EPA Ag Wg
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Advancing the Science of Nutrient Fluxes from Small Agricultural Catchments in Maryland: *Current Research & Collaboration Opportunities*

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COLLEGE OF AGRICULTURE & NATURAL RESOURCES

FEARLESSLY FORWARD

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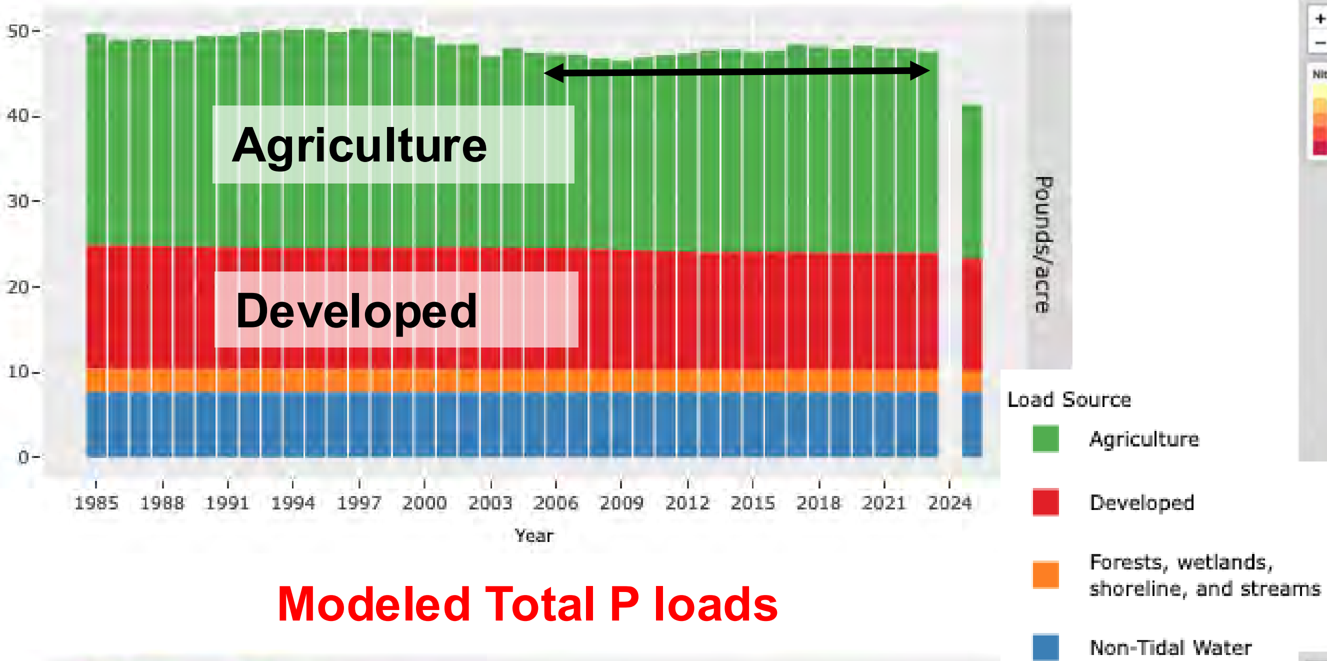
Roadmap

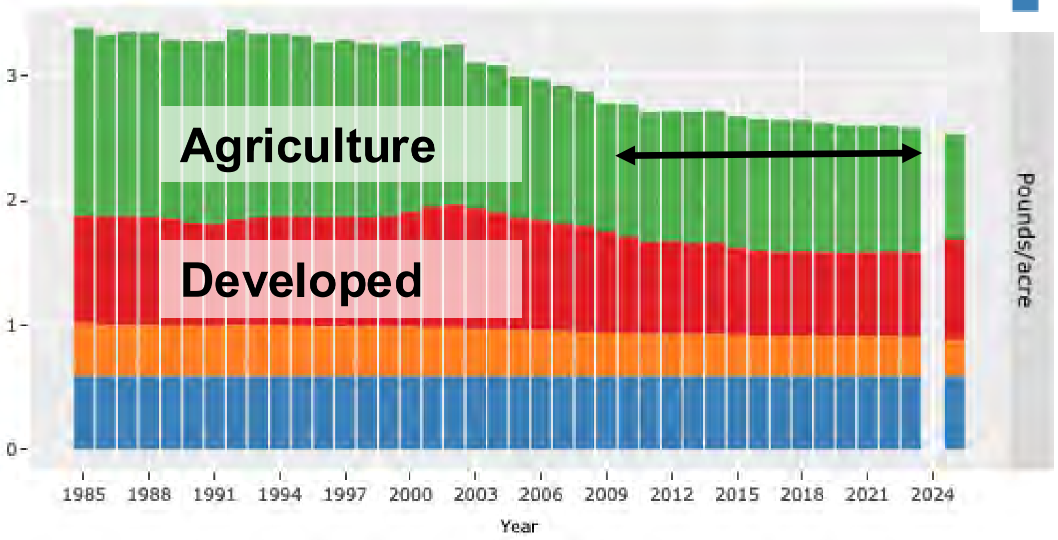
1. Context/Background
2. Catchments selection process
3. Instrumentation
4. Data discussion: a few examples
5. Future plans & opportunities to collaborate: *modeling, decision support tools*

1. Context: Nutrient losses to Chesapeake Bay

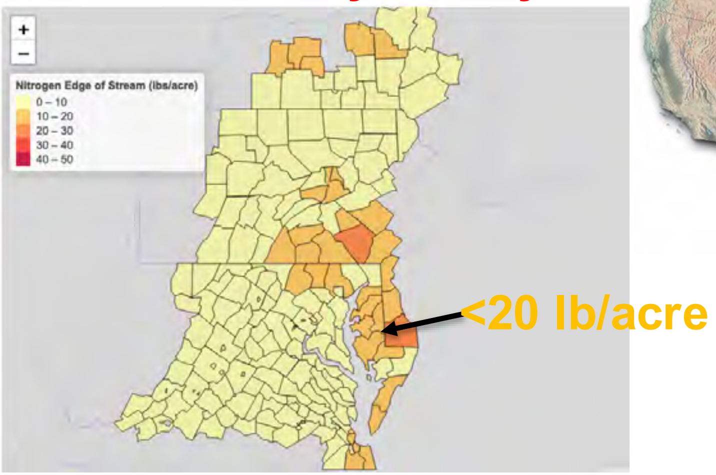
Modeled Total N loads



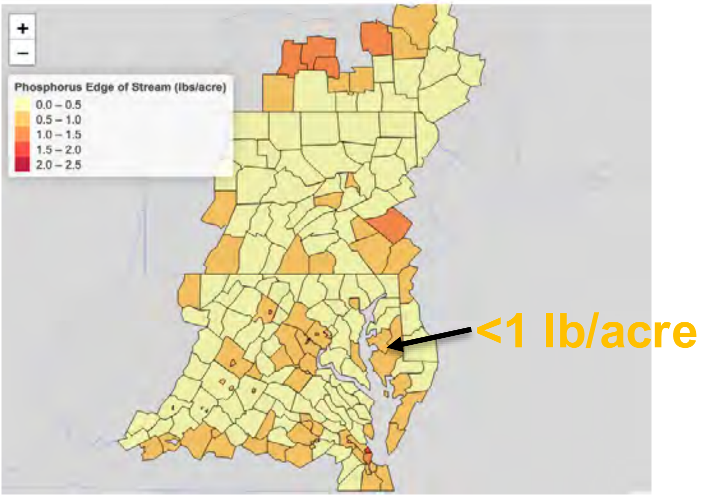
Modeled Total P loads



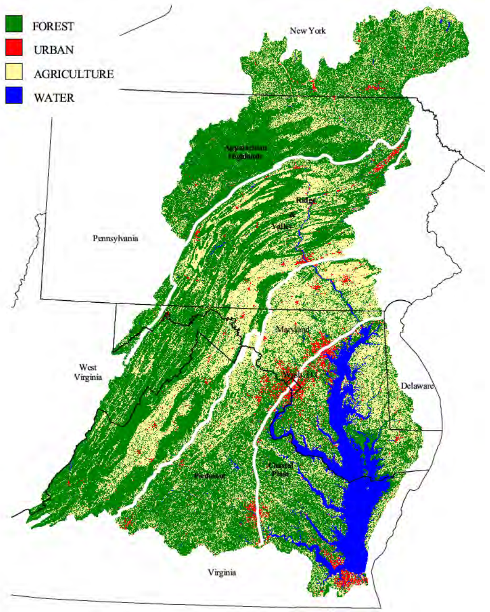
Total N loss by county



Total P loss by county



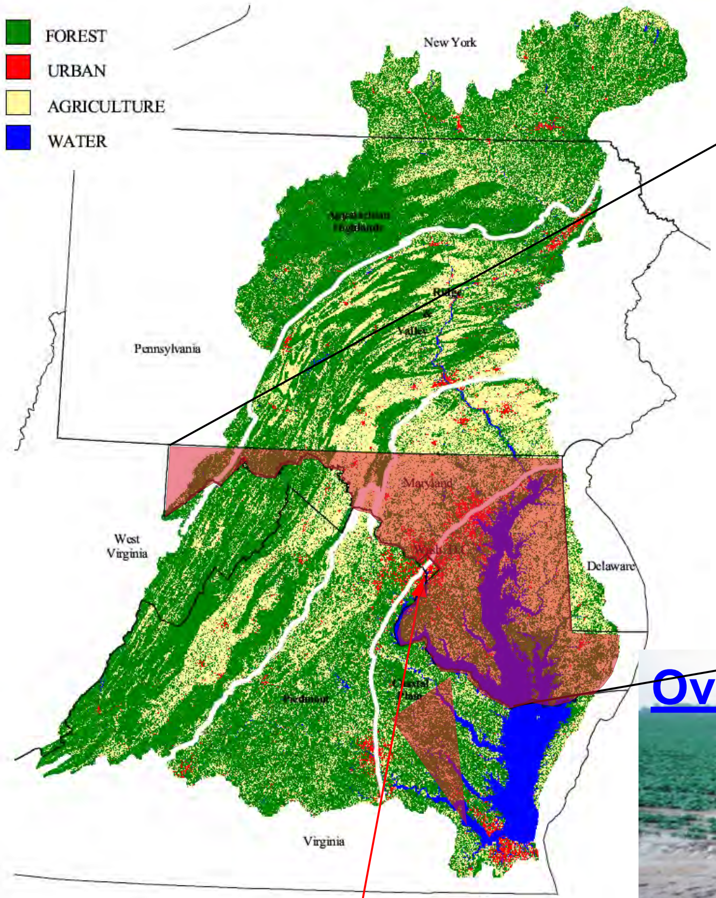
Chesapeake Bay Watershed



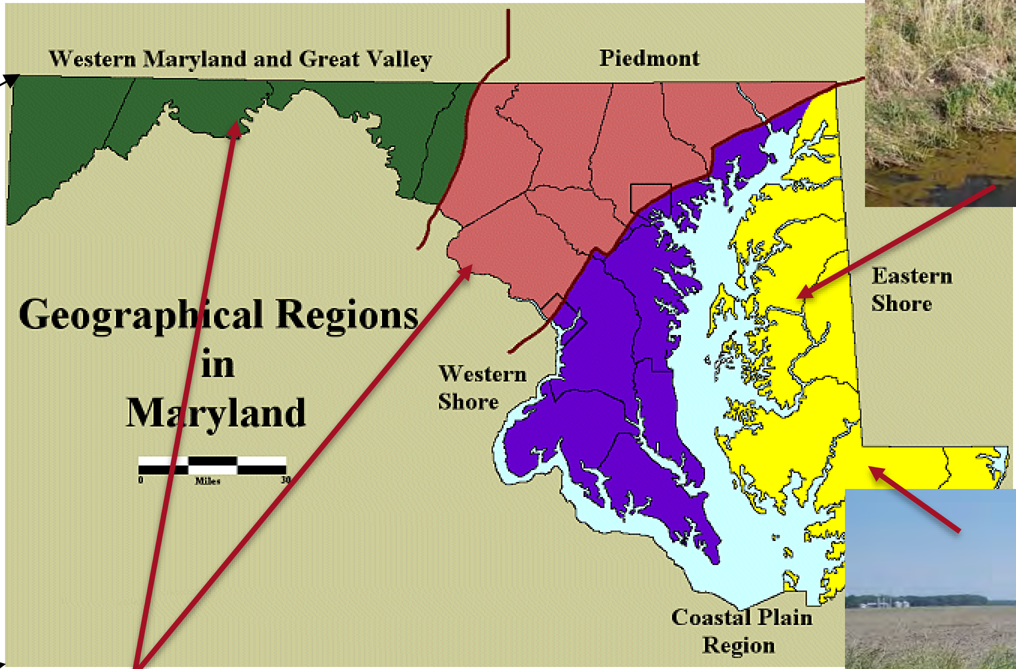
https://cast.chesapeakebay.net/EstuaryTrends/Loads

Flow Pathways in the Landscapes

Chesapeake Bay Watershed



Washington DC

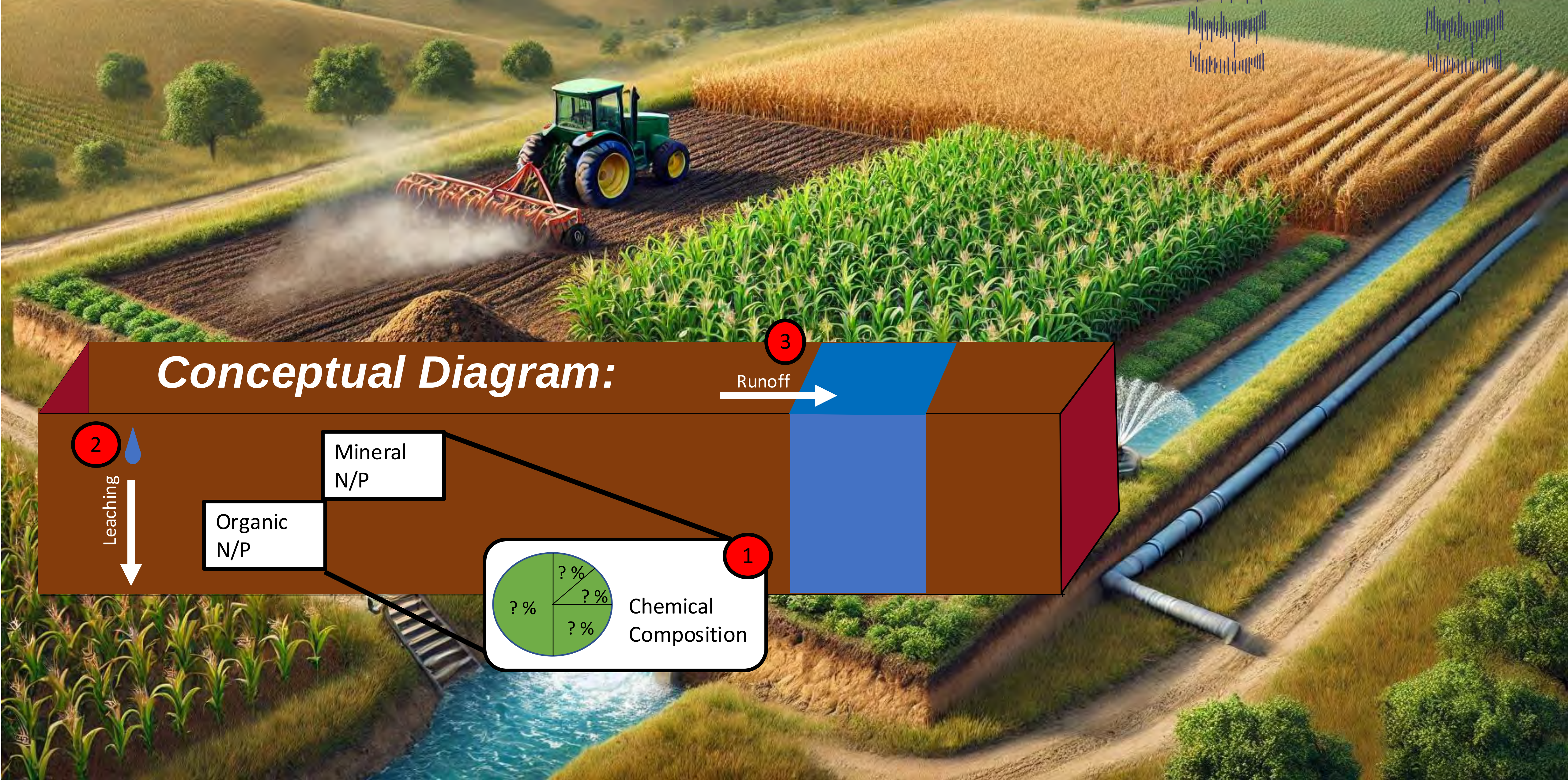


Tile drains: Less connectivity to the sources (nutrients loss through soil profile)

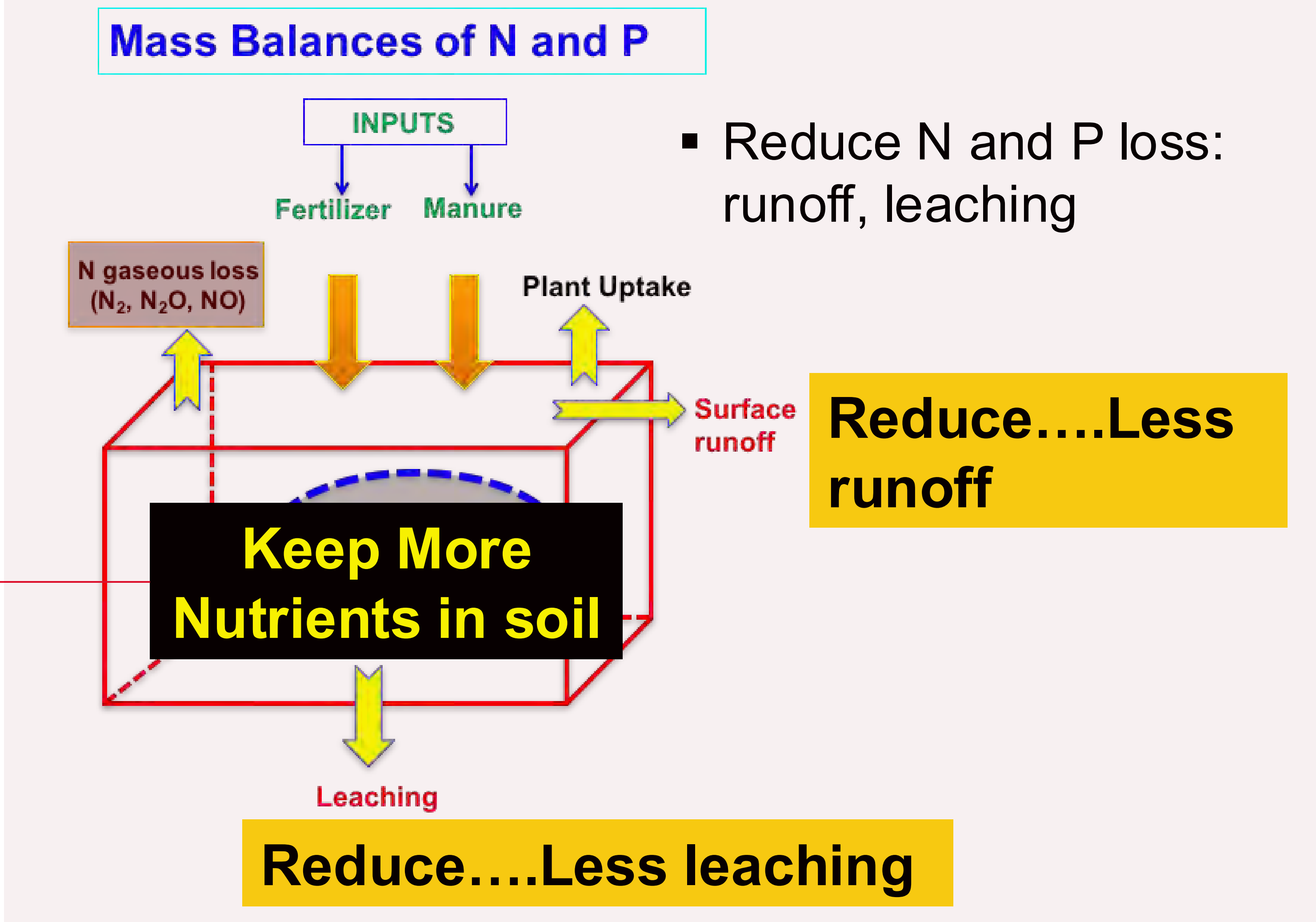
Overland flow: hydrology + sources

Open Ditches: Groundwater contribution, processing in the ditches (sink or source?)

Motivation: Catchments as a Box



Quantitative data on N and P (and C) in various pools (soil, water)



- Reduce N and P loss: runoff, leaching

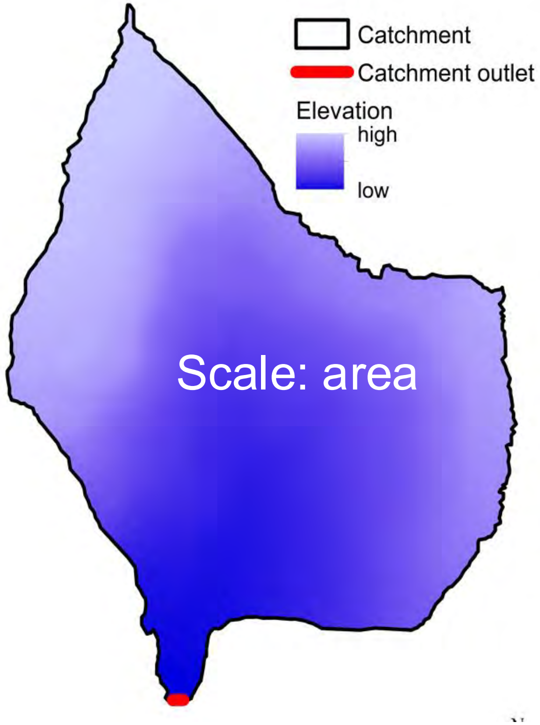
Reduce….Less runoff

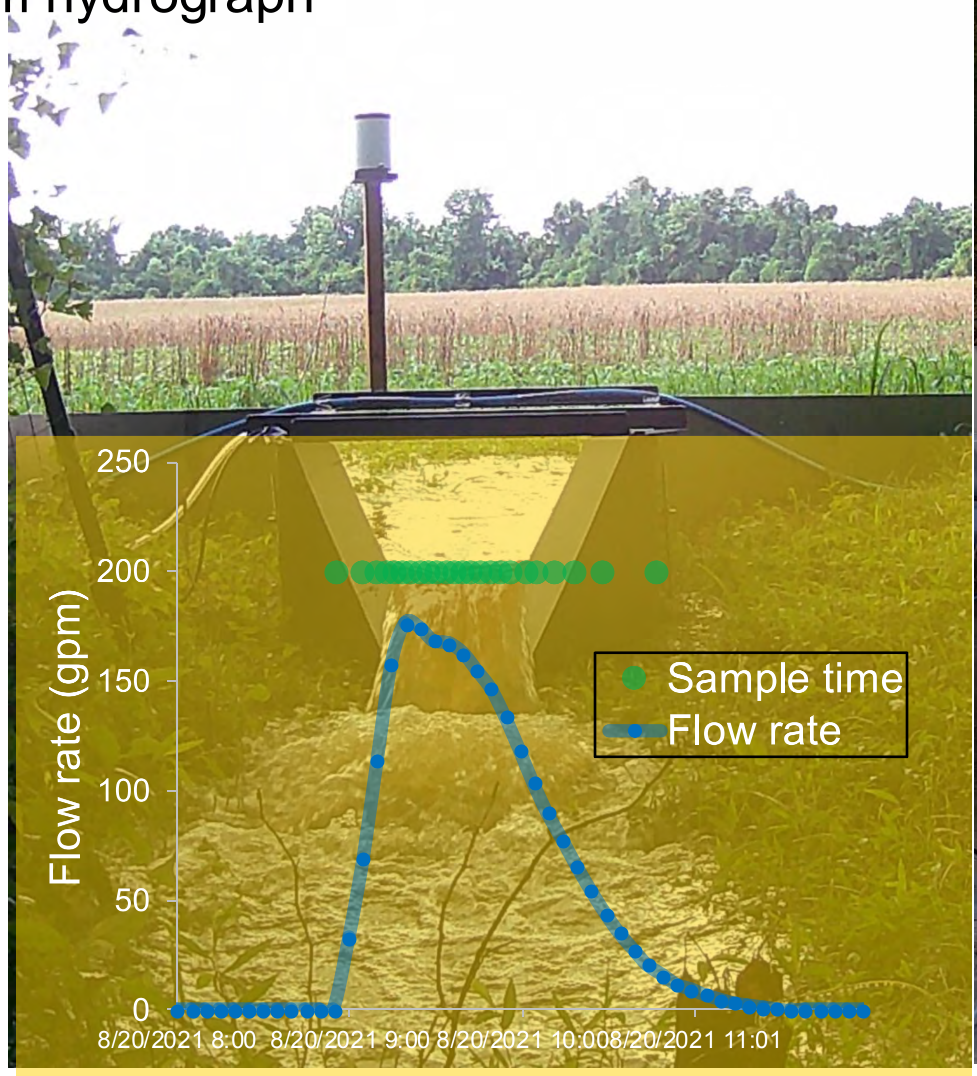
Reduce….Less leaching

More nutrients in soils, exploit the use of this pool for plant needs. Reduce inputs (thus cost) and losses.

Non-Point Source Water Quality Monitoring Challenges

- *Location (scale): plot* < field < small catchments < stream < river
- *Traditional sampling*: Grab; Composite sample over a storm event(s)
- *Enhanced sampling:* Limited # of bottles (24)
- Limited sampling coverage of storm hydrograph
- Sample preservation
- Sample analysis (# of analytes)
- Time, labor, and cost-intensive

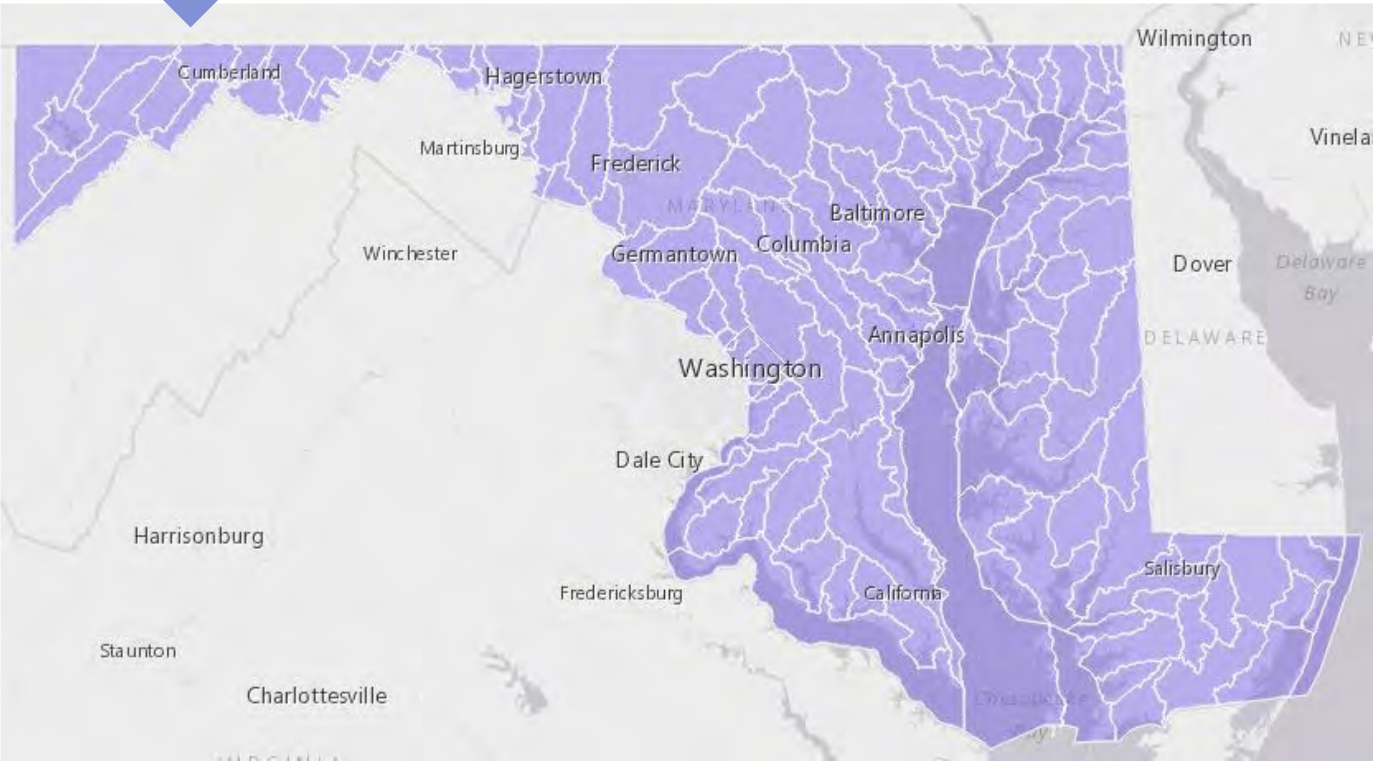


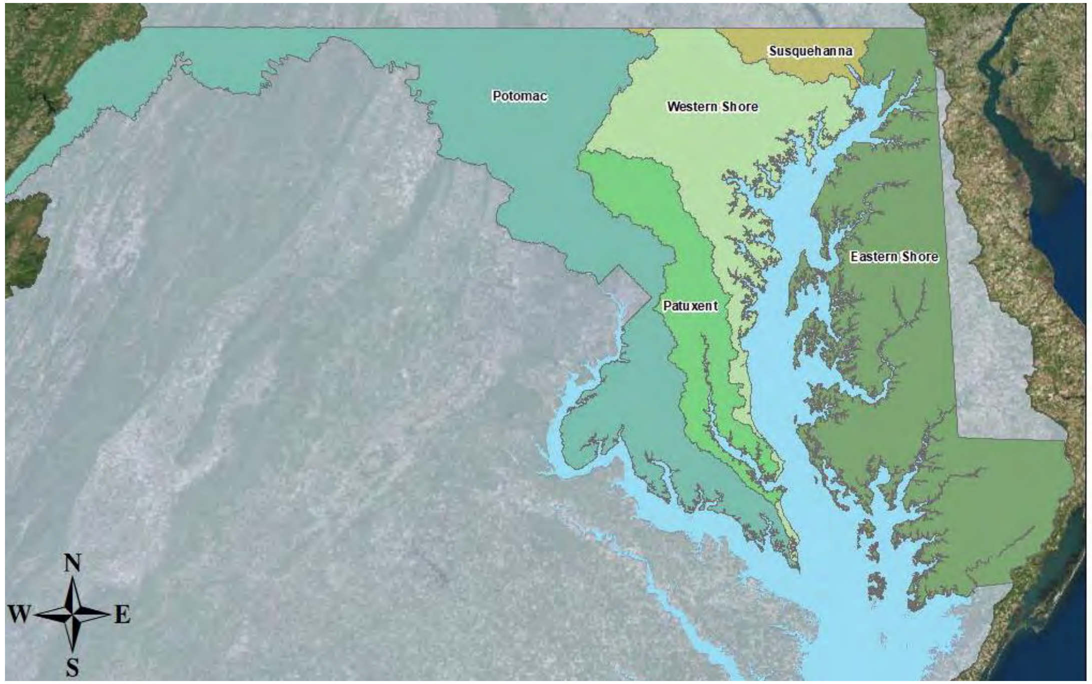


2. Catchments Selection

Basics:

- For TMDLs purpose–5 basins in MD
- 133 sub-watersheds (8-digits HUC)

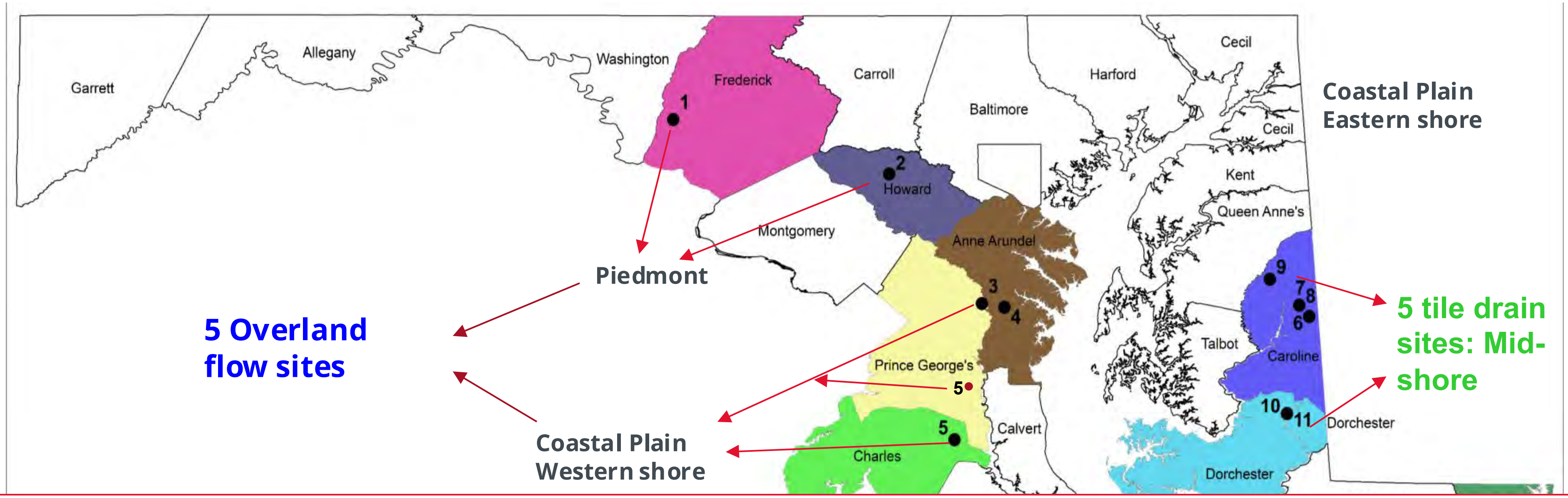


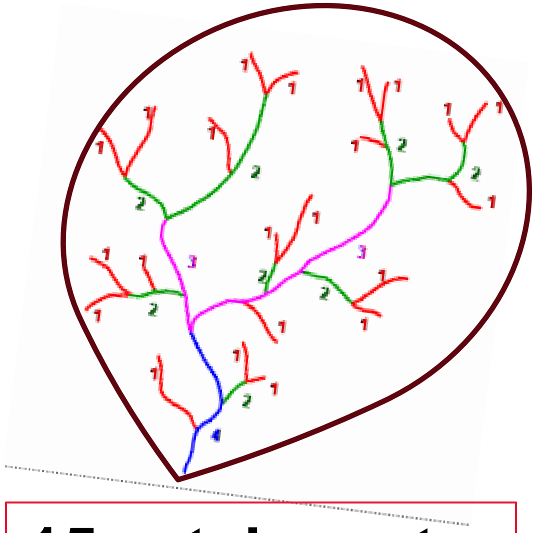


Agriculture in 2023 in MD

- Corn: *480,000 acres [Silage +30,000]*
- Soybeans: 470*,000 acres*
- Winter Wheat: *340,000 acres [Barley +31,000)*
- Cover Crops: *>400,000 acres* (with ~$20M funding from MDA)
- Chickens: 278 Million

Small agricultural catchments (1st order) located in 9 sub-watersheds (5–140 acres, or 2-57 ha)





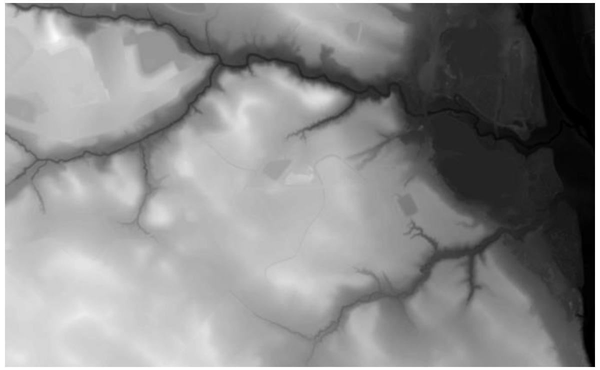
15 catchments instrumented

- 5 Overland flow (Western shore)
- 5 tile-drain (mid Eastern shore)
- 5 open ditches (lower Eastern shore)

What are we doing in these catchments?

- **Enhanced traditional approaches:** Autosamplers (sequential flow-based, time-based)
- **New approaches:** Insitu spectroscopic sensors, wet chemistry sensors

Catchments characterization:



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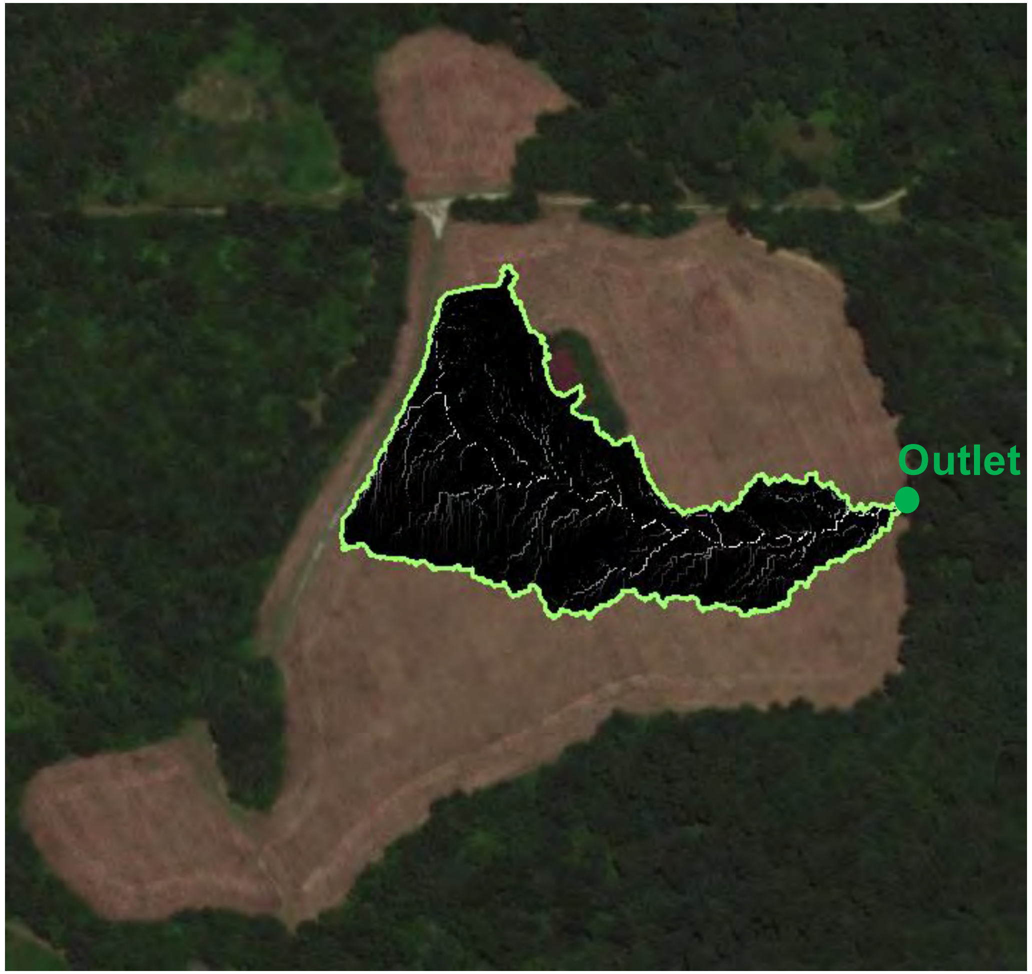
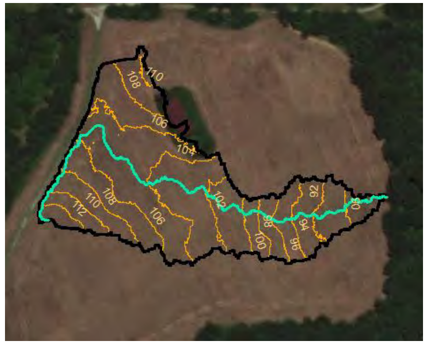
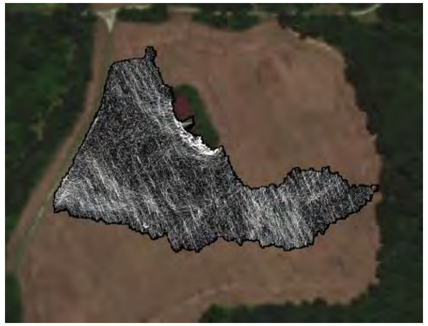


Area



Longest flow path



Slope

Field visits to observe runoff

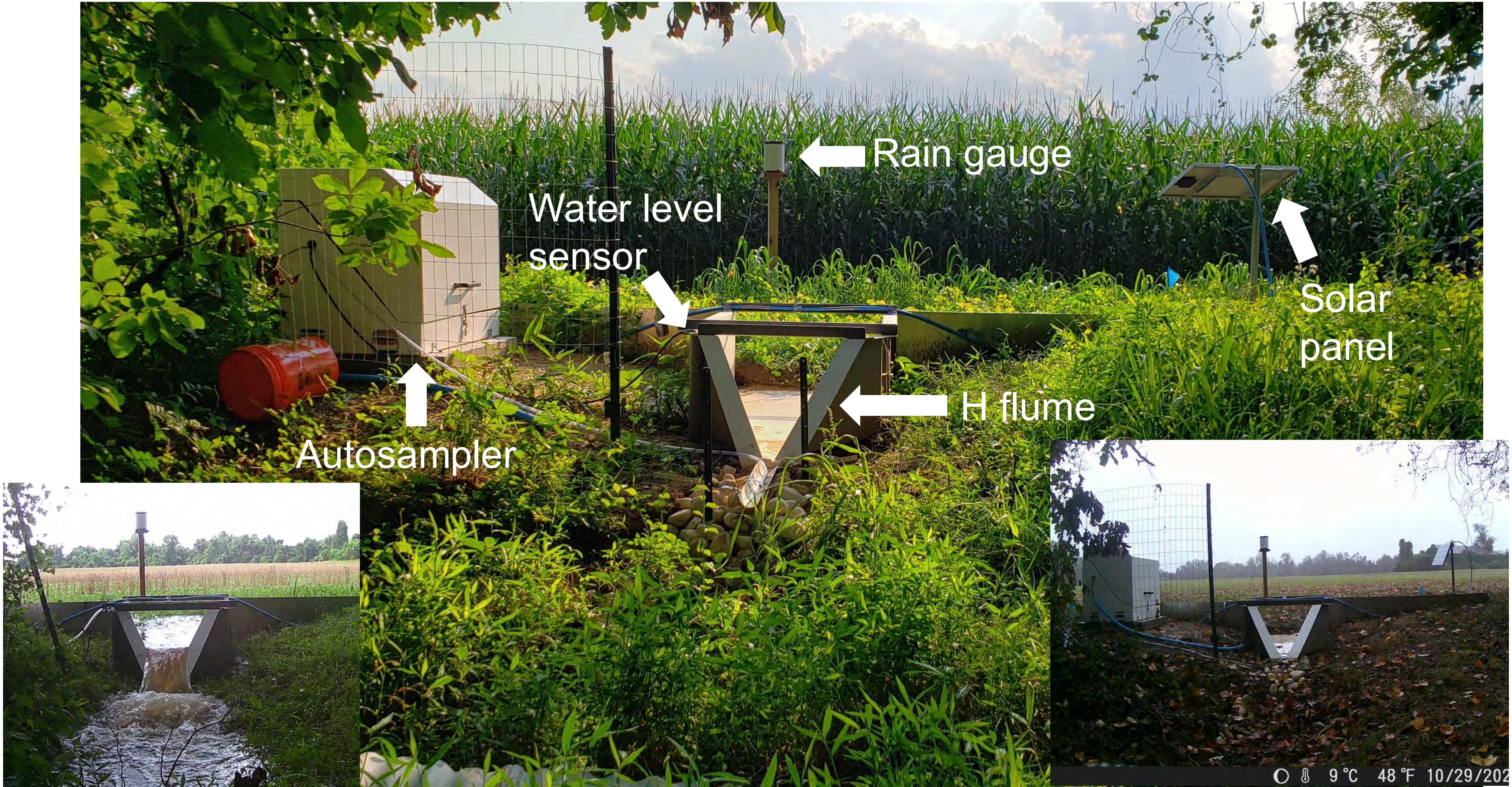
- Meet with farmers/land owners
- Confirm runoff pathways
- Determine suitability for monitoring equipment

3. Instrumentation

Flume Installation: overland flow sites

Concrete pads → Flume anchoring → Wing walls

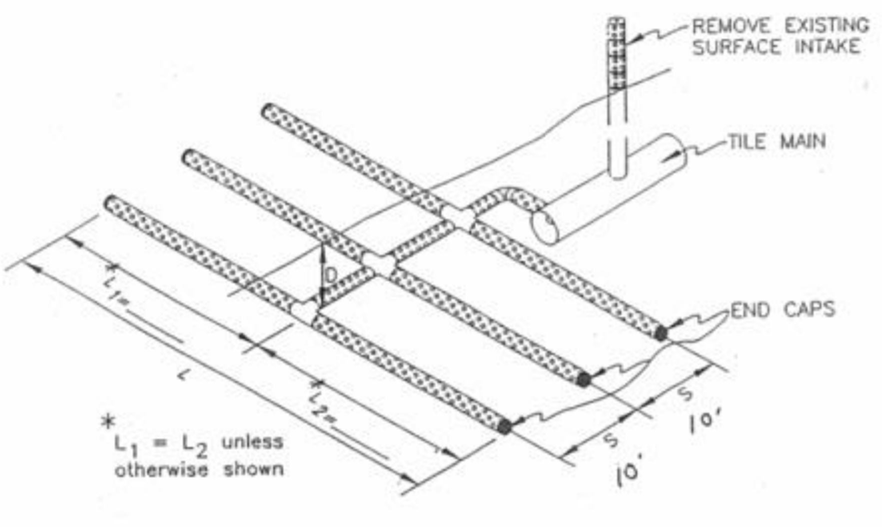
PG County Catchment: *monitoring equipment*

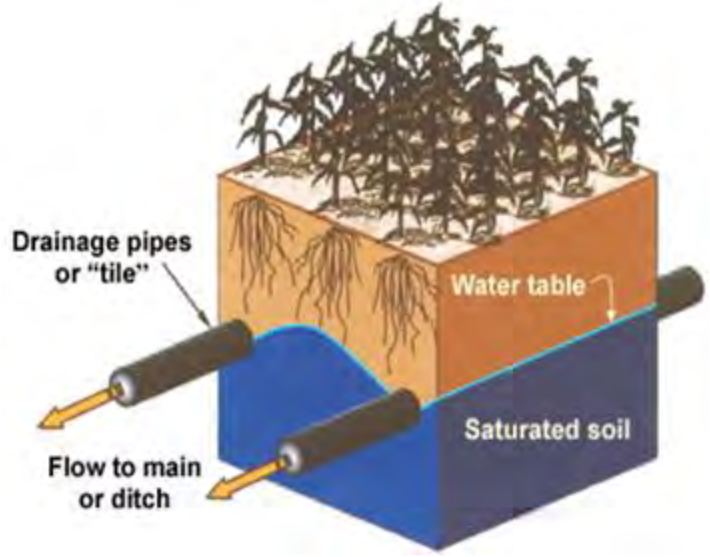


Tile-drainage Background:

- **US:** 22.5 million ha under tile-drainage
  - 84% in six Midwestern states. Area doubled since 1987; 14% increase from 2012-2017
- **Europe (NW):** 34% of cropland is tile-drained
- **18,000 ha or ~45,000 acres under tile-drainage in Maryland**
  - 14% of drained farmland; 3.5% increase from 2012-2017

Pattern tile

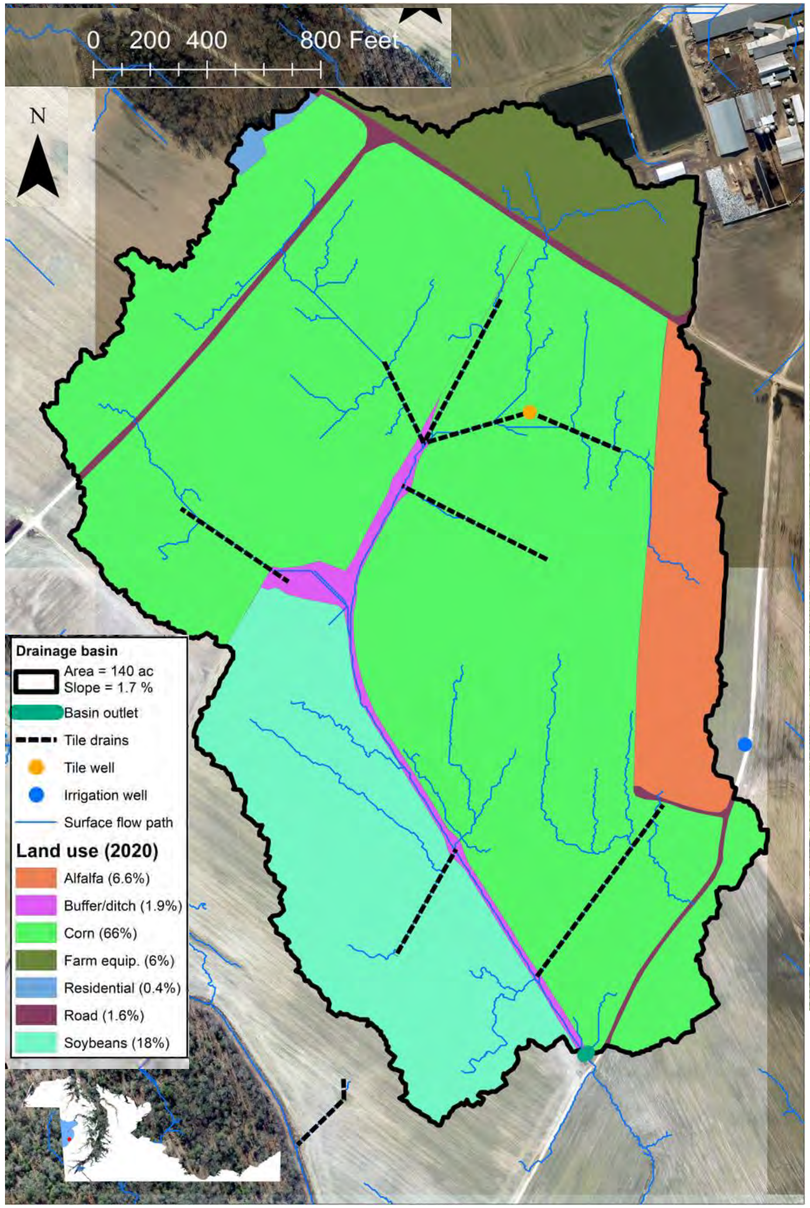




Tile riser or Tile well

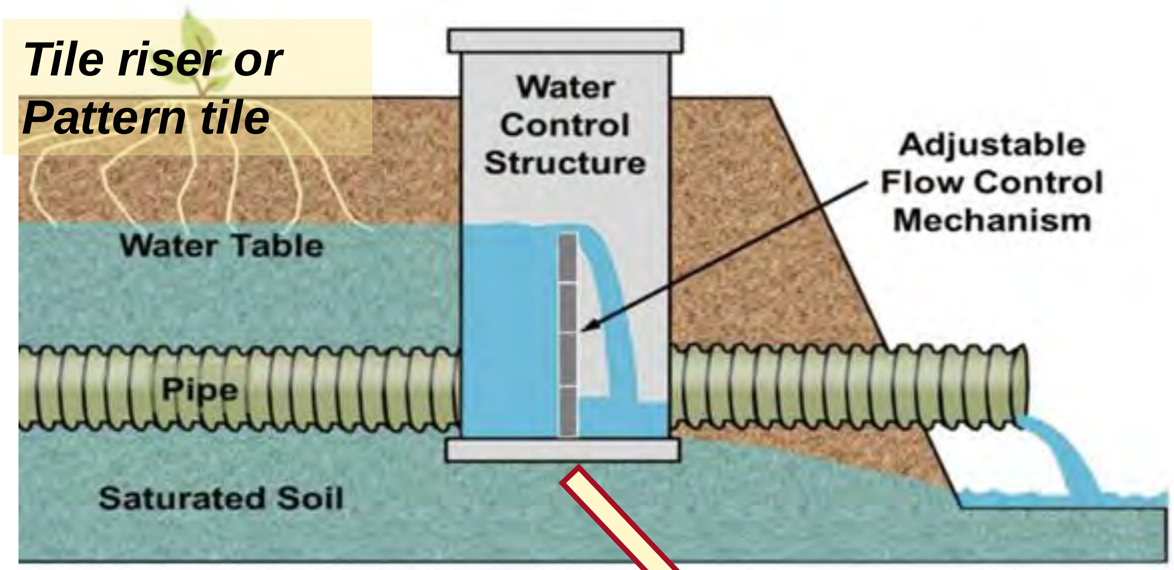
Data from USDA NASS 2017

Tile-drainage + Open Ditch Catchment on the Eastern Shore

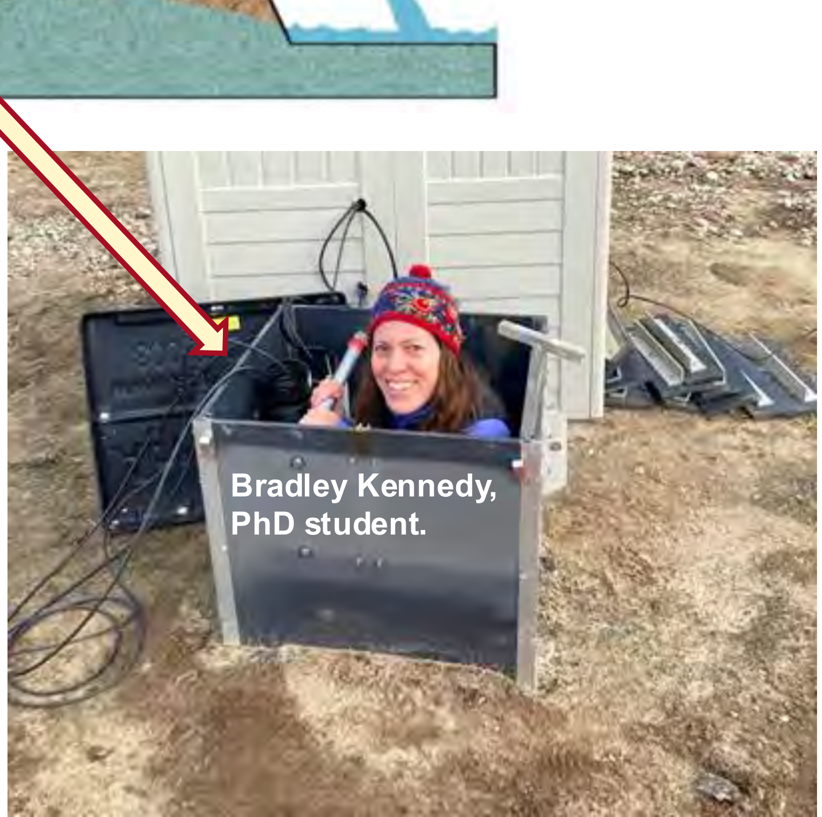


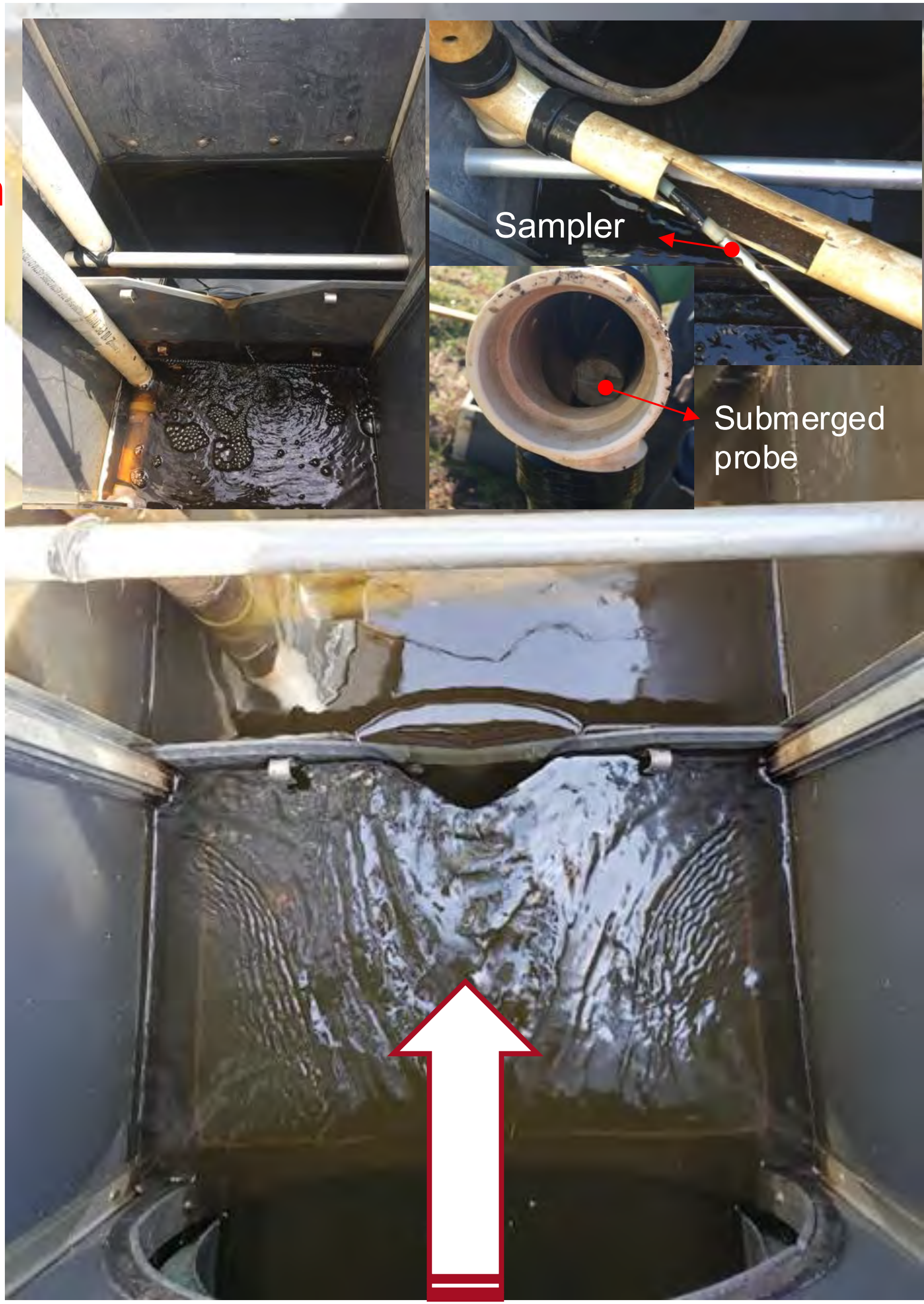
Tile-drainage + Open Ditch Catchment on the Eastern Shore

Methods: tile-drainage catchments



Water level control structure with V-notch weir

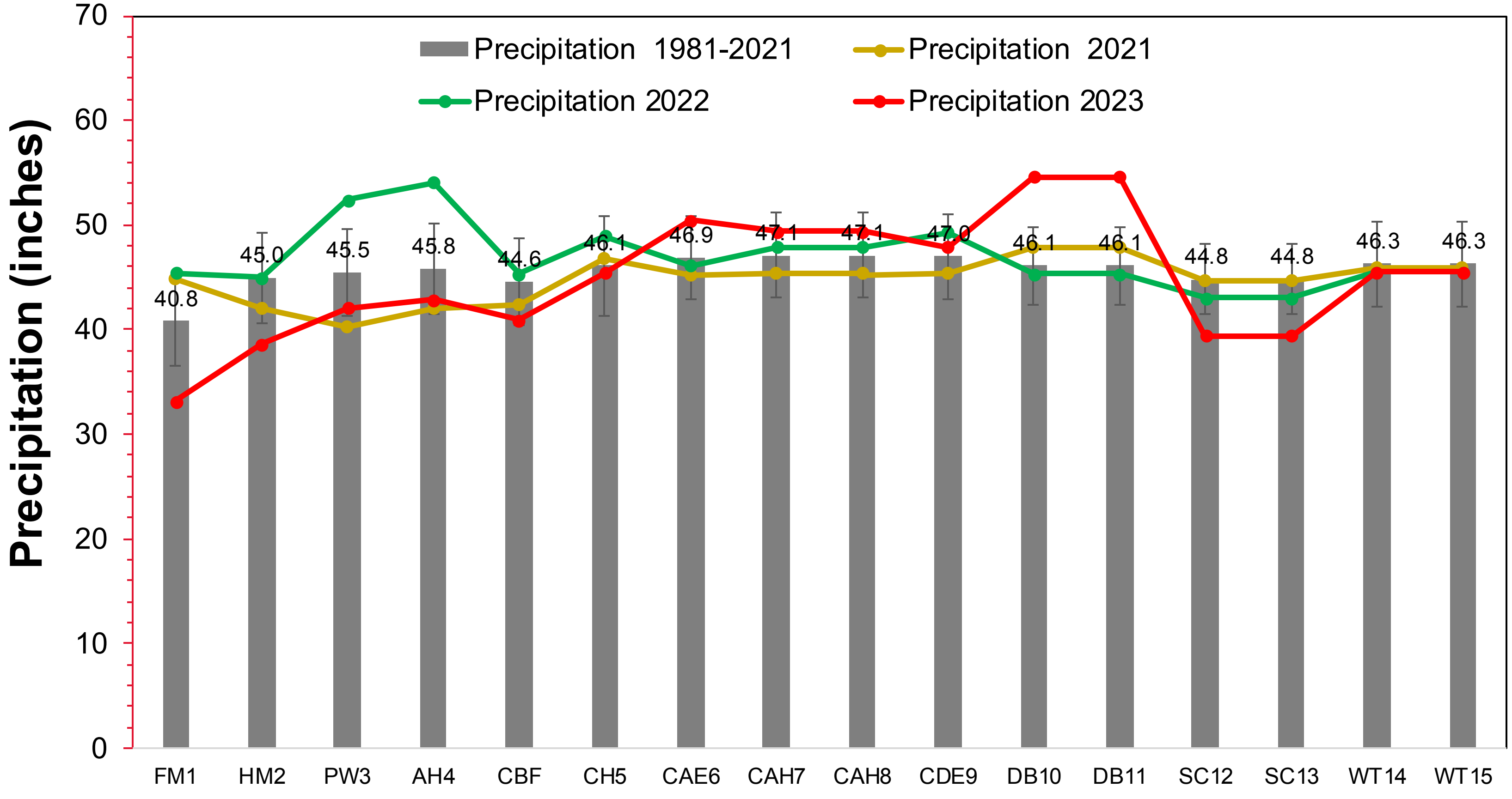




Instruments installed in water control structures (flow, sampler tubing, sensors, etc.)

Data discussion

Rainfall in Maryland: Comparing 40 years (1981-2021) rainfall with last 3 years (2021, 2022, 2023)

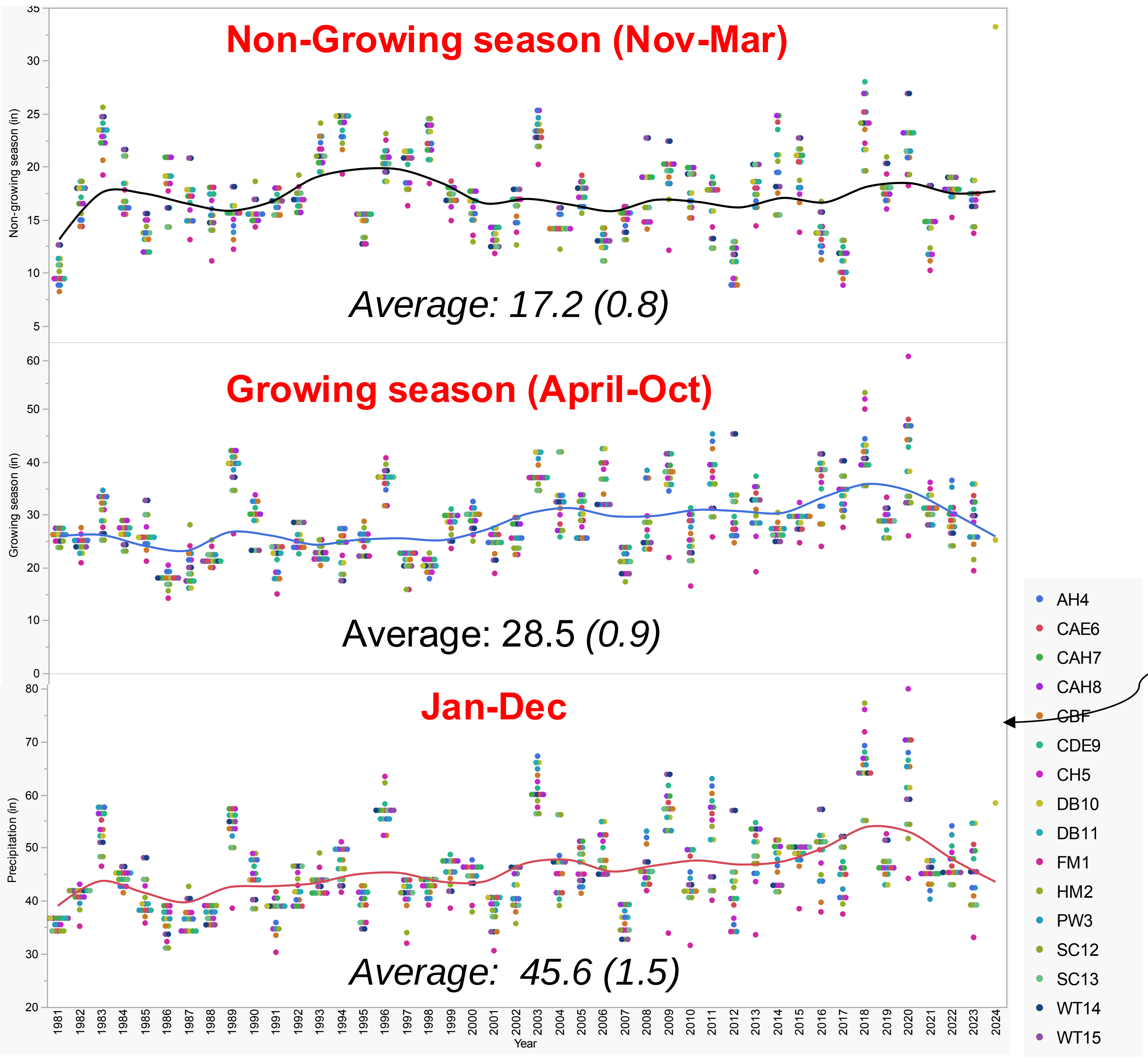


Catchments (Fredrerick ----> Worcester)

Years	Inches
1981-2021:	45.6 *(1.5)*
2021:	44.8 *(2.1)*
2022:	46.9 *(3.0)*
2023:	44.9 *(5.8)*

1 inch rainfall in 1 acre field = 26840 gallons

40+ Years (1981-2023) of Rainfall in Maryland: Growing vs Non-Growing Seasons



Single day maximum rainfall (intensity): 1.3 mm/year increase, or

13 mm/10 years (~0.5 inch)

Total runoff water samples collected so far…

Site/County	Code	Start of monitoring	Last sampling date	# of events sampled	# of samples
Frederick	FM-1	8/19/2021	8/3/24	10	89
Howard	HM-2	7/14/2021	8/3/24	13	119
PG	PW-3	5/11/2021	4/1/24	27	212
Anne Arundel	AH-4	6/11/2021	8/20/24	18	226
Charles	CH-5	11/0/2021	8/22/22	9	126
PG	PC-5	8/1/2022	2/6/23	9	123
Caroline	CAE-6	7/21/2021	8/26/24	39	601
	CAH-7	7/30/2021	8/2/24	38	475
	CAH-8	6/1/2021	8/2/24	56	561
	CAE-9	7/21/2021	7/19/24	48	591
Dorchester	DB-10	7/30/2021	8/26/24	29	395
	DB-11	10/27/2021	8/26/24	67	728
Somerset	SC-12	10/14/2021	7/15/24	21	320
	SC-13	10/14/2021	7/15/24	22	280
Worcester	WT-14	10/13/2021	8/19/24	70	691
	WT-15	10/13/2021	4/8/24	32	452
				508	**5989**

Overland flow

Events	Samples
86	895

Tile-drainage

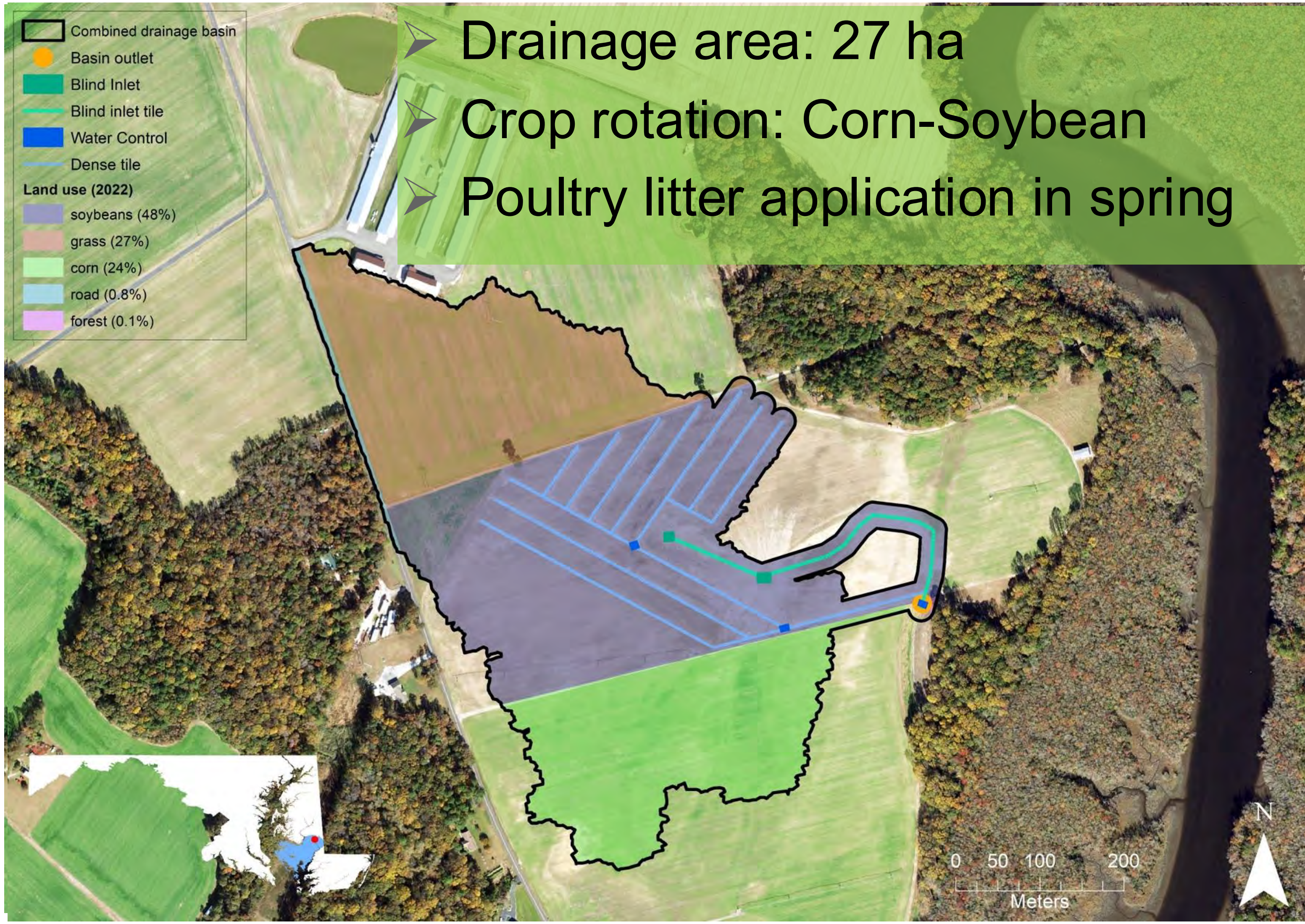
Events	Samples
181	2228

Open ditch

Events	Samples
145	1743

Example 1: High-frequency insitu determination of NO_3, PO_4, and DOC with UV-Vis Spectrophotometer in a tile-drainage catchment

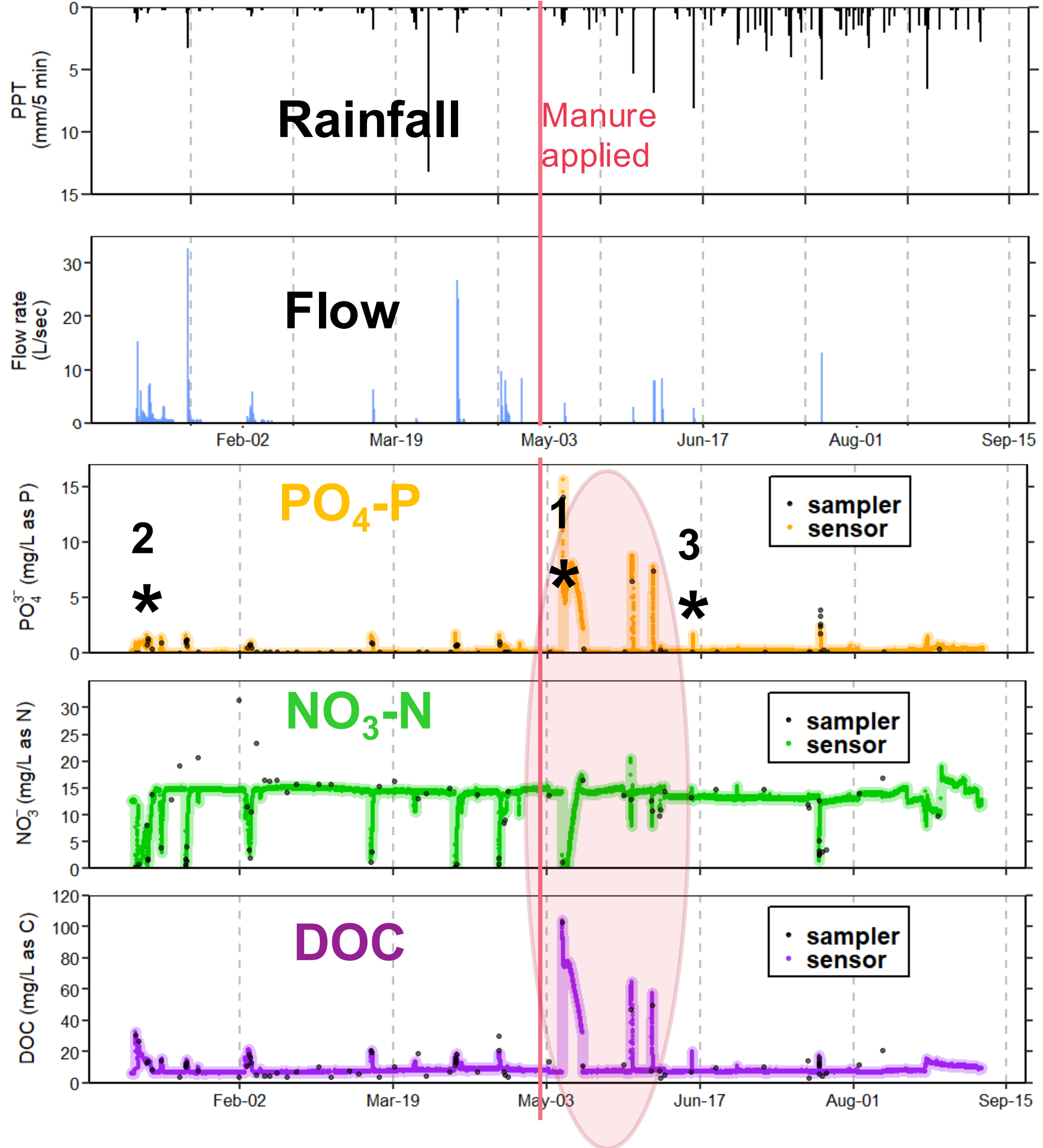
- Autosamplers (flow-based)
- Insitu sensor high temporal-resolution (5 min)
- Absorbance spectrum: 200-720 nm
- Works well for NO_3, DOC, TSS
- **Expanded analysis to PO_4 with proxy correlations**



- Drainage area: 27 ha
- Crop rotation: Corn-Soybean
- Poultry litter application in spring


s::can
sensor

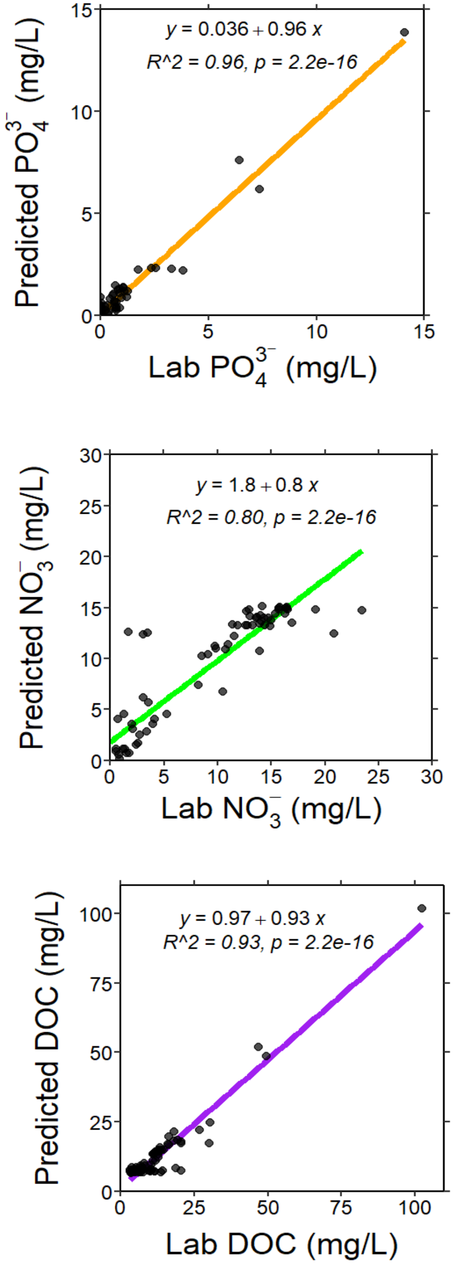

Long-term NO_3-N:
Storm events: >60
# of Samples: >660
Mean: 10.1 mg/L (86% of TN)
Median: 11.7 mg/L (82% of TN)



Tile-drainage catchment

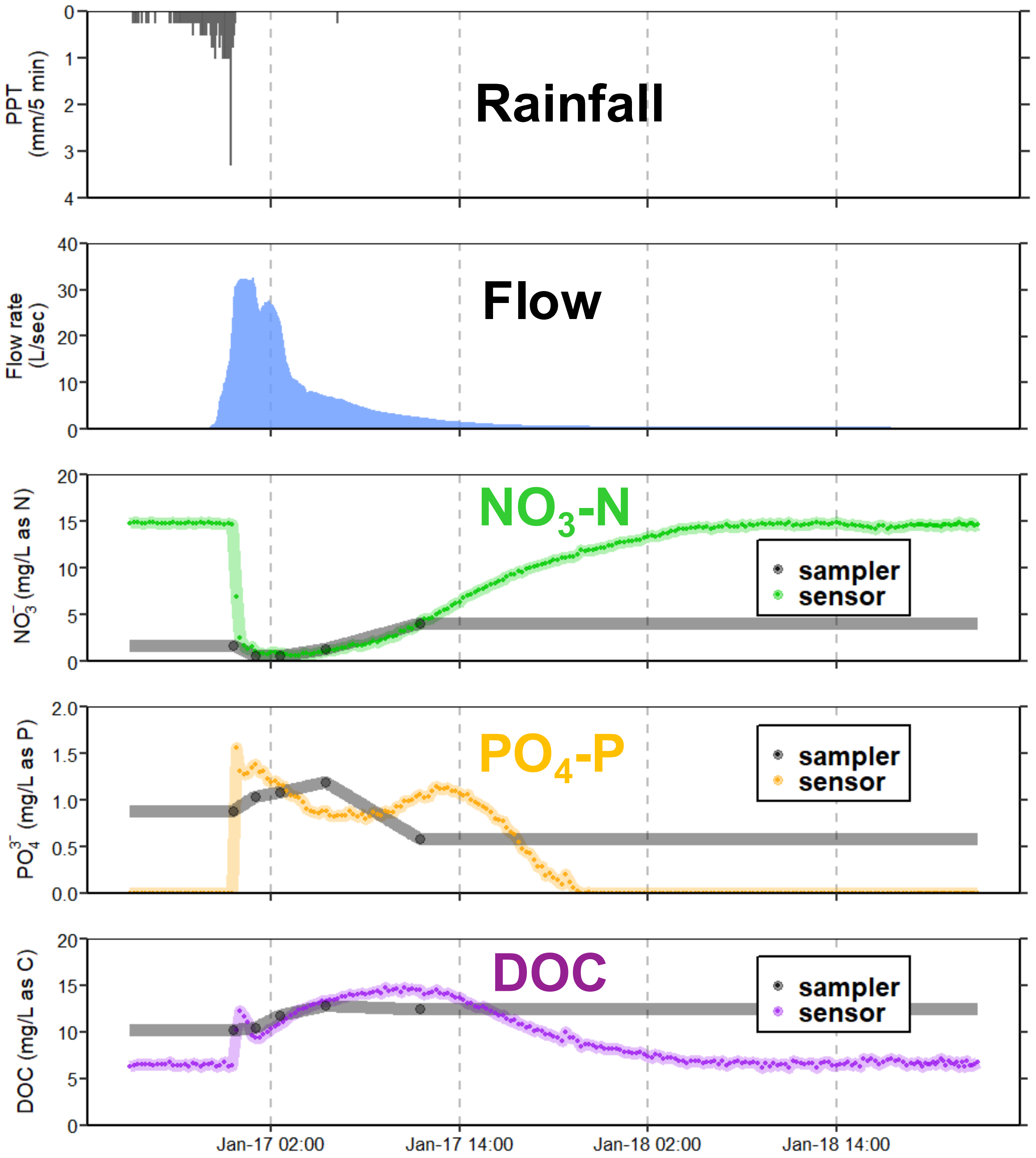
- 9 months: Jan-Sep
- S::CAN (5-mins): ~77,760 data points
- ISCO: 19 storm events, 80 samples

S::CAN vs. ISCO



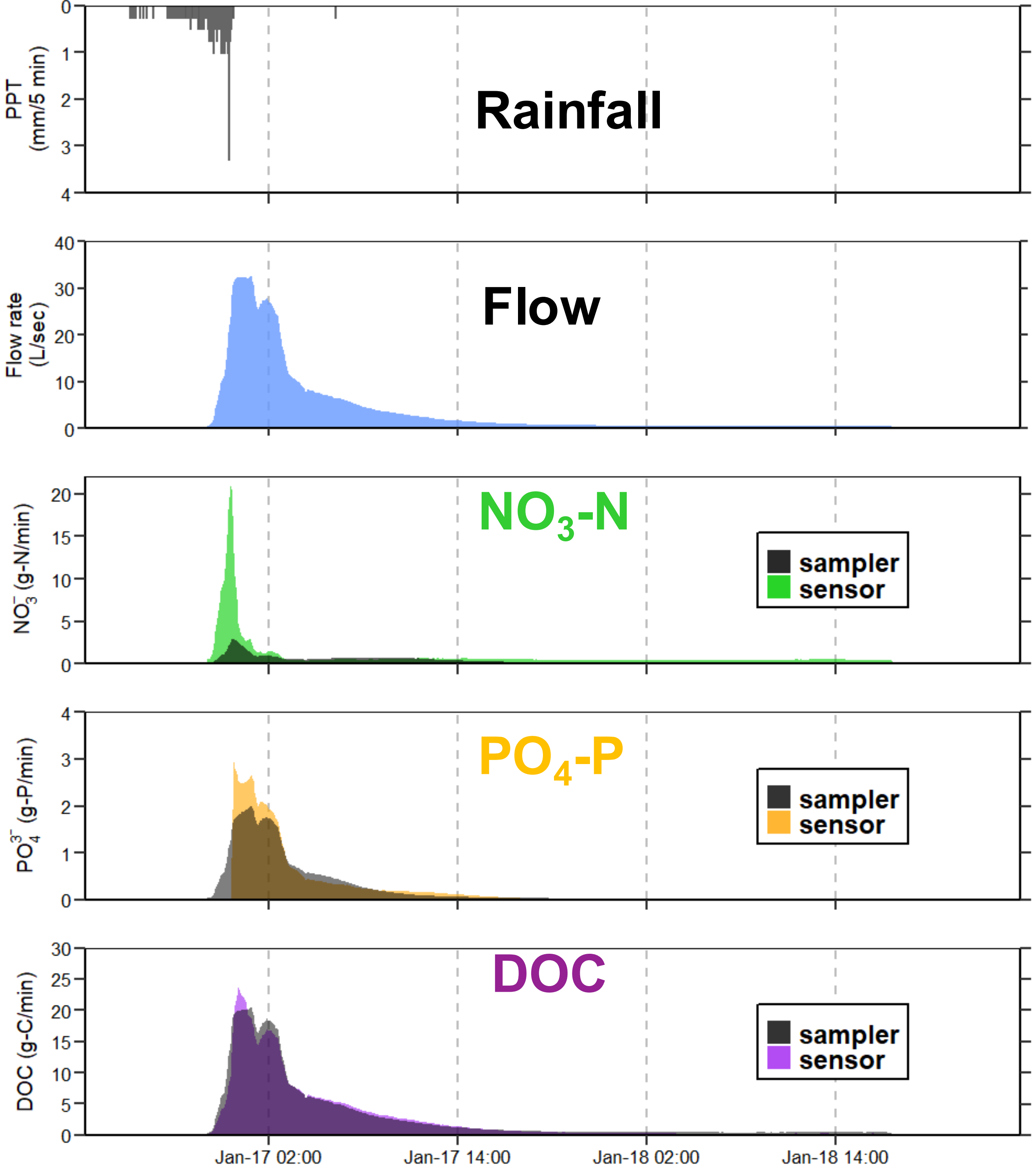
*2. Concentrations: sensor vs. sampler

- 1.2 inches (30.5) mm event on 1/17/22 (lasted for ~26 hours)
- ISCO sampling (flow-paced): 5 samples collected
- S::CAN measurements (5-min intervals, 26 hours): 312
  - $[NO_3^-] \propto 1/\text{flow rate}$
  - $[PO_4^{3-}] \propto \text{flow rate}$
  - $[DOC] \propto \text{flow rate}$



*3. Loads: sensor vs sampler (June 17-18 storm)

- **NO_3-N**
  - Sampler: 1.1 kg
  - Sensor: 2.6 kg
- **PO_4-P**
  - Sampler: 0.63 kg
  - Sensor: 0.64 kg
- **DOC**
  - Sampler: 7.6 kg
  - Sensor: 7.2 kg

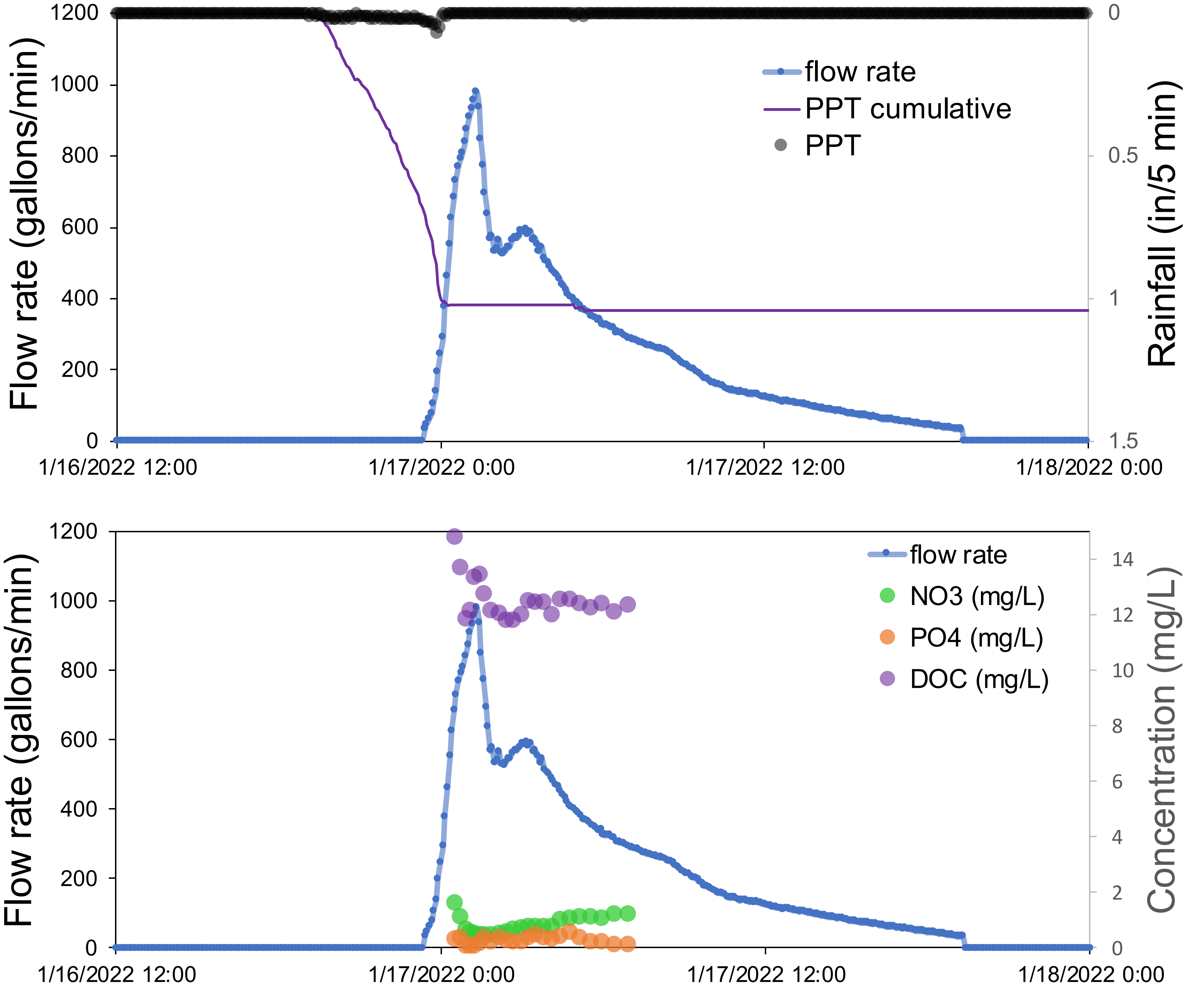


Example 2: Caroline County Catchment (tile-drained + ditch)

- ISCO sequential storm sampling (24 samples)
- Storm on 1/17/22
- Precipitation: 1.0 inch (25 mm)
- Flow: 2,269 gal/acre

Load calculations:

- **Nitrate-N:** 1.0 Kg
- **PO_4-P:** 0.4 Kg
- **DOC:** 15 Kg

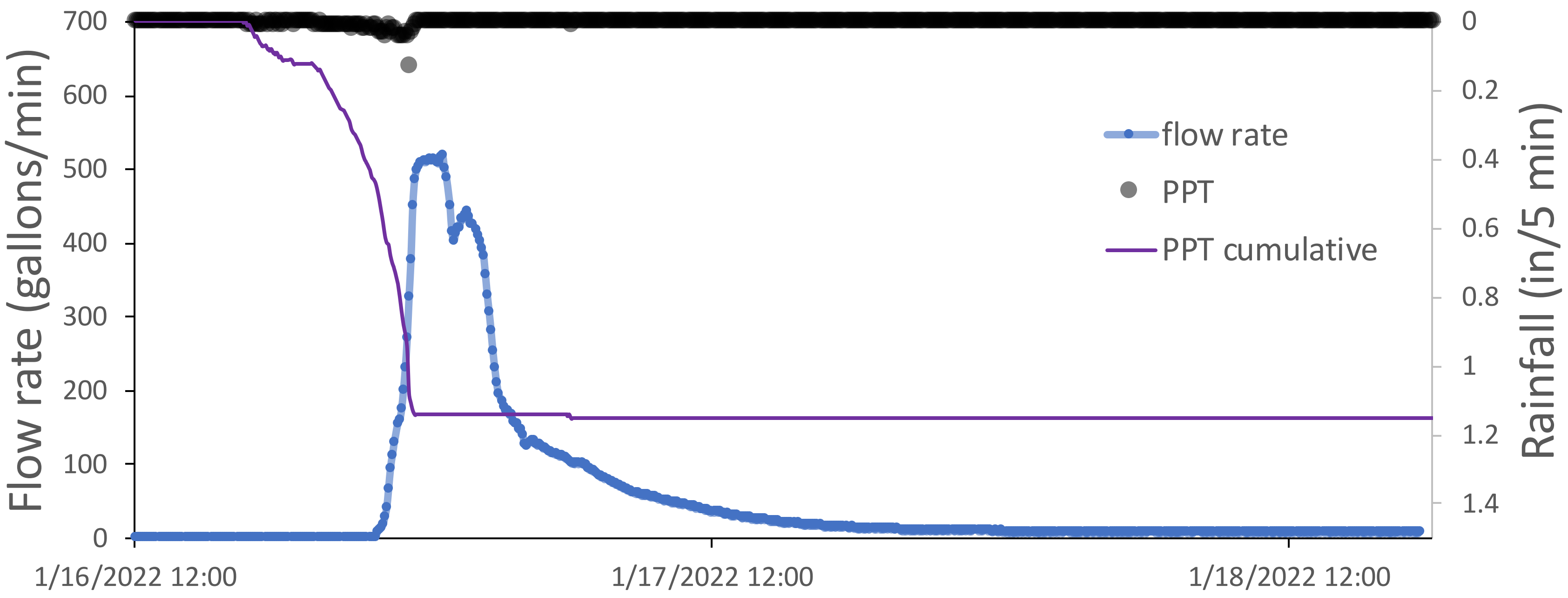


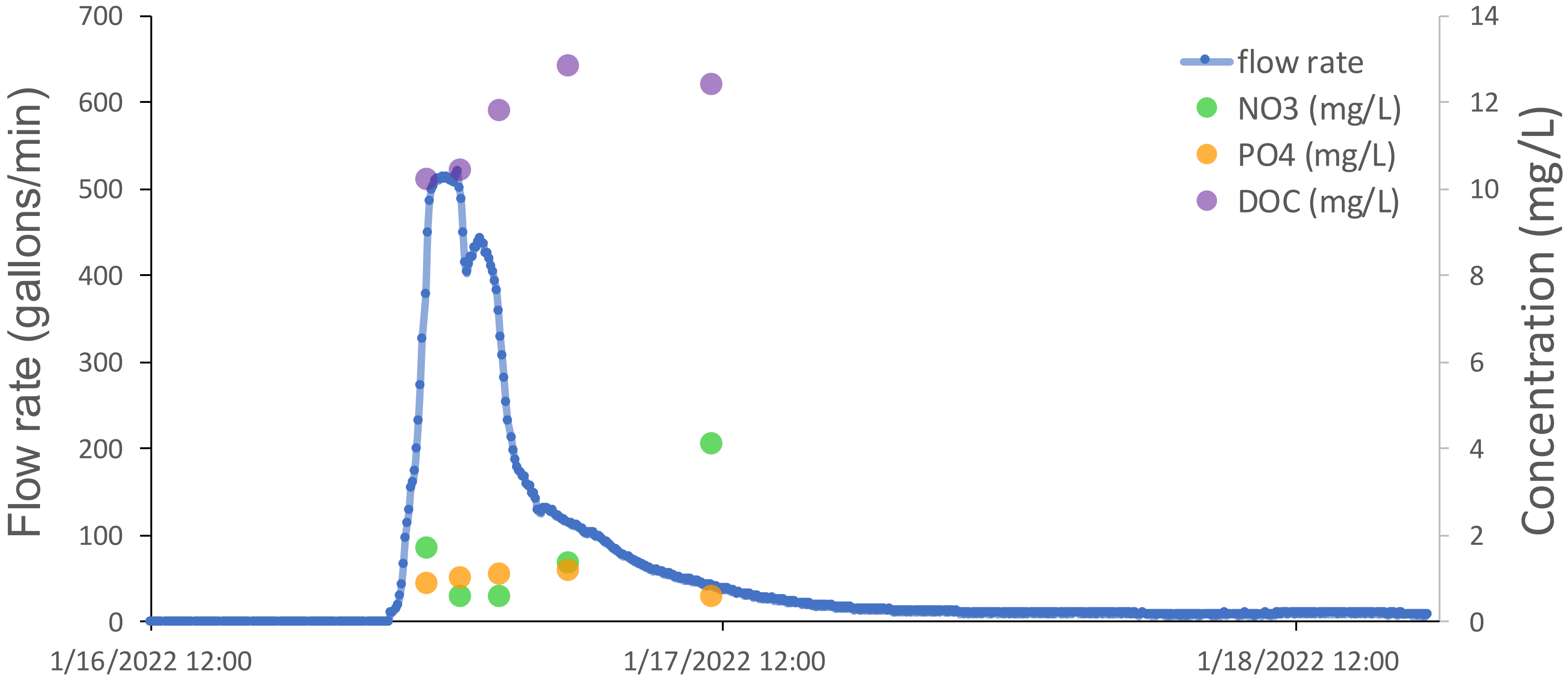
Example 3: Dorchester County Catchment (tile-drained)

- ISCO sequential storm sampling (5 samples)
- Storm on 1/17/22
- Precipitation: 1.2 inch (30.5 mm)
- Flow: 1,730 gal/acre

Load calculations:

- **Nitrate-N:** 1.1 Kg
- **PO_4-P:** 0.6 Kg
- **DOC:** 7.6 Kg

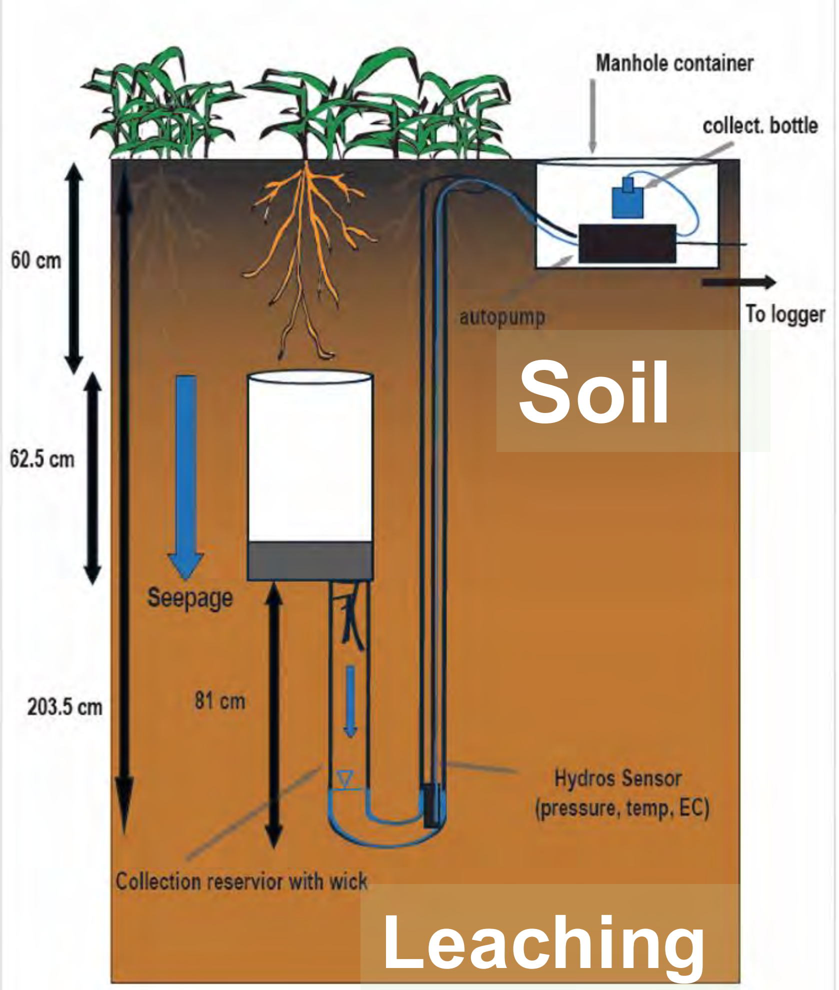




5. Future plans & collaboration: more field instruments, modeling, decision support tools

- **Instrument selected sites for sub-surface monitoring:**
  - Leaching: drainage lysimeters; suction lysimeters
  - Vadose zone: soil sensors (EC, water, temp)
  - Groundwater: piezometers?

- **Remotely control sites:** downloading and managing data
- **Expand real-time in-situ sensors:** for N and P species in runoff waters (along with DOC)
- **Expand research & collaboration:** modeling, decision support tools



Drainage Lysimeter: installed at a Pasture site in PG County

Q&A!

Funding:

USDA NIFA
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Maryland Department of Agriculture

Harry R. Hughes
CENTER FOR AGRO-ECOLOGY

More info?

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