USGS Water Quality Research –
National Water Quality Assessment Program

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NP211 Customer/Stakeholder Workshop,

USDA-ARS, Beltsville MD

Wednesday, May 20th, 2015

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National Water Quality Assessment Program

- Decadal – Cycle 3 started in 2013
- **Surface water quality**:

  National Monitoring and Status Assessment Trend Analysis

  SPARROW and WARP Modeling

- **Groundwater quality**:

  Status and Trends

  Modeling and Mapping (statistical methods, MODFLOW/MODPATH)

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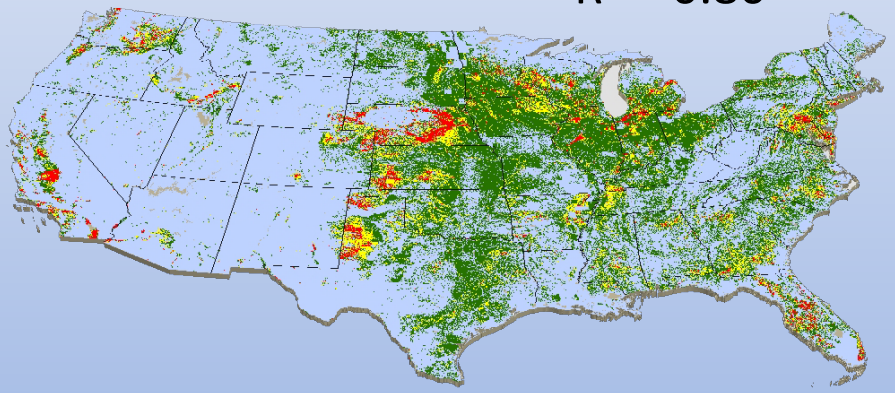
Previous Modeling (Nitrate), Cycle 2 (2003-2012)

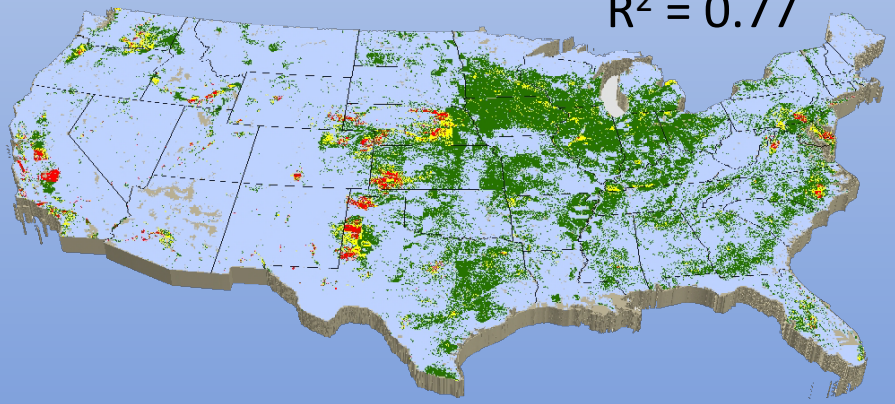
SHALLOW GROUNDWATER (< 50 m)

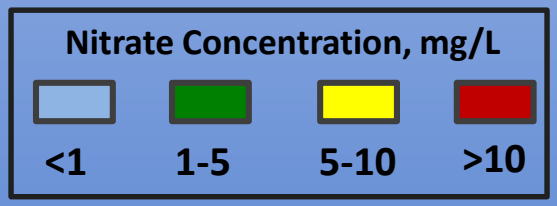
$R^2 = 0.80$



GROUNDWATER AT DEPTH USED FOR DOMESTIC SUPPLY

$R^2 = 0.77$





Nolan and Hitt, 2006, ES&T

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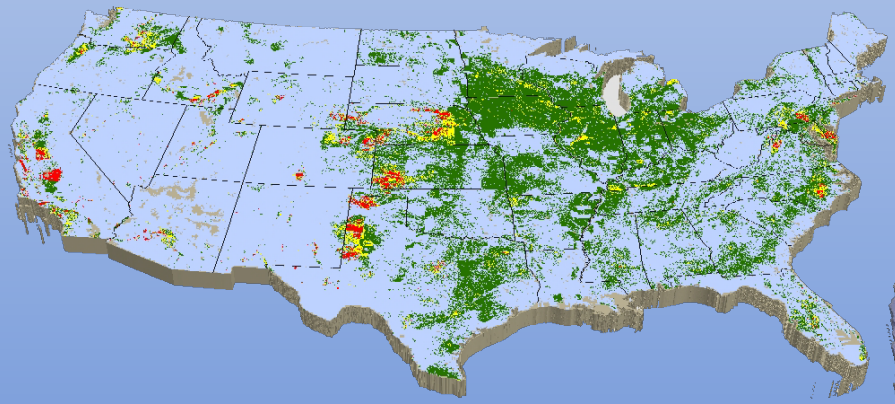
Planned National Scale Models in Cycle 3

- Trace elements (arsenic, uranium, boron)
- Nutrients (nitrate, phosphorus)
- Nuisance constituents (iron, dissolved solids, manganese)

Intermediate Depth
Used for Domestic Supply



Deeper Depth
Used for Public Supply

Nitrate Concentration, mg/L

<1	1-5	5-10	>10

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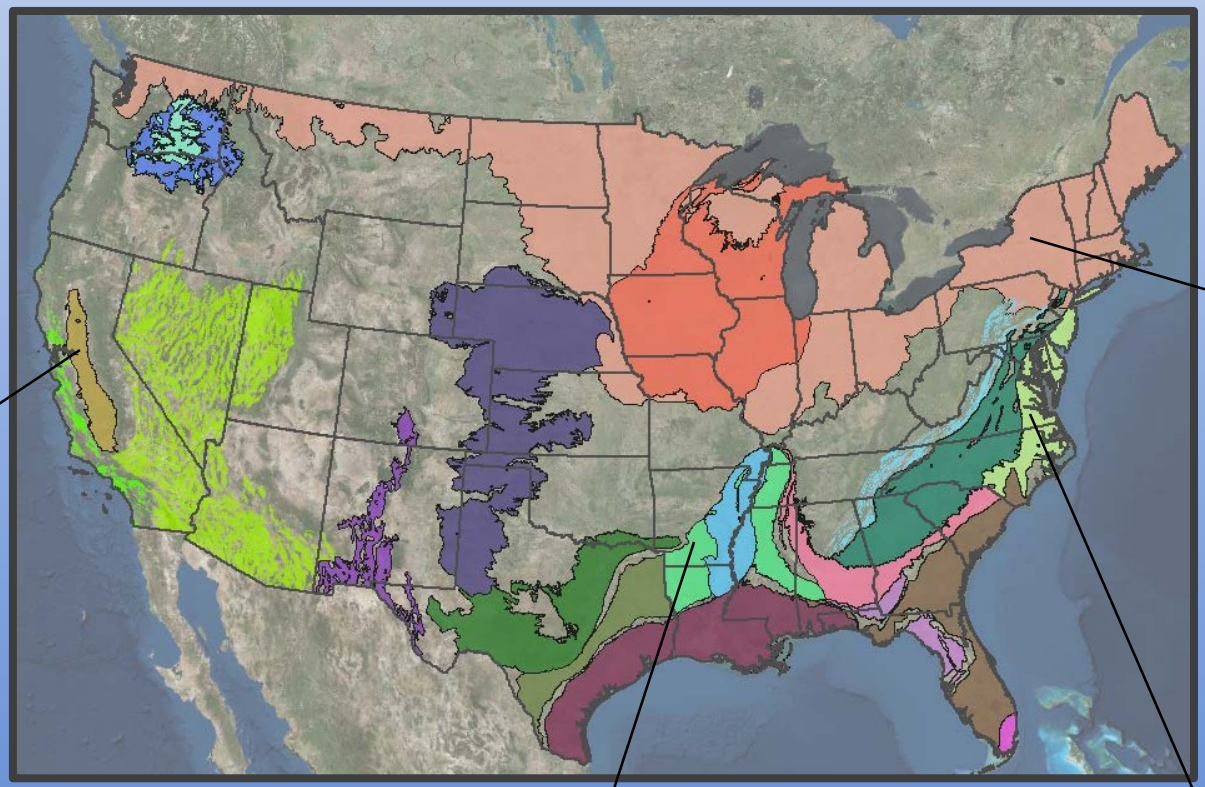
Nolan and Hitt, 2006, ES&T

Planned Principal Aquifer Scale Models

DOMESTIC & PUBLIC-SUPPLY WELL DEPTH ZONES

- Trace elements (arsenic, uranium, boron)
- Nutrients (nitrate, phosphorus)
- Nuisance constituents (iron, manganese, dissolved solids)
- Others



Central Valley Principal Aquifer (2013 – 2018)

Glacial Principal Aquifer (2014 – 2019)

Mississippi Embayment Principal Aquifer (2016 – 2021)

Northern Atlantic Coastal Plain Principal Aquifer (2015 – 2020)

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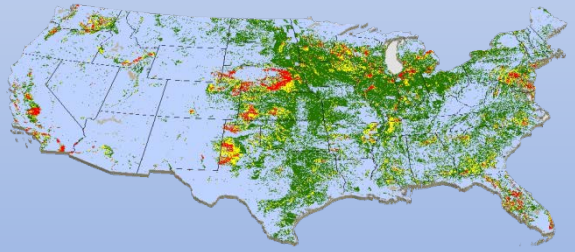
National Groundwater Nitrate Model



Parameter	Significance Level
Nitrogen source (β)	
Farm fertilizer (county sales)	0.002
Confined manure (Census of Ag)	0.004
Orchards/vineyards	0.023
Population density	<0.001
Cropland/pasture/fallow	0.014
Transport to aquifer (α)	
Water input	0.009
Carbonate rocks	0.001
Basalt and volcanic rocks	0.105
Drainage ditch	<0.001
Slope	0.001
Glacial till	0.001
Clay sediment	<0.001
Attenuation (δ)	
Fresh surface water withdrawal	<0.001
Irrigation tailwater recovery	<0.001
Histosol soil type	0.100
Wetlands	0.036

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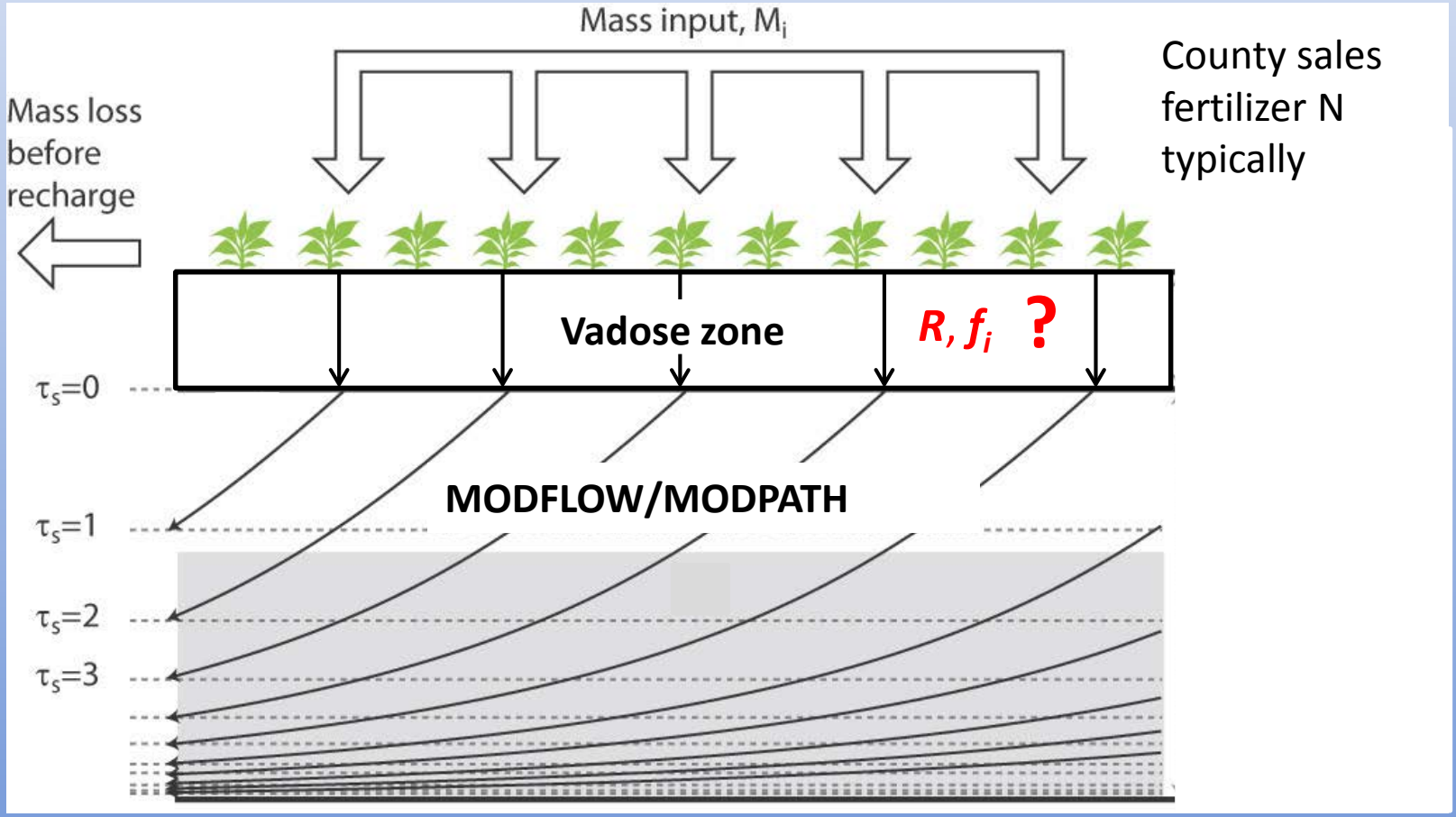
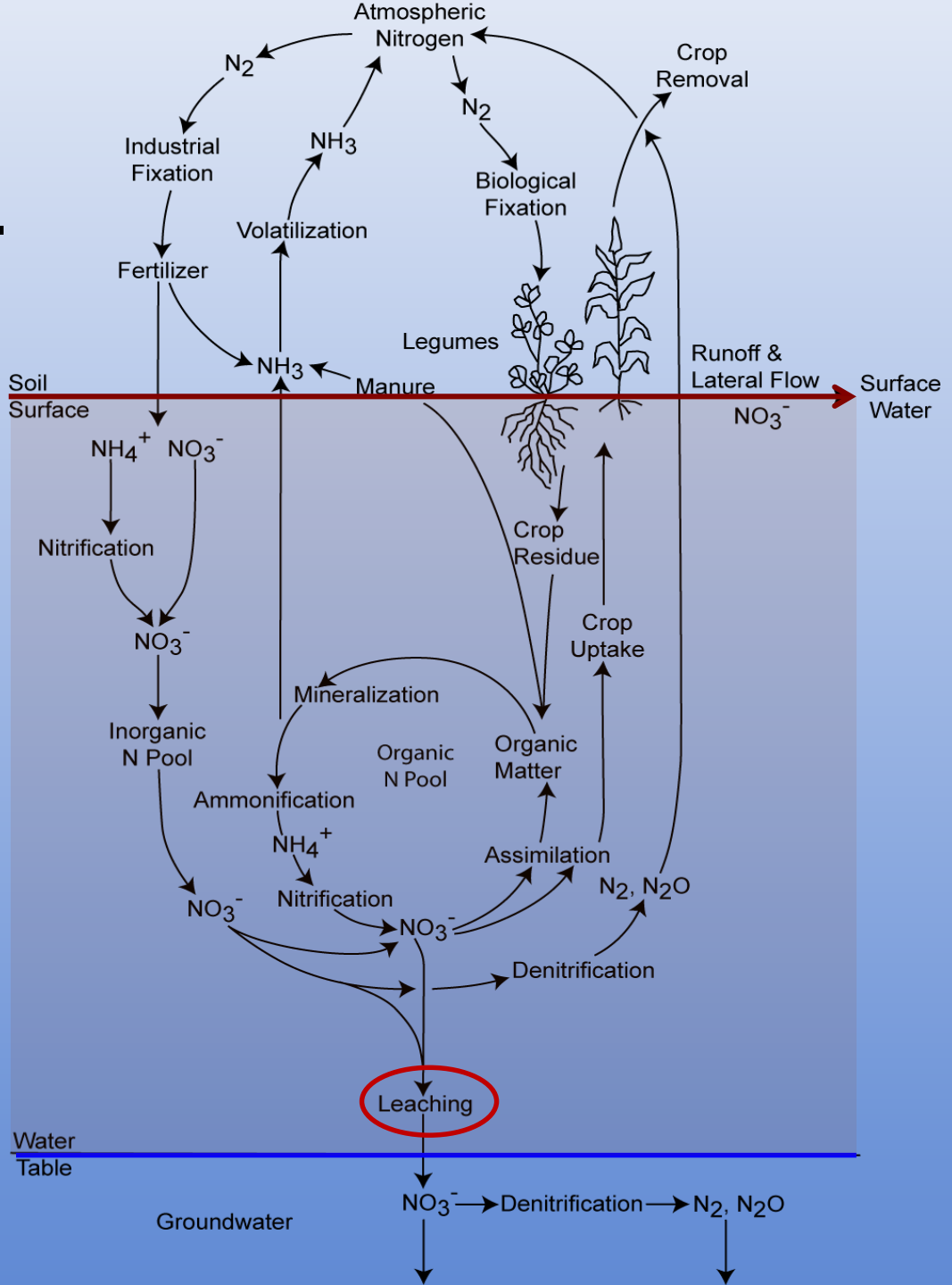
MODFLOW/MODPATH



County sales fertilizer N typically

from Chris Green et al., AGU 2011

f_i influenced by many processes.



Knowledge Gaps for Models

- Better understanding of unsaturated zone – what is net N flux to water table?
- What is water flux (recharge) to water table?
- Can these be estimated at regional and national scales?
- How improve on county-sales fertilizer N estimates that previous models used?
  - Statistical water-quality models (GWAVA, SPARROW)
  - MODFLOW/MODPATH

Prior USDA-USGS Collaborations

L. Ahuja, L. Ma, R. Malone, P. Bartling

- RZWQM for understanding unsaturated zone N mass balances
- Scale-up of RZWQM using “metamodel” approach (Corn Belt)
- Successful integration of Parameter ESTimation software (Doherty) into RZWQM’s GUI for autocalibration
- Beopest for parallel operation of RZWQM in PEST


Thank you for your attention.
Questions?
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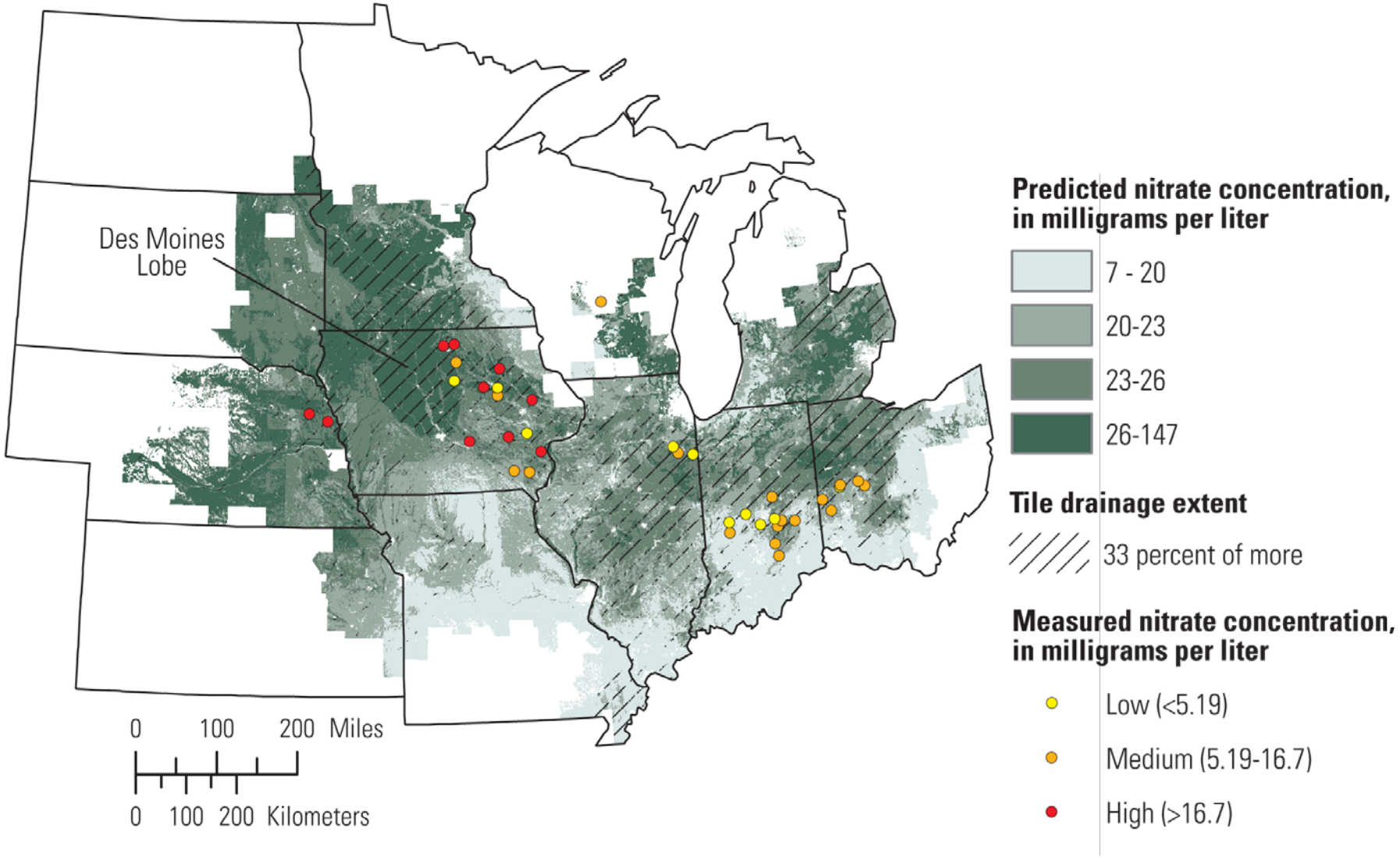
Table 3.12. Frequency of exceedance (percent) of a human health benchmark by constituent class by predominant well type by study components (LUS, MAS, PAS) (Modified from Ayotte and Gronberg, 2011). [E. coli, *Escherichia coli*; VOCs, volatile organic compounds; Ag, agricultural; LUS, land-use study; MAS, major aquifer survey; SWA, source water assessment; PSW, public supply well].

			Pathogens			Radiochemistry			
Network Type	Trace Elements	Nitrate	Total coliform	E. coli	Enteric viruses	Gross alpha	Ra 226 & 228	VOCs	Pesticides
Ag LUS Monitoring wells	26	20	67	30				3	1
Urban LUS Monitoring wells	28	3	35	17				2	4
MAS Domestic wells	13	4	33	8				<1	<1
MAS Public Supply wells	13	2	16	3	24			2	2
MAS & SWA PSW	10+					5	19		
Mixed well types							4		

Contaminant	Contaminant type	Number of wells sampled	Frequency of concentrations greater than benchmark (percent of wells)	Human-health benchmark		Potential health effects from exposure above the human-health benchmark
				Value	Type	
Radon	Radionuclide	1,958	4.4 65	4,000 pCi/L 300 pCi/L	Proposed MCLs	Increased risk of lung cancer [1,2]
Strontium	Trace element	488	7.3	4,000 µg/L	HBSL	Abnormal bone development [3]
Arsenic	Trace element	1,774	6.8	10 µg/L	MCL	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer [4,5]
Manganese	Trace element	2,159	5.2	300 µg/L	HBSL	Neurological effects [6]
Nitrate	Nutrient	2,132	4.4	10 mg/L as N	MCL	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome [4,5]
Uranium	Trace element	1,725	1.7	30 µg/L	MCL	Increased risk of cancer, kidney toxicity [4,5]
Boron	Trace element	535	1.3	1,000 µg/L	HBSL	Gastrointestinal, reproductive, and developmental effects [7,8]
Fluoride	Major ion	2,157	1.2	4 mg/L	MCL	Bone disease (pain and tenderness of the bones); children may get mottled teeth [4,5]

Previous Work with RZWQM – Scale-Up for Nitrate in Leachate and Drains



Nolan, Malone, Ma et al., 2012, ES&T