Depth to Water Table and Climate Data

(During Bromide Tracer study)

- 356 mm precipitation
- 343 mm irrigation

30 year averages

- 715 mm precipitation

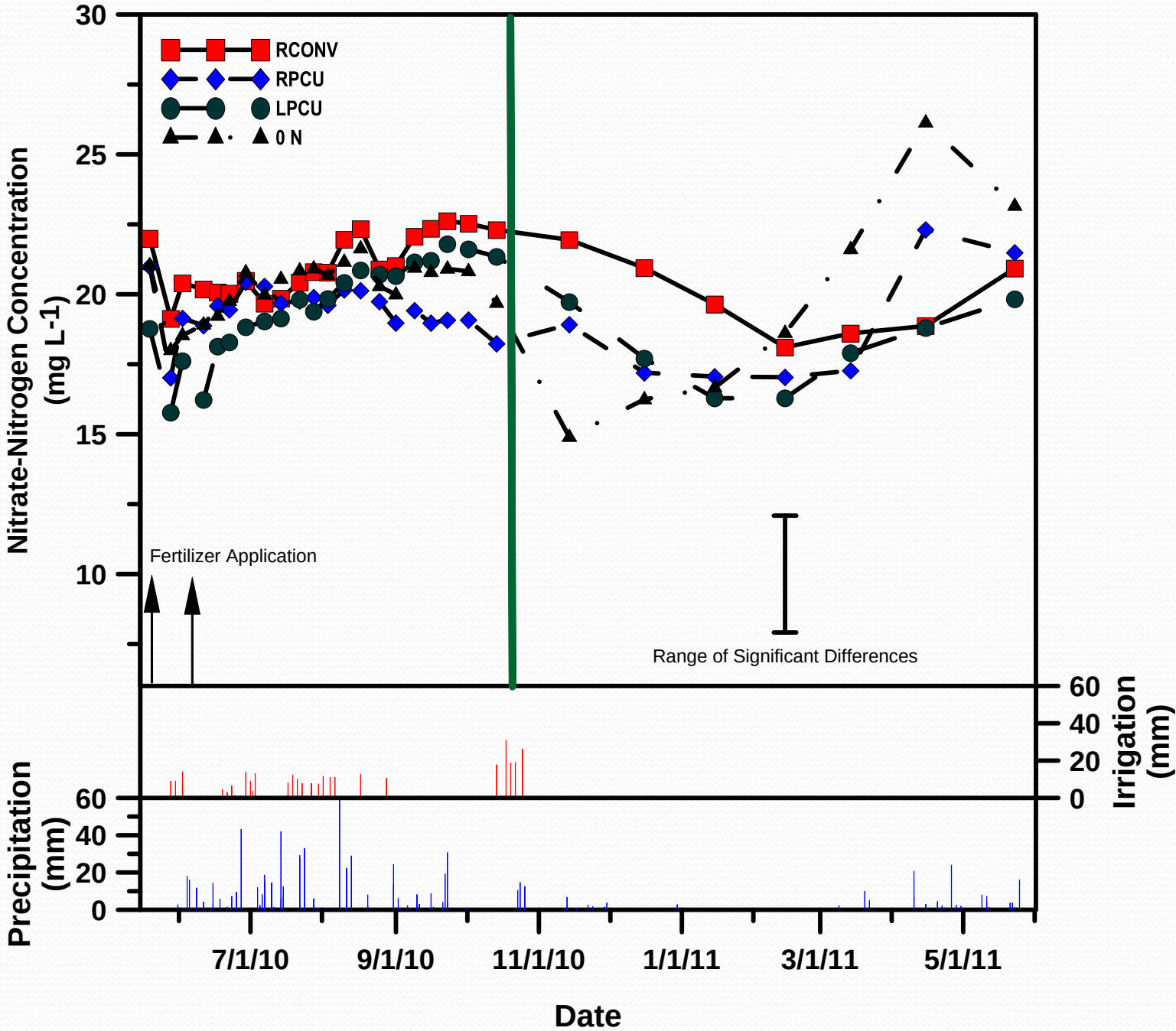


Water Quality Results

2010 Potato Groundwater Well NO₃-N Concentrations

Plot averages

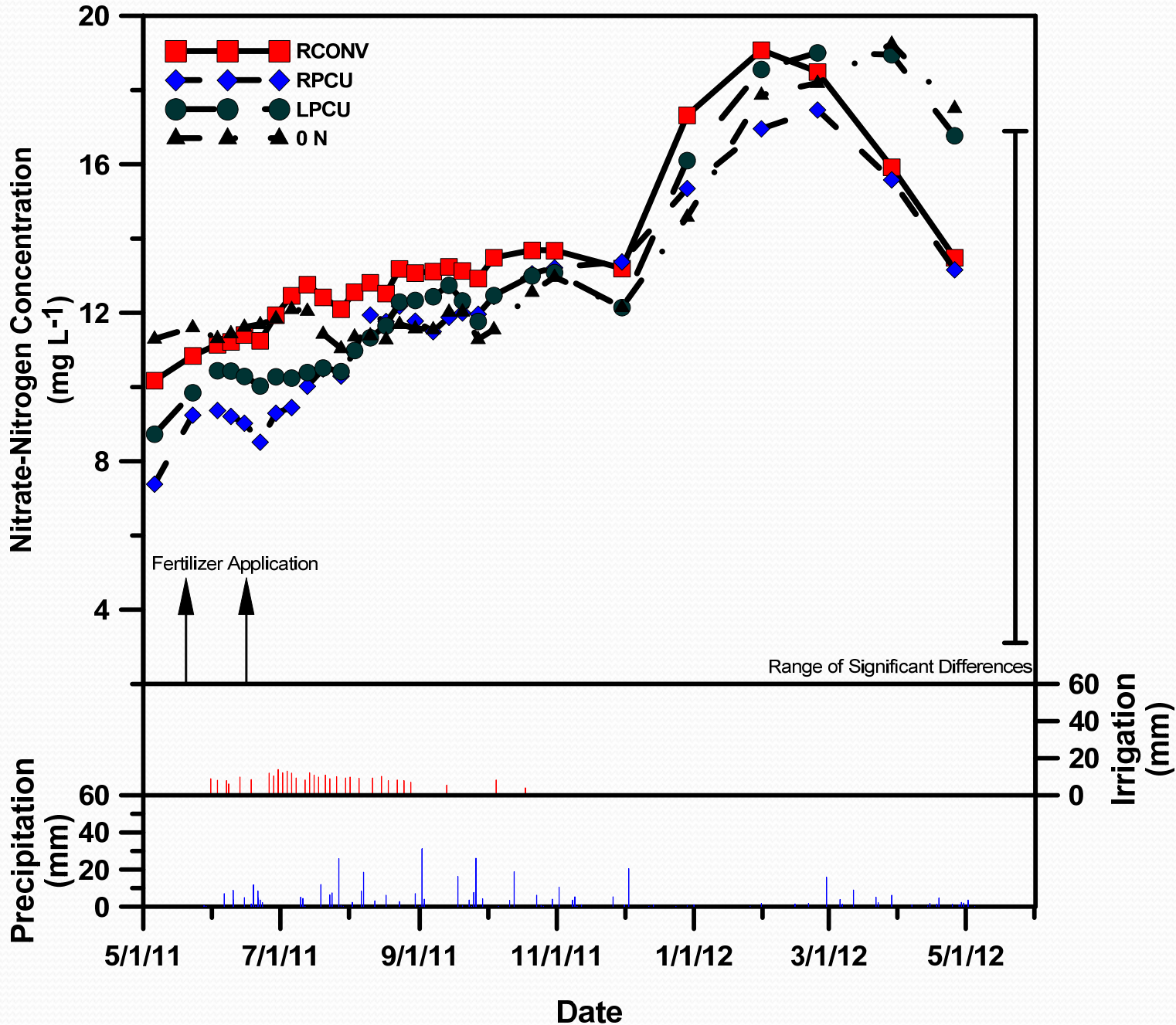
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Water Quality Results

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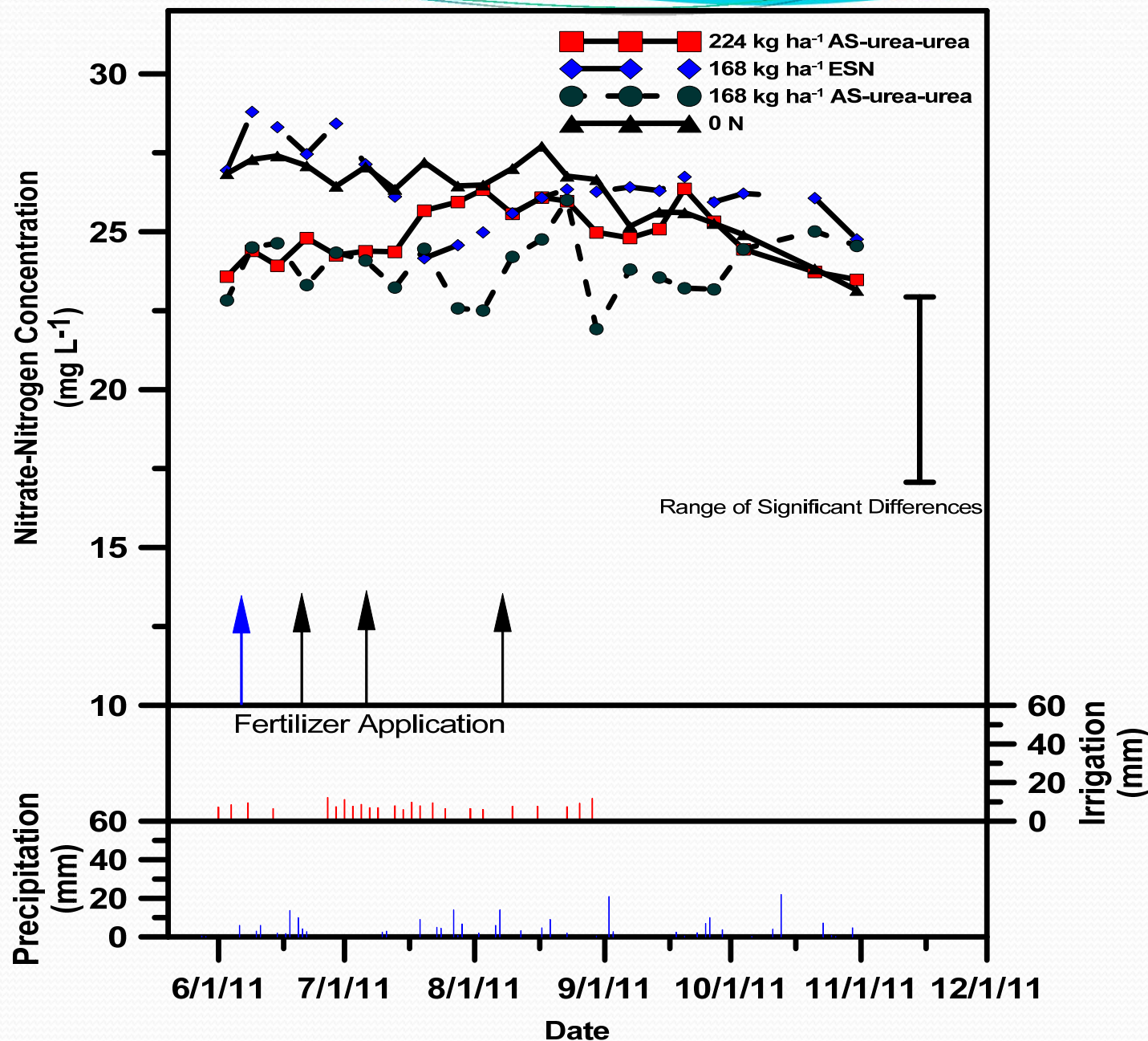


Water Quality Results

2011 Sweet Corn Groundwater Well NO₃-N Concentrations

Plot averages

- 19.1 – 36.9
NO₃-N (mg L⁻¹)



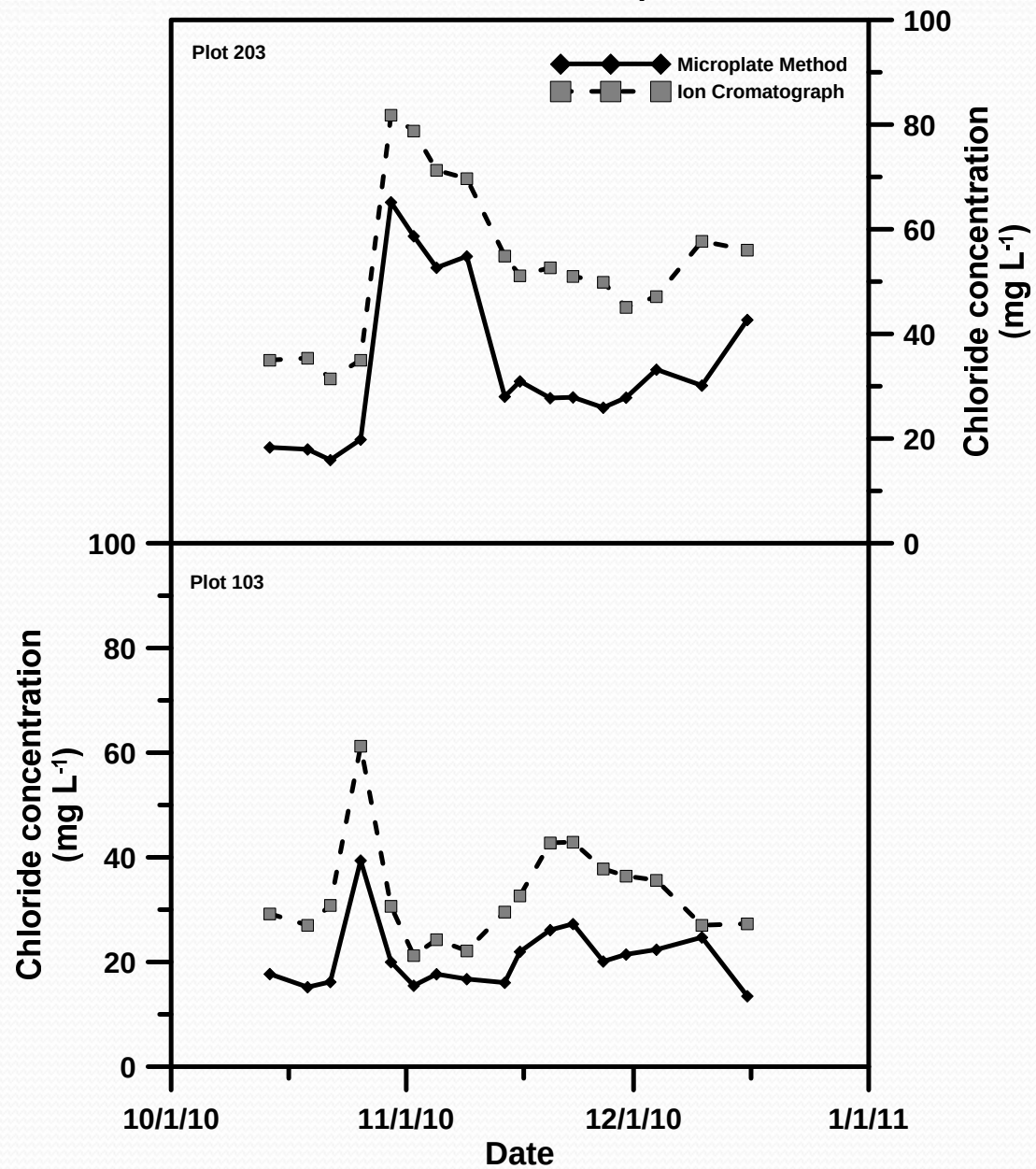


Climate information

Growing Season	Precipitation (in)	Irrigation (in)	Average Temperature (°F)
29 April – 30 August 2010	21.3	8.4	67
25 April – 12 September 2011	8.5	11.1	65
30 yr average	17.1	N/A	64

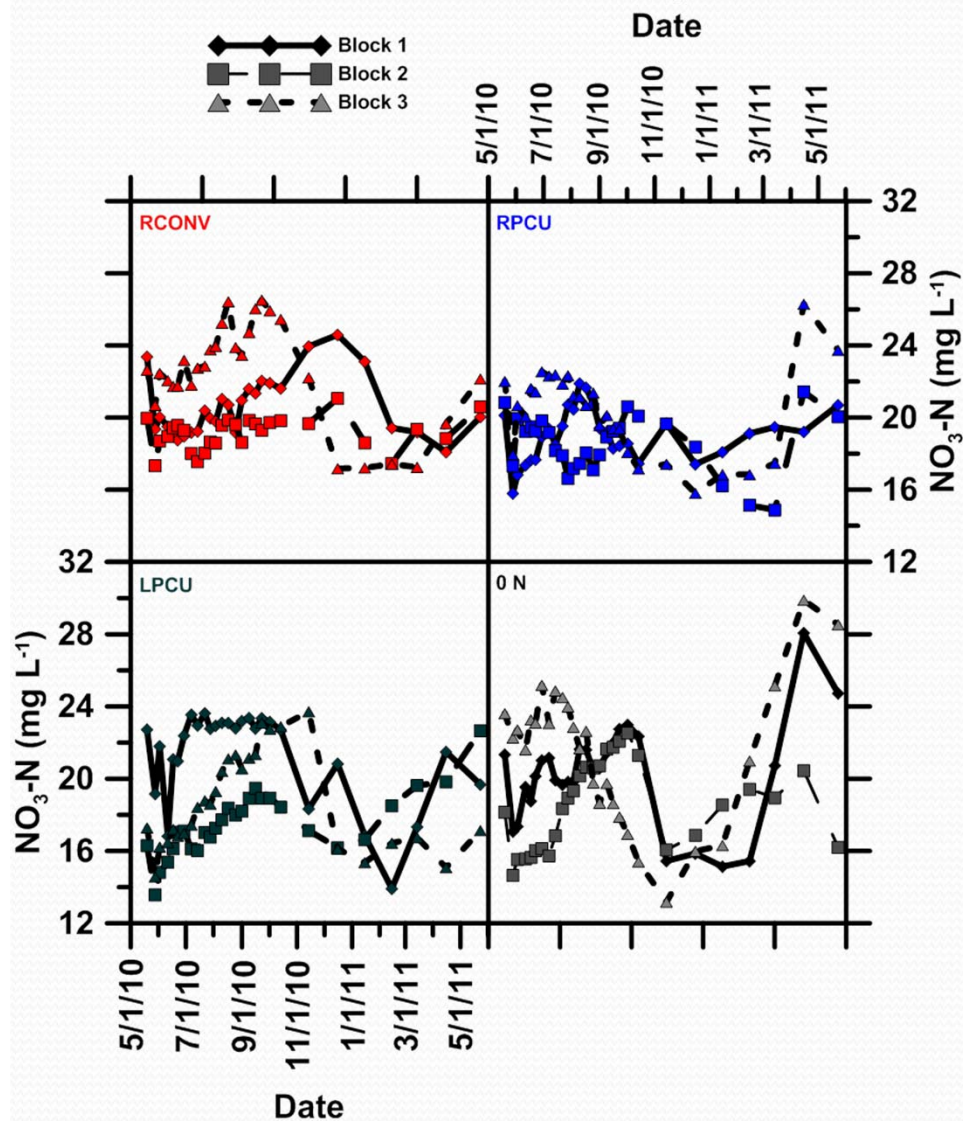
Bromide-Chloride tracer results--Chloride

Chloride Methods Comparison

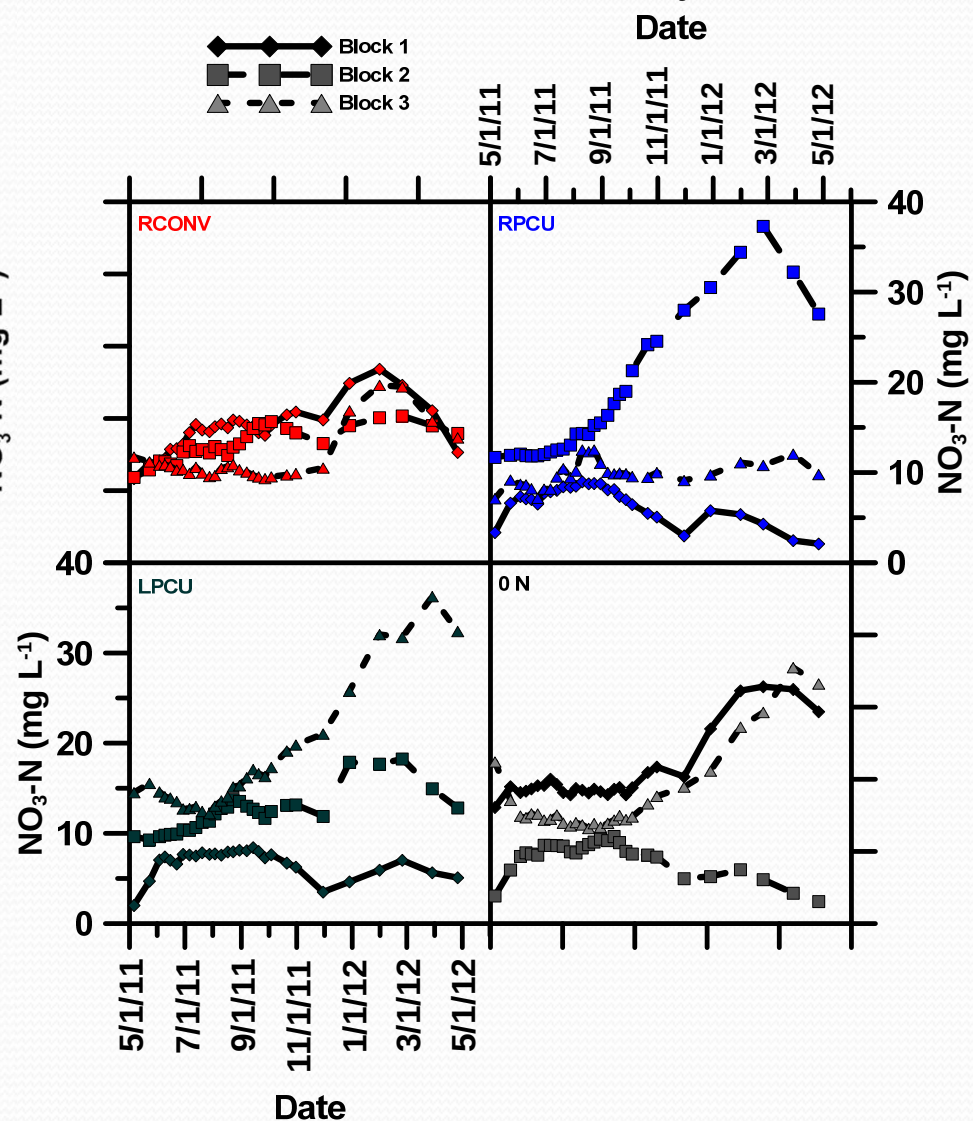


Water Quality Results

2010 Potato NO₃-N Concentration by Treatment



2011 Potato NO₃-N Concentration by Treatment



Potato plant N status and growth results

Potato nitrogen use efficiencies

	Treatment	PNB (kg N ha ⁻¹ /kg N ha ⁻¹)	PFP (kg ha ⁻¹ /kg N ha ⁻¹)	NUE (whole) (kg N ha ⁻¹ /kg N ha ⁻¹)	NUE (tuber) (kg N ha ⁻¹ /kg N ha ⁻¹)
2010	RCONV	0.33 b	175 b	0.35 (15)	0.21
	RPCU	0.34 b	179 b	0.29 (13)	0.22
	LPCU	0.43 a	214 a	0.39 (8)	0.26
	P>F	*	**	ns	ns
2011	RCONV	0.68 b	195 b	0.45 (19)	0.20 b
	RPCU	0.71 b	202 b	0.42 (24)	0.23 b
	LPCU	0.92 a	252 a	0.52 (2)	0.32 a
	P>F	**	*	ns	*

PNB – Partial Nutrient Balance = N in harvested portion of crop/fertilizer applied

PFP – Partial Factor Productivity = Yield/fertilizer applied

NUE – Nitrogen Uptake Efficiency = N uptake (treatment) - N uptake (0 N)/fertilizer applied

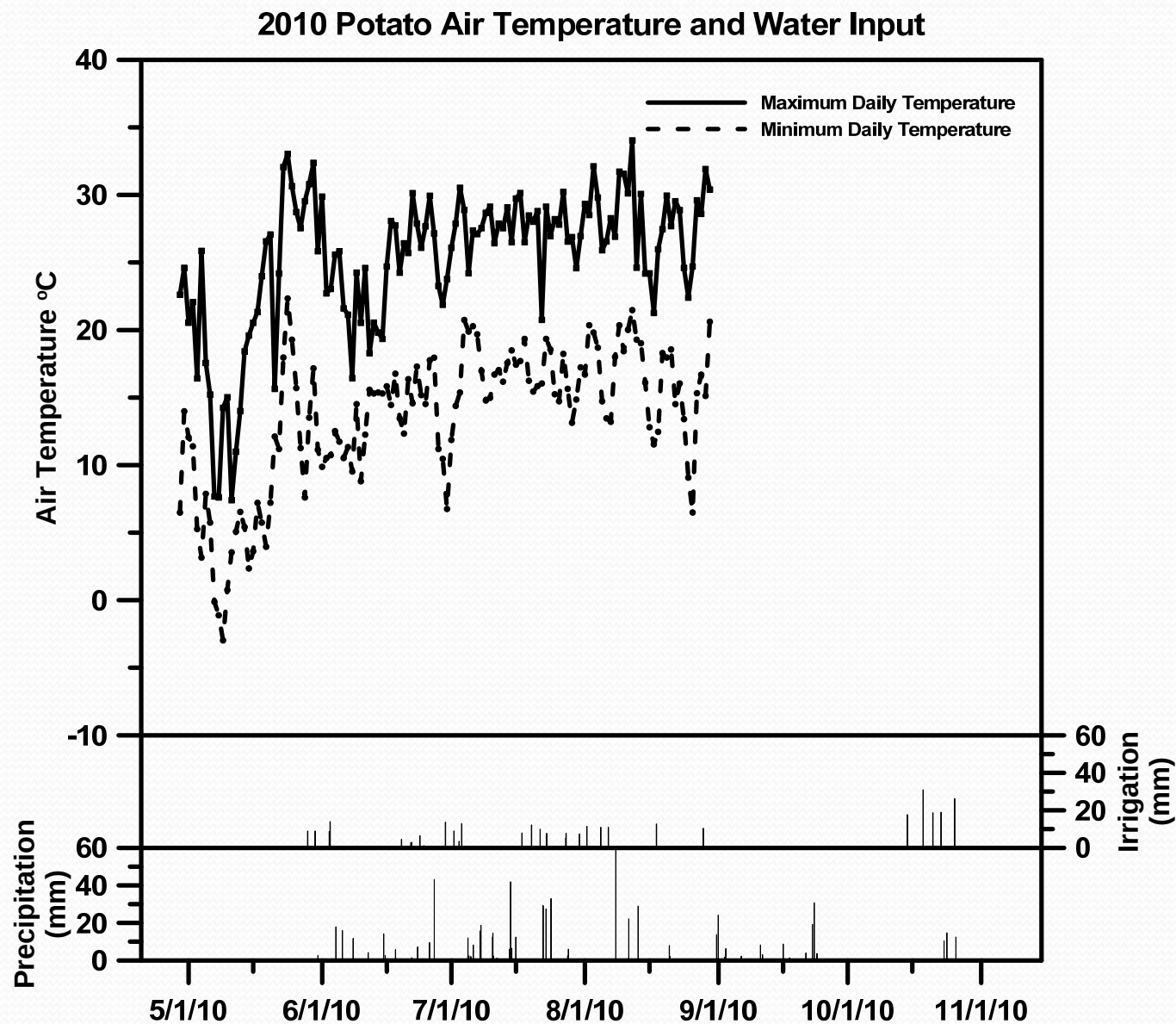
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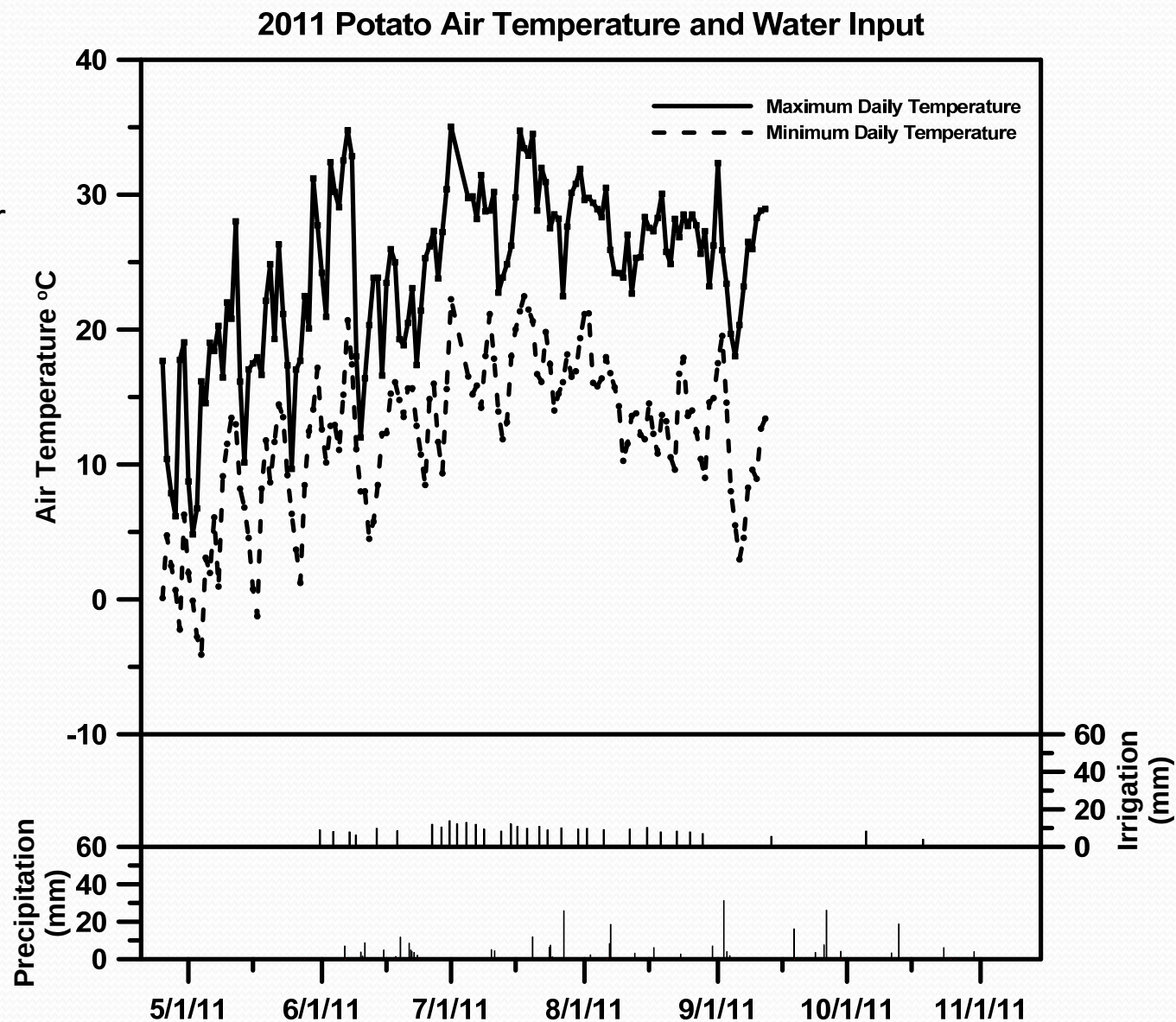
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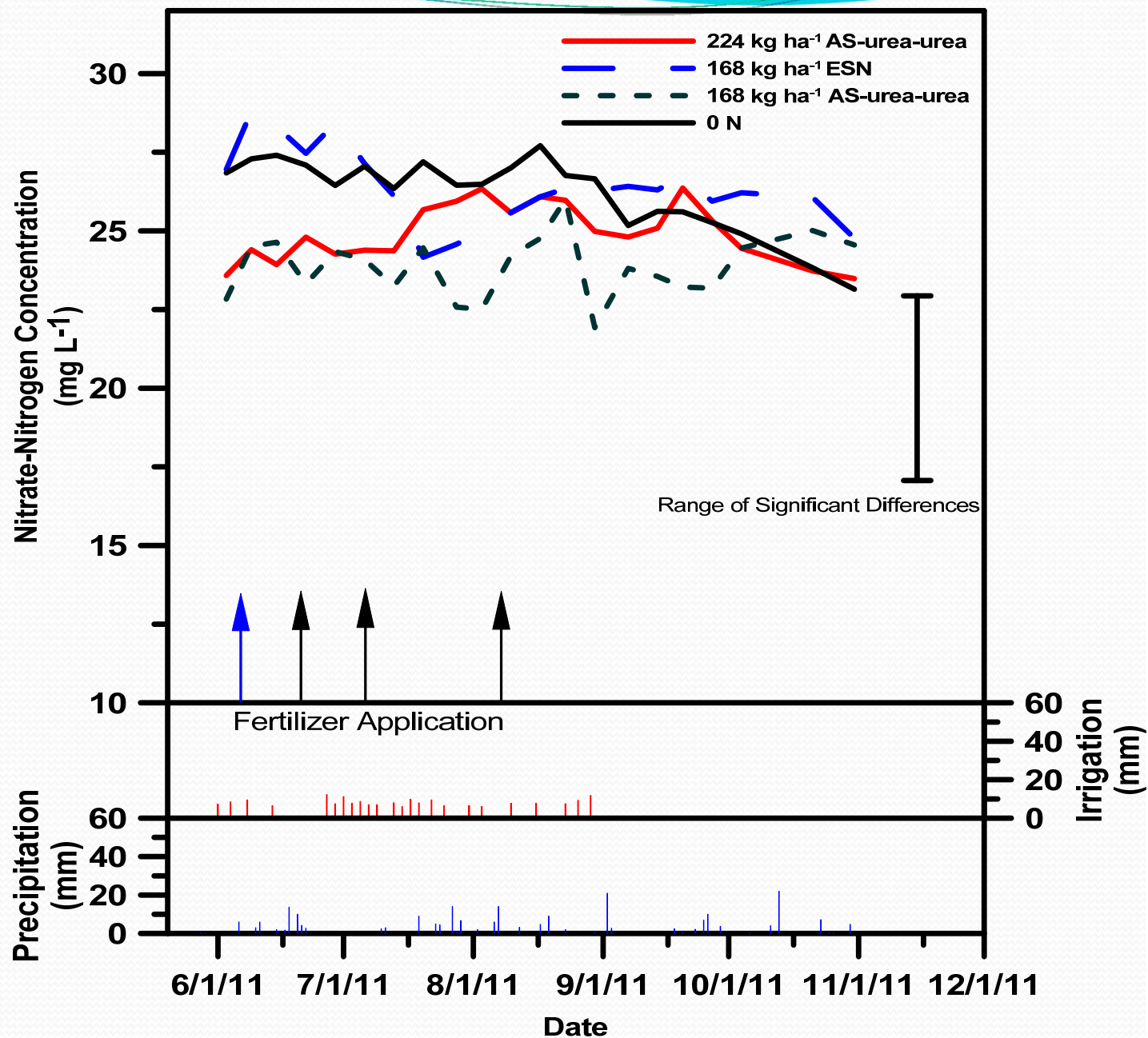


Water Quality Results

2011 Sweet Corn Groundwater Well NO₃-N Concentrations

Plot averages

- 19.1 – 36.9
NO₃-N (mg L⁻¹)

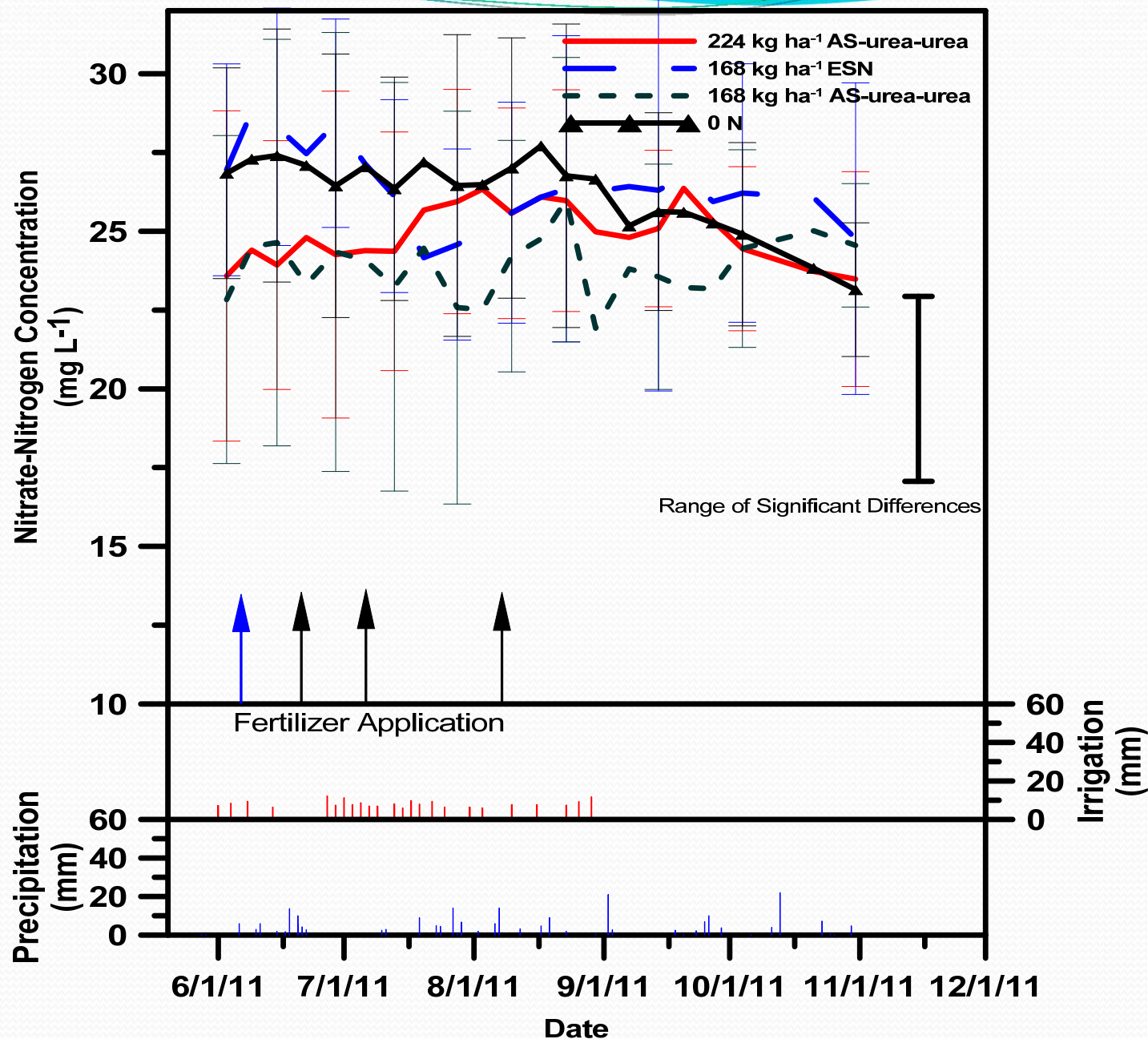


Water Quality Results

2011 Sweet Corn Groundwater Well NO₃-N Concentrations

Plot averages

- 19.1 – 36.9
NO₃-N (mg L⁻¹)



Potato plant N status and growth results

- Potato Petiole Nitrate-Nitrogen

2010

Treatment	32 DAE	44 DAE	58 DAE	73 DAE
	-----Nitrogen concentration (%)-----			
RCONV	2.4 a	2.2 a	1.5 a	0.63 ab
RPCU	2.2 ab	1.6 b	1.1 ab	0.85 a
LPCU	1.7 b	0.89 c	0.67 bc	0.42 b
0 N	0.28 c	0.01 b	0.01 c	0.02 c
P>F	***	***	**	***

DAE – Days after emergence
Emergence on 17 May 2010

Potato plant N status and growth results

- Potato Petiole Nitrate-Nitrogen

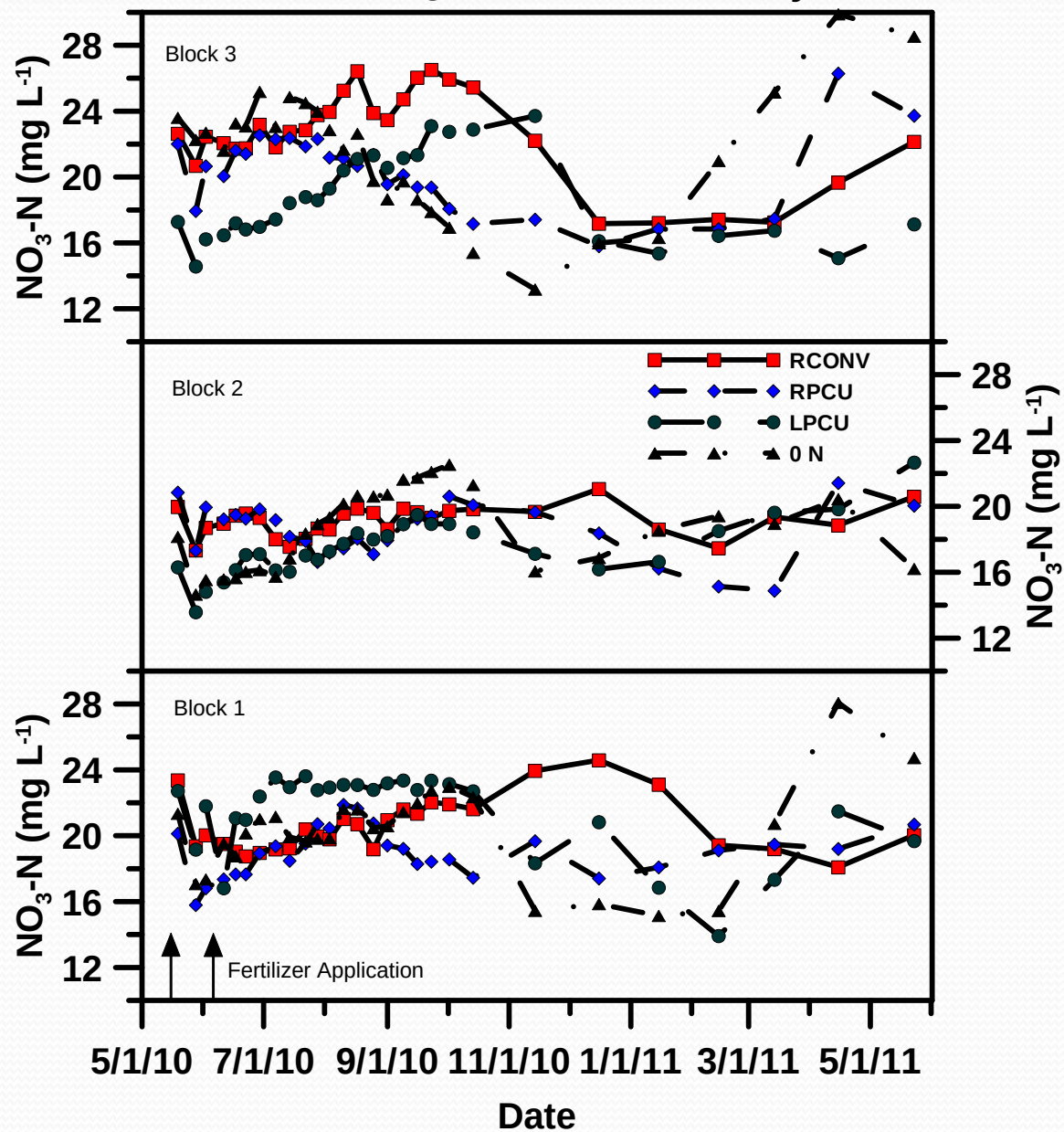
2011

Treatment	27 DAE	40 DAE	54 DAE	67 DAE
	-----Nitrogen concentration (%)-----			
RCONV	3.5 a	1.9 a	1.7 ab	1.4 a
RPCU	3.2 a	1.8 a	1.8 a	1.4 a
LPCU	3.3 a	1.6 b	1.5 b	1.3 a
0 N	2.6 b	0.14 c	0.02 c	0.01 b
P>F	**	***	***	***

DAE – Days after emergence
Emergence on 20 May 2010

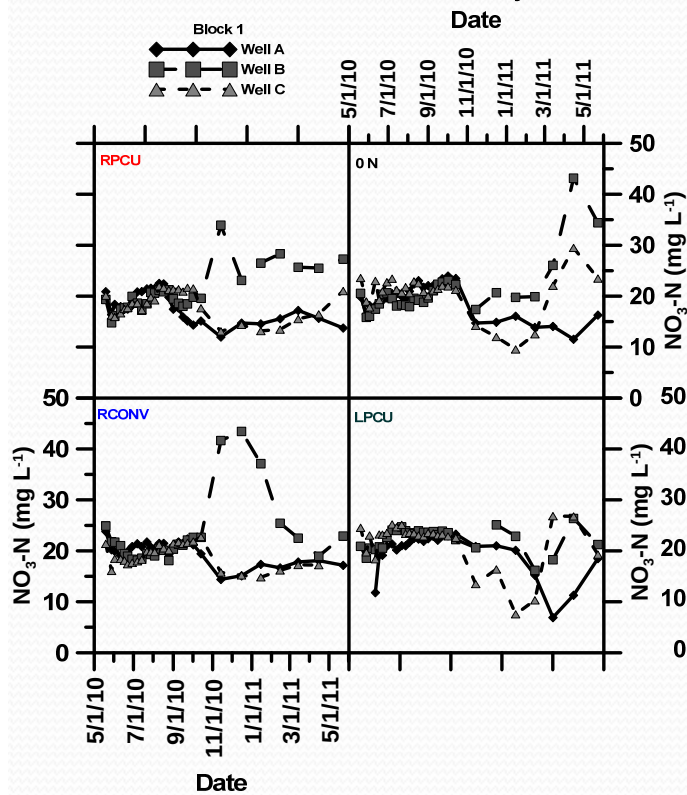
Water Quality Results

2010 Potato NO₃-N Concentrations by Block

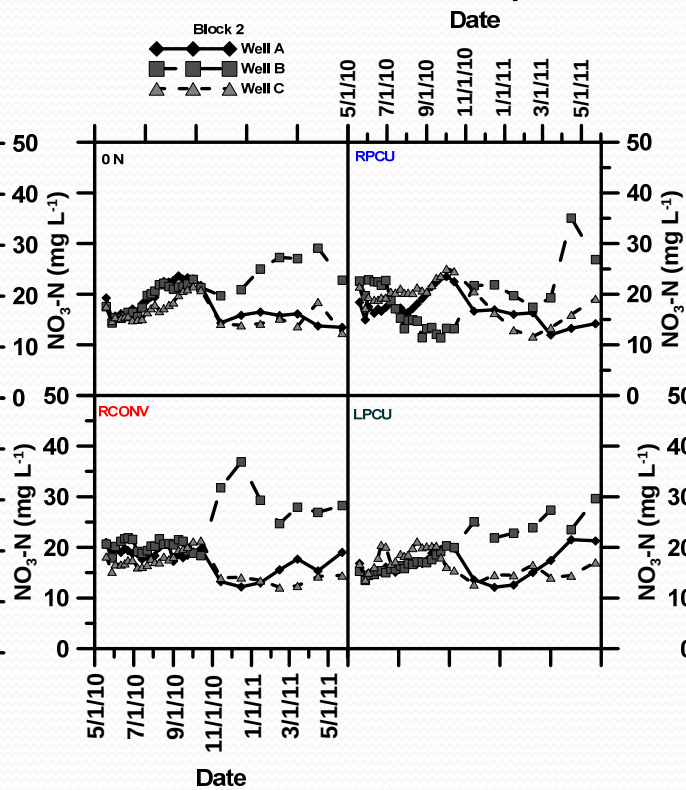


Water Quality Results

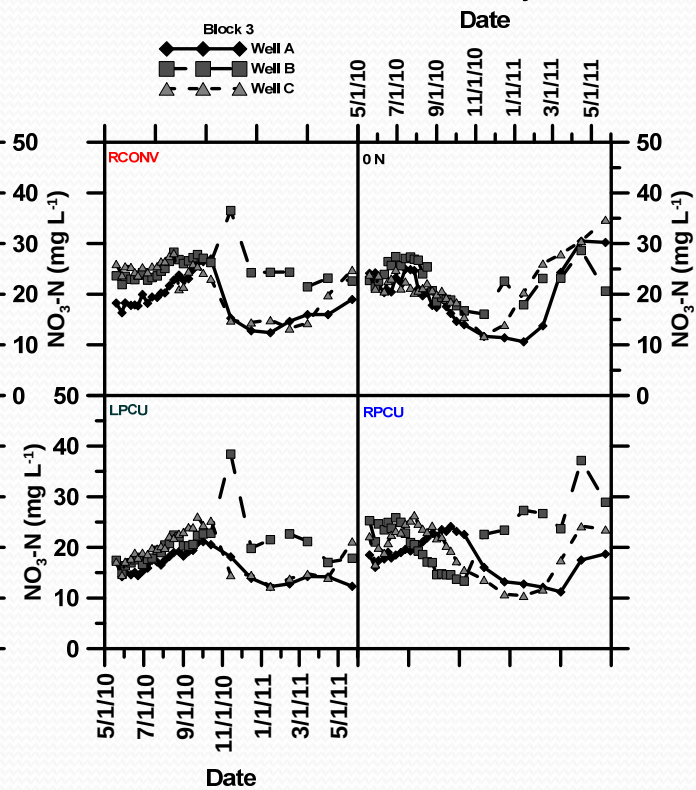
2010 Potato NO₃-N Concentration by Well



2010 Potato NO₃-N Concentration by Well

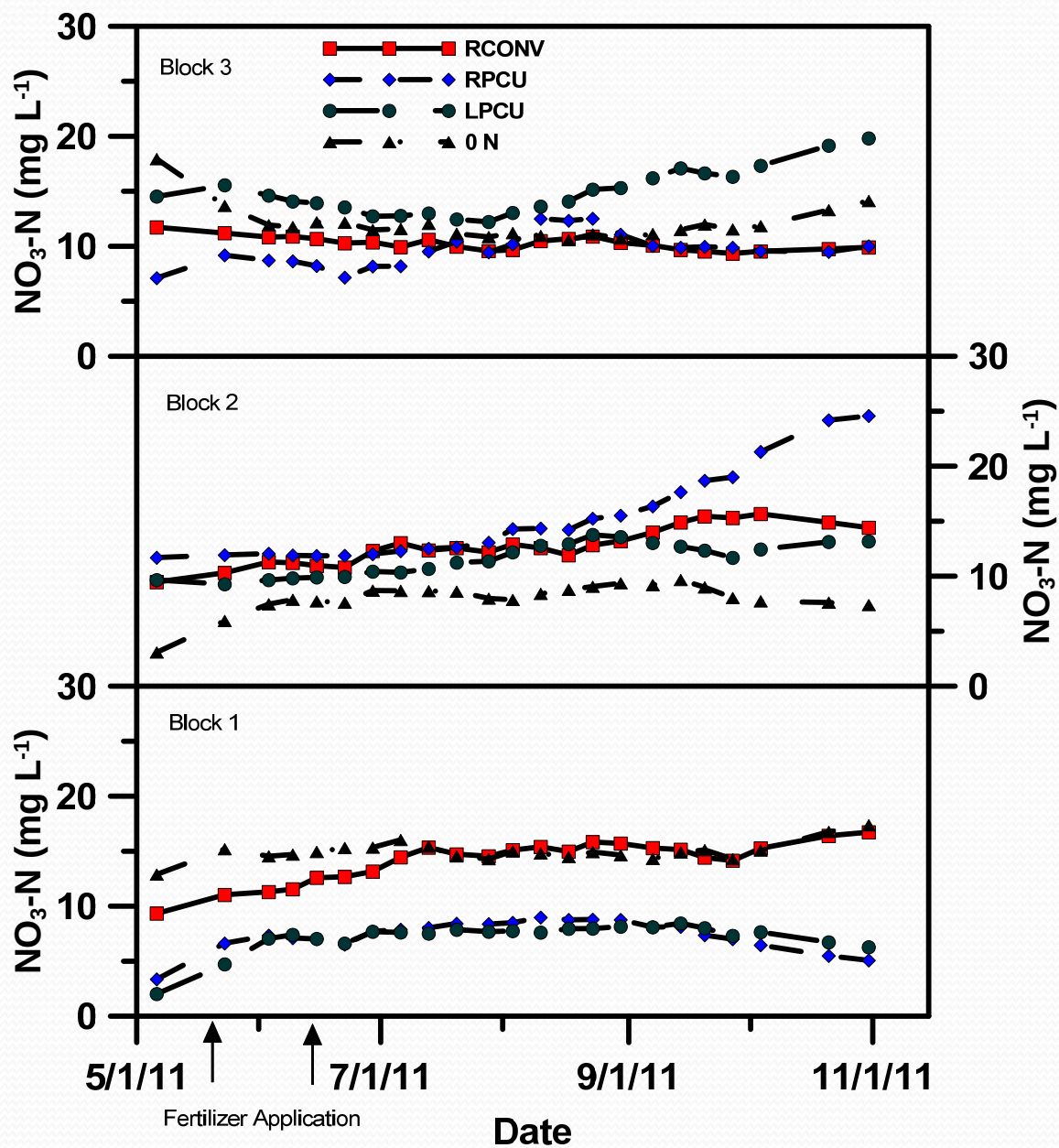


2010 Potato NO₃-N Concentration by Well

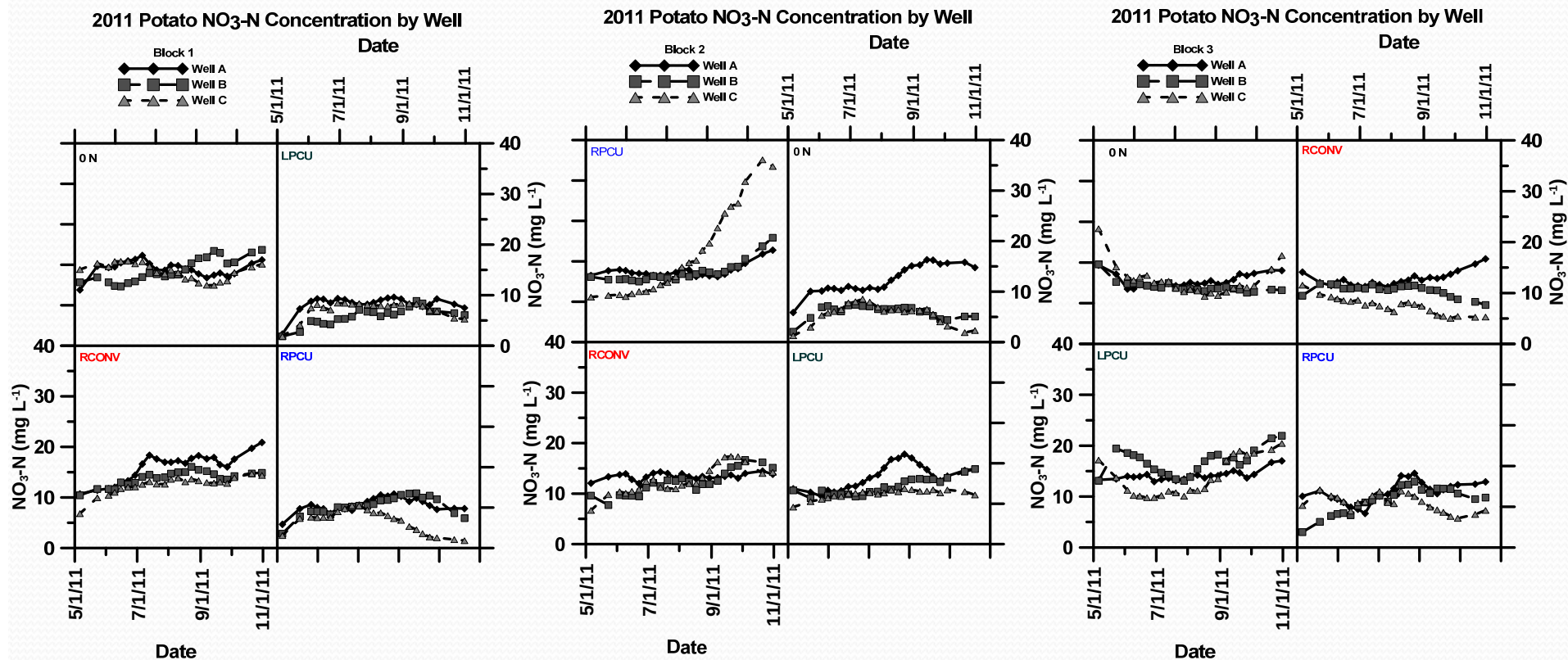


Water Quality Results

2011 Potato NO₃-N Concentrations by Block

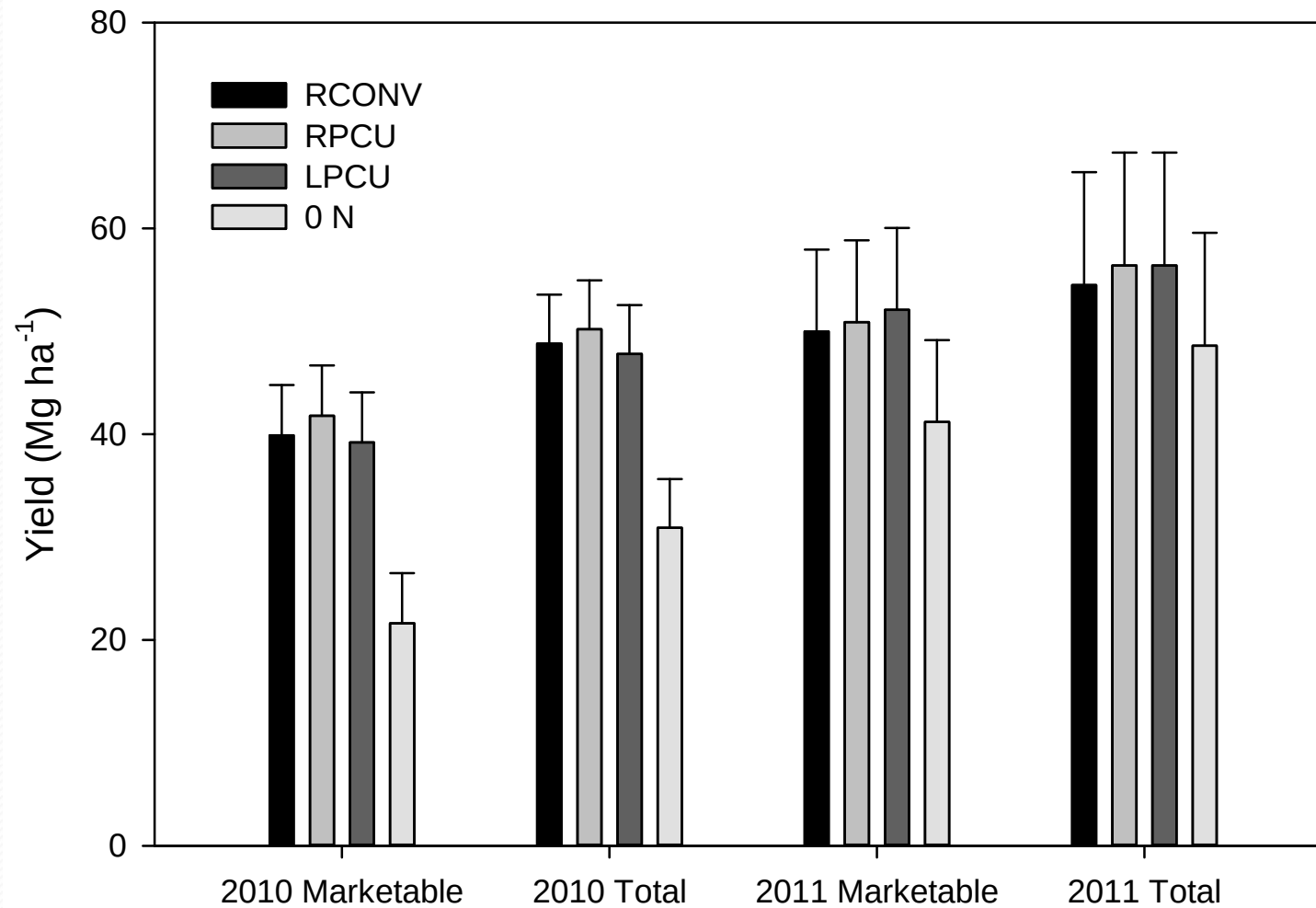


Water Quality Results



Potato plant N status and growth results

Potato Yields



- Harvest date was 30 August 2010 and 12 September 2011
- (C.V.)

Potato plant N status and growth results

- Potato quality

Specific Gravity		
Treatment	2010	2011
RCONV	1.0757 a	1.0730
RPCU	1.0717 bc	1.0717
LPCU	1.0723 ab	1.0713
0 N	1.0683 c	1.0703
P>F	**	ns