Re-plumbing the Chesapeake Watershed
9 –10 October 2014

Re-plumbing roadside ditches to reduce flooding and pollution, and improve stream health

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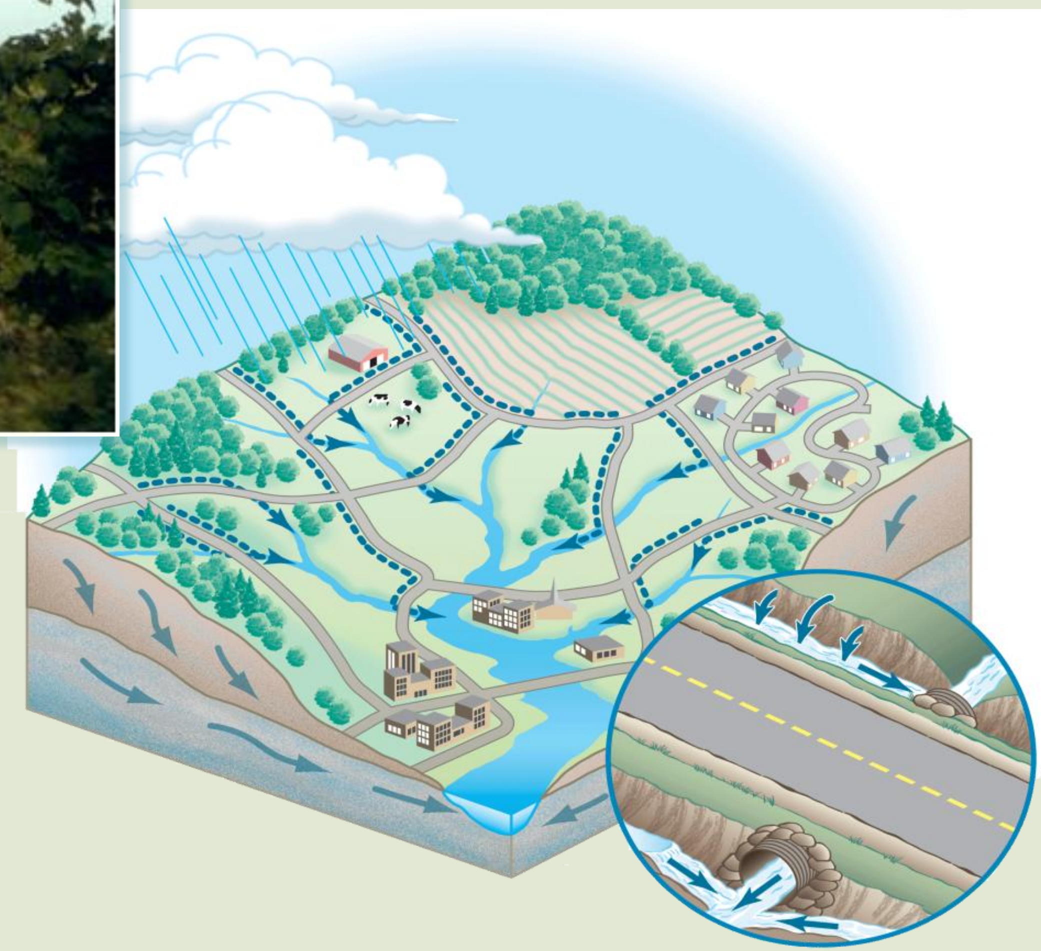
Roadside Drainage Networks



What role do they play in:

- ***Floods?***
- ***Water pollution?***
- ***Stream ecosystem health?***

Roadside Ditch Team

Faculty:

- **T. Walter** ***Dept. Biological and Environ. Engineering***
- **D. Orr** ***Cornell Local Roads Progrm***
- **D. Buckley, P. Bergholz** ***Dept. Crops and Soils***
- **R. Marino, K.& J. Sparks** ***Dept. Ecology***
- **S. Allred** ***Dept. Natural Resources***

Graduate Students:

K. Falbo, B. Buchanan, J. Diaz-Robles, L. McPhillips

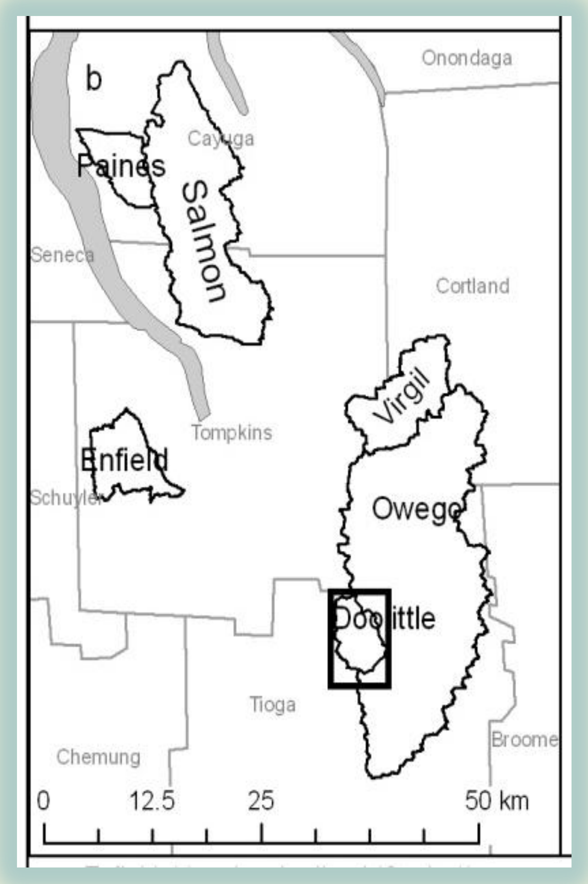
A. Johnson, J. Kimchi (Undergr)

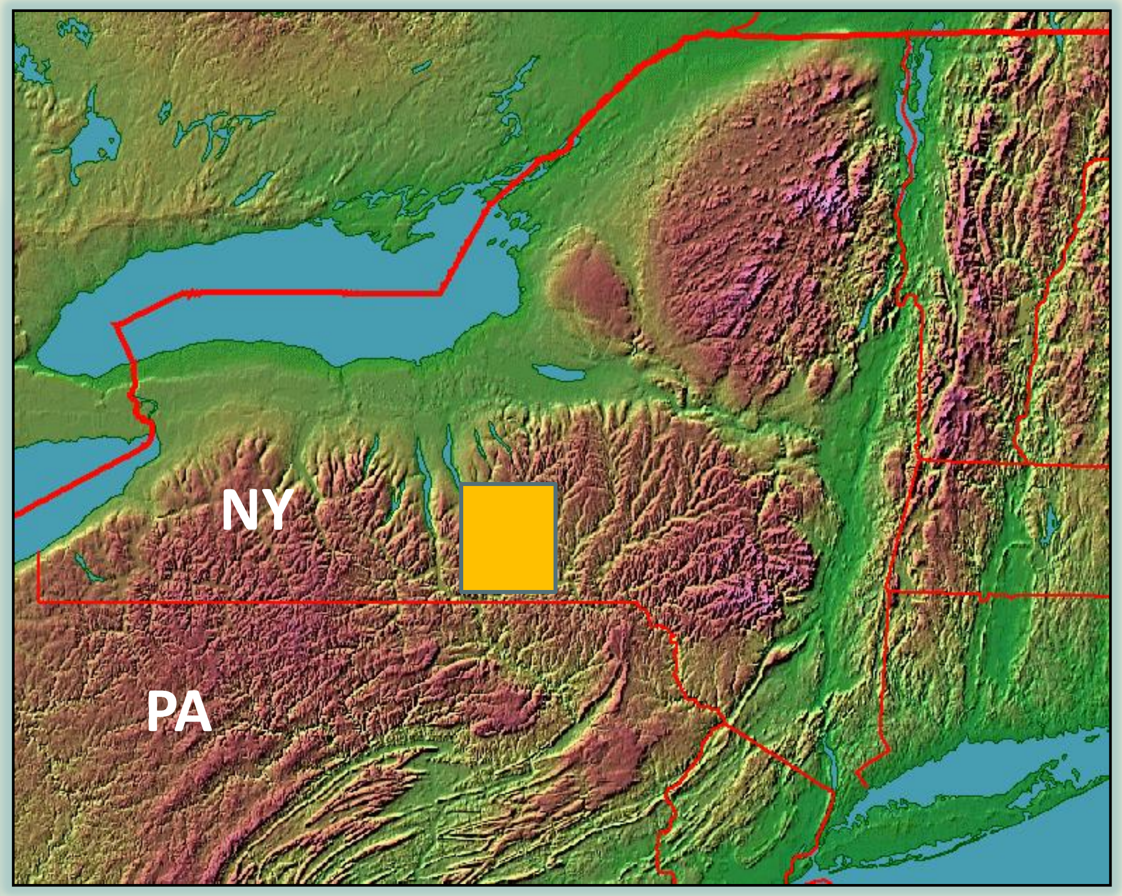
Cornell University

USDA United States Department of Agriculture National Institute of Food and Agriculture

NYSWRI

Study Sites

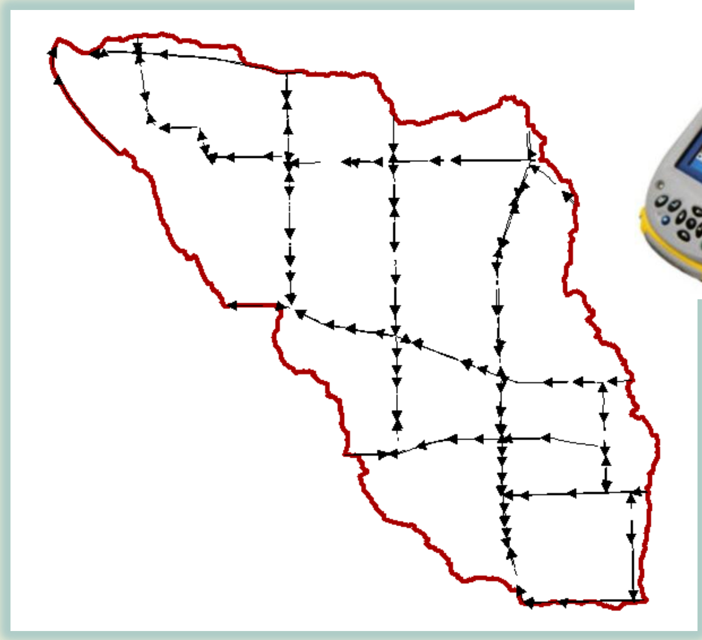

b
Onondaga
Cayuga
Paines
Salmon
Seneca
Cortland
Virgil
Tompkins
Enfield
Schuyler
Owego
Doolittle
Tioga
Broome
Chemung
0
12.5
25
50 km

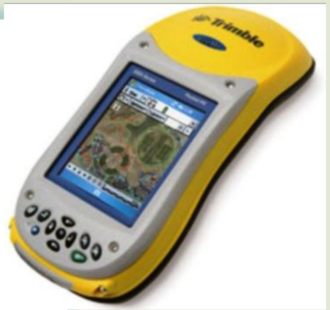

NY
PA

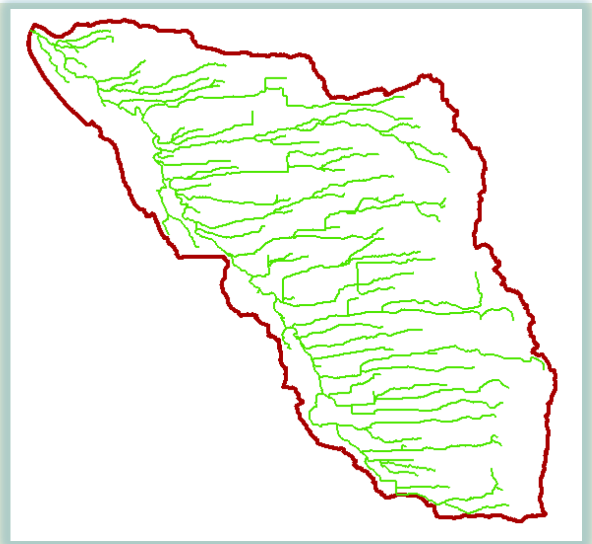
Methods - Mapping

GPS and GIS mapping of ditch networks

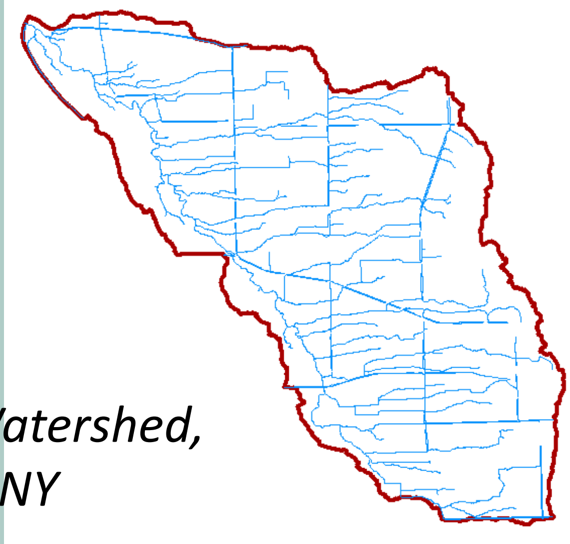
- *Ditch lengths*
- *Management types*
- *Connections to streams*







Without Ditches



With Ditches

Paine's Creek Watershed, Lansing, NY

Ditch Study Sites

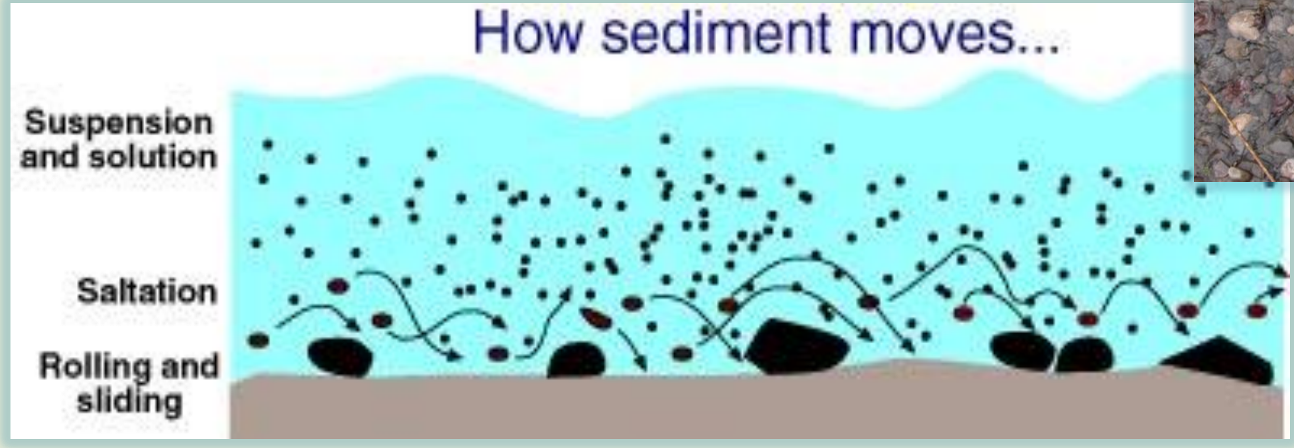
vegetated

exposed, scraped

Methods - Monitoring

Monitor

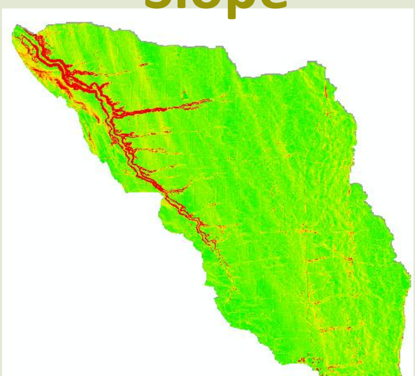
- *Total water flow*
- *Suspended sediment*
- *Dissolved chemicals*
- *Bedload*



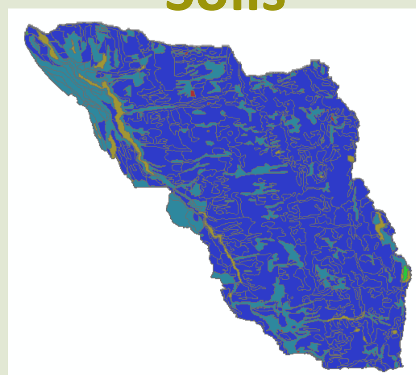
Methods – Hydrologic Model

INPUTS:

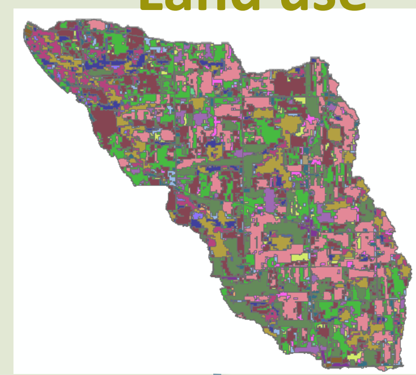
Slope



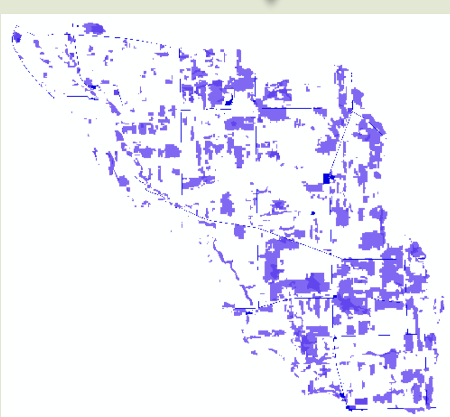
Soils



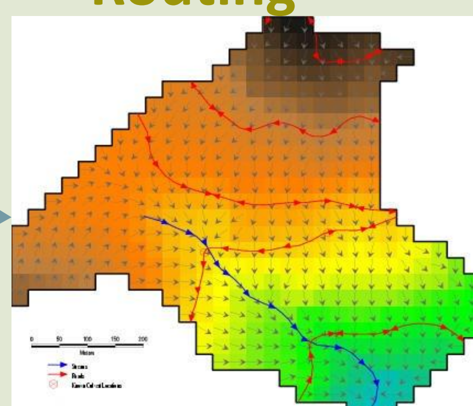
Land use

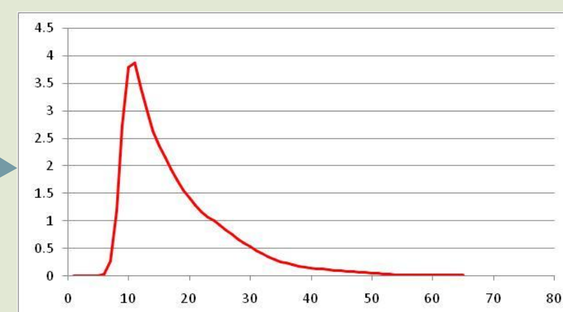


Runoff



Routing



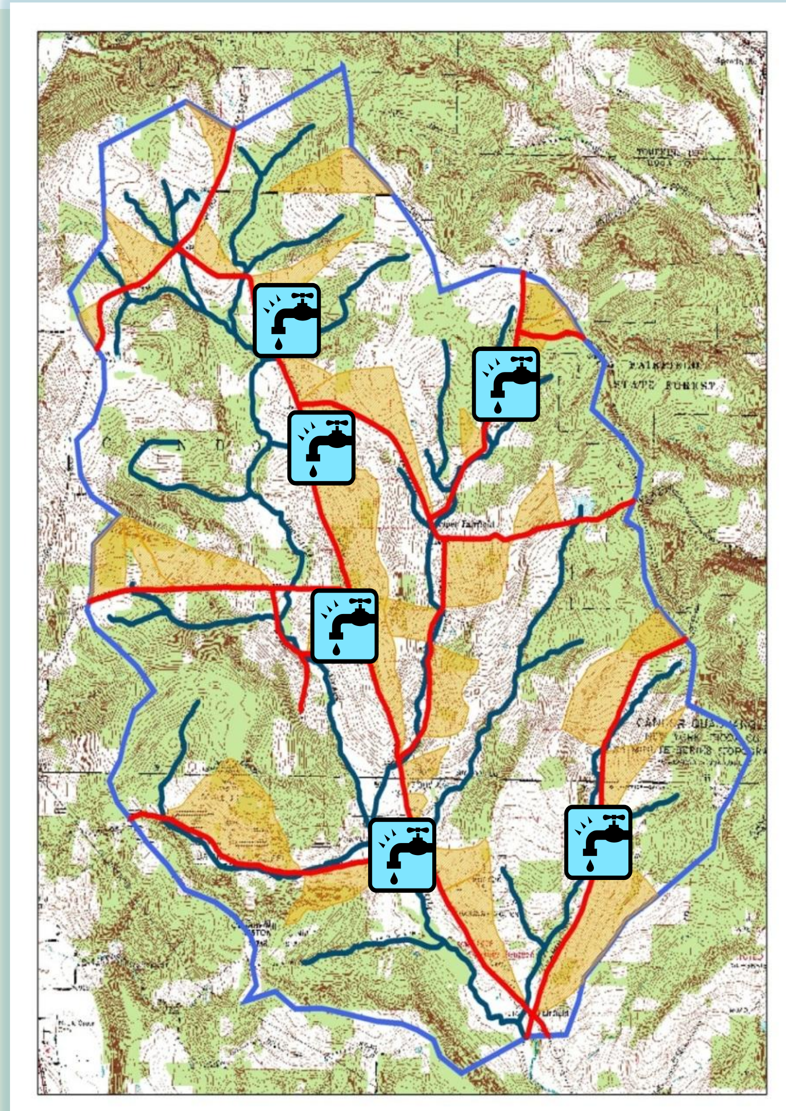


Results - Drainage Mapping

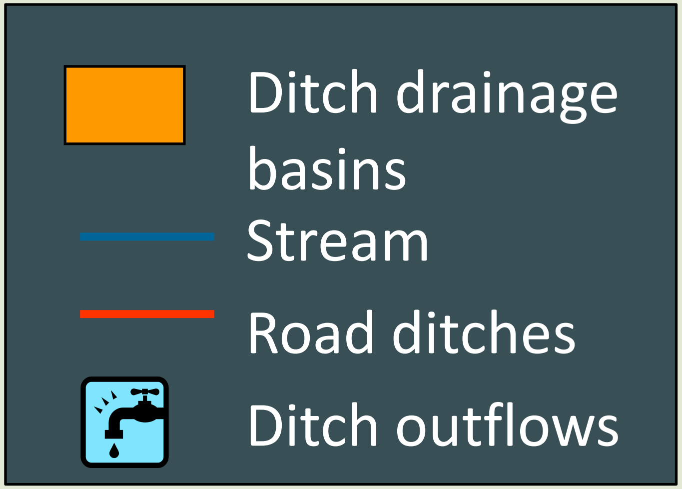
Characteristic	Average value
Watershed area	16 sq. mi (42.3 km^2)
Road length	33.7 miles (54.3 km)
% road surface area of wtshd	0.69 %
Roadside ditch length	50.6 miles (81.4 km)
Total # of direct connections to strms	94
Total ditch length connected to strms	31.7 miles (51.0 km)
Area of basins draining to ditches	3.1 sq. mi (8.1 km^2)
% of watershed draining to ditches	19.1 %
Stream channel length (no ditches)	41.0 miles (66.0 km)
Stream channel density w/o ditches	1.55 (km/km2)
Stream channel density with ditches	2.73 (km/km2)

Schneider et al. 2014

Results – Drainage Mapping



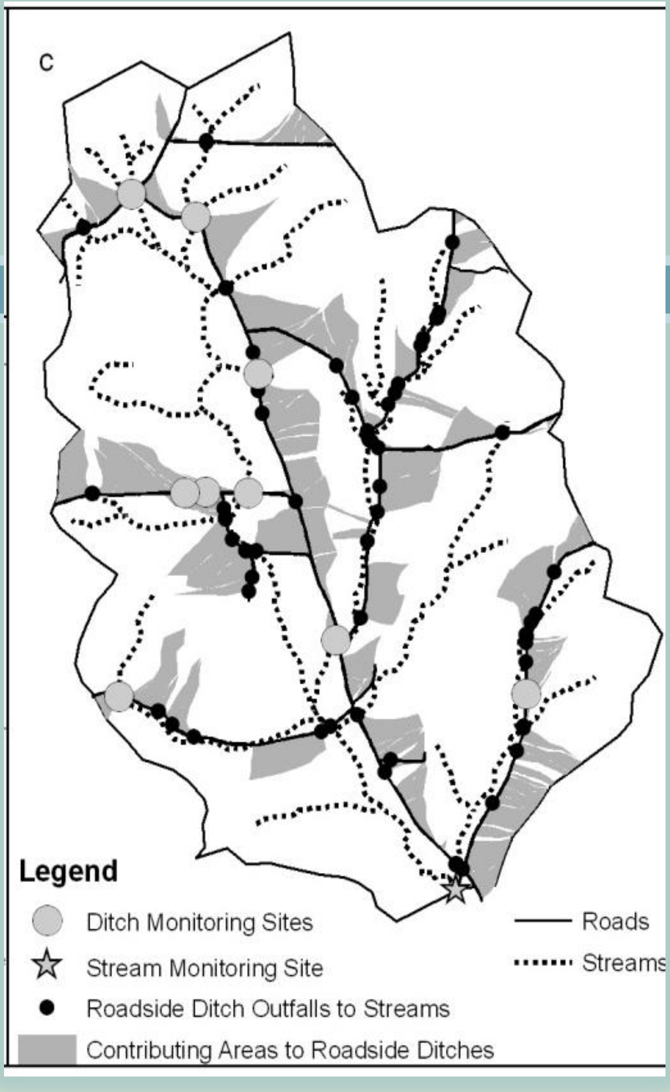
Ditch drainage basins intercept ~ 19 % of the surface runoff and shallow groundwater from each watershed and rapidly shunt it to the nearest stream (94 outlets).



Results – Hydrology

Doolittle Creek Watershed

- *8 ditch monitoring stations and Doolittle Crk*
- *10 storms 2005-2006; 1.3 – 12.9 cm total rain/event*
- ***Each ditch captured avg of 51% of rainfall in the ditch's basin***



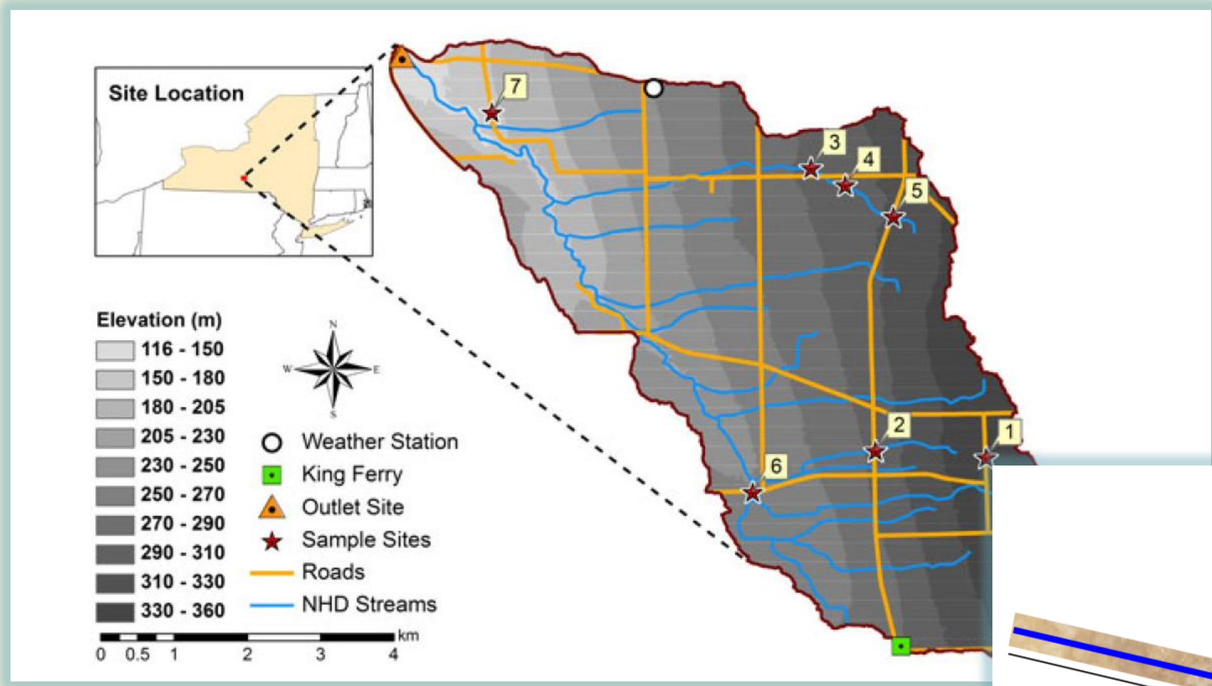
Diaz-Robles 2007

Results – Hydrologic Model

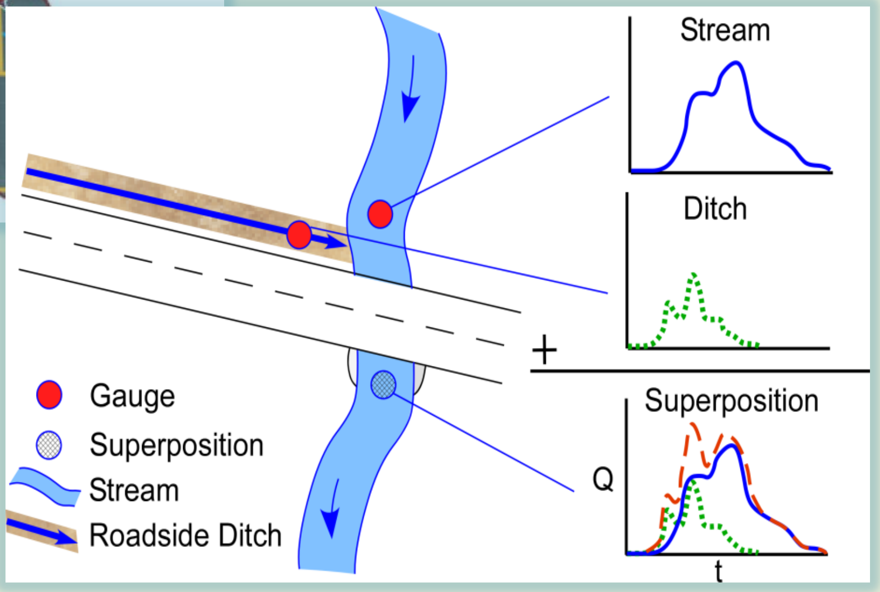
Entire Modeled Ditch Drainage Networks:

- ***Doolittle: transported 45,400 m^3 water / storm = 3.6% (+/- 1.4%) of incoming precipitation and 19.5% (+/- 9.7%) of total stream flow measured in each storm***
- ***Paine's Creek: 22% of total stream flow in spring storm event and 29% of total stream flow in a summer storm event.***

Results - Hydrology



7 ditches
34 storms
2.5 – 40 mm rain
April – Dec. 2009

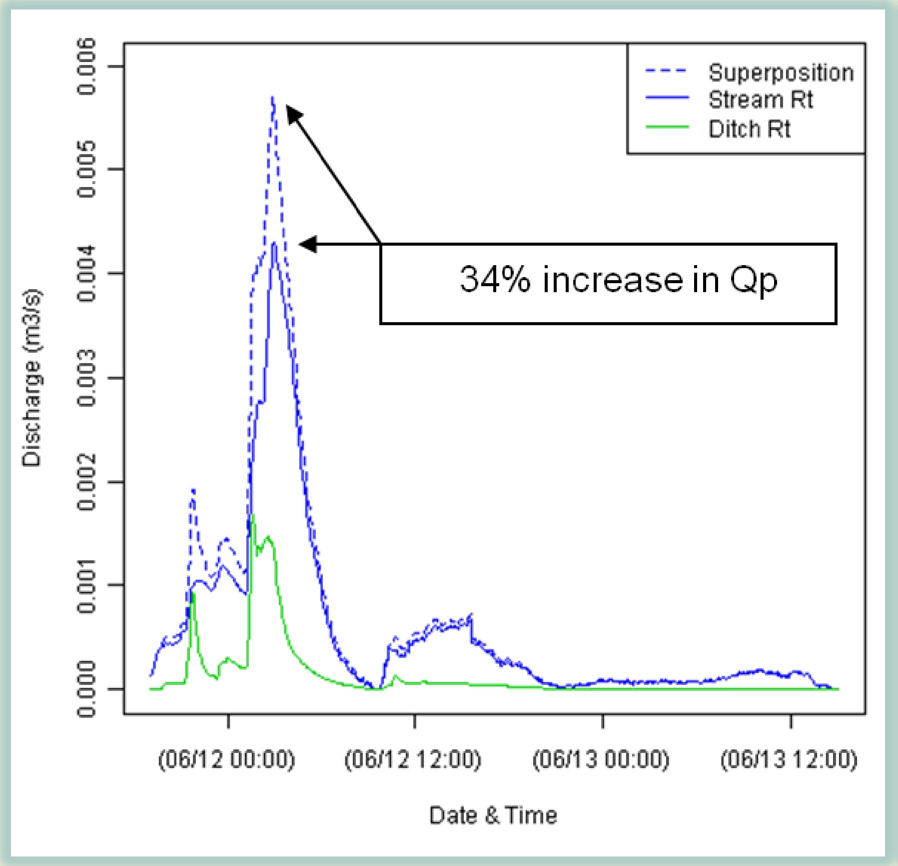


Paine's Creek Watershed

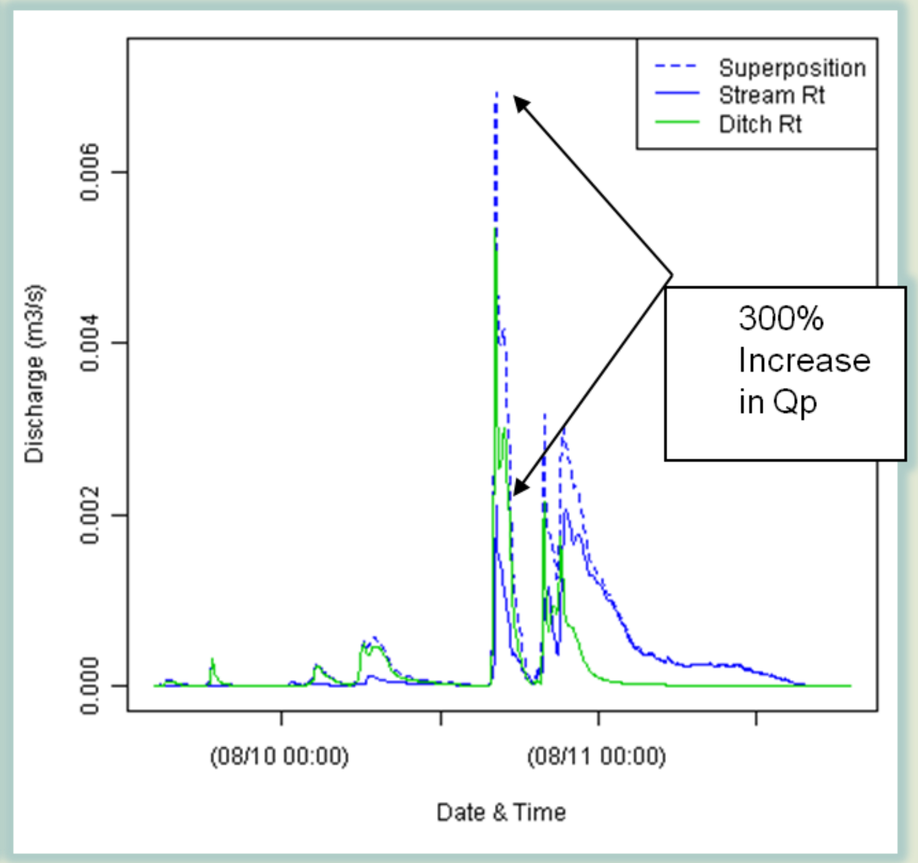
Buchanan et al. 2012

Results – Hydrology

spring



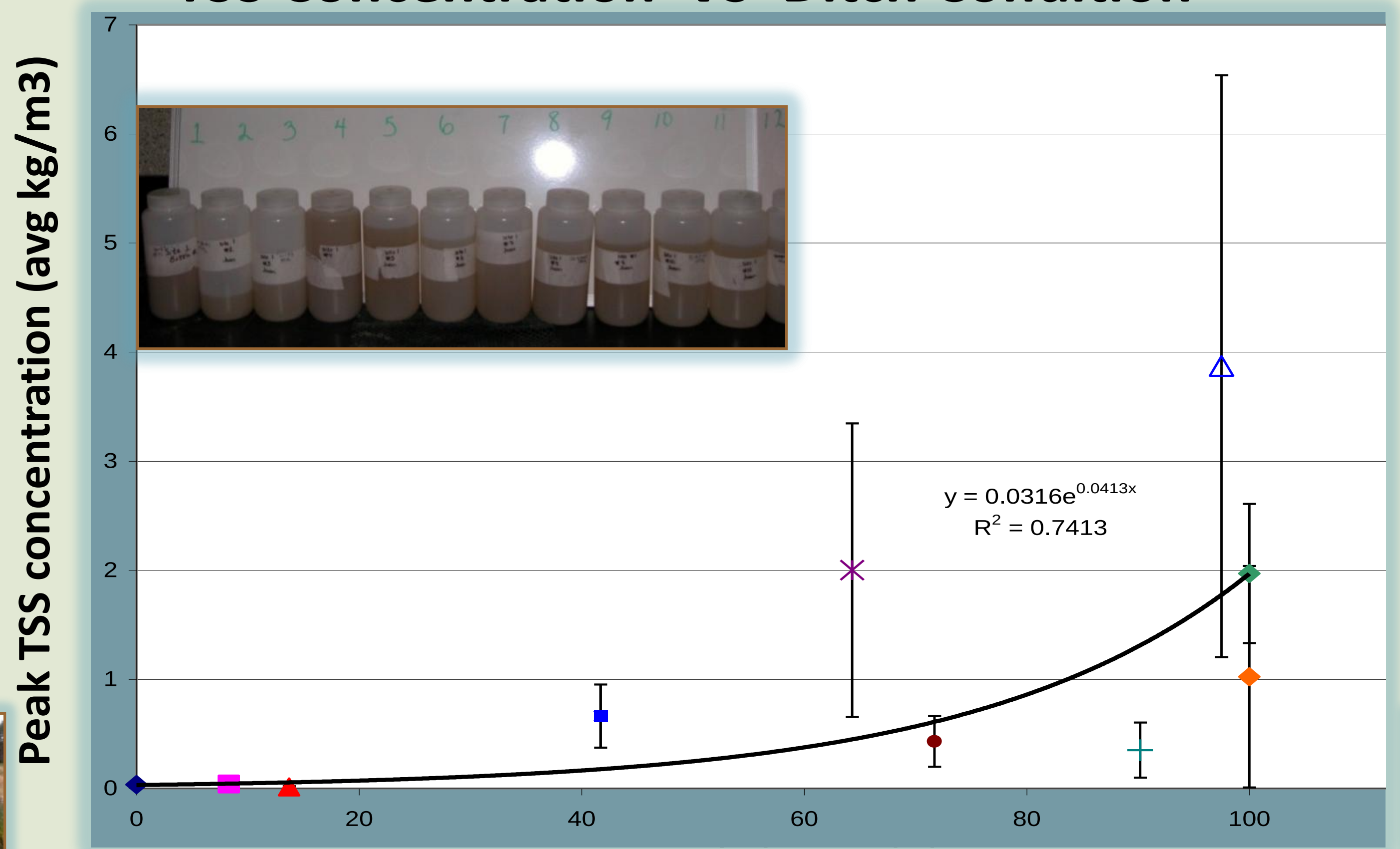
summer



Ditch discharges contribute to increased peak flows (avg 78%) and total flows (avg 57%) in streams. *Buchanan et al. 2012*

Results – Suspended Sediments

TSS Concentration VS Ditch Condition



% exposed bottom substrate

VEGETATED

BARE

Diaz-Robles 2007

Results – Suspended Sediments

TSS - Doolittle Creek Watershed

(62% forest – 33% ag – 2% developed)

- ***Avg Storm [] 0.25 g/L***
- ***Max recorded [] 38.3 g/L***
- ***Avg TSS load per ditch:***
  65 kg/storm-day
- **Total ditch network:**
  1,660 kg/ storm-day
  37% (+/- 27%) of total sediment load in Doolittle Creek

(Avg of 21 days, 7 storms; range 106-6,111 kg/storm-day)

Results – Sediment

Ditches are a source, and a conduit, of sediment and associated contaminants to downstream waters, especially when scraped.

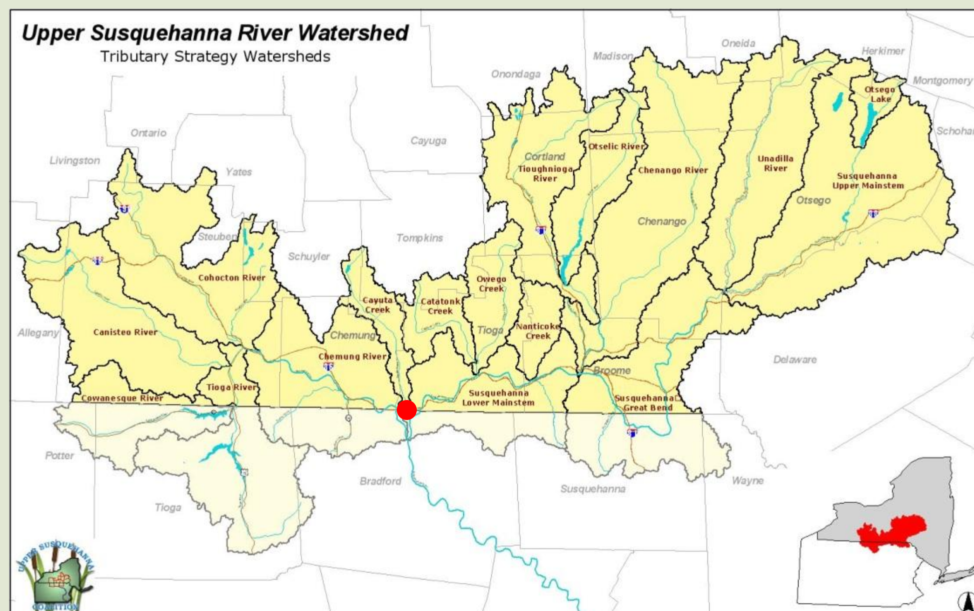
Diaz-Robles, 2007

Results – Suspended Sediments

Potential ditch contributions to Susquehanna River at Waverly, NY in 3 storms (2005-2006) monitored by SRBC's Sediment & Nutrient Assessment:

- ***Sediment from ditches***

0.6 – 11.4 % of TSS load in Susquehanna R.



Results - Microbes

Manure spreading, livestock pasturing, exposed soils

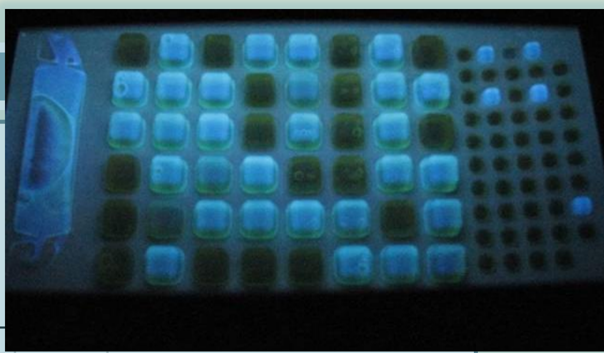
Subsurface flow via tile drains

Overland runoff and erosion

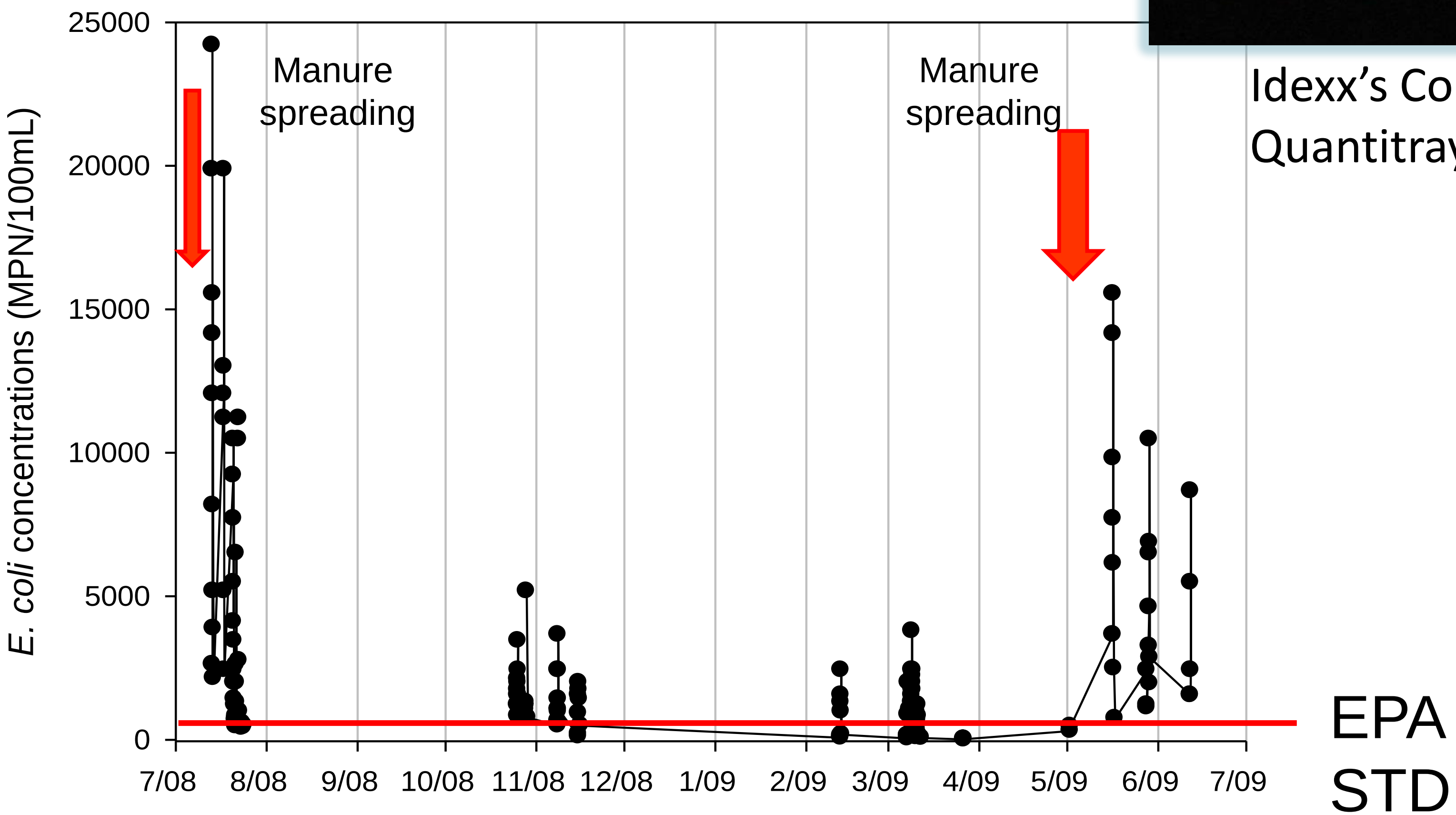
Both dump into roadside ditches

Results - Microbes/ E.coli

Positive
for *E. coli*



Idexx's Colilert/
Quantitray ™



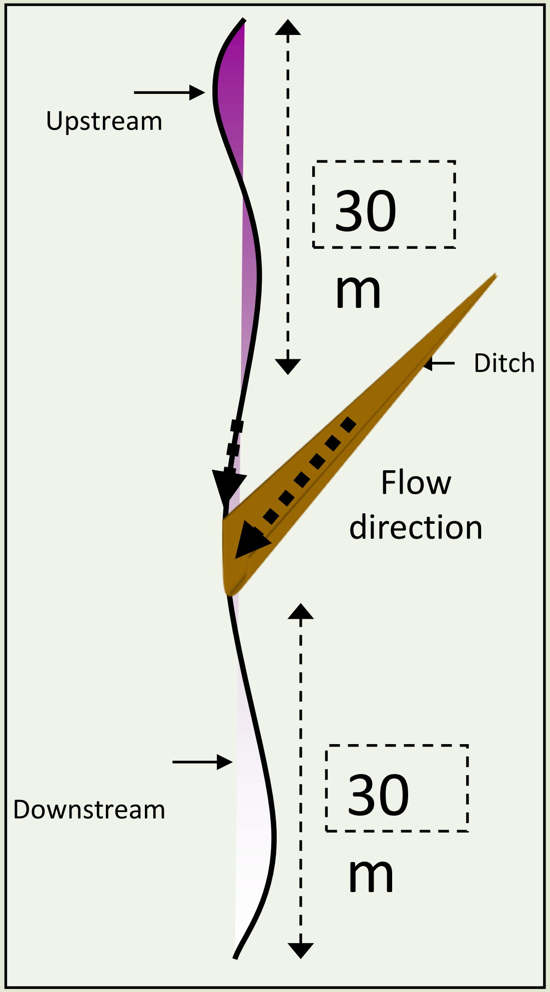
Results – Bedload

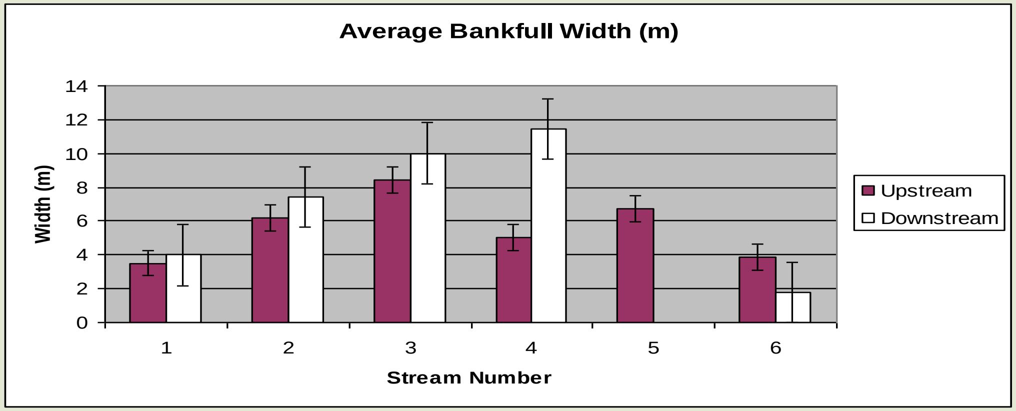
Large quantities of gravel, rocks and other bedload move out of ditches and form deltas in the streams.

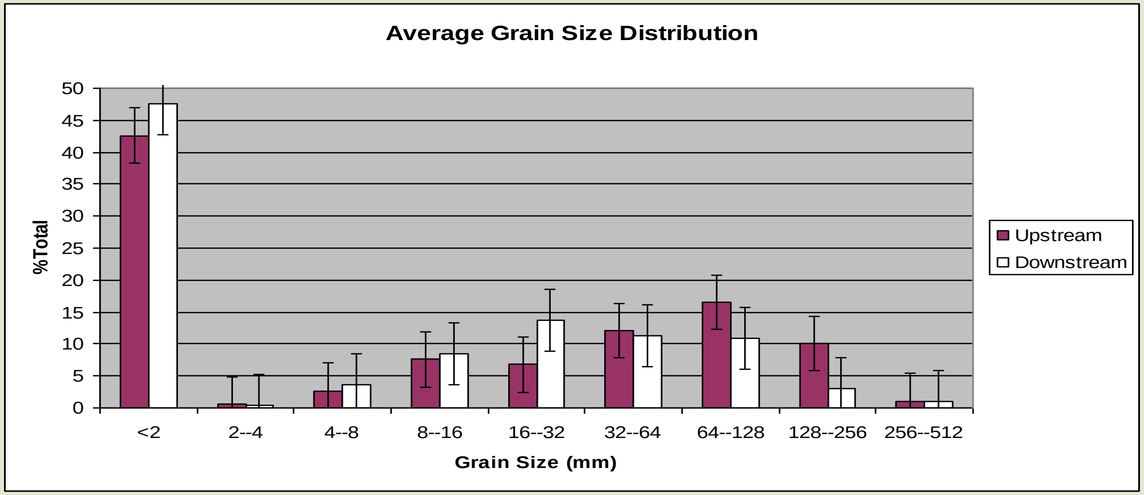
Results – Bedload, Discharge
Stream Geomorphology

High velocity discharges, bedload deltas impact stream at ~94 locations in each watershed.

Results – Hydraulic Radius and Substrate

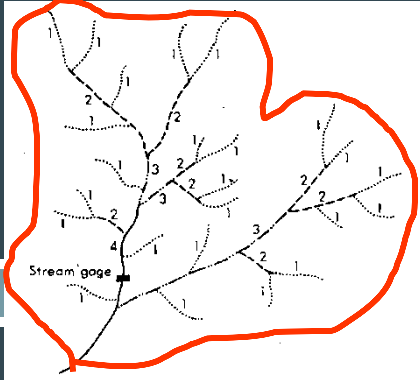






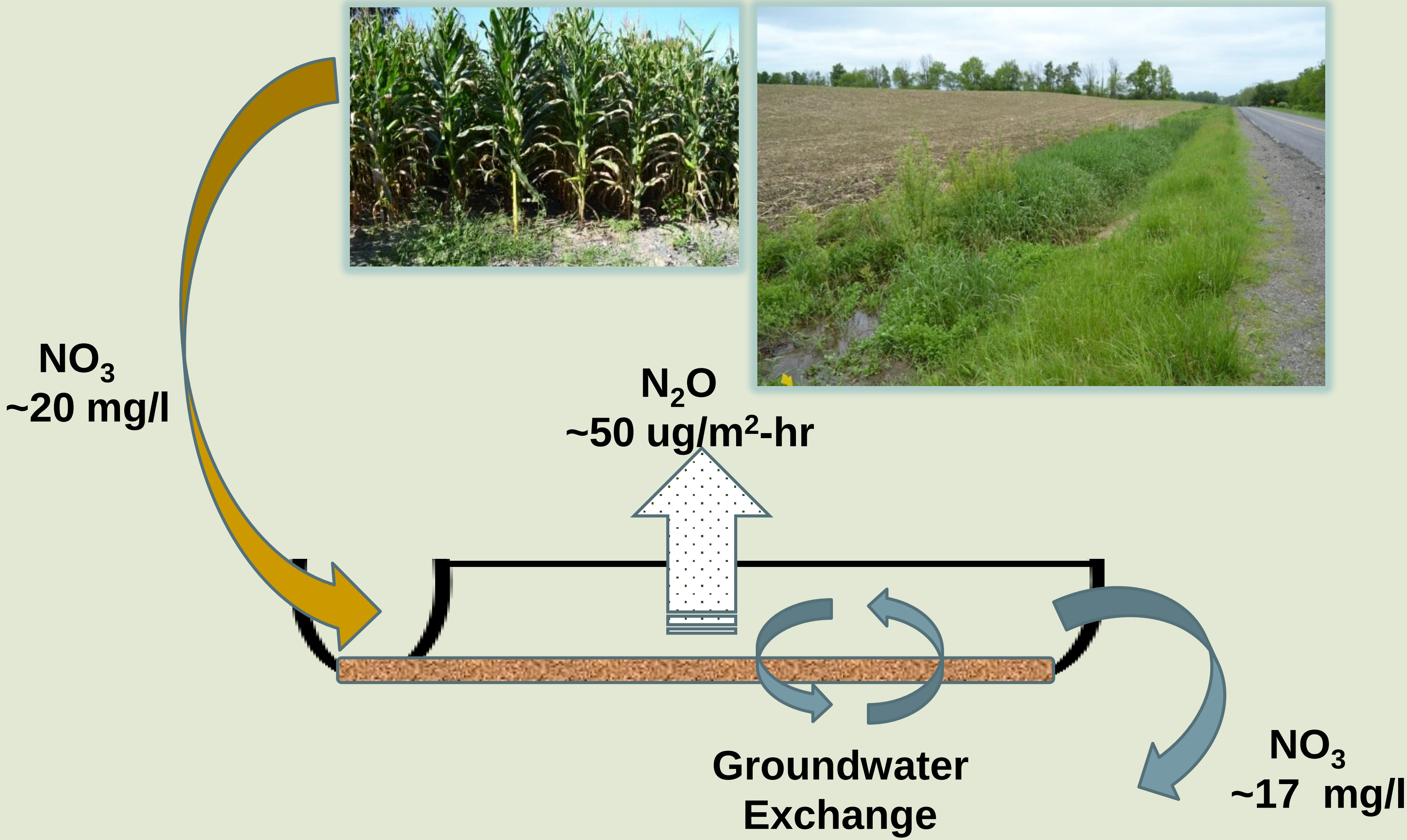
Kimchi 2010

Impacts on stream biota



- Change hydrologic regime – higher floods
- Dry out headwaters
- Increase turbidity, pollution
- “storm-driven” geomorphology

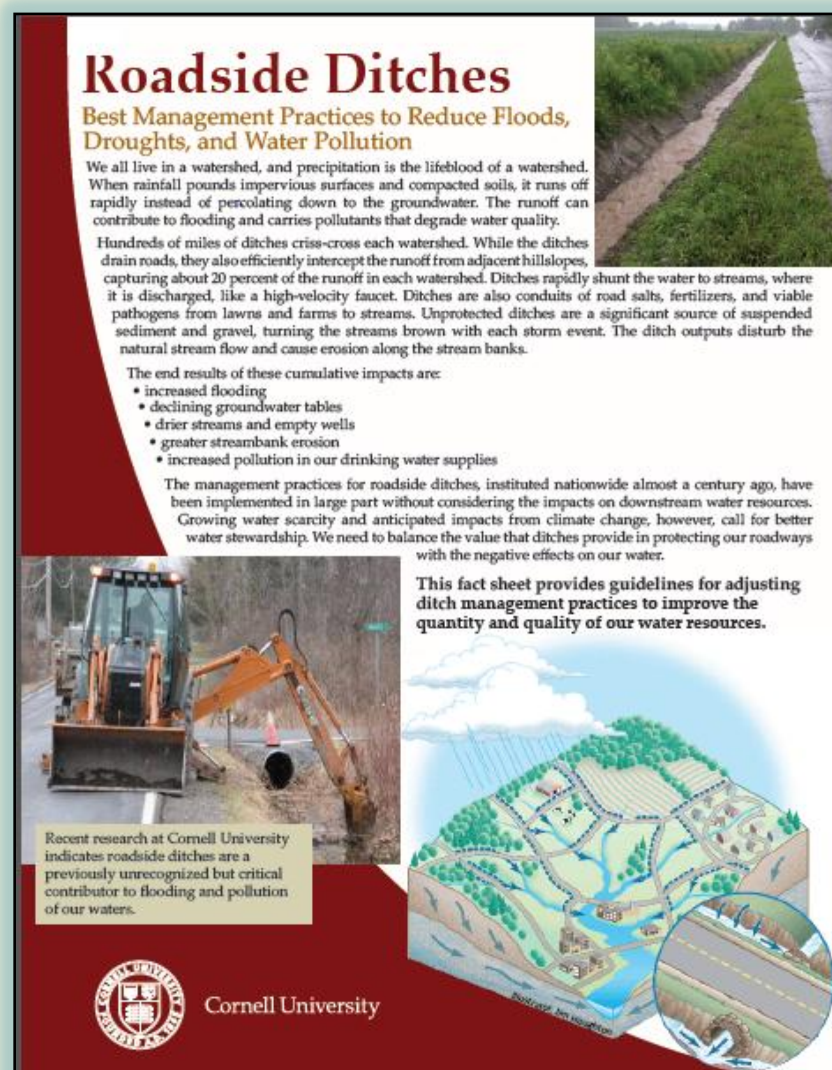
On-going Research: Conduits/ filters of Nitrogen?



Guidelines for Improved Ditch Management

BMP Bulletin

- *Presentations to ~2,500 town highway staff*



Roadside Ditches

Best Management Practices to Reduce Floods, Droughts, and Water Pollution

We all live in a watershed, and precipitation is the lifeblood of a watershed. When rainfall pounds impervious surfaces and compacted soils, it runs off rapidly instead of percolating down to the groundwater. The runoff can contribute to flooding and carries pollutants that degrade water quality.

Hundreds of miles of ditches criss-cross each watershed. While the ditches drain roads, they also efficiently intercept the runoff from adjacent hillslopes, capturing about 20 percent of the runoff in each watershed. Ditches rapidly shunt the water to streams, where it is discharged, like a high-velocity faucet. Ditches are also conduits of road salts, fertilizers, and viable pathogens from lawns and farms to streams. Unprotected ditches are a significant source of suspended sediment and gravel, turning the streams brown with each storm event. The ditch outputs disturb the natural stream flow and cause erosion along the stream banks.

The end results of these cumulative impacts are:

- increased flooding
- declining groundwater tables
- drier streams and empty wells
- greater streambank erosion
- increased pollution in our drinking water supplies

The management practices for roadside ditches, instituted nationwide almost a century ago, have been implemented in large part without considering the impacts on downstream water resources. Growing water scarcity and anticipated impacts from climate change, however, call for better water stewardship. We need to balance the value that ditches provide in protecting our roadways with the negative effects on our water.

This fact sheet provides guidelines for adjusting ditch management practices to improve the quantity and quality of our water resources.

Recent research at Cornell University indicates roadside ditches are a previously unrecognized but critical contributor to flooding and pollution of our waters.

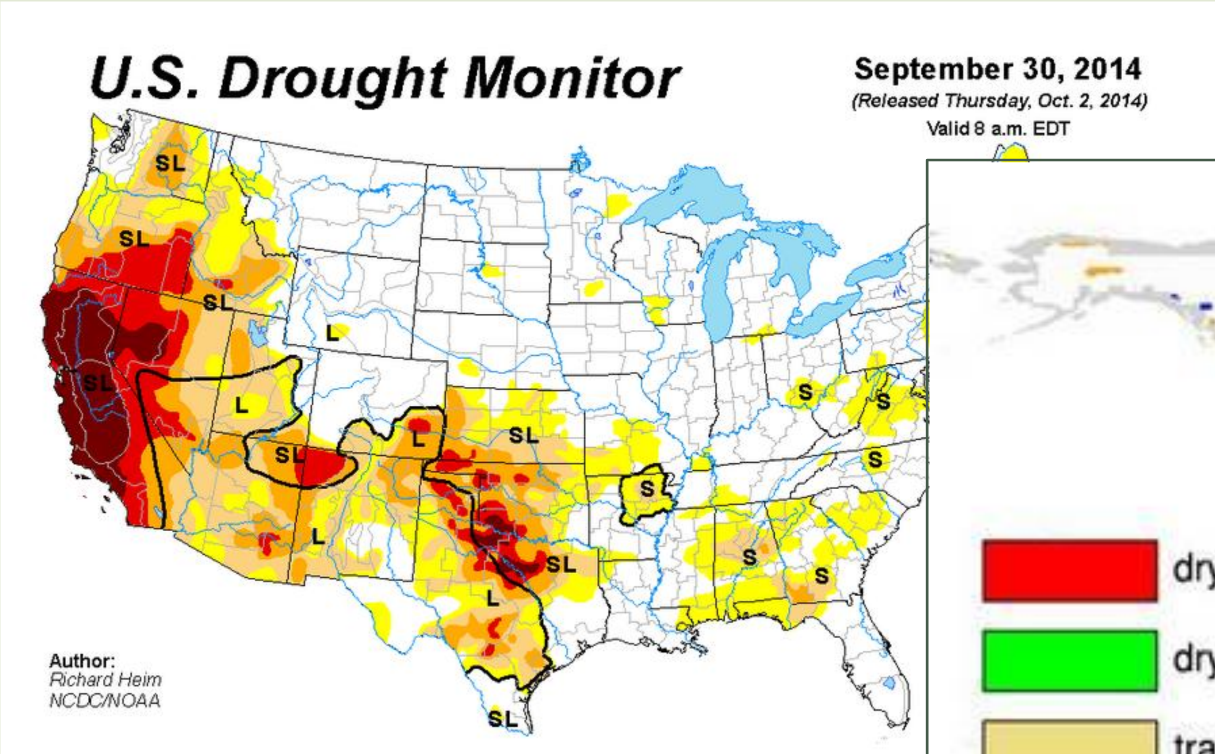
Cornell University

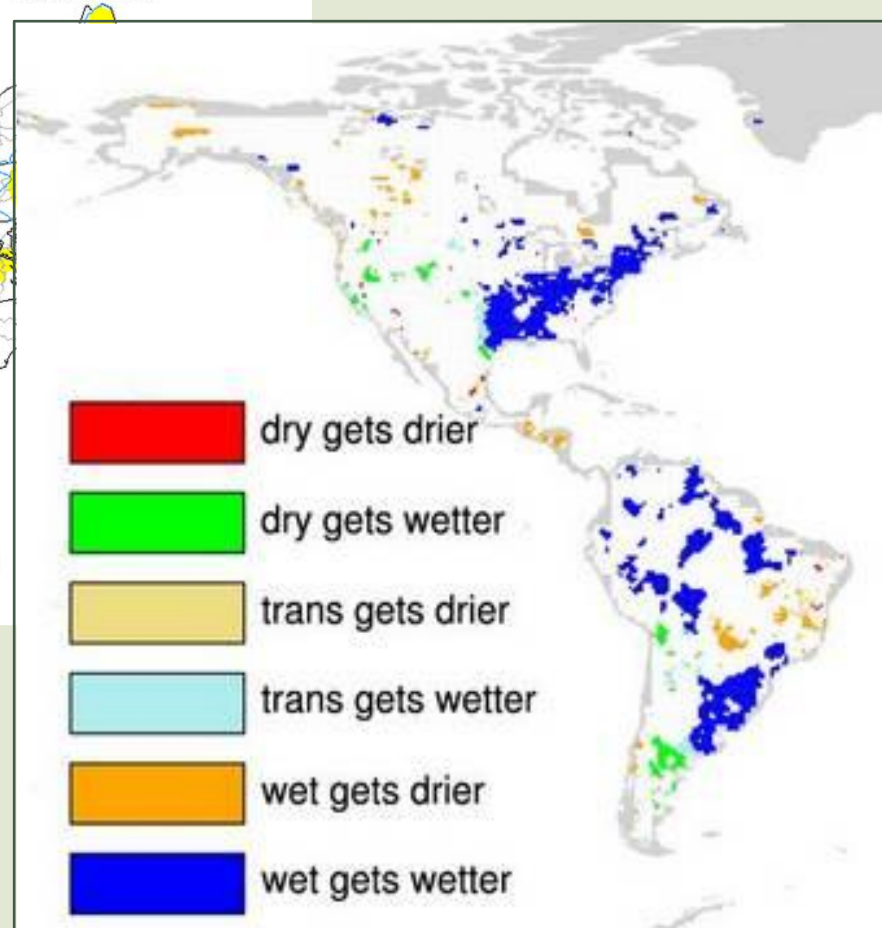
Strategies to Reduce Impacts

Disconnect ditches from streams to reduce flooding.

Slow down the flow.

Save the rain for a droughty day!





14th September 2014
Northeast US is getting wetter.
Greve et al. Nature Geoscience

Strategies to Reduce Impacts

Vegetate / hydroseed ditches after scraping.

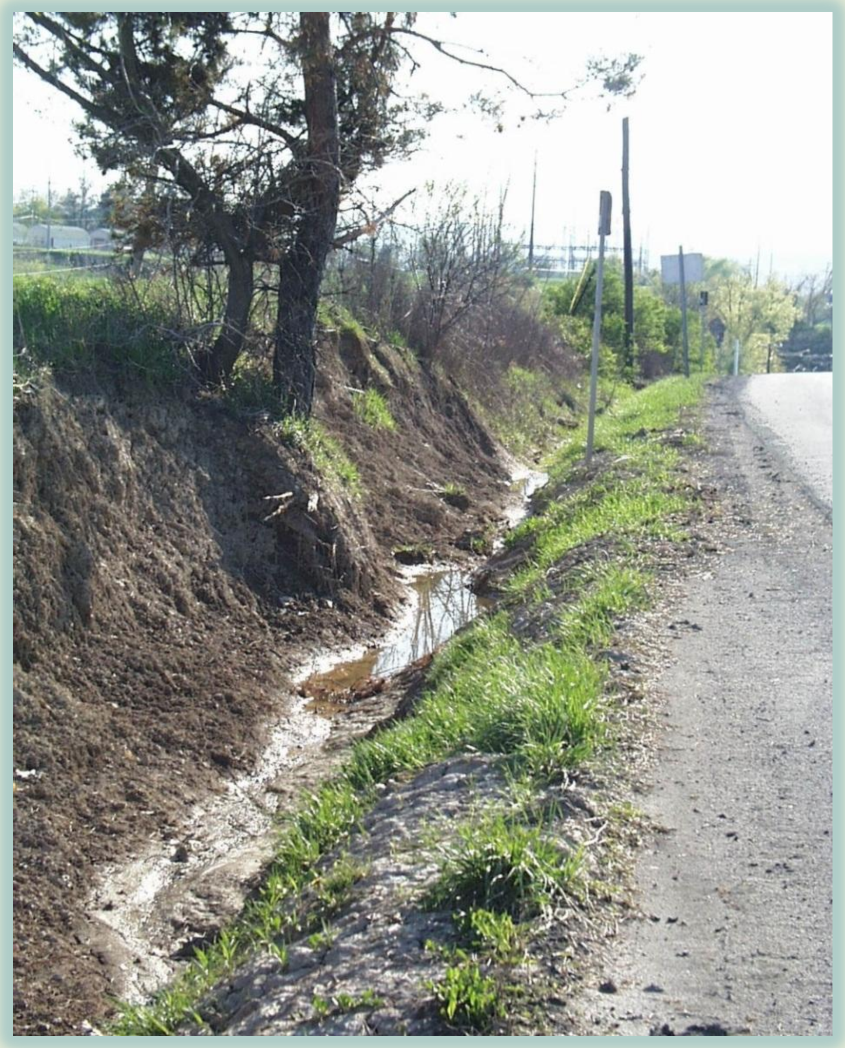
Survey of NYS Town Highway Depts

- 60% HDs report scraping as most common method
- 42% of HDs scrape 1x/ 2-4 yrs
- 50% HDs reported 0% are reseeded immediately

Strategies to Reduce Impacts

Don't over-ditch!

- Deep walls capture more subsurface flow
- V-shaped ditches become incised
- Steeply sloping ditches become destabilized

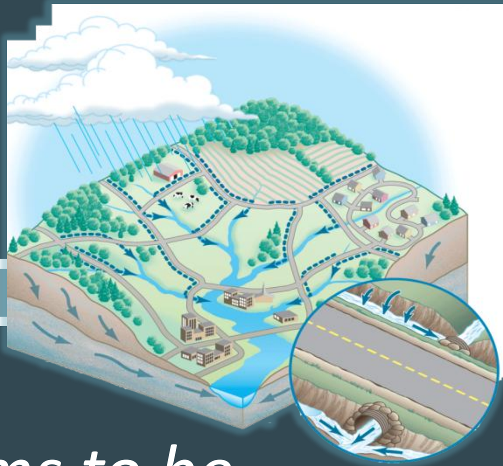


Elsewhere in the Chesapeake Watershed

Regional differences in roadside ditch systems?

- Flatter topography
- Sandier, more porous soils
- County vs town control
- Resource limitations

NYS Highway Dept. Quotes



“The frequency of ditch maintenance seems to be increasing…probably due to more severe weather patterns.”

“With the increase of the amount of rainfall per storm in recent years, it is hard to manage the amount of water entering the ditches which contributes to larger ditches, culverts, etc.”

Improved road ditch management is critical for reducing Floods and pollution, … as well as increasing traffic safety!

Publications

Buchanan, B.P., K. Falbo, R.L.Schneider, Z.M. Easton, and M.T. Walter. 2012. Hydrological impact of roadside ditches in an agricultural watershed in Central New York: implications for non-point source pollutant transport. Hydrological Processes. Wileyonlinlibrary.com DOPI: 10.1002/hyp.9305

Falbo, K., R.L. Schneider, D.H. Buckley, M.T. Walter, P.W. Bergholz, B.P.Buchanan. 2012. Roadside ditches as conduits of fecal indicator organisms and sediment: Implications for water quality and management. J. Environmental Management. *In press.*

Buchanan, B., Z.M. Easton, R.L.Schneider, and M.T. Walter. 2012. Incorporating variable source area hydrology into a spatially distributed direct runoff model. J. Amer. Water. Res. Assoc. 48(1): 43-60

Schneider, R. L., T. Walter, K. Falbo, B. Buchanan, D. Buckley, P. Bergholz, J. Kimchi. 2014. Re-plumbing watersheds: consequences of roadside drainage networks on water resources. *In prep.*

Diaz-Robles, J. 2007. Evaluation of the effects of ditch management practices on suspended sediment, bedload and dissolved chemical contaminants transported to downstream receiving waters. M.S. Thesis. Cornell University.