Name of Project: Mansker Creek Watershed Based Plan
Lead Organization: The Cumberland River Compact

Watershed Identification (name, location, 12-digit HUC, etc.):

The project is located within the watershed of Mansker Creek (HUC12 051302020301, officially listed as Madison Creek). The Mansker Creek watershed straddles the border of Davidson and Sumner County, encompassing parts of Nashville, Goodlettsville, Millersville, and Hendersonville. Mansker Creek drains to the Cumberland River just downstream of Old Hickory Dam. The watershed is approximately 30,000 acres (47 mi^2) in area and contains approximately 70 miles of streams listed on the national hydrographic dataset. The population of the watershed is estimated from 2010 census data at approximately 32,000, giving a population density of 680/mi^2.

Mansker Creek Watershed Location Map

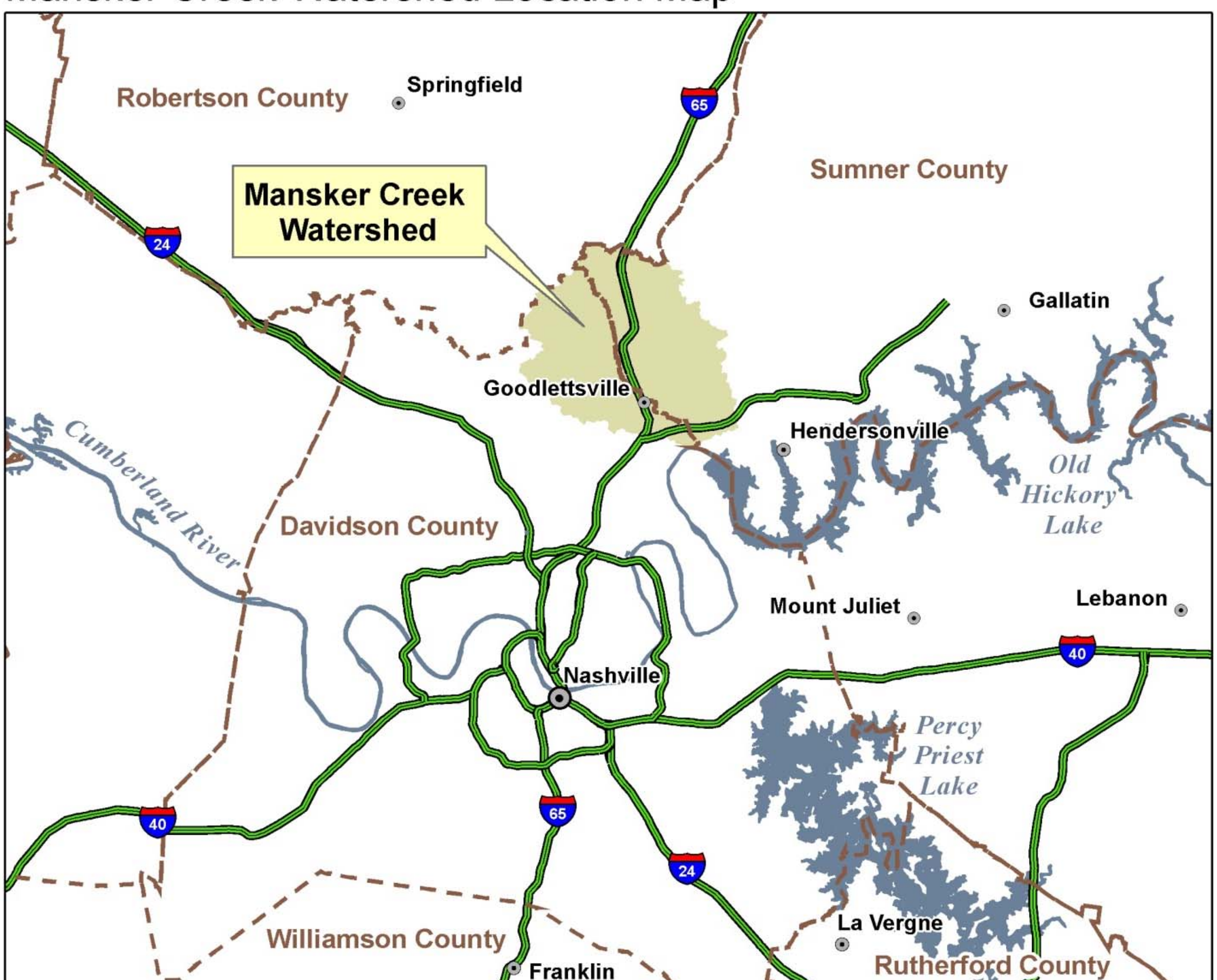

Figure 1: Location of Mansker Creek Watershed within the Greater Nashville Region

Causes and Sources of Nonpoint Source Pollution in the Watershed

According to the current Draft 303(d) list for 2014, every stream in the Mansker Creek Watershed except one (Bakers Fork) is considered impaired. Center Point Branch is the newest impaired stream, having been added to the impaired list in its most recent update. Total impaired waters make up 57.6 of 70 total stream miles in the watershed, or 82%.

The following stream segments within the watershed are listed on the Tennessee 303(d) list:

Waterbody ID	Impacted Waterbody	County	Miles Impaired
TN05130202220 – 0100	Lumsley Fork	Davidson	4.7
TN05130202220 – 0200	Walkers Creek	Davidson	6.49
TN05130202220 – 0210	Unnamed Trib. to Walkers Creek	Davidson	1.47
TN05130202220 – 0300	Slaters Creek	Sumner	0.99
TN05130202220 – 0350	Slaters Creek	Sumner	10.24
TN05130202220 – 0400	Madison Creek	Sumner	14.4
TN05130202220 – 0500	Center Point Branch	Sumner	3.8
TN05130202220 – 1000	Mansker Creek	Davidson, Sumner	7.9
TN05130202220 – 2000	Mansker Creek	Davidson, Sumner	7.6

Of these segments:

Segments TN05130202220 – 0100 (Lumsley Fork), TN05130202220 – 0200 (Walkers Creek), TN05130202220 – 0300 (Slaters Creek), TN05130202220 – 0350 (Slaters Creek), TN05130202220 – 1000 (Upper Mansker Creek), and TN05130202220 – 2000 (Lower Mansker Creek) are impaired for ***E. coli.***

Segments TN05130202220 – 0300 (Slaters Creek), TN05130202220 – 0400 (Madison Creek), TN05130202220 – 1000 (Upper Mansker Creek), and TN05130202220 – 2000 (Lower Mansker Creek) are impaired for **loss of biological integrity due to siltation**.

Segment TN05130202220 – 0210 (Unnamed tributary to Walkers Creek) is impaired for **flow alteration** due to upstream impoundments (Lakewood Lake). Flow alteration will not be addressed in this watershed plan due to the anticipated difficulty of removing a fairly large dam (~30ft high) on private land in order to restore original flows.

Segment TN05130202220 – 0500 (Center Point Branch) is impaired by **organic enrichment**

Segment TN05130202220 – 2000 (Lower Mansker Creek) is impaired by **low dissolved oxygen**

See Figure 2 below for map of impaired streams and their respective impairments.

This watershed based plan addresses sediment, pathogen, dissolved oxygen, and organic enrichment impairments within the Mansker Creek watershed. With full implementation, the goal of the plan will be to remove all impaired segments (with the exception of Segment TN05130202220 – 0210 [Unnamed tributary to Walkers Creek], as mentioned above) from the 303(d) list of impaired streams.

The most common source of sediment and *E. coli* loading, according to the 303(d) list, is MS4 discharges. Flashy conditions due to high urbanization carry pathogens into the storm sewers and streams, and the high flows contribute to bank erosion. This suggests that restoration work in the watershed should be centered around three primary activities – runoff containment, infiltration, and mitigation through green infrastructure practices; bank repair/protection; and public education about pathogen sources and pathogen mitigation practices. MS4 discharges are also the source of the organic enrichment and low dissolved oxygen impairments observed in the watershed, so these activities will contribute to reducing these impairments as well.

Mansker Creek Impaired Streams Map

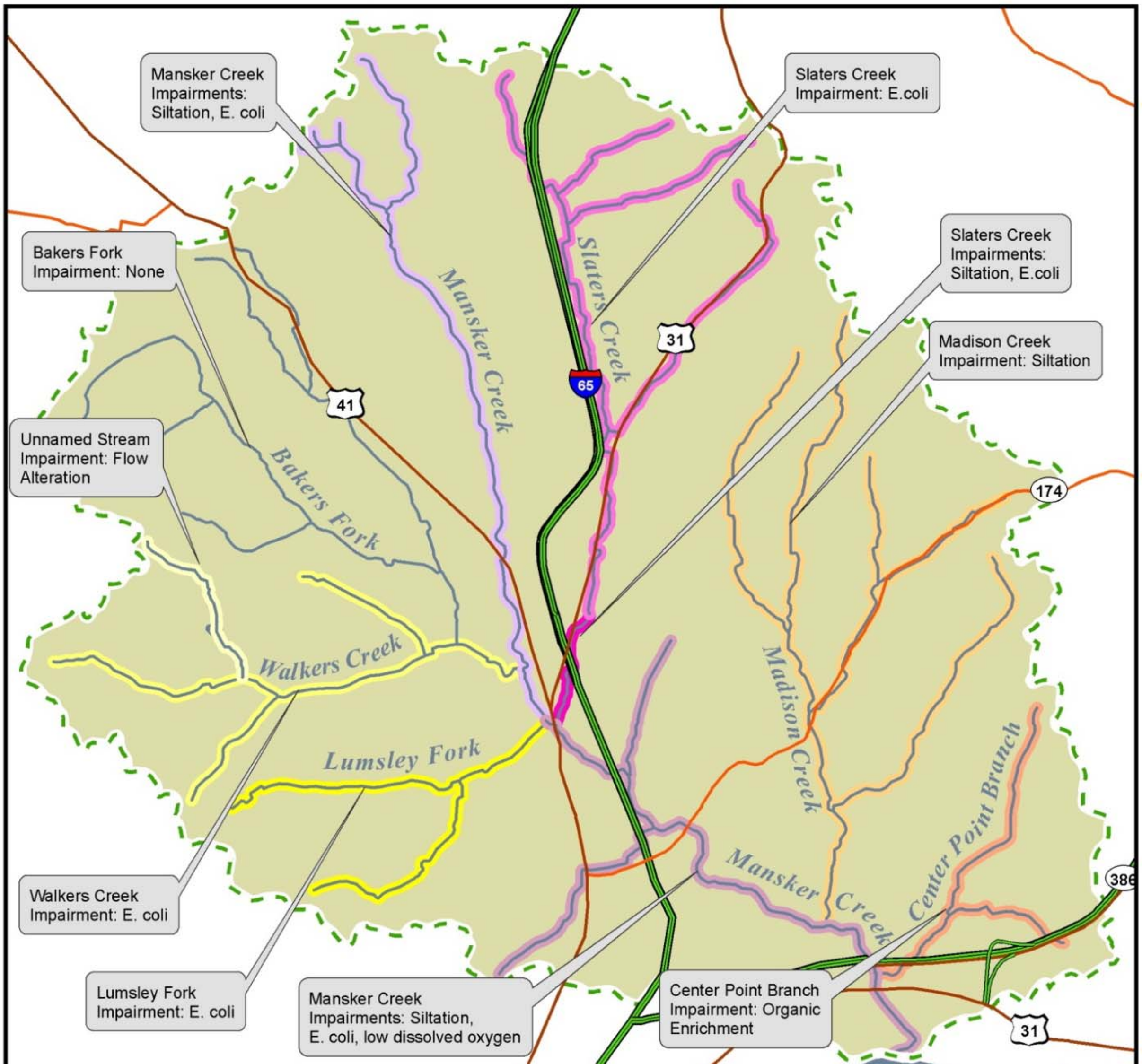

Figure 2: Map of impaired streams in the Mansker Creek watershed

Each stream segment on the map is highlighted with a different color, and impairments for that segment are indicated. Segments are shown defined on the TDEC 2014 Draft 303(d) list. The Mansker Creek watershed includes nine 303(d) listed impaired stream segments totaling 57.6 miles. The remaining healthy stream, Bakers Fork, totals 12.4 miles. Total stream miles in the watershed total 70 miles, though this does not include many wet-weather conveyances, intermittent small streams, and other small drainages.

Total annual precipitation in the basin was estimated at 48 inches, amounting to approximately 120,000 acre-feet/yr. for the watershed. Storm runoff load was estimated from the model as ~11,000 acre feet. The Plan presumes most of this storm load is driven by urbanization. Typical evapotranspiration ratios in Middle Tennessee are 0.5-0.6, indicating a likely range of runoff of 48,000-60,000 acre-feet/yr. for a watershed of this size. Choosing a value of 0.45 for the runoff ratio (54,000 acre-feet/yr.) and adding the ~11,000 acre-feet of storm load (as this urban watershed will have a higher than normal runoff), we end up with a final estimate of runoff ratio of 0.54 (65,000 acre-feet/yr.) for total flow at the outlet of Mansker Creek. This is a reasonable runoff ratio for a partially urbanized watershed in this region of the country, and this estimate produces an estimated flow at the mouth of Mansker Creek of $90ft^3/s$. Long-term discharge data is generally unavailable in the watershed, but $90ft^3/s$ is a reasonable average value for a watershed of this size. This figure was used as our average discharge in loading calculations. The areal runoff generation average of ~$2ft^3/s/mi^2$ ($90ft^3/s$ over a $47mi^2$ watershed) is similar to that of the Cumberland River Basin as a whole (~$40,000ft^3/s$ over a ~18,000 mi^2 watershed).

Total sediment loading in the Mansker Watershed was estimated from the Center for Watershed Protection Model, using publicly available data from the NLCD 2011 dataset, the NRCS, and the city of Goodlettsville. Unavailable data was estimated using our best educated guess. Using the CWP model, the Plan estimated total sediment loading in the watershed to be 2507 tons annually. Stream bank erosion is noted to be a major contributor to sediment loading, with examples of collapsing, rapidly eroding stream banks in both the Upper Mansker Creek and Lower Mansker Creek sub watersheds. Minor eroding banks exist throughout the watershed and are also a significant source of sediment.

Total nutrient loads for phosphorus and nitrogen were not estimated, as the impairments are not present in the Mansker Creek Watershed. However, BMP's implemented as part of this project will have also help to reduce nitrogen and phosphorus loading in Mansker Creek, helping reduce the possibility that these impairments will arise in the future.

The most recent available data for pathogen loading was provided by Metro Nashville Water, regarding sampling conducted in 2012 on Lumsley Fork, Walkers Creek, and Upper and Lower Mansker Creek. In this sampling, FCU/100ml ranged from 6-866 in Lumsley Fork, 26-1046 in Upper Mansker Creek, 25-1046 in Lower Mansker Creek, and 35-435 in Walkers Creek. Geometric means for these 4 segments were 173, 156, 101, and 106 FCU/100ml respectively. Metro Nashville Water did not test Slaters Creek as it lies outside of Davidson County, but previous tests suggest that pathogen levels are similar. These values are in comparable with observations used in calculating the TMDL for *E. coli* for the Cheatham Reservoir. The Plan will base loading reduction goals on the Cheatham TMDL for *E. coli*.

Maximum concentrations (calculated from TDEC criteria and the Cheatham Watershed TMDL) are 126FCU/100ml for a 30-day geometric mean, and a maximum value of 941FCU/100ml for all streams except Upper Mansker Creek, for which the TMDL mandates a lower maximum value of 487FCU/100ml.

In the case of the Metro Nashville Water sampling listed above, Lumsley Fork continues to exceed water quality criteria for 30-day geometric mean and comes very close to the maximum load value. Upper Mansker Creek exceeds both criteria. Lower Mansker Creek exceeds the maximum load criteria but not the 30-day geometric mean. Walkers Creek is technically no longer in violation under this according to this data, though barely so. We suspect that wet weather values may be higher in some sub watersheds (e.g. if livestock/farming is present) and lower in others (e.g. if most of the contamination is coming from dry weather sewage leaks or illicit flows).

Estimate of Load Reductions

Sediment

Total load reductions needed to reach sediment standards were estimated by comparing existing loading with appropriate criteria for total loading. As Tennessee uses qualitative sediment standards, for modeling purposes the Plan examined other states' criteria to see what reasonable quantitative sediment standards might be in order to determine estimated load reductions needed. Most states either use qualitative standards or have multi-criteria exceedance standards, which complicate modeling efforts and preclude an estimation of a specific load reduction value. We observed that New Jersey, South Dakota, and Utah do have numerical sediment standards (calculated as a 30-day average) of 25.0mg/L, 30.0mg/L, and 35.0 mg/L respectively. Of these three criteria, we chose to use New Jersey's criteria of 25.0mg/L, both because it was the lowest and because of the three states, New Jersey was closest to Middle Tennessee in climate and land cover (being mostly urban or forest).

Based on an estimated precipitation (48") and estimated runoff ratio for the watershed of 0.54 (see above), the Plan estimated the average discharge for Mansker Creek to be approximately 90ft^3/s. Using a value of 25.0mg/L (708 mg/ft^3) as our total suspended sediment criteria, the Plan estimated the maximum annual TSS load for Mansker Creek at ~2009 tonnes (~2215 tons).

Based on this figure and our maximum figure of 2507 tons annually estimated above, evidence suggests that annual sediment loading in Mansker Creek will need to be reduced by a minimum of 292 tons. To account for some of the uncertainties in loading values and BMP efficiency, the Plan sets a load reduction goal of **400 tons/yr.** in order to reach water quality standards.

Total load reductions to be achieved through BMP implementation were estimated at 400 tons/yr. See BMP list in the following section for BMP sediment reduction estimates. Additional reduction as a result of behavioral changes driven by the educational outreach components of this plan is not included in this figure, but will supplement this total.

E. Coli

Total load reductions needed to reach pathogen standards were based on the Percent Load Reduction Goals (PLRGs) provided in the Cheatham Reservoir TMDL for *E. coli.* PLRGs in the 5 *E. coli*-impaired streams had PLRG values ranging from 5.3% in Walkers Creek to 54.1% in Lower Mansker Creek. Since the Plan models the Mansker Creek watershed as a whole, estimated an overall reduction needed. For the Mansker Creek watershed as a whole, the needed reduction (calculated by area-weighted averaging of the 8-subwatersheds) the necessary *E. coli* reduction is 15%.

For *E. coli* loading reductions, the Plan again used the Center for Watershed Protections Watershed Treatment Model. This model accounts for coliform loading on land and does not account for in-stream die off, so the absolute loading values calculated by the model will be orders of magnitude higher than the concentrations required by the TMDL, and not reflective of the final in-stream loads. However, we can still get an estimate of what practices needed by comparing load reductions generated by the model to the total loading generated by the model. Many of the variables in this model are by necessity rough estimates, but in general primary sources of loading are urban stormwater runoff and sewer leakage/illicit connections. Goodlettsville has no combined sewer system and has invested heavily in renovating its aging sewer system, so we estimated minimal overflows from the sanitary sewer system. As a result, our model predicts that the bulk of total loads will result from urban stormwater and illicit connections. We estimated roughly 40-50 illicit connections present in the watershed. Goodlettsville screens all of its MS4 outfalls semi-annually and in 2015 discovered and corrected 2 illicit connections. The Plan presumes that the low number of illicit connections discovered is indicative of a low rate of illicit connections in the basin. The Plan further assumes that the detection rate by the city will remain approximately constant, at about 2/yr. Under these assumptions, (and presuming 40% detection and elimination of unknown illicit connections over 10 years) illicit connection detection and repair alone should be nearly enough to achieve the necessary PLRGs (~98% of the reduction goal). Given Goodlettsville's recent investment in its sewer systems and the lower *E. coli* concentrations observed by Metro Nashville Water sampling (as compared with TDEC data in the TMDL, and sampled several years after the promulgation of the TMDL), it is also possible that much of the PLRGs for these sub watersheds may have already been achieved.

This Watershed Based Plan recommends the following additional work to achieve the remaining reduction. Using the modeling values, we estimated that riparian buffer plantings and structural stormwater management practices (rain gardens, detention basins, etc.) would cover an additional 5% of the PLRG. The model does not account for livestock exclusion, so the Plan assumes that cattle exclusion fencing (described in BMP list below) will have the equivalent impact of removing 200 cattle from the basin – this will account for another 3% of the PLRG, reaching a total of 106% of the PLRG between. Structural stormwater management practices will be distributed throughout the watershed based on the amount of reductions needed in each individual stream segment. As the project progresses, individual stream segment sub watersheds will be modeled individually to provide more accurate descriptions of watershed conditions and inform BMP decision making and implementation.

Many of the pathogen reduction activities will also be mitigating sediment pollution, with pathogen reduction occurring as a secondary benefit. Regardless of the values needed to reach the state water quality criteria, and the accuracy or inaccuracy of the pathogen modeling described above, *any* activities that lower coliform loading will be useful in promoting healthier waters and communities. Therefore, the Plan assumes that pathogen loading reduction activities will be worth funding even if reduction figures and results of best management practices cannot be modeled with complete accuracy.

BMP List, Educational Activities and Budget

The following BMP activities should be adequate to restore the Mansker Creek watershed. BMPs will be located in specific sub watersheds based on the impairments found in those stream segments. These BMPs focus first on sediment reduction and secondarily on pathogen reduction. However, by reducing MS4 flows, they will also contribute to addressing the issues of organic enrichment and low dissolved oxygen found in Center Point Branch and Mansker Creek respectively.

BMPs

Major stream bank stabilization projects: The Plan identified 3 major unstable stream bank sections within the Mansker Creek watershed, and anticipates the existence of at least one more needing a significant, intensively engineered project in order to correct. The highest priority locations are two locations in Moss Wright Park, each consisting of a high bank (>20ft) that poses a public health hazard in addition to its environmental dangers. Both of these banks are slated for correction by the City of

Goodlettsville, pending funding availability. A third location has been noted in Upper Mansker Creek. The Plan anticipates these major projects to account for much of the costs of implementing the watershed plan. Due to the rapid erosion rates at these sites these major projects should account for much of the sediment loading reduction as well. Major stream bank stabilization projects will address only sediment loading and will be conducted in the sub watersheds of Upper Mansker Creek, Lower Mansker Creek, and possibly Slaters Creek or Madison Creek depending on need.

General stream bank stabilization: As mentioned above, problematic erosion exists throughout the watershed, and fixing only the most visible and dangerous instances of stream bank erosion will not be enough to address sediment-loading issues. Stormwater flow reduction will help reduce the erosive power of the watershed's waterways, but the existing eroded banks are vulnerable and will need repair in order to maximize load reductions. For this watershed plan, a minimum of 4000 feet of bank will be stabilized using natural methods (e.g. cedar revetments, coir logs, etc.). Stream bank stabilization will address only sediment loading and will be conducted in the sub watersheds of Upper Mansker Creek, Lower Mansker Creek, Slaters Creek, and Madison Creek.

Riparian buffers: while some of the waterways in the watershed do have riparian buffers, they are often inadequately narrow, and in some places nonexistent. The Plan assumes an adequate riparian buffer is 50ft wide, the 70 miles of waterways in the Mansker Creek watershed should have about 850 acres of buffer within this 50-foot zone (2.8% of the watershed area). Based on a visual assessment of the condition of the riparian buffer zones of the watershed using Google Earth aerial imagery, the Plan estimates that ~50% of waterway miles are adequately buffered, 30% is inadequately buffered, and the remaining 20% is unbuffered. These figures provide ample reason and opportunity for installation of riparian buffers. Where needed, riparian buffers will be co-located with stream bank stabilization measures in order to provide additional protection to vulnerable areas. As part of this watershed plan, the Plans estimates that roughly 30 acres of riparian buffer will be installed, amounting to over 25,000 linear feet if the buffers are 50 feet wide. Riparian buffers can help minimize both sediment and pathogen loading and will be implemented in all sub watersheds.

Pet waste dispensers: One of the main sources of pathogens in urban waterways is pet waste. Pet waste bag dispensers will be installed and stocked in highly visible public locations or high use private locations (such as large apartment complexes). This will help build awareness of the importance of pet waste control and provide residents with the easy means to do so. Pet waste bags are currently being designed by the Cumberland River Compact for another project and will be custom printed with tips on actions residents can take to improve water quality. The Plan anticipates installing 40 dispensers in the watershed. Although *E. coli* is not yet a problem in the eastern portion of the watershed (Madison Creek and Center Point Branch), pet waste bags will be implemented in all sub watersheds (except rural Walkers Creek), both to prevent future pathogen loading in these sub watersheds and to continue to increase community awareness of the problem.

Rain gardens: Rain gardens contribute to sediment and pathogen control, by infiltrating stormwater containing pathogens, trapping sediment, and reducing high storm flow volumes which contribute to channel erosion downstream. Rain gardens can be placed adjacent to any impervious surface that would otherwise connect to a storm drain or wet weather conveyance, and can mitigate the effects of such surfaces. The Cumberland River Compact has had great success with our rain garden program and anticipates that finding collaborators for rain gardens will not be difficult. This plan will incorporate 160 rain gardens within the watershed. Rain gardens will be implemented in all sub watersheds except for Walkers Creek, which may be too rural to find appropriate rain garden locations.

Cattle exclusion fencing: Though Mansker Creek is a mostly suburban watershed, much of its northern and western fringes are relatively undeveloped, and there are several farms, including cattle farms. Though cattle are a smaller problem than in many other watersheds, they still contribute to sediment and pathogen loading if left unfenced from streams and small drainages. Horses may also be a problem and horse exclusion can also be addressed. We identified at least one unfenced cattle pasture in Lumsley Fork, and there are likely several others. The Plan anticipates needing a minimum of 2000 feet of cattle exclusion fencing to address this issue, possibly more. Fencing is one of the cheapest BMPs and additional fencing needs are unlikely to greatly affect the budget or feasibility of this project. Cattle exclusion fencing will be implemented in Lumsley Fork and possibly Walkers Creek, Upper Mansker Creek and Slaters Creek. Madison Creek and Center Point Branch are not impaired by E. coli, and Lower Mansker Creek is significantly more urbanized and unlikely to contain livestock.

Water/Sediment Control Basins and/or Stormwater/Retrofits: This class of BMPs is a catch all, potentially including sediment-trapping basins on rilled agricultural land or detention ponds draining parking lots. The Plan estimates that there will be opportunities to do several medium sized projects to capture and infiltrate stormwater as an erosion and pathogen control measure. For this plan, we estimate that 5 such structures will be implemented. These will take place mostly in Lower Mansker Creek, the most urbanized portion of the watershed and the most in need of stormwater capture and mitigation. However, depending on circumstances these projects may be implemented basin wide.

Calculations suggest that these BMPs should satisfy our 400-tons/yr. load reduction target for sediment. Using the pollutant load reduction estimation tool provided in the watershed based plan guidelines, the Plan estimates the following:

Stream bank/shoreline protection: 0.047 tons/ft./yr. * 4,000 ft. = 188 tons/yr.
Riparian buffers: 0.002 tons/ft./yr. * 25,000 ft. = 50 tons/yr.
Fencing: 0.006 tons/ft./yr. * 2000 ft. = 12 tons/yr.
Water/sediment control structures: 6 tons/basin/yr. * 5 basins = 30 tons
Total sediment reduction from these measures: **280 tons/yr.**

In addition, the Plan estimates the load reduction of our major stabilization projects as follows: Currently, recession rates of roughly 3-6"/yr. for a 20ft high/200ft long bank are observed. This amounts to 1,000-2,000 cubic feet of bank loss annually. Assuming a dry density of about 80lbs/ft^3, the Plaestimate annual sediment losses from the bank are approximately 40-80 tons. Assuming a middle value of 60 tons for our estimate and an equal division between total suspended sediment and bed load (which is quite conservative), we end up with a final estimate of total suspended sediment reduction of 30 tons/yr./project, or **120 tons/yr.** for all 4 projects. Two of these projects will take place in Lower Mansker Creek, and one in Upper Mansker Creek. The location of the fourth is to be decided.

This brings our total estimated sediment reduction to our 400 tons/yr. goal, without even considering the impact of our other incorporated measures, such as rain gardens, or behavioral changes driven by our educational outreach.

The majority of E. coli reduction will be handled by existing local government programs to detect and eliminate illicit connections, but the remainder will be handled by structural stormwater practices – rain gardens, water/sediment control basins.

Educational Activities

Part of the watershed based plan recommends increasing awareness through educational outreach within the watershed. Outreach should be multifaceted, and while some will be incorporated directly into BMPs, specific activities should be conducted with education and outreach in mind.

As an example of the outreach, the Cumberland River Compact has recently begun an annual free festival celebrating the Cumberland River, which call WaterFest. At this festival, held annually in Cumberland Park, we provide water-related entertainment (e.g. water-slides, etc.) and educational booths for kids. Non-profit organizations and government agencies such as TDEC and Metro Nashville Water attend and host some of the educational booths. As part of the day, we give out prizes – to be eligible, a participating child must complete an educational scavenger hunt by visiting each of the educational booths and seeing a demonstration or participating in an activity at that booth. This is a great way to engage children (and their parents) in learning about the environment. As part of this watershed plan, we recommend an analogous festival for the city of Goodlettsville, dedicated to teaching the residents of the Mansker Creek watershed about water issues facing their community.

Another example of outreach in which we have had great success at the Cumberland River Compact is educational talks. We have been hosting a series of weekly talks in the spring and fall at our event space in downtown Nashville, dedicated to a variety of topics relating to the science, history, and preservation of the Cumberland River. These seminars have been well attended and benefit both the public and other non-profits. As part of this plan, we suggest a similar talk series for Mansker Creek, covering project work, water issues, and other environmental topics.

Based on estimates from our own previous work and that of some of our collaborating organizations, we estimate a possible budget breakdown for this watershed based plan as follows.

BMP Name	**Quantity**	**Cost/Unit**	**Budget Estimate**
Major Bank Stabilization Projects	4	$200,000 each	$800,000
Stream bank Stabilization with Revetments/Coir Logs	4,000 linear feet	$75/ft.	$300,000
Riparian Buffers	30 acres	$2,500/acre	$75,000
Pet Waste Bag Dispensers w/ bags	40	$750 each	$30,000
Rain Gardens	160	$500 each	$80,000
Cattle Exclusion Fencing	2000 linear feet	$5/ft.	$10,000
Water/Sediment Control Structures and/or Stormwater Retrofits (detention basins, etc.)	5	$24,000	$120,000
		Total	**1,415,000**

Educational Activities

BMP Name	**Quantity**	**Cost/Unit**	**Budget Estimate**
Annual Educational Festival (over 10yrs)	10	$6,000	$60,000
Educational Talks/Seminars	25	$1,000	$25,000
		Total	**$85,000**

Total Budget for Project:	**$1,500,000**

Timeline, Tasks, and Assessment of Progress

This Watershed Based Plan is envisioned as a comprehensive, 10-year long plan, to be completed by 2026. This plan will be divided into five 2-year long phases, with Phases 1-4 addressing 4 different sections of the watershed and Phase 5 serving as a wrap up phase to address trouble spots or neglected areas from Phases 1-4. Phase 1 will consist of Lower Mansker Creek, the most urbanized area, and Phases 2-4 will consist of Madison Creek and Center Point Branch, Slaters Creek and Upper Mansker Creek, and Walkers Creek and Lumsley Fork. The project area of each Phase under this arrangement ranges from approximately 4500-8500 acres. Each phase is envisioned to cost roughly $300,000 to complete. Funds will be sought from numerous sources, including the cities of Goodlettsville (Phase 1-5), Hendersonville (Phases 2, 5), Millersville (Phases 3, 5), and Metro Nashville/Davidson County (Phases 4-5); federal funding, private donors, and corporate sponsors.

See map on following page for description of project phases and BMPs involved in each phase.

Tasks are described in detail above in the BMP section. Project tasks will be distributed among individual phases and sub watersheds based on specific sub watershed impairments and needs. Further modeling coinciding with Phase 1 will identify specific locations and tasks for each sub watershed in the basin.

Progress will be assessed based on percentage of progress tasks completed, remaining work to be done, and updated water quality monitoring data. Tasks associated with each phase will be described in proposals at the beginning of each phase, and each phase will conclude with a report detailing the proportion of project tasks completed, remaining needs, and expected efficacy and impact of completed tasks. This will inform future decision making and help shape the tasks for Phase 5, which will serve as a wrap up phase addressing any uncompleted tasks. At completion of the watershed plan, total BMP implementation can be compared for phases 1-5 can be compared to the values laid out in this document.

Mansker Creek Project Phases

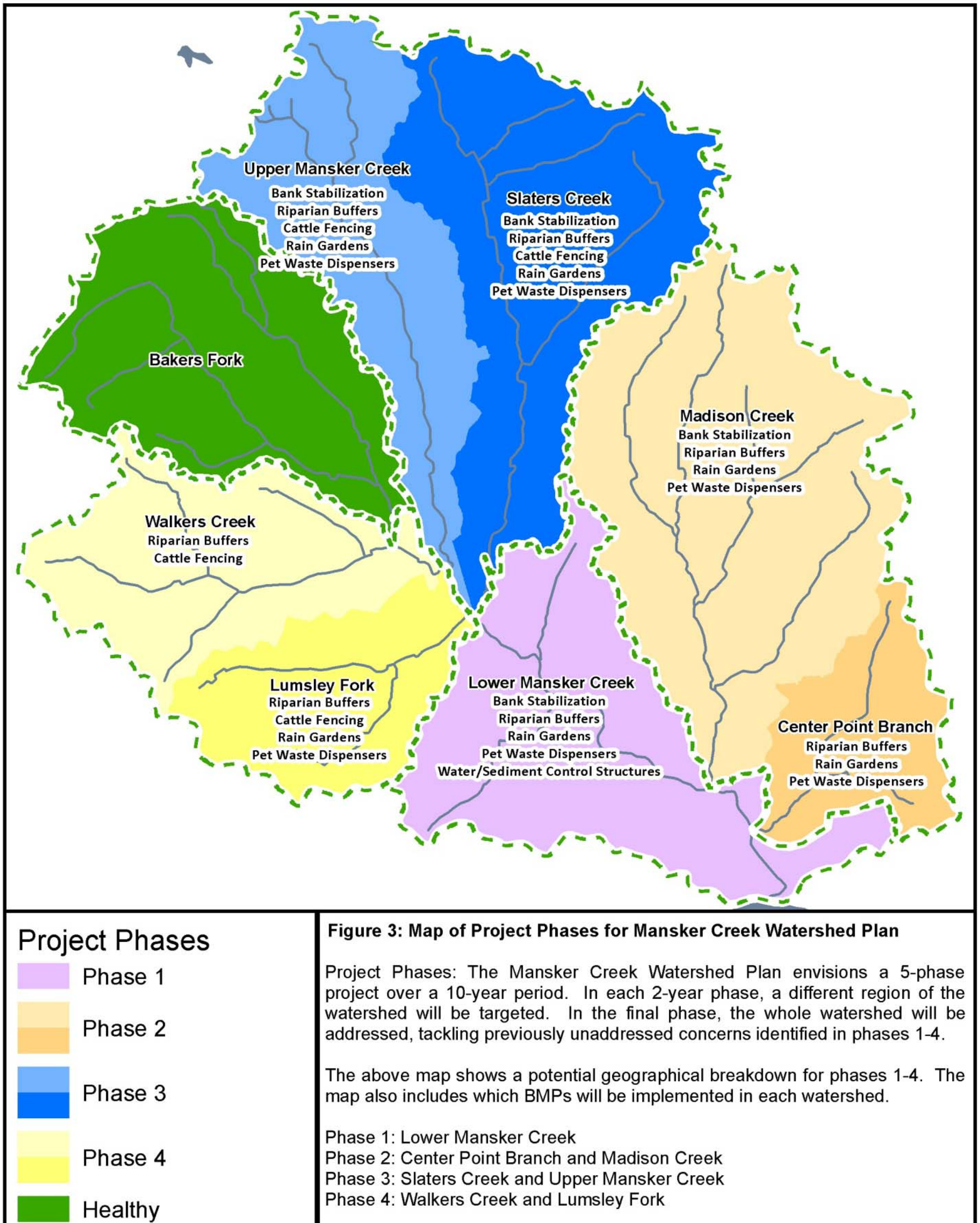

Figure 3: Map of Project Phases for Mansker Creek Watershed Plan

Project Phases: The Mansker Creek Watershed Plan envisions a 5-phase project over a 10-year period. In each 2-year phase, a different region of the watershed will be targeted. In the final phase, the whole watershed will be addressed, tackling previously unaddressed concerns identified in phases 1-4.

The above map shows a potential geographical breakdown for phases 1-4. The map also includes which BMPs will be implemented in each watershed.

Phase 1: Lower Mansker Creek
Phase 2: Center Point Branch and Madison Creek
Phase 3: Slaters Creek and Upper Mansker Creek
Phase 4: Walkers Creek and Lumsley Fork

Criteria to Assess Achievement of Load Reduction Goals

If load reduction goals are met, affected streams will no longer exceed TDEC's state water quality criteria. Independent sampling coinciding with phase 4 will allow identification of areas in need of additional work, allowing modification of the project during phase 5 to address the most problematic locations. Since riparian buffers and other natural methods take time to grow and reach full effectiveness, the Plan anticipates that state water quality criteria may not be achieved immediately, but should be achieved for a given stream segment no later than 5 years after the end of the end of the project phase addressing that segment's sub watershed. Under this plan, BMP implementation would be completed by 2026 and fully supporting conditions in all streams would be achieved no later than 2026.

Monitoring and Documenting Success

The Cumberland River Compact and others involved in carrying out the watershed plan will keep TDEC-Division of Water Resources aware of restoration activities to allow coordination of sampling. Restoration activities do not have immediate effects and positive results may take several years to appear. However, the duration of the plan means that the early phases of the plan can be assessed, allowing us to go back during phase 5 and address problem areas or unresolved issues.

In addition to coordinating monitoring efforts with TDEC, the city of Goodlettsville has an existing relationship with Western Kentucky University, which currently conducts a stream monitoring program for the city. Continuation of these monitoring efforts will supplement TDEC's findings and help ascertain whether the project is meeting its goals during the course of its implementation. Implementers of the Plan should seek additional opportunities to provide tools for Goodlettsville Stream Watch or other local groups to do more frequent monitoring of TSS, which compared to *E. coli* is substantially easier to monitor.

Observed water quality measurements should be on a positive trend by the end of the plan timeline, such that extrapolating results (i.e. assuming that continued riparian buffers will trap more contaminants as they grow, etc.) would demonstrate meeting state criteria by 2-3 years after the end of the plan implementation. If observations indicate that meeting these criteria are unlikely, the program can be adjusted/extended in light of additional information. Again, for phases 1 and 2, it will be possible to assess the effectiveness of the program prior to Phase 5 of the project, allowing us to go back and revise the plan as needed.

Results of an implemented Watershed Based Plan will be boosted by Goodlettsville's new stormwater regulations http://www.cityofgoodlettsville.org/DocumentCenter/View/2031. Official in March 2015, these standards require among other things 100% capture and infiltration of the first inch of rainfall. These regulations will mitigate the impact of increased development in the watershed. The regulations aim for a net zero impact from new construction. The regulations, when combined with implementation of this watershed based plan, should yield a fully supporting system by 2026.

Successes and needed revisions should be documented at the end of each phase of plan implementation, allowing flexibility in implementation and improving the effectiveness of the plan.