



Ecological Credit Trading Pilot Study for the Beaver Creek Watershed

Prepared for
Beaver Creek Task Force
Knox County

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EXECUTIVE SUMMARY

The Beaver Creek Task Force (BCTF) conducted a study to evaluate and demonstrate how an ecological credit trading market could help improve and protect water quality and other ecological resources in the creek's watershed. A credit market would supplement other programs to help stakeholders more effectively balance economic development objectives with water quality and environmental protection goals in an environmentally challenged watershed. The study was funded with a grant from the U.S. Environmental Protection Agency (EPA) Region IV, with the cooperation of Knox County and the Tennessee Department of Environment and Conservation (TDEC).

Water quality in the Beaver Creek watershed is poor because of impacts by: sediment, nutrients, and pathogens from agricultural and urban stormwater runoff; nutrients and pathogens from two municipal point sources; and habitat alteration associated with land development. This condition is not surprising since the current land use in the 86 square mile watershed located entirely in Knox County is roughly 40 percent urban, 20 percent agriculture, and 35 percent forested land. Because of the poor water quality, the entire length of the creek was placed on TDEC's 303(d) list of impaired waters. This listing resulted in the completion in 2006 of a Total Maximum Daily Load (TMDL) for siltation (i.e., sediment, also called total suspended solids, or TSS) and habitat alteration; TMDLs for phosphorus (a nutrient) and/or pathogens may be developed in the future.

To address these problems, the BCTF launched a variety of evaluation and planning efforts, culminating in the release of the Beaver Creek Watershed Restoration Plan (the Plan) in November 2006. Among other things, the Plan identifies pollutant loading reduction targets for different source categories and identifies general and specific actions that can control loadings and improve water quality.

Concurrent with development of the TMDLs and the Plan, Knox County was developing, and in 2008 implemented a new ordinance requiring post-development stormwater controls to maintain or improve existing watershed conditions. Specifically, the ordinance requires developers to meet a TSS reduction goal of 80 percent (average annual post-development load) by treating runoff from 85 percent of the rainfall events that occur in an average year. The ordinance also imposes other requirements relating to controlling the volume of post-development runoff under defined rain events, and specifically encourages green infrastructure practices.

To support implementation of the Plan and the Knox County stormwater ordinance, the objective of the pilot study was to identify and characterize how a credit trading market could provide opportunities for private and public parties to fulfill their responsibilities more cost-effectively than without trading. This included looking at how to provide economic incentives for investments in priority watershed plan actions that go above and beyond regulatory requirements or voluntary targets.

A key component of the study was an analysis of the relative costs and benefits of selected TSS and phosphorus control options. Installation and maintenance costs and pollutant reduction levels were estimated for 19 best management practices (BMPs) that could be applied to the different land uses in the watershed. These estimates were normalized into unit costs—\$/lb/yr—so that the cost-effectiveness of the different BMP-land use combinations could be compared.

Another component of the study examined the potential credit demand and supply patterns that might occur among the potential trading partners. Credit demand would exist when someone does not meet their pollutant load or flow reduction obligation; credit supply could be created where someone beats their obligation and provides “surplus” reductions—i.e., credits.

Based on the results of the cost-effectiveness and demand-supply analysis, a nonpoint-nonpoint credit market was proposed for consideration by the County and other stakeholders. The market would help participants evaluate relative costs and benefits of different control options and select the most advantageous alternative for them. In particular, the market would incentivize voluntary actions by enabling potential buyers and sellers to place an economic value on them and provide a means to exchange the credit commodity. Such activity would help leverage financial resources for greater environmental returns in a shorter period.

With the proposed credit market, those subject to the stormwater ordinance would submit site development plans to the County that comply with the ordinance in one of three ways: comply on-site (no trading); comply on-site with extra credits (sellers); or comply with credit purchases (buyers). Also, those not subject to the ordinance could submit project proposals to the County that would generate credits that could be sold, banked, or perhaps retired. Participants would use market tools to trade, bank, and track credits for improving and protecting ecological resources.

A graphic depiction of the proposed credit market framework was developed to illustrate the features, processes, and potential participants. An Excel-based ordinance compliance and credit evaluation tool also was developed. This tool was used to create pro forma BMP implementation plans for five actual sites in Knox County to illustrate how different combinations of BMPs result in debit and credit situations with respect to baseline requirements.

The proposed framework outlines how nonpoint-nonpoint credit trading could be implemented in a first phase in conjunction with deployment of the ordinance compliance and credit evaluation tool. The first phase results could then lead to a more formal and complete second phase ecological credit trading program for the Beaver Creek watershed.

BEAVER CREEK WATERSHED GEOGRAPHY AND LAND USE

The Beaver Creek watershed is located in Knox County, Tennessee, near the City of Knoxville. It is roughly 25 miles long and 3.5 miles wide, with a total drainage area of approximately 86 square miles. The creek itself is a tributary to the Clinch River and flows approximately 44 miles from its headwaters in northeastern Knox County to the confluence with the Clinch River in the county’s southwest. There are five primary communities within the watershed: Gibbs, Halls, Powell, Karns, and Solway. Exhibit 1 shows the location of the watershed in two resolutions.

The topography in the watershed is characterized by a broad floodplain and rolling hills between two ridges: Copper Ridge to the northwest and Black Oak Ridge to the southeast. A third ridge, Beaver Ridge, is contained within the watershed and runs along the south bank of the creek.

The population of the Beaver Creek watershed is approximately 74,400, according to the Knoxville-Knox County Metropolitan Planning Commission (MPC). The MPC has projected population increases for transportation purposes, using the assumption that recent growth rates will continue, and estimates that the population within the watershed will increase to 108,000 by the year 2030, an increase of 45 percent.

Approximately 35 percent of the land in the Beaver Creek watershed is used for residential land purposes compared to 6 percent for commercial and industrial uses, based on aerial photography provided by the Knox Geographic Information System (KGIS) and interpretation by the University of Tennessee Geography Department. Currently, agricultural land uses occupy 21 percent of the watershed, and forest covers 35 percent. Exhibit 2 presents the current distribution of these land uses within the watershed.

EXHIBIT 1
Beaver Creek Watershed Location

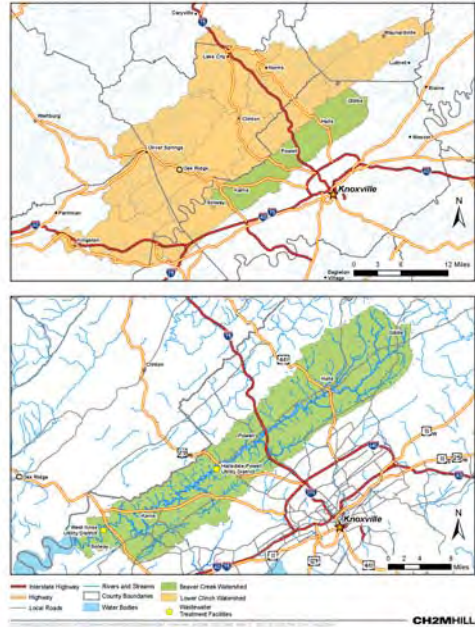


EXHIBIT 2
Existing Land Use in Beaver Creek Watershed



Land use conditions in the Beaver Creek watershed are projected to change dramatically over the next 25 years as population growth and development continue, as shown in Exhibits 3 and 4. The MPC has projected that by 2030 approximately 56 percent of the land in the watershed will be used for residential land purposes—a 21 percent increase. This largely reflects the conversion of forests and agriculture land uses to residential land uses. For example, forested land use is projected to decline from 35 percent in the watershed in 2006 to 21 percent in 2030, whereas agricultural land use is projected to decline from 21 percent in 2006 to 13 percent in 2030.

EXHIBIT 3
Actual 2004 Land Use in Beaver Creek Watershed

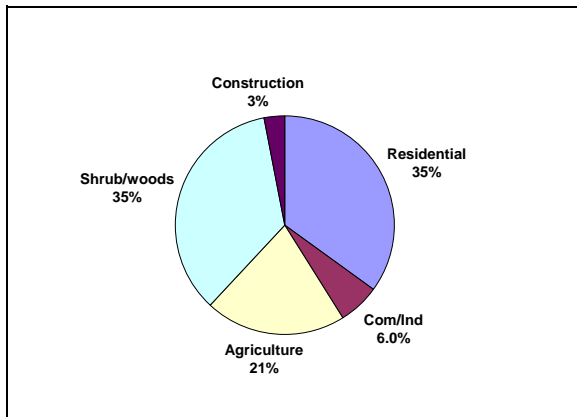
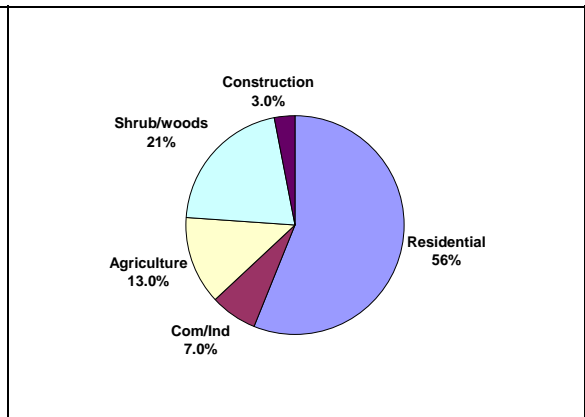
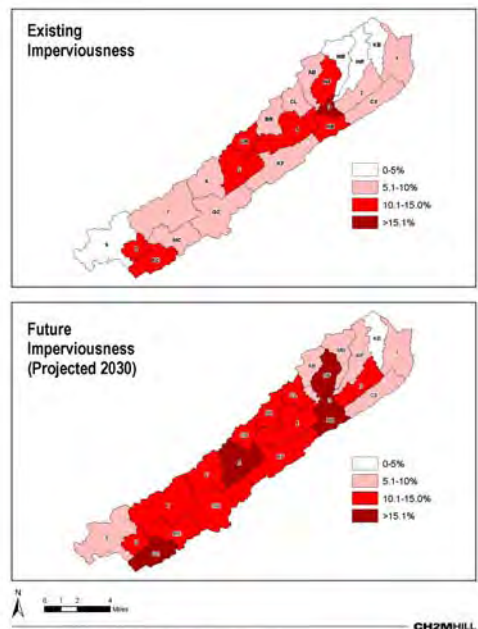


EXHIBIT 4
Projected 2030 Land Use in Beaver Creek Watershed



Projected land use changes will substantially alter the amount of impervious cover, producing a 36 percent increase by 2030, as seen in Exhibit 5. Previous studies have clearly documented that water quality and biotic integrity decline substantially once the total imperviousness in a watershed increases above 15-20 percent.¹ The total impervious area under current conditions is approximately 8.7 percent across the entire watershed, with the highest percentage in a subwatershed of 28.5 percent. The level of imperviousness is predicted to increase dramatically (36 percent) to 11.8 percent by 2030. Interestingly, the number of watersheds with greater than 15 percent impervious is predicted to increase from 1 subwatershed in 2006 to 5 subwatersheds in 2030 (Exhibit 5). Without appropriate control measures, these increases in imperviousness will result in increased pollutant loadings and deteriorated hydrologic and water quality conditions in the watershed.

EXHIBIT 5
Comparison of Imperviousness: 2006 v. 2030



BEAVER CREEK WATER QUALITY

Since as early as 1998, the water quality in the watershed has generally been regarded as poor, according to assessments conducted prior to 2006 and as reconfirmed in the 2006 Beaver Creek Watershed Restoration Plan.

Conditions in the upper reaches are somewhat better than in the lower ones and conditions in some tributaries remain relatively good. Even so, TDEC's 303(d) list identifies the entire creek as impaired by *Escherichia coli* (E. coli), low dissolved oxygen, loss of biotic integrity due to siltation, and physical substrate habitat alterations; the lower creek is impaired by phosphorus and nitrates. The four primary causes of these impairments are described below.

Upland Erosion–Sediment, Nutrients, and Pathogens from Agricultural and Urban Runoff

This problem is largely a function of how the surface of the land is used and how human activities can change the land's "covering," as illustrated in Exhibit 6.

Sediment erodes from natural areas and enters streams, taking nutrients and pathogens along with the sediment. When the land is disturbed in some way, usually pollutant loads will increase. For example, agricultural lands can generate much greater sediment loads than a natural undisturbed setting, depending on the type of agriculture. Additionally, when people convert natural areas or agricultural land to urban uses, such as a residential or commercial development, bare soil is often left exposed to rainfall during the construction phase. Without adequate erosion controls, urbanization can severely impact streams with above normal sediment loads.

In-Channel Streambed and Stream Bank Erosion

Excessive sediment loads from stream bank erosion occurs when water channels are physically modified and when watersheds experience changes to land uses and land cover, as illustrated in Exhibit 7. For example, when people straighten the channel to improve land drainage, physical modification of a stream occurs. This "channelization" increases the stream's power and erosive energy, which increases sediment loading to the waterbody. Over time, natural processes will often adjust the channels back to a more stable formation, but the modified channel can have higher sediment loads for decades. Increased sediment loads to streams are also caused by changes in watershed land use patterns that increase the amount of impervious surfaces (such as asphalt and roofs).

EXHIBIT 6
Upland Erosion: A Primary Source of Sediment in the Beaver Creek Watershed



EXHIBIT 7
Channel Erosion: Contributes to Habitat Degradation and Sedimentation Problems in Beaver Creek



This increases the total and peak volumes of stormwater runoff during rain events, which then causes more streambed and streambank erosion. This can be particularly serious during flood events if channels have become incised (i.e., deeper or more channelized) and stream banks fail (i.e., cave in or erode).

Nutrients from Municipal Wastewater Treatment Plants (WWTPs)

There are only two point sources permitted under the National Pollutant Discharge Elimination System (NPDES) program that discharge treated wastewater to Beaver Creek. The Hallsdale Powell Utility District (HPUD) discharges to the creek at mile 23.5, with a permitted limit of 9.0 million gallons per day (MGD); and the West Knox Utility District discharges to the creek at mile 10.7, with a permitted limit of 4.0 MGD.² These WWTPs contribute the majority of the total nutrient load to the creek. Both are expected to require expansions in the future to accommodate the anticipated growth and associated wastewater treatment demands.

Habitat Alteration Due to Land Development in the Watershed

Habitat degradation results primarily from limited riparian vegetation and excessive sediment loading, as illustrated in Exhibit 8. This is one of the primary stressors for the biotic communities in the creek. Biotic communities include aquatic insects (benthic macro invertebrates) and fish that live in streams, lakes, and other water bodies. Biological and habitat assessments of the watershed conducted between 1995 and 2004 found that biotic integrity for both fish and benthic macro invertebrates ranged from fair to poor.³ The most recent studies conducted in 2004 indicated that three out of four sites sampled for benthic macro invertebrates were rated poor. Anticipated increases in development and the associated changes in land use within the watershed will only increase these existing water quality and habitat degradation problems.

THE BEAVER CREEK TASK FORCE

The Beaver Creek Task Force (BCTF) was formed in 1998 with a primary purpose of restoring Beaver Creek back to a healthy stream that fully supports its designated uses. The BCTF advocates and implements various restoration practices while promoting sound economic development.

EXHIBIT 8 Habitat Alteration: Impacts Aquatic Biota Throughout the Beaver Creek Watershed



EXHIBIT 9 Beaver Creek Task Force Accomplishments

- 1998: Beaver Creek Task Force Formed
- 1998: Updated FEMA Flood Study
- 2000: Floodplain no fill line expanded
- 2002: Initial Beaver Creek Watershed Assessment
- 2002: Tennessee Growth Readiness
- 2002: Site Planning Roundtable convened
- 2003: Beaver Creek Watershed Association formed
- 2003: Part time Watershed Coordinator hired
- 2003: Intensive Watershed Education initiated
- 2004: Water Quality sampling & analysis
- 2005: Green Infrastructure plan completed
- 2005: GIS Land Use Map update
- 2005: Awarded 604(b) Watershed Planning Grant
- 2005: BMP projects initiated
- 2005: Water quality models developed
- 2005: Watershed Plan process initiated
- 2005: Stakeholder Advisory Council convened
- 2006: Awarded an EPA Cooperative Agreement Grant to create and test a Pilot Ecological Credit Trading Market
- 2006: Models calibrated
- Hydrologic Simulation Program – Fortran (HSPF) for sediment and nutrients
- AnnAGNPS for sediment
- 2006: Watershed Plan Complete
- 2007: Awarded \$912,000 319h grant from the Tennessee Department of Agriculture

Member organizations have made significant contributions toward assessing and understanding water quality conditions and needed restoration and management efforts. Exhibit 9 (above) presents a chronology of major accomplishments; three are described below.

Knox County Site Planning Roundtable

The Roundtable was convened in 2002 to review and recommend changes to the development review process to address stormwater and water quality concerns. Since 2002, several BCTF partners have participated in the Roundtable with representatives of county, city, and state government agencies, environmentalists, lawyers, bankers, developers, builders, and homeowners. In 2005, the Roundtable reached consensus on recommended changes to development rules and processes. Twenty-one of the recommendations were incorporated into Knox County's new stormwater regulations.

Water Resource Assessment and Modeling

The University of Tennessee's (UT) Department of Civil and Environmental Engineering conducted 12 sampling events during 2004 at 13 sites in the Beaver Creek watershed and developed a sediment loading model. Under a separate effort sponsored by BCTF, researchers at Tennessee Valley Authority (TVA), led by Jim Hagerman, evaluated data for sediment, phosphorus, nitrates, and pathogens, and in 2006 developed a water quality model for sediment and nutrients.

The TVA water quality models were used to estimate sediment and nutrient loadings to Beaver Creek and to evaluate the effectiveness of various management options in the Watershed Restoration Plan (see below). The Hydrologic Simulation Program – Fortran (HSPF) was used to model hydrology, sediment, and nutrients in the Beaver Creek watershed. HSPF simulates detailed hydrologic, erosion, and nutrient cycling processes, and provides time series outputs of concentration as well as total loads. Data to support the modeling were obtained from the following sources:

- Land use data came from analysis of high-resolution color aerial photography provided by KGIS and interpreted by UT's Geography Department;
- Water quality data were provided by John Schwartz, with UT's Department of Civil and Environmental Engineering;
- The MPC performed a detailed analysis of impervious area based on existing building footprint and road paved-area data, along with estimated driveway areas;
- Weather data came from the National Oceanic and Atmospheric Administration weather station at Knoxville-McGee Tyson airport (including air temperature, dew point, wind speed, and sky condition), the University of Tennessee Agricultural Experiment Station (pan evaporation), and HPUD (hourly rainfall); and
- U. S. Geological Survey gage data were available near the downstream end of the watershed and were used in conjunction with the discharge data gathered during stream monitoring to develop and calibrate the model.

Beaver Creek Watershed Restoration Plan

In 2005, the BCTF initiated development of a watershed restoration plan (WRP) for the Beaver Creek watershed. An important driver for this plan was the impending sediment TMDL (approved in March 2006). The WRP, first released in 2006 and republished in 2007, provides 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 plan focuses on promoting the use of Best Management Practices (BMPs) to reduce siltation, which poses the most severe problem for Beaver Creek at this time. Results from water quality modeling helped identify priority areas. The plan identifies sediment issues in the watershed and outlines a strategy for reducing sediment loads in the watershed by 38 percent.

Based on the results of the modeling and biotic community and habitat assessments, the Beaver Creek WRP established source category reduction targets as follows: 40 percent from agricultural areas; 20 percent from urban areas; and 70 percent from construction sites (note that no TSS reduction target was imposed on point sources). This is expected to be sufficient to meet the TMDL goals.⁴ Pathogens and nutrients will likely be addressed in a subsequent WRP.

MODELED CURRENT AND FUTURE SEDIMENT LOADS

Sediment loading is one of the primary concerns in the Beaver Creek watershed. Exhibits 10 and 11 show the estimated existing and future sediment loads by percent source contribution, based on the HSPF models.

EXHIBIT 10
Actual 2006 Sediment Loads by Source

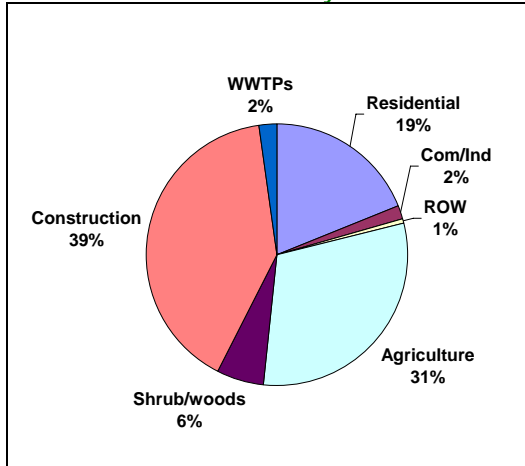
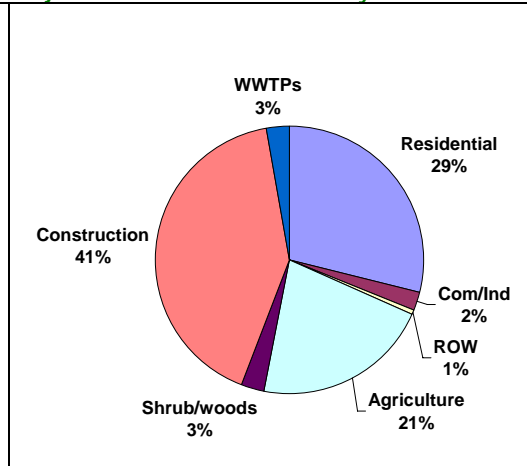


EXHIBIT 11
Projected 2030 Sediment Loads by Source



Existing sources of sediment are primarily ongoing construction, agricultural, and residential land uses at 39 percent, 31 percent, and 19 percent, respectively. Construction land uses were identified as areas currently under construction and susceptible to surface sediment runoff during rain events. Forest (shrub/woods) and commercial areas contributed relatively low quantities of sediment to the system.

The most significant change predicted between now and 2030 is that loadings from residential land uses will increase significantly from 19 to 29 percent, while the contribution from agricultural land uses will decrease from 31 to 21 percent. This change reflects the modeler’s assumptions about the conversion of agricultural areas to new residential developments.

The good news is that the net effect will be a decrease in overland-delivered sediment loads in virtually all Beaver Creek subwatersheds, as shown in Exhibit 12.⁵ This result is due to agricultural land uses having relatively higher sediment loading rates than residential land uses, on a per acre basis.

The bad news is that this net result does not change the fact that the total sediment loading from residential areas is increasing and loads from construction areas are still significant, even if unchanged. Sediment reductions targeted to these specific land use categories will be required to meet the sediment reduction goals established in the TMDL and WRP. Additionally, urban areas generate other pollutants (metals, pesticides, hydrocarbons, etc.) that are a significant concern. Urbanization would be expected to lead to increases in these other pollutants.

Based on predicted changes in land use by 2030, the primary sources of sediment will still be construction, residential, and agricultural land uses. Barely any increase in loading from construction and right-of-way land use areas is expected, based on an assumption that these acreages will remain relatively constant. Even so, the contribution from construction will continue to be the largest overall source of sediment in the watershed. It is possible that some reduction in loadings from this source could be achieved by improved compliance with sedimentation and erosion control requirements.

MODELED CURRENT AND FUTURE PHOSPHORUS LOADS

Total phosphorus (TP) loading in the Beaver Creek watershed has been identified as an important concern by TDEC. Based on the HSPF modeling, the dominant sources of phosphorus in the watershed are the two WWTPs, representing more than 95 percent of the existing and future loading, as shown in Exhibit 13.

EXHIBIT 12
Comparison of TSS Loading: 2006 v. 2030

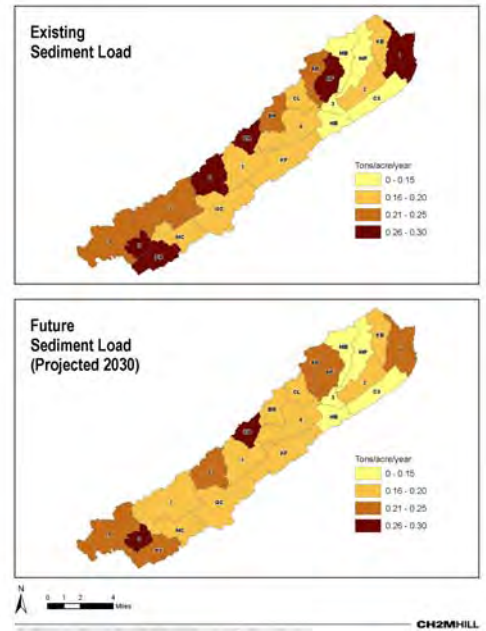
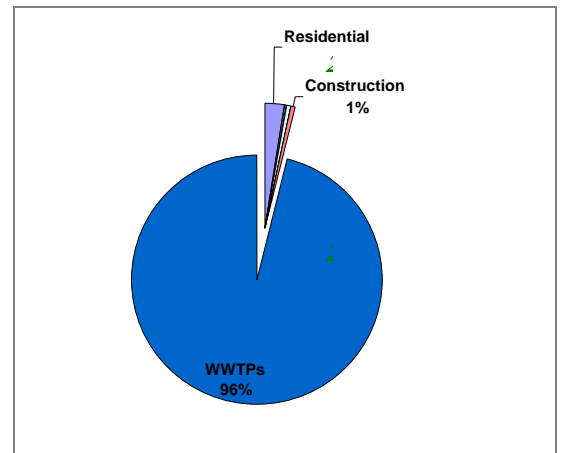


EXHIBIT 13
Existing Total Phosphorous Loads by Source

The relative distribution of future loads is projected to be very close to this existing distribution.



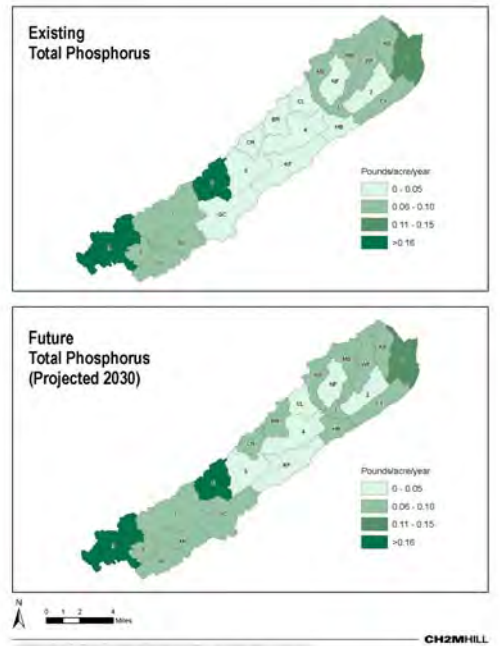
Although the WWTPs will continue to be the largest overall source of phosphorus, several sources show some significant increases in loading based on predicted changes in land use by 2030 (see Exhibit 14). Phosphorus loadings from both residential and commercial/industrial sources are expected to increase by 26 percent, compared to a 32 percent decrease from agricultural sources. As with sediment, these changes reflect the conversion of agricultural areas to new residential and commercial/industrial properties. However, the total phosphorous loadings from these sources remain less than 4 percent of the total loadings in the future.

The two dark green-colored subwatersheds in Exhibit 14 that have the highest total phosphorus loadings correspond to the location of the two WWTPs. While the phosphorus loadings are decreasing in several subwatersheds, the majority of the subwatersheds are expected to see significant increases in phosphorus loadings based on 2030 projected land use. In contrast to urban land having relatively lower TSS loads than agricultural lands, and seeing TSS loads decrease overall with urbanization, TP has the opposite effect: urban areas have relatively higher TP loadings than agricultural areas, therefore as urban areas increase, TP loads will increase.

REDUCING SIGNIFICANT SOURCES OF SEDIMENT LOADING: KNOX COUNTY'S NEW STORMWATER ORDINANCE

The new stormwater ordinance, enacted in January 2008, is the primary mechanism by which the urban nonpoint source requirements of the Beaver Creek TSS TMDL will be implemented. The ordinance is consistent with and also implements portions of the County's Municipal Separate Storm Sewer System (MS4) stormwater permit (these permits impose NPDES program requirements on municipalities over a certain size).⁶ Within the Beaver Creek watershed, the County itself is the only MS4 permittee. A very small area of the watershed is located within the City of Knoxville, and thus covered by the City's MS4 and not subject to the County's stormwater ordinance. Thus, most private urban nonpoint sources in the watershed are unpermitted stormwater sources not directly subject to any NPDES or MS4 requirements.⁷ The exception is construction activities that result in the disturbance of one acre or more of total land area: these must be authorized under the State of Tennessee General NPDES Permit for Discharges of Stormwater Associated with Construction Activities (the Construction General Permit, or CGP), and comply with the terms of that permit, in addition to the sector specific requirements in the County's ordinance. Post-construction BMPs are not subject to the CGP, but are subject to the ordinance as described below.

**EXHIBIT 14
COMPARISON OF PHOSPHORUS LOADS: 2006 V. 2030**



Under the Knox County Stormwater Management Ordinance, non-exempted⁸ development and redevelopment activities that disturb more than one acre are required to submit a stormwater management plan that addresses the following four Integrated Site Design (ISD) criteria:

- **Water Quality (WQv)**— TSS reduction goal of 80% average annual post-development load by treating runoff from 85% of the rainfall events that occur in an average year (1.1 inches);
- **Channel Protection (CPv)**— The runoff volume from the 1-year frequency, 24-hour storm must be captured and discharged over no less than a 24-hour period;
- **Overbank Flood Protection (Qp25)**— Provide peak discharge control of the 2, 10 and 25-year return frequency, 24-hour duration storm events such that the post-development peak rate does not exceed the pre-development rate; and
- **Extreme Flood Protection (Qp100)**— Provide peak discharge control of the 100-year return frequency, 24-hour duration storm event such that the post-development peak rate does not exceed the pre-development rate.

These requirements are described extensively in the Knox County Tennessee Stormwater Management Manual,⁹ which states that the criteria were designed to be “blended together, enabling the site engineer to size and design structural stormwater controls to address all of these objectives to achieve water quality and quantity goals.” Green infrastructure approaches are encouraged. Applying the four criteria listed above to a specific development site dictates the size and design of structural stormwater controls.

The manual describes a set of BMPs and assumed removal efficiencies that, “used alone or in series [in a “treatment train” approach], can be used to meet [the] minimum design standard.”¹⁰ These are listed in Exhibit 15 on page 10.

Knox County staff will be reviewing new developments for compliance with the four ISD criteria. “For purposes of compliance with local and State regulations, [including the County’s MS4 permit,] it is presumed that developments and redevelopments are meeting the 80% TSS removal standard so long as stormwater management systems are designed, constructed, and maintained in accordance with the design criteria and specifications discussed in [the] manual.”¹¹

Depending on site conditions, four compliance scenarios are possible:

1. **All four criteria met exactly**—in a credit trading context, this outcome would neither generate credits nor require offsets;
2. **All four criteria bettered**—in a credit trading context, this outcome would potentially create credits that could be banked or exchanged, depending on the effect of any trading area restrictions or trading ratio requirements that might diminish or preclude credit trading;

3. **Mixed performance where one or more criterion not met, one or more criterion met exactly, and one or more criterion bettered**—it is certainly conceivable that in trying to optimize BMP design across all criteria that trade-offs may occur and result in a situation where there could be a demand for one type of credit (sediment or flow), and possibly the creation of the other type of credit (flow or sediment); and
4. **No criteria met**—a variety of circumstances could make it difficult or impossible to comply with the criteria, on a technical and/or economic basis.

EXHIBIT 15

Knox County Tennessee Stormwater Management Manual BMP Pollutant Removal Efficiencies¹²

General application BMPs listed first (ponds through grass channel) were evaluated for relative cost-effectiveness in this study (see later in the report); limited application BMPs identified by italics were not evaluated. "Knox County will accept [general application] BMPs for use with a wide variety of land uses and development types."¹³ " Limited application BMPs will be allowed only when the use of general application BMPs is not feasible because special site or design conditions prohibit their use and will be approved for use in Knox County on a site-by-site basis."¹⁴

Knox County Stormwater Ordinance Urban BMPs	Percent Removal		
	TSS	TP	TN
Stormwater Ponds (aka wet basins, retention/detention basins)	80	55	30
Conventional Dry Pond (aka dry basin)	10	--	--
Dry Extended Detention Pond (aka dry basin)	60	35	25
Stormwater Wetlands (aka constructed wetlands)	75	45	30
Bioretention Areas (aka bioretention filters)	85	60	50
Sand Filters	80	50	30
Infiltration Trench	90	60	60
Water Quality (WQ) Dry Swale	90	50	50
Wet Swale	75	25	40
Filter Strip	50	20	20
Grass Channel (aka grass swale)	30	25	20
<i>Organic Filter</i>	80	60	40
<i>Underground Sand Filter</i>	80	50	25
<i>Submerged Gravel Wetland</i>	80	50	20
<i>Alum Treatment</i>	90	80	60
<i>Gravity (oil-grit) Separator</i>	30	5	5

The ordinance recognizes that some potentially meritorious projects may have difficulty meeting one or more criteria and specifically allows for “alternative approaches” to meet the channel protection volume requirement.

The alternative approaches are not specified in the ordinance but must provide “adequate channel protection from erosion.” This clause supports the potential for a flow-based credit trading option (see below) to meet the channel protection requirement.

ECOLOGICAL CREDIT TRADING COULD SUPPORT IMPLEMENTATION OF THE WATERSHED RESTORATION PLAN AND THE COUNTY'S STORMWATER ORDINANCE

In recognition of the challenges and opportunities to achieve water quality improvements with regulatory and voluntary programs, in 2005 the Beaver Creek Task Force and Knox County collaborated on seeking funding from EPA Region 4 to evaluate how market-based approaches, including water quality credit trading, could help support watershed restoration. In 2006, they were awarded a grant to develop and demonstrate how an ecological credit trading market could be used to create opportunities for stakeholders to implement watershed restoration actions more quickly, in more priority locations, and more cost-effectively than would be the case without market-based mechanisms.

Water quality credit trading involves at least two parties exchanging a “credit” that usually represents a reduction of a specified amount of a named pollutant over a defined time period, for example: a reduction of 100 pounds of nitrogen over one year. The term “ecological” credit trading is used in this report to refer to similar transactions that involve more than one pollutant at a time (also called multi-credit trading), or that involve a water quality benefit that is not a pollutant, such as flow, which was evaluated as a potential credit for Beaver Creek.

Stormwater best management practices (BMPs), point source pollutant control technologies, and watershed restoration projects can—and usually do—deliver more than one environmental benefit at once, such as the following:

- A stormwater BMP can reduce sediments, nutrients, and other pollutants, and reduce or at least change the temporal runoff pattern of the area managed by the BMP;
- A municipal wastewater treatment plant (WWTP) can employ a variety of technologies that use biological and/or chemical processes to reduce nitrogen and phosphorus; and
- A stream restoration project that involves tree-planting and other revegetation can create habitat values and sequester carbon, reduce instream sediment loading, reduce instream temperatures, and reduce nutrient loading through riparian buffer preservation.

This study evaluated credit trading opportunities that involve two types of commonly considered water quality credits—sediment and nutrients, as well as a third type of credit that would represent reductions in specified flows consistent with the three volume control requirements established in Knox County's stormwater ordinance, as listed earlier.

This report documents the consolidated results of evaluating the potential applicability and benefits of ecological credit trading markets in the Beaver Creek watershed. This study concludes that a relatively uncommon trading program structure that involves only unpermitted nonpoint sources is best suited for the Beaver Creek watershed in the near term. Though uncommon today, nonpoint-nonpoint credit trading, especially structured within a local stormwater ordinance program, may have broad applicability.¹⁵ The study process, methods, and full

results are documented in detail in the series of Technical Memoranda listed in the References section of this report.

What Makes it a “Trade”?

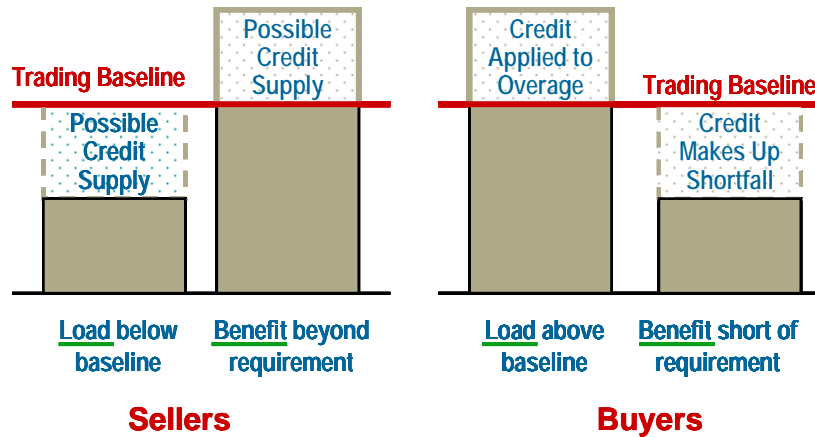
States and local governments establish pollutant control, loading reduction, and other requirements (such as maximum flow levels) for individual dischargers and categories of sources, as applicable, to protect water quality generally, or to secure improvements to water quality, such as required under a TMDL. These requirements typically define “default” actions that would be taken to comply, such as upgrading a wastewater treatment plant to a certain level, or installing a certain type or number of best management practices at regulated locations.

Trading describes situations where at least one party subject to one of these environmental requirements meets its responsibilities by implementing an alternative to the default action, often involving another location(s) and another party(ies), to provide equal or better environmental results than the default action would have provided.

Trading Baselines Define What is Creditable

A trading baseline is the pollutant loading cap or level of other environmental benefit that must be achieved or maintained. Performance better than the baseline provides an opportunity to create credits, while performance worse than the baseline is a situation where credits might be used to “offset” the exceedance or shortfall, as illustrated in Exhibit 16.

EXHIBIT 16
Illustration of Credit Trading Baselines for Potential Sellers and Buyers



People Look at Trading for a Variety of Reasons

- **Cost-Effectiveness:** Trading can make compliance more cost-effective and save money, because credits are less expensive than on-site options, and/or credit purchases let parties optimize sizing and scheduling their own projects.
- **Targeting Improvements:** Trading can encourage pollutant reductions and environmental restoration projects in priority locations where they might not otherwise occur, and can create incentives for types of projects that are desired but that might not otherwise be economical.

- **Speeding Results:** Trading can help regulated parties and those acting voluntarily produce load reductions and other water quality improvements on a faster time schedule than without trading when the creditable projects have a shorter permitting and/or construction schedule and/or when they require less financial investment.

Examples of Trading Programs in Place and Under Development

- **Point-Point Nitrogen Credit Trading:** Wastewater treatment plants in Connecticut, North Carolina (Neuse and Tar Pamlico River Basins), and Virginia trade nitrogen credits among themselves, as some plants upgrade and some do not, to meet collective watershed-based loading caps.
- **Point-Nonpoint Temperature Credit Trading:** A municipal wastewater treatment and stormwater management district in Oregon purchases temperature credits through the local soil and water conservation district generated by landowners' planting trees and shrubs along the tributaries.
- **Nonpoint-Nonpoint Nitrogen and Selenium Credit Trading:** Local governments and private land developers in one California watershed are developing a program to collaboratively fund projects that would reduce nitrogen and selenium loadings to meet individual and collective TMDL loading caps.

What Types of Credits Might Be Traded in Beaver Creek?

Sediment: Urban Nonpoint Source Sector May Need and/or Create Credits

The existing TMDL for sediment provides the primary driver for sediment credit trading by establishing percentage reduction targets by source sector. The new Knox County stormwater ordinance provides an additional mechanism for implementing the TMDL by establishing requirements for sediment removal from urban nonpoint sources, to address problems such as that illustrated in Exhibit 17. No other practical source of demand was found: construction sources covered by the state's CGP were deemed ineligible for the trading framework proposed for the near term (see later in this report); there are no other permitted (MS4) nonpoint sources in the watershed; and the two point sources in the watershed do not have wasteload allocations (i.e., mass-based loading caps) for TSS as a result of the TMDL, as they are not a significant source of TSS (only 2 to 3 percent, as shown in Exhibits 10 and 11).

EXHIBIT 17
Upland Erosion: A Significant Source of Sediment in the Beaver Creek Watershed



Nonpoint-to-nonpoint credit trading for sediment appears feasible: urban sources are likely to be buyers or sellers (depending on the land use and BMP[s] selected) because they will have baseline requirements associated with the stormwater ordinance; and agricultural landowners who are likely to be sellers because their sediment control requirements are lower relative to urban sources.

Nutrients: Initial Opportunities Appear to Involve Phosphorus and Nonpoint Sources

Nutrient reductions will be a secondary benefit of the ordinance implementation as the application of post-development BMPs targeted at sediment control will also provide ancillary nutrient removal for stormwater runoff from new development. These will address problems such as that illustrated in Exhibit 18. As with sediment, the initial nutrient trading opportunities appear to be focused on nonpoint-to-nonpoint transactions.

While the TMDL for nutrients has not been developed, it was assumed that the key concern is the delivery of nutrients to the downstream TVA impoundment (Melton Hill Reservoir) rather than instream loadings within the Beaver Creek watershed. The 2006 303(d) list referenced phosphorus and nitrates as a TMDL priority; the nutrient of concern in the watershed is phosphorus (since it is the limiting nutrient in freshwater).

In the near term, it is expected that most of the demand and supply for nutrient credits would come from the urban nonpoint source sector, driven by compliance with the stormwater ordinance. Point source interest and ability to participate in nutrient credit trading is not expected to materialize in the near term for several related reasons: TDEC has not established the phosphorus TMDL; so there is no immediate regulatory driver for nutrient reductions from the wastewater treatment plants (as noted above, there are no permitted nonpoint sources in the watershed); and without mass-based wasteload allocations, it will be difficult to establish point source baselines for credit creations using concentration-based effluent limits alone.

In the future, point-to-point and/or point-to-nonpoint source trading opportunities could exist if WWTPs needed to make nutrient loading reductions, especially considering that the majority of the total phosphorus (TP) loadings to the watershed are from the WWTPs.

EXHIBIT 18
Nutrient Enrichment, Which Can Lead to Nuisance Algal Blooms, is a Water Quality Problem in Beaver Creek



Flow: Flow-Based Credit Trading Could Improve Biotic Integrity

While addressing sediment and nutrient loadings in the watershed has been the focus of TDEC and the BCTF, other watershed-related improvements will be needed to address the loss of biological integrity: this could include flow-based credit trading opportunities.

Design requirements in the ordinance for post-development BMPs require that an additional increment of runoff volume be retained to provide downstream channel protection, to provide benefits such as those illustrated in Exhibit 19. This flow volume provides another opportunity for potential ecological credit trading as it is a requirement for future development and can be directly linked to potential improvements in stream habitat conditions and, eventually, biological integrity.

Whereas the new county ordinance requires implementation of post-development BMPs to address both water quality and stream channel protection volume control, there appears to be an opportunity to link ecological credit trading opportunities to this new requirement. This ordinance will provide the mechanism for Knox County to help address the TMDL for sediments and the opportunity for secondary aquatic habitat benefits from the reduction in stormwater flows.

What Credit Units Would Be Traded?

Credits need to be denominated in units consistent with the nature of the pollutant and the applicable treatment and/or control requirements. For sediment, it may make the most sense to trade credits denominated in “pounds per year.” This is consistent with the TMDL, and is implementable within the stormwater ordinance framework. It also is possible that participants would choose to trade credits representing the full term of compliance based on assumed BMP performance lives: for example, “pounds per 20 years.”¹⁶

For a flow-based credit trading system, the credit units also must be derived from and consistent with the ordinance requirements. There are several performance metrics in the ordinance. A flow reduction credit could be measured in volume (acre-feet [ac-ft]) available to treat the channel protection volume (CPv=the runoff from the 1-year, 24-hour storm event for that project site to be released over a 24-hour period).¹⁷

For purposes of this study, it is assumed the credit unit for TSS will be lbs/year, and this has been reflected in the demand-supply analysis and cost-effectiveness calculations summarized in this report. The proposed flow-based credit unit is CPv. Both units are reflected in the Knox County Stormwater Quality Site Development Review and Credit Evaluation developed to support implementation of the ordinance and the proposed credit trading program (see full description of tool on page 39 of this report).

EXHIBIT 19
Improved Hydrologic Controls Will Support Restoration of Biotic Integrity



With respect to the temporal relationship between a credit and the compliance deficit it offsets, these will need to be the same. Thus, if the accounting period is annual and the units are lb/yr, then credits generated in Year N can only be applied as offsets in Year N. They may not be rolled-over or otherwise banked beyond the accounting period; but they may be banked within the accounting period and used anytime within it. Beyond Year N, so long as the BMP generating the credits remains in place and performing at applicable standards, then the BMP can “re-generate” credits for the next accounting period. The same approach would apply for credit units that represent reductions over a longer temporal period: the credits are valid so long as the BMP is performing during the accounting period, but not after.

The final decision regarding credit units for TSS, phosphorus, and flow will need to be made prior to initiating formal trading. The County and Beaver Creek stakeholders retain some flexibility and discretion in establishing credit units, so long as they are consistent with the TMDL and ordinance because there are no NPDES permittee buyers or sellers whose compliance period must be matched.

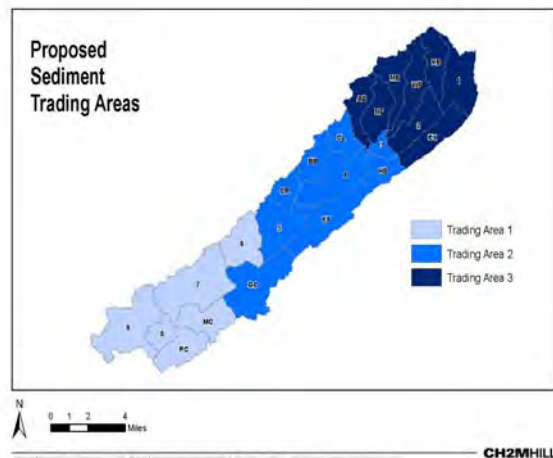
Where Could People Trade Within the Watershed?

The most appropriate trading area is usually specific to the pollutant being considered, based on the location of impairments and the behavior of the pollutant in the water column and as it travels through the waterbody. For each of the three pollutants, three general sizes of trading areas were evaluated, as described below and summarized on the next page in Exhibit 22.

Sediment Credit Trading Area

In the Beaver Creek watershed, sediment contributes to loss of biotic integrity and habitat alteration at a relatively small to medium scale.¹⁸ The fact that the sediment-driven degradation in the Beaver Creek watershed is greater in the lower half than in the upper half suggests that establishing three trading areas in the Beaver Creek watershed—the upper, middle, and lower watersheds—is appropriate, as illustrated in Exhibit 20. Trading areas demarcated along these subwatersheds would minimize the chance of localized negative impacts while creating the potential for more trading partners and more trades.

EXHIBIT 20
Three Trading Areas are Proposed for Sediment Credits



Phosphorus Credit Trading Area

In the Beaver Creek watershed, the main concern regarding phosphorus is its cumulative impact downstream where Beaver Creek meets the Lower Clinch River. Given that the TMDL will likely be developed for the entire Beaver Creek watershed without suballocations to smaller areas, it would be consistent with the behavior of this pollutant within the waterbody and with EPA guidance to establish a single trading area covering the entire watershed, as shown in Exhibit 21.

Flow Credit Trading Area

Design requirements in the County’s stormwater ordinance for post-development BMPs require that an additional increment of runoff volume be retained to provide downstream channel protection. The County’s “10% Rule” used to guide implementation of these requirements requires a developer to “assess the impacts of a development downstream to the point where the developed property is 10 percent of the total drainage area, and there are no adverse impacts on peak flow increase.” This rule recognizes the fact that structural controls providing detention have a “zone of influence” downstream where its effectiveness can be observed. Given the range in size of developments expected in Knox County (from a few acres to hundreds of acres) and the size of the watershed and subwatersheds, this would generally align to a trading area around the size of the subwatersheds (or smaller). This would be the same scale as proposed for sediment trading areas, shown in Exhibit 20 above.

EXHIBIT 21
One Trading Area is Proposed for Phosphorus Credits

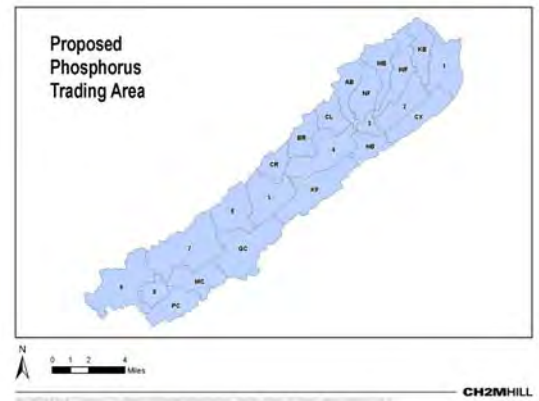


EXHIBIT 22
Summary of Trading Area Options for the Beaver Creek Watershed

Trading Area	Nutrients	Sediment	Flow
Watershed-wide	Most appropriate	Possible, but not likely per EPA guidance	Not appropriate
Subwatersheds	Possible, but limiting	Most appropriate	Most appropriate
Tributaries/Segments	Not necessary and too limiting	Not necessary and too limiting	Possible, but limiting

Trading Ratios Help Assure Equal or Better Results

Since trading involves one party doing more than they have to, and creating credits, to make up for another party not doing as much as they otherwise would, and having debits, it is important that the trading program ensure that the credits and debits are equal. Sometimes, nutrient load reductions in one location are more or less beneficial to water quality than in another location. Also, there can be some uncertainty in the level of nutrient reduction that will actually be achieved by the credit seller, compared to what the credit buyer could have achieved. Oftentimes, BMP performance and load reductions are based on estimates and cannot be practically or accurately documented.

To address these issues, one or more types of trading ratios can be used to define equivalency or provide additional certainty between the credit and debit side of a trade. For example, a ratio of 2:1 would mean that a BMP would have to deliver two pounds of nutrient reduction for every one pound it would be credited with. Two types of trading ratios were recommended for consideration in the Beaver Creek watersheds: location and uncertainty ratios.¹⁹

Location Ratios: Appropriate for Sediments and Phosphorus

Location ratios help equalize credits and debits in different hydrologic segments of the subwatersheds. They can be developed from delivery factors (also called transport factors) that are often included in water quality models.

Delivery factors account for the attenuation of a pollutant (or other environmental benefit) as it moves through the watershed. Some pollutants may travel between two points in the watershed relatively unchanged, or undiminished in their ability to impact water quality. The effects of others may diminish substantially as each distance unit traveled increases the chances that the pollutant is taken up by aquatic plants, settles into/onto the bottom of the waterbody, or is otherwise diminished or removed (e.g., adsorption-sedimentation, water supply intake, irrigation diversion channel).

Mathematically, a delivery factor usually specifies the fraction of one pound of a pollutant released into the waterbody at a specific segment that is assumed to reach the some secondary location, or a terminal waterbody. To calculate the location ratio from a delivery factor, divide the factor into one. This method normalizes all reductions or loads above loading caps into comparable units.

In general, it was concluded that the need for location ratios for a Beaver Creek trading program may depend on the size of the trading area ultimately adopted for each pollutant. With a small enough trading area relative to the pollutant's behavior, location ratios might not be needed. If trading extended beyond that defined area, location ratios may well be needed to establish equivalency between the credit and debit sites, as summarized below for each type of credit considered. The establishment of any trading ratios would take place prior to the implementation phase of a trading program.

- **Sediment Location Ratios:** If the three proposed trading areas are accepted, it is not yet clear whether delivery and/or location ratios will be needed to support trading within each area. Because the proposed trading areas are relatively small, alternative sediment control and loading patterns attributed to trades might not induce localized negative impacts on biota. This situation implies a location ratio of 1:1. However, it is possible that location ratios of greater than 1:1 might be needed for trades between all or only selected sub-watersheds in order to keep sediment loads and siltation at the credit buyer's site at acceptable levels.
- **Phosphorus Location Ratios:** Given that Beaver Creek is a fairly small watershed at 86 square miles, it is possible that water quality modeling would indicate that all or most sources would have a delivery factor of 1, or close to 1. For example, the model might indicate that a pound reduced somewhere in the watershed was equivalent to 1 pound or 0.9 pounds reduced at the terminal normalizing location. In such a case,

the location trading ratio would be 1:1 or 1.11:1 (to calculate the location ratio from a delivery factor divide the factor into 1, e.g. 1/0.9). However, some potential trading candidates may be farther up in the watershed where the real delivery factor could easily be less than 1, making the location ratio greater than 1:1.

- **Flow Location Ratios Not Needed:** Location ratios would not be appropriate for flow as the equivalency and local protection issues they address will be addressed by limiting trades to subwatersheds, or even smaller areas as may be necessary under the 10% Rule described above.

Uncertainty Ratios: Generally Not Needed for the Nonpoint Source Credits

Uncertainty ratios are usually developed and applied to account for mathematical variance in assumptions used to develop underlying models, construct margins of safety, or estimates of the performance of best management practices and other actions that will be relied upon to generate water quality credits. The need for an uncertainty ratio for sediment, phosphorus, or flow reduction credit trading in the Beaver Creek watershed depends upon whether or not uncertainty has already been addressed in the water quality models used to make future projections, margins of safety in the TMDL and/or target load reduction percentages, and BMP performance assumptions in the stormwater ordinance.

While there is clearly some uncertainty in the TVA’s HSPF model, it is assumed the TMDL and reduction targets account for this uncertainty so it is not necessary to incorporate a “model uncertainty factor” into a trading ratio—such an approach would effectively double-count, or double-correct for the uncertainty.

With regard to accounting for uncertainty about BMP performance, it is recommended that if a proposed trade involves a BMP approved by the Knox County Stormwater Manual, and the credit generator complies with applicable design guidance, then that BMP would be assumed to deliver the assumed performance specified in the ordinance and manual, subject to the same reviews, pre-approvals, inspections, and final approvals the County applies for BMPs installed to comply with the ordinance that do not involve trading.

As noted in the section describing the County’s stormwater ordinance requirements: “For purposes of compliance with local and State regulations, [including the County’s MS4 permit,] it is presumed that developments and redevelopments are meeting the 80% TSS removal standard so long as stormwater management systems are designed, constructed, and maintained in accordance with the design criteria and specifications discussed in [the] manual.”²⁰

The BMP efficiency assumptions reflected in the ordinance are generally conservative and as such already account for some uncertainty. According to the County’s manual, the assumed removal efficiencies (see Exhibit 15): “are median pollutant reduction percentages for design purposes that have been derived from existing sampling data, modeling and research. A structural BMP design may be capable of exceeding these performances; however, the values

in [Exhibit 15] are considered median values that can be assumed to be achieved when the structural BMP is sized, designed, constructed and maintained in accordance with recommended specifications in this manual.²¹

With this built-in conservativeness, for BMPs that follow the manual an uncertainty ratio should not be necessary. This approach appears to be consistent with the technical and legal presumptions of the ordinance and what constitutes compliance irrespective of trading.²² It also is consistent with the presumption that the Beaver Creek credit trading program will support only nonpoint-nonpoint trades in the near term. This means it is only necessary to account for uncertainty in an individual BMP's performance, and for differences in expected performance between the BMP generating a credit and the modified or foregone BMP at the buyer's site. It is not necessary in this case to use uncertainty ratios to establish equivalency in expected performance between a weather-driven nonpoint source BMP and the well documented performance via effluent monitoring of a point source treatment technology.

Alternatively, if a proposed trade involved a BMP not included (pre-approved) in the ordinance, then it would be reasonable and necessary to require documentation of the expected performance, underlying assumptions, and associated low-high range. This is consistent with the County's policy that "proprietary, new, and other BMPs not included in this manual may be approved by the Director of Engineering and Public Works (Director) for treatment of stormwater quality on a case-by-case basis provided that the conditions outlined in Volume 2, Chapter 2 of this manual are met."²³ Depending on the confidence in the data and assumptions, an uncertainty ratio may be needed. This ratio could be developed from a combination of the documentation provided; results from BMPs implemented under the ordinance; and/or relevant literature values (as was cited for the pre-approved BMPs).

Monitoring Programs Will Support Credit Trading

As part of this study, the project team conducted an assessment of the existing monitoring program to determine if whether it can support the implementation of the proposed Ecological Credit Trading program. In addition to needing sufficient monitoring capabilities for the three parameters evaluated for trading in this study—sediment (TSS), phosphorus, and, flow—measures of habitat and biotic integrity could also be important to evaluating the results of any trading program, in addition to pollutant reduction and flow controls. As such, the evaluation of existing monitoring programs relative to supporting a potential water quality credit trading program focused on these parameters.

The evaluation concluded that, with some enhancements, the existing monitoring program can support the types of trading being contemplated for the Beaver Creek watershed. Some of these enhancements would be important to understanding the water quality conditions and progress toward improvement being made under the TMDL and Knox County stormwater management program even without trading. Other enhancements would be targeted to the unique evaluation needs associated with providing an opportunity to implement pollutant load reductions and other ecologically

beneficial actions in locations other than where they would occur without trading.

Additionally, all BMPs built to comply with the stormwater ordinance, whether they are involved in trading or not, will have to comply with the post-implementation requirements, including monitoring, as must be specified in each project’s Operations and Maintenance Plan and as enforced through the executed Covenants for Permanent Maintenance of Stormwater Facilities and Best Management Practices.²⁴

In general, with or without trading, the County does not anticipate the need for additional BMP-specific monitoring of those BMPs that meet the County’s design manual and have otherwise been approved through the stormwater ordinance compliance determination process, including having duly executed and files the maintenance covenants referenced above. On-site monitoring may be required for BMPs proposed for credits that are not covered by the manual, or involve some other special circumstance. Because no point sources will be involved in the proposed trading program, their monitoring programs were not targeted for enhancement in the field, or in permit requirements.

Exhibit 23 identifies the locations of the 14 existing monitoring stations currently in place and operating in the watershed. Exhibit 24 lists the parameters being monitored and the sampling/testing method being used. Highlights of the recommended enhancements to the habitat and biological monitoring program, which constituted the majority of the recommended enhancements, are presented following these exhibits.

EXHIBIT 23
Existing Water Quality Monitoring Stations in Beaver Creek

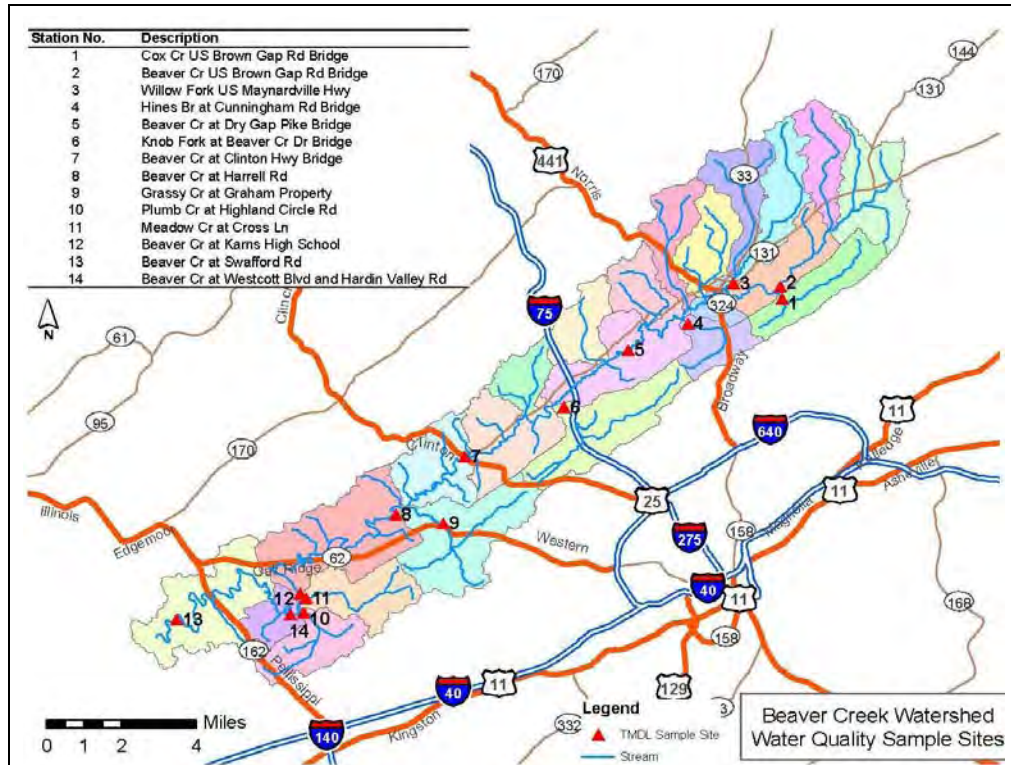


EXHIBIT 24
Water Quality Parameters and Analysis Methods

Parameters	Units of Measure	Equipment/ Lab Method	Parameters	Units of Measure	Equipment/ Lab Method
Alkalinity	mg/L	field probe	Nitrogen, Ammonia	mg/L	K0604048
BOD5	mg/L	K0604048	Nitrogen, NO3 & NO2	mg/L	K0604048
Conductivity	umhos	field probe	Nitrogen, Total Kjeldahl	mg/L	K0604048
Turbidity	NTUs	Field probe	Orthophosphate	mg/L	HPUD
Dissolved Oxygen	mg/L	field probe	pH	pH units	field probe
E. Coli	cfu/100ml	HPUD	Suspended Solids	mg/L	K0604048
Fecal Coliform	cfu/100ml	HPUD	Temperature	Celsius	field probe
Flow	cfs	field probe	Total Phosphate	mg/L	K0604048
Gage Depth	in	field reading	VSS	mg/l	HPUD

Highlights of the Recommended Enhancements to the Habitat and Biological Monitoring Program

The recommended enhancements to the existing monitoring program focus on the biological monitoring activities. Water quality monitoring elements of the program would be adequate to track compliance with the watershed restoration program, TMDL implementation, and the proposed credit trading program. Since Knox County will be the administrator of the overall credit trading program, it was recommended that the County be responsible for maintaining the overall monitoring program data base. Several enhancements to the biological monitoring program, listed below, were recommended to evaluate watershed improvements, track compliance with the sediment and habitat TMDL, and ensure that localized problems are not created as part of the credit trading program.

- Five additional monitoring stations are recommended at locations on the main stem spaced relatively equidistant between the confluence with the Clinch River in Solway and the upper reach in Gibbs.
- Habitat characteristics should be determined using the Environmental Protection Agency’s Rapid Bioassessment Protocols (RBPs) for use in streams and rivers.²⁵

- Biological monitoring should include benthic macroinvertebrates and fish, and should be conducted annually. Benthic macroinvertebrate community sampling should be conducted using Tennessee’s standard operating procedures for Semi-Quantitative Single Habitat Samples.²⁶ Fish sampling should follow the procedures described in EPA’s RBP for streams and rivers.²⁷
- Results should be compared with macrobenthic invertebrate and habitat assessment data for TDEC-identified reference streams and data from previous years to assess whether biotic integrity and habitat conditions are improving. In addition, the Index of Biotic Integrity (IBI) metrics should be compared against TDEC biometrics for the reference stations to determine whether the stream biotic conditions are meeting the requirements for the designated use of “fish and recreation.” In particular, results of the fish sampling should be compared against previous data collected by TVA and TDEC, and the TDEC biometrics to assess improvements.

ASSESSMENT OF CREDIT TRADING OPPORTUNITIES IN THE BEAVER CREEK WATERSHED

This assessment of trading opportunities was framed by the following assumptions.

1. Based on the results of the modeling and biotic community and habitat assessments, the Beaver Creek WPR sets out a TMDL implementation strategy to reduce sediment by 40 percent from agricultural areas, 20 percent from urban areas, and 70 percent from construction sites (note that no TSS reduction target was imposed on point sources).²⁸
2. The new Knox County Stormwater Ordinance and Stormwater Management Manual places requirements on new development and redevelopment designed to help reduce sediment loadings to the watershed.
3. An ecological credit market can help achieve these goals more cost-effectively while promoting activities that go beyond minimum compliance and generate measurable pollutant reductions.

Under these assumptions, trading opportunities were evaluated for each of the four potential source sectors: point sources; agricultural land; construction sites; and urban development.

As described earlier, it was determined that sediment trading opportunities would primarily involve agricultural and urban sources as potential buyers and sellers, and that these sectors would not need or be interested in phosphorus trading. Additionally, while it is clear the urban sector would be the driver for any flow-based credit trading, it is not yet clear how easy or difficult it will be for those subject to the stormwater ordinance to meet their flow-based requirements on-site without trading. Only limited TSS credit trading opportunities involving point sources were identified in the near term, which would not involve buying or selling credits against their effluent limits.

Based on these considerations, sediment credit trading among unpermitted sources is the central focus of this assessment. Potential longer-term, future phosphorus credit trading opportunities for construction and point sources are briefly addressed, in the interest of providing a comprehensive summary of the alternatives examined. Flow-based credit trading opportunities are not further assessed, except for a short discussion of flow-based credit trading issues and the implications for designing the proposed trading and banking framework provided at the end of this section.

**Baseline Analysis and Relative Cost-Effectiveness
Forms Basis for Trading Opportunity Assessment**

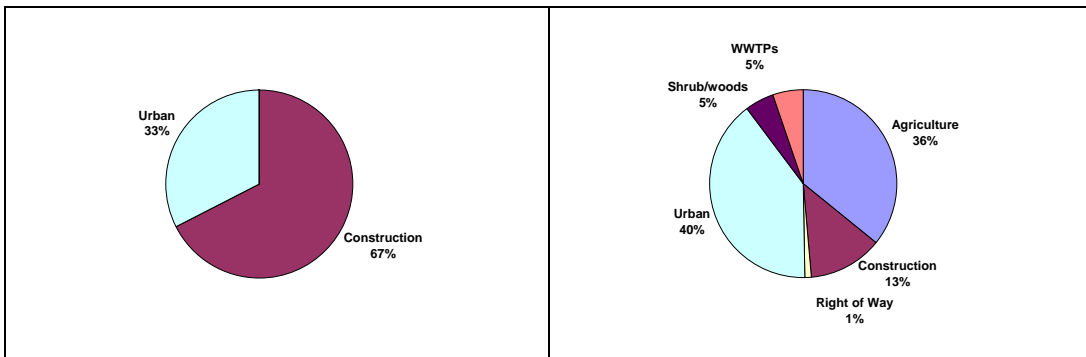
Screening-level analyses of potential credit demand and supply were conducted for the four major land use categories and point sources and used in conjunction with screening level estimates of the relative cost-effectiveness of 19 defined BMPs to provide a basis on which to assess trading opportunities in the Beaver Creek watershed. Insufficient cost data were available to develop unit cost estimates for point source controls. The methodology used to develop this basis is briefly summarized below. The results of the assessment are then presented for each source sector and collectively.

Aggregate Assessment of Potential TSS Credit Demand and Supply²⁹

Using the HSPF modeling data, GIS data, and spreadsheet-based calculations, sediment loads were attributed to the total acreage in each of five land use categories: agriculture; construction; right of way; urban; and shrub-woods. Credit trading baselines were then defined for each category, consistent with the TMDL, the Watershed Restoration Plan, and the Knox County stormwater ordinance, as applicable. Assumptions were then made about two levels of possible BMP implementation in the aggregate (as a percent of acreage managed by a defined BMP package): (1) the coverage needed to meet the baseline; and (2) the maximum practical BMP coverage.

EXHIBIT 25
Distribution of Maximum Potential TSS Demand:
Total = 5,010 tons/yr

EXHIBIT 26
Distribution of Maximum Potential TSS Supply:
Total = 2,950 tons/yr



While the baselines stay constant over the period 2008 to 2030, the “current” load without BMPs and with BMPs will shift over time as land use conversions occur. Recognizing this, demand and supply were then modeled in the year 2030 as follows: Maximum credit demand = the difference between current loads and the baseline; and Maximum credit supply = the difference between the loads under maximum BMP coverage and the baseline. Exhibits 25 and 26 (above) presents the results of this assessment in graphic format; Exhibit 27 provides the tabular data and notes about assumptions.

EXHIBIT 27
Sediment Credit Demand-Supply Estimates at 2030 (exclusive of any trading ratios)

Source	Estimated Max Demand tons/yr	Estimated Max Supply tons/yr	Notes
Agriculture	0	1,060	Demand assumes 40% load reduction feasible with BMPs on 15% of agricultural land area, per Exhibit 24. Recall that there is a reduction in agricultural land use from 21% to 13% of total land use in watershed. Supply assumes new BMP capacity such that total 2030 load could be reduced by half.
Construction	3,380	380	Demand assumes no BMPs on ongoing construction—essentially representing a maximum demand, per Exhibit 25. Supply assumes 100% BMPs on ongoing construction for illustration purposes only, since it is likely that this would be practically and economically infeasible. In reality, supply is likely to be closer to zero.
Right of Way	0	30	Demand assumes zero reduction required. Supply assumes future load of 59 tons/yr could be reduced by 50%.
Urban (Residential and Commercial at approximately 92.5% and 7.5% respectively)	1,630	1,180	Demand assumes no new development controls and no retrofits, per Exhibit 26, essentially representing a maximum demand. Supply assumes new controls and 100% retrofit for illustration purposes only and reflects a theoretical maximum. For every additional 10% retrofit beyond the 40% assumed in Exhibit 26, urban sources could supply 197 tons/yr.
Shrub/woods	0	150	Demand assumes zero reduction required. Supply assumes future load of 302 tons/yr could be reduced by 50%.
Total Maximum	5,010	2,950	

Relative Cost-Effectiveness for Selected Nonpoint Source BMPs

Unit cost estimates for 10 BMPs applicable to selected land uses and one pasture BMP, representing a “package” of several BMPs applicable for pasture land,³⁰ were developed in order to gauge whether potential credit buyers could potentially save money with compliance strategies that include trading, compared to compliance without trading. In an actual trading program, credit prices, and not necessarily credit costs, will determine the level of cost savings (or profit) that may be realized. This study did not examine potential credit pricing schemes; however, the existence of

significant spreads in relative costs among BMP options is usually a good indicator of meaningful trading potential.

Unit cost estimates are calculated by dividing the total annualized per acre cost of installing, operating, and maintaining a BMP by the number of pounds of sediment the BMP controls per acre managed. This approach involves making assumptions about interest rates, inflation, discounting future costs into present values, pollutant loading rates into a BMP, BMP pollutant removal efficiencies, BMP lifespans, and land costs which are not detailed in this report.³¹ Exhibit 28 presents the unit cost estimates for the BMP-land use combinations examined. Exhibits 29 and 30 present these results graphically.

EXHIBIT 28

Unit Cost-Effectiveness Results for TSS, Without and *With* Land Acquisition Costs: \$/lb/yr

Most values rounded to the nearest \$0.10

BMP/Land Use	Residential	Comm/ Ind/ROW	Agriculture	Wood/ Shrub	Construction
Stormwater Ponds	\$4.30	\$12.60	\$0.97		\$0.26
With Land Costs	\$4.70	\$15.20	\$0.99		\$0.30
Conventional Dry Pond	\$26.00	\$63.20			\$1.30
With Land Costs	\$28.80	\$83.90			\$1.60
Dry Detention Basin	\$4.30	\$10.50			\$0.22
With Land Costs	\$4.80	\$14.00			\$0.26
Stormwater Wetlands	\$3.00	\$7.00	\$0.67		\$0.16
With Land Costs	\$3.40	\$9.70	\$0.69		\$0.19
Bioretention Areas	\$8.00	\$21.90			\$0.43
With Land Costs	\$8.40	\$24.30			\$0.47
Sand Filters	\$12.70	\$30.40			\$0.62
With Land Costs	\$13.00	\$33.00			\$0.66
Infiltration Trench	\$13.70	\$38.50	\$3.35		\$0.75
With Land Costs	\$14.00	\$40.80	\$3.37		\$0.78
Water Quality Dry Swale	\$11.10	\$35.50	\$2.47	\$4.60	\$0.67
With Land Costs	\$11.70	\$45.20	\$2.49	\$4.60	\$0.77
Wet Swale	\$13.30	\$42.60	\$2.96	\$5.60	\$0.80
With Land Costs	\$14.00	\$54.30	\$2.98	\$5.60	\$0.90
Filter Strip	\$1.80	\$5.80	\$0.39	\$0.60	\$0.10
With Land Costs	\$2.80	\$23.40	\$0.43	\$0.60	\$0.30
Grass Channel	\$3.30	\$10.60	\$0.74	\$1.40	\$0.20
With Land Costs	\$5.10	\$39.90	\$0.80	\$1.40	\$0.50
Pasture Package			\$1.50		
With Land Costs			\$1.59		

EXHIBIT 29
Cost-Effectiveness Results for TSS: View #1

This shows all results for the BMP-land use combinations plotted together—the “L” series includes land costs. These data indicate that most BMPs on commercial property are more expensive than the other options—and that land costs can be a big factor for BMPs on this land use. These data also show that residential BMPs are less expensive than ones on commercial property, but generally are more expensive than those on other land uses.

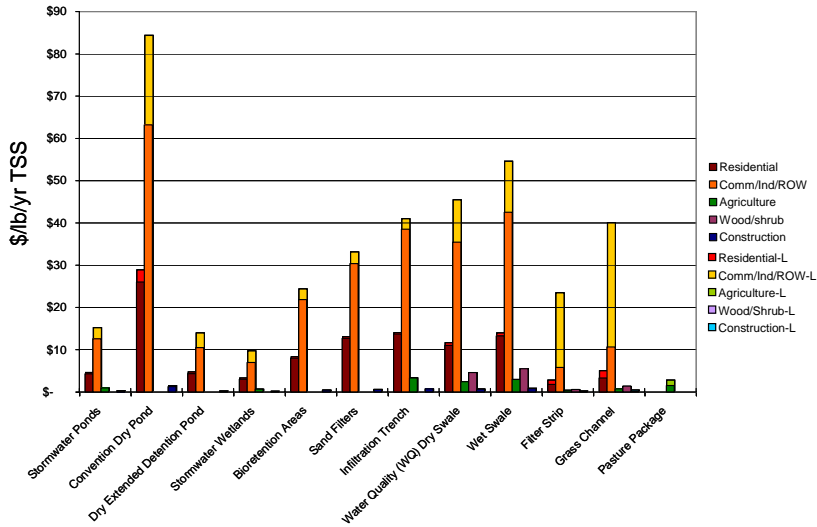
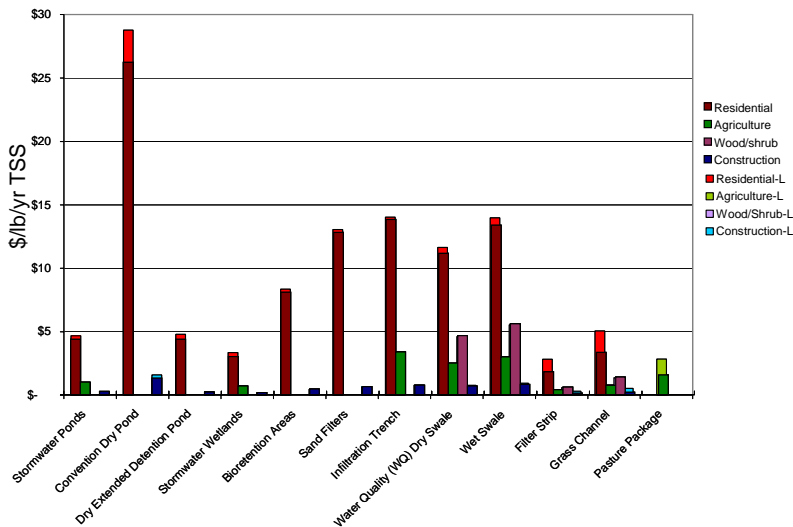


EXHIBIT 30
Cost-Effectiveness Results for TSS: View #2

This chart shows the results presented in View #1 without commercial BMPs so the other combinations can be seen more clearly—the “L” series includes land costs. All options on agricultural land are less expensive than all residential options except filter strips. It is noted that construction-based BMPs are the most cost-effective of all on a unit cost basis; however, these may not be a significant source of credits for owners of other land uses because the baseline assessment concluded that construction sources would have to install significant controls for their own compliance and might not generate extra reductions that would be creditable/sellable.



Sediment Credit Trading Opportunities

Agricultural Source TSS Credit Trading Opportunities

Discussion. The Beaver Creek Watershed Restoration Plan identified a 40 percent reduction target for agricultural sources. However, there are few mechanisms to force achieving this goal. Even where reductions could be made on a voluntary basis, fairness and the mathematical integrity of the 40 percent reduction goal suggest establishing a policy requirement that the 40 percent target be achieved before credits could be generated for use by an entity with a regulatory requirement, such as would exist for urban sources falling under the stormwater ordinance's provisions: Mathematically, agricultural sources cannot sell credits for reductions up to the 40 percent to another source that will count the credit toward its own reduction and have the agricultural sector still collectively achieve its 40 percent reduction target. Therefore, the final trading framework will need to address how a 40 percent reduction requirement (or other baseline) is applied to agriculturalists that have already implemented one or more BMPs, compared to agriculturalists that have no BMPs by establishing rules for calculating baselines for individual sites so as to not unduly penalize good stewards and overly reward laggards.

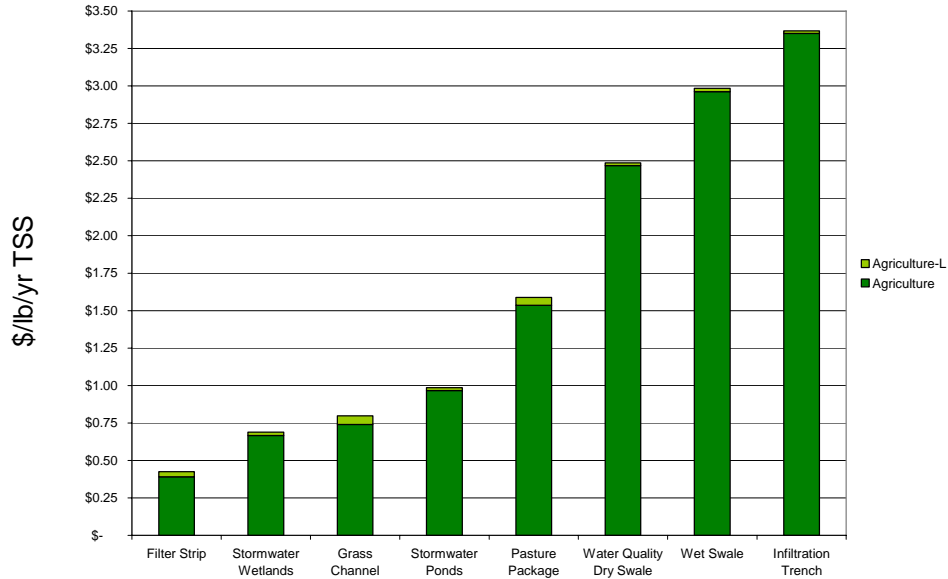
Agricultural sources could be an important source of credit supply. The preliminary market assessment showed that agricultural sources were estimated at 31 percent of the total TSS load today, with their contribution decreasing to 21 percent by 2030 as land is converted to other uses. It was estimated that the agricultural sector could comply with the 40 percent TSS reduction target if currently installed BMPs were maintained and additional BMPs were placed on 15 percent of the total agricultural acreage. This would appear to indicate additional capacity for the agricultural sector to create credits even as it complies with the 40 percent sector reduction goal, potentially generating up to 1,000 tons of reduction annually. This potential supply compares favorably with an estimated maximum urban sector demand of 1,600 tons of TSS per year, without considering any trading ratios, which would likely reduce the creditable supply.

It also appears that agricultural credits could be more cost-effective than urban source controls, on average, assuming trading ratios were not so high as to diminish the cost-effectiveness advantage. Agricultural TSS reductions were estimated to cost between \$0.50 and \$3.25 per pound per year as shown in Exhibit 31, compared to urban TSS reductions costing between \$2.50 and \$30 per pound per year.

Conclusion. Under these circumstances, it seems most likely that agricultural sources would participate in a credit market only as sellers, rather than buyers, unless the 40 percent reduction requirement was to be strictly enforced. Therefore, the market framework needs to accommodate agricultural credit sellers on a policy and logistical basis, especially where credit sellers are geographically dispersed in the watershed.

EXHIBIT 31
Cost-Effectiveness Results for TSS: Agricultural BMPs

This chart shows the agricultural BMPs only, ordered from most to least cost-effective—the “L” series includes land costs. This shows that there are some relative cost differences among this category that are not as apparent in the other views.



Construction Source TSS Credit Trading Opportunities

Discussion. The Beaver Creek Watershed Restoration Plan calls for a 70 percent reduction of TSS from construction sources. This is an important slice of the loading pie, accounting for approximately 40 percent of the total load over the 2008 to 2030 period. The preliminary market assessment estimated that construction sources would need to place BMPs on 90 percent of ongoing construction acreage in order to meet the reduction target.

Mathematically, this leaves little room for doing better than required and generating credits for sale, and instead suggests that construction sources could be significant buyers. However both the demand-supply analysis and the cost-effectiveness analysis indicate that, to the contrary, construction sources would be most likely to satisfy their requirements on-site. First, the potential TSS credit demand from construction sources could be as high as 3,400 tons per year, compared to a practical case supply of 1,500 tons per year from other sources. More importantly however, the cost-effectiveness analysis estimated that construction BMPs are among the least expensive on a \$/lb/yr basis: only a few agricultural and wood-shrub BMPs are less expensive. Thus, even if credits were available in sufficient supply, the economic analysis indicates construction sources would not find others’ credit prices attractive.

Furthermore, construction projects disturbing more than one acre will have to also comply with the CGP, in addition to the county's ordinance. According to EPA guidance, construction stormwater permits involved in a trading program would have to have numeric effluent limits, additional monitoring, and a generally higher level of reporting than necessary if not involved in trading. This would be a significant disincentive for any source trying to beat the 90% reduction target to become a seller. And as noted above, the economics indicate construction sources would more likely comply on-site than seek off-site credits.

Conclusion. It is not expected that construction sources would be a significant participant in the credit market, either by number of participants or credit volume. In addition, it would be difficult to meet the overall targets for sediment reduction within the watershed without construction sources meeting the maximum potential for sediment removal or containment. Therefore, the trading framework proposed for the near term does not include construction sites.

Urban Source TSS Credit Trading Opportunities

Discussion. The Beaver Creek Watershed Restoration Plan calls for a reduction of 20 percent in TSS from urban sources. While this seems moderate, practical mechanisms only exist to secure reductions from new or changing sources—it is very difficult to secure reductions from retrofitting or otherwise changing land use management at existing urban sources. The preliminary market analysis showed that new development controls alone would not be sufficient for urban sources to meet their target on their own; additional retrofits on 40 percent of the existing urban area would be needed to meet the target. Given the difficulty in requiring retrofits, or even incentivizing them—as retrofits tend to be more expensive on a \$/lb/yr basis than controls on new development, or than controls on some other sources—it appears that leveraging requirements on new development and redevelopment will be the only way Knox County can achieve this target.

With respect to sediment, the preliminary demand-supply analysis indicated that urban sources would have to rely on urban controls for a significant proportion but not necessarily the entirety of their mass load reduction obligation. Thus, the credit framework should be optimized to accommodate unpermitted (non-MS4) urban sources as the primary sediment credit buyers—but also potential sellers, agricultural sources as the primary sellers, and other types of landowners, excluding the construction sector subject to the CGP, as less significant participants.

In the absence of a formal trading program, as described later in this report and as may or may not be adopted in whole or in part, the ordinance recognizes that some potentially meritorious projects may have difficulty meeting one or more criteria and it specifically allows for “alternative approaches” to meet the channel protection volume requirement.³² The alternative approaches are not specified in the ordinance but must provide “adequate channel protection from erosion”.

With respect to sediment, the preliminary demand-supply analysis indicated that urban sources would have to rely on urban controls—whether they be satisfying requirements on-site or generating credits from urban controls beyond the 80 percent reduction target—for a significant proportion but not necessarily the entirety of their mass load reduction obligation. These observations³³ are summarized below.

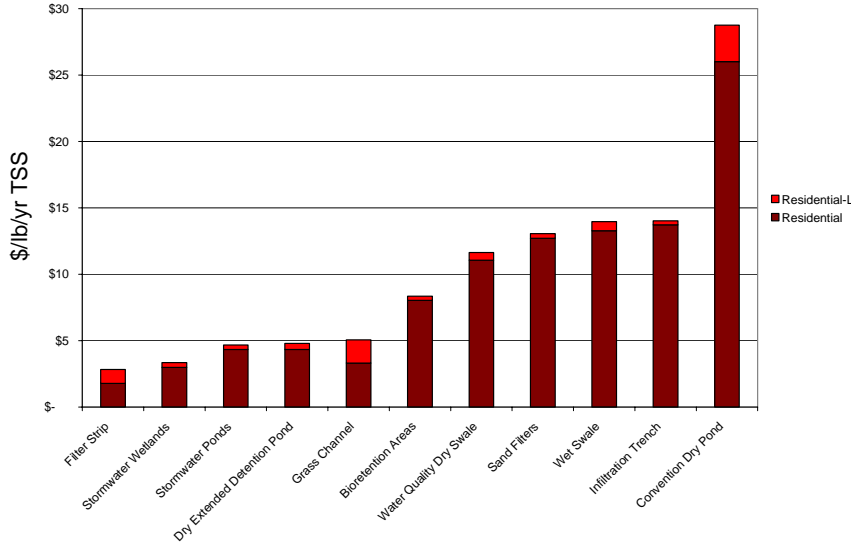
- Urban sources are estimated to grow from 22 percent to 32 percent of the total load from 2008 to 2030.
- Neither point sources nor construction sources are believed to be a significant source of credits for urban compliance.
- Agricultural sources, at 31 percent to 21 percent of the total load from 2008 to 2030, would first likely have to meet a 40 percent reduction target before they could generate credits, and some wood/shrub areas at only 6 percent to 3 percent of the total load from 2008 to 2030.
- The agricultural sources could generate 1,000 pounds per year with BMPs on 50 percent of the acreage.
- Urban sources would need approximately 750 pounds per year, but that assumes all new and redevelopment can meet the 80 percent target on site.
- Urban sources could generate credits themselves and reduce their sector demand to the extent they could beat the 80 percent target, which may be feasible by using one of the BMPs with a 90 percent control efficiency or by using multiple BMPs together.

Also, the cost-effectiveness analysis estimated that urban BMPs were generally less cost-effective than agricultural BMPs, as noted in the agricultural source market assessment presented above. But, potentially importantly for optimizing control choices on-site and fostering an urban-to-urban source credit market, there are cost differentials among urban BMPs: for example, five of the 11 came in under \$5/lb/yr while five came in over \$10/lb/yr.³⁴ Because of the interrelationship of TSS and flow control requirements under the stormwater ordinance, urban-urban trades may be even more important if agricultural BMPs are less able to satisfy the other integrated site design requirements identified earlier, or if it is more difficult to calculate those benefits.

Conclusion. For these reasons, the credit framework should be optimized to accommodate unpermitted urban sources as the primary sediment credit buyers—but also potential sellers, agricultural sources as the primary sellers, and other landowners (excluding CGP-covered construction sites) as less significant participants. Given apparent lack of significant excess capacity for the agricultural sector to supply credits, the framework should also accommodate third party participants that would be in a good position to generate cost-effective credits through stand-alone special projects or piggy-backing on projects implemented for other, non-conflicting purposes.

EXHIBIT 32
Cost-Effectiveness Results for TSS: Residential BMPs

This chart shows the residential BMPs only, ordered from most to least cost-effective category—the “L” series includes land costs. Although residential land owners might seek TSS credits from agricultural sources, this chart illustrates that they might be able to lower their compliance costs through BMP choice. If their own BMP options are limited, this chart illustrates which BMPs on someone else’s residential property are likely to produce the most cost-effective credits.



Flow Credit Trading Opportunities

With respect to flow credits, a quantitative, watershed-wide supply-demand assessment is outside the scope of this study, however several site-specific examples were presented in Technical Memos prepared under this study.³⁵ These examples illustrated situations where CPv requirements might be met for a master development collectively (similar to a regional BMP(s) concept) rather than for each parcel individually, and also where a developer in a defined drainage area might meet his requirements by installing or purchasing credits from controls off-site sufficient to meet the on-site compliance shortfall.³⁶ These examples addressed situations where new development comes under the stormwater ordinance requirements, but also identified situations that might generate credits where the project sponsor is not subject to the stormwater ordinance, including for example where a landowner with private funds, or the County with public funds implements stormwater “retrofit” projects that would not otherwise be required.

As only urban sources will be held to flow-based criteria—as the TMDL and watershed restoration plan don’t set specific flow control targets for other sectors—the credit framework for flow reduction will need to focus on urban sources as buyers of any flow-based credits. To the extent urban sources subject to the ordinance can create flow credits, the framework should encourage and facilitate such transactions. Until otherwise proven, however, it should be presumed that flow reduction credits may be needed from sources not subject to the ordinance, including those in the urban and agricultural sector, as well as third parties and so the framework should encourage and accommodate these participants as well.

Phosphorus Credit Trading Opportunities for Point Sources

The two point sources in the watershed—Hallsdale-Powell Utility District (HPUD) and West Knox Utility District (WKUD)—currently face no requirements to reduce sediment or nutrient loadings below current permitted levels that cannot be readily accomplished with existing treatment technologies. For this reason, they do not appear to be a potential buyer of credits in the near term.

A review of the supply-demand analysis indicates that a point-point trading program would be a more feasible strategy than point-nonpoint source trading, should the WWTPs eventually be interested in phosphorus trading. Since the WWTPs are estimated to discharge 96 percent of the current and future phosphorus load, a meaningful point-nonpoint trading program is unlikely due to insufficient nonpoint source credit supply potential. Therefore, the framework design will not consider point-nonpoint source trading involving WWTPs as significant buyers for either phosphorus or TSS. It is not expected that the WWTPs would ever have TSS limits that would create a need for TSS credit trading. Exhibits 33 and 34 illustrate the relative potential demand for and supply of phosphorus credits that forms the basis for this conclusion (the methodology for the assessment is the same as for sediment, described in association with Exhibit 27.)

EXHIBIT 33
Distribution of Maximum Potential TP Demand:
Total = 51,100 lbs/yr

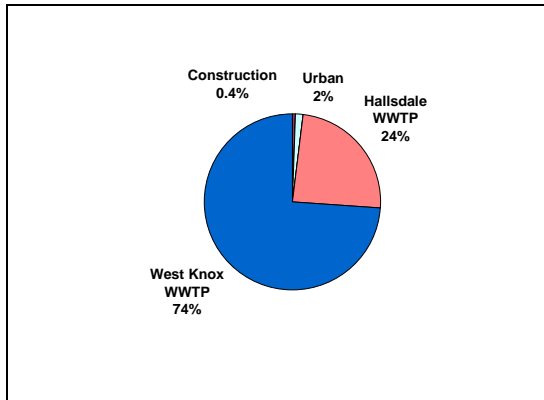
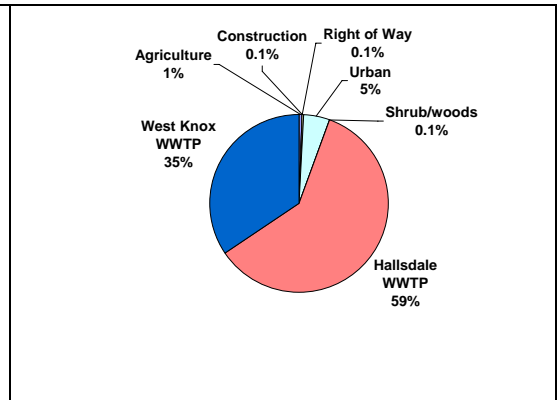


EXHIBIT 34
Distribution of Maximum Potential TP Supply:
Total = 22,890 lbs/yr



Without wasteload allocations (WLAs), comparable mass-based compliance targets would need to be established to support trading. This would necessitate applying a feasible method of establishing a mass-based trading baseline from concentration-based effluent limits were applied. Such a method was not pursued under this study because it is not needed in the near term for point sources to participate in the proposed trading program.

Instead, under the program proposed for Beaver Creek, a WWTP could make a financial (or in-kind) investment to a credit bank or individual's credit project and earmark its proportionate share of the credits as its contribution to the watershed restoration plan. It could then receive proportionate, or otherwise negotiated revenues from credit sales, bank the credits, or retire them as a contribution to watershed enhancement. In this scenario, the WWTP would never claim the credits in relation to its own permit limits. This scenario appears the most likely avenue for point source participation in the predominantly nonpoint-nonpoint market being designed for Beaver Creek in the near term, and could easily be accommodated under the trading framework proposed in this report.

WHAT TYPE OF CREDIT MARKET WILL BEST SERVE THE TRADING OPPORTUNITIES IDENTIFIED IN BEAVER CREEK?

A credit trading framework for Knox County should initially focus on the priorities summarized below so as to tailor a program to the best opportunities without excluding projects that would advance water quality protection and watershed restoration goals.

- Primarily, support sediment and flow reduction credit trading driven by urban sources' need to comply with the stormwater ordinance criteria.
 - Assume entities subject to the ordinance will be the preponderance of credit purchasers.
 - Assume urban, agricultural, and not for-profit entities will constitute the source of credit supply.
 - Assume baselines for credit generation from sources without regulatory criteria will need to be established and consistent with TMDL goals and general considerations about equity and fairness.
- Secondly, support phosphorus credit banking and trading to the extent that phosphorus reduction credits and debits can easily be calculated and tracked along side the sediment and flow reduction credit markets and to the extent sufficient participant interest materializes.
 - Assume point sources would provide the primary source of credit demand in the near term exclusively in association with generalized watershed restoration commitments and not at all to apply credits toward their NPDES phosphorus effluent limit. and
 - Assume a phosphorus control requirement would not be added as a fifth criteria to the stormwater ordinance that measures sediment and three flow-related performance criteria.

Proposed Ecological Credit Market Framework: A Centralized Bank and Exchange

Based on these conclusions, a centralized credit bank and exchange, managed initially and likely into the longer term by Knox County, appears to be the best model to efficiently develop and implement a multi-credit, stormwater-focused trading option as an integrated component of the County's stormwater management program and other watershed-related initiatives.

Because the market-based approach is proposed as an expansion of an existing program, it is not necessary to develop the policy and regulatory framework for sediment, flow, and nutrient credit trading from scratch.

As noted earlier, sufficient authority to implement this program already exists within the County’s stormwater ordinance, as it recognized that some may need “alternative approaches” to achieve compliance. Following a first phase implementation period (see “Possible Next Steps” on page 49 of this report), the County may elect to modify the ordinance to better support the final program. Because no point sources are expected to be direct buyers or sellers of credits for compliance purposes, the absence of provisions for trading in the TSS TMDL or the Beaver Creek WRP was not deemed problematic.

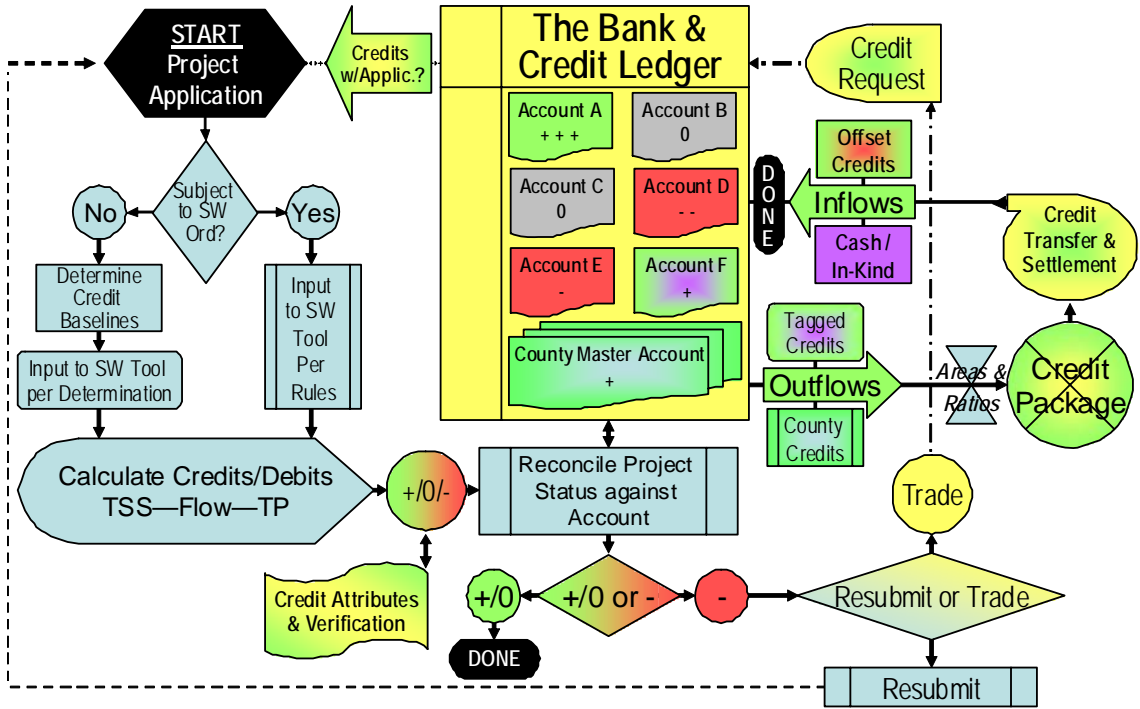
The proposed trading prototype graphically represented in Exhibit 35 (below) is designed to be entirely integrated within the existing policy and regulatory structure of the stormwater management program, with some enhancements and modifications. Extensive administrative procedures that establish responsibilities of project proponents and the County from initial project application, through approvals, and into the longer term, including operation and maintenance of BMPs, already exist. As such, the proposed trading framework described in this report does not develop or address such oversight and enforcement mechanisms in detail. These are well documented in Volume 1, Administration and Procedures, of the Knox County Tennessee Stormwater Management Manual.³⁷ It is assumed the County will apply the same level of review, approval, and oversight to all BMPs implemented to comply with the ordinance, irrespective of whether they represent a trade or not.

Highlights of the Volume 1 coverage that address issues related to credit assurances include, but are not limited to, the following sections:

- 2.4 Enforcement—Notice of Violation, Civil Penalties and Damage Assessments, and Corrective Measures;
- 4.4 The Stormwater Management Plan (details how ordinance will be satisfied);
- 4.5 Operations and Maintenance Plan—Requirements;
- 4.8 As-Built Certifications;
- 4.9 Inspections and Maintenance During Construction—Permittee Responsibilities, County Authority and Responsibilities, Inspections, and Corrective Actions; and
- Appendix F – Covenants for Permanent Maintenance of Stormwater Facilities and Best Management Practices.

The proposed trading framework, exclusive of most of the preexisting programmatic mechanisms addressed above, is described in more detail in the following pages. The Knox County Stormwater Quality Site Development Review and Credit Evaluation Tool Design Criteria, referenced in the framework and described later in this report, will be used whether or not a project generates or buys credits.

EXHIBIT 35
Graphic Depiction of Proposed Credit Trading Framework for Beaver Creek Watershed



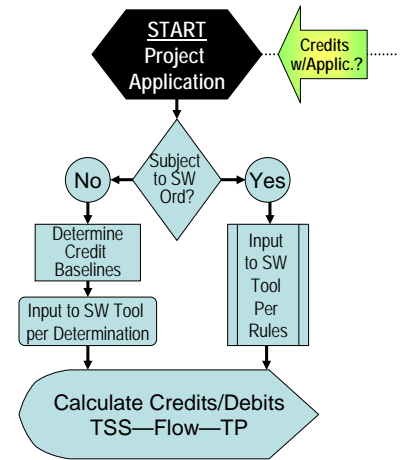
Project Application through Credit/Debit Determination

The process would start with an application for a project that disturbs and/or restores land areas upland or adjacent to waterbodies, as indicated by the black hexagon in Exhibit 36. The application may or may not already include extra credits, as indicated by the green and yellow arrow.

The first determination is whether the project falls under the stormwater ordinance:

- If **YES**, the project data are input into an evaluation tool (see following section on Site Development Review and Credit Evaluation Tool), if they have not already been submitted in the tool (electronically), or in hard copy outputs. For a project subject to the ordinance, important requirements, credit baselines, and other considerations consistent with the ordinance will be known and preset as fixed or variable assumptions in the tool. The tool will calculate compliance and document one of three outcomes for the applicant: credits (+), debits (-), or exact compliance (0) for the three parameters, and the project sponsor could end up being a seller, buyer, or neutral, respectively.
- If **NO**, the project applicant would be considered a seller/banker and a baseline appropriate to the project, land use, and proponent category would need to be determined per pre-established policies, guidelines, or negotiated on a case by case basis. The same tool would be used, with modified baselines to calculate credits.

EXHIBIT 36
Calculation of Credits/Debits



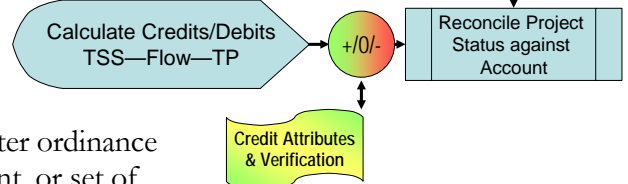
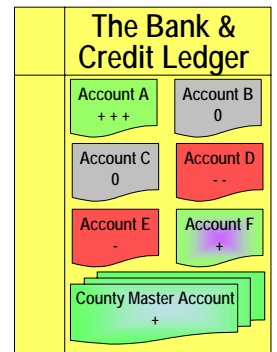
Documenting Credit Attributes and Project Status v. Accounts

The tool would calculate the credits/debits, as represented by the green and red circle in Exhibit 37. Important credit attributes would be inputs to the tool, or calculated by it, and “attached” to the credit data, as represented in the green and yellow flag. These attributes will be verified at the time of project approval and credit submission. Examples of such information include, but are not limited to: watershed and subwatershed code; BMP type(s) and sizes; and credit life. Additionally, information regarding ongoing maintenance (if applicable), periodic inspections (if required), and credit verification/re-certification could also be attached to the credits at this stage, or later in the process.

The “+ / 0 / -“ credit status results would be reconciled against The Bank and Credit Ledger, as represented by the yellow box, which the County would maintain. Individual entities (developers, non-profits, individuals) participating in the program or otherwise subject to the stormwater ordinance would need to maintain or establish an account, or set of accounts, accounts subject to program rules, as represented by the “folder” shapes in green, red, and grey (indicating positive, negative, and zero balances).

The County would maintain a Master Account, as represented by the labeled green and blue account folder. In this account, the County could hold credits on a short-term basis, for example to use that account to facilitate transactions between other participants that are not direct, serving a clearinghouse function. It also could hold credits for a longer term, including retiring them completely. Relative to this Master Account, the County would not buy or sell credits against its own compliance requirements under its MS4 permit.

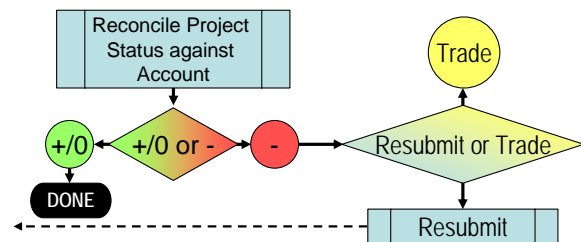
EXHIBIT 37
Documenting Credits in
The Bank’s Accounts



Project Status Reconciliation Results

The results of the reconciliation will be one of two situations, as depicted in Exhibit 38.

EXHIBIT 38
Account Reconciliation



1. The applicant needs no credits, has sufficient credits in his account, or generates extra credits, as represented by the green circle with “+ / 0”. In these situations, the applicant is compliant with the ordinance, or has simply generated credits if not covered by the ordinance, and his account is updated. This project sponsor is **DONE**, with the process, as indicated in the black oval, until such time as he may sell or otherwise need any extra credits generated.
2. The applicant does not meet some or all of his requirements for TSS, Flow, or TP, and needs credits for compliance, as represented by the red circle with “-”. At this juncture, he may revise and resubmit his

application, as represented by the yellow and blue diamond. If he resubmits, as represented by the blue rectangle, he re-enters the application process described above, perhaps with different and/or additional BMPs, or “tagged” credits (see definition below). Or, he may enter the trading program facilitated by the County, as represented by the yellow circle.

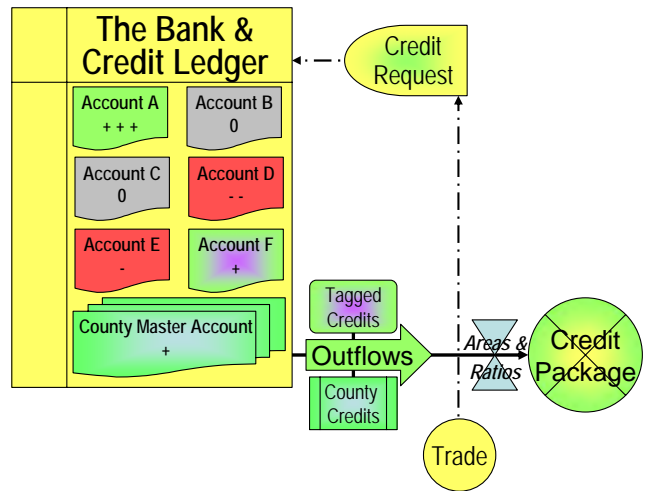
Requesting Credits and Trading

If the project applicant wishes to trade for compliance, he would submit a request to the County’s Bank and Credit Ledger, as represented by the yellow and green bullet in Exhibit 39. The County will evaluate the needs as compared to holdings in individual accounts and its Master Account.

The County would assemble a credit package including one or both of two types of credits.

- **“Tagged Credits”** which are still owned by the generator (or subsequent buyer, if allowed), as represented by the green and purple rectangle; and
- **“County Credits”** which the County owns, as represented by the green and blue rectangle. The County may own credits through having previously purchased them from a developer or third-party not subject to the ordinance under a program to seed the Master Account, or as the County may have otherwise acquired in a middleman function specifically for this situation. As noted above, relative to the Master Account and County Credits, as they are termed for convenience, the County would not buy or sell credits against its own compliance requirements under its MS4 permit.

EXHIBIT 39
Credit Requests and Packaging Credits for Sale/Transfer



Tagged, County, and other credits assembled into a credit package, as represented by the green and yellow circle, would constitute outflows from the Bank and Exchange, as represented by the green arrow. During assembly of the credit package, any necessary consideration will be given to restrictions on trading areas and need for trading ratios so that the proper type and number of credits are packaged for compliance, as represented by the blue hourglass located between the outflows arrow and the credit package symbol.

Credit Transfer, Settlement, and Reconciliation

Once the Credit Package is ready, it would go through a transfer and settlement process in which the credits will be debited from the seller's account and deposited into the buyer's account, as represented in Exhibit 40 by the yellow and green ovoid and the "inflows" arrow.

The buyer's newly purchased credits will then offset any shortfall in complying with the ordinance; with the credits, compliance will be reached, as represented by the green and red rectangle. The credits will have been verified prior to deposit into the bank, as depicted in Exhibit 37 and associated narrative.

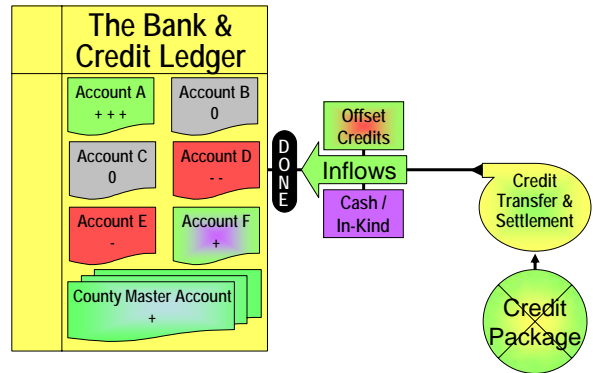
The buyer will remit cash and/or perhaps in-kind services, depending on the interests of the parties involved, to the County for distribution or directly to the seller if so specified, as represented by the purple rectangle.

At that point, the project applicant is DONE, as represented by the black oval.

The process will be completed as follows:

- The County will update its own and others' accounts as needed to reflect the completed transaction.
- Each individual account will show a cumulative record of stormwater compliance, trading, and banking activity.
- The County's cumulative records of individual accounts and its own will provide a way to track net progress toward TMDL and other goals, including measuring the results of stormwater ordinance implementation.

EXHIBIT 40
Finalizing Trades



THE KNOX COUNTY STORMWATER QUALITY SITE DEVELOPMENT REVIEW AND CREDIT EVALUATION TOOL

Overview of Tool Development Process

For analytical, educational, and demonstration purposes of this project, a tool was needed to conduct analyses of the credit potential for various development projects to support the pro forma market transactions described in the next section of this report. Additionally, Knox County was interested in a tool that would simultaneously support implementation of Knox County's stormwater ordinance by providing developers and planners with a way to readily evaluate the compliance of every project subject to the ordinance with the new requirements.

The project team worked with Knox County to develop a list of minimum required functions and features to support this project as well as ordinance implementation. These design criteria are presented in Exhibit 41.

EXHIBIT 41

Knox County Stormwater Quality Site Development Review and Credit Evaluation Tool Design Criteria

These describe the desired features and functionality, as well as other considerations.

- Define site characteristics and drainage areas
- Select/apply one or more pre-defined BMPs by drainage area
- Set TSS and TP baselines for ordinance compliance determination and trading purposes
- Calculate performance against those baselines
- Inputs by drainage area; summary info by drainage area and for whole site
- WQv (Water Quality Volume) computations meet Knox County's requirements
- Provide "Stormwater Better Site Design Credits" for WQv using non-structural best practices
- Expandable platform with the ability to add CPv (Channel Protection Volume) and other Pollutants of Concern in future (CPv was added in May 2009 in a separately-funded effort)
- Analyze multiple BMPs
- Analyze Site-Design scenarios with ease
- Build a new tool or modify existing tool within project budget
- Public platform (no fees or intellectual property issues)

The project team performed a preliminary assessment of several tool platforms as candidates for this application, considering the design criteria outlined in Exhibit 41, and several were subjected to a more detailed evaluation of their capabilities and other attributes against the design criteria. The result of this process was the selection of the Georgia Stormwater Design Manual's Site Development Review Tool as the platform that would be modified and enhanced for application in this project, and for Knox County's future use.

Modification of the Georgia Tool for Use in Knox County

The Georgia Stormwater Design Manual's Site Development Review Tool³⁸ is an automated Excel spreadsheet tool that was developed by the Metropolitan North Georgia Water Planning District to facilitate the evaluation of development projects in accordance with recommendations in the Georgia Stormwater Management Manual. This tool allows both developers and local government review staff to quickly evaluate the water quality performance of stormwater management plans for proposed land development projects.

Despite its ready applicability, the selected platform had to be customized to meet all the design criteria and provide the functionality needed to support the pro formas under this project and implementation of Knox County's stormwater ordinance. This customization involved several revisions and enhancements to the data inputs, mathematical formulas, user inputs and interface, and result outputs.

A summary list of the major revisions and enhancements made to the Georgia tool for use in Knox County is presented below.

- **Credit Baseline by Project Type**—A new feature was added to identify Project Type. This was necessary to enable the user to establish the proper credit baselines for the calculations by land use type for four categories: New Development; Re-Development, Agricultural Restoration; or Non-Agricultural Restoration.

- **BMPs Tailored for Knox County**—The list of best management practices included in the tool was changed to match those listed and approved in the Knox County Stormwater Manual.
- **Pollutant Loads Against Baselines and Debit/Credit Calculations and Displays**—Pollutant loading calculations against the credit baselines were added, along with graphic displays of the results by drainage area and for the entire site against the applicable baseline. A calculation of the total number of debits or credits was also added, along with a graphic result display.
- **Total Phosphorus (TP) Added**—Calculations and displays for TP site review and debit/credit analyses were added (the original platform only displayed results for TSS).
- **Channel Protection Volume (CPv) Added**—Calculations and displays for CPv site review and ordinance compliance analysis were added under a separately-funded effort (the original platform only included WQv).

An instruction and guidance manual³⁹ for the Knox County Stormwater Quality Site Development Review and Credit Evaluation Tool (the Tool) was prepared as part of this project to facilitate its use by the County and those subject to the ordinance, and those that may engage in water quality credit trading in the future.

Tool Inputs and Outputs

Exhibit 42 provides a narrative summary of the data entered into and calculated by the Tool. Exhibits 43 and 44 (below) present some screen captures from the tool corresponding to one of the pro formas described in the next section.

EXHIBIT 42

Major Components: Knox County Stormwater Quality Site Development Review and Credit Evaluation Tool

<ul style="list-style-type: none"> • Site Summary <ul style="list-style-type: none"> – Location – Predevelopment Use – Development Scenarios, including Debit, Neutral, and Credit Scenarios • Site Plan/Map • Land Use Distribution <ul style="list-style-type: none"> – Number of drainage areas – Total acreage – Impervious Acres/% – Disturbed Pervious Acres/% – Natural Conservation Acres/%⁴⁰ – Percent Imperviousness 	<ul style="list-style-type: none"> • Structural Controls (BMPs) Used • TSS and TP Compliance <ul style="list-style-type: none"> – Control Baseline – Reduction by Drainage Area – Total Load Comparison versus Baseline – Credit/Debit Summary • Water Quality Volume <ul style="list-style-type: none"> – Without Credits – With Credits from Non-Structural Controls • Channel Protection Volume (added with funding outside this grant)
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EXHIBIT 43
The Tool's Summary of Site and Structural Control Information by Scenario: HPUD's New Buildings

<i>Land Use Distribution for All Scenarios</i>		<i>Neutral Scenario</i>																																																																																							
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Education and Outreach Plan for the Tool

It is expected that Knox County will use the Stormwater Quality Site Development Review and Credit Evaluation Tool the Tool in two main ways:

- The Tool will help Knox County staff and project applicants determine compliance with stormwater ordinance, irrespective of any credit trading; and
- The Tool will assist in determination of debit/credit positions for proposed site BMPs by County plan reviewers, project applicants subject to ordinance, and others not subject to ordinance that may create bankable or tradable credits.

To advance these uses, a series of educational and outreach activities have been recommended to support the introduction and implementation of the Tool to its target audience. These are listed in Exhibit 45.

EXHIBIT 44

The Tool's Load Reduction Summary and Credit/Debit Results: HPUD's New Buildings

See the next section for a description of HPUD's site and the other pro forma development sites.



EXHIBIT 45
Recommended Activities to Support Tool Utilization

These could be sponsored by Knox County and/or the Beaver Creek Task Force.

Educational and Outreach Objectives	Corresponding Activities
Train county, developers, educators and other professionals on Tool’s use, input requirements, and function.	<ul style="list-style-type: none"> • Present Pro Forma Market Transactions and analyses of different types of development projects to estimate sediment and nutrients loadings relative to BMP implementation
Engage stakeholders in the comprehensive experience of stormwater science including pollution control options and watershed management.	<ul style="list-style-type: none"> • Present results of pilot program to participants, interested stakeholders, and local news outlets
Allow for communication and collaboration among those whose input and buy-in are needed for program success.	<ul style="list-style-type: none"> • Communicate pilot program updates regularly to Hallsdale-Powell and West Knox Utility districts
Allow stakeholders the opportunity to offer information and to provide input related to how the pilot program is structured or managed.	<ul style="list-style-type: none"> • Include basic information in Newspaper Articles • Post and update information on BCTF Website • Present Trading 101 Information to promote awareness and interest • Make Presentations at civic and community meetings and symposia
Provide for one-way communication to create general awareness and express opinion.	<ul style="list-style-type: none"> • Include basic information in Newspaper Articles • Make Presentation at civic and community meetings and symposia

ILLUSTRATING CREDIT TRADING OPPORTUNITIES WITH PRO FORMA PROJECTS AND A “MINI-MARKET”

Pro forma projects help illustrate how different types of development projects may fare in complying with the Knox County stormwater ordinance with respect to their individual and collective potential for needing or creating TSS and TP reduction credits that might be bankable or tradable under the proposed credit market framework.⁴¹ “Pro forma” projects are based on real data provided by the site owners, including input on already selected and/or potentially feasible BMPs, however some or all of the credit/debit scenarios presented have not yet, and may never occur. Due to the timing of the implementation of the new stormwater ordinance, the planning review process, and this project’s delivery schedule, it was not possible to include real credit transactions in this report.⁴²

The Project Team worked with the Beaver Creek Task Force, Knox County, and other stakeholders to identify candidate pro forma sites and used the Site Development Review and Credit Evaluation Tool⁴³ described above to estimate TSS and TP loadings under various assumptions about what BMPs could be implemented at the sites. Debits and credits were calculated by comparing post-development loadings at individual sites to compliance baselines established by the ordinance. The range of the collective results illustrates the different market possibilities associated with the selected sites, e.g., demand greater than supply, demand less than supply, and demand and supply in balance. The site owners’ agreement to include their projects in this study does not reflect any promise or obligations to buy or sell credits.

Summary Descriptions of the Pro Forma Sites

A brief description of each of the five pro forma sites, with respect to their location in the watershed, current land use, and development plans follows.

- **Roland Farm:** This 250 acre site is in the Solway community of Knox County. Beaver Creek borders the east, south, and west side of the property. It is currently pasture land and used as a cattle farm. A pasture renovation plan was proposed under which selected best management practices would be installed on approximately 180 acres. The acreage distribution is 100 percent disturbed pervious.
- **Hardin Valley Crown Center:** The 44.5 acre site is situated on Hardin Valley Road, just east of Pellissippi Parkway. It was a residential property containing a single house with a combination of pasture and forested land. The landowner has proposed site plans that would convert 12.72 acres of the property into a small commercial complex, with five lots as follows: one commercial bank, one strip mall center, one restaurant and one office building, and two empty lots. The acreage distribution breaks down as follows: 32 percent impervious; 68 percent disturbed pervious; and 0 percent natural conservation.
- **Hallsdale-Powell Utility District's (HPUD) new building:** The project is on Cunningham Road in Knox County, at the lower northeast section of Beaver Creek Watershed. The main stem of Beaver Creek is north of the site and a tributary of Beaver Creek, Hines Branch, is to the south. The site is currently the main administration building area and operations facility for the Utility, with ground conditions for the site of mostly gravel parking and storage areas with minimal asphalt surfaces for customer access. The redevelopment will consist of the construction of a new administrative office and operations facility for HPUD. The acreage distribution breaks down as follows: 54 percent impervious; 41 percent disturbed pervious; and 5 percent natural conservation.
- **Norris Freeway Commercial Development:** The 53.4 acre site is located north of Norris Freeway just west of the intersection with Emory Road in the Halls area of Knox County. Beaver Creek bisects the property and is a wet weather conveyance for most of its length. Approximately 10 acres had been platted as a residential subdivision and roads and utilities were installed on this acreage, but no building permits were ever requested/ issued. The remainder of the site was pasture in good hydrologic condition. The acreage distribution breaks down as follows: 73 percent impervious; 14 percent disturbed pervious; and 13 percent natural conservation.
- **Rosewood Estates:** The 9.45 acre site is located in the Gibbs area of Knox County west of Tazewell Pike on the east side of Karnes Drive. Its topography is gently rolling, and its soils are silt loam or loam. Beaver Creek runs through portions of the property. The site was used as a hayfield prior to being subdivided into 24 single family lots, with five new drainage areas. The acreage distribution breaks down as follows: 8.5 percent impervious; 72 percent disturbed pervious; and 19.5 percent natural conservation.

Pro Forma Debit, Neutral, and Credit BMP Scenarios

The project team developed up to three scenarios for each of the pro forma sites using site plans provided by the Knox County Engineer or site owner’s Project Engineer, along with other information as available. Most of the plans had been developed before implementation of the new stormwater ordinance. Not surprisingly then, with the exception of Roland Farm, the existing plans produced the “debit” scenarios, in which the proposed BMPs did not provide sufficient sediment control to comply with the ordinance. Using best professional judgment, the project team then developed a “neutral” and “credit” scenario for each site by sequentially adding and or substituting BMPs compared to the debit scenario.

Exhibit 46 identifies the BMPs assumed for each site under the three scenarios and the percent reduction of sediment (total suspended solids, or TSS) achieved.

EXHIBIT 46 Pro Forma Scenario BMPs and Estimated TSS Control

The new stormwater ordinance requires 80% reduction in TSS from non-agricultural properties.

	Debit Scenario	Neutral Scenario	Credit Scenario
Roland Farm			
BMPs (#)	NA	NA	Pasture Package (1)
TSS Compliance: <i>Baseline = 40%</i>	NA	NA	87%
Hardin Valley Crown Center			
TSS Compliance: <i>Baseline = 80%</i>	60%	80%	85%
TSS Credits or (Debits) <i>lb/yr</i>	(280)	0	75
Hallsdale-Powell Utility District’s (HPUD) new building			
BMPs (#)	Stormwater Ponds (2) Bioretention Areas (2) Grassed Channel (1) Porous Pavement* (1)	Stormwater Ponds (2) Dry Extended Detention Pond (1) Bioretention Areas (2) Wet Swale (1) Porous Pavement* (1)	Stormwater Ponds (3) Bioretention Areas (2) Grassed Channel (1) Porous Pavement* (1)
TSS Compliance: <i>Baseline = 80%</i>	75%	80%	84%
Norris Freeway Commercial Development			
BMPs (#)	Dry Extended Detention Pond (2)	Dry Extended Detention Pond (1) Stormwater Pond (1) Water Quality Dry Swale (1)	Stormwater Pond (2)
TSS Compliance: <i>Baseline = 80%</i>	64%	80%	81%
Rosewood Estates			
BMPs (#)	Dry Extended Detention Pond (2)	Stormwater Pond (2) Wet Swale (1) Filter Strip (1)	Stormwater Pond (2) Wet Swale (2)
TSS Compliance: <i>Baseline = 80%</i>	51%	80%	83%
*Note: Porous pavement is not considered a recommended practice by Knox County for reducing pollutants due to its high clogging potential. It is an application to reduce the effective impervious area on a site which reduces the water quality volume that must be treated. Currently, the Credit Evaluation Tool does not account for this water quality volume reduction.			

Individual and Collective Pro Forma TSS Debit/Credit Results

Under each of the scenarios for the pro formas, a specific number of debits or credits are calculated by the Tool relative to the compliance baseline. The neutral scenarios were purposefully designed to get as close to zero debits/credits as possible. Exhibit 47 summarizes the results for each individual site, and tallies the collective results to illustrate a situation in which a “mini” credit market exists with just these five sites.

EXHIBIT 47
Credit/Debit Scenario Matrix for the “Mini” TSS Market

Site Name	Debit TSS lb/yr	Neutral TSS lb/yr	Credit TSS lb/yr
Rowland Farm	NA	NA	50,760
Hardin Valley Crown Center	-280	0	75
HPUD's new building	-60	-5	50
Norris Freeway Commercial Development	-954	3	50
Rosewood Estates	-592	-3	52
Max of Market	-1,886	-5	With Farm: 50,987 Without Farm: 227

As previously concluded, agricultural credits would be an important supply for the urban sector. With Roland Farm credits, all four other land owners could implement their “debit” scenario BMP package and buy 1,886 credits from Roland Farm. Without these credits, in this “mini”-market, only a few trades are possible among the other four pro formas, and most will have at least comply with the ordinance if there is not another source of credits. For example, Hardin Valley could generate 75 credits, sell 60 to HPUD (under its debit scenario) and 3 to Rosewood (under its just-shy-of neutral scenario). There are not enough credits available without the agricultural supply for Hardin, Norris, and/or Rosewood to not at least implement their neutral scenario. These debit/credit balances are further illustrated in Exhibits 48 and 49.

EXHIBIT 48
Pro Forma Debit/Credit Positions with Roland Farm

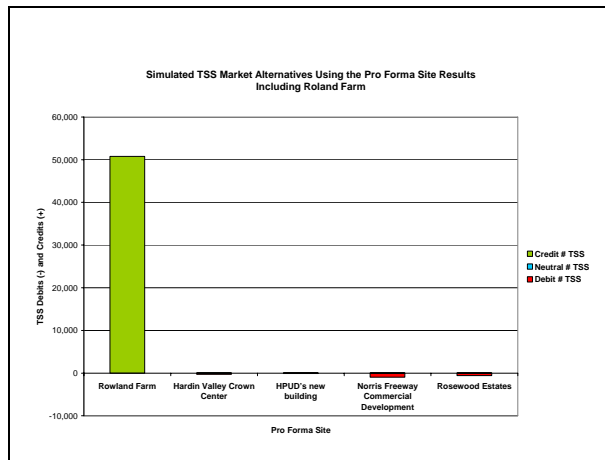
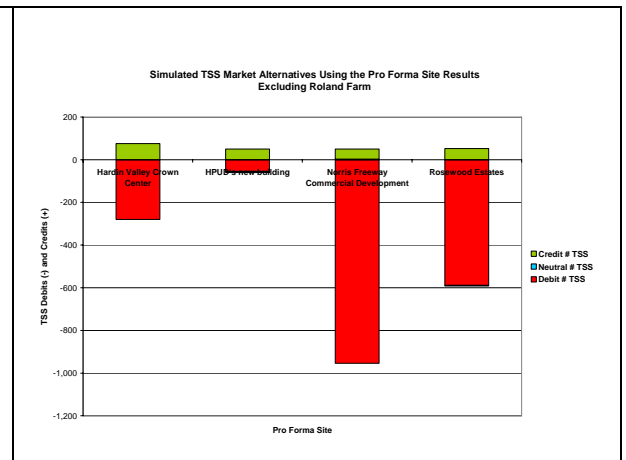


EXHIBIT 49
Pro Forma Debit/Credit Positions w/out Roland Farm



Potential Implications of the Pro Forma Results

Extrapolating these results of the limited pro forma analyses to a larger market presumes the sites, BMP packages, and debit/credit results are representative of other sites in the land use sub-categories represented here. This may or may not be the case. The following observations identify likely similarities and possible differences between the pro forma sites and the larger potential market.

- **Agricultural landowners** should be able to generate significant credits so long as they have not (1) already maxed out their BMP potential, and (2) baselines are set at 40 percent for TSS and 20 percent for TP. With respect to the baselines, the assumptions used here are consistent with the existing watershed plans. It would not be expected that trading policies would establish higher ones; however, a policy decision could also be made to establish lower baselines for agricultural credits than the ones assumed here. This would have the effect of making more of the reductions achieved with agricultural BMPs creditable.
- **Urban landowners** should be able to comply with the TSS targets by implementing multiple BMPs, either separately in different drainage areas, or in series, as illustrated by the pro formas. However, it appears they will have difficulty generating significant supplies of credits under reasonable assumptions about how many and which additional BMPs might be installed above and beyond those assumed for the neutral scenarios. Certainly compared to the potential debit level, individually and collectively, the potential credit supply is less by an order of magnitude.

These observations also support pursuing another component of the proposed trading framework in which the County would facilitate establishing and “stocking” a credit bank with credits from publicly-funded projects and/or solicited credits from privately-funded projects.⁴⁴ Even with agricultural credit supplies—and especially without them if the pro forma and mini-market results are indicative of how an actual market might (not) balance, there appears to be an important role for the County to play in implementing any in-lieu fee and/or credit trading program for TSS (and TP to the extent a market may develop) to help ensure an adequate supply of credits.

Three other factors will influence how credit demand and supply patterns illustrated in the mini-market may develop in a larger market: trading areas, trading ratios, and credit prices.

- **Three trading areas** for TSS were suggested; if implemented this would have the effect of segmenting the total market and limiting demand and supply to potential trading partners within those three areas.⁴⁵ To the extent a trading area had relatively less agricultural land compared to urbanizing land, the supply of agricultural credits might not be as significant as illustrated in the pro formas.

- **Trading ratios**, to the extent they are applied, they will have the effect of reducing the number of available credits.⁴⁶ For example a 2:1 trading ratio would mean that Roland Farm would have to generate two pounds of reduction for every one pound of credit she could sell. Trading ratios would presumably be applied to both agricultural and urban credits, but different ratios could be assigned to BMPs by category and/or BMP type. Thus, trading ratios could reduce the available credits from one source by more or less relative to another, depending on their relative ratios.
- **Effective credit prices**, calculated after the application of any required ratios, will also influence how credit estimated demand and supply are converted into actual trades. Under the proposed trading framework, it was presumed that private sellers participating in a County-facilitated market would set their own prices on a trade by trade basis, and that County-owned credits could be priced on a “lot” or average cost basis (which would provide a more stable and predictable pricing scheme, than pricing by BMP project, for example).⁴⁷

POSSIBLE NEXT STEPS

The proposed credit trading program for Beaver Creek appears feasible for sediment, phosphorus, and, potentially, flow. Implementation would be enhanced by utilization of the proposed framework which would be linked to the new Knox County ordinance review process and may facilitate implementation of the new program for post development stormwater controls on a county-wide basis.

The proposed framework for credit trading and banking is well tailored to the opportunities and challenges faced by the County and other stakeholders in implementing the new stormwater ordinance and otherwise supporting the Beaver Creek Watershed Restoration Plan. Implementing the recommendations could be accomplished in two phases, as described below.

Phase One

Phase One would transition from the demonstration project described in this report to implementation of the ordinance with a credit trading option. This would include deployment of the County’s Stormwater Quality Site Development Review and Credit Evaluation Tool by the County and project applicants. This will entail formally integrating the Tool’s use as part of the project review and approval process, which could not be accomplished during this study, except for the pro formas, due to the timing of the completion of the Tool. The Tool developed for the demonstration phase, as may be modified, provides sufficient outputs to judge project compliance and creditability on an individual project basis. The Tool would need to be enhanced or augmented with a separate tool in order for the County to establish credit accounts for applicants and itself, conduct credit status evaluations against those accounts, entertain credit requests, assemble credit packages, facilitate transactions, and reconcile accounts following credit banking or exchanges.

Additionally, there are a number of critical elements to the banking and trading program, above and beyond those needed to support implementation of the stormwater ordinance without trading that need additional analysis and/or deliberation so they can be sufficiently finalized to support trading, as described below.

- Conduct additional evaluations and/or modeling as needed and finalize trading areas and location ratios.
- Review the analysis and recommendations of this study for uncertainty ratios and determine appropriate values for the BMPs included in the County's design manual.
- Finalize protocols for County to use (and others to be aware of) in management of the credit bank, exchanges, and reconciliation process, such as how to assemble credit packages in cases of credit surplus among account holders, or deficits versus request. Evaluate options to post bank and exchange data on the County's web-site for review and access by those involved in the exchange, as well as the general public, consistent with the County's policies and practices for the overall stormwater program, irrespective of trading.
- Review the existing site plan review and approval process to determine if any special trading eligibility requirements are needed to manage expected performance of an applicant as a buyer or seller. For example, additional consideration may be given to a prospective seller's past record of compliance with the stormwater ordinance, performance history of BMPs they installed, and other aspects of their relationship with the County.
- Determine if supplemental agreements are needed between the County and credit buyers and/or sellers in addition to the site plans, County review and approval documents, and project inspection/certification records to establish liability for credit performance and remedy responsibilities for poor BMP performance or failure (under fault and force majeure circumstances). It appears that the provisions in Volume 1 of the stormwater manual are sufficient, including in particular the maintenance covenants.⁴⁸ Modify or augment existing ordinance compliance documents to support credit trading as needed.
- Establish the credit verification requirements (covering initial installation), on-going periodic inspection or audit procedures (covering ongoing maintenance), and any credit re-certification process consistent with the County's oversight protocols for the stormwater ordinance independent of trading. This would include establishing any periodic reporting requirements for owners of BMPs generating credits, consistent with requirements placed on those not generating credits.
- Continue the planned outreach and education program for watershed stakeholders and project applicants covering the new ordinance generally, and the proposed credit option specifically, including distribution of the Tool for use in preparing applications.

- Evaluate the exclusion of the construction sector on the supply, demand, and economics of the credit market, and if warranted, further examine the opportunities and limitations of the CGP with respect to NPDES requirements that would have to be satisfied by a construction source as a buyer or seller of credits. Recommend any changes to the trading framework relative to construction sources that merit consideration.
- Conduct any additional evaluations needed to link the existing monitoring programs with the trading program, to support tracking and evaluating credit trading and banking.
- Establish a review process that would set program evaluation criteria and success metrics at the outset of Phase One, that would be tracked and periodically evaluated (the exact scope of the evaluations and frequency to be determined by the overall length of the Phase One period), and providing for a comprehensive review at/toward the end of Phase One to prepare for transition to Phase Two. This could include studies to quantify and validate BMP performance (removal efficiencies and load reductions) and assessment of beneficial impacts on water quality.
- Consistent with the County's existing public education and outreach program for its stormwater program generally, provide public access, review, and comment opportunities regarding the finalizing of the Phase One credit trading program prior to its launch, as well as participation opportunities during its implementation.

Phase Two

Following Phase One, which would be expected to run a minimum of one year, and could go longer depending on the experiences, a determination should be made as to the value of the credit banking and exchange option as a component of the County's stormwater management program and the Beaver Creek Restoration Plan. This determination would be based on the evaluations conducted during or at the end of Phase One, as outlined above. Assuming an affirmative decision, it may be desirable or necessary to formally adopt the program and its associated rules, protocols, tools, processes, materials, and outreach program as part of the County's program. This may entail a relatively simple action, such as a resolution or guidance memorandum, or something more procedural, such as amending the ordinance and/or creating formal policy guidance for County staff and/or program participants.

It would be expected that the Phase Two program would continue, improve upon, and expand the supporting and evaluation activities developed during this study and in the pilot program, including: public outreach and education; tracking transactions; and reporting program results against established goals.

CONCLUSION

Implementation of an ecological credit trading market will complement the new requirements being enacted through the stormwater ordinance (and corresponding guidance manual) and further support restoration of the Beaver Creek watershed. The move towards “better site design” practices represents a significant change in Knox County’s development practices. A properly structured credit market can help encourage development activities that go beyond the minimum standards and fully apply better site design practices. This credit market may also help mitigate some of the additional burden of this new requirement for stormwater controls by providing opportunities to meet some of these requirements through credit purchases.

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ENDNOTES

¹ Paul and Meyer, 2001.

² See Tennessee Department of Environment and Conservation, 2003a and 2003b. There are no other major NPDES wastewater permittees in the proposed trading area. As noted later in the report, certain construction projects are subject to the state's NPDES general stormwater permit for that sector.

³ Ogden Environmental and Energy Services, 2000.

⁴ The TMDL requirements and how the WRP implements those requirements is discussed in more detail in CH2M HILL, 2007d.

⁵ The watershed modeling to date has examined only how expected changes in land use and associated increases in impervious surfaces may change overland delivery of pollutant loads.

⁶ Permit number TNS075582. The permit covers only the unincorporated, non-college campus, non-interstate areas within Knox County.

⁷ Under EPA's guidances for water quality credit trading, including U.S. EPA, 2007, a number of policies and requirements must be satisfied when NPDES and/or MS4 permitted sources are directly involved, that either do not apply, or apply differentially when only unpermitted nonpoint sources are involved.

⁸ Knox County, 2008. Vol. 2, Section 4.1.2.

⁹ Knox County, 2007. Vol. 2.

¹⁰ Knox County, 2007. See Vol. 2, Section 4.1, page 4-1.

¹¹ Knox County, 2007. See Vol. 2, Section 4.1, page 4-1.

¹² Knox County, 2007. Vol. 2, excerpted from Table 4-3. Design Pollutant Removal Efficiencies (in %) for Structural BMPs, page 4-5.

¹³ Knox County, 2007. See Vol.2, Section 4.2.1, page 4-2.

¹⁴ Knox County, 2007. See Vol. 2, Section 4.2.2, page 4-3.

¹⁵ For more detail on why communities might consider integrating a credit trading option into their local stormwater program see CH2M HILL, 2008b.

¹⁶ For example, in the nutrient offset programs for North Carolina's Tar Pamlico and Neuse River basins, developers may comply with local stormwater ordinance requirements by purchasing 20-years worth of offsets from the state's Ecosystem Enhancement Program. See North Carolina Ecosystem Enhancement Program, 2007.

¹⁷ For more detail see CH2M HILL, 2008c.

¹⁸ BCTF, 2006.

¹⁹ See CH2M HILL, 2008c for more detail.

²⁰ Knox County, 2007. See Vol. 2, Section 4.1, page 4-1.

²¹ Knox County, 2007. See Vol. 2, Section 4.2.3, page 4-3. Based on the County's presumption that BMPs conforming to the manual will be compliant with the ordinance requirements when trading is not involved, the same standard of presumption was given to BMPs conforming to the manual that will generate credits. The manual lists three sources for the removal efficiency assumptions in its References for Section 4; additional detail regarding the performance ranges from which the median values were derived, and associated statistics (e.g., standard deviation), were not provided in the body or appendices to Section 4, and project resources did not permit further investigation of the cited material. To make a final determination as to the need for an uncertainty ratio(s), and potential value(s), the County could consult these source materials and employ a variety of simple to more complex methods to derive uncertainty ratios from the data underlying the median values.

²² See Knox County, 2007, Volumes 1, 2, and associated appendices.

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- ²³ Knox County, 2007. See Vol. 2, Section 4.1, page 4-1.
- ²⁴ Knox County, 2007. See Vol.1, Section 4.5 and Appendix F.
- ²⁵ Barbour et al., 1999.
- ²⁶ TDEC, 2006b.
- ²⁷ Barbour et al., 1999. Chapter 8 - Fish Protocols.
- ²⁸ The sediment TMDL for the Beaver Creek watershed requires a 42.8 percent to 48.4 percent reduction in sediment load. However further analysis showed that a watershed-wide sediment reduction of 38 percent should be sufficient to support fish and aquatic life. Therefore the Beaver Creek WRP established a sector-wide reduction target of 40 percent that was allocated among the source categories. For more detail, see CH2M HILL, 2007d.
- ²⁹ This analysis is presented in CH2M HILL, 2007d.
- ³⁰ The pasture package included the following BMPs: pasture renovation; fencing; buffers; and streambank stabilization.
- ³¹ See CH2M HILL, 2007a for more detail.
- ³² Knox County, 2008. Section 4.5.3(b).
- ³³ From CH2M HILL, 2007a Exhibits 7, 8, and 33.
- ³⁴ From CH2M HILL, 2007a, Exhibit 19.
- ³⁵ See CH2M HILL 2008e and 2008c.
- ³⁶ See CH2M HILL 2008e, Exhibits 4 and 5 and associated text.
- ³⁷ Knox County, 2007.
- ³⁸ Georgia Stormwater Design Manual's Site Development Review Tool: <http://www.northgeorgiawater.com/html/131.htm#SiteReviewTool>
- ³⁹ See CH2M HILL, 2009c.
- ⁴⁰ Technically, this space qualifies for managed area preservation credit which is 80 percent reduction in TSS and water quality volume credits, as opposed to a natural conservation area which qualifies as 100 percent reduction and water quality volume credits. But since the Credit Evaluation Tool currently does not have the open space option, the Tool considers open space as natural conservation area.
- ⁴¹ See CH2M HILL, 2008b.
- ⁴² See CH2M HILL, 2008b, Section 4 for a description of the proposed credit trading pilot program under which real transactions could occur.
- ⁴³ See CH2M HILL, 2009c.
- ⁴⁴ See CH2M HILL, 2008b, Sections 3 and 4.
- ⁴⁵ See CH2M HILL, 2008c for a discussion of the basis for establishing three trading areas for TSS-- an upper, middle, and lower section of Beaver Creek watershed-- based on land use conditions and stream gradients.
- ⁴⁶ See CH2M HILL, 2008c for a discussion of the application of trading ratios and how they could be derived from water quality models and/or BMP performance estimates. No specific recommendations for the numerical value of trading ratios were offered as additional data evaluation and policy decisions outside the scope of this study will be needed before such ratios can be established.
- ⁴⁷ See CH2M HILL, 2008b, Sections 3 and 4.
- ⁴⁸ Knox County, 2007. Vol. 1, Appendix F, Covenants for Permanent Maintenance of Stormwater Facilities and Best Management Practices.