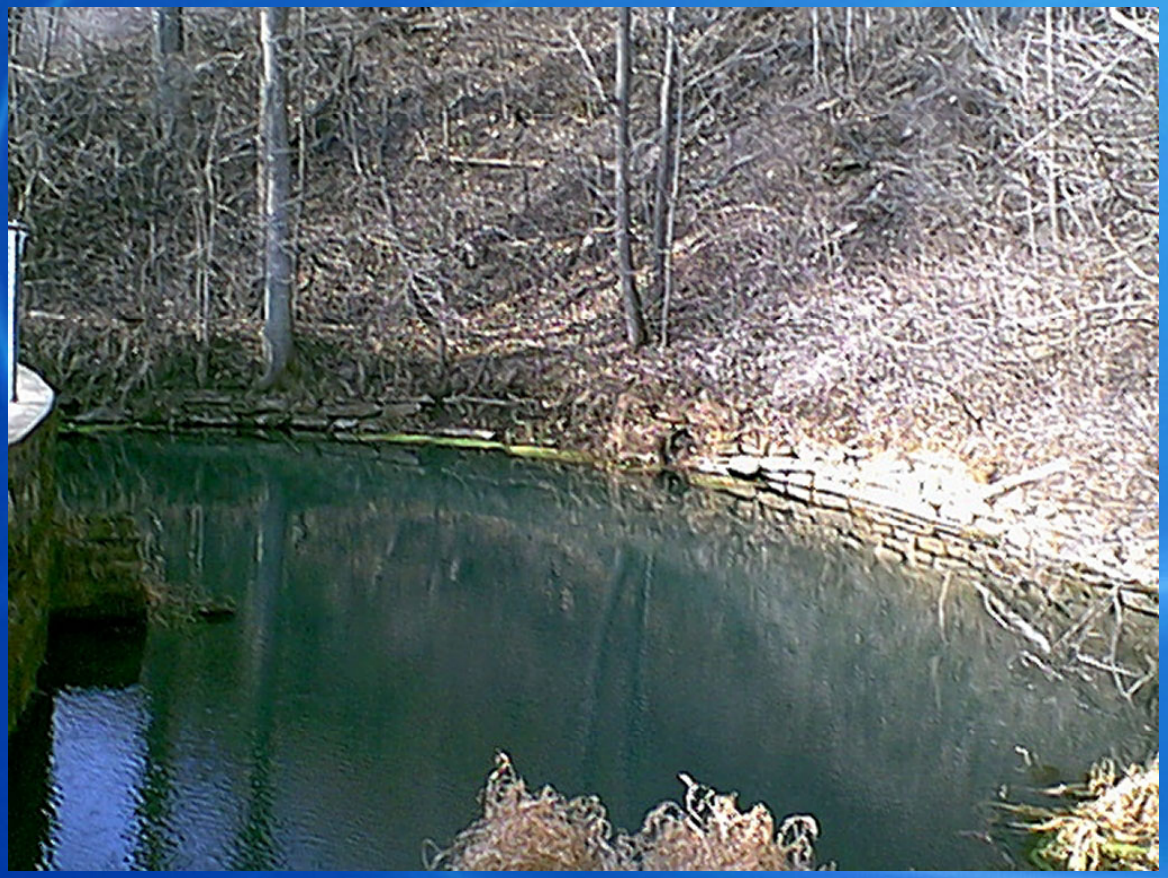
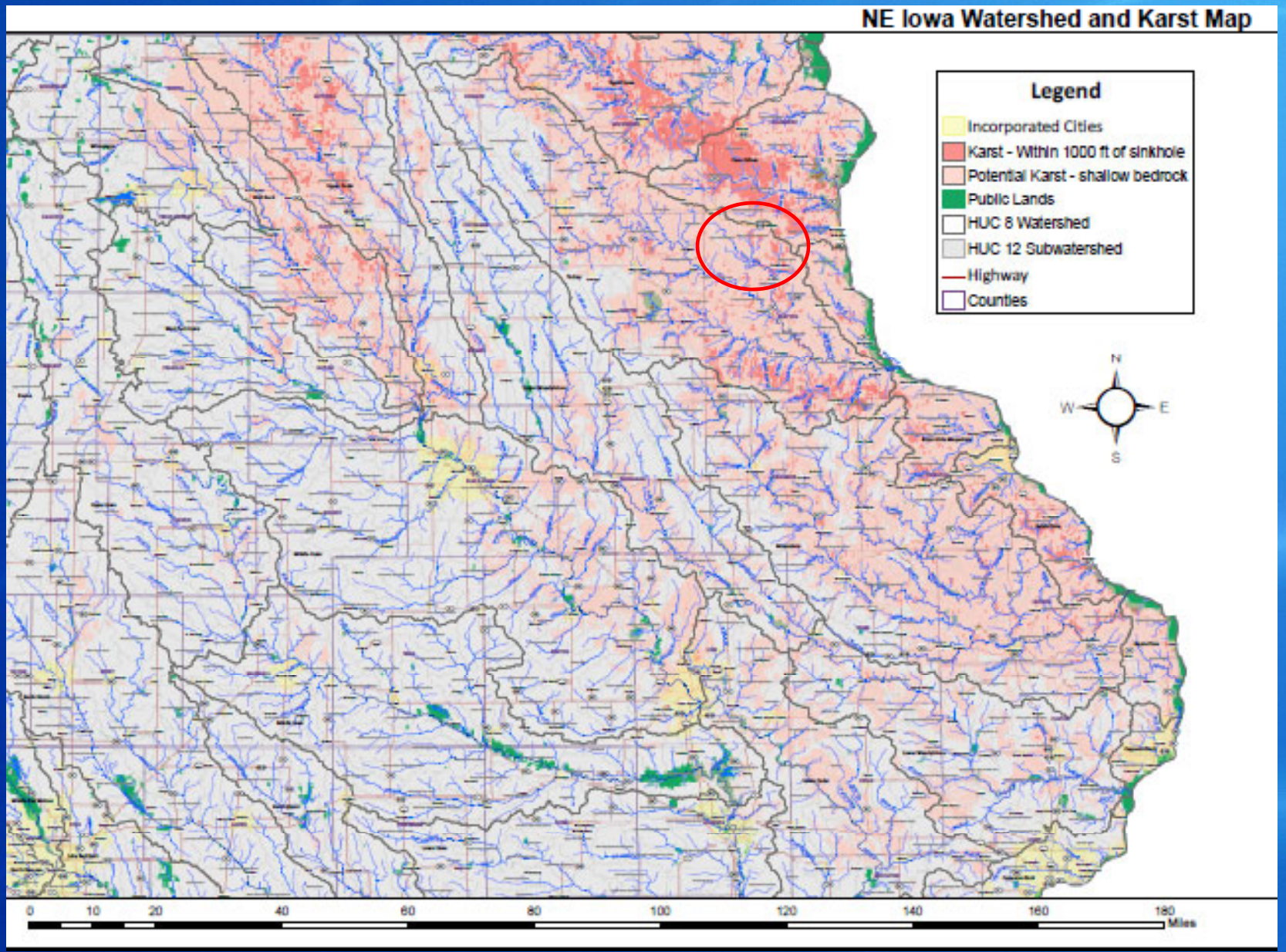
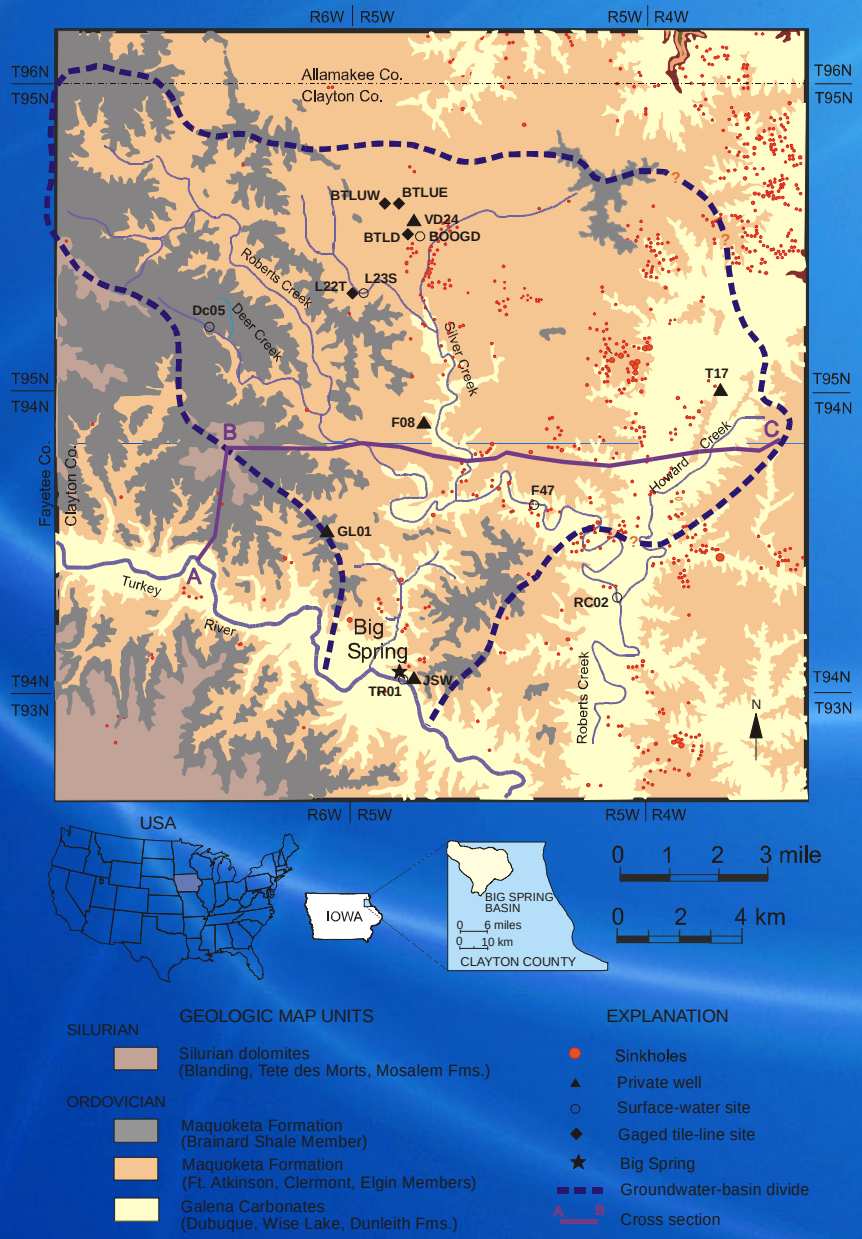
Karst, Groundwater, and Water Quality: Lessons from Big Spring

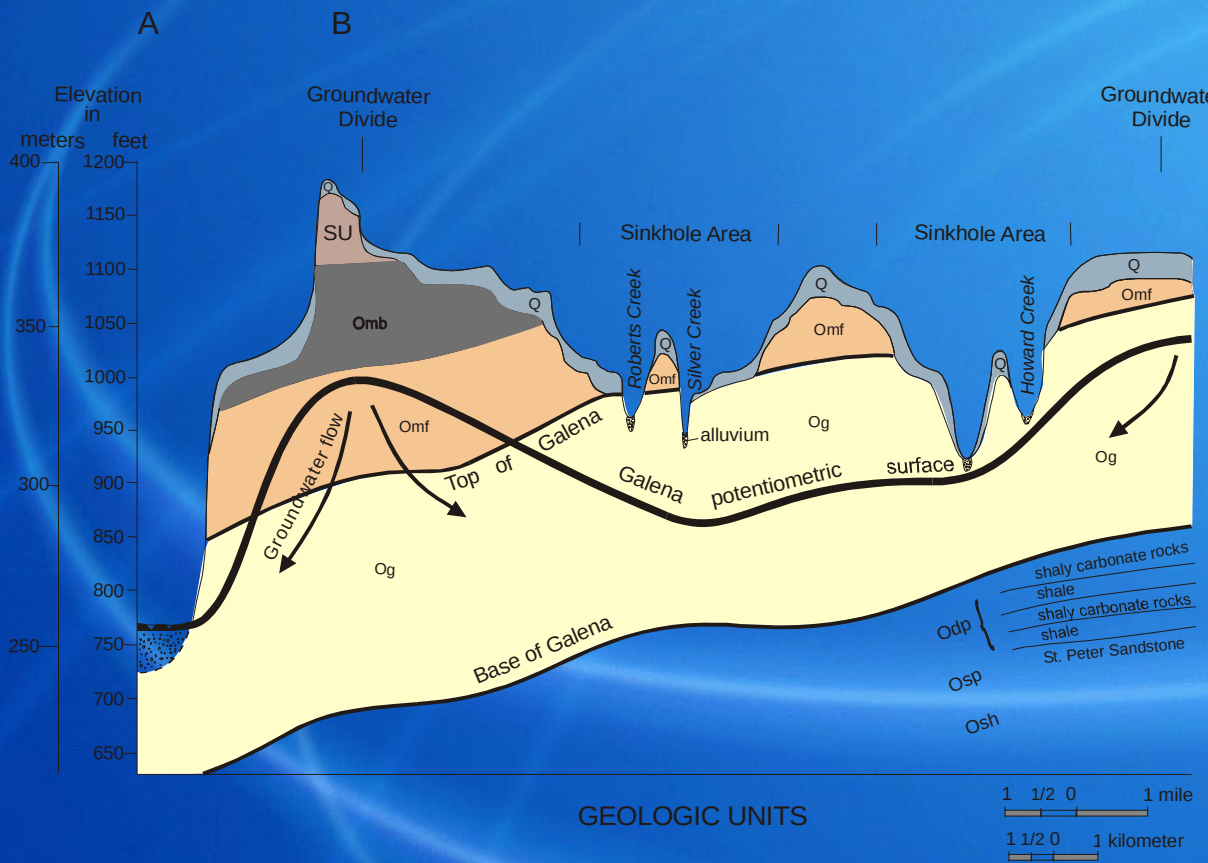


Bob Libra – State Geologist of Iowa
DNR – Iowa Geological & Water Survey


NE Iowa Watershed and Karst Map
Legend
Incorporated Cities
Karst - Within 1000 ft of sinkhole
Potential Karst - shallow bedrock
Public Lands
HUC 8 Watershed
HUC 12 Subwatershed
Highway
Counties
N
W
E
S
0
10
20
40
60
80
100
120
140
160
180
Miles

Geography and Geology of Big Spring





GEOLOGIC UNITS

Holocene alluvium (stream deposits)

Q Quaternary deposits undiferentiated loess, till, etc.

SU Silurian dolomites

Omb Maquoketa Formation Brainard Shale Member

Omf Maquoketa Formation Ft. Atkinson, Clermont, and Elgin Members

Og Galena carbonate rocks

Odp Decorah, Platteville, and Glenwood Fms.

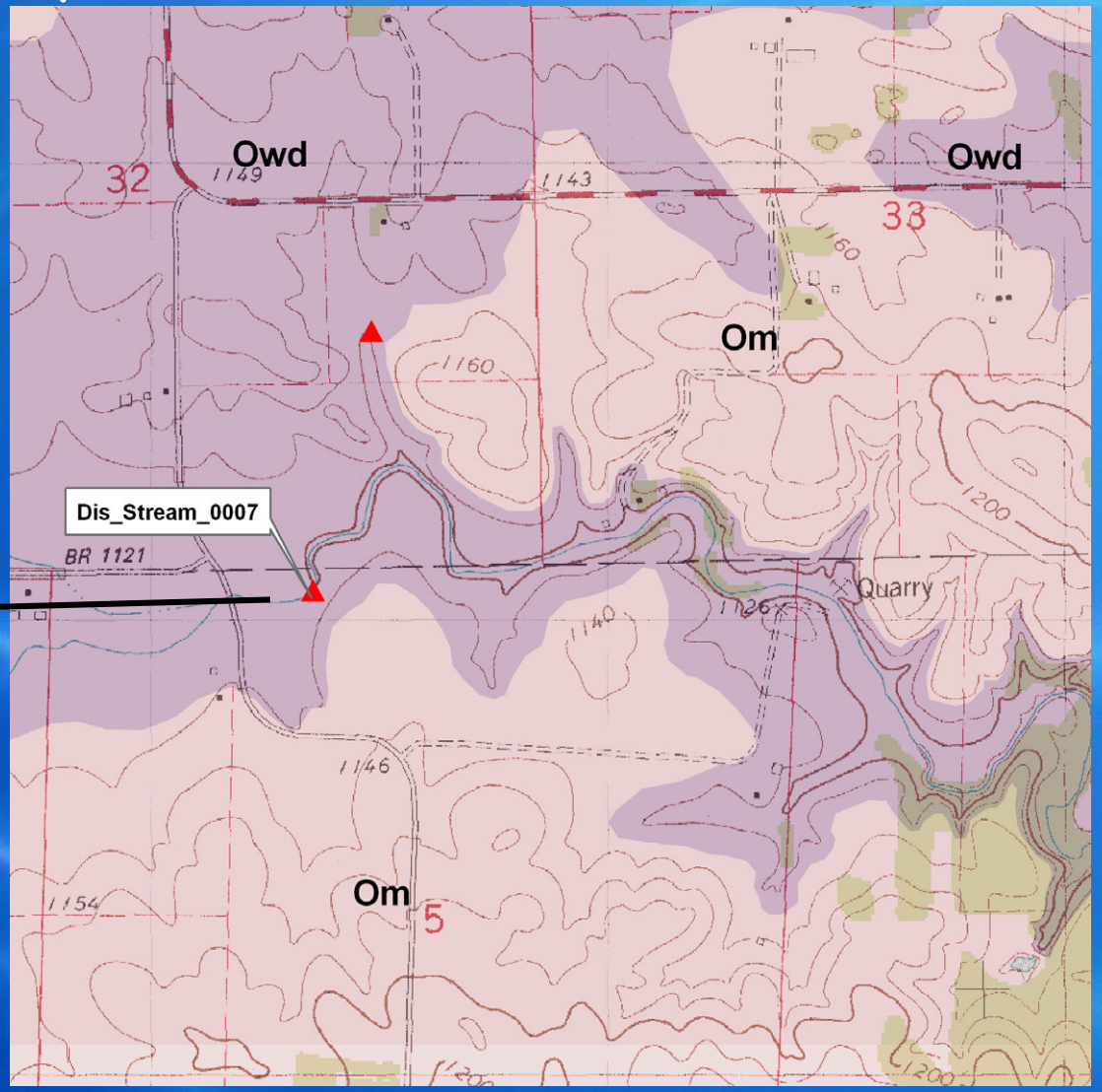
Osp St. Peter Sandstone

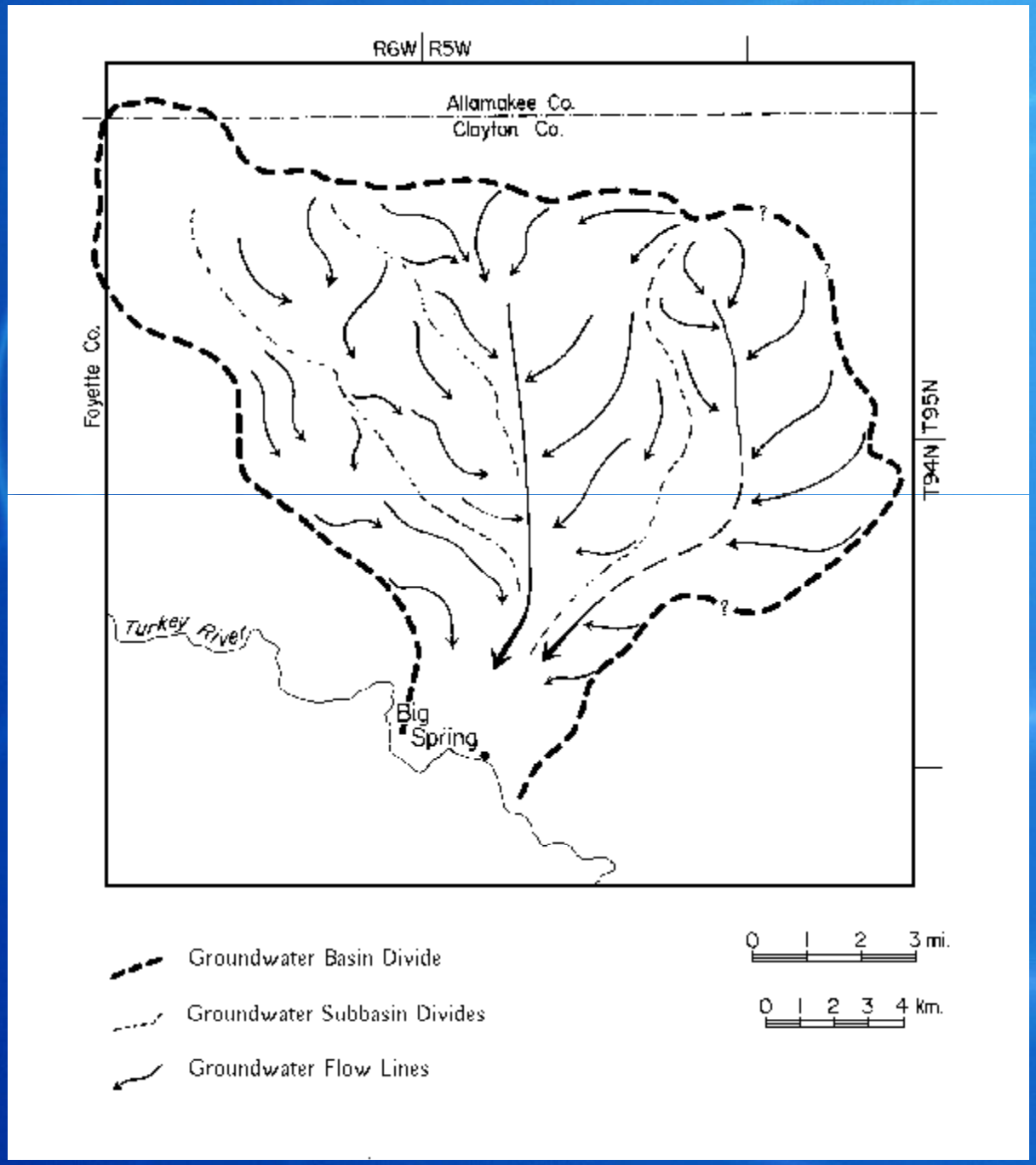
Osh Shakopee Formation

Disappearing Stream at the Maquoketa – Dubuque contact

Maquoketa

Dubuque




R6W
R5W
Allamakee Co.
Clayton Co.
Fayette Co.
T94N
T95N
Turkey River
Big Spring
Groundwater Basin Divide
Groundwater Subbasin Divides
Groundwater Flow Lines
0 1 2 3 mi.
0 1 2 3 4 km.

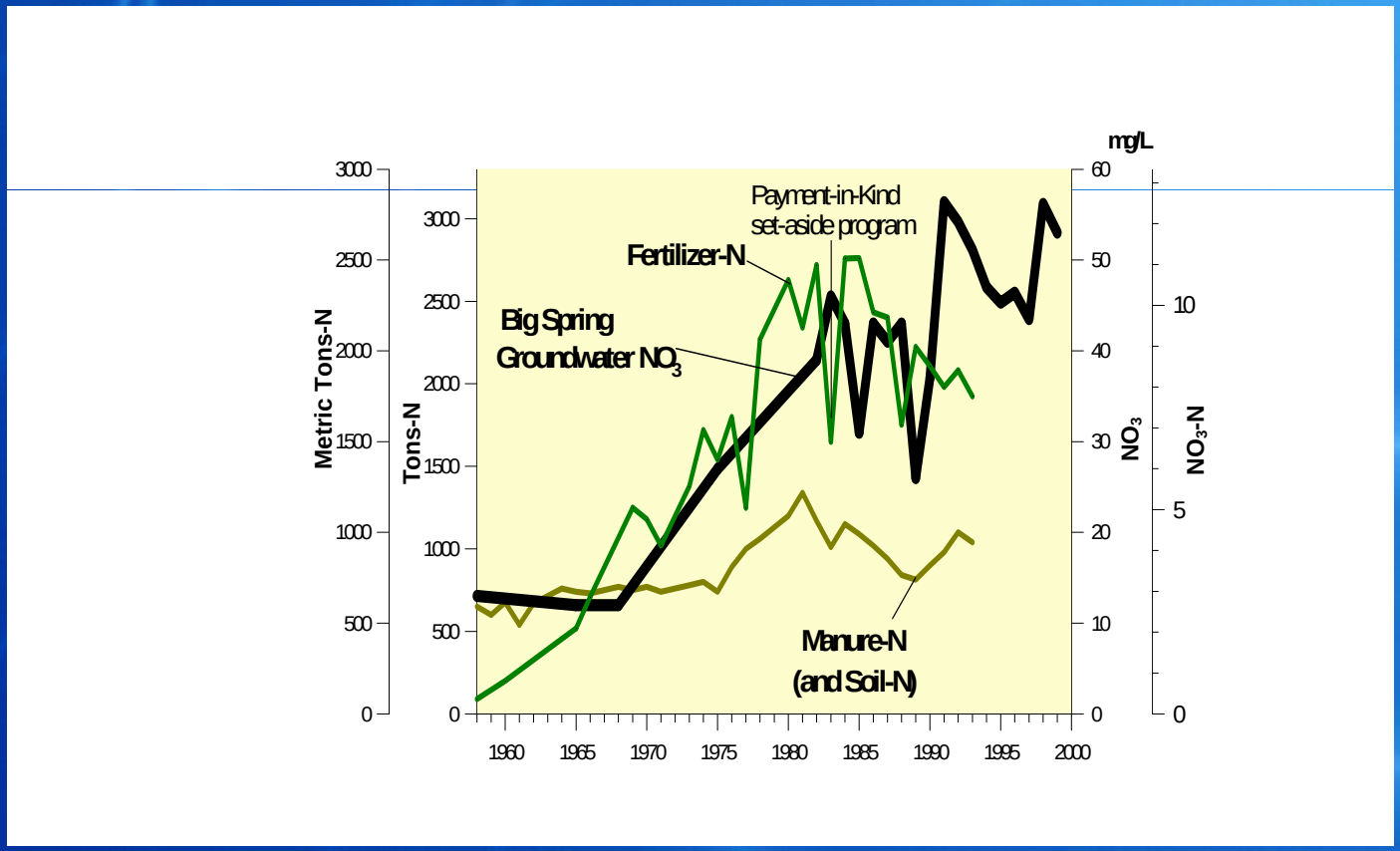
Big Spring Basin Demonstration Project

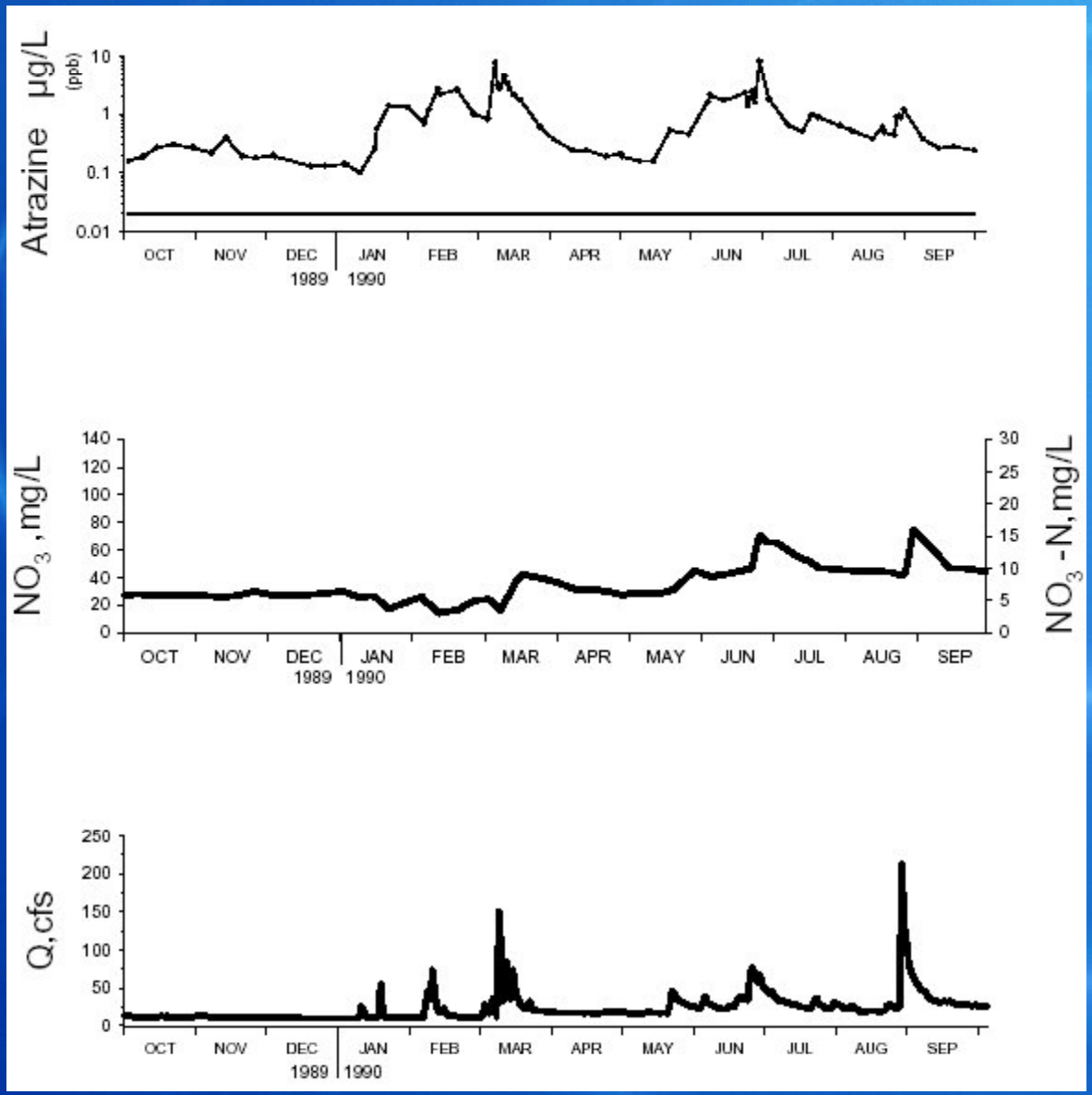
Increase the Economic and Environmental Performance of Agriculture

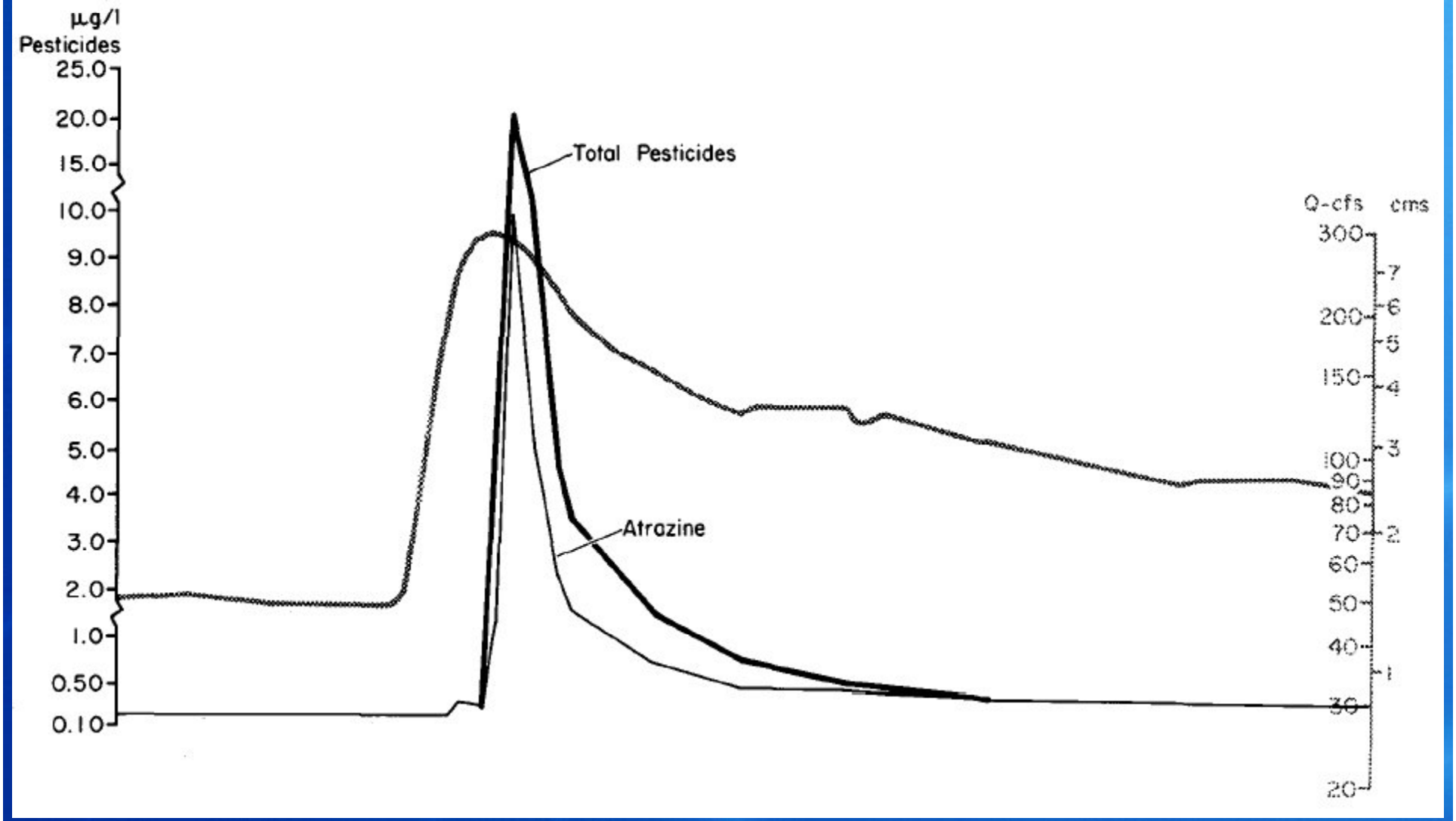
Target inputs to Actual needs

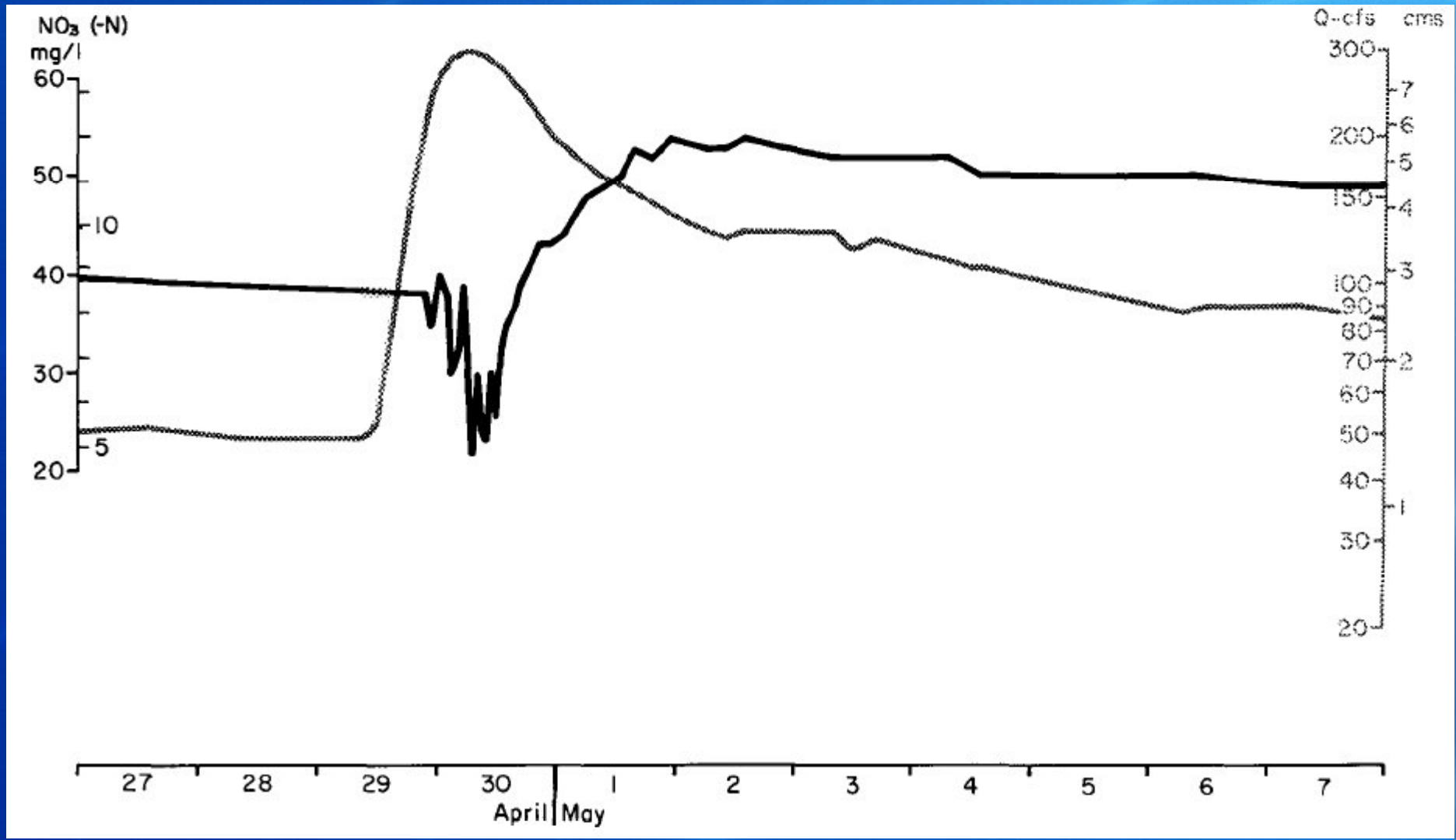
"Unused" Fertilizer and Chemicals are an Economic *and* Environmental Negative

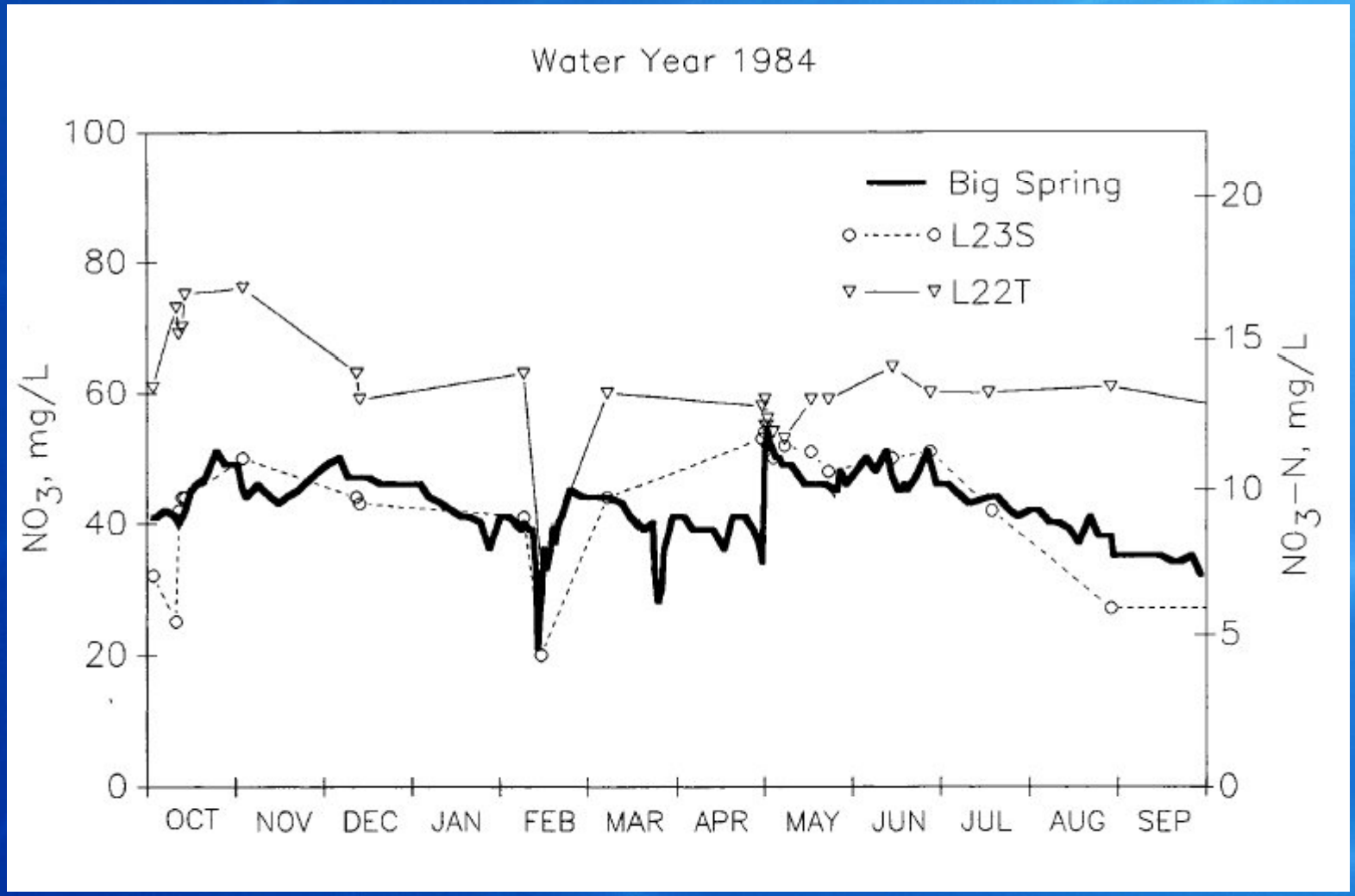
NO3 in water and N-Inputs to Big Spring Basin

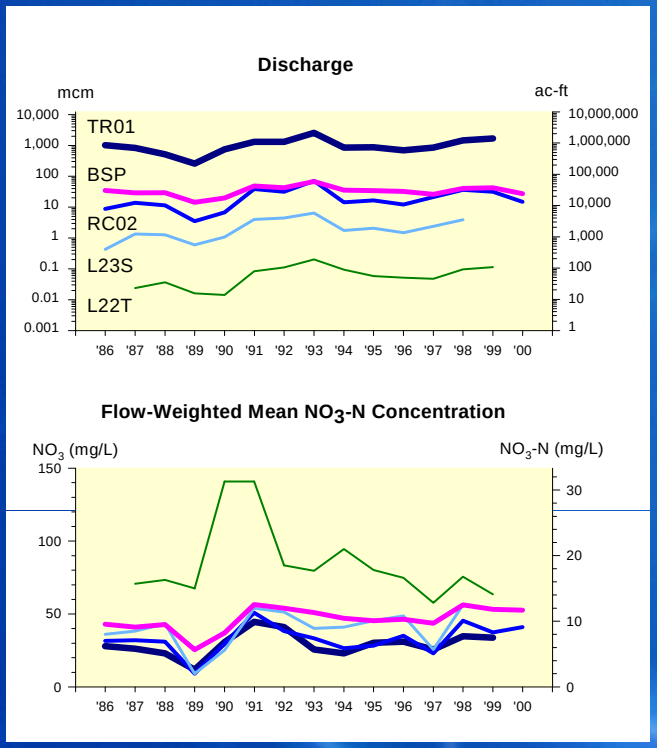


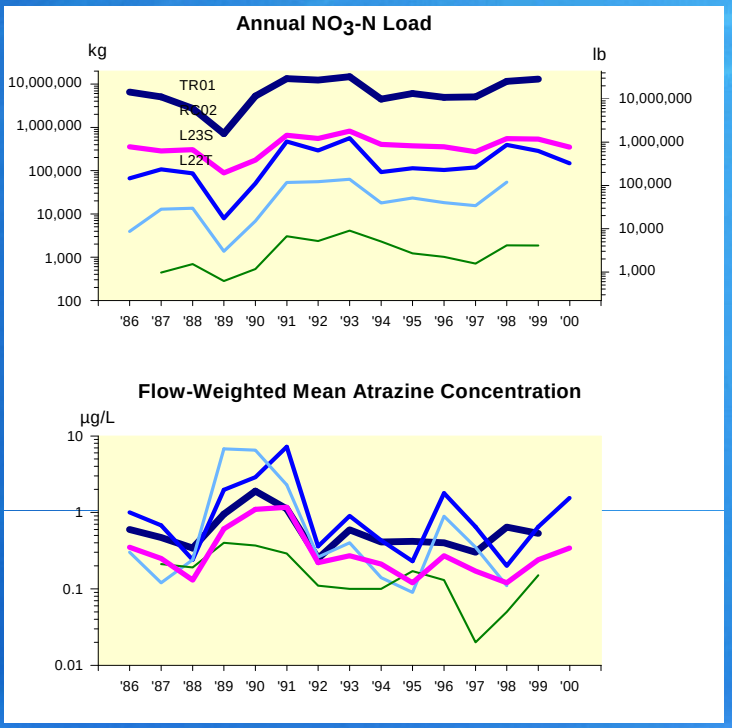

Atrazine µg/L
(ppb)
10
1
0.1
0.01
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1989
1990
NO3 ,mg/L
140
120
100
80
60
40
20
0
NO3 -N,mg/L
30
25
20
15
10
5
0
Q,cfs
250
200
150
100
50
0

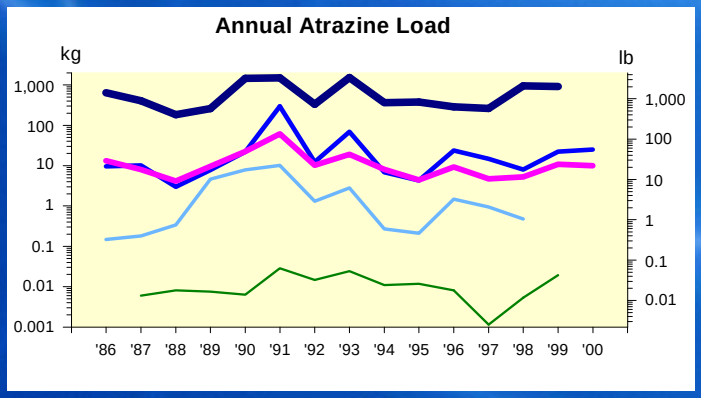

µg/l
Pesticides
25.0
20.0
15.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.50
0.10
Total Pesticides
Atrazine
Q-cfs
cms
300
200
150
100
90
80
70
60
50
40
30
20
7
6
5
4
3
2
1

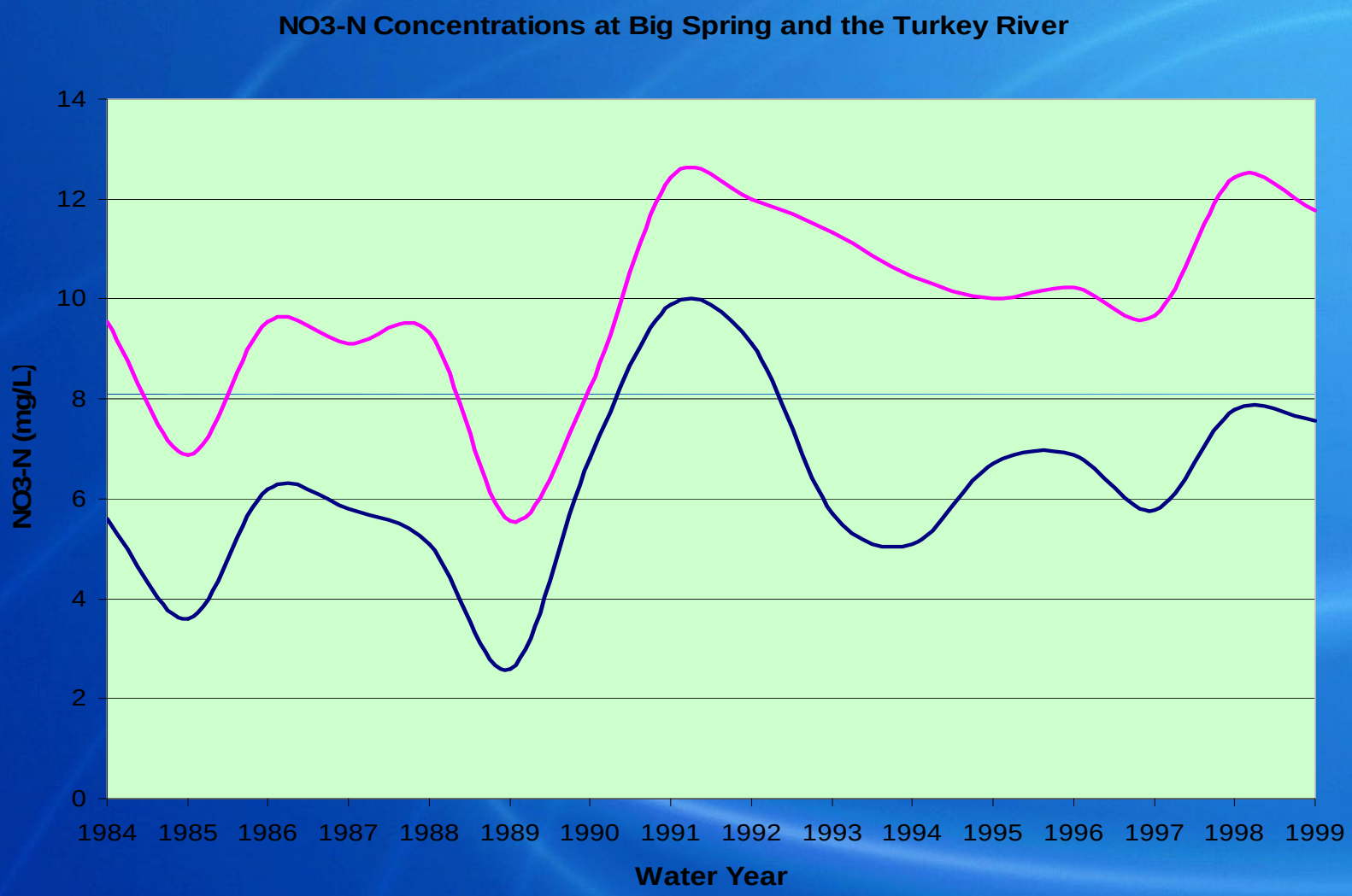

NO3 (-N)
mg/l
60
50
40
30
20
10
5
Q-cfs
cms
300
200
150
100
90
80
70
60
50
40
30
20
7
6
5
4
3
2
1
27
28
29
30
April
May
1
2
3
4
5
6
7

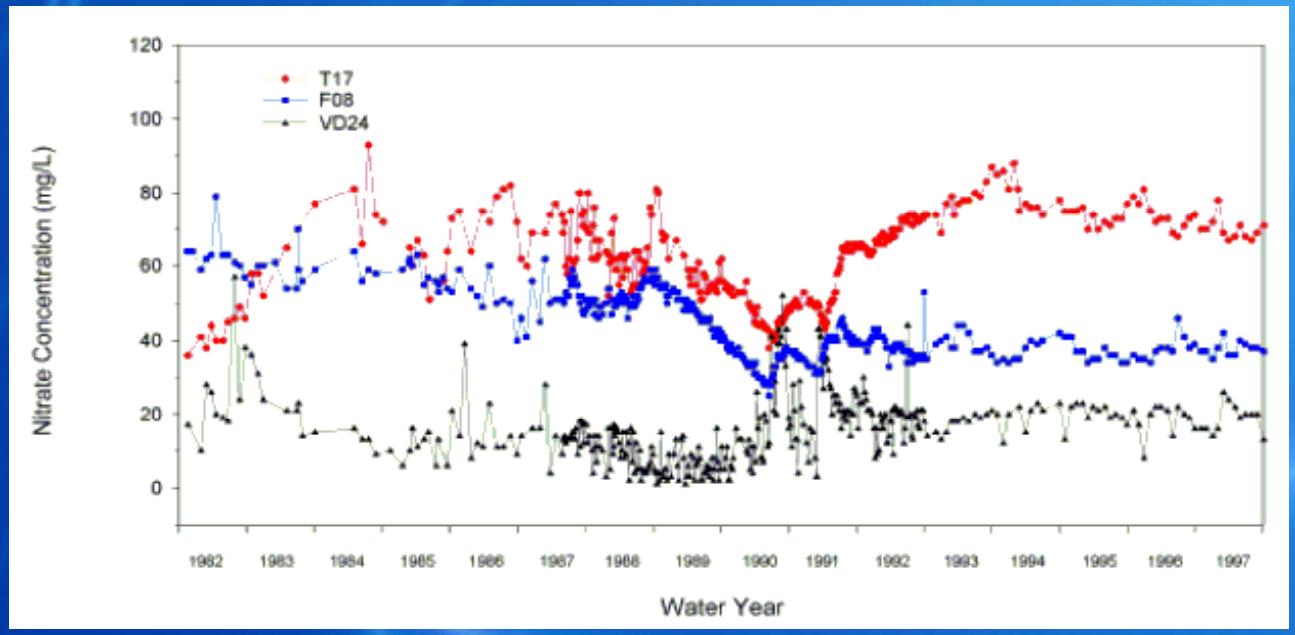

Water Year 1984
Big Spring
L23S
L22T
NO_3, mg/L
NO_3–N, mg/L
100
80
60
40
20
0
20
15
10
5
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP


Discharge
mcm
ac-ft
10,000
1,000
100
10
1
0.1
0.01
0.001
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
TR01
BSP
RC02
L23S
L22T
'86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00
Flow-Weighted Mean NO3-N Concentration
NO3 (mg/L)
NO3-N (mg/L)
150
100
50
0
30
20
10
0
'86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00


Annual NO3-N Load
kg
lb
10,000,000
1,000,000
100,000
10,000
1,000
100
10,000,000
1,000,000
100,000
10,000
1,000
TR01
RC02
L23S
L22T
'86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00
Flow-Weighted Mean Atrazine Concentration
µg/L
10
1
0.1
0.01
'86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00


Annual Atrazine Load
kg
lb
1,000
100
10
1
0.1
0.01
0.001
1,000
100
10
1
0.1
0.01
'86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00


NO3-N Concentrations at Big Spring and the Turkey River
NO3-N (mg/L)
0
2
4
6
8
10
12
14
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Water Year


T17
F08
VD24
Nitrate Concentration (mg/L)
120
100
80
60
40
20
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
Water Year

NO3-N Losses in the Big Spring Hydrologic System

Dry Years--Negligible

"Average" Years--Equivalent to 25-40% of Applied N

1993--Equivalent to over 100% of Applied N

Herbicides

Atrazine--Present year-round; others after recharge

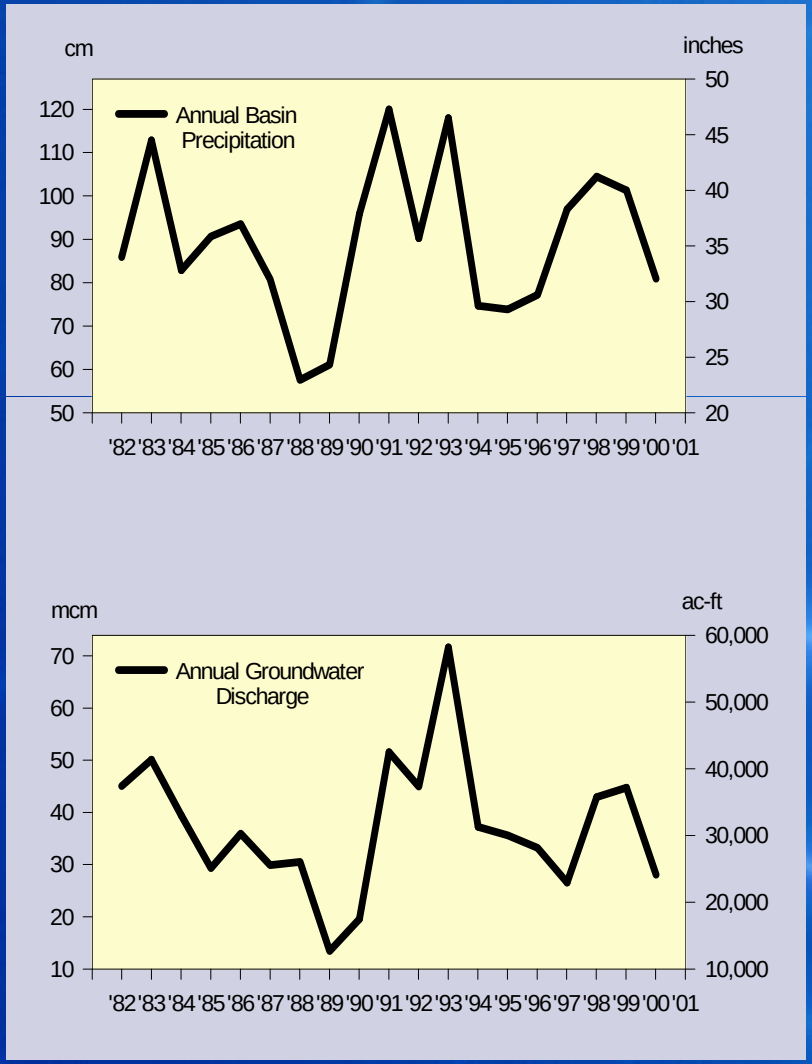
Basin average fertilizer-nitrogen rates

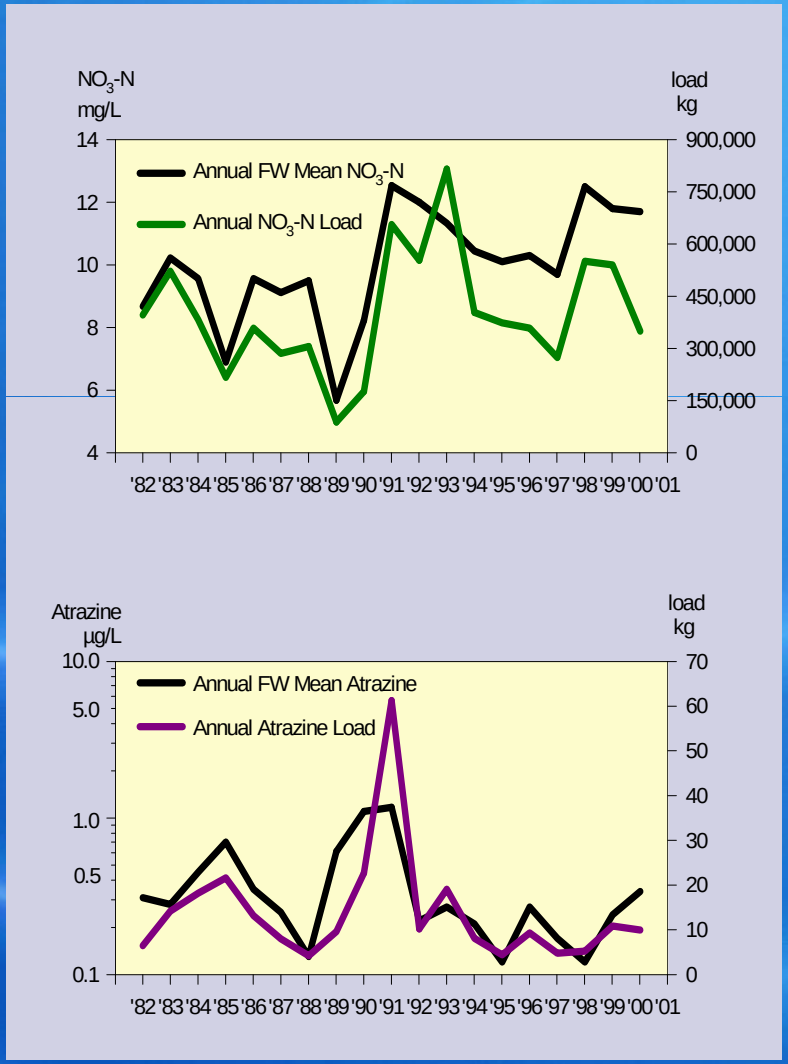
Rotation	All corn	1st-year corn after alfalfa	2nd-year corn after alfalfa	Continuous corn	Average Yield Continuous corn yields
Year	.....lbs N/Acre.....				Bushels/Acre
1981	174	123	160	178	128
1982	174	123	...	178	138
1984	158	115	155	169	130
1986	147	96	...	153	149
1987	149	84	121	157	141
1988	141	84	124	151	79*
1989	138	82	125	148	147
1990	123	66	121	145	145
1991	117	59	112	131	138
1992	117	...	...	128	165
1993	115	55	117	124	110**

* drought lowered yields in the basin and across Iowa

** frequent rains lowered yields in the basin and across Iowa

Big Spring
Water Years 1982-2000





Demonstration Project Results:

Producers incrementally decreased N-inputs by 30%

Watersheds respond slowly to changes in N-inputs

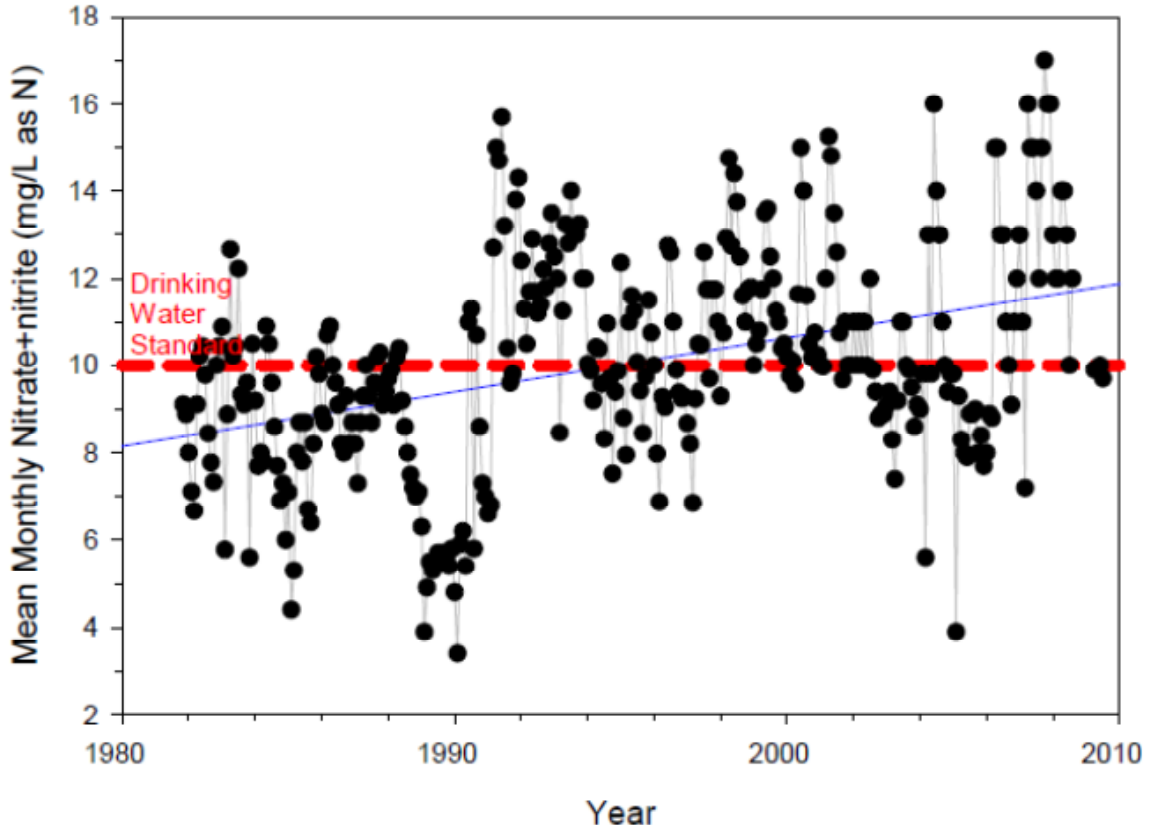
Water-flux varied 5-fold

Changes in NO3 lost in the hydrologic "noise"

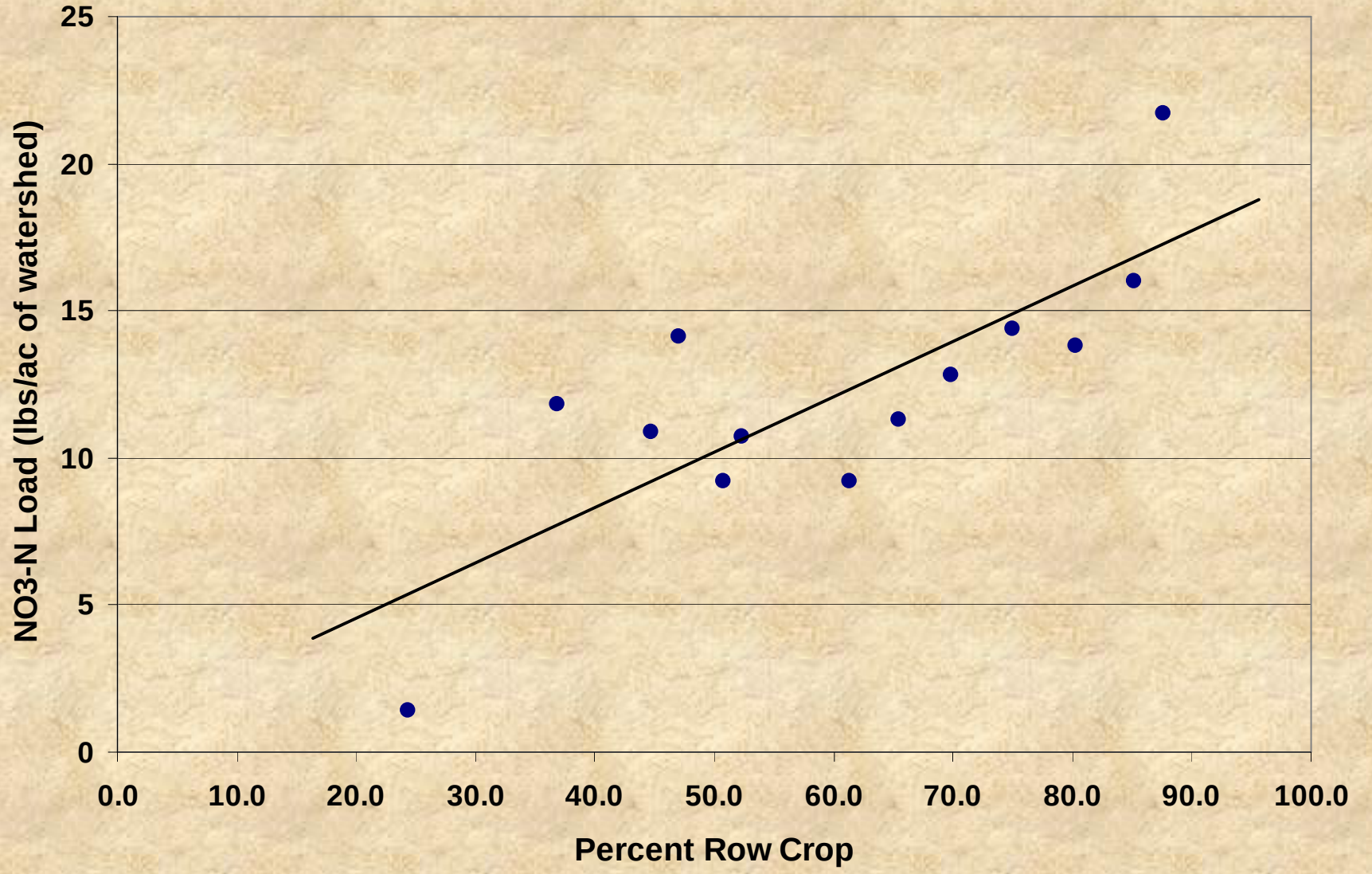
Factors Beyond N-Inputs—*Cropping*, Tillage

Nitrate – Big Spring Groundwater

Row – Crop:	45%	57%	64%	71%
	(1982)	(1992)	(2002)	(2009)

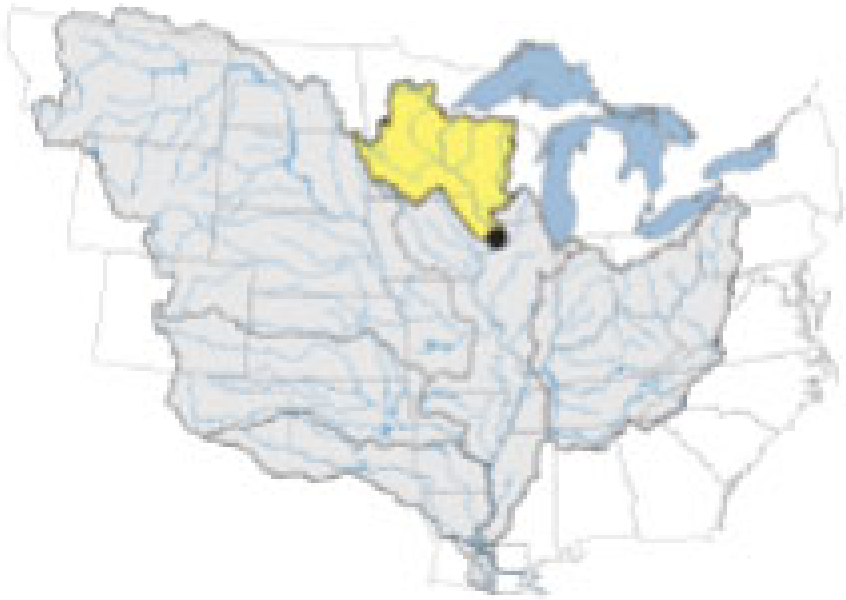


Row Crop vs Nitrate - IA HUC-8 Watersheds



Nitrate in the Mississippi River and Its Tributaries, 1980 to 2008: Are We Making Progress?

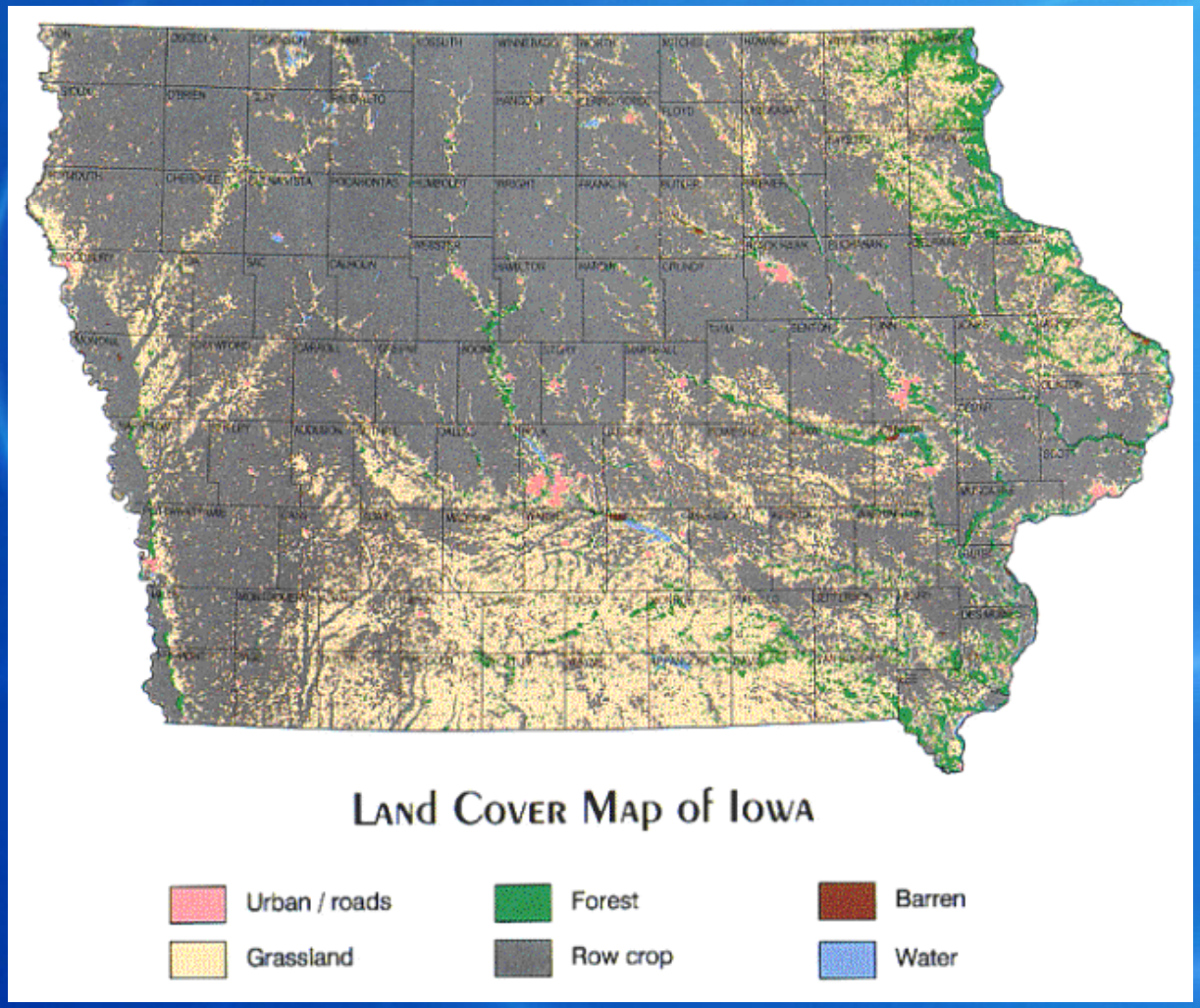
Lori A. Sprague, Robert M. Hirsch, and Brent T. Aulenbach

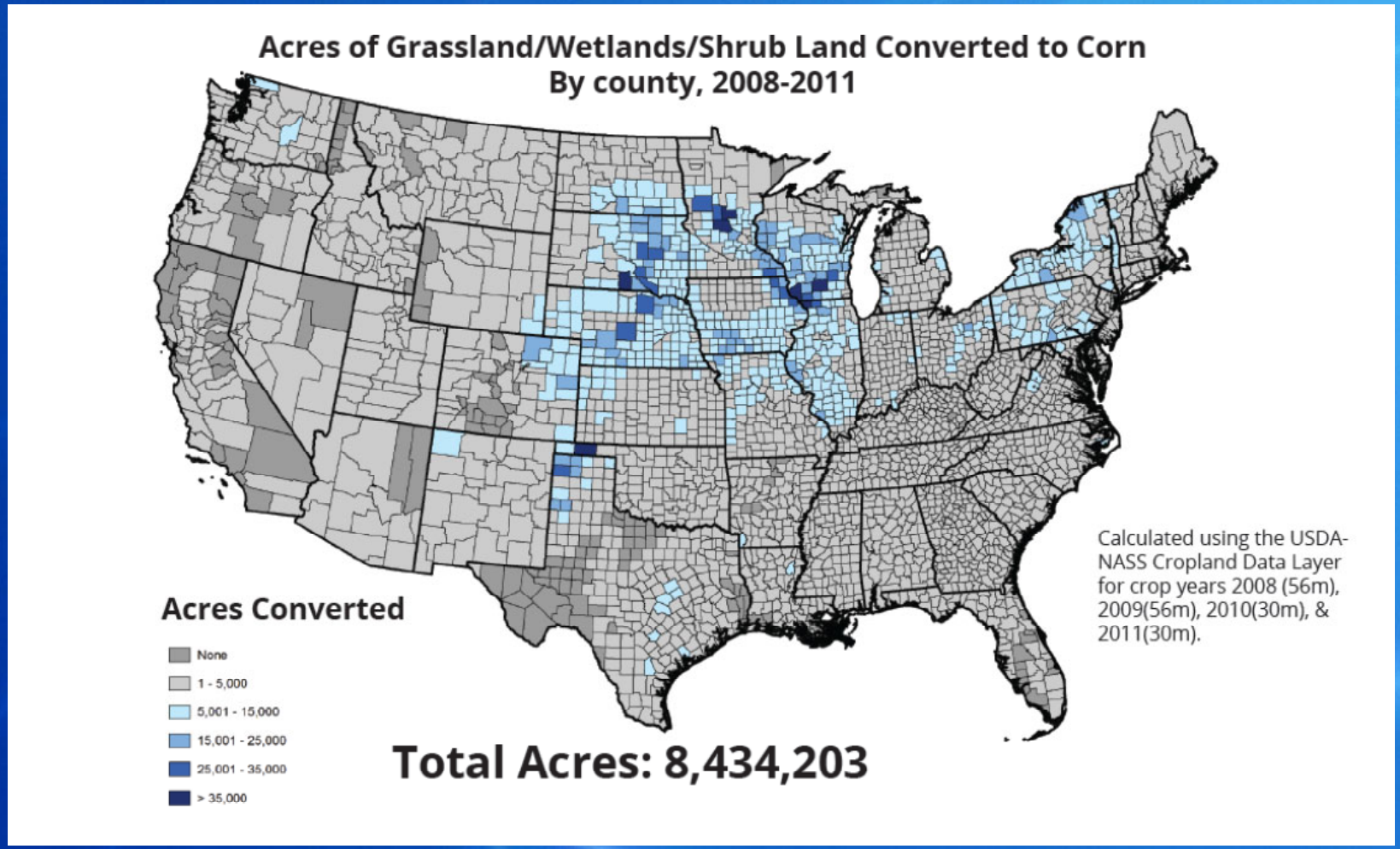


Mississippi above Clinton IA:

Nitrate Concentration
Increased 76%

Nitrate Load
Increased 67%


Land Cover Map of Iowa
Urban / roads
Forest
Barren
Grassland
Row crop
Water



From "Plowed Under". Faber, Rundquist, and Male, *The Environmental Working Group*