Comparing Water Quality Functional Uplift Outcomes from Common Models and Direct Measurement Using the Stream Function Quantification Tool (SQT) : A Case Study

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Stream Function Pyramid Framework

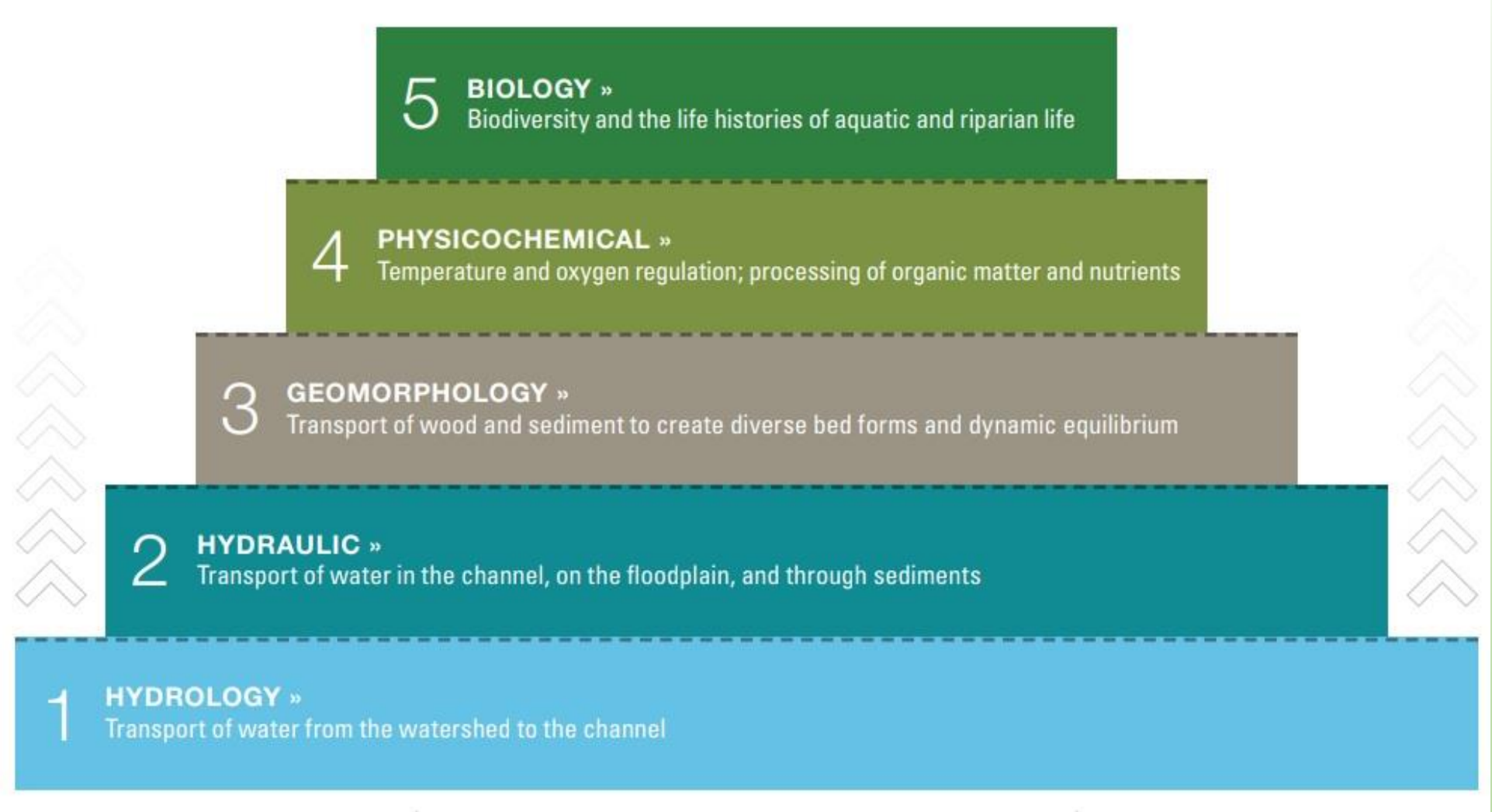
In April 2008, the United States Army Corps of Engineers (USACE) and the United States Environmental Protection Agency (EPA) jointly issued regulations clarifying compensatory mitigation requirements for Department of the Army permits (33 C.F.R. § 332/40 C.F.R. § 230):

"*...With this rule, we are encouraging the use of functional and condition assessments to determine the appropriate amount of compensatory mitigation needed to offset authorized impacts, instead of relying primarily on surrogate measures such as acres and linear feet.*"

The Final Rule stated:

"...In cases where appropriate functional or condition assessment methods or other suitable metrics are available, these methods should be used where practicable to determine how much compensatory mitigation is required (33 C.F.R. § 332.3FR Vol 73, 19633)."

Stream Function Pyramid Framework



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Stream Function Quantification Tool (SQT)

Determine numerical difference between existing stream condition and proposed condition

Link restoration activities to changes in stream functions

Estimate restoration potential

Functional Category	Function-Based Parameters	Measurement Method
Hydrology	Catchment Hydrology	Curve Number
	Reach Runoff	Curve Number
		Concentrated Flow Points
		Soil Compaction
Hydraulics	Floodplain Connectivity	Bank Height Ratio
		Entrenchment Ratio
Geomorphology	Large Woody Debris	LWD Index
		# Pieces
	Lateral Stability	Erosion Rate (ft/yr)
		Dominant BEHI/NBS
		Percent Streambank Erosion (%)
	Riparian Vegetation	Left Canopy Coverage (%)
		Right Canopy Coverage (%)
		Left Riparian Vegetation Width (ft)
		Right Riparian Vegetation Width (ft)
		Left Basal Area (sq.ft/acre)
		Right Basal Area (sq.ft/acre)
		Left Stem Density (stems/acre)
		Right Stem Density (stems/acre)
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)
	Bed Form Diversity	Pool Spacing Ratio
		Pool Depth Ratio
		Percent Riffle
		Aggradation Ratio
	Sinuosity	Plan Form
Physicochemical	Temperature	Temperature (°F)
	Bacteria	Fecal Coliform (Cfu/100 ml)
	Organic Carbon	Leaf Litter Processing Rate
		Percent Shredders
	Nitrogen	Monitoring (mg/L)
	Phosphorus	Monitoring (mg/L)
Biology	Macros	Biotic Index
		EPT Taxa Present
	Fish	North Carolina Index of Biotic Integrity

Physiochemical Function

The nutrient (nitrogen and phosphorus) parameter is included in both the BMP Routine and the reach condition assessments in SQT.

SQT suggests to use the Jordan/Falls Lake Stormwater Nutrient Load Accounting Tool (JFSLAT), if a BMP is being installed.

Four common water quality models are selected and results of model runs are compared with direct in-stream monitoring results for a DMS mitigation project.

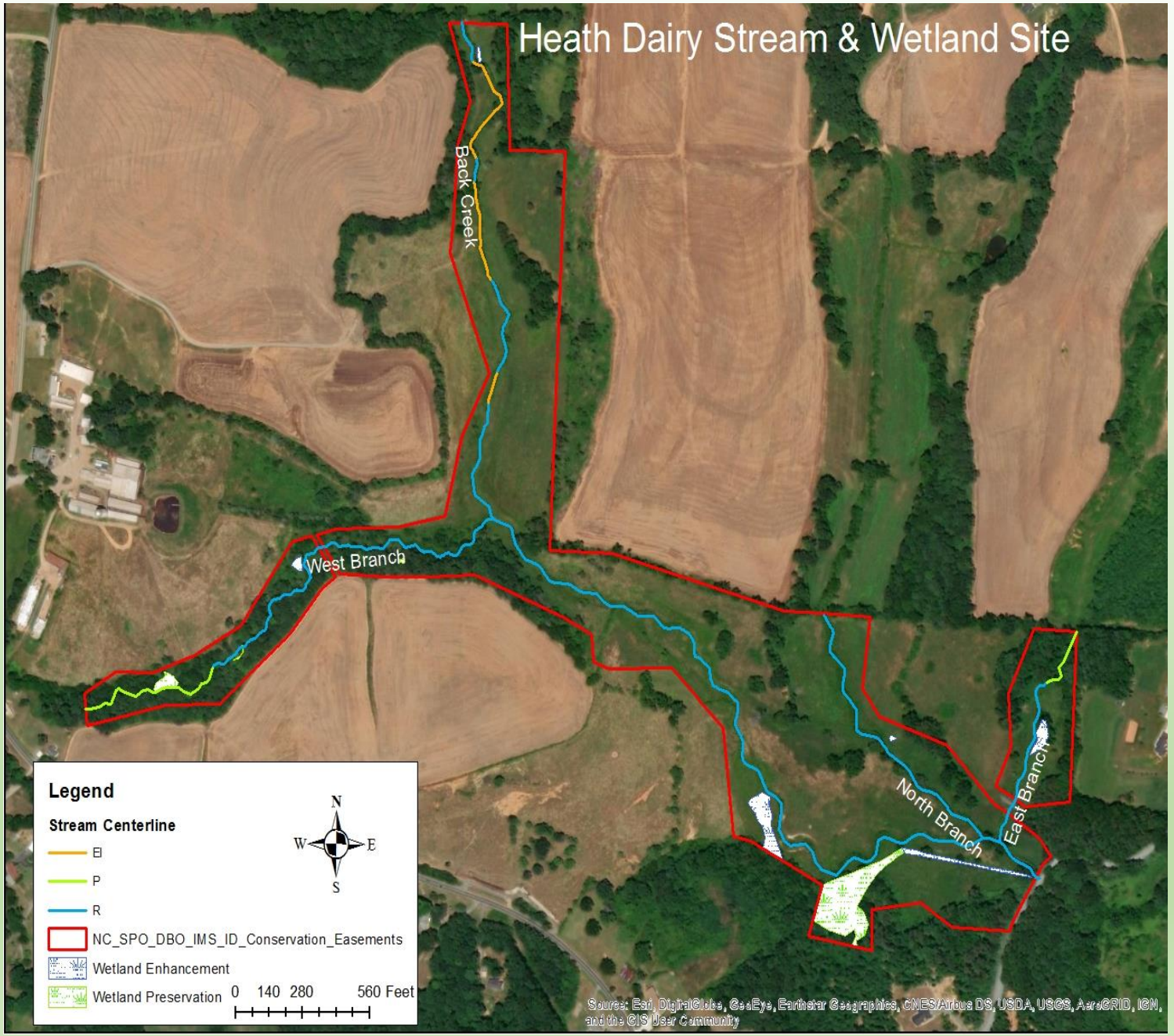
Heath Dairy Road Restoration Site

Cape Fear River Basin

Provides 7,791 LF of stream restoration, 960 LF of enhancement and 636 LF of preservation

Construction completed in 2013, and current in year 4 monitoring

NCSU Water Group conducted pre and post restoration monitoring



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Water Quality Models

Two Export Coefficient Models

- DMS tool for Quantifying Benefits to Water Quality from Livestock Exclusion and Riparian Buffer Establishment for Stream Restoration (DMS)
- Total Nitrogen (TN) and Total Phosphorus Loading Calculation Worksheet – Piedmont of the Tar-Pamlico River Basin (DWR)

Two Storm Water Based Models

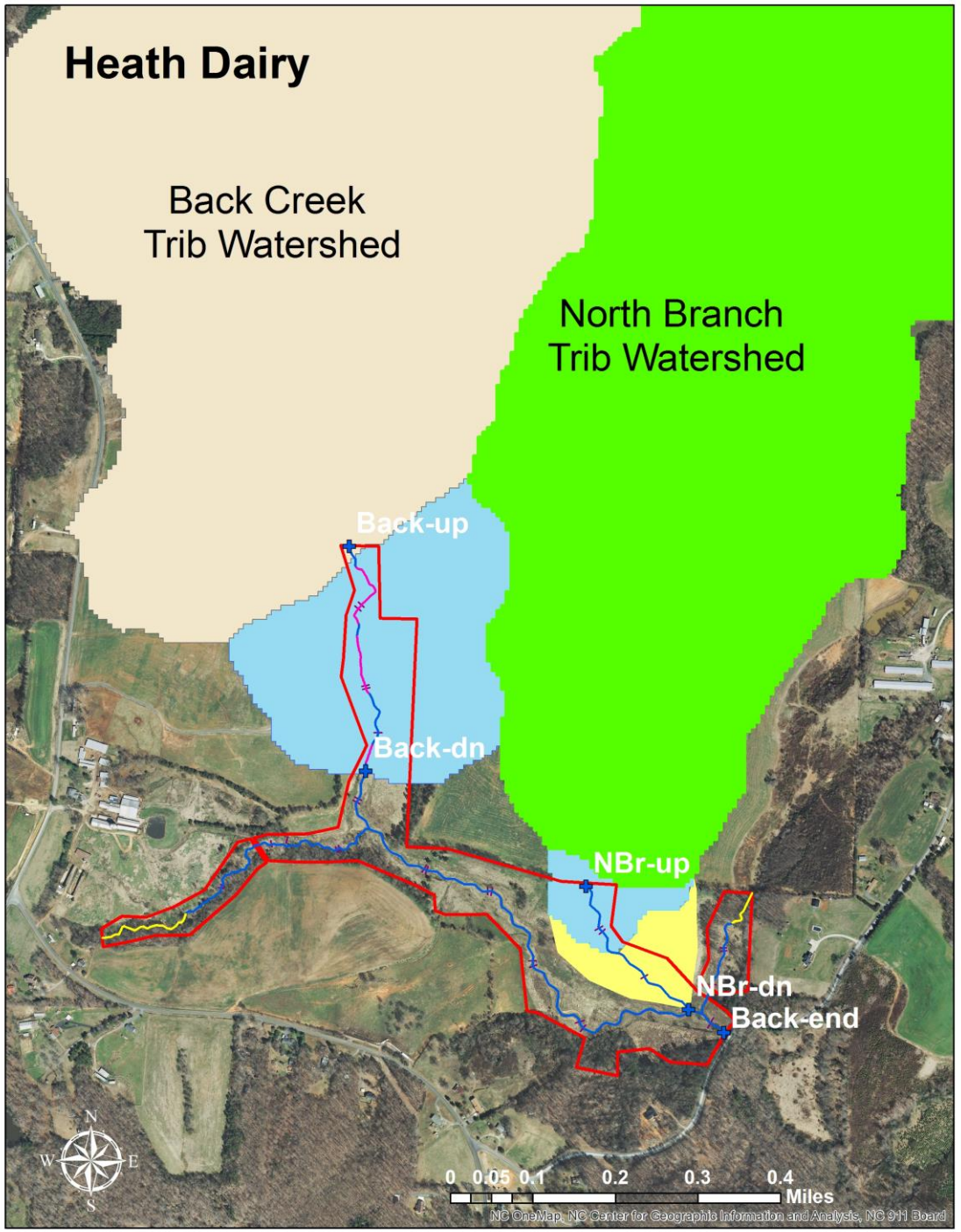
- Jordan/Fall Lake Stormwater Nutrient Load Accounting Tool (JFSLAT) (DWR & NCSU BAE)
- Stormwater Nutrient Accounting Tools (SNAP) (DWR)

Back Creek Reach – Heath Dairy

- Catchment size – 1.08 sq mi, buffer planted area – 6 ac, and lateral drainage area – 52 ac
- Predominant agricultural land use (55%, mostly pasture)

North Branch Reach – Heath Dairy

- Catchment size – 1.14 sq mi, buffer planted area – 6.04 ac, and lateral drainage area – 17 ac
- Predominant agricultural land use (60%, mostly pasture)



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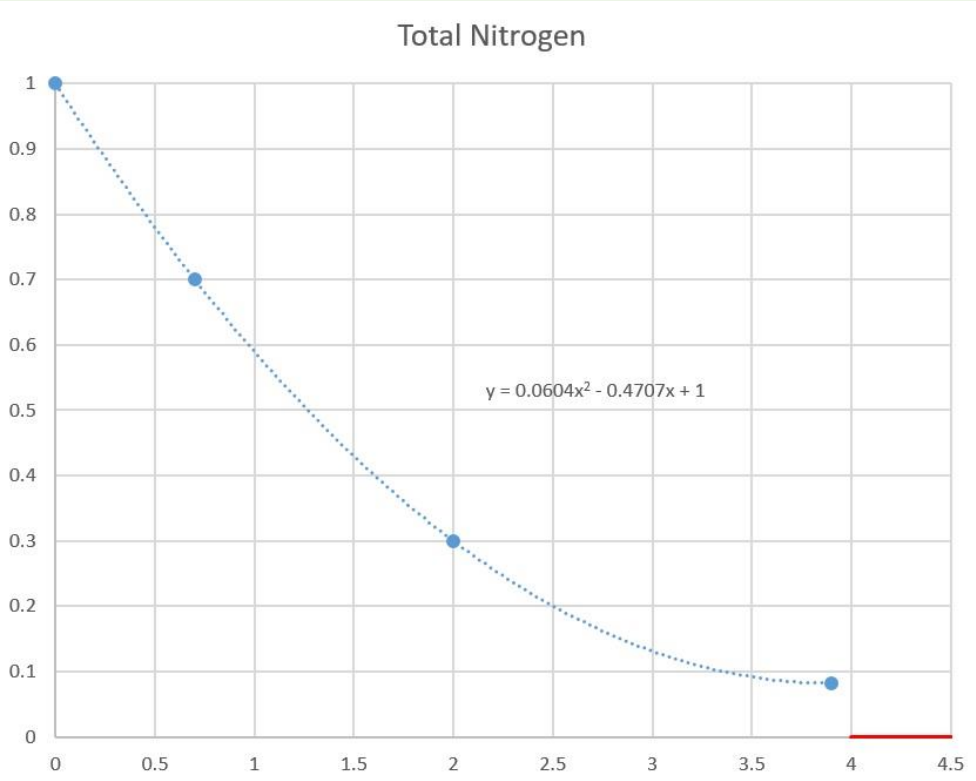
Back Creek Reach - Water Quality Models Results and Monitoring Data

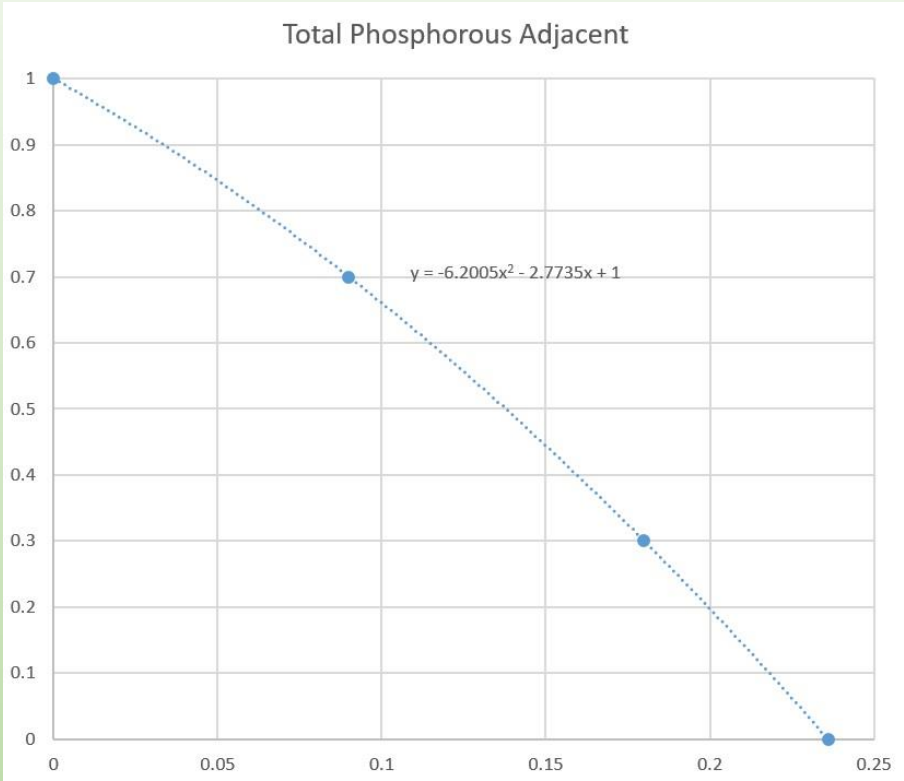
	TN (mg/L) Pre-restoration	TN (mg/L) Post-restoration	% Change	TP (mg/L) Pre-restoration	TP (mg/L) Post-restoration	% Change
Tar-Pam Nutrient Loading Calculation Worksheet	1.89	1.83	3.2	0.48	0.46	4.2
JFLSAT	2.07	2.02	2.4	0.55	0.54	1.8
SNAP	1.71	1.63	4.7	0.34	0.33	2.9
Monitoring Data	5.59	2.29	59.0	1.97	0.48	75.6

North Branch Reach - Water Quality Models Results and Monitoring Data

	TN (mg/L) Pre-restoration	TN (mg/L) Post-restoration	% Change	TP (mg/L) Pre-restoration	TP (mg/L) Post-restoration	% Change
Tar-Pam Nutrient Loading Calculation Worksheet	1.76	1.74	1.1	0.45	0.45	0
JFLSAT	1.74	1.73	0.5	0.44	0.44	0
SNAP	1.69	1.68	0.5	0.31	0.31	0
Monitoring Data	5.51	3.39	38.5	1.81	0.80	55.8

SQT Application – BMP Routine





Not Functioning (NF): 0.0 - 0.29
Functioning at Risk (FAR): 0.3 - 0.69
Functioning (F): 0.7 - 1.0

SQT Physicochemical Function Application
Back Creek Reach

		TN Scores	TP Scores	Overall Score
Tar-Pam Nutrient Loading Calculation Worksheet	Pre-restoration	0.33	0	0.16
	Post-restoration	0.34	0	0.17
JFLSAT	Pre-restoration	0.29	0	0.14
	Post-restoration	0.30	0	0.15
SNAP	Pre-restoration	0.37	0	0.19
	Post-restoration	0.39	0	0.20
Monitoring Data	Pre-restoration	0	0	0
	Post-restoration	0.24	0	0.12

Not Functioning (NF): 0.0 - 0.29
Functioning at Risk (FAR): 0.3 - 0.69
Functioning (F): 0.7 - 1.0

SQT Physicochemical Function Application
North Branch Reach

		TN Scores	TP Scores	Overall Score
Tar-Pam Nutrient Loading Calculation Worksheet	Pre-restoration	0.36	0	0.18
	Post-restoration	0.36	0	0.18
JFLSAT	Pre-restoration	0.36	0	0.18
	Post-restoration	0.37	0	0.19
SNAP	Pre-restoration	0.38	0	0.19
	Post-restoration	0.38	0	0.19
Monitoring Data	Pre-restoration	0	0	0
	Post-restoration	0.10	0	0.05

Not Functioning (NF): 0.0 - 0.29
Functioning at Risk (FAR): 0.3 - 0.69
Functioning (F): 0.7 - 1.0

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Conclusions

Model Limitations – Catchment Size, Nutrient EMC, Nutrient Removal Mechanism

SQT Limitation – Reference Condition, no Change / Improvement

Going Forward

Testing Additional Models, like EPA's STEP

Questions