Treating Runoff from Tile Outlet Terrace Systems: What we Know and What We're Doing

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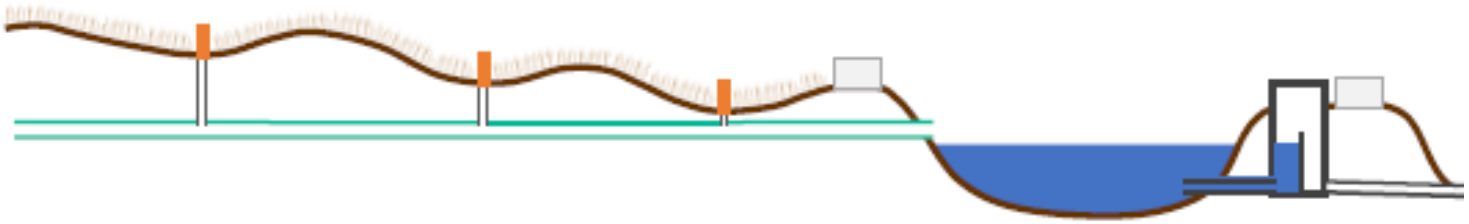
Tiled Outlet Terrace (TOT) Drainage



- Terracing on sloping land minimizes channelized runoff and reduces soil erosion
  - Conventional terraces drain to grassed waterways that filter sediments and remove nutrients
- Underground tile outlet terrace drains allow for more planting area, but more pollutant transport
- Adding created wetlands at TOT outlet can mitigate drainage impacts on water quality

Project History

- Two Studies supported by the Kansas Water Office and EPA Region 7's Wetland Development Program

1. Study Number 1 (2016-2016)
   - Collected experimental data on water quality at three sites and adjacent streams
   - Final report presented in August, 2016

2. Study Number 2 (2016- 2018)
   - Collect additional field-scale data to better understand wetland performance
   - Construct hydrologic and water-quality models to assess long-term impact of wetland installation

Project Scope

- **These projects examines the water quality impacts of tile outlet runoff from terrace fields and the performance of three wetlands constructed to provide on-site treatment of storm runoff**
  - Wetlands installed to NRCS specifications (Practice Code 658)

1. Determine solid and nutrient loadings in tile outlet terrace (TOT) runoff
2. Assess wetland impacts on downstream water quality
3. Develop best management practices for wetland installation and operation
4. Examine TOT runoff impact on local waterways (Project 1)
5. Create models of wetland performance over longer-term (Project 2)

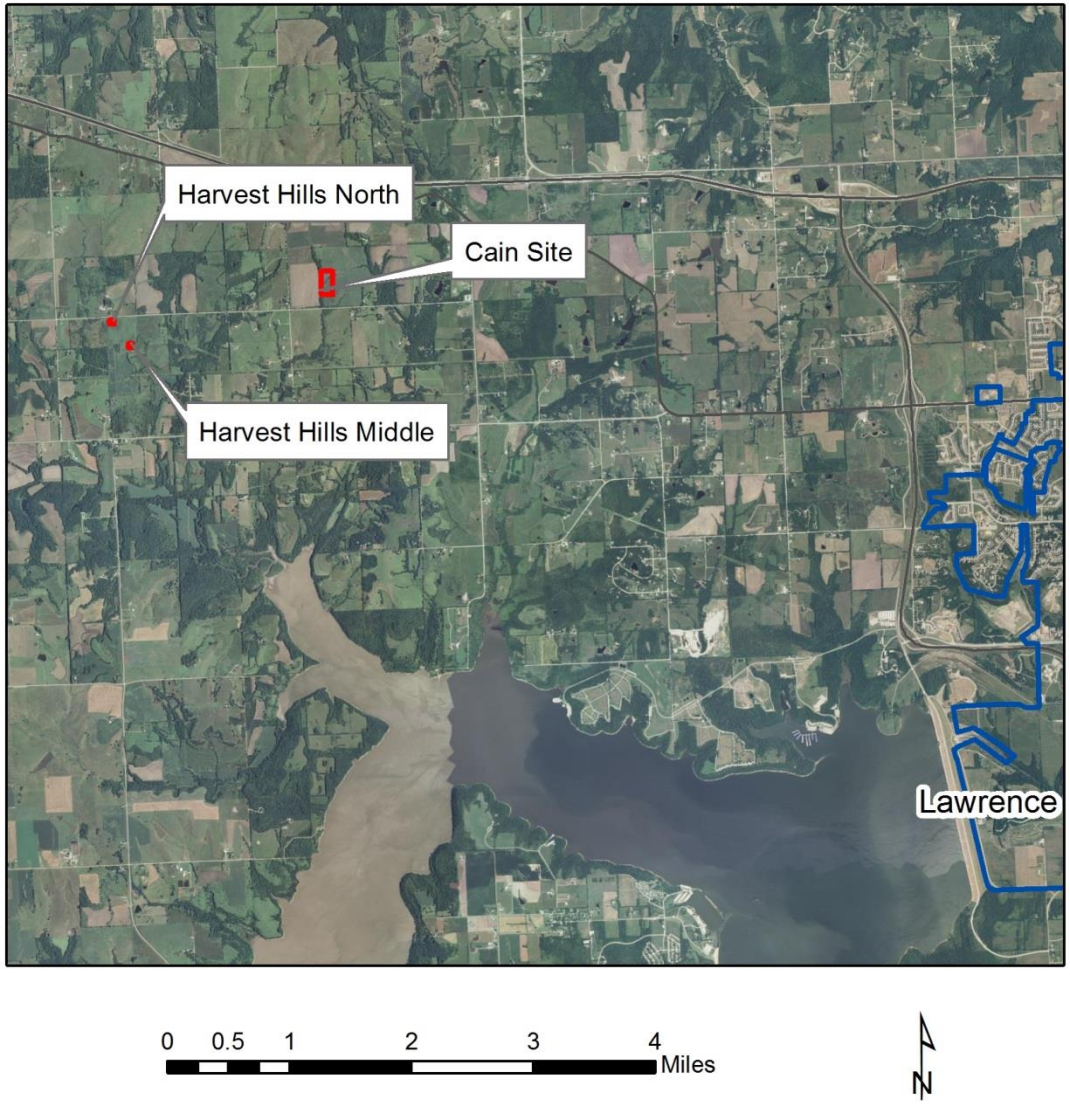
Field Sampling

Study Sites

Three wetland ponds in northeastern KS, constructed between 2008 and 2011

Two intermittent streams, one receiving wetland effluent, one with direct TOT runoff

All drain to Clinton Lake, which supplies drinking water to the City of Lawrence



Sampling Equipment

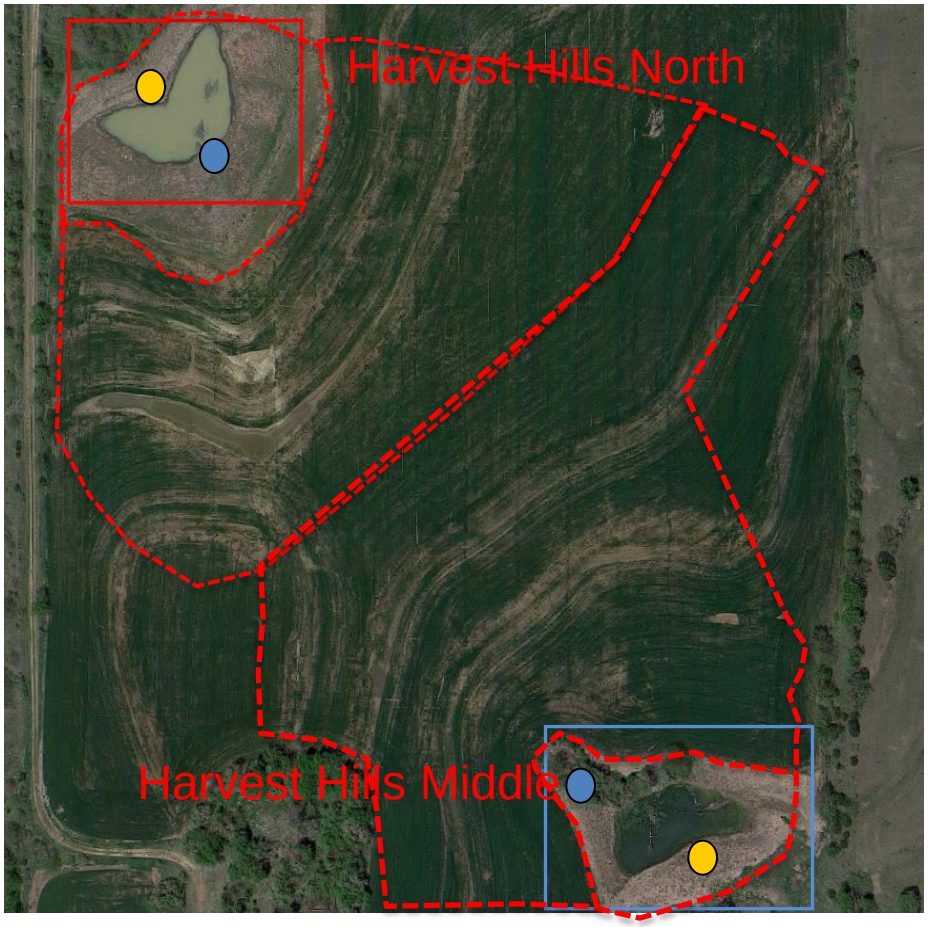
ISCO 6712 portable automated sampler

750 Area-Velocity meter triggers sampling during a rain event

Tipping Bucket rain gage installed at each site to measure precipitation

Samplers installed at Harvest Hills North site

Harvest Hills Sites

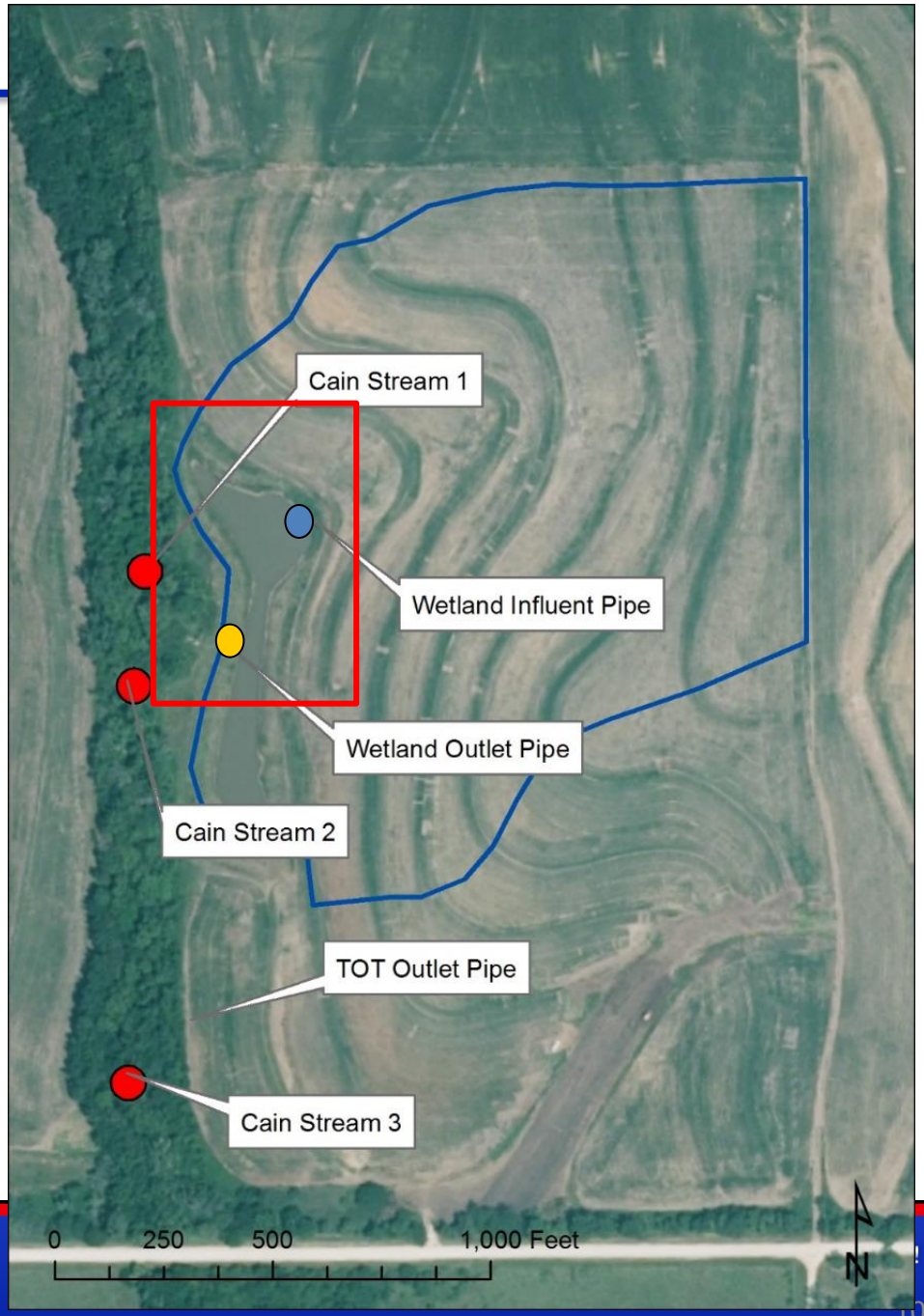


-Inlet pipe -Outlet weir

- Sites drain ~ 10.6 acres each
- Runoff collected at tile drainage outlet to pond, and in pond effluent weir box
- North site has exposed riser on 2nd terrace, leading to increased sediment transport
- Planted with soybeans (2014) and corn (2015)
- Samples collected from June-November, 2014 and May – November, 2015

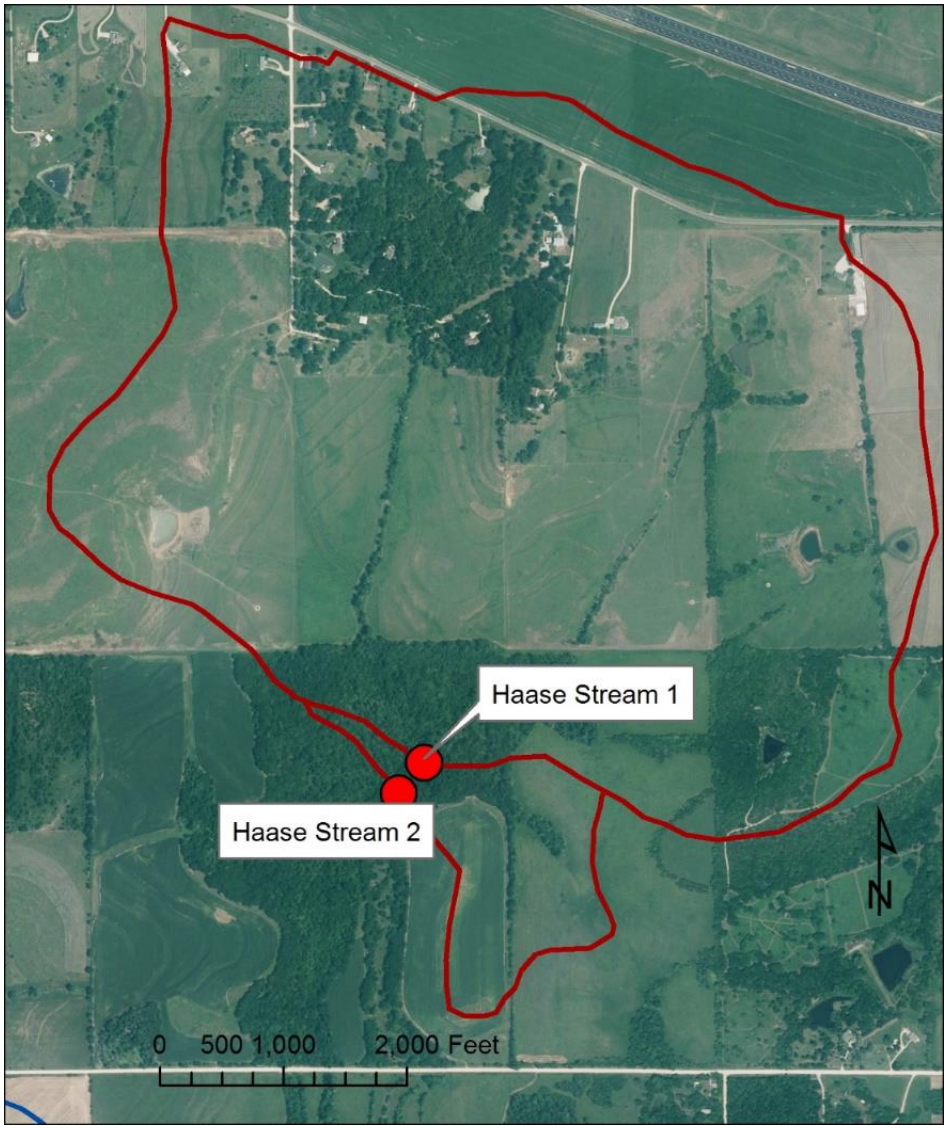
Cain Site

- Drains 29 acres (6 terraces plus small area near wetlands)
- Submerged pond inlet, with standing water and sediments in pipe at lower two terraces
  - Influent sampled from upper four terraces only
- Effluent exits through steep pipe
- Planted with soybeans in both 2014 and 2015
- Automated sample collection began in September, 2014



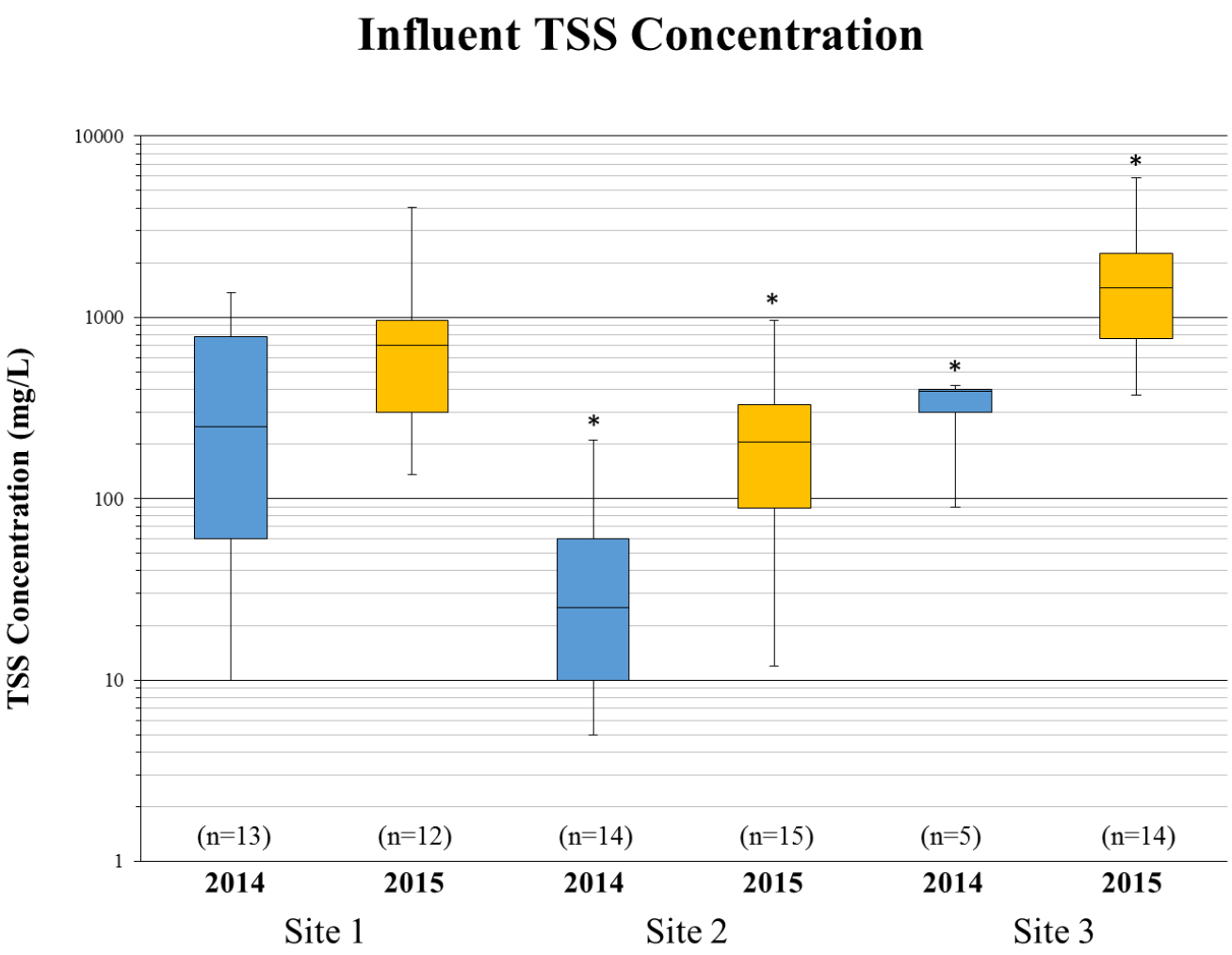
Haase Stream Site

- Comparative site with stream sampling only
- Farmed in same manner as Harvest Hills site, but no wetland
  - Effluent discharges from TOT system into stream
- Planted with corn in 2014, soybeans in 2015
- Stream samples upstream and downstream of TOT discharge
- Stream also sampled at TOT outfall



Results Part 1: Wetland Performance

Influent Water Quality



All influent concentrations higher in 2015

Similar patterns for N and P

Influenced by rainfall pattern and sampling period

Nitrogen increased more at HH sites, where crop switched to corn

Water Quality Improvements:

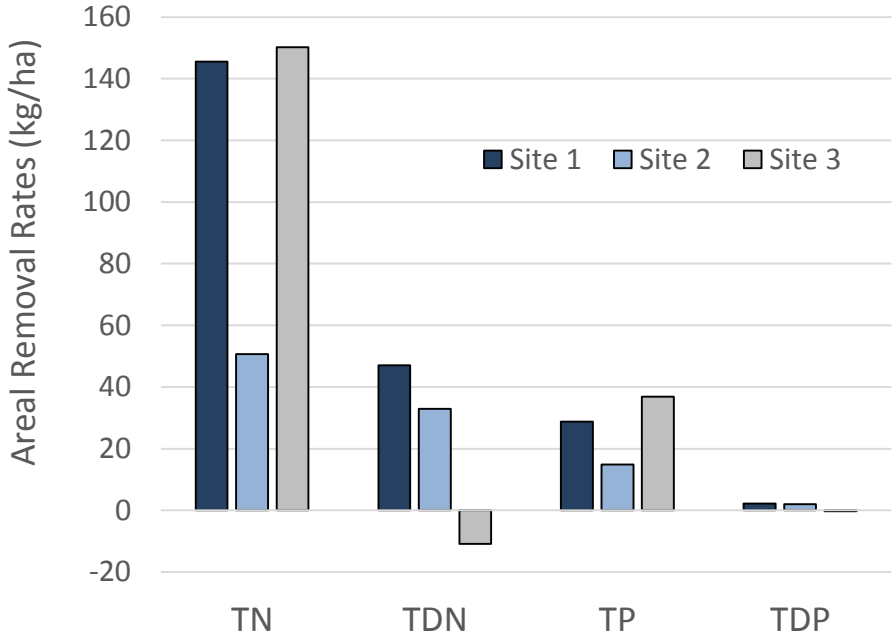
- **Mass-based removal efficiencies at each site**

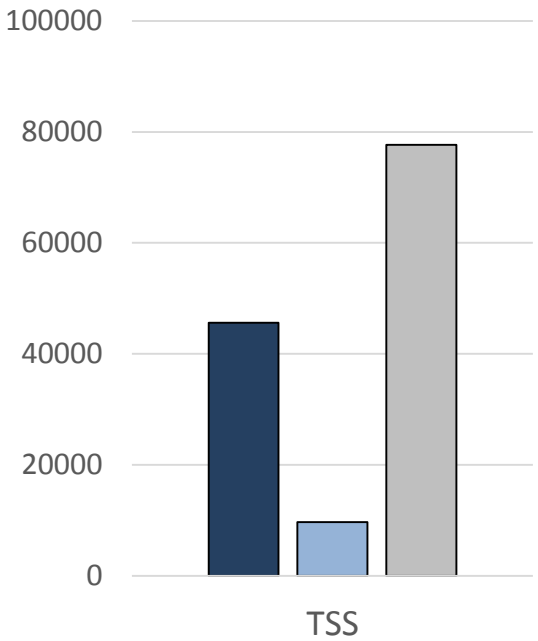
	TSS		TN		TP	
	%	Mass (kg)	%	Mass (kg)	%	Mass (kg)
Site 1 (HHN)	**67%**	9969	**32%**	31.8	**38%**	6.3
Site 2 (HHM)	**57%**	2275	**17%**	11.9	**40%**	3.5
Site 3 (Cain)	**83%**	53,748	**53%**	103.9	**56%**	25.5

- **These results weight concentration changes in runoff by total volume entering and leaving the wetland**
  - Outflow/Inflow Ratios at each site

  Site 1: 86%, Site 2: 71%, Site 3: 92%

Wetland Performance on Areal Basis



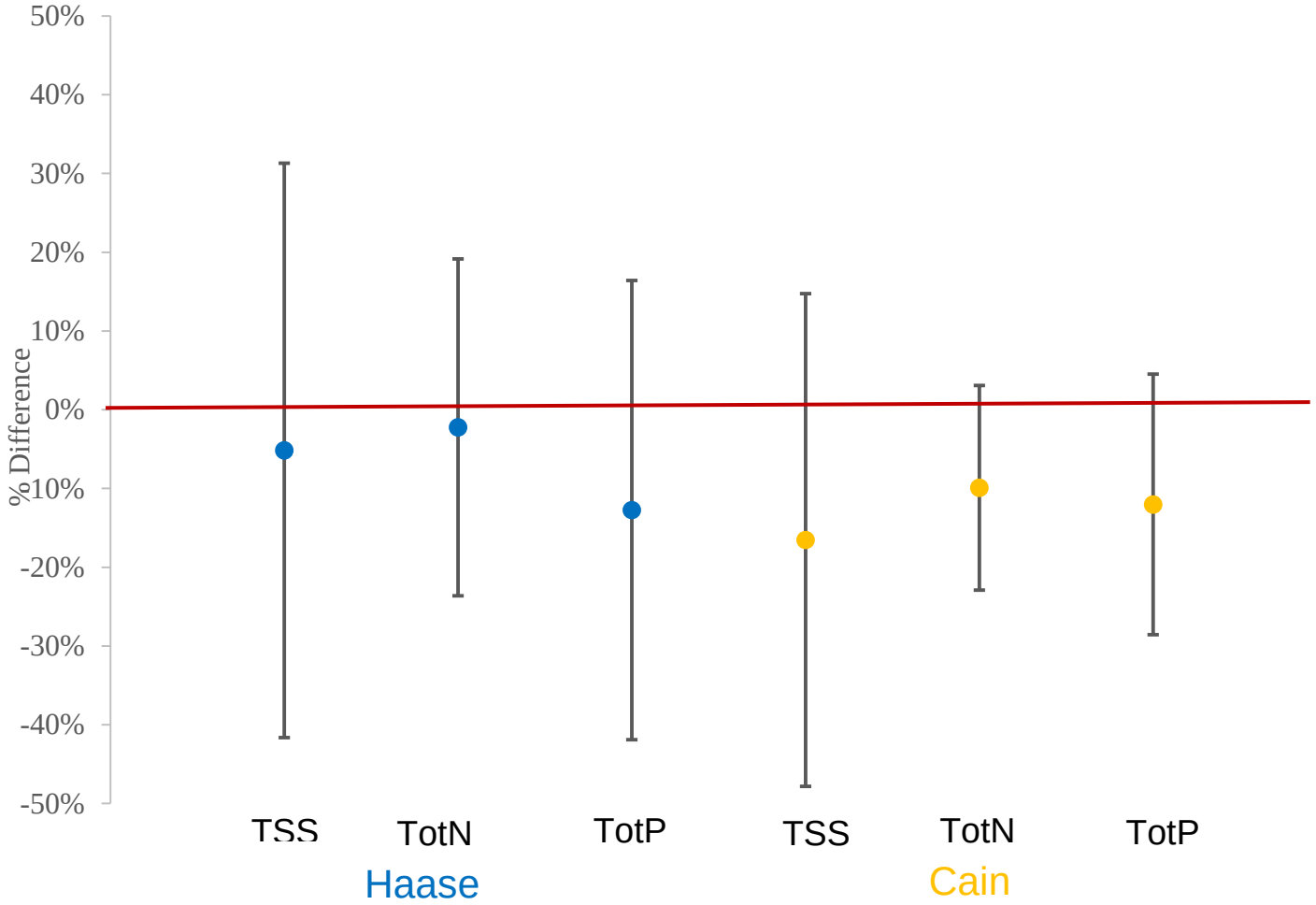


(Dissolved N and P values are for 2015 only)

Site 3 (Cain) had much lower influent concentrations of TDN and TDP, along with lower removal rates in the wetland

Results Part 2: Stream Sampling

Impact of TOT Runoff: Upstream/Downstream Comparison



No direct impact of runoff on stream quality was observed in our study

Stream Quality Compared

- However, even upstream nutrient concentrations are elevated at both sites
- TP Concentrations are in the upper 15% of agricultural watersheds measured by USGS
- Median values in Upper and Middle Kansas River tributaries are 0.4-1.25 mg/l for TN, and < 0.1-0.25 mg/l for TP (Banner, 2008)

	HAASE		CAIN		Benchmark
	Upstream	Downstream	Upstream	Downstream	
TN	3.3	3.4	4.3	3.2	0.9
TP	0.57	.57	0.75	0.51	.075

Major Findings from 1st Project

1. TOT runoff contains elevated concentrations of nitrogen, phosphorus and total suspended solids

2. The treatment wetlands were effective at suspended solids removal

3. The treatment wetlands had some success at nutrient removal, with substantial variation between sites

4. Wetland design impacted treatment capabilities
   - The Cain site had deeper water, steeper slopes, and more areas. It was the most effective at removing solids and solid-associated particles, but weakest at dissolved nutrient removal

5. TOT runoff likely impacts stream quality, but a direct impact was not observed in the adjacent streams

Ongoing work for Project 2

- Samplers will go back in the field in April, 2017 at the same three sites

- Targeted sampling to address
  - Nitrogen retention and reaction in the wetlands
  - Impacts of different rainfall patterns and crop plantings
  - More detailed wetland performance data

- Model development using Project 1 and Project 2 data
  - Runoff estimates using HEC-HMS
  - Wetland performance models based on hydrologic parameters

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