5-alt REPORT FOR BEAVER CREEK
IN THE LOWER CLINCH RIVER WATERSHED (06010207)

AN ALTERNATIVE RESTORATION APPROACH UNDER THE LONG-TERM VISION FOR TMDLs

Tennessee Department of Environment and Conservation
Division of Water Resources

Submitted January 5, 2016

I. Background.

EPA's Vision for the 303(d) program enhances overall efficiency of the CWA 303(d) program. In particular, it encourages focusing attention on priority waters and acknowledges that states have flexibility in using available tools beyond TMDLs to attain water quality restoration and protection. In Integrated Reporting Guidance issued for 2016, EPA acknowledges that the most effective method for achieving water quality standards for some water quality impaired segments may be through controls developed and implemented in advance of TMDL development. Alternatives approaches designated in the Integrated Report as sub-category 5-alt—in advance of a TMDL—recognize that some actions are more effective than TMDL reports in returning impaired waters to their water quality goals. If an alternative restoration approach does not show progress in attaining water quality standards, the impaired segment will be reprioritized for TMDL development.

Tennessee has identified HUC-12s with both nutrient impaired streams and source water protection areas in its priority framework. Tennessee has committed to using the watershed approach in meeting the goals of the Vision. In keeping with our watershed approach schedule, Tennessee considered Group 3 watersheds for alternative plans in FY-2016 and FY-2017. This report addresses the Beaver Creek Subwatershed 060102070202 in the Lower Clinch River Watershed (06010207), which has both a source water protection area and nutrient-impaired streams within its boundary.

II. Impaired Waterbodies to be Addressed.

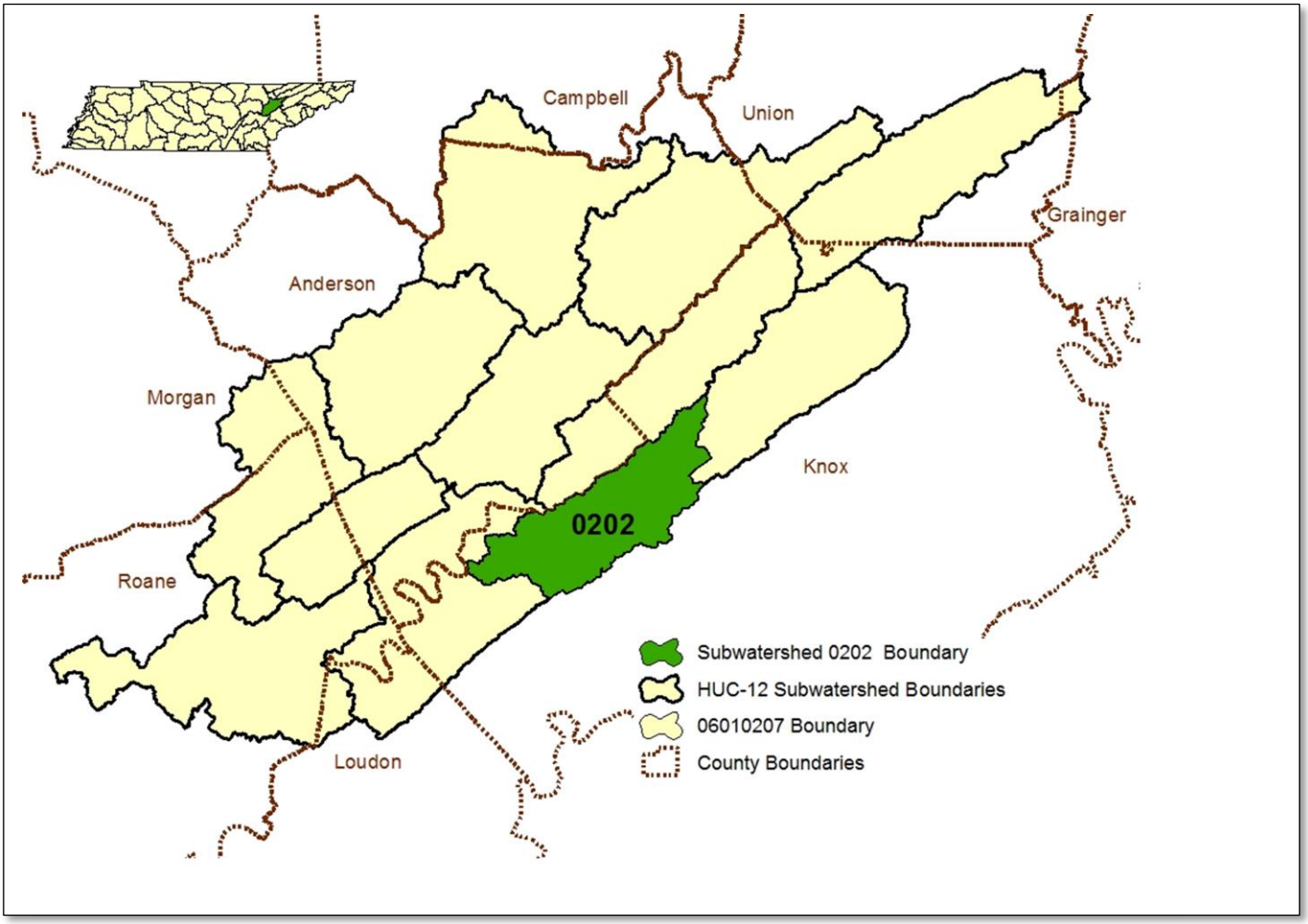

Figure 1. Location of HUC-12 Subwatershed 060102070202.

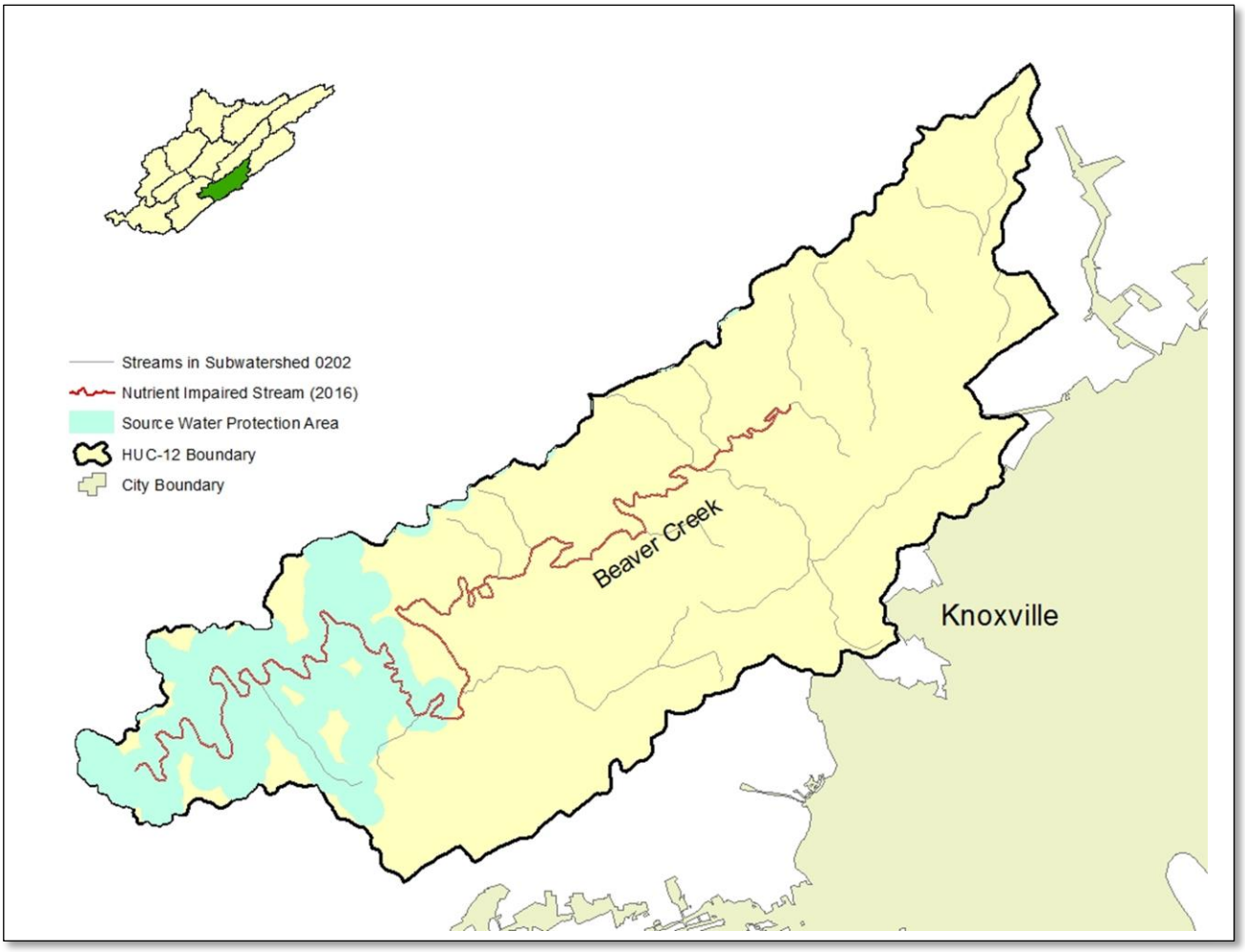

Figure 2. Illustration of Nutrient-Impaired Stream and Source Water Protection Area in HUC-12 Subwatershed 060102070202.

SEGMENT NUMBER	NAME	COUNTY	MILES	CAUSES (PRIORITY)	SOURCES
TN06010207011 _1000	Beaver Creek	Knox	22.5	**Total Phosphorus (L)**, **Nitrate+Nitrite (L)**, Escherichia coli (NA), Low Dissolved Oxygen (L), Loss of biological integrity due to siltation (NA), Physical Substrate Habitat Alterations (NA)	Municipal Point Source Collection System Failure, Pasture Grazing, Discharges from MS4 Area

Table 1. Water Quality Descriptions of Beaver Creek from 2016 303(d) List. *NA, Not Applicable because a TMDL has been approved by EPA; L, Low. Table 1 is the complete listing of causes of impairment for Beaver Creek from the draft 2016 303(d) List. This 5-alt report only addresses Nitrate+Nitrite and Total Phosphorus.*

III. Action Plan that Addresses Point and Nonpoint Sources.

Tennessee is using both a point source and nonpoint source approach for addressing nutrients in the Beaver Creek subwatershed.

Point Sources. There are two NPDES facilities that discharge within the Beaver Creek Subwatershed (see Figure 3). Tennessee will use the process described in the Tennessee Nutrient Reduction Framework ("the Framework") to address these point sources.

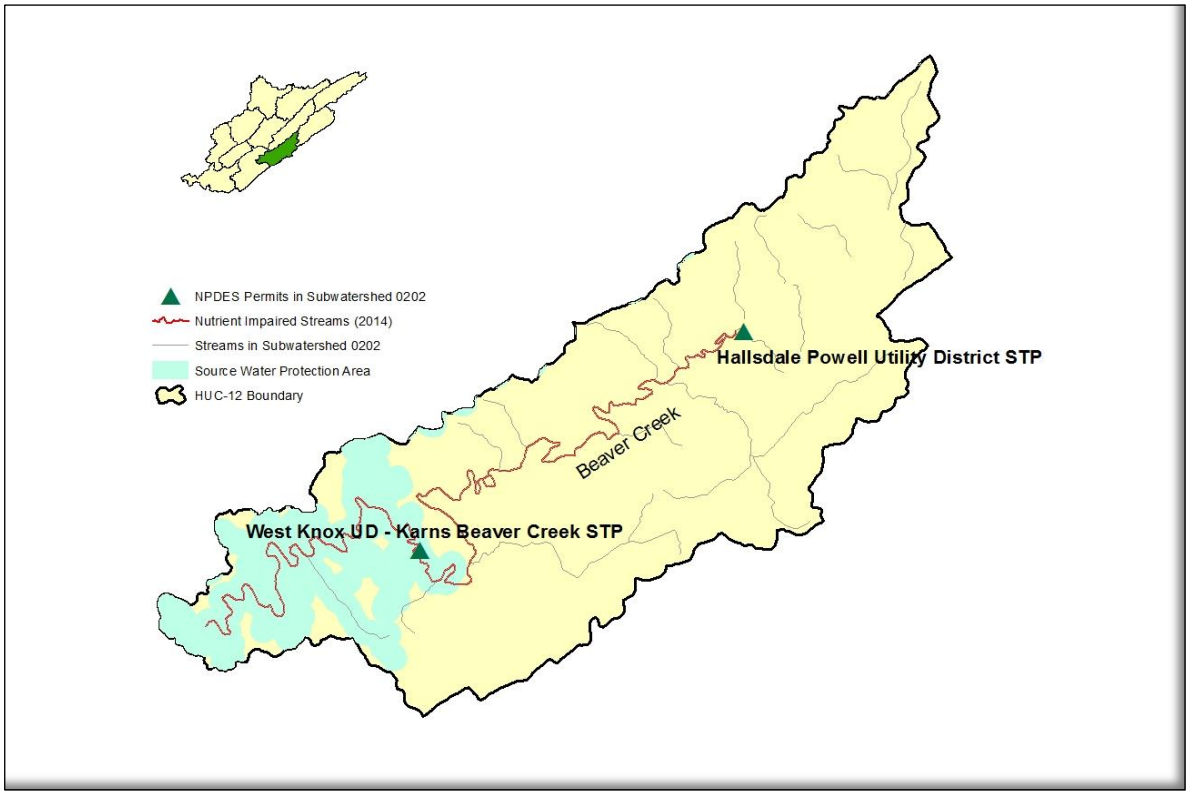

Figure 3. Illustration of Nutrient-Impaired Streams, Source Water Protection Areas, and NPDES Facilities in HUC-12 Subwatershed 060102070202. *TN0078905 (Hallsdale-Powell Utility District STP) discharges to Beaver Creek @ RM 23.5. TN0060020 (West Knox Utility District-Karns Beaver Creek STP) discharges to Beaver Creek @ RM 10.7.*

Under the framework, planning is HUC-10-based and uses SPARROW-derived (**Spa**tially **R**eferenced **R**egressions **o**n **W**atershed attributes) loads to describe a process to calculate an enrichment factor (total load divided by background load) and the percent contribution by point sources. NPDES permit writers use this information to consider when setting permit limits for nutrients.

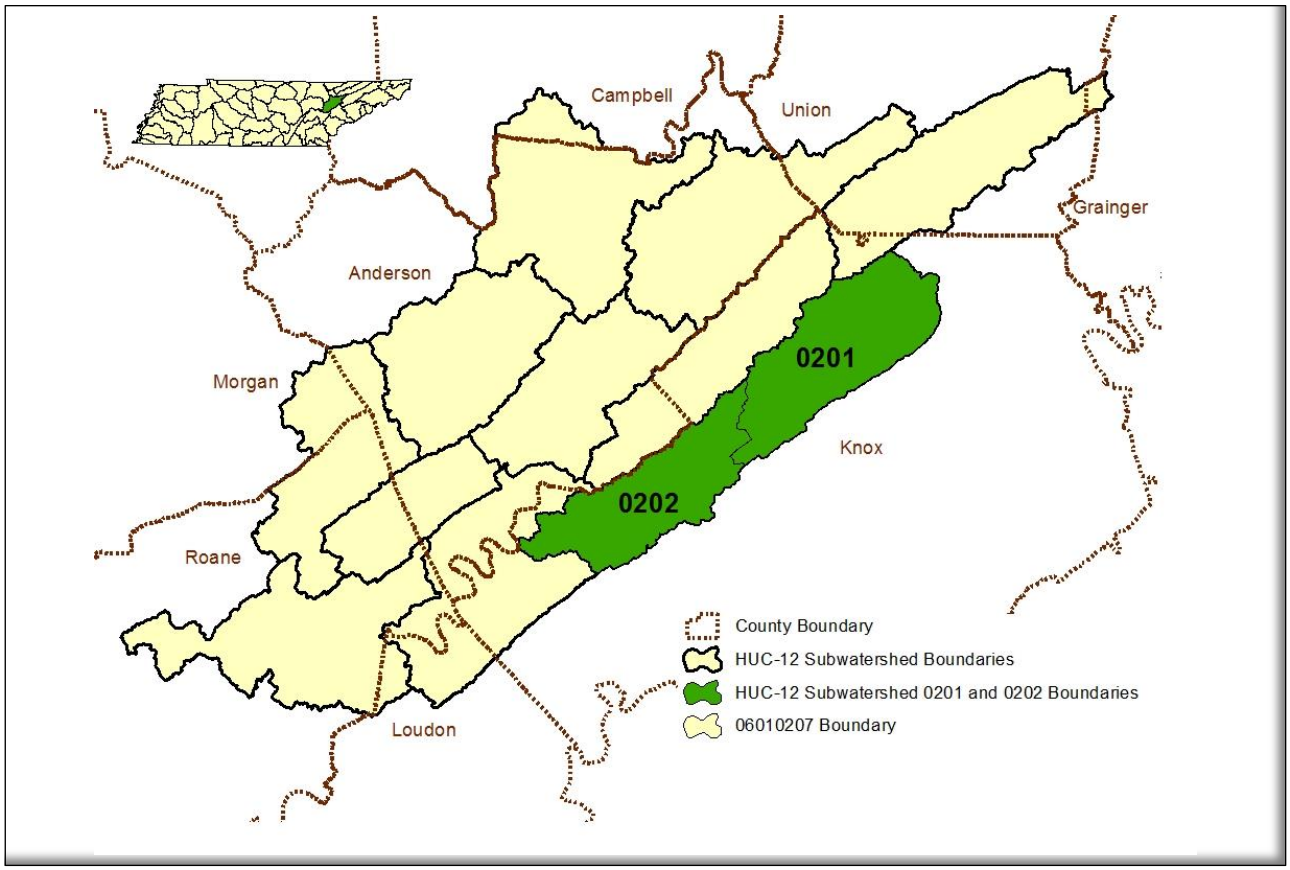

Figure 4. Location of HUC-10 Subwatershed 0601020702. *Subwatershed 0601020702 is composed of two HUC-12s, 060102070201 and 060102070202.*

Using data from the USGS SPARROW model, fact sheets have been created for the two point sources in subwatershed 0601020702 (Figures 5 and 6). The location of subwatershed 0601020702 is illustrated in Figure 4.

SPARROW SAGT HUC10 TOTAL NITROGEN FACT SHEET

BEAVER CREEK WATERSHED (HUC10: 06010207 - 02) vs 11/4/15

SPARROW Modeled TN Load at Outlet of HUC10 (02)

Source Category	Contribution (%)		
Air Deposition ("background")	30.6		
Manure	6.9		
Fertilizer	9.8		
Urban	9.5	90% CI	
Wastewater	43.2	25.3	- 72.2
Total			
Total Load	551,464	lbs/yr	
Drainage Area	91	sq mi	
Unit Area Load	9.506	lbs/ac/yr	
Mean Annual Streamflow	233.8	cfs	

WWTP Contribution	Enrichment Factor EF < 1.53	1.53 ≤ EF < 2.04	EF ≥ 2.04
%C ≥ 10.92%	Low	Medium	High
4.02% ≤ %C < 10.92%	Low	Medium	Medium
%C < 4.02%	Low	Low	Low

TN Enrichment Factor = Total Current Load / Total "Background" Load = **3.27**

Impact Category: **High**

Proposed WWTP Treatment Performance: **5 mg/L**

Point Source Characteristics

Facility	Permit #	Design Flow (MGD)	Average Flow (MGD)	Ratio (Avg/ Design)	Avg TN Conc (mg/L)	Recommended Reduction (%)	# of Samples	Data Source	Discharge to Nutrient Impaired Waterbody (2014)			
Hallsdale-Powell Utility	TN0078905	9.7	7.41	76.4%	4.16	NR *	64	DMRs (2010-15)	Beaver Ck RM23.5			
West Knox UD - Karns Beaver Ck STP	TN0060020	4	3.8547	96.4%	13.71	62.1	20	DMRs (2008-13)	Beaver Ck RM10.7	52.84794	20	0.621556

* Discharge from Hallsdale-Powell Utility does not require a reduction because the average load is already below the target load.

Recommended Point Source Facility Load

Facility	Permit #	Allowable Annual Load *	Recommended Monitoring
Hallsdale-Powell Utility	TN0078905	122,836	semi-monthly composite sample + monthly in-stream
West Knox UD - Karns Beaver Ck STP	TN0060020	60,882	semi-monthly composite sample + monthly in-stream

* Allowable Annual Load calculated based on expected treatment performance (if reduction is recommended) or monitoring data (if no reduction is recommended). In the absence of monitoring data, load is calculated from design flow and a default TN concentration of 45 mg/L.

Potential Trading

Ratio -- WWTP/(fertilizer+manure)	2.59
Ratio -- (WWTP+urban)/(fertilizer+manure)	3.15

Figure 5. Fact Sheet for Total Nitrogen for NPDES Facilities in 0601020702.

Based on the WWTP contribution (43.2%) and the enrichment factor (3.27) and using the process described in the framework, facilities in this HUC-10 are categorized as “High” for nitrogen, indicating that some reductions may be necessary.

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SPARROW SAGT HUC10 TOTAL PHOSPHORUS FACT SHEET

BEAVER CREEK WATERSHED (HUC10: 06010207 - 02) vs 11/4/15

SPARROW Modeled TP Load at Outlet of HUC10 (02)

Source Category	Contribution (%)
Soil Parent Rock ("background")	11.0
Mines	0.0
Manure	3.9
Agriculture	10.4
Urban	36.7
Wastewater	37.9
Total	

90% CI: 14.2 - 91.0

WWTP Contribution	Enrichment Factor EF < 2.78	2.78 ≤ EF < 4.12	EF ≥ 4.12
%C ≥ 21.74%	Low	Medium	High
8.83% ≤ %C < 21.74%	Low	Medium	Medium
%C < 8.83%	Low	Low	Low

TP Enrichment Factor = Total Current Load / Total "Background" Load = 9.06

Total Load	66,344	lbs/yr
Drainage Area	91	sq mi
Unit Area Load	1.144	lbs/ac/yr
Mean Annual Streamflow	233.8	cfs

Impact Category: High

Proposed WWTP Treatment Performance: 0.3 mg/L

Point Source Characteristics

Permittee	Permit #	Design Flow (MGD)	Average Flow (MGD)	Ratio (Avg/ Design)	Avg TP Conc (mg/L)	Recommended Reduction (%)	# of Samples	Data Source	Discharge to Nutrient Impaired Waterbody (2014)			
Hallsdale-Powell Utility	TN0078905	9.7	7.68	79.2%	1.87	79.7	67	DMRs (2010-15)	Beaver Ck RM23.5	14.3616	2.91	0.797376
West Knox UD - Karns Beaver Ck STP	TN0060020	4	3.8547	96.4%	1.71	81.8	20	DMRs (2008-13)	Beaver Ck RM10.7	6.591537	1.2	0.817948

Recommended Point Source Facility Load

Facility	Permit #	Allowable Annual Load *	Recommended
Hallsdale-Powell Utility	TN0078905	8,858	semi-monthly composite sample + monthly in-stream
West Knox UD - Karns Beaver Ck STP	TN0060020	3,653	semi-monthly composite sample + monthly in-stream

* Allowable Annual Load calculated based on expected treatment performance (if reduction is recommended) or monitoring data (if no reduction is recommended). In the absence of monitoring data, load is calculated from design flow and a default TP concentration of 5 mg/L.

Potential Trading

Ratio -- WWTP/(ag+manure)	2.63
Ratio -- (WWTP+urban)/(ag+manure)	5.19

Figure 6. Fact Sheet for Total Phosphorus for NPDES Facilities in 0601020702.

Based on the WWTP contribution (37.9%) and the enrichment factor (9.06), and using the process described in the framework, facilities in this HUC-10 are categorized as "High" for phosphorus, indicating that some reductions may be necessary.

These fact sheets act as a decision matrix and help permit writers establish nutrient limits based on 1) enrichment factors and 2) percent contribution in the watershed using the process described in the Tennessee Nutrient Reduction Framework Implementation Plan. The fact sheets indicate the trading potential between point and nonpoint sources. TDEC is exploring establishing a trading program. In support of that, TDEC has secured a grant from TVA to explore the feasibility of trading in the Tennessee Valley.

Both permits will expire in 2018 and the fact sheets will be used to establish nitrogen and phosphorus limits. Currently, nitrogen and phosphorus requirements are:

PERMIT NUMBER	PERMITTEE	NITROGEN	PHOSPHORUS
TN0078905	Hallsdale-Powell Utility District	Report Only	Report Only
TN0060020	West Knox Utility District-Karns Beaver Creek STP	Report Only	Report Only

Table 2. Summary of Nitrogen and Phosphorus Requirements for NPDES facilities in Subwatershed 0601020702.

In addition, Tennessee is looking to see if either facility would be a good candidate for plant optimization, the process by which waste water treatment plants develop standard operating

procedures for optimizing nitrogen removal, phosphorus removal, and energy consumption. Tennessee has undergone two rounds of plant optimization and plans to continue encouraging WWTPs to use this nutrient reduction approach. Although it is too soon for a complete analysis of results from these facilities, both high and low capacity facilities seem to show improvement. Authorized discharges from Hallsale-Powell and West Knox-Karns fall somewhere in between Baileytown and Dry Creek STPs. One facility in the HUC-12 subwatershed—West Knoxville-Karns WWTP—has indicated (via 02/01/2016 e-mail) that they plan to begin plant optimization.

FACILITY	PERMITTEE NUMBER	DISCHARGE	%N REDUCTION (lb/day)	%P REDUCTION (lb/day)
Baileytown STP	TN0063932	0.2 MGD	22.0	13.7
West Knox-Karns STP	TN0060020	4.0 MGD	Planning	
Hallsdale-Powell STP	TN0078905	9.7 MGD	Planning	
Nashville Dry Creek STP	TN0020648	24 MGD	18.2	26.5

Table 3. Example Results From Current Plant Reduction Activities. *Reductions are 2016 compared to 2015. N, Nitrogen; P, Phosphorous; Lb, Pound; STP, Sewage Treatment Plant; MGD, Million Gallons per Day.*

Nonpoint Sources. It seems intuitive that streamside buffers and rain gardens decrease nitrogen from entering streams by intercepting, sequestering, degrading, and processing nutrients. A 2014 publication by Newbold and Sweeney reviewed literature about streamside buffers and water quality, habitat, and biota. The authors documented the relationship between (forest) streamside buffers and subsurface nitrogen removal and found that the median removal efficiency of buffers to remove nitrates ranged from 55% to 89% and was a function of buffer width. Other studies in the southeast confirmed and quantified nitrogen removal, showing that buffers up to 90 meters could remove 80-95% of nitrates as they pass through the buffer. The authors point out that understanding of the conditions under which streamside buffers are effective has advanced greatly. Finally, Mayer *et al.* (2007) compared 65 studies of nitrate removal by buffers and reported removal efficiencies with a median removal rate of 91%.

The 319 program (administered by the Tennessee Department of Agriculture) has examined best management practices and used the EPA STEP-L model to calculate average responses to various BMPs implemented. Their studies indicate effective nitrogen removal with the use of BMPs such as vegetative buffers. The Tennessee Permanent Stormwater Management and Design Guidance Manual (2014) recommends buffers for nutrient reduction and calls for the use of riparian buffers to facilitate the uptake and treatment of total suspended solids (TSS) and nutrients. The manual illustrates that TSS, a surrogate for nutrients, is reduced by 25-80% using the most common practices of green infrastructure.

The 2014 release of the International Stormwater BMP database is the product of analyzing data in a long-term project that began in 1994. The report based on these studies compares the effectiveness of several BMPs for total nitrogen, Total Kjeldahl Nitrogen, nitrate and nitrite, total phosphorus, dissolved phosphorus, and orthophosphate removal. The study illustrates that BMPs associated with artificial wetlands are the best for both nitrogen and phosphorus removal.

The 5-alt approach that Tennessee is using utilizes sediment reduction as a nutrient control measure for agricultural nonpoint sources of nutrients. Actions implemented in subwatershed 060102070202 were designed to address stormwater and sediment transport by using green infrastructure practices such as establishing streamside buffers, installation of raingardens, and use of other infiltration techniques.

The work on the ground was organized and led by the Beaver Creek Task Force who prepared a watershed plan (Beaver Creek Plan) that includes a broad scope of water quality restoration activities that, when implemented, provide the opportunity to improve water quality in advance of TMDL development. The Beaver Creek taskforce worked with their partners to install stormwater controls and other BMPs in the watershed. The Beaver Creek Plan states that "The Beaver Creek Watershed Restoration plan was developed to provide a comprehensive plan for restoring Beaver Creek and its tributaries to fully support their designated uses and remove them from the 303(d) List." The full action plan is at http://web.knoxnews.com/pdf/1223beavercreek.pdf. This document summarizes their implementation activities in Beaver Creek Watershed.

BMP practices in the Beaver Creek Plan include grass strips, bioretention, bioswales, composite/treatment train BMPs, detention basins (surface/grass-lined), media filters (mostly sand filters), porous pavement, retention ponds (surface pond with a permanent pool), wetland basins (basins with open water surface), a combined category including both retention ponds and wetland basins, and wetland channels (swales and channels with wetland vegetation), all of which have been demonstrated to be effective in reducing nutrients (see references above).

BMPs. The Beaver Creek Plan addresses nonpoint sources with the following specific BMPs:

- Rain Gardens
- Retrofit extended detention basins
- Artificial wetlands
- Ponds
- Biofilters
- Pervious pavement
- Cattle exclusion
- Cross fencing for rotational grazing
- Alternative watering systems for livestock
- Heavy use area pads
- Enhancement/creation of riparian buffers
- Streambank stabilization
- Riparian stream tree plantings

In addition, the following activities are in place through the Beaver Creek Plan:

Construction stormwater controls

- Require Erosion Control and Sediment Reduction certified personnel onsite whenever a grading permit, building permit, or other soil-disturbing activities take place
- Compliance with construction stormwater permit

Adoption of stormwater ordinances

- Flood mitigation (bond-funded)
- Environmental restoration (landscaping design)
- Wetlands preservation and mitigation (easements, acquisitions, restoration)
- Streambank stabilization (bank restoration and riparian buffers)
- Slope and ridgetop protection (limits on development, land use activities, easements)
- Parks and greenways (easements, land acquisition, enhanced greenways, new parks)

Ecological credit trading

- Pilot a water pollution trading study for sediment and nutrients (EPA-funded)

Education and Outreach

- Published 16-page tabloid on Beaver Creek that was distributed to stakeholders as inserts in local newspapers
- Partnered with Tennessee Water Resource Research Center (University of Tennessee) to implement the Adopt-A-Watershed program in six high schools and middle schools in the watershed
- Partnered with Hallsdale-Powell Utility District to create a traveling environmental education program for elementary schools in the watershed
- Presented educational programs to over 25 stakeholder groups

The Task Force plans to maintain and/or expand the scope of its existing projects while adding new projects designed to deepen the knowledge and involvement of watershed residents. Initial plans for new project strategies include the following, although all strategies will be periodically re-evaluated and adapted as necessary to ensure their relevance and effectiveness:

- Awareness strategies
- Educational strategies
- Involvement strategies

Details, including associated costs, are provided in the Beaver Creek Plan.

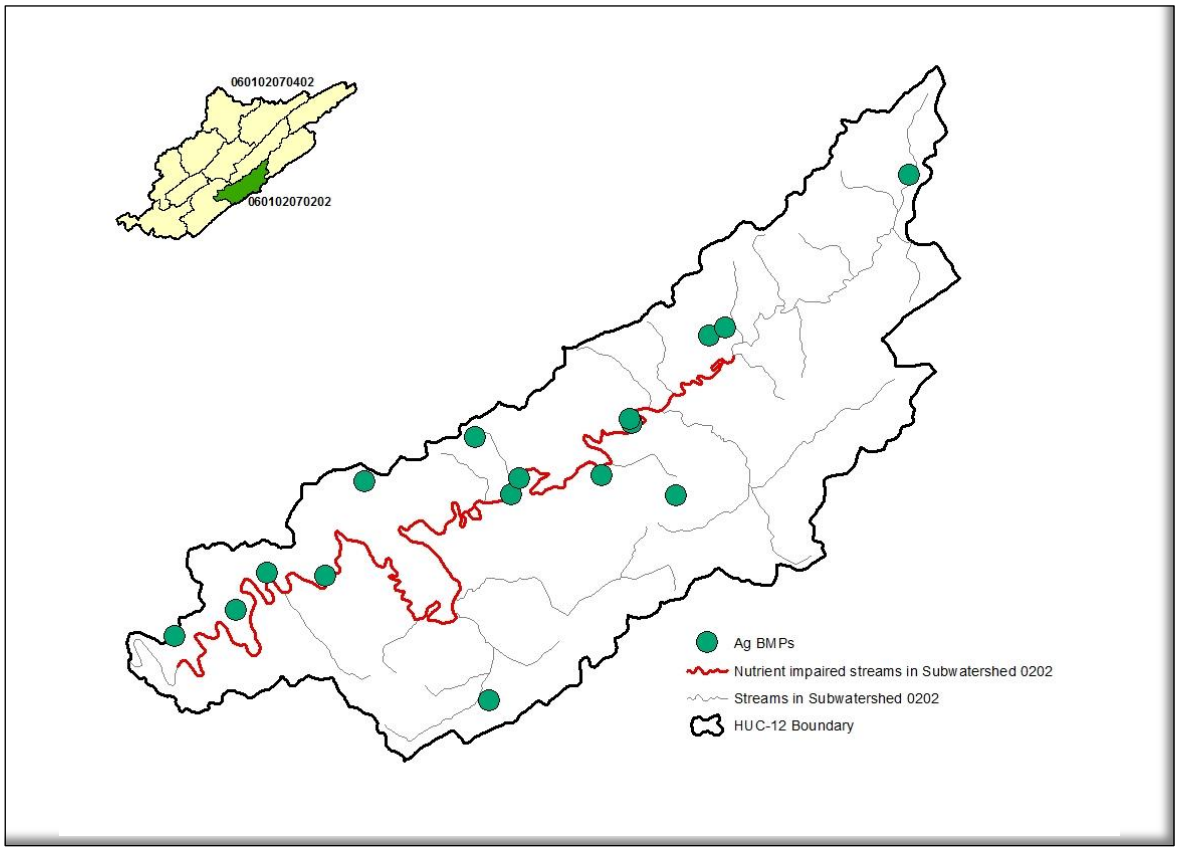

Figure 7. BMPs Installed in Beaver Creek Subwatershed with Tennessee Department of Agriculture Funds from 2003 to 2014. *There are 41 BMPs installed using 319 or state (Agricultural Resource Conservation) funds. NRCS has installed an additional 18 practices in this watershed between 2008 and 2015.*

IV. Nonpoint Source Funding Opportunities and Commitment of Partners.

Funding was a combination of direct funding from multiple sectors in the community and in-kind services. According to the Beaver Creek Plan, funding was primarily from these sources:

319 Program ($919,385)
Tennessee Healthy Watershed Initiative ($95,400)
Legacy Parks Foundation ($16,000 for BMPs)
Water Resources, LLC ($6,000)
Perfect Water, Inc. ($5,000)

Additional support was from these sources:

Local

Knox County Engineering and Public Works/Stormwater Division:

- Public Education/Outreach
- Adopt-A-Watershed program in six middle and high schools ($50,000/year)
- Rain gardens and swales through the Environmental and Stewardship Program ($25,000/year)
- Debris jam removal

Highway Department:

- Drainage crew for installation of retrofits
- Dirty lot crew to clear project sites
- Road crew for installation of pervious asphalt and porous concrete

Hallsdale Powell Utility District

- Lab analyses

West Knox Utility District

- Lab analyses

Knox County Parks and Recreation

- Educational kiosks, signs, project sites, trail building, labor

Knox County School District

- Project sites, student service projects

Legacy Parks Foundation

- Conservation easements

Beaver Creek Watershed Association

- Public Education/Outreach

Beaver Creek Landowners

- BMP implementation, public programs
- Knox County Soil Conservation District
- Conservation planning, agricultural BMP installation, education/outreach

Homeowners Association

- Project sites, cash match, and in-kind labor for rain gardens, bio-retention cells, and stream bank rehabilitation

University

Tennessee Water Resources Research Center (UT)

- Reports, supervision of Adopt-a-Watershed program, Tennessee Smart Yards

University of Tennessee Extension (UT-Extension)

- Technical assistance, education/outreach

State

Tennessee Department of Environment and Conservation (TDEC)

- Lab analyses

Tennessee Department of Transportation

- Technical assistance to Knox County for conducting in-system HUC-12 mitigation projects

Tennessee Wildlife Resources Agency (TWRA)

- Technical assistance for native grass installation, animal food plots, vegetative cover for wildlife

Federal

Natural Resources Conservation Service (NRCS)

- Technical assistance for agricultural conservation planning and implementation

Tennessee Valley Authority (TVA)

- Technical assistance

Private

AMEC

- Consulting services, education/outreach (both donated)

Cannon-Cannon, Inc.

- Engineering services and surveying (donated)

Carol R. Jones Associates

- Consulting services, education/outreach (both donated)

Perfect Water, Inc.

- Labor ($5,000 value donated), additional monetary support for education/outreach

Robin Easter Design

- Graphic services (donated)

Third Rock, Inc.

- Consulting services, education/outreach (both donated)

Water Resources, LLC

- Consulting services (donated), $6,000 match for tree grant

V. Date When Water Quality Standards are Expected to be Achieved.

The Beaver Creek Report states that partners expect water quality standards to be achieved by 2023 (15 years from the publication of the report) for sediment (See Section III, “Nonpoint Sources” for sediment control as a means to reduce nutrients). TDEC monitoring data show an improvement in biology and nutrients since the sediment controls have been put in place (See Section VI for details). Assessment for Beaver Creek took place in 2016 and the relevant passage from the 2016 Assessment Database is: “Due to past fluctuations in biology, we would like to see this stream pass two cycles in a row.”

Therefore, we expect the stream to meet water quality standards for nutrients after the next water quality assessment in 2021.

VI. Effectiveness Monitoring.

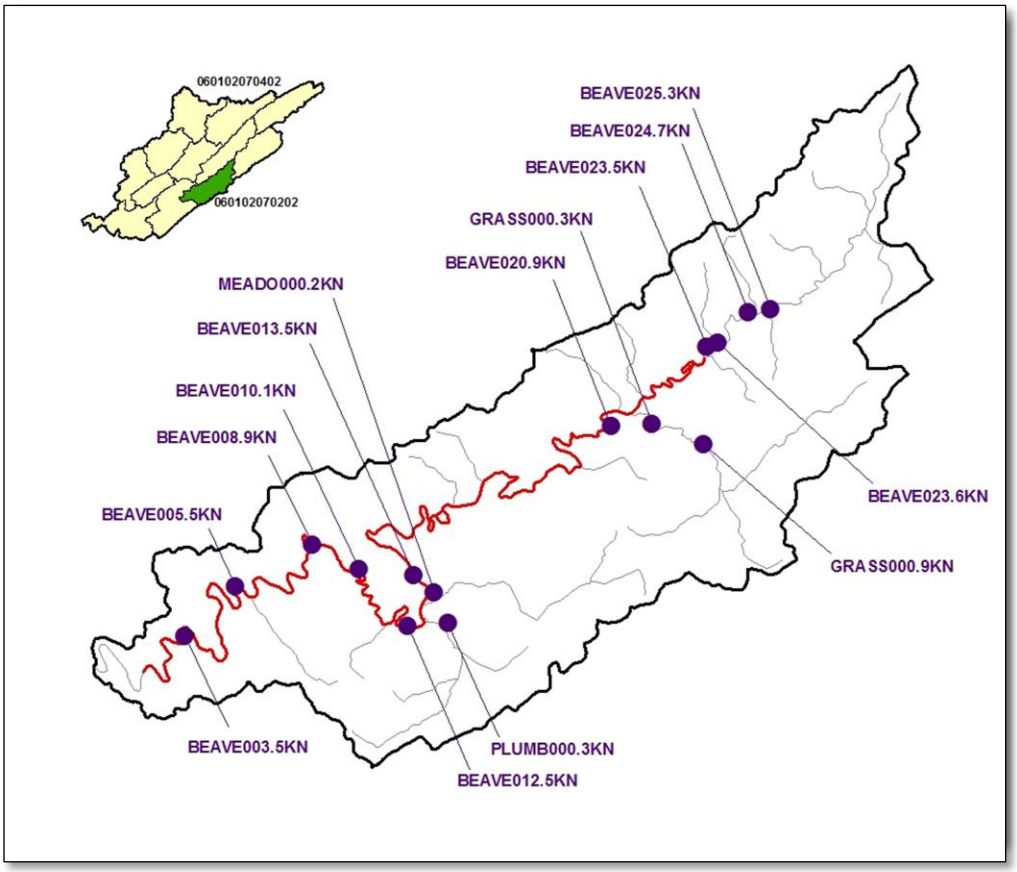

Figure 8. Illustration of Monitoring Sites in Subwatershed 060102070202.

Of the fifteen monitoring sites in the watershed, seven are on the nutrient-impaired segment of Beaver Creek:

MONITORING SITE	LOCATION	COUNTY
BEAVE0003.5KN	Beaver Creek @ RM 3.5	Knox
BEAVE0005.5KN	Beaver Creek @ RM 5.5	Knox
BEAVE0008.9KN	Beaver Creek @ RM 8.9	Knox
BEAVE0010.1KN	Beaver Creek @ RM 10.1	Knox
BEAVE0012.5KN	Beaver Creek @ RM 12.5	Knox
BEAVE0013.5KN	Beaver Creek @ RM 13.5	Knox
BEAVE0020.9KN	Beaver Creek @ RM 20.9	Knox

Table 4. Monitoring Sites on Nutrient-Impaired Waters in Subwatershed 060102070202.

And four sites are upstream of the nutrient-impaired segment:

MONITORING SITE	LOCATION	COUNTY
BEAVE0023.5KN	Beaver Creek @ RM 23.5	Knox
BEAVE0023.6KN	Beaver Creek @ RM 23.6	Knox
BEAVE0024.7KN	Beaver Creek @ RM 24.7	Knox
BEAVE0025.3KN	Beaver Creek @ RM 25.3	Knox

Table 5. Monitoring Sites Upstream of Nutrient-Impaired Waters in Subwatershed 060102070202.

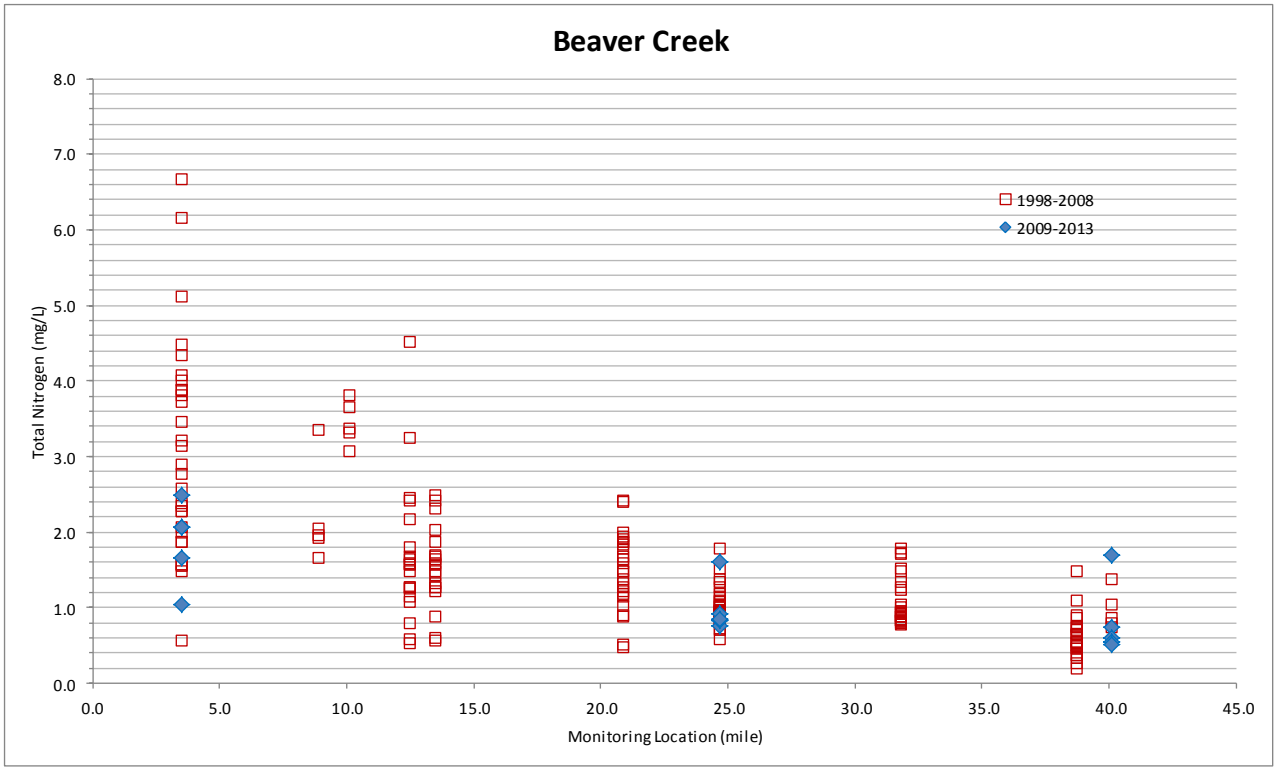

Figure 9. Total Nitrogen Data from Monitoring Sites in Subwatershed 060102070202.

Figure 9 illustrates that, when comparing pre-2008 and post-2008 data, the largest reduction in total nitrogen is observed at the most downstream site (River Mile 3.5).

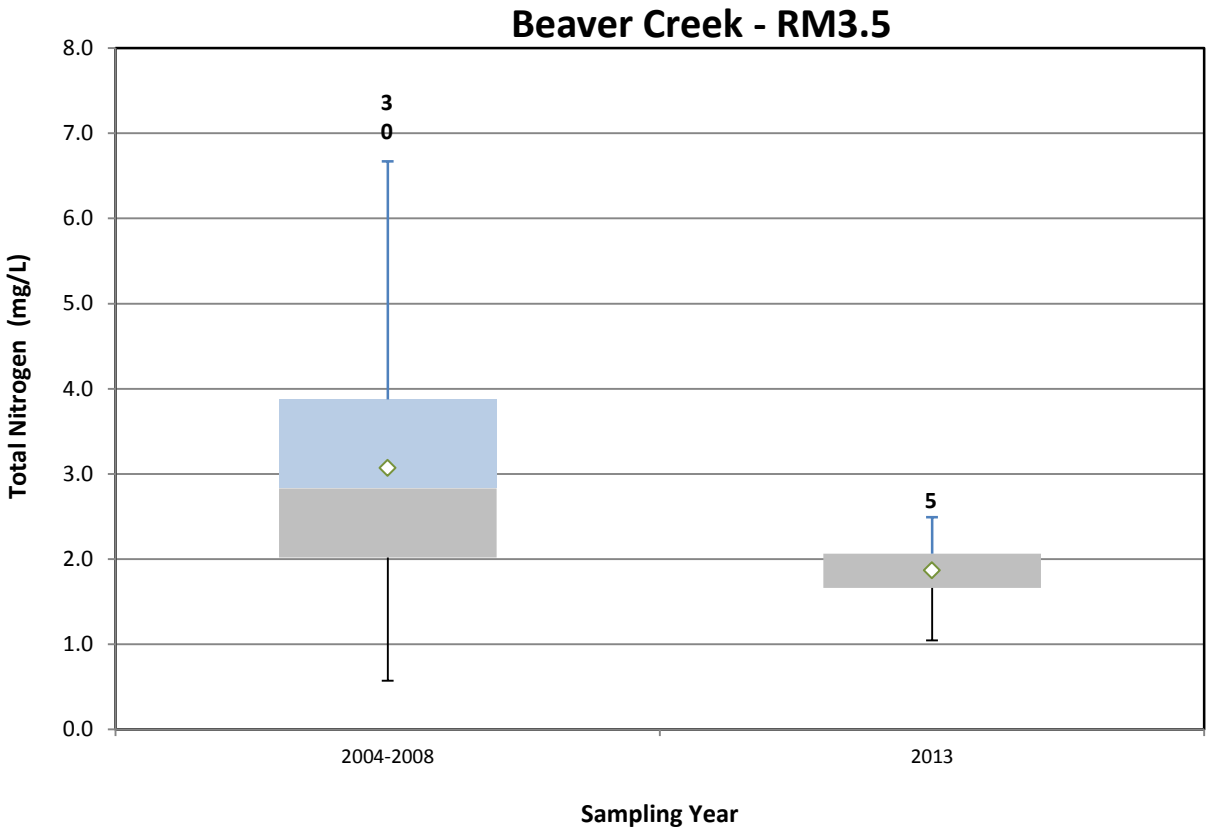

Figure 10. Comparison of Total Nitrogen at Beaver Creek Monitoring Site at River Mile 3.5 in 2004-2008 and 2013. *Numbers indicate number of samples in the analysis (n).*

Figure 10 illustrates the decrease in total nitrogen at River Mile 3.5 when comparing data from 2004-2008 and 2013. Insufficient data was collected at other sites for similar analyses.

Figures 9 and 10 show that the data indicate a decrease in total nitrogen in Beaver Creek at River Mile 3.5 since the Beaver Creek Plan was implemented.

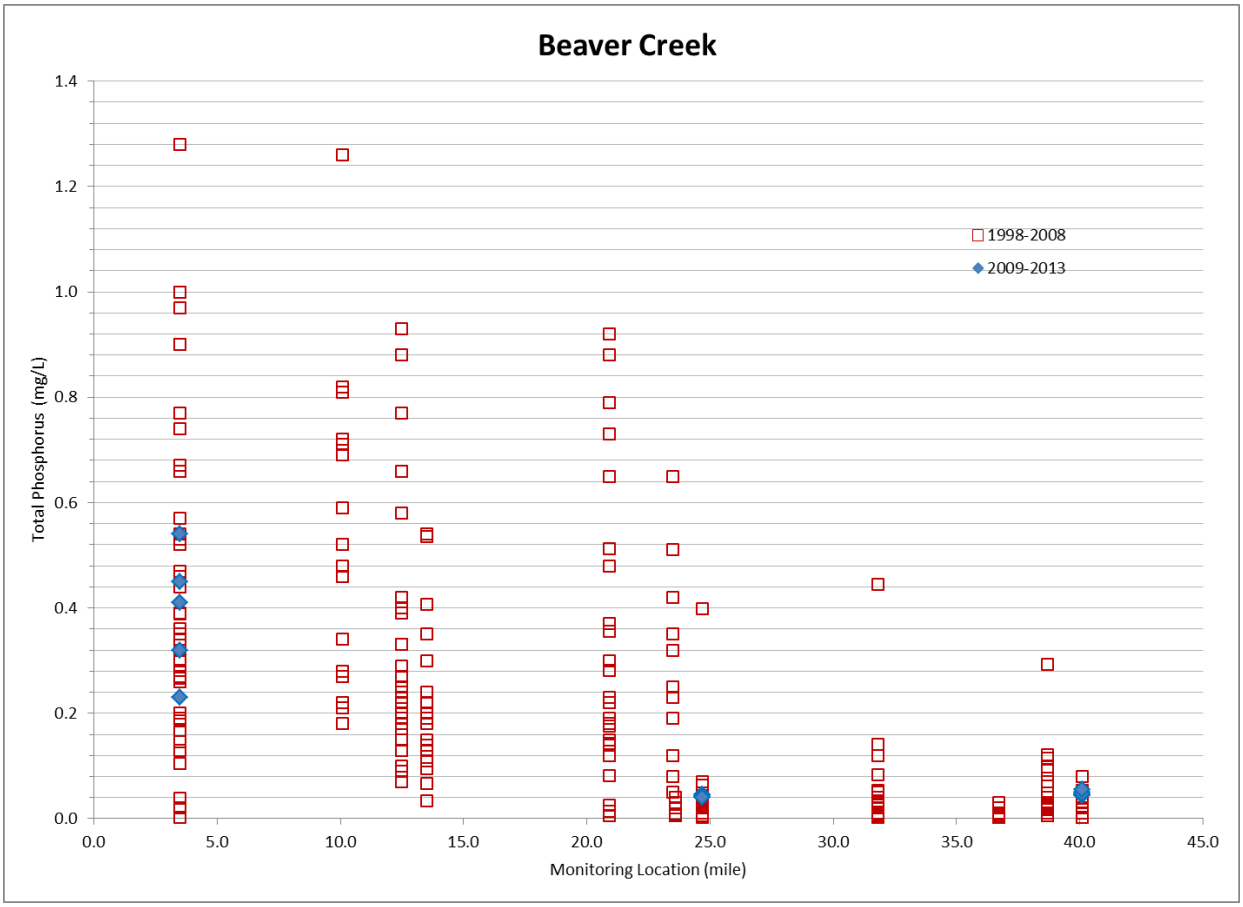

Figure 11. Total Phosphorus Data from Monitoring Sites in Subwatershed 060102070202.

Figure 11 illustrates that, when comparing pre-2008 and post-2008 data, the largest reduction in total phosphorus is observed at the most downstream site (River Mile 3.5).

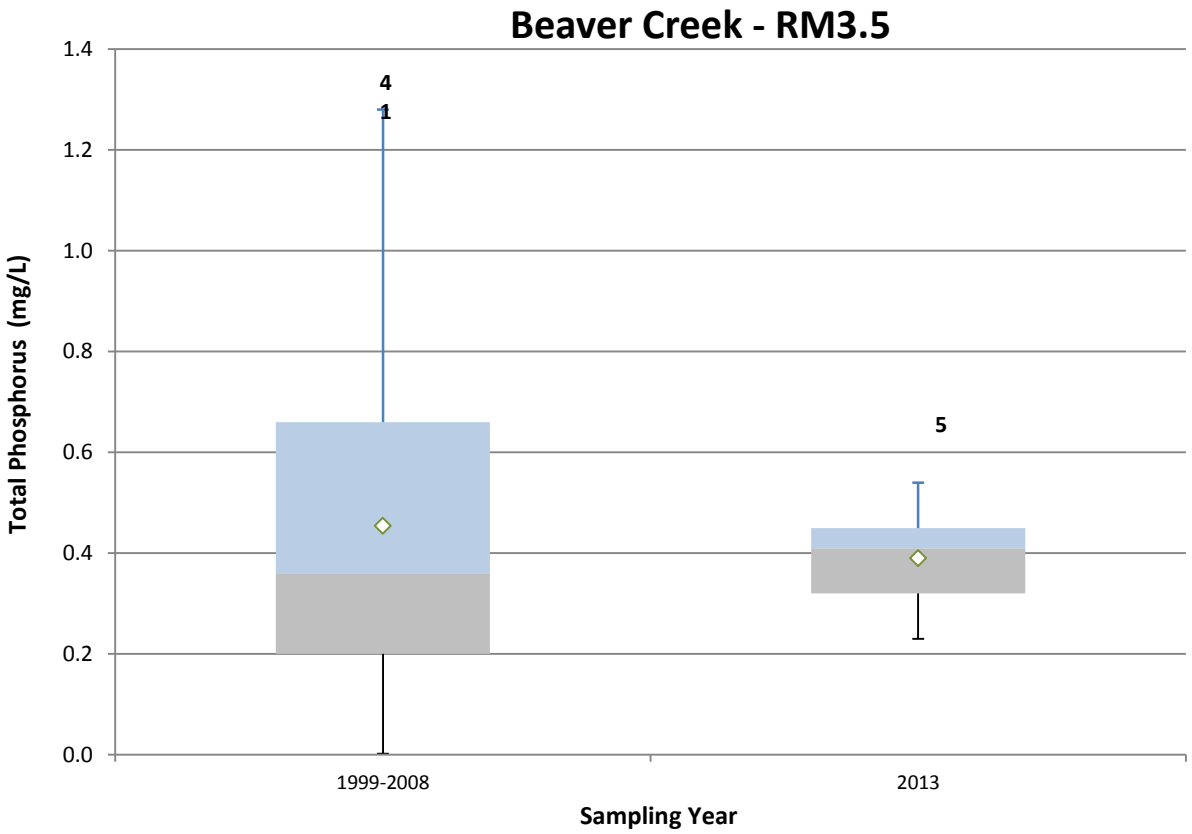

Figure 12. Comparison of Total Phosphorus at Beaver Creek Monitoring Site at River Mile 3.5 in 2004-2008 and 2013. *Numbers indicate number of samples in the analysis (n).*

Figure 12 illustrates the decrease in total phosphorus at River Mile 3.5 when comparing data from 2004-2008 and 2013. Insufficient data was collected at other sites for similar analyses.

Figures 11 and 12 show that the data indicate a decrease in total phosphorus in Beaver Creek at River Mile 3.5 since the Beaver Creek Plan was implemented.

Tennessee's nutrient water quality standards are narrative and have both a chemical (nutrients) and biological (benthic macroinvertebrates) component. Benthic macroinvertebrate data were collected from two sites in Beaver Creek before and after the Beaver Creek Plan was implemented (data from other sites are not available or were collected before or after implementation, but not both).

SITE	DATE	TMI	TOTAL TAXA	%EPT-CHEUM	% NUTRIENT TOLERANT	HABITAT SCORE
BEAVE003.5KN	07/15/2003	34	20	49.5	40.9	132
BEAVE003.5KN	10/03/2003	30	14	43.8	52.8	-
BEAVE003.5KN	10/22/2007	36	20	62.1	26.1	158
BEAVE003.5KN	10/02/2013	38	19	71.1	13.2	168

Table 6. Benthic Macroinvertebrate Data from Monitoring Site at Beaver Creek River Mile 3.5. *TMI, Tennessee Macroinvertebrate Index; EPT, Ephemeroptera, Plecoptera, Tricoptera.*

SITE	DATE	TMI	TOTAL TAXA	%EPT-CHEUM	% NUTRIENT TOLERANT	HABITAT SCORE
BEAVE024.7KN	07/21/2003	26	22	33.1	36.7	101
BEAVE024.7KN	10/20/2003	34	22	31.7	43.1	107
BEAVE024.7KN	10/22/2007	32	23	55.7	26.2	110
BEAVE024.7KN	08/05/2014	38	30	56.5	25.8	133

Table 7. Benthic Macroinvertebrate Data from Monitoring Site at Beaver Creek River Mile 24.7. *TMI, Tennessee Macroinvertebrate Index; EPT, Ephemeroptera, Plecoptera, Tricoptera.*

Data from both sites indicate improvement in benthic macroinvertebrates when comparing pre- and post-implementation of the Beaver Creek Plan:

- TMI Score. TMI (or Tennessee Macroinvertebrate Index) scores have increased over time at each site. More information about Tennessee's TMI score is in TDEC's Benthic macroinvertebrate SOP at: http://tn.gov/assets/entities/environment/attachments/bugsop11.pdf.
- Total Taxa. Total Taxa have remained constant over time at site River Mile 3.5 and have increased at river mile 24.7.
- %EPT-Cheum. This category is a finer-tuned representation of aquatic health than EPT because it excludes macroinvertebrates that are not clean water organisms. The data indicate an improvement over time at each site.
- % Nutrient Tolerant. The data indicate a decrease in nutrient-tolerant organisms over time at each site, indicating an improvement in water quality.
- Habitat Score. The data indicate in improvement in habitat over time at each site.

VII. Current and Future Activities.

The Beaver Creek Task Force continues to lead the project for nonpoint sources. A recent article appearing in the local paper: https://issuu.com/knoxvillemercury/docs/mercury_issue_2, page 10) described the Beaver Creek project. In contrast, the Beaver Creek Watershed Association, originally funded by the Beaver Creek Task Force, ended their operations in 2015. The Beaver Creek Task Force continues its emphasis on restoration. Today, lead organizations in the Task Force are involved in planning and implementation activities. Lead members are:

- Knox County Stormwater
- University of Tennessee
- Hallsdale Powell Utility District

Secondary organizations are involved in specific projects. Secondary organizations are:

- Knox County Highway Department
- Knox County Parks and Recreation
- Knox County Health Department
- Knox County School System
- Legacy Parks Foundation
- Water Quality Forum
- USGS

More information about activities in Beaver Creek is found at these sites:

- http://isse.utk.edu/wrrc/projects/beavercreek/beavercreek.html
- http://knoxcounty.org/stormwater/pub_WI.php
- http://media.wix.com/ugd/b9f40d_9e5c5aeaf9fb47eab44a16375760fbd7.pdf (page 3)

The Task Force summarizes their progress this way:

> Since 2007 over 1.58 million dollars in grant funding has been secured and spent in Beaver Creek on projects. In addition approximately $500,000 has been contributed locally. Projects include over a mile of streambank restoration, several bio-retention projects, infiltration projects including pavers and pervious concrete, over 25 rain gardens installed (25+ projects on agricultural property), yearly Adopt-A-Watershed education in 6 local middle and high schools, and an abundance of education/outreach.
>
> Progress has been made. Cox Creek, a major tributary, was de-listed in 2012. Benthic scores are improving. *E. coli* scores are improving. We do not test for nutrients as the State of Tennessee has no target values for phosphates and nitrates. The last testing for benthics was conducted in 2014 and *E. coli* testing is currently underway. The Task Force is in conversations with USGS to do comprehensive benthic studies in 2017-18 as a means of determining whether the BMPs placed on the ground are showing improvement to Beaver Creek.

The Task Force has contracted with Environmental Services and Consulting to conduct an independent benthic survey and erosion control effectiveness study.

LIST of INITIALS and ACRONYMS USED

303(d). Section 303(d) of the Clean Water Act that addresses impaired waters.

BMP. Best Management Practice.

CWA. Clean water Act.

EPA. Environmental Protection Agency.

FY. Fiscal Year.

HUC. Hydrologic Unit Code.

NPDES. National Pollutant Discharge Elimination System.

NRCS. Natural Resources Conservation Service.

RM. River Mile.

SPARROW. Spatially Referenced Regressions on Watershed attributes.

STP. Sewage Treatment Plant.

TDA. Tennessee Department of Agriculture.

TDEC. Tennessee Department of Environment and Conservation.

TMDL. Total Maximum Daily Load.

TSS. Total Suspended Solids.

TVA. Tennessee Valley Authority.

USGS. United States Geological Survey.

UT. University of Tennessee.

WWTP. Wastewater Treatment Plant.

REFERENCES CITED

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http://tnpermanentstormwater.org/manual.asp

Mayer, P.M., S.K. Reynolds, Jr., M.D. McCutchen, and T.J. Canfield, 2007. Meta-Analysis of Nitrogen Removal in Riparian Buffers. Journal of Environmental Quality 36:1172-1180, doi: 10. 2134/jeq2006.0462.

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Leisenring, Marc, Clary, J, and Hobson, P. (2014) International Stormwater Best Management Practices (BMP) Database Pollutant Category Statistical Summary Report
http://www.bmpdatabase.org/Docs/2014%20Water%20Quality%20Analysis%20Addendum/BMP%20Database%20Categorical_StatisticalSummaryReport_December2014.pdf

International Stormwater BMP Database (2014):
http://www.bmpdatabase.org/Docs/2014%20Water%20Quality%20Analysis%20Addendum/BMP%20Database%20Categorical_StatisticalSummaryReport_December2014.pdf

Tennessee Nutrient Reduction Framework (2015):
http://tn.gov/assets/entities/environment/attachments/wr-ws_tennessee-draft-nutrient-reduction-framework_030315.pdf

Beaver Creek Action Plan:
http://web.knoxnews.com/pdf/1223beavercreek.pdf