Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1

1 FORWARD

On September 24, 2015, Mississippi State University (MSU) submitted its *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed* (WRMP) to the Mississippi Department of Environmental Quality (MDEQ) for review and consideration of potential 319 Nonpoint Source Pollution Prevention Program (NPS) funding support. After a review of the plan by MDEQ and the U.S. Environmental Protection Agency (EPA), the plan was not initially funded; however, guidance was provided to MSU to address specific elements of the plan in order to meet MDEQ/EPA requirements. Following are EPA's comments about the WRMP:

1. The Watershed Plan does not meet the 9-key elements.
    a. Proposed Management Measures (Element 3). The Watershed plan has not prioritized the most critical areas that need to be addressed. Are all the critical areas in the watershed that contribute towards WQ degradation indicated? For example, several agricultural areas were noted downstream in the watershed (see Watershed Plan, Page 45, Land Use map). A comparative analysis is needed (Tiers 1, 2, & 3 prioritization; see "Checklist for Review of Watershed Management Plans," previously provided).
    b. (Element 3). It is unclear what specific tasks and deliverables will the requested $200,000 be used to fund for FY16. Is the $200,000 going towards to highest priority critical needs in the watershed (Tier 1, see Comment 1.a above).
    c. Implementation Schedule (Element 6) and Measureable Milestones and Project Outcomes (Element 7). The proposed watershed plan does not provide a scheduled order of implementation and milestones <u>with</u> anticipated completion dates.

This *Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1* was developed to address these comments (and elements) and ensure that the Information and Education component (Element 5) and the Monitoring component (Element 9) are addressed to the satisfaction of both MDEQ and EPA. It is hoped that the submission of this plan to MDEQ and EPA will result in the awarding of 319 NPS funding support for MSU's Red Bud-Catalpa Creek Watershed Restoration and Protection Project and Watershed DREAMS (Demonstration, Research, Education, Application, Management and Sustainability) Center.

2 PROCESS FOLLOWED

The process followed during development of the WRMP and this *Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1* was based upon guidance from EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters.* This 6-step process is identified in Table 2.1 with the supporting activities, and the locations where the narratives in the WRMP and this plan can be found (in the Reference column).

Table 2.1
EPA's 6 Steps to Effective Watershed Management

Step		Supporting Activities	Reference
1	Build partnerships	a. Identify key stakeholders	a. WRMP, Chapters 7 and 8
		b. Identify issues of concern	b. WRMP, Chapter 10 WIP-1, Appendix C
		c. Set preliminary goals	c. WRMP, Chapter 10 WIP-1, Appendix C
		d. Develop indicators	d. WRMP, Chapter 10
		e. Conduct public outreach	e. WRMP, Chapter 8 WIP-1, Appendix C
2	Characterize the watershed	a. Gather existing data	a. WRMP, Chapter 9
		b. Create a watershed inventory	b. WRMP, Chapter 9
		c. Identify data gaps	
		c. Collect additional data if needed	
		d. Analyze data	e. WRMP, Chapter 10
		f. Identify causes and sources of impairment*	f. WRMP, Chapter 10
		g. Estimate pollutant loads	g. WRMP, Chapter 10
3	Set goals and identify solutions	a. Set overall goals and management objectives	a. WRMP, Chapter 10
		b. Develop indicators/targets	b. WRMP, Chapter 10
		c. Determine load reductions needed*	c. WRMP, Chapter 10
		d. Identify critical areas	d. WIP-1, Chapter 5
		e. Develop management measures to achieve goals*	e. WRMP, Chapter 11 WIP-1, Chapter 5
4	Design implementation program	a. Develop an implementation schedule*	a. WIP-1, Chapter 7
		b. Develop interim milestones to track implementation of management measures*	b. WIP-1, Chapter 8
		c. Develop criteria to measure progress toward meeting watershed goals*	c. WRMP, Chapter 10
		d. Develop monitoring component*	d. WRMP, Chapter 12 WIP-1, Chapter 9
		e. Develop information/education component*	e. WRMP, Chapters 13, 15 WIP-1, Chapter 6

		f. Develop evaluation process	f. WRMP, Chapter 10
		g. Identify technical and financial assistance needed to implement plan*	g. WRMP, Chapter 11 WIP-1, Appendix B
		h. Assign responsibility for reviewing and revising the plan	h. WRMP, Chapter 17
5	Implement watershed plan	a. Prepare work plans	
		b. Implement management strategies	
		b. Conduct monitoring	
		c. Conduct information/education activities	
		d. Share results	
6	Measure progress and make adjustments	a. Track progress	
		b. Make adjustments	

Key: * EPA Key Element of a Watershed Plan
WRMP – Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed
WIP-1 – Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1

3 Phased Implementation Approach

A phased implementation approach is planned for habitat and water quality restoration and protection activities in the Red Bud-Catalpa Creek Watershed.

Phase 1: Headwaters – South Farm

1. Solicit resources and implement Phase 1 agricultural BMPs;
2. Upgrade nonstructural management practices, where needed, to improve water quality and ecosystem health;
3. Conduct hydrologic analysis (field measurements, modeling), if funding available;
4. Conduct monitoring (pre- and post-implementation); and
5. Implement education and outreach.

Headwaters – Urban Areas

1. Engage and advance, where possible, collaborative Master Planning activities and Catalpa Creek restoration and protection activities with MSU and the City of Starkville; and
2. Engage the City of Starkville and Oktibbeha County to address storm water issues.

Broad Watershed (HUC #031601040601)

1. Solicit resources and finalize implementation plan; and
2. Assimilate and integrate multi-disciplinary data sets.

Phase 2: Headwaters – South Farm

1. Implement Phase 2 agricultural BMPs;
2. Upgrade nonstructural management practices, where needed, to improve water quality and ecosystem health (cont.);

3. Facilitate planning for stream restoration (structure/function):
    a. Concept development and feasibility review,
    b. Potential Demonstration Site #1 – Bridge at South Farm & East Line Roads, and
    c. Potential Demonstration Site #2 – Large sediment detention basin (“NRCS watershed lake”);
4. Conduct monitoring (pre- and post-implementation); and
5. Implement education and outreach.

Headwaters – Urban Areas

1. Engage and advance, where possible, collaborative Master Planning activities and Catalpa Creek restoration and protection activities with MSU and the City of Starkville (cont.); and
2. Engage City of Starkville and Oktibbeha County to address storm water issues (cont.).

Broad Watershed (HUC #031601040601)

1. Solicitation of resources and implementation of Phase 2 agricultural BMPs

Concurrent: Watershed DREAMS Center visioning, planning, leveraging, resource generation.

Future: Conceptualize future phases of project using the *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed* as reference.

This *Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1* focuses on the implementation of Phase 1 activities. A subsequent plan will be developed for Phase 2 and future phases and both will be incorporated into a revised *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed*.

4 Key Watershed Planning Elements

In its handbook, EPA describes 9 key elements of a watershed plan that are minimum requirements for 319 NPS funding support and describes what each element means. This *Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1* builds upon the *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed* by providing more details and specifics for watershed planning elements 3, 5, 6, 7, and 9 (noted below in bold font).

Element 1: Identification of causes and sources of impairments;
Element 2: Expected load reductions;
Element 3: Proposed management measures;
Element 4: Technical and financial assistance needs;
Element 5: Information and education;
Element 6: Implementation schedule;
Element 7: Measurable milestones and project outcomes;
Element 8: Load reduction evaluation; and
Element 9: Monitoring.

5 Proposed Management Measures (Element 3 of EPA's 9 Key Elements)

5.1 Identification of Critical Management Areas

A two-step process was used to identify critical management areas targeted for the implementation of Phase 1 management practices. The first step in this process was the identification of management areas of concern throughout the watershed. The second step focused on identifying critical management areas in the headwaters of the watershed.

Step 1: Identification of Management Areas of Concern. Management areas of concern that focused on attributes related to soil erosion, nutrient loadings, and stream processes were identified throughout the Red Bud-Catalpa Creek Watershed. The results, screening methodology, and supporting information developed to identify these areas in the Red Bud-Catalpa Creek Watershed are described in Appendix D of this plan. Factors and coverages considered for delineation of these areas included the following:

1. Land Slope and Runoff Pathways;
2. Water Stored by Soil;
3. Soil Drainage Classification;
4. Soil Hydrologic Groups;
5. Watershed Runoff Potential;
6. Watershed Flooding Frequency;
7. Land Cover/Land Use;
8. Soil Erodibility Factor;
9. RUSLE Cover Management Factor;
10. Erodibility Index;
11. Annual Soil Erosion Rates;
12. Soil Loss Tolerance;
13. Estimated Average Nitrogen Yield;
14. Estimated Average Phosphorus Yield;
15. Site Verification; and
16. Best Professional Judgment.

Through this process, management areas of concern were identified.

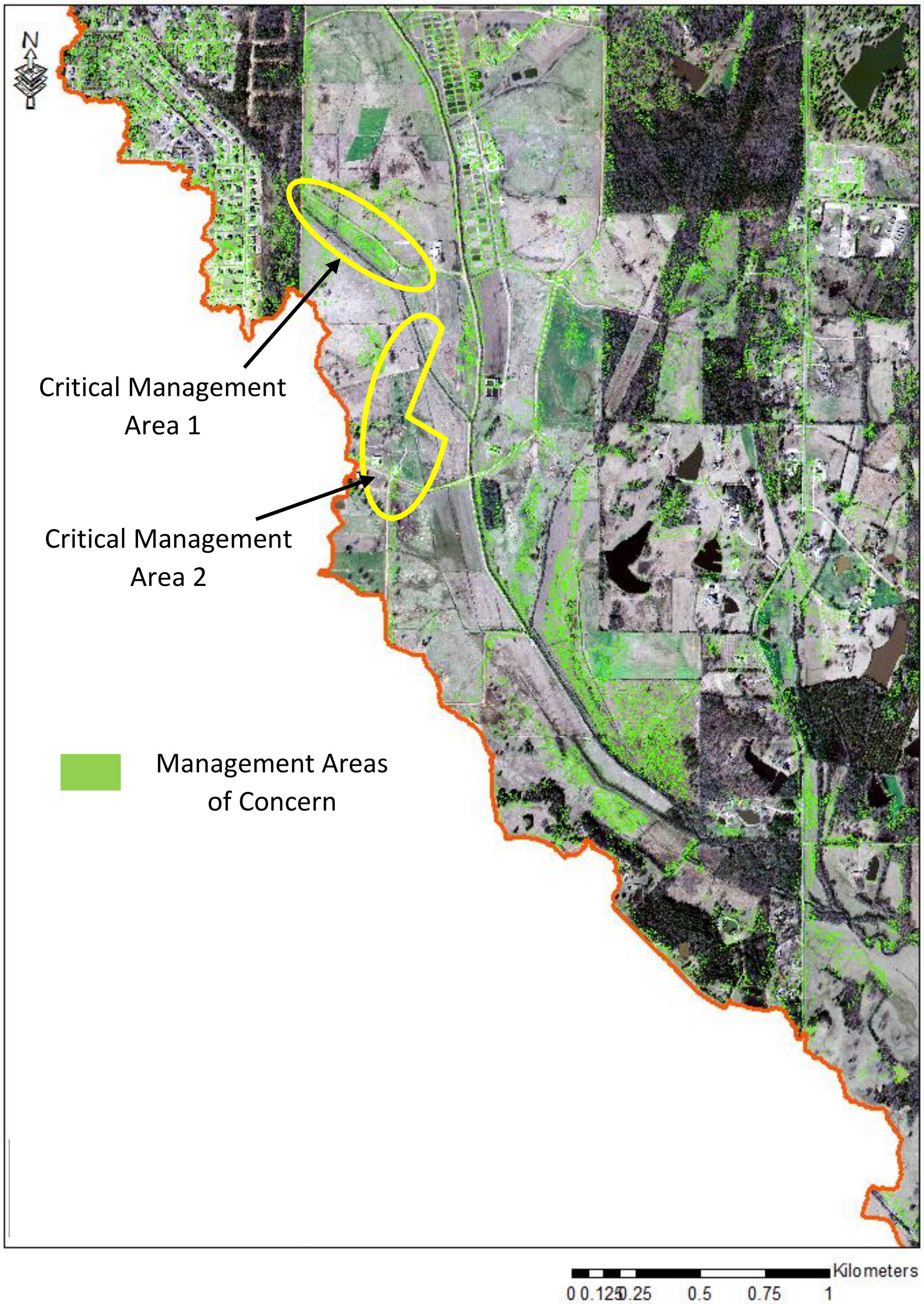
Step 2: Delineation of Critical Management Areas. In addition to the methodology described in Appendix D, additional factors were considered for determining specific locations within the identified management areas of concern for the placement of best management practices (BMP) during Phase 1. This step included consideration of the following attributes based upon best professional judgment:

1. Likely water quality benefit;
2. Willing landowners;
3. Desire to use Phase 1 BMPs to raise awareness (i.e., visibility and easy access/ability to use as showcase sites);
4. Implementation of the recommendations of the TMDL (i.e., "it is recommended that water bodies within [the watershed] be considered a priority for streambank and riparian buffer zone restoration and any sediment reduction BMPs, especially for road crossings, agricultural activities, and construction activities);
5. Cost of BMPs must be within available funding levels;
6. Strategy to include range of BMP types in initial installation (not just the same BMP installed at different sites);
7. Usefulness in fulfilling the teaching/research mission of MSU as well as serve as leverage for the education and outreach chapter;
8. Ease of showing effectiveness of the BMP(s) through monitoring;
9. Shorter length of time for anticipated results (i.e., within the grant period);

The overarching desired considerations, and associated outcomes, are to reduce sediment to the quantifiable level specified in the TMDL and achieve a 'good' IBI score at MDEQ's downstream biological monitoring site (or, at the least, to make documented progress in this direction). The positioning of MSU's South Farm in the headwaters of the watershed as a willing landowner; the increased likelihood for leveraging of in-kind services; high visibility for the installed BMPs; opportunities to create experiential learning activities through planning, installation, monitoring, and education activities; proximity to pollutant sources; and resource eligibility all led to the selection of three Critical Management Areas on the South Farm as the focus of Phase 1 implementation.

Map 5.1.1 illustrates a portion of the headwaters of the watershed in which management areas of concern are identified as well as Critical Management Areas 1 and 2 (highlighted in yellow). Due to the lack of 1 meter LiDAR data, this same resolution is not currently available for Critical Management Area #3. Field verification and photo documentation was used to support the delineations of the three critical management areas for Phase 1. Presented later in this chapter is photo documentation of the identified critical management areas and sites where BMPs are proposed for Phase 1 implementation. Following is the narrative for Critical Management Area 1 and 2. The narrative for Critical Management Area 3 begins on page 21.

Map 5.1.1
Management Areas of Concern within MSU's South Farm
with Critical Areas 1 and 2 Outlined in Yellow



5.2 Proposed Agricultural Best Management Practices

To determine the BMPs that would likely result in quantifiable improvements in water quality, the expertise of a variety of conservation professionals was sought. These included conservationists with USDA's Natural Resources Conservation Service (NRCS), the Mississippi Soil & Water Conservation Commission (MSWCC), the Oktibbeha County Soil & Water Conservation District (OCSWCD), environmental scientists with the MDEQ, and numerous administrators, researchers, and farm management staff with MSU. Numerous meetings and site visits were made to document the sources contributing to water quality and habitat degradation and identify appropriate management measures that could improve water quality.

Within the headwaters of the Red Bud-Catalpa Creek Watershed, 24 BMPs in three critical areas have been selected for implementation in Phase 1. The BMPs that are proposed for Phase 1 implementation are identified below. Where possible, green infrastructure solutions will be used.

Critical Management Area 1 – Livestock Forage Area. Table 5.2.1 identifies the BMPs proposed for implementation in the livestock forage area during Phase 1. Descriptions of these practices follow Map 5.2.1. See Appendix A for additional details.

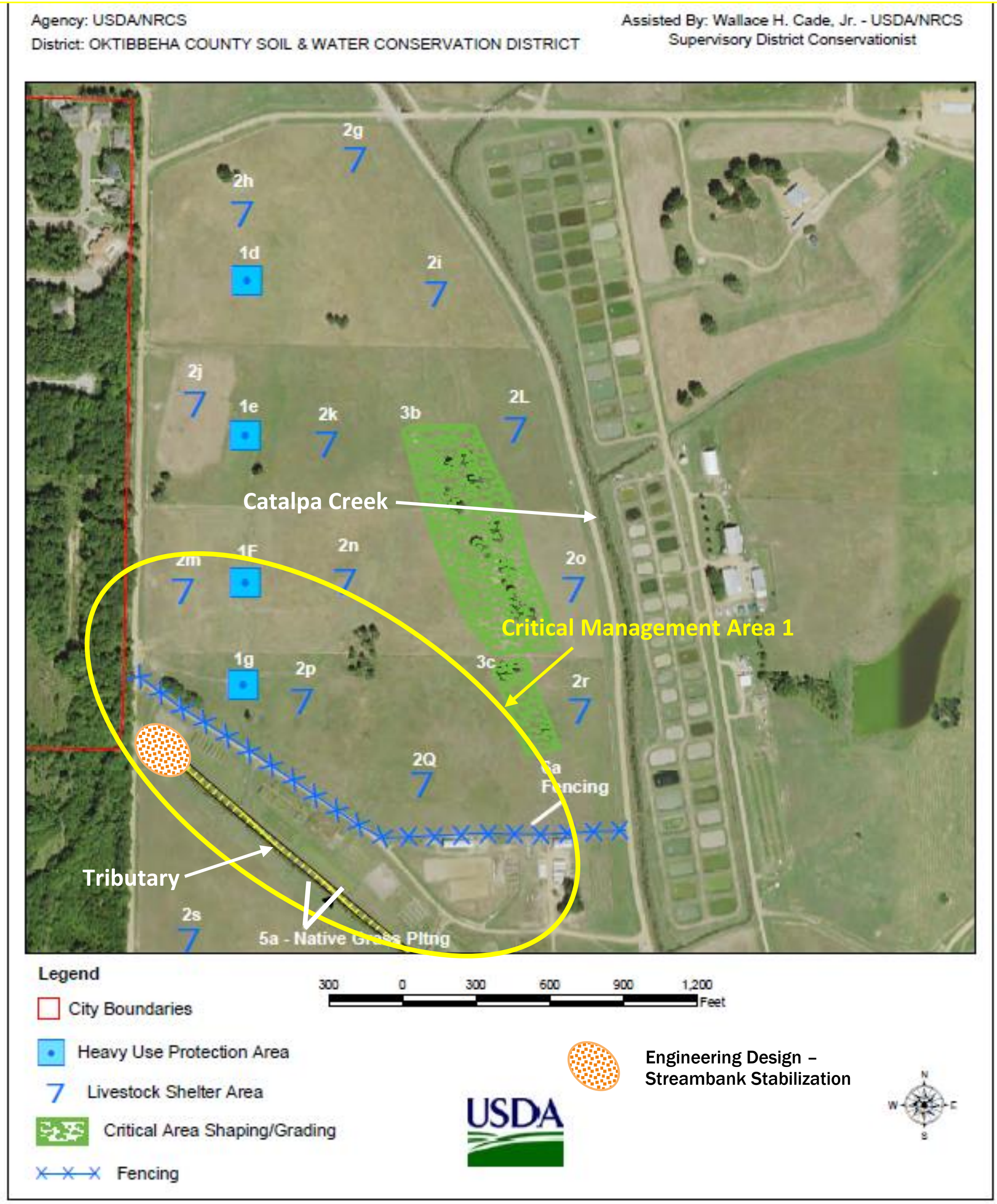
Table 5.2.1
Critical Management Area #1 – Livestock Forage Area
Proposed Phase 1 Best Management Practices

NRCS Practice	Site #	[1] Estimated Costs to Fully Implement BMPs (100% Basis)	[2] 319 NPS Eligible Funding (60% of Costs to Fully Implement BMPs)	[3] Match
561 – Heavy Use Protection (Beef Feeding Area)	1f	$5715	$3429	
561 – Heavy Use Protection (Beef Feeding Area)	1g	5715	3429	
576 – Livestock Shelter Structure	2m	3940	2364	
576 – Livestock Shelter Structure	2p	3940	2364	
576 – Livestock Shelter Structure	2Q	3940	2364	
512 – Native Grass Planting	5a	1693	1016	
382 – Fencing [4]	6a	6666	4000	
342 – Critical Area Planting (Heavy)	Sites around fences	1107	664	
Bank Stabilization (per NRCS engineering design)	West Line Road	52654	31592	
Estimated Total – Critical Area #1		$85370	$51222*	$34148

*Rounding may result in slight differences between column totals and multiplication products.

Map 5.2.1 identifies Critical Area #1 and within this area the sites proposed for Phase 1. Other sites will be addressed in future phases.

Map 5.2.1 – Critical Management Area 1
Livestock Forage Area
Proposed Phase 1 Best Management Practices



NRCS Practice 561 – Heavy Use Protection Area. The stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, surfacing with suitable materials, and/or installing needed structures. To provide a stable, non-eroding surface for areas frequently used by animals, people or vehicles and to protect and improve water quality.

NRCS Practice 576 – Livestock Shelter Structure. A portable framed structure with mesh fabric roof to provide shade for livestock. This practice applies to areas where animal productivity and well-being is adversely affected by heat generated from sunshine or where livestock are excluded from natural shade along stream banks or other water courses. This practice included as a part of a Resource Management System provides shaded areas for livestock, helps protect surface waters from pollution, and assists the livestock from excessive heat.

NRCS Practice 342 – Critical Area Planting. Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices. The purpose of this practice is to stabilize the soil, reduce erosion and damage from sediment and runoff to downstream areas, to improve water quality, to improve wildlife habitat, and to improve visual resources.

NRCS Practice 512 – Biomass (Native Grass) Planting (legumes inter-seeding or cropland conversion). Establishing and reestablishing native species. To establish adapted compatible species, varieties, or cultivars, reduce soil erosion by wind and/or water. This specific application will establish a buffer along the north and south sides of the tributary and improve wildlife habitat.

NRCS Practice 382 – Fencing. Dividing or enclosing an area of land with a suitable structure that acts as a barrier to livestock. To subdivide grazing lands to create additional grazing cell that will allow the implementation of a prescribed grazing system. The fencing along site 6a is failing and needs replacement. It is needed to keep cattle out of the tributary.

Stream Bank Stabilization. This work will consist of placing rock riprap 20ft. upstream of an existing 6ft. x 10ft. arched pipe on West Line Road at a tributary to Catalpa Creek. Also, 20ft. of grouted rock riprap will be placed immediately downstream of the pipe, and then an additional 20ft. of rock riprap without grout. However, green infrastructure options will also be considered.

The following photographs document the conditions that exist where Phase 1 BMPs are proposed in Critical Management Area 1.

Site 1F
NRCS Practice 561 – Heavy Use Protection

Site 1g
NRCS Practice 561 – Heavy Use Protection

Site 2m
NRCS Practice 576 – Livestock Shelter Structure

Site 2p
NRCS Practice 576 – Livestock Shelter Structure

Site 2Q
NRCS Practice 576 – Livestock Shelter Structure

Site 6a
NRCS Practice 382 – Fencing

Sites Around Fences
NRCS Practice 342 – Critical Area Planting (Heavy)

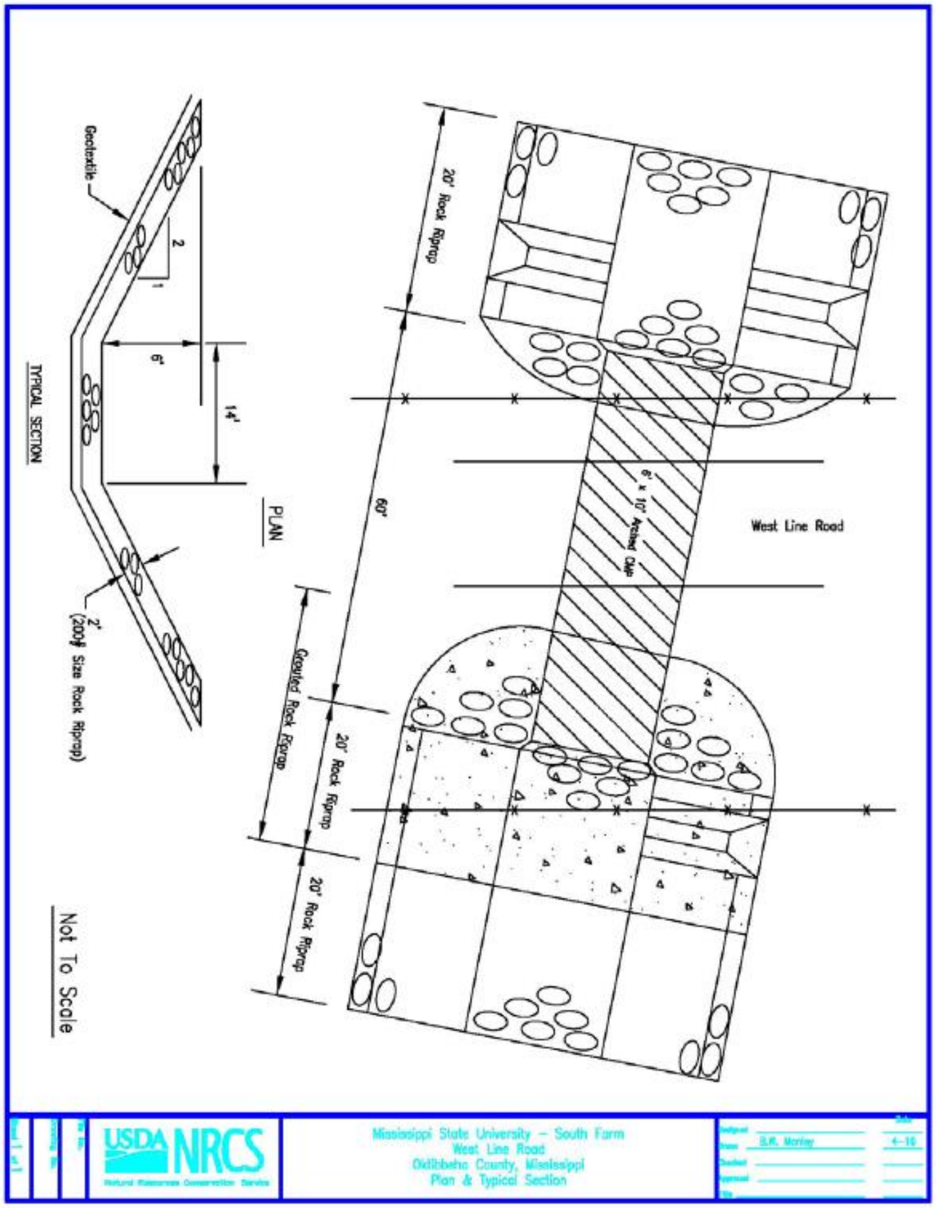
West Line Road at Tributary
Engineering Design – Bank Stabilization

West Line Road at Tributary
Engineering Design – Bank Stabilization

Site 5a
NRCS Practice 512 – Native Grass Planting

West Line Road at Tributary to Catalpa Creek

Engineering Design – Stream Bank Stabilization



Critical Management Area 2 – Beef Research Unit. Table 5.2.2 identifies the BMPs proposed for implementation during Phase 1 adjacent to the beef research unit where concentrated livestock management operations occur. Descriptions of these practices follow. Refer to Appendix A for details.

Table 5.2.2 Critical Management Area #2 – Beef Research Unit Phase 1 Proposed Management Measures				
NRCS Practice	Site #	[1] Estimated Costs to Fully Implement BMPs (100% Basis)	[2] 319 NPS Eligible Funding (60% of Costs to Fully Implement BMPs)*	[3] Match
561 – Heavy Use Protection (Concentrated Operations)	1j	$48698	$29219	
561 – Heavy Use Protection (Beef Runway)	1k	38862	23317	
342 – Critical Area Shaping/Grading (Heavy)	3d	2214	1328	
382 – Fencing [4]	6b	2879	1727	
410 – Grade Stabilization Structure (Standard Cantilever)	7a	6000	3600	
410 – Grade Stabilization Structure (Standard Cantilever)	7b	6000	3600	
410 – Grade Stabilization Structure (Drop Pipe/Riser)	7c	6000	3600	
410 – Grade Stabilization Structure (Check Dams)	7d	10000	6000	
Estimated Total – Critical Area #2		$120653	$72392	$48261

*Rounding may result in slight differences between column totals and multiplication products.

NRCS Practice 561 – Heavy Use Protection Area. The stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, surfacing with suitable materials, and/or installing needed structures. To provide a stable, non-eroding surface for areas frequently used by animals, people or vehicles and o protect and improve water quality.

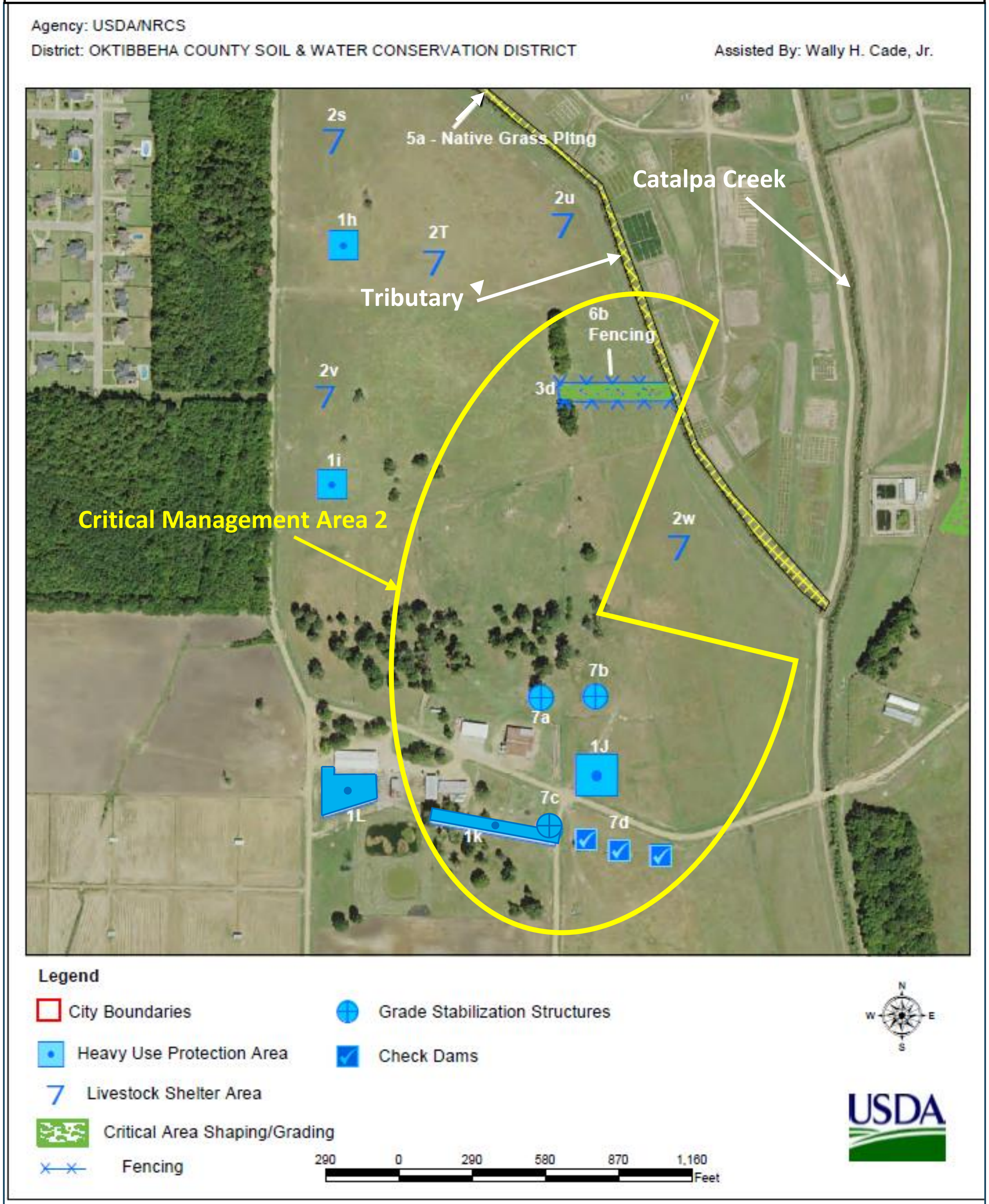
NRCS Practice 342 – Critical Area Shaping/Grading/Planting. Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices. The purpose of this practice is to stabilize the soil, reduce erosion and damage from sediment and runoff to downstream areas, to improve water quality, to improve wildlife habitat, and to improve visual resources.

NRCS Practice 382 – Fencing. Dividing or enclosing an area of land with a suitable structure that acts as a barrier to livestock. To subdivide grazing lands to create additional grazing cell that will allow the implementation of a prescribed grazing system.

NRCS Practice 410 – Grade Stabilization Structure. A structure used to control the grade and head cutting in natural or artificial channels. To stabilize the grade and control erosion in these settings, to prevent the formation or advancement of gullies, and to enhance environmental quality and reduce pollution hazards. Individual structure types include standard cantilever structures, drop pipes/risers, and check dams.

Map 5.2.2 identifies Critical Area #2 and within this area the sites proposed for Phase 1. Other sites will be addressed in future phases.

Map 5.2.2 – Critical Management Area 2
Beef Research Unit—Proposed Phase 1 Best Management Practices



The following photographs document the conditions that exist where Phase 1 BMPs are proposed in Critical Management Area 2.

Site 7a
NRCS Practice 410 – Grade Stabilization Structure (Standard Cantilever)

Site 7a
NRCS Practice 410 – Grade Stabilzation Structure (Standard Cantilever)

Site 7b
NRCS Practice 410 – Grade Stabilization Structure (Standard Cantilever)

Site 7b
NRCS Practice 410 – Grade Stabilzation Structure (Standard Cantilever)

Site 7c
NRCS Practice 410 – Grade Stabilization Structure (Drop Pipe-Riser)

Site 7c
NRCS Practice 410 – Grade Stabilization Structure (Drop Pipe-Riser)

Site 7d
NRCS Practice 410 – Grade Stabilization Structure (Check Dam)

Site 7d
NRCS Practice 410 – Grade Stabilization Structure (Check Dam)

Site 1J
NRCS Practice 561—Heavy Use Protection

Site 1k
NRCS Practice 561—Heavy Use Protection

CRITICAL MANAGEMENT AREA 3 – DAIRY GRAZING AREA. Table 5.2.3 identifies the BMPs proposed for implementation during Phase 1 at a highly eroded dairy grazing area where dairy cows congregate along and degrade the stream bed. Descriptions of these practices follow Map 5.2.3. See Appendix A for details.

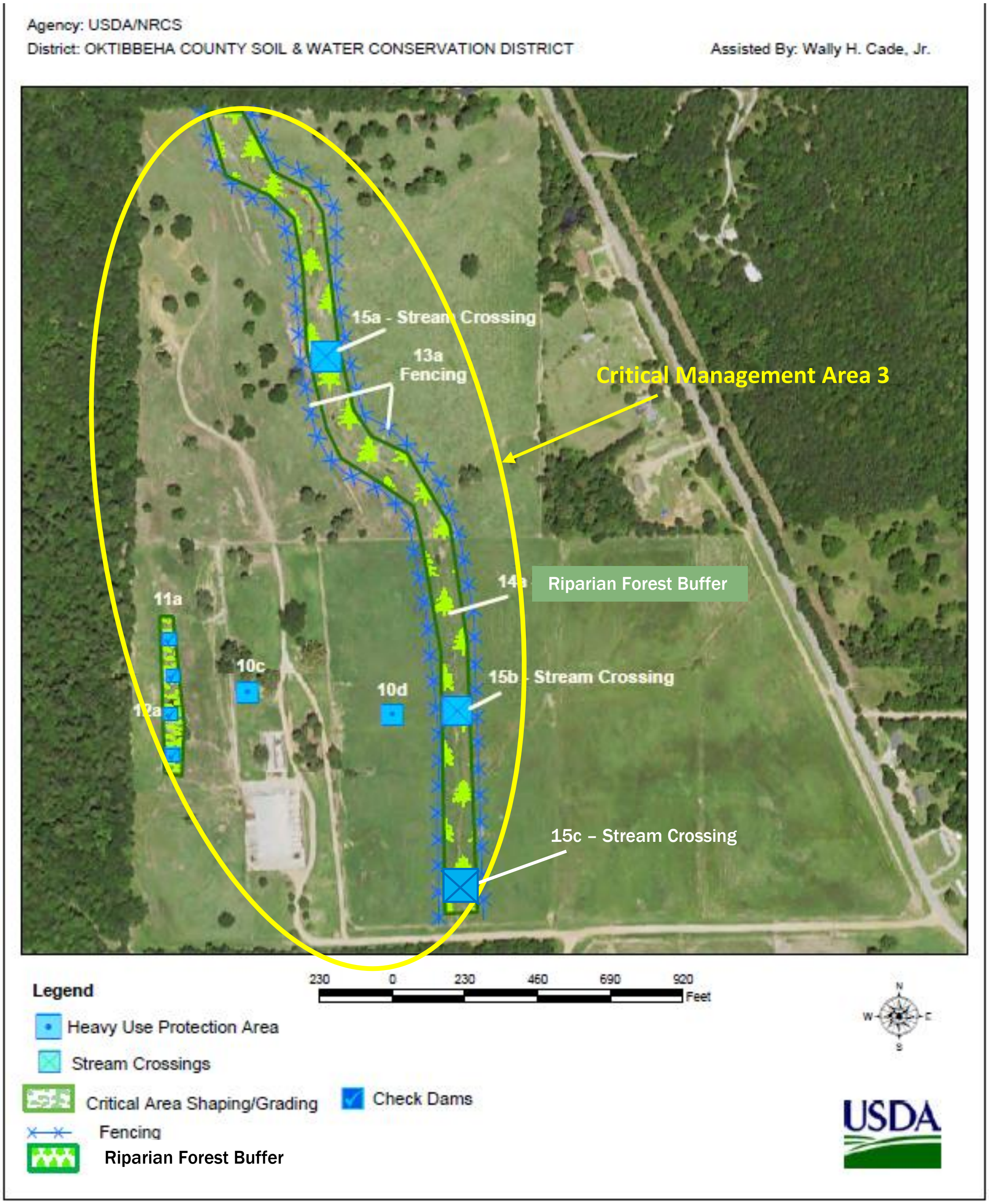
Table 5.2.3
Critical Management Area #3 – Dairy Grazing Area
Phase 1 Proposed Management Measures

NRCS Practice	Site #	[1] Estimated Costs to Fully Implement BMPs (100% Basis)	[2] 319 NPS Eligible Funding (60% of Costs to Fully Implement BMPs)*	[3] Match
342 – Critical Area Planting (Heavy)	11a	$2214	$1328	
410 – Grade Stabilization Structure (Check Dams)	12a	10000	6000	
382 – Fencing [4]	13a	17574	10544	
391 – Riparian/Forest Buffer	14a	3979	2387	
578 – Stream Crossing	15a	4440	2664	
578 – Stream Crossing	15b	4440	2664	
578 – Stream Crossing	15c	4440	2664	
Estimated Total – Critical Area #3		$47087	$28252	$18835

*Rounding may result in slight differences between column totals and multiplication products.

Map 5.2.3 identifies Critical Area #3 and within this area the sites proposed for Phase 1. Other sites (such as 10c and 10d) will be addressed in future phases.

Map 5.2.3 – Critical Management Area 3
Dairy Grazing Area
Proposed Phase 1 Best Management Practices



NRCS Practice 342 – Critical Area Shaping/Grading/Planting. Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices. The purpose of this practice is to stabilize the soil, reduce erosion and damage from sediment and runoff to downstream areas, to improve water quality, to improve wildlife habitat, and to improve visual resources.

NRCS Practice 382 – Fencing. Dividing or enclosing an area of land with a suitable structure that acts as a barrier to livestock. To subdivide grazing lands to create additional grazing cell that will allow the implementation of a prescribed grazing system.

NRCS Practice 391 – Riparian Forest Buffer. An area consisting predominantly of trees and/or shrubs located adjacent to and up-gradient from water sources or water bodies.

NRCS Practice 410 – Grade Stabilization Structure. A structure used to control the grade and head cutting in natural or artificial channels. To stabilize the grade and control erosion in these settings, to prevent the formation or advancement of gullies, and to enhance environmental quality and reduce pollution hazards. Individual structure types include standard cantilever structures, drop pipes/risers, and check dams. Associated practices in this resource concern are 342 and 460.

NRCS Practice 578 – Stream Crossing. A stabilized area or structure constructed across a stream to provide a travel way for livestock. Practice will provide access to another land unit; to improve water quality by reducing sediment, nutrient, organic, and inorganic loading of the stream; and to reduce stream bank and streambed erosion. *(This practice requires fencing off both sides of the stream in which the stream crossing is installed).*

The following photographs document the conditions that exist where Phase 1 BMPs are proposed in Critical Management Area 3. Essentially, streambed restoration and protection will be accomplished through critical area shaping/grading/planting, fencing, and establishing three stream crossings throughout this entire stream reach in addition to establishing a riparian forest buffer and a heavy use protection area. A smaller degraded streambed to the west will require critical area shaping/grading/planting and the installation of a series of check dams.

Site 15a
NRCS Practice 578 – Stream Crossing

Site 15b
NRCS Practice 578– Stream Crossing

Site 15c
NRCS Practice 578 – Stream Crossing

Site 14a
NRCS Practice 391– Riparian Forest Buffer

Site 13a
West Side of Creek
NRCS Practice 382 – Fencing

Site 13a
East Side of Creek
NRCS Practice 382– Fencing

Site 11a
NRCS Practice 342 – Critical Area Shaping/
Grading/Planting (Heavy)

Site 12a
NRCS Practice 410 – Grade Stabilization
Structure (Check Dams)

In addition to the examples of erosion seen in the photographs above of Critical Area #3, a high level of sedimentation can be seen occurring downstream of a road culvert on the south boundary of the dairy grazing area (note the turbid water in the stream and sediment buildup on the stream bank).

ESTIMATED COSTS OF PHASE 1 AGRICULTURAL BMPS. Table 5.2.4 identifies all of the agricultural BMPs proposed for Phase 1 as well as their eligible cost share as determined by NRCS. Installation of these BMPs will be provided by MSU as an in-kind contribution.

Table 5.2.4
Cost Estimates of Phase 1 BMPs

NRCS Practice	Site #	[1] Estimated Costs to Fully Implement BMPs (100% Basis)	[2] 319 NPS Eligible Funding (60% of Costs to Fully Implement BMPs)*	[3] Match
Critical Area #1 – Livestock Forage Area				
561 – Heavy Use Protection (Beef Feeding Area)	1f	$5715	$3429	
561 – Heavy Use Protection (Beef Feeding Area)	1g	5715	3429	
576 – Livestock Shelter Structure	2m	3940	2364	
576 – Livestock Shelter Structure	2p	3940	2364	
576 – Livestock Shelter Structure	2Q	3940	2364	
512 – Native Grass Planting	5a	1693	1016	
382 – Fencing [4]	6a	6666	4000	
342 – Critical Area Planting (Heavy)	Around fences	1107	664	
Bank Stabilization (per NRCS engineering design)	West Line Road	52654	31592	
Estimated Total – Critical Area #1		$85370	$51222	$34148
Critical Area #2 – Beef Research Unit				
561 – Heavy Use Protection (Concentrated Operations)	1j	$48698	$29219	
561 – Heavy Use Protection (Beef Runway)	1k	38862	23317	
342 – Critical Area Shaping/Grading (Heavy)	3d	2214	1328	
382 – Fencing [4]	6b	2879	1727	
410 – Grade Stabilization Structure (Standard Cantilever)	7a	6000	3600	
410 – Grade Stabilization Structure (Standard Cantilever)	7b	6000	3600	
410 – Grade Stabilization Structure (Drop Pipe/Riser)	7c	6000	3600	
410 – Grade Stabilization Structure (Check Dams)	7d	10000	6000	
Estimated Total – Critical Area #2		$120653	$72392	$48261
Critical Area #3 – Dairy Grazing Area				
342 – Critical Area Planting (Heavy)	11a	$2214	$1328	
410 – Grade Stabilization Structure (Check Dams)	12a	10000	6000	
382 – Fencing [4]	13a	17574	10544	
391 – Riparian/Forest Buffer	14a	3979	2387	
578 – Stream Crossing	15a	4440	2664	
578 – Stream Crossing	15b	4440	2664	
578 – Stream Crossing	15c	4440	2664	
Estimated Total – Critical Area #3		$47087	$28252	$18835
Estimated Total – Critical Areas 1, 2, & 3	23 Sites	$253110	$151866	$101244

*Rounding may result in slight differences between column totals and multiplication products.

Notes (on next page):

[1] Estimated Costs to Fully Implement BMPs (100% Basis). The cost estimates provided by NRCS for these BMPs are based upon the FY2016 USDA/NRCS Base Cost Estimate and apply to agricultural producers that have been farming for more than 10 years and do not qualify as a Beginning Farmer, Limited Resource Farmer, or a Socially Disadvantaged Farmer. The Base Cost Estimate, compiled by USDA/NRCS for Mississippi, Arkansas, and Louisiana, is a combined average cost estimate that typically represents 50% of the costs to actually implement the practice in these three States. The estimated costs to fully implement the Phase 1 BMPs listed in the preceding table represent 100% of the total costs (or NRCS' Base Cost Estimate X 2).

[2] 319 Eligible Funding (60% of Costs to Fully Implement BMPs). These costs represent 60% of the estimated costs to fully implement the selected BMPs, which is the amount that is eligible for a 319 NPS funding award (pursuant to other program requirements).

[3] 319 In-kind Match Requirement (40% of Implementation Costs). 319 NPS funding requires a 40% match (in-kind services or monetary contribution). It is anticipated that MSU will contribute in-kind services to install he designated BMPs and cover this requirement.

[4] Fencing Requirements. USDA/NRCS handles requests from agricultural producers that desire to substitute wooden post with metal pipes, angle iron, etc. by first requesting from the producer what is desired for braces, H-braces, corner posts, and line (pull) posts. This information is then provided to the USDA/NRCS State Grazing Land Specialist for consideration of a waiver to use the materials desired by the producer. Normally, MDEQ requires that conservation practices implemented under 319 NPS funds follow USDA/NRCS practice standards and specifications. Because of this, MDEQ's approval would also be required in the event a waiver is requested.

[5] 20% Administrative Management (Indirect) Costs. MDEQ and MSU have negotiated an indirect rate of 20% of the total project components eligible for 319 NPS funding ($220,002) to offset MSU's administrative management costs. This amount is $44,000.

[6] 319 NPS Eligible Costs. Costs eligible for 319 NPS funding support.

Types and Quantity of Phase 1 Agricultural BMP Applications. Table 5.2.5 comprehensively identifies all of the types agricultural BMP applications proposed for Phase 1 and the number of each type.

Table 5.2.5
Cumulative Phase 1 BMPs

Practice/Application	# of Sites
561 – Heavy Use Protection (Beef Feeding Area)	2
576 – Livestock Shelter Structure	3
512 – Native Grass Planting	1
382 – Fencing	3
342 – Critical Area Planting (Heavy)	2
Stream Bank Stabilization	1
561 – Heavy Use Protection (Concentrated Operations)	1
561 – Heavy Use Protection (Beef Runway)	1
342 – Critical Area Shaping/Grading (Heavy)	1

410 – Grade Stabilization Structure (Standard Cantilever)	2
410 – Grade Stabilization Structure (Drop Pipe/Riser)	1
410 – Grade Stabilization Structure (Check Dams)	2
391 – Riparian/Forest Buffer	1
578 – Stream Crossing	3
14 Total Practices/Applications	24 Total Sites

5.3 Phase 1 Urban Storm Water Mitigation Activities

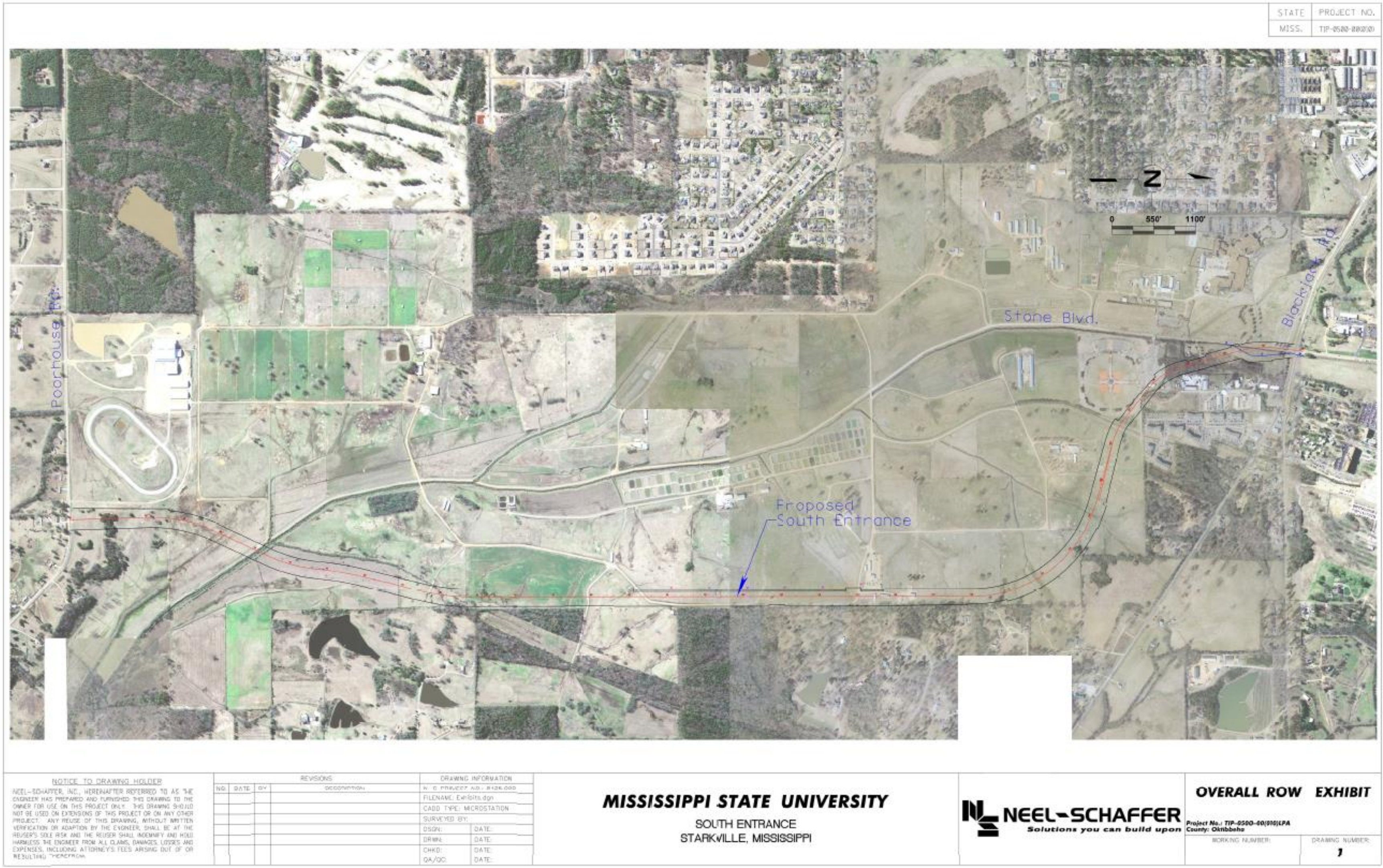
Chapter 11.3 of the *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed* describes in detail components of MSU's Master Plan (2010) that identify both structural and nonstructural management practices to mitigate the harmful effects of urban storm water. During 2015, MSU announced plans to update its Master Plan. As a component of this Phase 1 watershed implementation plan, efforts will be made to engage MSU's Master Planning Committee to incorporate these proposed and future watershed activities into its planning efforts.

Currently, MSU is constructing a new entrance road to the southern portion of its campus. This road will transect South Farm and the headwaters of the Red Bud-Catalpa Creek Watershed by connecting Poor House Road with the south campus entry at Blackjack and Stone Boulevard (see Map 5.3.1). Proposed improvements include application of the Green Corridor concept contained in the Master Plan. During implementation of Phase 1 of this watershed implementation plan, coordination with the Mississippi Agriculture and Forestry Experiment Station's (MAFES') engineer, who also serves as the south entry road project manager, will continue to be a priority.

An additional MSU Master Plan activity for which coordination and potential leveraging will be a Phase 1 focus is developing a hydrologic model for Catalpa Creek. Such a model will have multiple uses – siting and sizing a future storm water retention basin south of the Blackjack and Stone Boulevard entrance, stream restoration design, and urban storm water campus planning.

The City of Starkville is currently in the process of updating its Master Plan. Efforts will be made to engage the City Engineer and identify mutual urban storm water management needs and discuss potential solutions. During Phase 1, Oktibbeha County representatives will also be engaged for the same purposes.

Map 5.3.1
New South Entrance Road to MSU Campus (Under Construction)



New South Entrance Road to MSU Campus (Under Construction)

5.4 Phase 1 Broad Watershed (HUC #031601040601) Activities

Phase 1 activities of this plan are not limited to implementation of agricultural BMPs in the headwaters area of MSU's South Farm. In fact, these activities also focus on the broad 12-digit watershed, HUC #031601040601. Specifically, the following activities are planned to address the entire watershed during Phase 1:

1. Continuous solicitation of watershed restoration and protection resources from a variety of potential sources for future implementation activities by the Funding and Incentives Work Group and other interested parties (this includes annual U.S. Department of Agriculture Requests For Proposals, such as the Regional Conservation Partnership Program and Conservation Innovation Grant Program, as well as recurring cost-share programs, such as the Environmental Quality Incentive Program and Wildlife Habitat Incentive Program);

2. Assimilation and integration of multi-disciplinary data sets related to indicator species, fisheries, biology/habitat, water resources, and other watershed management interests;
3. If resources are available, collection of data to support development of a hydrologic model;
4. If resources are available, development and implementation of social indicators and civic engagement indicator surveys in watershed and metropolitan area;
5. Finalization of a phased implementation plan for the entire Red Bud-Catalpa Creek Watershed and incorporation into a revised *Water Resources Management Plan for the Redbud-Catalpa Creek Watershed.*

5.5 Watershed DREAMS (Demonstration, Research, Education, Application, Management and Sustainability) Centers Activities During Phase 1

Because of the significant interest in the Red Bud-Catalpa Creek Watershed Restoration and Protection Project and the recognition of the potential to leverage these efforts into an ongoing Watershed DREAMS (Demonstration, Research, Education, Application, Management and Sustainability) Center, activities will be planned to advance MSU's Watershed DREAMS concept into fruition. In support of this concept, activities planned during Phase 1 are identified below:

1. Visioning;
2. Planning;
3. Broadening support among the watershed practitioners' community;
4. Engaging potential external stakeholders and users;
5. Identifying and generating resources; and
6. Identifying and capitalizing on leveraging opportunities.

MSU's Watershed DREAMS Center has the potential to be useful to a broad spectrum of interests, including:

- Students through facilitated experiential learning activities – from secondary through college;
- Educators – at all levels;
- Researchers – who desire to design and nest new project concepts into a watershed setting;
- Conservation professionals – where training and CEUs can be made available through appropriate agencies;
- Producers – who desire to learn the latest results and applications of research;
- Policy-makers and legislators – to give them "hands-on" experience as they consider challenging issues;
- Community Service groups – to foster more watershed stewardship; and
- Many more interests.

6 INFORMATION AND EDUCATION (ELEMENT 5 OF EPA'S 9 KEY ELEMENTS)

6.1 GOAL AND OBJECTIVES

The educational goal of this plan is to enhance awareness and knowledge of watershed issues in local, regional and national stakeholders and increase use of watershed conservation/management practices through educational programs associated with the implementation and assessment of best management practices in the Red Bud-Catalpa Creek Watershed. This goal will be achieved through accomplishing the following objectives:

- Demonstrating the effectiveness and benefits of sediment, nutrient, pathogen and other BMPs and water management approaches to a diverse audience of stakeholders.
- Providing for information and technology transfer of current and future watershed management applications to resource managers, water resources planners, agricultural producers, urban and rural residents, University and secondary education students and educators and other stakeholders.
- Increased use of BMP and other watershed protection practices by producers, municipalities and rural/urban residents.

Given the complex nature of the management and recovery of the Red Bud-Catalpa Creek Watershed, a phased approach will be used to address initial concerns. As practices are implemented, monitoring is advanced and funding becomes available, the education/outreach program will be expanded to take full advantage of new opportunities and address other needs. Leveraging with existing programs at MDEQ and others affiliated with state and federal agencies and stakeholder organizations will be pursued. This document describes the first phase of activities for the Technology Transfer, Education/Outreach and Public Relations Team.

6.2 ACTIVITIES AND TIMELINE

Table 6.2.1
Summary of Phase 1 Activities

Target Audience	Activity	Project Year
University Faculty and Students	1. Recruit faculty and provide educational support materials for experiential learning for undergraduate/graduate classes; facilitate coordinated monitoring or modelling efforts by students that may contribute to watershed data	1 – 3
	2. Assess knowledge and perceptions of watershed issues of collaborating faculty and university students	1 – 3
	3. Develop a virtual field trip of the Red Bud-Catalpa Creek Watershed featuring elements of watershed protection, restoration and management (e.g., hydrology, storm water effects, soils, etc.) for use in diverse educational applications	1 – 2

	4. Develop educational background materials (watershed maps, photos, sample data sets, etc.) for distribution for class use	2 – 3
	5. Develop and place educational signage at relevant sites (e.g., at implemented BMP’s) on University property within the watershed	1 – 3
	6. Develop content and presentation format for 8 educational display panels (approx. 3’x5’ each) on watershed function and protection for the Wetland Education Theater on the MSU campus	1
	7. Stream corridor clean-up by MSU student professional groups	
Youth: – Schools – Youth Development Groups – Summer Camp Participants	1. Identify existing watershed educational programs for use for youth outreach; identify gaps that may be addressed by this project	1 – 2
	2. Develop and incorporate a 1/2-day watershed curriculum for 4 annual summer camps	1 – 3
	3. Repair an existing, large-scale, trailer-mounted stream table owned by MSU for use in outreach efforts	1
	4. Develop and offer a one-day Field Day program on watersheds featuring Catalpa Creek for local schools	1, 3
	5. Assess knowledge and perceptions of watershed issues in select youth groups	1 – 3
	6. Develop a virtual field trip of the Red Bud-Catalpa Creek watershed featuring diverse elements of watershed protection, restoration and management (e.g., hydrology, storm water effects, soils, etc.) for use in diverse educational applications	1 – 2
	7. Develop content and presentation format for 8 educational display panels (approx. 3’x5’ each) on watershed function and protection for the Wetland Education Theater on the MSU campus	1 – 3
Educators: – School Teachers – Youth-development leaders (e.g., FFA, 4-H, Envirothon)	1. Identify existing watershed educational programs for use in schools and extracurricular activities; identify gaps that may be addressed by this project	1 – 2
	2. Develop and offer a 1-day workshop for youth formal and informal educators on watershed function and protection featuring Catalpa Creek as a case study	2
	3. Repair an existing, large-scale, trailer-mounted stream table owned by MSU for use in outreach efforts	1
	4. Assess knowledge and perceptions of watershed issues of select Mississippi youth educators	2
	5. Develop content and presentation format for 8 educational display panels (approx. 3’x5’ each) on watershed function and protection for the Wetland Education Theater on the MSU campus	1 – 3
Resource Professionals: – Extension Service Agricultural and Natural Resources Agents – NRCS Personnel	1. Identify existing watershed educational material available for professional development of land specialists; identify gaps that may be addressed by this project	1 – 2
	2. Develop and offer a 1/2-day in-service training for Extension Service personnel featuring Catalpa Creek as a case study	2

	3. Develop and offer a 2-day professional development workshop for NRCS personnel on watershed protection and restoration, incentive programs, BMP's, etc. featuring Catalpa Creek as a case study 4. Repair an existing, large-scale, trailer-mounted stream table owned by MSU for use in outreach efforts 5. Assessment of knowledge and perceptions of watershed issues of MSU Extension Service agents and NRCS personnel; compare with that of stakeholders as reported in the literature	3 1 2-3
Civic Leaders	1. Conduct an informational meeting / listening session with relevant city leaders on the Red Bud-Catalpa Creek Watershed issues related to urban planning, storm water management, etc. 2. Assess knowledge and perceptions of watershed issues of select civic leaders and planners within the Red Bud-Catalpa Creek Watershed	3 3

Needs Assessment of Stakeholders. Effective education begins with an understanding of the knowledge base, perceptions, misconceptions and educational needs of the target audience. Therefore, convenience surveys of community/municipal leaders, public educators (both formal and non-formal; K-16), secondary and post-secondary students and agriculture and natural resources agents from select organizations (i.e., NRCS, MSU Extension Service) will be conducted throughout Phase One to provide baseline information from which more intensive surveys will be developed in Phase Two of the education/outreach plan. Additional stakeholders such as watershed residents, developers and agricultural producers will be also included in similar surveys in later phases of the outreach/education plan.

University Outreach. The contiguity of the Mississippi State University campus within the Red Bud-Catalpa Creek Watershed provides the unique opportunity to provide relevant, experiential learning to undergraduate and graduate students, thereby impacting watershed conservation into the future and beyond the confines of this plan. The close proximity of students, instructors and researchers to watershed elements allows for demonstration (both of impairments and mitigation approaches), case study, land use planning, research and monitoring learning experiences.

Phase 1 activities of the education/outreach plan will include engaging relevant faculty and their undergraduate classes and graduate researchers in watershed experiential learning. The Red Bud-Catalpa Creek Watershed will be used as a case study for water quality monitoring, hydrologic and geomorphological modeling, soil assessments, etc., thus simultaneously promoting learning and baseline data collection. Watershed knowledge and perceptions will be assessed in participating students and faculty to inform future educational needs and approaches.

A virtual field trip, educational signage at BMP's and background data sets associated with the watershed will also be developed to facilitate learning. Furthermore, the Red Bud-Catalpa

Creek Watershed will be featured in the Wetland Education Theater scheduled for construction on the MSU campus in 2017. Eight, large display panels featuring educational text, photographs and figures on watershed function and protection will be incorporated into this larger project focused on the beauty and function of natural wetlands. Classes, tour groups and casual campus visitors will benefit from the informal and experiential learning opportunities associated with this new facility.

Youth Outreach. Mississippi State University has enjoyed a long and successful history in youth education, primarily through programs such as 4-H and FFA which provide development of life skills and promote acquisition of subject area knowledge. Existing connections to youth educational programs (e.g., summer camps) and groups (e.g., area environmental classes and clubs) will be leveraged in Phase 1 of the education. A half-day focus on watersheds will be incorporated into four annual summer camps during each of the three project years. An existing, trailer-based stream table will be renovated to provide a platform for demonstrating hydrological processes to youth and other audiences.

Students from local schools will be invited to the MSU campus for a one-day Watershed Field Day featuring Catalpa Creek during two of the three project years. However, many schools lack the financial support for field experiences; virtual field trips can provide many of the same features and benefits without the associated costs in travel time and expense. We propose to develop in years 1 and 2 of the project a web-based learning tool based upon Catalpa Creek that will highlight watershed function, protection and restoration. Curricula will be linked to the virtual field trip to provide learning opportunities with diverse applications.

Finally, students participating in these various outreach endeavors will be surveyed to determine their perceptions and knowledge of watershed issues. This information will contribute to future assessments of motivations for and barriers against conservation-oriented behaviors in young people that will be conducted in later phases of plan implementation. It will also guide selection and/or development of educational curricula for future project phases.

Educator Outreach. Although there are positive gains to be made through outreach to individuals and small groups, employing a "train-the-trainer" model is decidedly more efficient. Therefore, outreach to those with education responsibilities will be a key component of implementation of the outreach and education efforts associated with this *Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1*.

Teachers in public and private schools, youth development (e.g., 4-H and FFA) leaders and natural resources educators are tasked with improving learner knowledge; this is often best accomplished by showing relevance of the content to the learner. A one-day teacher workshop centered on Catalpa Creek will provide for experiential learning in science, technology, engineering, and math (STEM) topics using a case-study approach. Repair on an existing trailer-based stream trailer will allow for its incorporation to further expand learning about hydrology, stream modification, erosion and other physical factors at work in watersheds.

Educators will also be asked to participate in surveys of their knowledge and perceptions of watershed issues to allow for development and/or modification of curricula to meet educational needs.

Agents' Professional Development. Natural resources agents and personnel with groups such as the Natural Resources Conservation Service and the Extension Service interface with private land owners on conservation and management of natural resources. Watershed protection within agricultural settings remains a priority, yet not all of those tasked with working with the public are fully informed of the challenges associated with watershed protection and/or restoration and the diversity of conservation options available to mitigate issues. Providing current, research-based information on causes of watershed degradation, methods for restoration (e.g., best management practices, incentive programs) and benefits of sound environmental stewardship will promote change and enhance the adoption and implementation of sound management practices.

Civic Leader Outreach. Municipal and campus development in the headwaters of Catalpa Creek Watershed contributes to impairments in the watershed and to storm water management issues. Engaging civic leaders will be imperative in alleviating pressures on Catalpa Creek. This project proposes to host at least one meeting with relevant city leaders to identify their familiarity with watershed concerns and to inform them of available options for addressing the issues of concern.

6.3 PARTICIPANTS, ROLES, AND AFFILIATIONS

Table 6.3.1 identifies the participants, roles, and affiliations of the Technology Transfer, Education/Outreach and Public Relations Team.

Table 6.3.1
Participants, Roles, and Affiliations

Name	Role	Department/Affiliation
Baker, Beth	water quality evaluation/outreach	Wildlife, Fisheries and Aquaculture/Extension Service, MSU
Burger, Leslie	conservation/ environmental education	Wildlife, Fisheries and Aquaculture/Extension Service, MSU
Cade, Wally	soil conservation outreach	Natural Resources Conservation Service
Chapman, Janet	watershed/basin coordination	Mississippi Department of Environmental Quality
Cossman, Ron	social indicators	Social Science Research Center, MSU
Downey, Laura	program evaluation	School of Human Sciences, MSU
Ingram, Richard	water resources research and management	Water Resources Research Institute
Jack, Linda	FFA/Environmental Science instructor	Starkville School District
Neal, Kayla	soil and water conservation	Oktibbeha County Soil and Water Conservation District

Kelly, Lelia	Master Gardener Coordinator/native plant outreach	North MS Research and Extension Center/Extension Service, MSU
Lemus, Rocky	range management	Plant and Soil Science, MSU
Linhoss, Anna	environmental engineering and water resources	Agricultural and Biological Engineering, MSU
Oldham, Larry	soil science outreach	Plant and Soil Science/Extension Service, MSU
Philips, Tommy	human development	School of Human Science, MSU
Tagert, Mary Love	water management science	Agricultural and Biological Engineering/Extension Service, MSU
Smith, Brian	complex system modeling	Industrial and Systems Engineering
Swortzel, Kirk	agriculture education	Agriculture and Extension Education, MSU
Veeder, Deb	watershed outreach	MS Adopt-A-Stream, MS Wildlife Federation, MDEQ

6.4 Proposed Budget

Table 6.4.1 illustrates the proposed information and education budget.

Table 6.4.1
Proposed Information and Education Budget

Category	Activity	60% of Costs	[3] Match
Salaries			
	Project Oversight	$4732	
	Summer Intern/Project Assistance	$12079	
Commodities			
	Trailer Repairs	$1000	
	BMP Signage	3000	
	MSU Classes – Educational Materials	4500	
	Field Day for Local Schools – Materials and Support	2000	
	Profession Development: NRCS Training	5000	
	Educator Workshop	2500	
	In-Service Training: Extension Agents	1000	
	Watershed Management Workshop	500	
	Municipal Leaders' Workshop	250	
	Publication Costs; Educational Materials, Surveys	3000	
Contractual			
	Virtual field trip development	$13900	
Information and Education ----- Estimated Total Costs $89102		$53461	$35641

7 Implementation Schedule (Element 6 of EPA's 9 Key Elements)

Chapter 3 provides an overview of the phased implementation approach that is being designed for the Red Bud-Catalpa Creek Watershed to restore and protect water quality and habitat/ecosystem health, and Chapter 5 describes the proposed management measures (implementation activities) planned for the watershed. This chapter provides a schedule for the implementation of these activities during Phase 1. Activities planned for use of potential 319 NPS funding are noted with *.

<u>Months 1-3:</u> 1. Establish pre-implementation monitoring to establish pre-project baselines*.

<u>Months 1-12:</u>
1. Prepare educational and outreach materials, and facilitate leveraging opportunities for experiential learning applications*;
2. Collect needed data to support development of a hydrologic model;
3. Identify and assimilate South Farm nonstructural management practices/plans to highlight MSU activities;
4. Engage MSU Master Planning Committee to identify collaboration/leveraging opportunities during south entry road construction and Master Plan revision;
5. Engage City of Starkville and Oktibbeha County to discuss storm water management needs in the watershed;
6. If resources are available, develop and implement social indicators and civic engagement indicator surveys in watershed and metropolitan area; and
7. Finalize phased implementation plan for the entire Red Bud-Catalpa Creek Watershed (HUC #031601040601) and incorporate into a revised *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed.*

<u>Months 12-24:</u>
1. Implement Phase 1 agricultural BMPs in headwaters at South Farm*;
2. Implement education and outreach plan*; and
3. Explore/advance collaboration and leveraging opportunities related to storm water management with the MSU Master Planning Committee, City of Starkville, and Oktibbeha County

<u>Months 25-36:</u>
1. Conduct post-implementation monitoring*;
2. Assess water quality and habitat/ecosystem health restoration and protection progress;
3. Implement education and outreach plan*; and
4. Prepare and submit final Phase 1 report

<u>Months 1-36:</u> Solicit additional resources to support monitoring, modeling and implementation activities for the entire Red Bud – Catalpa Creek Watershed

<u>Concurrent:</u> Visioning, planning, identifying and generating potential resources, and identifying leveraging opportunities for MSU's Watershed DREAMS (Demonstration, Research, Education, Application, Management and Sustainability) Center

8 Measurable Milestones and Project Outcomes (Element 7 of EPA's 9 Key Elements)

The identification of measurable milestones and project outcomes are required as Element 7 of EPA's 9 Key Elements of a Watershed Plan.

8.1 Measurable Milestones

Chapter 7 provides a schedule for the implementation of Phase 1 activities. Chapter 8 establishes interim, measurable milestones for determining whether the planned BMPs or other implementation activities are being implemented on schedule and for measuring progress in implementing this plan. The Phase 1 activities listed below will potentially be supported by 319 NPS funding.

Milestone 1	End of Month 3	Pre-implementation monitoring has been implemented.
Milestone 2	End of Month 12	Educational and outreach materials are prepared, and leveraging opportunities for experiential learning planned.
Milestone 3	End of Month 18	All Phase 1 agricultural BMPs are installed in first critical area at South Farm; all planned education and outreach activities for this period have been completed according to schedule.
Milestone 4	End of Month 21	All Phase 1 agricultural BMPs are installed in second critical area at South Farm; all planned education and outreach activities for this quarter have been completed according to schedule.
Milestone 5	End of Month 24	All Phase 1 agricultural BMPs are installed in third critical area at South Farm; all planned education and outreach activities for this quarter have been completed according to schedule.
Milestone 6	End of Month 24	Post-implementation monitoring has been implemented.
Milestone 7	End of Month 36	Final report is submitted to MDEQ.

8.2 Measurable Outcomes

Chapter 10 of the *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed* provides significant narrative and information on the water quality biotic integrity status within the watershed. Also included is a lengthy section that describes an integrated restoration and protection goals and targets related to sediment, pathogens, nutrients, habitat, and social indicators.

9 Monitoring (Element 9 of EPA's 9 Key Elements) and Modeling

9.1 Pre- and Post-BMP Implementation Monitoring

The purpose of this monitoring plan is to assess the ecological integrity of critical areas for restoration in the Catalpa Creek Watershed pre- and post-best management practice (BMP) implementation. Monitoring activities will be performed on Mississippi State University owned lands adjacent to the Catalpa Creek Watershed. Monitoring is being performed to conduct pre- and post-conservation practice implementation water quality measurements in small-scale watersheds utilizing edge-of-field/in-stream monitoring. Three reference sites under similar land use and agricultural management within the same priority watershed will also be monitored to evaluate the effectiveness of these practices for reduction of sediment and nutrients. While sediment is the primary impairment of concern in this watershed, parameters to be analyzed at the Mississippi Department of Environmental Quality include Total Suspended Solids, Ammonia, Total Kjeldahl Nitrogen, Total Nitrite-Nitrate Nitrogen, Total Nitrogen, and Total Phosphorus.

Due to land use in critical areas as well as the presence of developed TMDLs for pathogens in the larger HUC in which the Red Bud-Catalpa Creek Watershed is located, replicate samples will also be collected for microbial analysis at the U.S. Department of Agriculture – Agriculture Research Service, Genetics and Sustainable Agriculture Unit. Water from each replicate will be analyzed with few exceptions as stated in Brooks et al. (2012) for the presence of Escherichia coli (USEPA 1103.1, 2002), staphylococci, enterococci (USEPA 1106.1, 2002), and Clostridium perfringens. Briefly, aliquots of water will be passed through membrane filter (0.45 um) and placed onto appropriate media. E. coli will be plated to mTEC agar at 44.5C overnight, staphylococci onto manitol salt agar incubated at 35C for 48 hours, enterococci plated to mENT agar incubated at 35C for 48 hours, and C. perfringens plated to CP chromoselect agar incubated anaerobically at 44.5C overnight. Selected isolates will be collected and further subjected to confirmation using colony polymerase chain reaction (PCR) and appropriate primers. Additionally, fecal samples will be collected from the surrounding grazing and poultry operations. Similar methods will be applied to these samples. All sites will be pre-monitored/baseline monitored for one year or at least ten sample events prior to BMP implementation. After implementation, BMPs will be monitored for the same amount of at least ten events or one year.

Site Description

Monitoring sites will be downstream of the group of practices (i.e., Critical Management Areas) listed in Table 9.2.1.

Table 9.2.1 Monitoring Sites	
Practices	BMP Site #
Monitoring Site #1 – Critical Management Area 1 (Livestock Forage Area)	
561 – Heavy Use Protection (Beef Feeding Area)	1f
561 – Heavy Use Protection (Beef Feeding Area)	1g
576 – Livestock Shelter Structure	2m
576 – Livestock Shelter Structure	2p
576 – Livestock Shelter Structure	2Q
512 – Native Grass Planting	5a
382 – Fencing	6a
342 – Critical Area Planting (Heavy)	Sites around fences
Engineering Design – Stream Bank Stabilization	West Line Road
Monitoring Site #2 – Critical Management Area 2 (Beef Research Unit)	
561 – Heavy Use Protection (Concentrated Operations)	1j
561 – Heavy Use Protection (Beef Runway)	1k
342 – Critical Area Shaping/Grading (Heavy)	3d
382 – Fencing	6b
410 – Grade Stabilization Structure (Standard Cantilever)	7a
410 – Grade Stabilization Structure (Standard Cantilever)	7b
410 – Grade Stabilization Structure (Drop Pipe/Riser)	7c
410 – Grade Stabilization Structure (Check Dams)	7d
Monitoring Site #3 – Critical Management Area 3 (Dairy Grazing Area)	
342 – Critical Area Planting (Heavy)	11a
410 – Grade Stabilization Structure (Check Dams)	12a
382 – Fencing	13a
391 – Riparian/Forest Buffer	14a
578 – Stream Crossing	15a
578 – Stream Crossing	15b
578 – Stream Crossing	15c
Total	24

WATER QUALITY MONITORING

System description. Site specific monitoring equipment will be the following:

- Pre-measured flow-structure: ditch/pipe section/box
- Depth sensor: OTT PLS pressure level sensor SDI 12 compatible; 0-4m
- Area velocity sensor: Starflow UNIDATA ultrasonic Doppler 2m range
- Automated sampler: SD900 SIGMA Composite sampler
- Manual Rain Gauge at one sampling location; additional precipitation from MSU weather station
- Power Source: Solar Panel 12V, 30W Pole/House mounted with Solar 1205 12V/5A charge controlled and a 12V deep cycle marine battery
- Housing: Framed 6x6’ house.

Sampling Protocol. (See QAPP for full details.) Monitoring will take place year round and the goal of the project is to obtain runoff data from every attainable event. Events on these particular sites will only be rainfall as pasture lands are non-irrigated and there is minimal chance of snow melt. Field crews will check samplers after every storm event to determine if samples were collected. Within 24 hours of storm event cessation, field crews will be on site and undertake the following tasks:

1. Open automated sampler and pour required samples into sampling containers for lab analysis.
   - Samples will include:
     - 1 L sample for inorganics (no acid preservation)
     - 1 L sample for inorganics (acid preserved)
     - 1 L Field duplicate from one random sampling station
     - 1 L container for turbidity measurements
     - 1 L sample for microbial analysis (no preservation)
2. Fill a 1 L sampling container with DI water as a field blank
3. Empty composite sampler and rinse twice with DI water
4. Replace composite sampler and reset sampler
5. Check sample intake for obstructions or debris
6. Check manual rain gauge and record rainfall amount
7. Once over all equipment for defects, tears, obstructions etc.
8. Collect physical water quality parameters of samples, including: pH, DO, Specific Conductance, and temperature
9. Measure Turbidity immediately following sample collection
10. Fill out field data sheet, including chain of custody form for MDEQ

All runoff event samples will be analyzed for the following constituents:

- Ammonium – NH_4-N
- Nitrate+Nitrite – NO_3+NO_2
- Total Kjeldahl Nitrogen – TKN
- Total phosphorus – TP
- Total suspended solids – TSS
- Total Organic Carbon-TOC

VEGETATION ASSESSMENTS

Vegetation will be considered a major ecological assessment factor, where vegetation composition will be measured pre- and post-BMP implementation to serve as a condition indicator. Specifically, this metric is defined as the percent cover of the native plant species, relative to total cover (sum of plant species). This method will be adapted from Faber-Langendoen et al. (2011) and applied to survey the impacted area of each tributary where BMPs will be implemented. Vegetation surveys will be conducted using a 1 meter^2 area to perform grid sampling across the entire area of the BMP site. Fixed belt transects in each of three zones will be sampled in each BMP site. The transects will be 1 meter wide and positioned in the upper, middle, and lower elevations of the stream cross section. Species diversity will be quantified as species richness (Magurran 2013) and evenness (Simpson's Index: Smith and Wilson 1996).

It is the intention of the Planning and Implementation Team to work with MAFES personnel to actively promote the management of invasive species throughout the growing season. The impact of this effort will depend on the ability of team members to establish functional working relationships, which has been actively encouraged by MAFES administration. This work will engage graduate and undergraduate students in the sampling effort. Photographic documentation will also occur at each transect beginning at construction.

Table 9.2.2
Pre- and Post-BMP Implementation Monitoring (Funded by 319 NPS Award)

Project Needs	Total Cost	Pre-BMP Implementation	Post-BMP Implementation	60% of Costs (Federal Contribution)	Match
Transportation of Samples to Jackson		$1438	$1437	$2875	
Equipment (6 samplers/flow meters)		In-kind	In-kind	In-kind	
Supplies (sampling jugs/labels)		300	300	600	
Undergraduate Stipend		5000	5000	10000	
Nutrient Analysis		TBD		TBD	
Microbial Analysis (10/sample x 10)		600	600	1200	
TOTALS	24458			$14675	$9783

9.2 Assessing and Predicting In-Stream Processes in the Catalpa Creek Watershed

Abstract

Excessive erosion and the transport and deposition of sediment in surface waters are major water-quality problems in Mississippi. Researchers in the state have shown that a significant portion of sediment loads exported from the watershed are contributed by streambeds and mostly from active unstable streambanks. The main channel of the Catalpa Creek has been listed as impaired due to sediments from headwaters to the outlet. The *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed* and *Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1* were formulated to restore and protect the ecosystem health, ecosystem services and quality of life, and water resources within the watershed; and create experiential learning activities for students, educators, and practitioners. To develop remedial measures and future BMPs within the Catalpa Creek Watershed for reducing water quality impairment, and a stream restoration design to improve stream morphology, biological integrity and function of the main stream and tributaries, it is necessary to identify stressors, sediment sources and loads currently transported, and critical zones for upland and in-stream management and/or restoration within the entire watershed. Hypothesizing in-stream processes are important mechanisms driving sediment supply into the streams and an important portion of the sediment budget for the Red Bud-Catalpa Creek Watershed. This research will focus on the identification, assessment, evaluation and prediction of in-stream processes within the study watershed. To address the research objectives three sub-studies will be undertaken using a combination of methods including field reconnaissance

and detailed data collection, laboratory analysis, and channel modeling. Modeling results can help to determine critical areas to be potentially considered for future management and restoration activities, as well as to optimize a design for a desired outcome and to understand what results might be expected. Project results will be transferred to a broad group of academic, technical and research stakeholders, supported in collaboration with private, federal and state agencies.

Nature, Scope, and Objectives

Stabilization of active streambanks and reestablishment of hydrologic connectivity between stream channel habitats and floodplain areas is relevant to improve stream corridor health. Although stabilizing streambanks along the main channel might seem a logical mitigation strategy to enhance upstream and downstream water quality, detailed numerical modeling of alternative mitigation strategies is imperative to reduce uncertainty in the effects of any restoration efforts. It is not common for stream restoration efforts to lead to further instabilities if properly planned and analyzed (Pollen et al., 2005).

The present investigation is based on a collaborative effort between MSU and USDA's Agricultural Research Service-National Sedimentation Laboratory (ARS-NSL) to develop a better understanding of the biological and physical characteristics of Catalpa Creek and the factors affecting the occurrence of morphological adjustments (e.g., type of threats, streambank/streambed erosion rates, sediment contribution from streambanks, restoration designs). The effort is ultimately expected to support implementation of management practices in the watershed and future restoration activities in Catalpa Creek.

This research will focus on the identification, assessment, evaluation and prediction of instream processes within the study watershed. Specific objectives include i) to evaluate spatial and temporal variation of suspended sediment transport rates, and an initial assessment of dominant mechanisms driving sediment supply and exportation within and from the Catalpa Creek; ii) to quantify in-stream erosion/deposition rates and determine the conditions and factors affecting those rates on different areas within the Catalpa Creek Watershed; and iii) to assess the application of the USDA-ARS CONservational Channel Evolution and Pollutant Transport System (CONCEPTS) model to predict in-stream processes and develop a sediment budget, and evaluate stream restoration design scenarios along the Catalpa Creek.

Methods, Procedures, and Facilities

To address the research objectives, this project will undertake three sub-studies using a combination of methods including field reconnaissance and detailed data collection, laboratory analysis, and channel modeling in order to assess the actual contribution of in-stream processes to sediment loads within the Red Bud-Catalpa Creek Watershed.

Sub-study 1. *Analysis of spatial and temporal variation of suspended sediment transport rates and initial assessment of dominant mechanisms driving sediment supply and exportation for the Catalpa Creek*.

The project will start on March 1st, 2017. Initial field reconnaissance will help to identify potential locations to develop systematic survey assessments to characterize physico-chemical (water quality), hydrological (flow analysis) and biological and habitat (macroinvertebrates) conditions. The biological and habitat assessment will be performed in collaboration with the staff of the Mississippi Wildlife Foundation's Adopt-A-Stream Program in Mississippi (supported by MDEQ's 319 NPS Program). Automatic monitoring stations will be set-up at three different locations along the main channel (upper 4 miles) to collect stormflow water samples and water flow velocity and depth measurements. Routine base flow grab samples will be collected weekly from at least 15 locations along the main channel and tributaries of the Catalpa Creek. Insitu testing will include the assessment of the physio-chemical (e.g. pH, temperature, total dissolved solids, dissolved oxygen concentration) and hydraulic (e.g. flow velocity and depth) characteristics of the flow. Grab samples will be subjected to laboratory analyses at the Kelly Gene Cook Environmental Lab to determine suspended sediment concentrations of all collected water samples. Relationships between flow discharge and sediment loads (sediment rating curves) will be constructed and related to the stage of channel evolution as proposed by Simon (1989). Establishing these relationships will initially indicate the spatial variation in suspended transport efficiency, trends and possible mechanisms driving sediment supply and exportation along and from the creek (e.g., streambed erosion, streambank erosion, and/or aggradation).

Sub-study 2. *Assessment of in-stream erosion or deposition rates along the main channel reach and main tributaries*.

Approximately 20 cross-section transects will be initially surveyed along the upper 4 miles on the main channel and tributaries by using a Real Time Kinematic (RTK) GPS system (TOPCON Hiperlite Plus) at the beginning of the study. Selected cross sections will include active and stable streambanks. Transects will be resurveyed after stormflow events or monthly, if stormflow events are not observed in a shorter period of time. The depth of streambank widening or contraction, and the changes in streambed elevation will be estimated for each survey. Volume and mass of eroded streambank and streambed material will be assessed by comparing cross section changes in different surveying dates. A total event, seasonal and annual load will be estimated considering individual transects and the entire reach in evaluation.

Sub-study 3. *Assessing the application of the computational model CONCEPTS and HECRAS, to predict in-stream processes, develop a sediment budget within the Catalpa Creek watershed, and evaluate stream restoration design scenarios*.

The computational model CONCEPTS will be evaluated (calibrated) on the surveyed stream segments to assess model performance and capability to simulate temporal and spatial streambanks and streambed changes and sediment transport along the entire studied reach. The model will be set up using information collected from Sub-studies 1 and 2. Additional information needed to set up the model, such as streambank and streambed material characteristics (e.g. particle size distribution, bulk density, organic matter content) and streambank stability parameters (e.g., critical shear stress, erodibility, soil cohesion, friction angle) will be collected *in-situ* at each individual cross section, for each individual side.

Researchers from ARS-NSL will support this task by lending the required testing equipment (i.e. jet test device, bore-hole shear test device) and training the project team in their use and results management. The calibrated model will be tested for proposed stabilization scenarios on most active streambanks. A sediment budget will be assessed by using the subroutine Sediment Impact Analysis Methods (SIAM) included in the Hydrologic Engineering Center-River Analysis System (HEC-RAS) model.

Statement of Results, Benefits, and/or Information Expected to be Gained

The proposed research effort first intends to provide qualitative and quantitative identification, and temporal and spatial variability and distribution of hydraulic and channel characteristics, stages of channel evolution, representative in-stream processes (e.g. streambank undercutting and instability, streambed erosion or deposition, and sediment transport and sediment supply), and the definitive identification of these processes as the driving mechanism of sediment supply within, and from the watershed. Collected and generated information will be used to produce a calibrated model for hydraulic, sediment transport and channel evolution conditions and a sediment budget for the Catalpa Creek, which will become important pieces to plan the development of a stream restoration design that will aim at long-term to improve stream morphology, biological integrity, and function of the Catalpa Creek.

In addition with the benefits described above, the project will be valuable for the development of maintenance and operation plans for in-stream BMPs, justification for continued government and private expenditures in conservation, reduced labor costs associated with survey tasks such as pre-/post-construction surveys and cut/fill analysis. The project activities and results will be presented and transferred to a broad group of stakeholders including watershed citizens, the entire MSU campus community, Starkville schools, and private, state and federal agencies related to the quality improvement of the Catalpa Creek, an EPA 319(h) priority watershed. Generated publications will include research reports, peer-reviewed journals papers and professional conference presentations and proceedings.

Project Term, Amount of Funding, and Funding Source

The term of this project is March 1, 2017-February 28, 2018. The total funding level of this project is $65,818. Non-federal funding is $44,155. Funding is provided through MWRRI’s 104b Water Resources Research Grant Program.

9.3 Applied Use of Unmanned Aerial Vehicles in Surface Water Protection

Abstract

Erosion represents a significant detriment to Mississippi’s surface waters, as a source of both chemical (i.e., phosphorus) and physical (i.e., sediments) pollutants. Accordingly, erosion

control will be necessary for maintaining the quality of Mississippi's surface water resources, and identifying and monitoring erosion in critical areas will enable stakeholders to better manage the State's water resources by addressing a key source of degradation. The objective of this research is to evaluate the accuracy of erosion calculations derived from Structure from Motion (SfM) captured with unmanned aerial vehicles (UAVs). The research project will combine results from SfM assessments of erosion with ground-truthed measurements of erosion to determine the accuracy of this approach for use in calculating erosion values, and extend this approach to evaluate the ability of SfM to monitor erosion over time. Derived values will be incorporated into existing models (e.g., BSTEM, CAESAR-Lisflood) to determine if SfM data are a valid model input. Data will be collected from MSU-owned and managed research properties where significant erosion has been identified; some of these sites are within an EPA-designated 319(h) priority watershed. The result of this research is a scientific validation of the accuracy of erosion calculations derived from UAV-collected SfM assessments. When used appropriately, UAVs have the potential to enable rapid assessment of landscapes with reduced labor costs. The research serves as a proof-of-concept project to develop a method by which UAVs could be employed to identify, quantify, and monitor erosion in drainage channels and other eroded areas. This would enable federal, state, and local agencies to utilize this technology to more efficiently monitor, remediate, and regulate degradation of surface waters. Outputs from this research project include transfer of information on the appropriate data collection strategies for UAV-based SfM assessments, as well as best practices, along with methods, estimates of accuracy, and any necessary cautions. This data will be communicated to stakeholders through scientific exchange and interaction, in addition to the established University Extension network.

Nature, Scope, and Objectives of Project

The objective of this research is to evaluate the accuracy of erosion calculations derived from Structure from Motion (SfM). Structure from Motion is a technique which relies on the concept of parallax to estimate 3D surfaces from 2D images. This technique has more recently been accomplished with UAVs to create digital surface models for other applications. At present, SfM is gaining acceptance as a low-cost alternative to other methods which estimate surface topography (e.g., LIDAR, terrestrial laser scanning). The research project will combine results from SfM assessments of erosion with ground-truthed measurements of erosion to determine the accuracy of this approach for use in calculating erosion values, and extend this approach to evaluate the ability of SfM to monitor erosion over time. Derived values will be incorporated into existing models to determine if SfM data are a valid model input. Because of the nature of the data, imagery is being collected which may show surface water quality impacts from erosion. This data will be investigated for the potential to perform pollution monitoring and tracking, but this is not the primary purpose of this research.

Methods, Procedures, and Facilities

An investigation is proposed to be performed at MSU research locations, including Foil, Andrews, Bearden, and Leveck research properties, all located near the main campus in Starkville, MS. All locations have drainage ditches and additional areas of the property which exhibit erosion, evidenced by channel incision and sidewall cutting; in some cases this erosion is quite substantial (Figure 1). In fact, the Bearden and Leveck locations are located in the Red Bud-Catalpa Creek Watershed, which was recently designated as an EPA 319(h) priority watershed. This system is listed as impaired under Section 303(d) of the Clean Water Act for its sediment load, among other pollutants, making these locations ideal testbeds.

A multirotor UAV will be utilized to perform SfM analysis and monitoring of erosion over the course of the study period. Imagery will be taken with a significant (70%) frontal and side overlap between successive images to create a dense point cloud of images. Identifiable structures in each image (e.g., telephone poles, plot markers, sewer caps) will be used to align the images properly. Geographic coordinates for these structures can be used to further increase the accuracy of the alignment, thus target research locations will be marked and geotagged appropriately. UAV missions will be conducted at no less than monthly intervals for the first 10 months of the study period, with the remaining two months reserved for data analysis and information transfer.

Concurrent with UAV imagery collection, field data will be collected to provide ground-truthing information. Cross-section transects along the channels of Sand and Catalpa Creeks near active gullies, and morphological characteristics of these channel cuts will be surveyed using a Real Time Kinematic (RTK) GPS system at points of interest at the beginning and end of the UAV data collection period (months 0 and 10), and after individual rainstorm events during the first 10 months of the research. The depth of streambank widening or contraction, and the displaced volume of soil in gullies will be estimated for each survey. Volume and mass of eroded streambank and streambed material will be assessed by comparing cross-section changes between surveys. Displaced volume of soils in gullies will be estimated using the direct computation method included in the Part 650 - Engineering Field Handbook of the USDA Natural Resources Conservation Service National Engineering Handbook (NRCS, 2012). Additional information, such as streambank and streambed material characteristics (e.g. particle size distribution, bulk density, organic matter content) and streambank stability parameters (e.g.. critical shear stress, erodibility, soil cohesion, friction angle) will be collected in-situ at each individual cross-section, for each individual side, as these are necessary for model incorporation.

Additional physical measurements will be taken in the field to monitor dimensionality of sheet, rill, and gully erosion identified as study sites. Markers will be also placed which passively illustrate erosion, and which will be captured in UAV imagery as well. In order to accomplish the primary research objective, field and SfM measurements will be compared to evaluate the agreement between the two methods. To capture the ability of this method to monitor erosion over time, change detection analysis will be performed on the time series of SfM surfaces to determine the extent and location of erosion, and monitor development of additional erosion in these research areas. Field data collected will be used to validate change detection analysis. In order for an agency of other stakeholder to derive value from erosion estimates, the data must be readily usable for decision making. Accordingly, we propose to evaluate the ability of SfM erosion surfaces to be incorporated into existing models which offer predictive capacity.

The selected models include BSTEM and CAESAR-Lisflood. Both models are driven by surface elevation models and site characteristics related to soil parameters. BSTEM (Bank Stability and Toe Erosion Model) is a model developed by the National Sedimentation Laboratory in Oxford, Mississippi (Simon et al., 2000), in order to predict streambank retreat due to both fluvial erosion and geotechnical failure. To model bank stability, BSTEM calculates a factor of safety (FoS) using three different limit equilibrium-method models: horizontal layers, vertical slices, and cantilever shear failure. As many river management situations require information on the stability of the channel banks, the use of the tool may facilitate predicting the effect that changes in riparian land use, or designing new channels, may have on the stability of studied channels. CAESAR (Cellular Automation Evolutionary Slope and River)-Lisflood (Coulthard et al., 2012; Coulthard et al., 2013) is a downscaled landscape evolution model which has been selected based on its key advantages. First, using a landscape evolution model in lieu of a soil erosion model results in better simulation of fluvial erosion and deposition. Second, a landscape evolution model better represents dynamic interactions between topography, flow, and sediment transport, which are missed by some soil erosion models (Coulthard et al., 2012). Moreover, the CAESAR-Lisflood model is free and open-source, available to anyone with the scientific capacity to collect the necessary data.

Statement of Results, Benefits, and/or Information Expected to be Gained

The result of this research is a scientific validation of the accuracy of erosion calculations derived from UAV imagery. The research serves as a proof-of-concept project to develop a method by which UAVs could be employed for this purpose. This project has broad and limitless applicability. This is because (1) the issue of erosion is ubiquitous in managed landscapes and (2) UAVs are immediately accessible in the marketplace to anyone with sufficient (as low as $500) funds. This research creates enabling technology for future research endeavors and use by stakeholders for necessary data collection to drive their decision making ability. The long-term benefits include those items previously listed under section 13. Some additional benefits include development of maintenance and operation plans for BMPs, justification for continued government and private expenditures in conservation, and reduced labor costs associated with survey tasks such as pre-/post-construction surveys and cut/fill analysis. In short, assessing erosion with UAVs would be a significant application of UAV technology with tangible economic benefits that could be implemented in the near-term future.

The leveraged skills of the investigators include backgrounds in agricultural, civil, and environmental engineering, along with soil science and agronomy. Each investigator has also participated in research on water quality and the applied use of geospatial technologies. The cross-disciplinary research approach of this project (speaking more academically) also fills knowledge gaps noted in recent scientific literature which call for more attention to spatially explicit research on soil erosion which considers anthropogenic influences (Svoray et al., 2015), specifically at fine-spatial and medium-temporal scales (Ciampalini et al., 2012), and an identified need (Guzmán et al., 2013) for inexpensive, rapid analysis approaches that quickly process a large number of samples for tracer-based soil erosion studies. This is accomplished by utilizing an inherently-spatial model, and also finer-scale spatial and temporal erosion research, as the UAVs can be flown on demand (temporal) and at low altitudes (spatial); because of the nature of the images taken, geographic information systems can be employed to perform analyses on the impact of land use and management. It also provides an inexpensive, rapid assessment tool which overcomes the limits of tracer studies by eliminating the need for tracer data. This additionally fills a research gap within the technical side of the project which calls for more investigation into the accuracy of the proposed methods (detailed in section 15) in different environments (Fonstad et al., 2013; Mancini et al., 2013).

Project Term, Amount of Funding, and Funding Source

The term of this project is March 1, 2017-February 28, 2018. The total funding level of this project is $45,676. Non-federal funding is $30,423. Funding is provided through MWRRI's 104b Water Resources Research Grant Program.

9.4 Hydraulic Model to Support Conservation and Ecosystem Restoration Efforts within an Impaired, Priority Watershed

Abstract

Over the past several years, there has been an increased awareness on the part of Mississippi Agriculture and Forestry Experiment Station (MAFES) administration and faculty that remedial actions must be taken to address erosion and flooding issues associated with Catalpa Creek, the major outflow channel and drainage system emanating from the main campus of MSU and through the H.H. Leveck Animal Research Facility. Under leadership from the Mississippi Water Resources Research Institute (MWRI) at MSU, in conjunction with MAFES, 21 units on campus have contributed to a comprehensive watershed management plan to restore the Red Bud-Catalpa Creek Watershed, demonstrating MSU's ability to be a leader in conservation demonstration, teaching, and research. With the recent designation of this watershed as an EPA 319(h) priority watershed, there are expectations of monitoring and assessment on the part of MSU. Many state agency personnel have identified a hydraulic model as a needed planning and implementation component of conservation efforts on MSU-owned properties. This research will focus on the identification, assessment, evaluation and prediction of in-stream processes within the study watershed, so that such a hydraulic model can be developed. This research will generate information and tools necessary to inform targeted placement of BMPs, as well as predict and monitor improvements to impairments within Catalpa Creek, enabling future efforts in demonstration, research, and experiential learning for MSU. This supports the mission and vision set forth in the watershed management plan which was authored by MSU as a first step in obtaining EPA 319(h) funding for this watershed.

The PI (Dr. Tim Shauwecker) and Co-PI (Dr. Joby Czarnecki) for this proposal are members of the Steering Committee for the overall watershed project. Additionally, the PI is co-chair of the Planning and Implementation Team and the Co-PI is co-chair of the Funding and Incentives Team. The recent efforts of this multi-disciplinary team have resulted in the designation of the

Red Bud-Catalpa Creek Watershed as an EPA 319(h) priority watershed, and an anticipated award from the Mississippi Department of Environmental Quality and U.S. EPA to restore water quality within the watershed. This anticipated 319(h) award represents an investment in excess of $450,000 from MDEQ/EPA and MSU. Several documents have been established which guide this process, among these are a comprehensive water resources management plan and this implementation plan for the first phase of effort. This process is designed to promote MSU as an exemplary example of functional conservation, which also provides demonstration, research, and experiential learning opportunities.

During the first phase, 14 different NRCS-described best management practices will be installed at 24 locations in the headwaters of the watershed on the Leveck and Bearden research facilities. Phase 1 installations target infield erosion sources which represent intermittent tributaries to Catalpa Creek. However, within the main channel of Catalpa Creek, there is a significant problem with flooding and back flow, contributing to channel incision, streambed outcrop, undercutting, streambank instability, and turbidity/sediment issues. Additional conservation efforts will be necessary to address these issues. It is the expectation of EPA 319(h) funded projects that monitoring and assessment will occur in tandem with installations of best management practices, so that success stories can be generated which assign economic and ecologic value to investments in conservation. One crucial element in this process is development of an accurate hydraulic model. This model is necessary to predict how remedial measures will affect water quality impairment, and will aid in placement of best management practices which improve morphology, biological integrity and function of the main channel of Catalpa Creek. This model relies on identification of stressors, sediment sources and loads, and critical zones. Further, an understanding of in-stream processes (streambank undercutting and instability, bed erosion or deposition, and sediment transport) is crucial for addressing important mechanisms which contribute to sediment loading and an important portion of the sediment budget for the Red Bud-Catalpa Creek Watershed. Sediments are one of the major impairments for which this watershed is listed under the section 303(d) of the Clean Water Act, and in order to provide the information MSU will be obligated to report, a hydraulic model is indispensable.

Approach

This research will focus on the identification, assessment, evaluation and prediction of instream processes within the study watershed. Specific objectives include i) to evaluate spatial and temporal variation of suspended sediment transport rates, and an initial assessment of dominant mechanisms driving sediment supply and exportation for the Catalpa Creek; ii) to quantify in-stream erosion/deposition rates and determine the conditions and factors affecting those rates on different areas within the Catalpa Creek watershed; and iii) to assess the application of the computational model Hydrologic Engineering Center River Analysis System (HEC-RAS), to predict in-stream processes an develop a sediment budget within the Catalpa Creek watershed. To address the research objectives, the present research will undertake three sub-studies using a combination of methods including field reconnaissance and detailed data collection, laboratory analysis, and channel modeling in order to assess the actual contribution of in-stream processes to sediment loads within the Red Bud-Catalpa Creek Watershed.

Sub-study 1. *Analysis of spatial and temporal variation of suspended sediment transport rates and initial assessment of dominant mechanisms driving sediment supply and exportation for the Catalpa Creek.*

Automatic water samplers will be set-up at three different locations along the main channel (upper 4 miles) to collect stormflow water samples and water flow velocity and depth measurements. Routine base flow grab samples will be collected weekly from at least 15 locations along the main channel and tributaries of the Catalpa Creek. In-situ testing will include the assessment of the physio-chemical (e.g., pH, temperature, total dissolved solids, dissolved oxygen concentration) and hydraulic (e.g. flow velocity and depth) characteristics of the flow. Grab samples will be subjected to laboratory analyses at the Kelly Gene Cook Environmental Lab to determine suspended sediment concentrations and turbidity of all collected water samples. Relationships between flow discharge and sediment loads (sediment rating curves) will be constructed and related to the stage of channel evolution as proposed by Simon (1989). Relationships would bring an initial indication of the spatial variation in suspended transport efficiency along the creek and trends and possible mechanisms along the creek (e.g. streambed erosion, streambank erosion, aggradation) driving sediment supply and exportation. Because many of the erosion problems within Catalpa are driven by management practices which remove beneficial vegetation, vegetative cover is perceived to play a pivotal role in regulating sediment supply. Thus, another avenue of data collection under this sub-study will be to assess the relationship between vegetative cover and streambank erosion. Vegetative cover in a 1-m wide belt transect, running parallel to each confluence of tributary and main channel, will be quantified in February, June, and October to observe and monitor community competition. Multivariate and canonical correspondence analysis will be used to determine the relationships between soil characteristics, vegetative cover, and streambank erosion.

Sub-study 2. *Assessment of in-stream erosion or deposition rates on periodically surveyed cross sections on the incised streambanks along the 4 miles channel reach and main tributaries.*

Approximately 18 cross-section transects will be initially surveyed along the upper 4 miles on the main channel by using a Real Time Kinematic (RTK) GPS system (TOPCON Hiperlite Plus) at the beginning of the study. Selected cross sections will include at least 20 transects considering active and stable streambanks. Transects will be resurveyed after a stormflow event occurs. The depth of streambank widening or contraction will be estimated for each survey and related. Volume and mass of eroded streambank and streambed material will be assessed by comparing cross section changes in different of surveying dates. A total annual load will be estimated considering individual transects and the entire reach in evaluation.

Sub-study 3. *Assess the application of the computational model HEC-RAS, to predict in-stream processes and develop a sediment budget within the Catalpa Creek watershed*.

The computational model HEC-RAS will be evaluated (calibrated and validated) on the surveyed reach segment to assess model performance and capability to simulate temporal and spatial streambanks and streambed changes and sediment transport along the entire studied reach. The model will be setup using information collected from Sub-studies 1 and 2. Additional information, such streambank and streambed material characteristics (e.g. particle size distribution, bulk density, organic matter content) and streambank stability parameters (e.g. critical shear stress, erodibility, soil cohesion, friction angle) will be collected in-situ at each individual cross section, for each individual side. The calibrated model could be tested for proposed stabilization scenarios on most active streambanks. A sediment budget will be assessed by using the subroutine SIAM included in HEC-RAS.

Anticipated Outcome

This research will generate information and tools necessary to inform targeted placement of best management practices, as well as predict and monitor improvements to impairments within Catalpa Creek, enabling future efforts in demonstration, research, and experiential learning for MSU. The generated information and calibrated model will be an important piece in the overall long term goals of developing a stream restoration design which improves stream morphology, biological integrity and function of the Catalpa Creek. In addition to the hydraulic model, the vegetation information collected can also be used to develop management goals and timelines for riparian habitat restoration along the main channel. This supports the mission and vision set forth in the watershed management plan which was authored by MSU as a first step in obtaining EPA 319(h) status for this watershed.

Potential Impact

First and foremost, this project is intended to be a step towards remediating impairments, protecting soil and water resources, and restoring the ecosystem services of Catalpa Creek and its tributaries on MSU-owned properties and private lands. Beyond the obvious, this project, as conceptualized, creates significant opportunities for MSU. These include taking self-initiative to mitigate a documented water quality problem rather than allowing the problem to persist and risk the potential for an externally-mandated solution; creating opportunities for significant federal, state and private investment into the project; generating new opportunities for applied research to develop innovative approaches to address water resources challenges; highlighting MSU’s capacity in the water resources restoration and protection arena for managers and policy-makers; and developing innovative experiential learning activities for students and educators. Additionally, the project will create experiential learning opportunities for four undergraduate students.

Project Term, Amount of Funding, and Funding Source

The term of this project is January 1-December 31, 2017. The funding level of this project is $33,300. Funding is provided through MAFES’ Special Research Initiative (SRI).

9.5 ASSESSING SOIL EROSION WITH UNMANNED AERIAL VEHICLES FOR PRECISION CONSERVATION

ABSTRACT

Soil erosion is a primary conservation concern due to impacts to soil health, land productivity, and surface water quality. Despite the increased implementation of conservation practices on the landscape, erosion remains a threat to agricultural sustainability. To fill a knowledge gap in the body of work on soil erosion, an unmanned aerial vehicle (UAV) will be utilized to perform Structure from Motion (SfM) analysis and monitoring of erosion over the course of the study period. Structure from Motion is a technique which relies on the concept of parallax to estimate 3D surfaces from 2D images. An investigation is proposed to be performed at local MAFES Research locations, including Foil, Andrews, Bearden, and Leveck research centers. All locations have drainage ditches and additional areas of the property which exhibit erosion, evidenced by channel incision and sidewall cutting; in some cases this erosion is quite substantial. SfM surfaces will be examined using change detection analysis, as well as modeling approaches, to validate the use of UAV-collected SfM data as a tool for quantifying erosion. Additional field data will be collected to validate SfM 3D surfaces and model outputs. This proof-of-concept study addresses the need for more spatially-explicit erosion research and also provides an inexpensive, rapid assessment tool which overcomes the limits of tracer studies. This project has broad and limitless applicability with few barriers to transferability, and should a successful outcome be achieved, the method could be widely adopted.

RELEVANT BACKGROUND

Soil erosion is a primary conservation concern due to impacts to soil health, land productivity, and surface water quality. Many best management practices (BMPs) are advocated for either reducing erosion (e.g. cover crops, reduced or no-till farming) or trapping resultant sediment in runoff (e.g., vegetated buffer strips, slotted inlet pipes). Despite the increased implementation of BMPs on the landscape, erosion remains a threat to agricultural sustainability (Montgomery, 2007). Quantitative studies on erosion are necessary to provide a basis for effective conservation and land management strategies (Guzmán et al., 2013).

This research proposal is motivated by several knowledge gaps noted in recent scientific literature. In short, more attention must be given to spatially-explicit research on soil erosion which considers anthropogenic influences, such as land use and management (Svoray et al., 2015), specifically at fine-spatial and medium-temporal scales (Ciampalini et al., 2012). At the same time, Guzmán et al. (2013) identified a need for inexpensive, rapid analysis approaches that quickly process a large number of samples for tracer-based soil erosion studies, noting that tracer studies are currently hampered by the uncertainty associated with the conversion of tracer concentration into erosion rates. The proposed research supposes both knowledge gaps can be addressed with Structure from Motion (SfM) techniques and downscaled landscape evolution models.

APPROACH

An investigation is proposed to be performed at local MAFES Research locations, including Foil, Andrews, Bearden, and Leveck research centers. All locations have drainage ditches and additional areas of the property which exhibit erosion, evidenced by channel incision and sidewall cutting; in some cases this erosion is quite substantial (**Error! Reference source not found.**). Additionally, these locations are subject to a diverse mix of land management practices due to their use as research facilities for a variety of different applications. This offers an opportunity for multiple investigations into the role management plays in preventing or promoting erosion.

Taking advantage of MSU's investment in UAV resources, a multirotor aircraft will be utilized to perform SfM analysis and monitoring of erosion over the course of the study period. Structure from Motion is a technique which relies on the concept of parallax to estimate 3D surfaces from 2D images. This technique has more recently been accomplished with unmanned aerial vehicles (UAV) to create digital surface models. Data are taken with a significant (70%) frontal and side overlap between successive images to create a dense point cloud of images. Identifiable structures in each image (e.g., telephone poles, plot markers, sewer caps) are used to align the images properly. Geographic coordinates for these structures can be used to further increase the accuracy of the alignment, thus target research locations will be marked and geotagged appropriately. At present, SfM is gaining acceptance as a low-cost alternative to other methods which estimate surface topography (e.g., LIDAR, terrestrial laser scanning). To perform the proposed research, SfM surfaces will be created for locations over time. Change detection analysis will be performed on the time series of SfM surfaces to determine the extent and location of erosion, and monitor development of additional erosion in these research areas. Field data will be collected to validate change detection analysis.

Recently SfM was evaluated for its potential to estimate bank erosion in agricultural drainage ditches and results were favorable for the use of SfM to not only identify eroded areas, but also to quantify sediment erosion and deposition volumes (Prosdocimi et al., 2015). In order to evaluate deposition and movement, SfM data will be utilized with the Cellular Automation Evolutionary Slope and River (CAESAR)-Lisflood model (Coulthard et al., 2012; Coulthard et al., 2013), a downscaled landscape evolution model. Although there are multiple model options available, this specific model has been selected based on three key advantages. First, using a landscape evolution model in lieu of a soil erosion model results in better simulation of fluvial erosion and deposition. Second, a landscape evolution model better represents dynamic interactions between topography, flow, and sediment transport, which are missed by some soil erosion models (Coulthard et al., 2012). Third, CAESAR-Lisflood has low initial input variables, requiring only a digital elevation model, rainfall data, and soil particle size. SfM will be used to derive the digital elevation model, rainfall data will be gathered with rain gauges which will be instrumented on-site, and field data will be taken to obtain soil particle size. Additional field data will be collected to validate SfM 3D surfaces and CAESAR-Lisflood model outputs.

This proof-of-concept study addresses the need for more spatially-explicit erosion research by utilizing an inherently-spatial model, and also finer spatial and temporal scale erosion research because the UAVs can be flown on demand (temporal) and at low altitudes (spatial). It also provides an inexpensive, rapid assessment tool which overcomes the limits of tracer studies by eliminating the need for tracer data. Additionally, because of the nature of the images taken, geographic information systems can be employed to perform analyses on the impact of land use and management.

Anticipated Outcome

With this approach, MSU will be uniquely positioned to conduct future research endeavors into precision conservation (i.e., strategic placement of BMPs on the landscape for maximum conservation benefit). It will also be possible to provide monitoring and assessment of BMP efficacy for multiple types of BMPs, allowing MSU researchers and extension personnel to assist agency personnel and landowners with precision placement of BMPs and quantification of conservation outcomes from BMP installation. This information is crucial for development of maintenance and operation plans for BMPs and also to justify continued government and private expenditures in conservation. This study will also serve as a proof of concept for the use of UAVs, and specifically SfM, to supply necessary input data at a low-cost for models requiring spatially-explicit topography data.

Potential Impact

This project has broad and limitless applicability. This is because (1) the issue of erosion is ubiquitous in managed landscapes and (2) UAVs are immediately accessible in the marketplace to anyone with sufficient (as low as $500) funds. Moreover, the CAESAR-Lisflood model is free and open-source, available to anyone with the scientific capacity to collect the necessary data. Thus there are few barriers to transferability, and should a successful outcome be achieved, the method could be widely adopted.

Speaking more practically, beyond the agriculture need, if it can be shown that the accuracy of SfM surfaces is sufficient, the engineering industry could greatly reduce labor costs associated with survey tasks such as pre-/post-construction surveys and cut/fill analysis. This could include mining and restoration activities as well. This would be a significant application of UAV technology with tangible economic benefits that could be implemented in the near-term future.

Project Term, Amount of Funding, and Funding Source

The term of this project is January 1-December 31, 2017. The funding level of this project is $17,980. Funding is provided through MAFES' Special Research Initiative (SRI).

9.6 Monitoring Timelines

Table 9.6.1 describes the proposed monitoring timelines.

Table 9.6.1 Proposed Monitoring and Modeling Timeline

A. Pre- and Post-BMP Implementation Monitoring

Performance Date	Activity
Months 1-3	Monitoring System Installation
Months 1-12	Pre-BMP Implementation Monitoring (all locations)
Month 12	Annual Report Submittal
Months 13-24	BMP Implementation – Cease Monitoring during Construction
Months 25-36	Post-BMP Implementation Monitoring (all locations)
Month 36	Annual Report Submittal
Month 36	Final Report to MDEQ/EPA

B. Assessing and Predicting In-Stream Processes in the Catalpa Creek Watershed

Task	3/17	4/17	5/17	6/17	7/17	8/17	9/17	10/17	11/17	12/17	1/18	2/18
Initial Survey												
Stream Recon												
Auto Mon Setup												
Grab Sampling												
Auto Sampling												
Lab Analysis												
X-Section Resurvey*												
Banks/Bed Charact												
Data Analysis												
Model Setup/Calib												
Sim Restoration Scenarios												
Reporting												
Info Transfer**												

C. Applied Use of Unmanned Aerial Vehicles in Surface Water Protection

Task	3/17	4/17	5/17	6/17	7/17	8/17	9/17	10/17	11/17	12/17	1/18	2/18
Baseline Survey												
Baseline Flight												
Monitoring Flight												
Monitoring Survey												
Post Flight												
Data Analysis												
Reporting												
Info Transfer**												

D. Hydraulic Model to Support Conservation and Ecosystem Restoration Efforts within an Impaired, Priority Watershed

Performance Date	Activity
TBD	TBD

E. Assessing Soil Erosion with Unmanned Aerial Vehicles for Precision Conservation

Performance Date	Activity
TBD	TBD

* Resurvey will be completed when stormflow events occur. **Combines MWF and NSL trainings and workshops, academic course *Stream Reconnaissance* (Fall 2017). Also considers presentation of results at MWRRI Conference in April 2018.

9.7 Coordination & Leveraging Plan

A key strategy of the Catalpa Creek Watershed Restoration & Protection Project and DREAMS (Demonstration, Research, Education, Application, Management and Sustainability) Center is the coordination of activities and leveraging of resources. The five monitoring and modeling projects described in this section are being funded contemporaneously which will allow for the potential coordination and leveraging of these projects to achieve the maximum benefit for the awarded funding and execution of this plan. Table 9.8.1 is an analysis of this potential.

Table 9.7.1 Project Coordination & Leveraging Analysis				
Project	SRI - Hydraulic Model	MWRRI - Streambank Erosion	SRI – SfM Accuracy	MWRRI – SfM Best Practices
Time Frame	Jan 1, 2017 – Dec 31, 2017	Mar 1, 2017 – Feb 28, 2018	Jan 1, 2017 – Dec 31, 2017	Mar 1, 2017 – Feb 28, 2018
No Cost Extension	N/A	6-12 months	N/A	
Students Team	Up to 4 undergrads (1 LAC, 1 CEE, 1 ABE, 1WF/FO)	1 graduate (2 years) 1 research associate (25%)	2 undergrads	2 undergrads
Student Work	Cross section surveying	Cross section surveying		Cross section surveying
	Grab sampling	Grab sampling		
	Vegetation surveying			
		Material sampling		
	Lab analysis	Water lab analysis		Water lab analysis
		Materials lab analysis	Materials lab analysis	Materials lab analysis
			Soil cores and composition analysis	
	Modeling	Modeling		Modeling
Field/Lab Tasks			UAV	UAV
	Assessment sediment yield main stream 1st year	Assessment sediment yield tributaries stream/tributaries 2 or more years		Assessment upland erosion and incoming loads
	Assessment streambank erosion rates main stream 1st year	Assessment streambank erosion rates main stream and tributaries 2 or more years		
	Characterizing streambank and streambed material	Characterizing streambank and streambed material	Site characterization	
	Characterizing vegetation			
			Monitoring of study sites	Monitoring of sentinel sites
			Significant field measurements for accuracy comparison	
Modeling Tasks	Hydraulic modeling main stream (HEC-RAS)	Hydraulic/channel evolution modeling (CONCEPTS in HEC-RAS)		
	Assessment sediment budget main stream 1st year (SIAM in HEC-RAS)	Assessment sediment budget main stream/tributaries (SIAM in HEC-RAS)		
			Deposition and removal of sediment over long time horizons	
			Change detection	Develop a method and accuracy rating for use of SfM surfaces in

				typical models (e.g., CAESAR-LisFlood, BSTEM)
		Stream Restoration Scenarios		
Field Equipment Deployed	3 autosamplers main stream	3 autosamplers tributaries instead of 3 autosamplers main stream	None	1 ISCO??
Laboratory Testing and Analysis	Automatic sampling			
	TSS	TSS		TSS
	Grab sampling			
	TSS	TSS		
	Turbidity	Turbidity		
	pH	pH		
	Electric conductivity	Electric conductivity		
	Salinity	Salinity		
	Material sampling			
	Particle size distribution	Particle size distribution	Particle size distribution	Particle size distribution
	Bulk density	Bulk density		Bulk density
		Cohesion		Cohesion
		Friction angle		Friction angle
		Jet testing		Jet testing

Principal Investigators (PIs) and cooperators for all five of the projects are members of both the Planning and Implementation Team and the Hydrology/Modeling Work Group for the overall project, and development of these individual monitoring projects/proposals was conducted through collaboration among these members.

9.8 MONITORING AND MODELING BUDGET FOR PHASE 1 PROJECT

Table 9.8.1 identifies the proposed monitoring budget.

Table 9.8.1
Proposed Monitoring and Modeling Budget for All Phase 1 Projects

A. Pre- and Post-BMP Implementation Monitoring ((Funded by 319 NPS Award)				
Category	Federal Contribution (NPS 319)	Match		Total
Transportation of Samples to Jackson	$2875			
Equipment (6 samplers/flow meters)	In-kind			
Supplies (sampling jugs/labels)	600			
Undergraduate Stipend	10000			
Nutrient Analysis	TBD			
Microbial Analysis (10/sample x 10)	1200			
Total	$14675	$9783		$24458
*B. Assessing &Predicting In-Stream Processes in the Catalpa Cr Watershed (Funded by MWRRI/USGS 104b Award)				
Category	Federal Contribution (USGS)	State/MWRRI Contribution	MSU/3rd Party Contribution	Total
Direct Costs	$21663	$10043	14998	
Facilities and Administrative Costs	0	4570	15544	
Total	$21663	$14613	$29542	$65818*
*C. Applied Use of Unmanned Aerial Vehicles in Surface Water Protection (Funded by MWRRI/USGS 104b Award)				
Category	Federal Contribution (USGS)	State/MWRRI Contribution	MSU/3rd Party Contribution	Total
Direct Costs	$15253	$5568	$10571	
Facilities and Administrative Costs	0	9474	4814	
Total	$15253	$15042	$15385	$45680*
D. Hydraulic Model to Support Conservation and Ecosystem Restoration Efforts within an Impaired, Priority Watershed (Funded by MAFES)				
Category	Federal Contribution	State/MWRRI Contribution	MAFES Contribution	Total
Salaries			$20800	
Commodities			12500	
Total	0	0	$33300	$33300
E. Assessing Soil Erosion with Unmanned Aerial Vehicles for Precision Conservation (Funded by MAFES SRI Award)				
Category	Federal Contribution	State/MWRRI Contribution	MAFES Contribution	Total
Salaries	$14780			
Commodities	3200			
Total	$17980	0	0	$17980
Total Monitoring and Modeling Budget				
Category	Federal Contribution (319 NPS, USGS, SRI)	Other (319 NPS Match, State/MWRRI, MSU/3rd Party, MAFES)		Total
Total	$69571	$117665		$187236

*These 104b awards are not eligible for match under section 319 as they have already been allocated under a different funding source.

10 CONCLUSION

In conclusion, this *Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1* describes the specific initial management activities planned for the Red Bud-Catalpa Creek Watershed Restoration and Protection Project and addresses the comments made by MDEQ and EPA as a result of evaluation of MSU's *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed.* Included in this Phase 1 plan are descriptions of the recommended EPA watershed planning process that was followed, MSU's phased implementation approach, prioritized critical management areas, proposed agricultural BMPs and urban storm water planning activities, information and education plan, implementation schedule, measurable milestones and project outcomes, monitoring plan, budgets for these activities, and input from watershed stakeholders.

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Appendix A

NRCS Conservation Specifications for Phase I Best Management Practices

Cost are most currently available to MDEQ as of February 15, 2017

Red Bud-Catalpa Creek Watershed Phase 1 BMPs						
Practice	**Site #**	**Total Unit Size**	**Unit**	**Unit Cost**	**BMP Cost**	**60% of BMP Cost**
CRITICAL AREA #1 Beef Unit Conservation Practices						
561-Heavy Use Area Protection	1f	4500	sqft	$1.27	$5,715	$3,429
561-Heavy Use Area Protection	1g	4500	sqft	1.27	$5,715	$3,429
576-Livestock Shelter Structure	2m	1000	sqft	3.94	$3,940	$2,364
576-Livestock Shelter Structure	2p	1000	sqft	3.94	$3,940	$2,364
576-Livestock Shelter Structure	2Q	1000	sqft	3.94	$3,940	$2,364
512-Native Grass Planting	5a				$1,693	$1,016
382-Fencing	6a	2200	ft	3.03	$6,666	$4,000
342-Critical Area Planting (Heavy)	3f-sites around fences				$1,107	$664
Bank Stabilization	West Line Road				$52,654	$31,592
Estimated Total for Critical Area #1					$85,370	$51,222
CRITICAL AREA #2 Beef Unit Conservation Practices						
561-Heavy Use Protection	1j	38345	sqft	1.27	48698	29219
561-Heavy Use Protection	1k	30600	sqft	1.27	38862	23317
342-Critical Area Shaping/Grading (Heavy)	3d	1	acre		2214	1328
382-Fencing	6b	950	sqft	3.03	2879	1727
410-Grade Stabilization Structure	7a				6000	3600
410-Grade Stabilization Structure	7b				6000	3600
410-Grade Stabilization Structure	7c				6000	3600
410-Grade Stabilization Structure	7d				10000	6000
Estimated Total for Critical Area #2					120653	72392
CRITICAL AREA #3 Dairiy Unit Conservation Practices						
342-Critical Area Planting (Heavy)	11a	1	acre		2214	1328
410-Grade Stabilization Structure	12a				10000	6000
382-Fencing	13a	5800	ft	3.03	17574	10544
391-Riparian/Forest Buffer	14a	7.5	acre		3979	2387
578-Stream Crossing	15a	1000	sqft	4.44	4440	2664
578-Stream Crossing	15b	1000	sqft	4.44	4440	2664
578-Stream Crossing	15c	1000	sqft	4.44	4440	2664
Estimated Total for Critical Area #3					47087	28252
BMP Total All Critical Areas	24 BMP sites				$253,110	$151,866

Streambank Stabilization Site – West Line Road

Materials	Quantities	Unit Cost	Total Cost
Rock Riprap	325.0 Tons	$120/Ton	$39,000
Concrete Grout	19.0 Cu. Yd.	$250/Cu. Yd.	$ 4,750
Geotextile	476.0 Sq. Yd.	$4/Sq. Yd.	$ 1,904
Excavation	300.0 Cu. Yd.	$10/Cu. Yd.	$ 3,000
Earth Fill	200.0 Cu. Yd.	$20/Cu. Yd.	$ 4,000
			$52,654

Appendix B
Implementation Plan for the Red Bud-Catalpa Creek Watershed Phase 1
Cumulative Budget for 319 NPS Award

A. Phase 1 BMP Implementation Funded by 319 NPS Award				
NRCS Practice	Site #	[1] Estimated Costs to Fully Implement BMPs (100% Basis)	[2] 319 NPS Eligible Funding (60% of Costs to Fully Implement BMPs)*	[3] Match Requirement
Critical Area #1 – Livestock Forage Area				
561 – Heavy Use Protection (Beef Feeding Area)	1f	$5715	$3429	
561 – Heavy Use Protection (Beef Feeding Area)	1g	5715	3429	
576 – Livestock Shelter Structure	2m	3940	2364	
576 – Livestock Shelter Structure	2p	3940	2364	
576 – Livestock Shelter Structure	2Q	3940	2364	
512 – Native Grass Planting	5a	1693	1016	
382 – Fencing [4]	6a	6666	4000	
342 – Critical Area Planting (Heavy)	Around fences	1107	664	
Bank Stabilization (per NRCS engineering design)	West Line Road	52654	31592	
Estimated Total – Critical Area #1		$85370	$51222	$34148
Critical Area #2 – Beef Research Unit				
561 – Heavy Use Protection (Concentrated Operations)	1j	$48698	$29219	
561 – Heavy Use Protection (Beef Runway)	1k	38862	23317	
342 – Critical Area Shaping/Grading (Heavy)	3d	2214	1328	
382 – Fencing [4]	6b	2879	1727	
410 – Grade Stabilization Structure (Standard Cantilever)	7a	6000	3600	
410 – Grade Stabilization Structure (Standard Cantilever)	7b	6000	3600	
410 – Grade Stabilization Structure (Drop Pipe/Riser)	7c	6000	3600	
410 – Grade Stabilization Structure (Check Dams)	7d	10000	6000	
Estimated Total – Critical Area #2		$120653	$72392	$48261
Critical Area #3 – Dairy Grazing Area				
342 – Critical Area Planting (Heavy)	11a	$2214	$1328	
410 – Grade Stabilization Structure (Check Dams)	12a	10000	6000	
382 – Fencing [4]	13a	17574	10544	
391 – Riparian/Forest Buffer	14a	3,979	2387	
578 – Stream Crossing	15a	4440	2664	
578 – Stream Crossing	15b	4440	2664	
578 – Stream Crossing	15c	4440	2664	
Estimated Total – Critical Area #3		$47087	$28252	$18835
Estimated Total – Critical Areas 1, 2, & 3	24 Sites	$253110	$151866	$101244

*Rounding may result in slight differences between column totals and multiplication products.

B. Phase 1 Information and Education Funded by 319 NPS Award			
Category	Activity	60% of Cost*	[3] Match Requirement
Salaries			
	Project Oversight	$4732	
	Summer Intern/Project Assistance	$12079	
Commodities			
	Trailer Repairs	$1000	
	BMP Signage	3000	
	MSU Classes – Educational Materials	4500	
	Field Day for Local Schools – Materials and Support	2000	
	Profession Development: NRCS Training	5000	
	Educator Workshop	2500	
	In-Service Training: Extension Agents	1000	
	Watershed Management Workshop	500	
	Municipal Leaders' Workshop	250	
	Publication Costs; Educational Materials, Surveys	3000	
Contractual			
	Virtual field trip development	$13900	
	Estimated Total – Information and Education $89102	$53461	$35641

C. Phase 1 Monitoring Funded by 319 NPS Award				
Project Needs	Pre-BMP Implementation	Post-BMP Implementation	60% of Costs*	[3] Match Requirement
Transportation of Samples to Jackson	$1438	$1438	$2876	
Equipment (6 samplers/flow meters)	In-kind	In-kind	In-kind	
Supplies (sampling jugs/labels)	300	300	600	
Undergraduate Stipend	5000	5000	10000	
Nutrient Analysis	TBD	TBD	TBD	
Microbial Analysis (10/sample x 10)	600	6000	1200	
	Estimated Total – Monitoring	$24458	$14675	$9783

D. Administrative Management (Indirect) Costs Funded by 319 NPS Award		
20% Admin Management (Indirect) Costs [5] on Projects Total of $220,002	44000	$29333

Total Phase 1 Project Costs Funded by 319 NPS Award			
	Total Estimated Costs	[6] 60% of Costs*	[3] Match Requirement
A. Phase 1 BMP Implementation	$253110	$151866	$101244
B. Phase 1 Information and Education	89102	53461	35641
C. Phase 1 Monitoring	24458	14675	9783
D. Phase 1 Administrative Management (Indirect) Costs	73333	44000	29333
Estimated Total Phase 1 Project Costs	$440003	**$264002**	$176001

*Rounding may result in slight differences between column totals and multiplication products.

Total Phase 1 Budget and Investment All Projects			
Funding Sources	Federal Contribution (319 NPS, USGS, MAFES SRI)	Non-Federal Contribution (319 NPS BMP Match, State/MWRRI, MSU/3rd Party, MAFES)	Total
MDEQ/EPA 319 NPS Program	$264000*	$176000*	440000*
MWRRI 104b Water Research Grant Program (2 grants)	36916	74582	111498
MAFES/Special Research Initiative Grant Program	17980	33300	51280
	$318896	**$283882**	**$602778**

***Rounded amounts were used in writing the 319 grant.**

[1] **Estimated Costs to Fully Implement BMPs (100% Basis).** The cost estimates provided by NRCS for these BMPs are based upon the FY2016 USDA/NRCS Base Cost Estimate and apply to agricultural producers that have been farming for more than 10 years and do not qualify as a Beginning Farmer, Limited Resource Farmer, or a Socially Disadvantaged Farmer. The Base Cost Estimate, compiled by USDA/NRCS for Mississippi, Arkansas, and Louisiana, is a combined average cost estimate that typically represents 50% of the costs to actually implement the practice in these three States. The estimated costs to fully implement the Phase 1 BMPs listed in the preceding table represent 100% of the total costs (or NRCS' Base Cost Estimate X 2).

[2] **319 Eligible Funding (60% of Costs to Fully Implement BMPs).** These costs represent 60% of the estimated costs to fully implement the selected BMPs, which is the amount that is eligible for a 319 NPS funding award (pursuant to other program requirements).

[3] **319 In-kind Match Requirement (40% of Implementation Costs).** 319 NPS funding requires a 40% match (in-kind services or monetary contribution). It is anticipated that MSU will contribute in-kind services to install the designated BMPs and cover this requirement.

[4] **Fencing Requirements.** USDA/NRCS handles requests from agricultural producers that desire to substitute wooden post with metal pipes, angle iron, etc. by first requesting from the producer what is desired for braces, H-braces, corner posts, and line (pull) posts. This information is then provided to the USDA/NRCS State Grazing Land Specialist for consideration of a waiver to use the materials desired by the producer. Normally, MDEQ requires that conservation practices implemented under 319 NPS funds follow USDA/NRCS practice standards and specifications. Because of this, MDEQ's approval would also be required in the event a waiver is requested.

[5] **20% Administrative Management (Indirect) Costs.** MDEQ and MSU have negotiated an indirect rate of 20% of the total project components eligible for 319 NPS funding ($220,002 to offset MSU's administrative management costs. This amount is $44,000.

[6] **319 NPS Eligible Costs. Costs eligible for 319 NPS funding support.**

Appendix C
Input Received During 9/28/15 Evening Meeting of Catalpa Creek Watershed Stakeholders

Presentation to Stakeholders

- *Catalpa Creek Restoration and Protection Project and Watershed D.R.E.A.M.S. Center*

Questions Asked to Stakeholders

- What water or ecosystem-related concerns do you have in the Catalpa Creek Watershed? How are you being affected?
- What would you like to see addressed through this project? What are your priorities?
- What challenges or barriers will this project face? What are your ideas to overcome these?
- Would you like to become involved in this project? In what way?
- What agricultural landowners might be interested in cost-share opportunities to reduce erosion from your lands?
- What agricultural landowners might be interested in cost-share opportunities to improve the ecosystem and habitat on your lands?
- What governmental entities are interested in supporting this project?
- What opportunities are you aware of that could be leveraged with this project? Who would be the contact?
- Are there statements or other comments you would like to make about this project?

General Stakeholder Thoughts and Comments

- What is the creek's history of channelization?
  - Evaluate land use changes over time
  - Research railroad construction
  - Research Board of Supervisors' minutes
- Tributary streams need to be identified to assist stakeholder identification.
- There is great potential for fisheries because of soil/water quality.
  - Good fisheries currently exist in some reaches of Catalpa Creek.
  - Doctoral and other fisheries research characterization data exists (past MSU project with MDEQ funding).

Stakeholder Concerns (and Selected Responses)

- Sources of debris and contaminants from upstream
- Cropping near creek sides (certain sections of the creek has a limestone base)
- Fishing pressure (trespassing)
  - Potential impact on private property along creek

- Will there be site visits to properties?
  - Response: No mandate exists for these voluntary financial assistance programs. NRCS will provide assistance in response to private landowners' requests. MSU will assess its landholdings to identify any pollutant sources and restoration needs.
- Will stream buffers/BMPs be implemented on MSU property?
  - Response: MSU/MAFES administration is very keen in making improvements in water quality, habitat/ecosystem health, and stream structure/function.
- Contamination of water from MSU dairy
- Education and funding needed to assist private landowners implement BMPs
- Dead animal bones (no meat) – apparent intentional disposal near creek
- Algal blooms
- Invasive species
- MSU Master Plan elements may not be feasible or implementable (e.g., 100-foot stream buffers, covered culverts).
  - Response: This is an opportunity to integrate urban storm water management concepts identified in the Master Plan and agricultural watershed-based planning, and to advance these integrated approaches through implementation actions.
- Stream bank erosion and loss of riparian zone

<u>How Stakeholders Are Being Affected</u>

- Loss of streamside trees due to bank failure
- Decreased fishing quality/experience

<u>Needs</u>

- Funding
- Cost-share opportunities (e.g., NRCS)
- Involve all stakeholders and keep this evening's meeting participants involved in the future.

<u>Solutions</u>

- Make CP-22 cost share program available through local SWCD/NRCS office for streamside buffers.

<u>Partnerships/Leveraging</u>

- City anticipates upgrades to storm water infrastructure over the next 10 years near headwaters at Oddfellows Cemetery and Cotton District.
- Facilitate education opportunities for city officials to learn available storm water options and coordinate planning with MSU.

- October 19, 2015 – Charrette at Starkville Sportsplex for stakeholder input as part of update to City's plan, which includes storm water management.

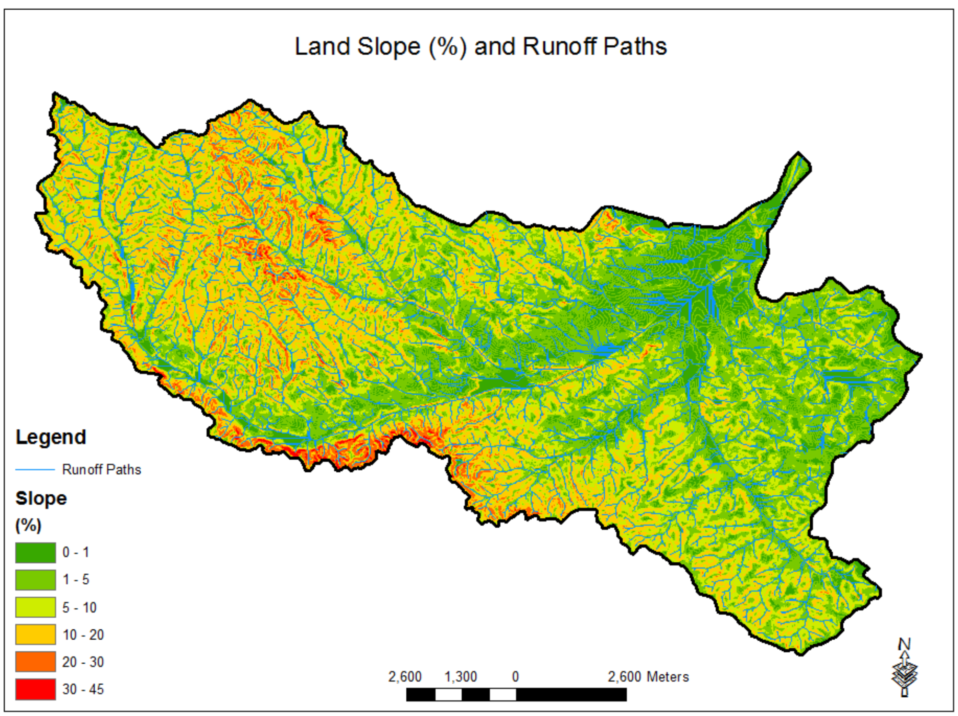
Appendix D

Determination of Management Areas of Concern to Establish Best Management Practices within the Catalpa Creek Watershed

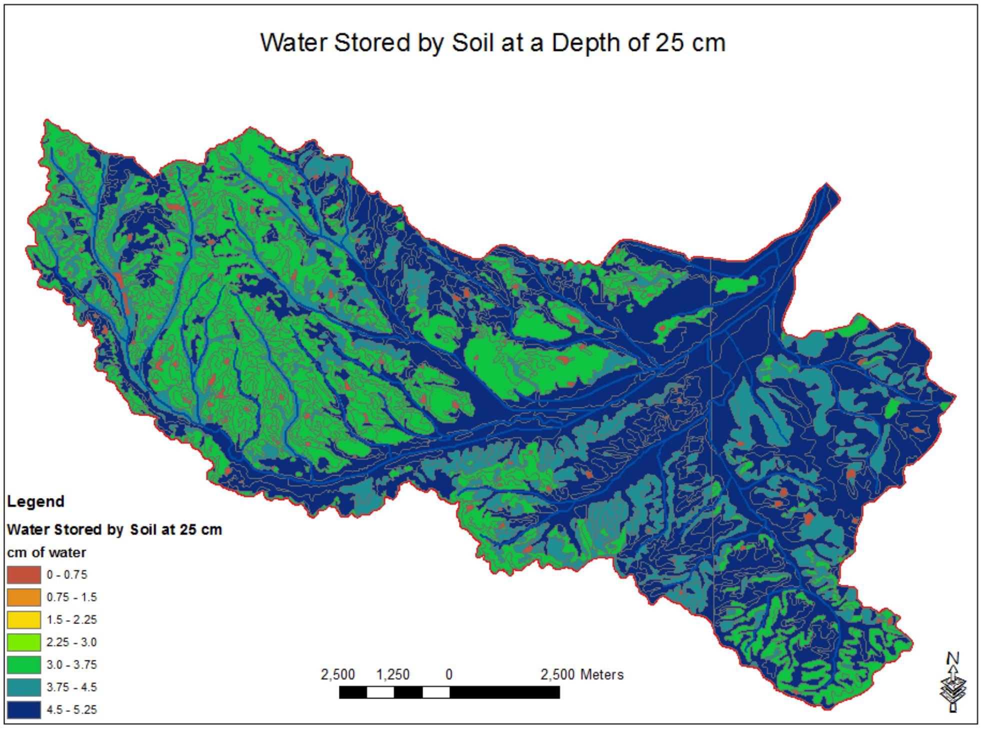
Identification of management areas of concern includes the assessment of soil erosion and the determination of existing and target nutrient loads. As the first procedure identifies more detailed areas of management, the second brings results at the level of sub watershed. The upper 4 miles of the main stream were identified as a critical management zone to control in-stream processes. Definition of this area comes from visual identification and professional judgment.

Generalities. Soils within the Catalpa Creek watershed are moderately well drained along most of the major part of the northern area of the watershed, where the higher slopes are observed and the soils could store up to 3 cm of water. This last condition makes the soils have a medium to high runoff potential during periods of continuous stormflow events.

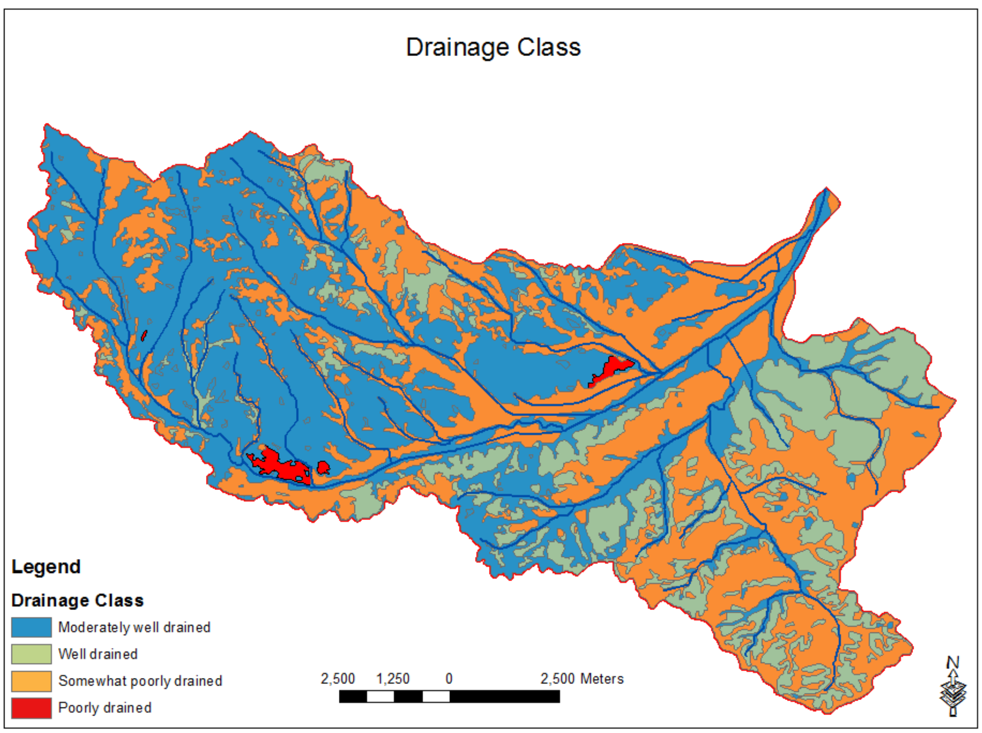
Along the southern area and some areas along the northeastern part of the watershed, somewhat poorly drained soils are predominant with a capability to store up to 5.25 cm of water. Hydrologic soil groups C and D are predominant for the entire watershed, which combined with the very high capability of the soils to retain soil moisture and become and remain in saturation, makes the runoff potential along these areas range from medium to very high.



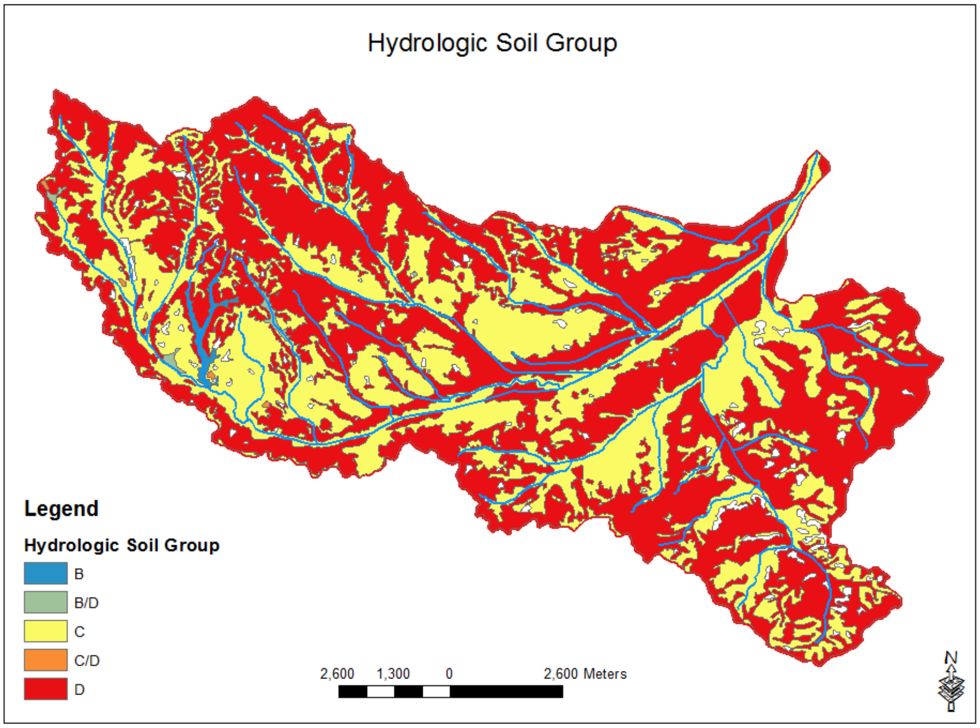
Land Slope and Runoff Accumulation Paths within the Watershed



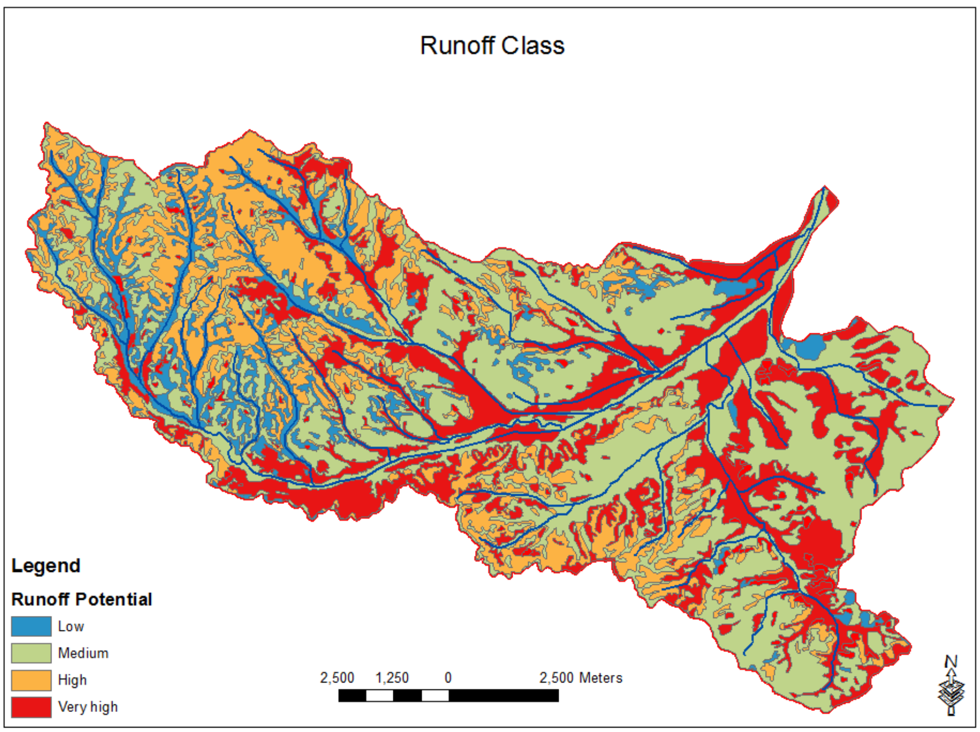
Soil Water Storage Capability



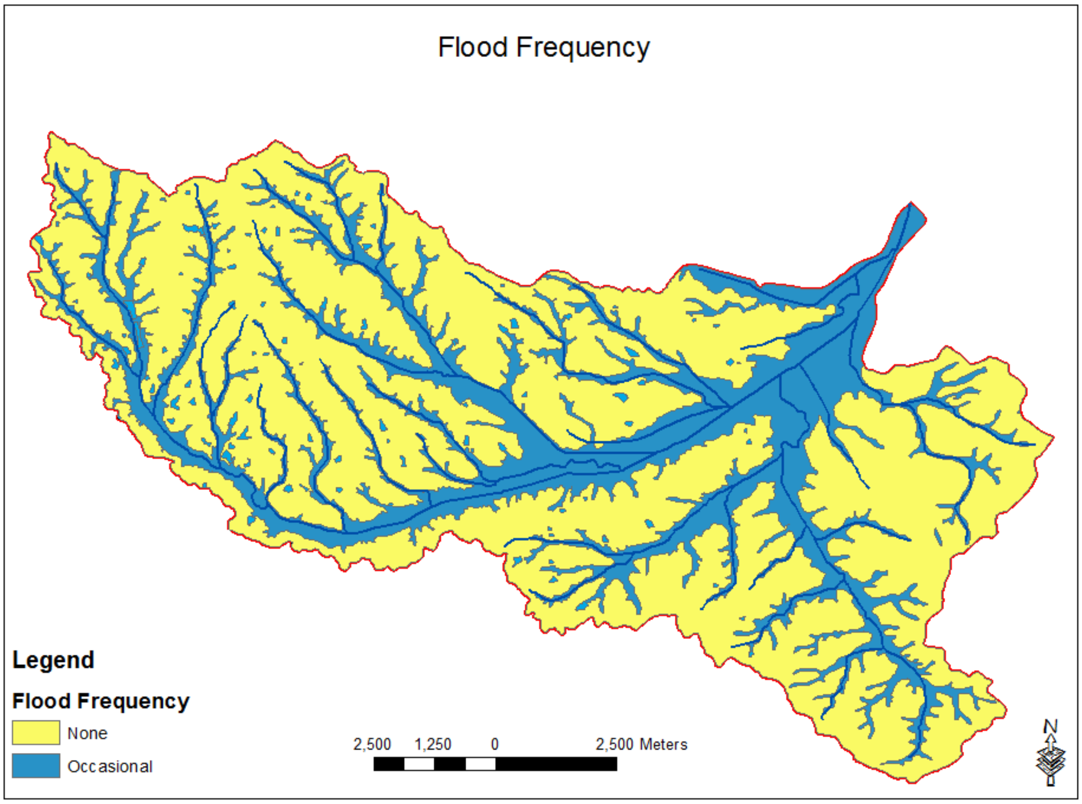
Soils Drainage Class



Soils Hydrologic Groups



Watershed Runoff Potential



Watershed Flood Frequency

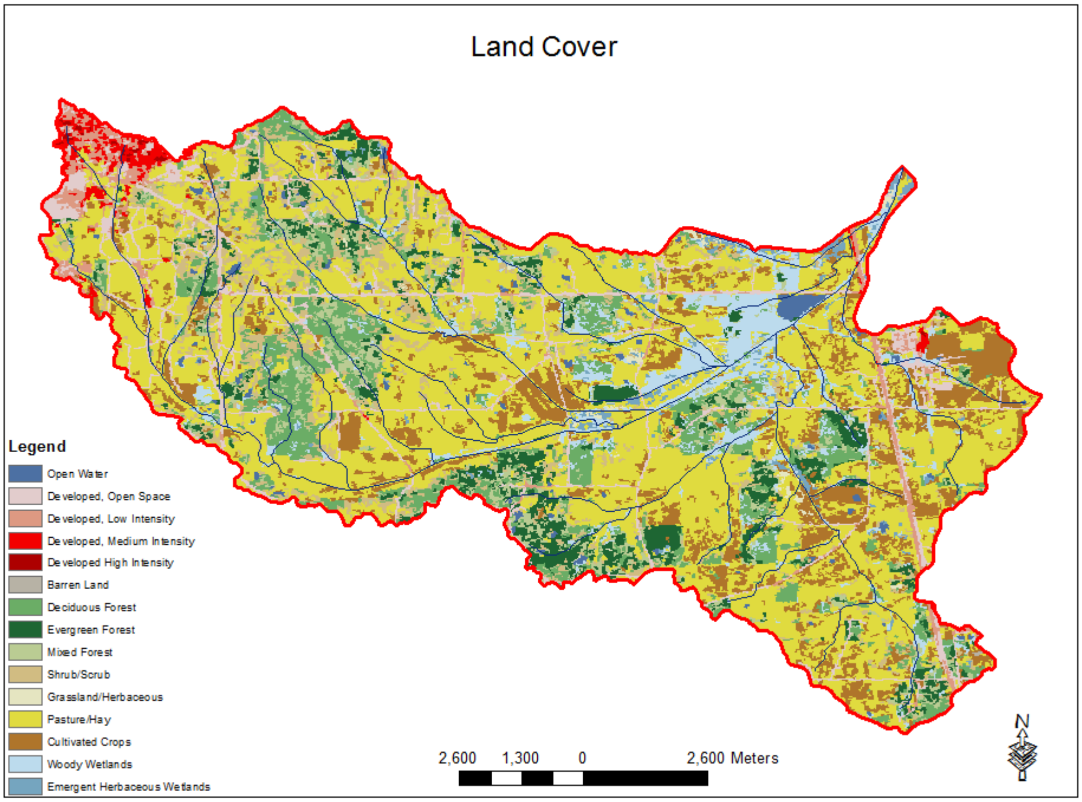
Management Areas of Concern for Soil Erosion Control

Management areas of concern for soil erosion control within the Catalpa Creek watershed were determined based on the assessment of annual soil erosion rates (A) by using the RUSLE2 algorithm (A=RKLSCP) on a geographical information system (ArcGIS). The erosion rates were generated for the different areas of the watershed, by combining information about predominant land cover/land use (C factor), the susceptibility of each soil map unit to be eroded (K factor), the topographic characteristics of the fields (LS factor), and assuming no management practices are currently performed in the area (P=1). The factor relating the energy of the precipitation (R) was obtained by using the rainfall erosivity calculator tool from EPA for the area of study. (http://www.epa.gov/npdes/rainfall-erosivity-factor-calculator-small-construction-sites#getTool).

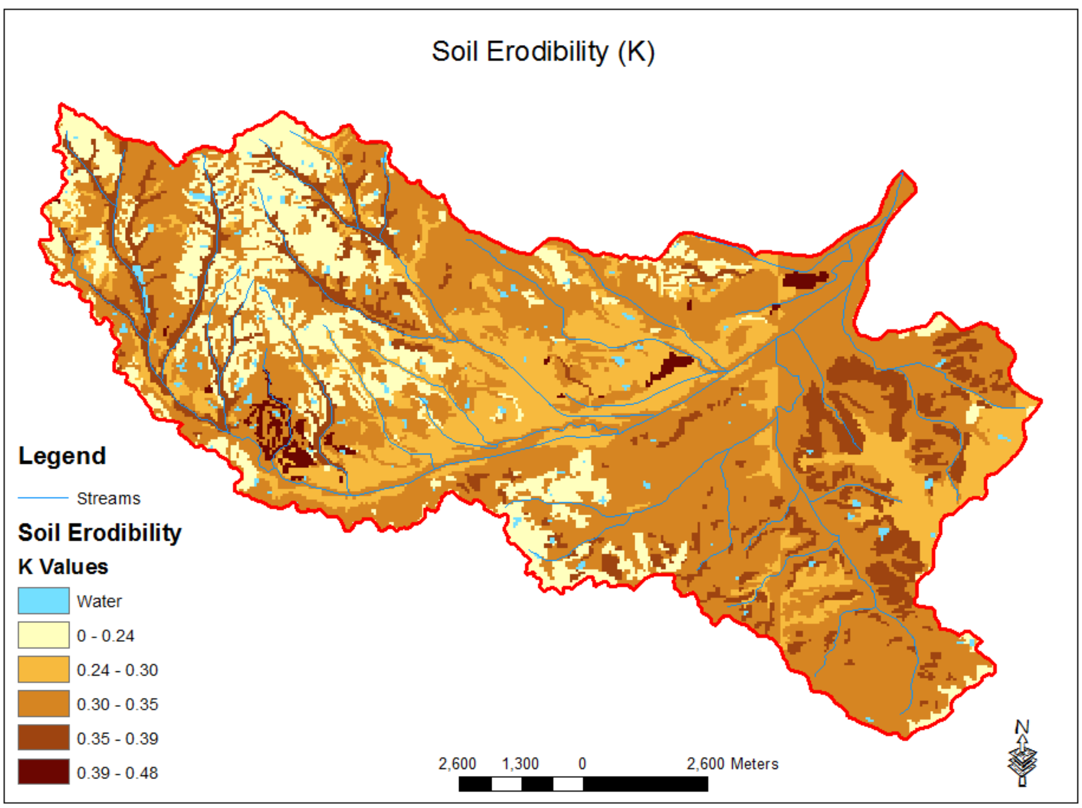
Once the annual erosion rates are estimated, they are compared to the soil loss tolerance (T) for each soil map unit. The T factor is defined as the maximum rate of annual soil erosion that will permit crop productivity to be sustained economically and indefinitely on the land. The T factors are integer values from 1 through 5 tons/acre/year. The lowest is for shallow or fragile soils, and the highest is for deep soils that are least susceptible to be degraded by erosion. Areas with annual erosion rates higher than the soil loss tolerance are included in the list of critical management zones for soil erosion control.

Soils within the watershed are mostly medium textured to fine soils with moderate to high susceptibility for erosion. This is reflected in the distribution of the values of the soil erodibility factor (K) within the watershed, which mostly range from 0.24 to 0.48, reflecting soils moderately susceptible to detachment and they produce moderate to very high runoff. Most of the soils within the watershed (84%) have a predominant soil loss tolerance (T) higher than 4 ton/acre/year.

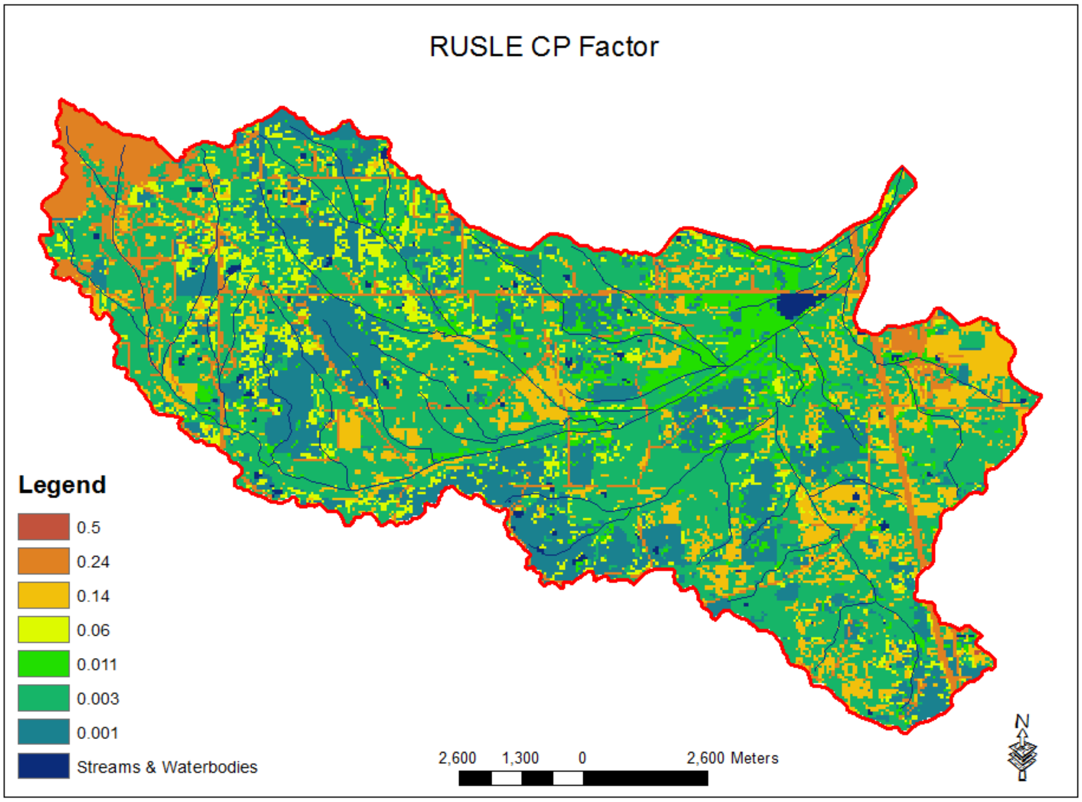
The highest soil loss tolerance rates for the soils in the watershed contrast with the identification of an important area of the watershed (80%) ranked as highly erodible land (HEL). A HEL is defined based on an erodibility index, a soil map unit (soil series) with an erodibility index of 8 or greater is a HEL. The erodibility index for a soil map unit is determined by dividing the potential erodibility for the soil map unit (R*K*LS), where R represents the precipitation energy, K is the soil erodibility and LS is the factor related to the gradient and length of the slope), with the soil loss tolerance (T).



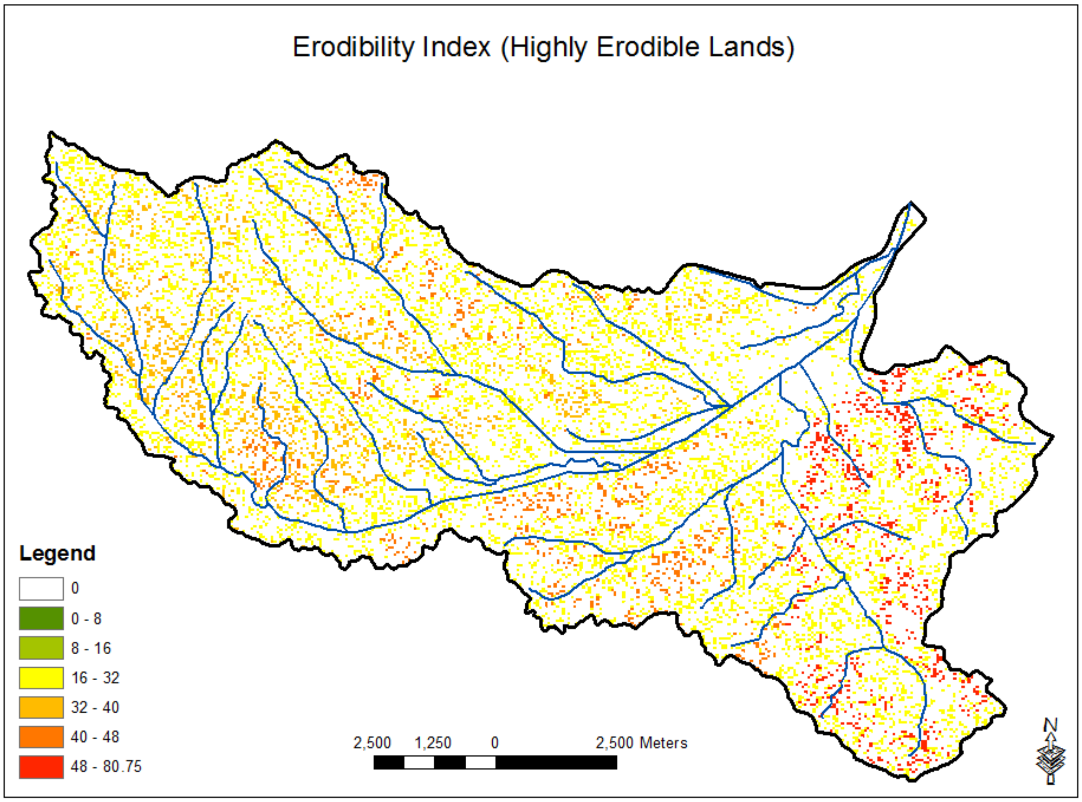
Land Cover/Land Use



Soil Erodibility Factor (K)



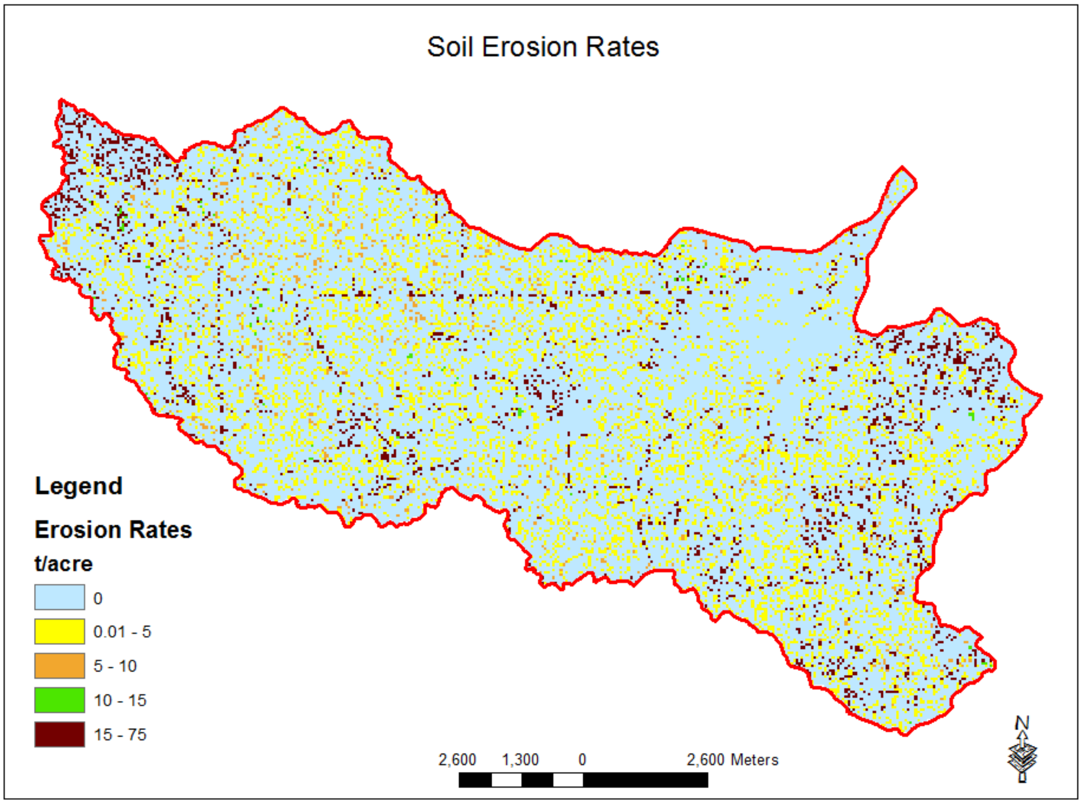
Cover Management Factor (CP) Assuming No Management Practices (P=1)



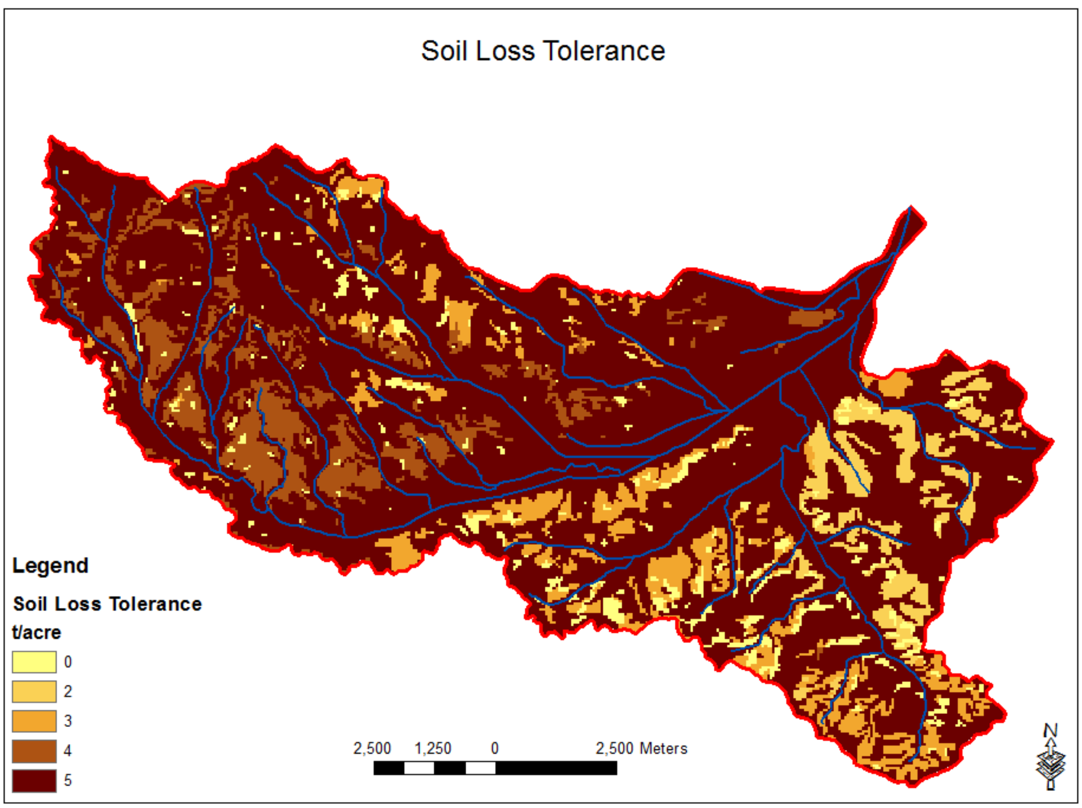
Erodibility Index Factor (Highly Erodible Lands)

Because lands under pastures/hay are the most predominant land use/land cover condition within the Catalpa Creek watershed, annual soil erosion rates appear to be predominantly low (smaller than 5 ton/acre), while soil erosion rates higher than 15 ton/acre were mostly observed from developed areas and cultivated crops.

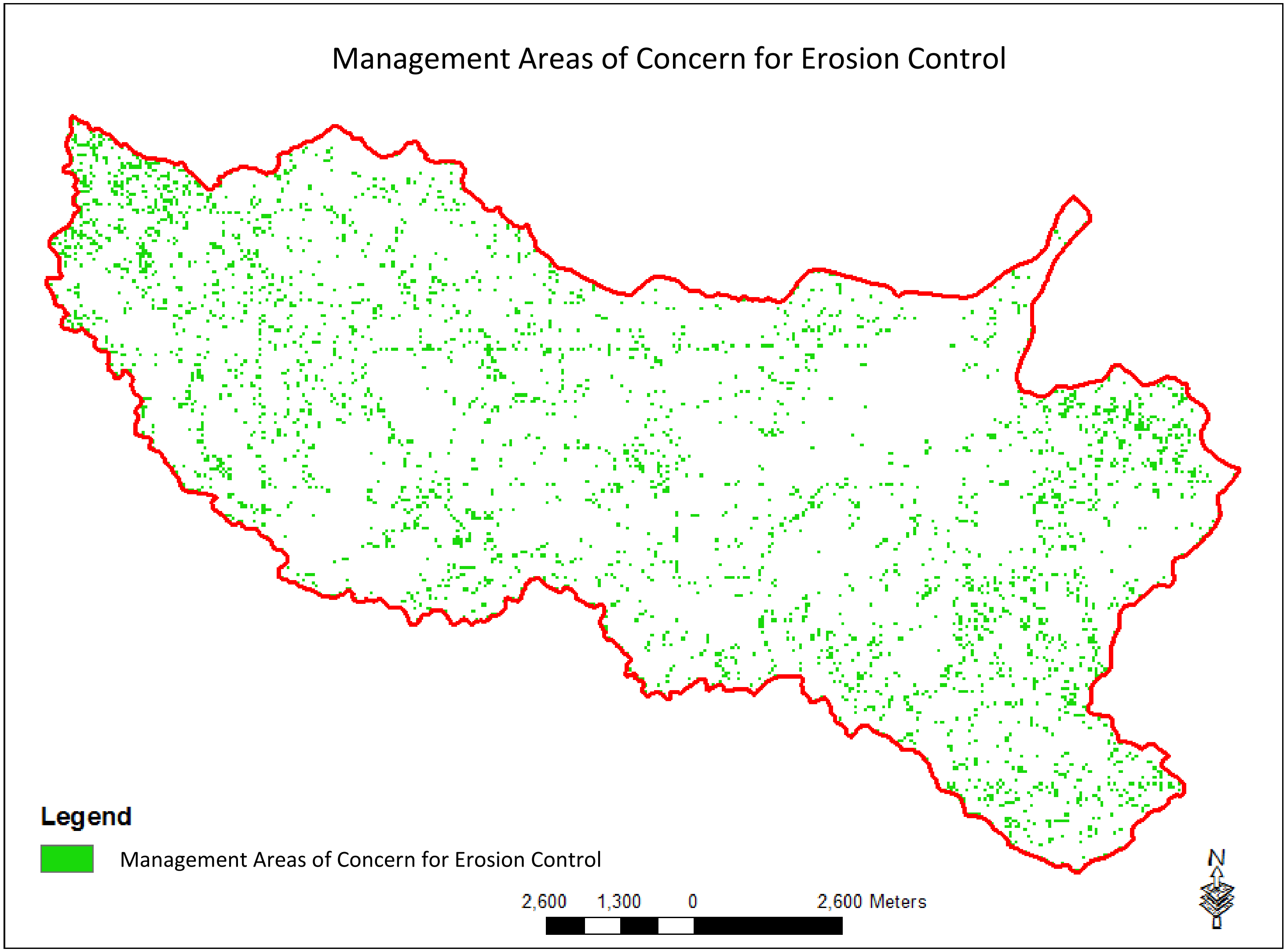
The management areas of concern for erosion control were determined by identifying areas with annual soil losses higher than the soil loss tolerance for the corresponding map unit. From the 28,928 acres in the watershed, approximately 7.6% of the area (2200 acre) was included within the critical management zones for erosion control. Around 650 acres correspond to areas under cultivated crops, 430 acres to areas under pastures/hay, 325 acres to shrub/scrub lands, and other 330 acres to developed areas and unpaved roads.



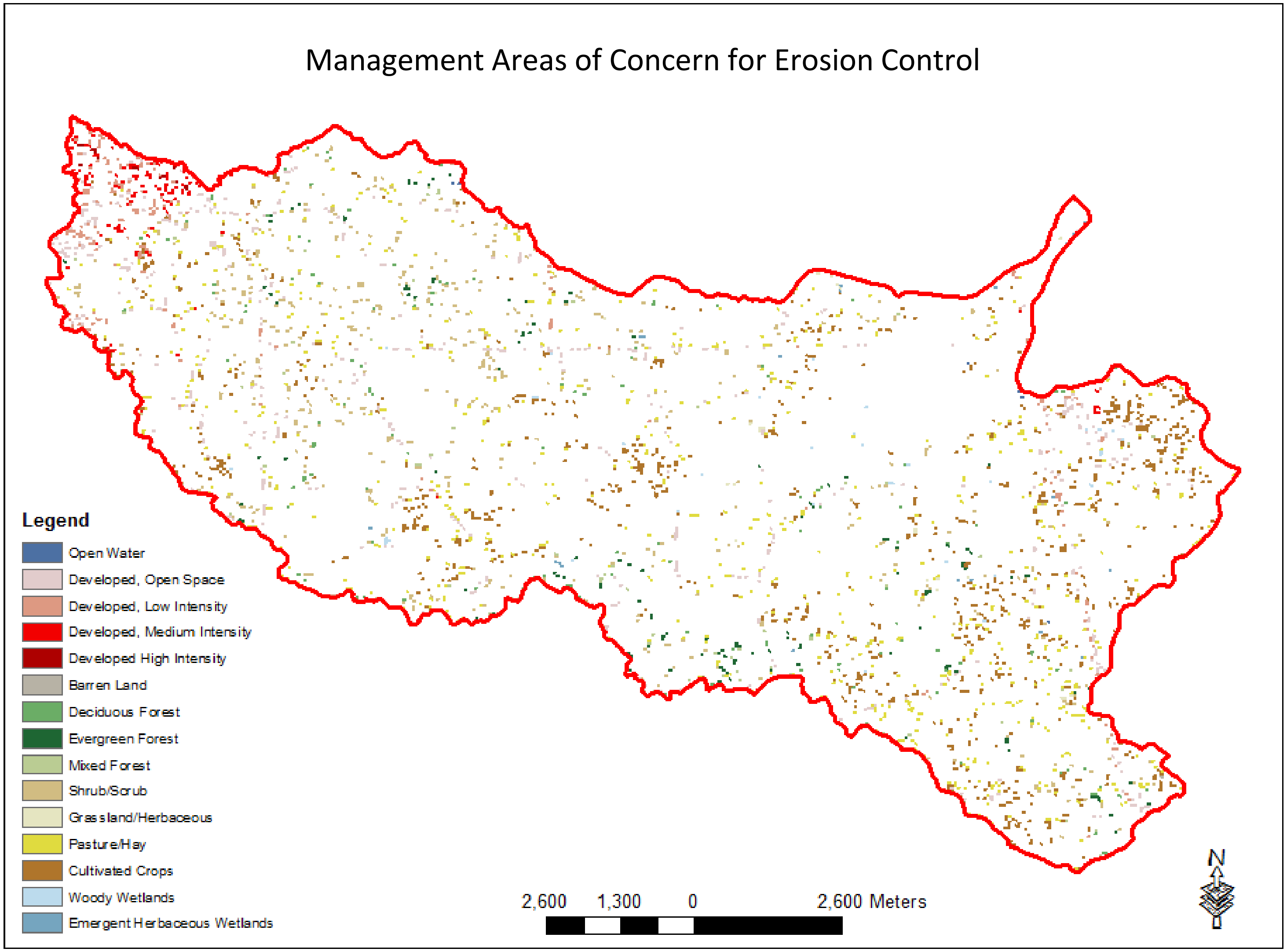
Annual Soil Erosion Rates



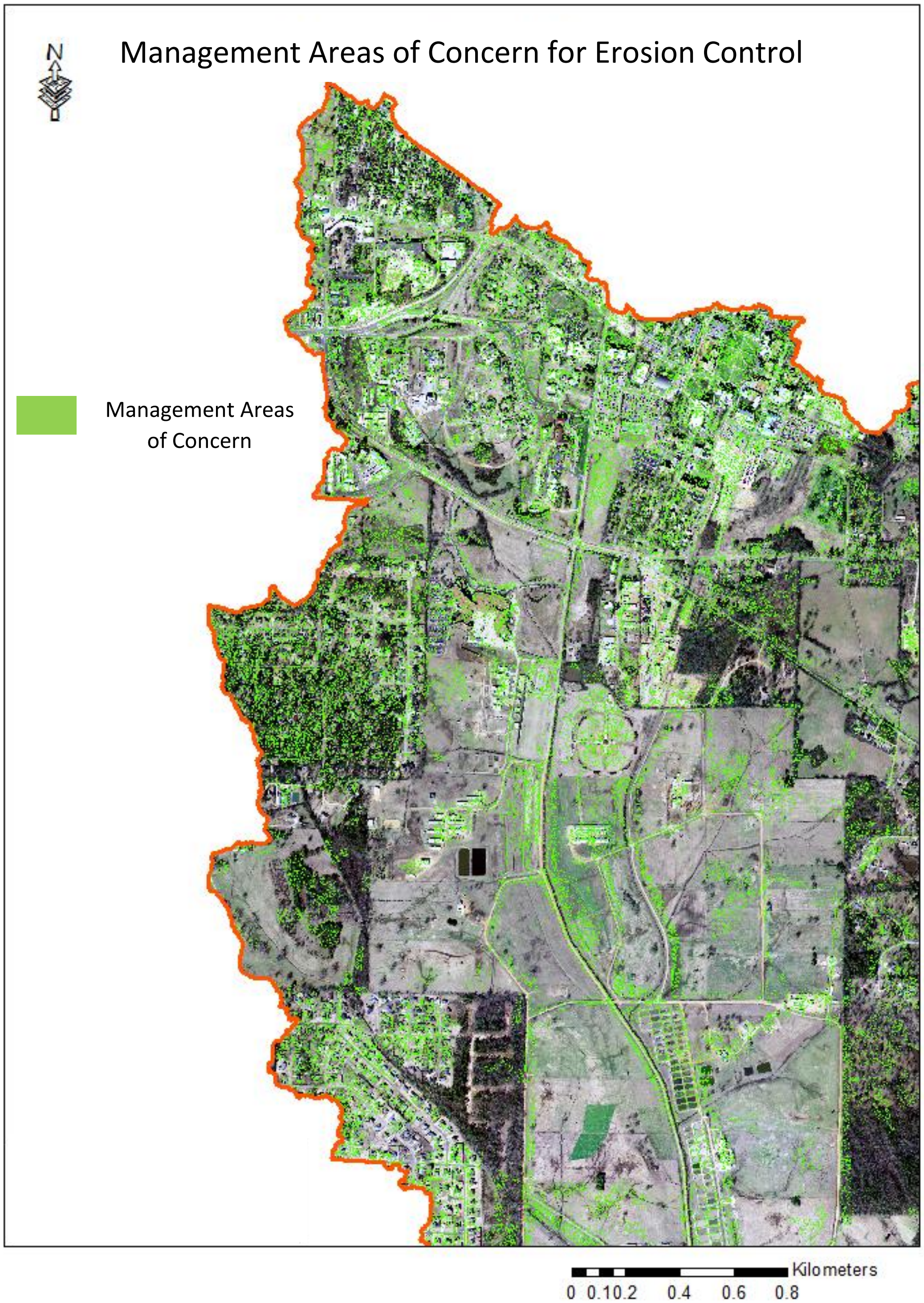
Soil Loss Tolerance for Different Soil Map Units



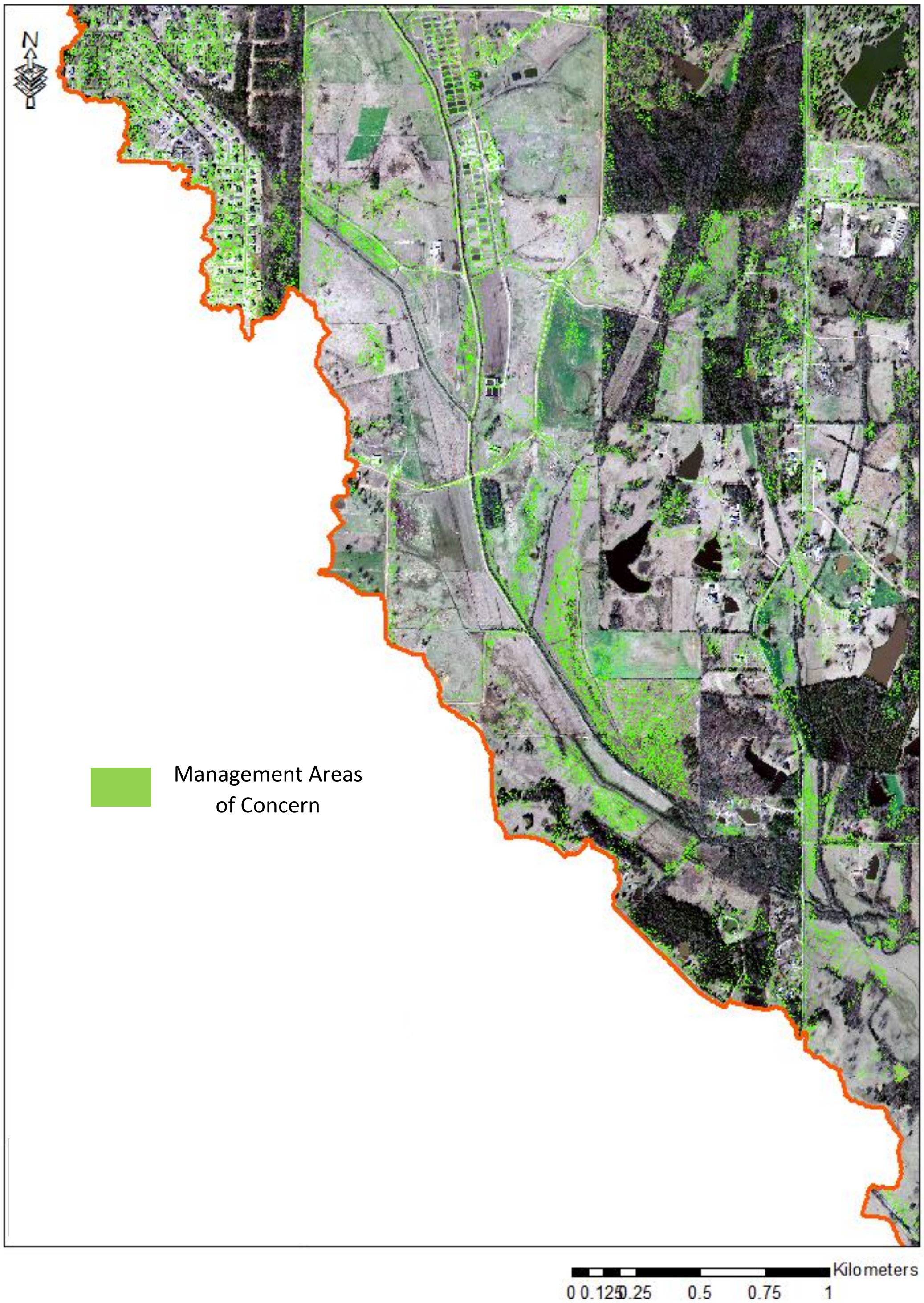
Management Areas of Concern for Erosion Control within the Red Bud-Catalpa Creek Watershed



Management Areas of Concern for Erosion Control for Different Land Use/Land Cover Types within the Red Bud-Catalpa Creek Watershed



Management Areas of Concern in the Upper Headwaters
of the Red Bud-Catalpa Creek Watershed



Management Areas of Concern in the Mid-Headwaters
of the Red-Bud Catalpa Creek Watershed

Determination of the C Factor for the Different Land Cover Types of the Watershed (Source: Reale, 2012; from http://www.unm.edu/~jreale/term_project.htm accessed March, 28 2016)

Class	Definition	C-Factor
Water	Open Water	0.00
Developed	Low Intensity Residential	0.24
Developed	High Intensity Residential	0.24
Developed	Commercial/Industrial/Transportation	0.24
Barren	Bare Rock/Sand/Clay	0.50
Barren	Quarries/Strip Mines/Gravel Pits	0.50
Barren	Transitional	0.50
Forested Upland	Deciduous Forest	0.006
Forested Upland	Evergreen Forest	0.006
Forested Upland	Mixed Forest	0.006
Shrub Land	Shrub Land	0.06
Non-natural Woody	Orchards/Vineyards/Other	0.37
Herbaceous Upland	Grasslands/Herbaceous	0.06
Herbaceous Planted/Cultivated	Pasture/Hay	0.37
Herbaceous Planted/Cultivated	Row Crops	0.37
Herbaceous Planted/Cultivated	Small Grains	0.37
Herbaceous Planted/Cultivated	Fallow	0.37
Herbaceous Planted/Cultivated	Urban/Recreational Grasses	0.10
Wetlands	Woody Wetlands	0.00
Wetlands	Emergent Herbaceous Wetlands	0.00

Management Areas of Concern for Nutrient Impairment

To determine the management areas of concern for nutrient impairment, estimated existing loads and nutrient targets were calculated from the NLCD land cover/land use distribution within the different tributary watersheds in the Catalpa Creek.

Nutrient loads from the different land cover/land use types were calculated by multiplying the land use category size (area) by the estimated nutrient load as proposed by Shields et al (2008) and frequently evaluated by MDEQ.

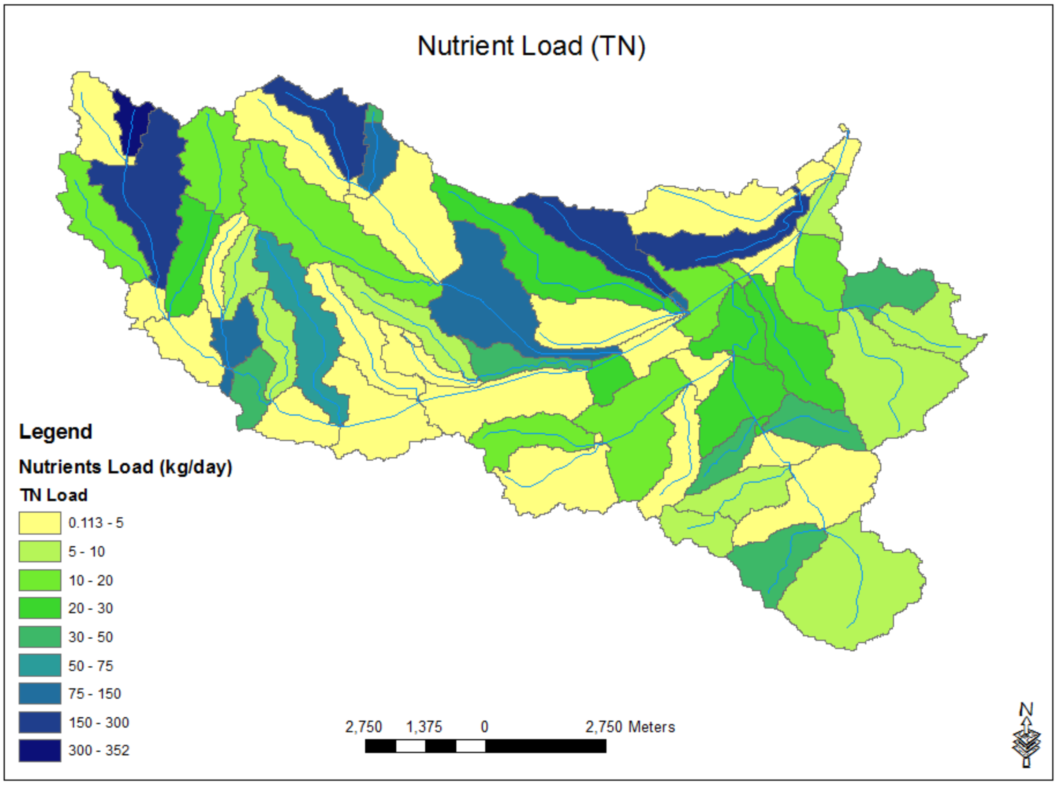
Estimated average annual total N load delivered to streams (Source: Shields, et al, 2008)

Land Use/Land Cover	Estimated Average Annual N Yield (Mg/km^2)	Estimated Average Annual P Yield (Mg/km^2)
Forest	0.043	0.024
Pasture	0.3	0.50
Cropland	2.0	1.0
Urban	0.11	0.014
Water	0.10	0.10
Wetland	0.10	0.10
Barren	0.043	0.024

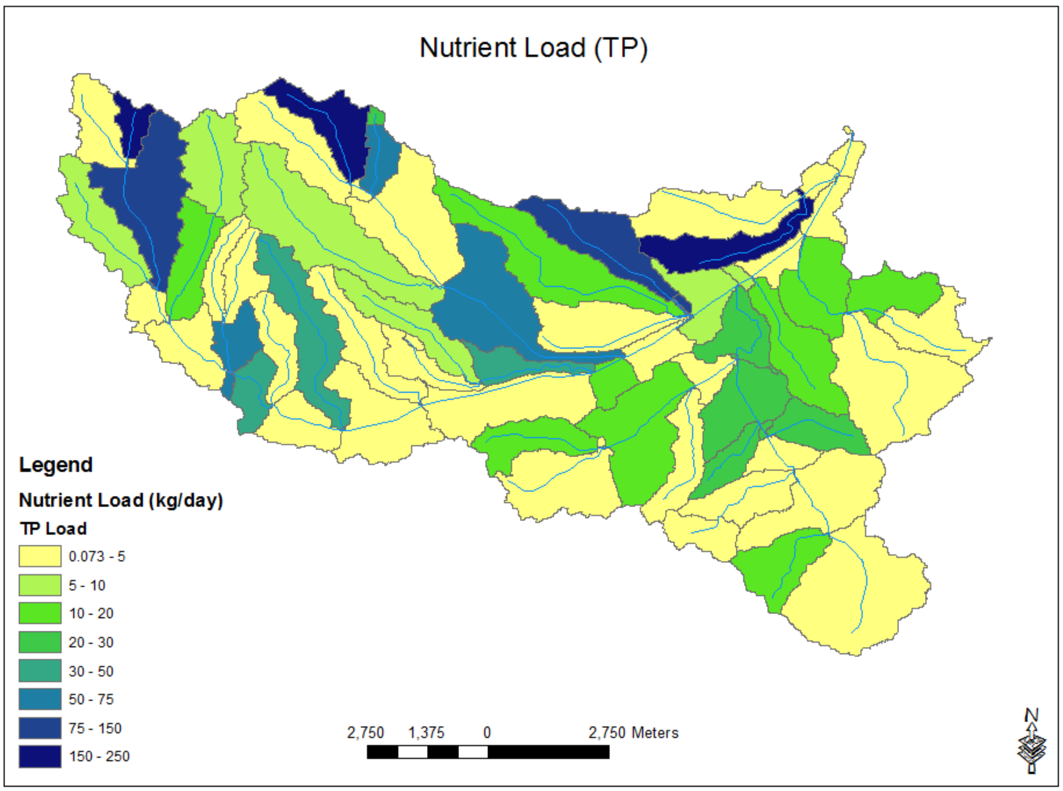
The relevant information for each sub watershed used to estimate the target load (e.g. area, average annual flow) was extracted from the NHDPLUS Dataset. Nutrient target loads were estimated based on EPA guidance for calculation of targets when considering all available data. The reference concentrations were 0.7 mg/l and 0.1 mg/l of TN and TP, respectively.

The difference between estimated existing loads and target loads is used to determine the nutrient reduction from each sub watershed, which becomes a critical management zone if an existing load exceeds the target.

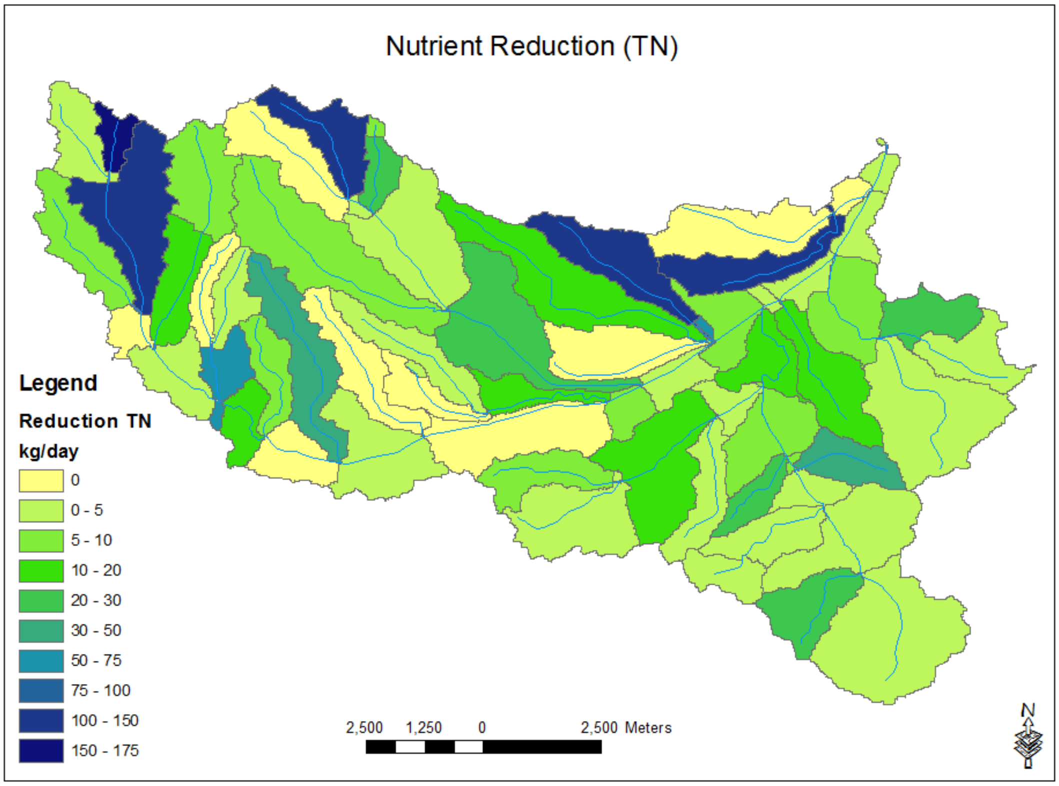
A total of 2727.5 acres along the northern headwaters, out of the entire watershed area (28,928 acres), especially those areas including the Mississippi State University Campus and the research farm, are part of the management areas of concern with most important contribution of nutrients (both, P and N) and highest rates of reduction needed to achieve the proposed targets. The most critical area is mostly urban (MSU Campus), as the other subwatersheds have very mixed land uses, but with a predominance of pasture/hay systems.



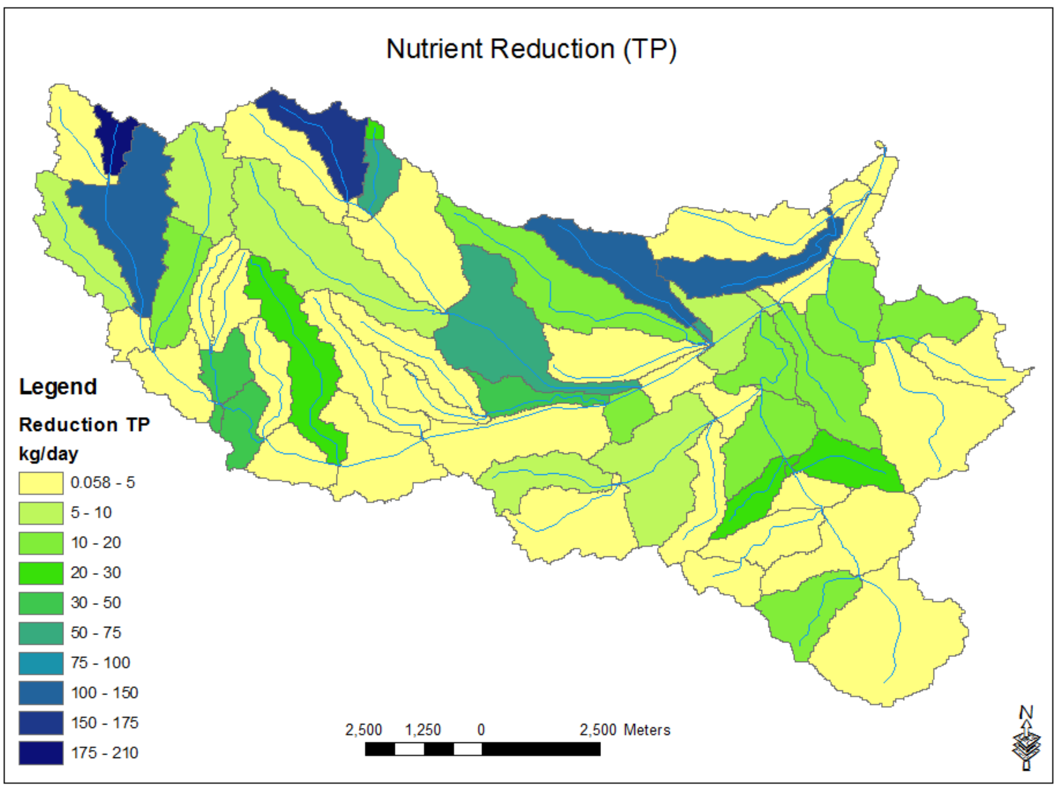
Total Nitrogen Load from Subwatersheds within the Red Bud-Catalpa Creek Watershed



Total Phosphorus Load from Subwatersheds within the Red Bud-Catalpa Creek Watershed



Total Nitrogen Load Reduction (kg/day) within the Red Bud-Catalpa Creek Watershed

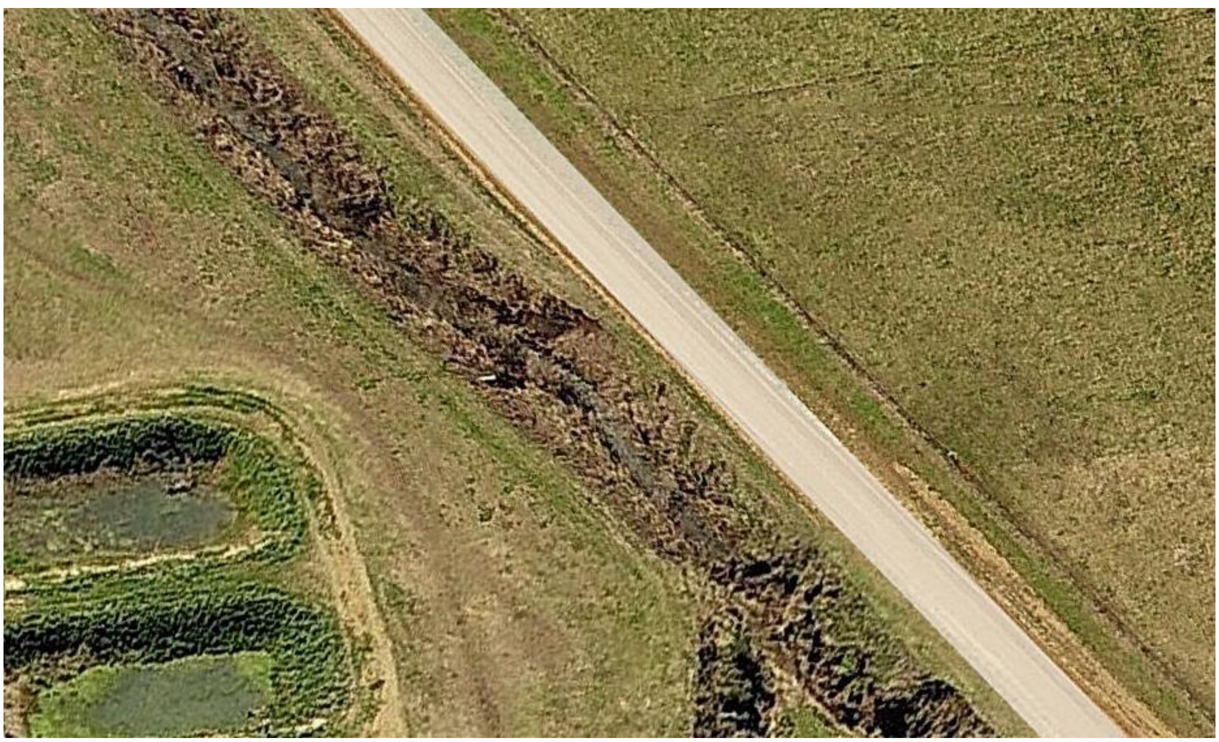


Total Phosphorus Load Reduction (kg/day) within the Red Bud-Catalpa Creek Watershed

Management Areas of Concern for Stream Processes

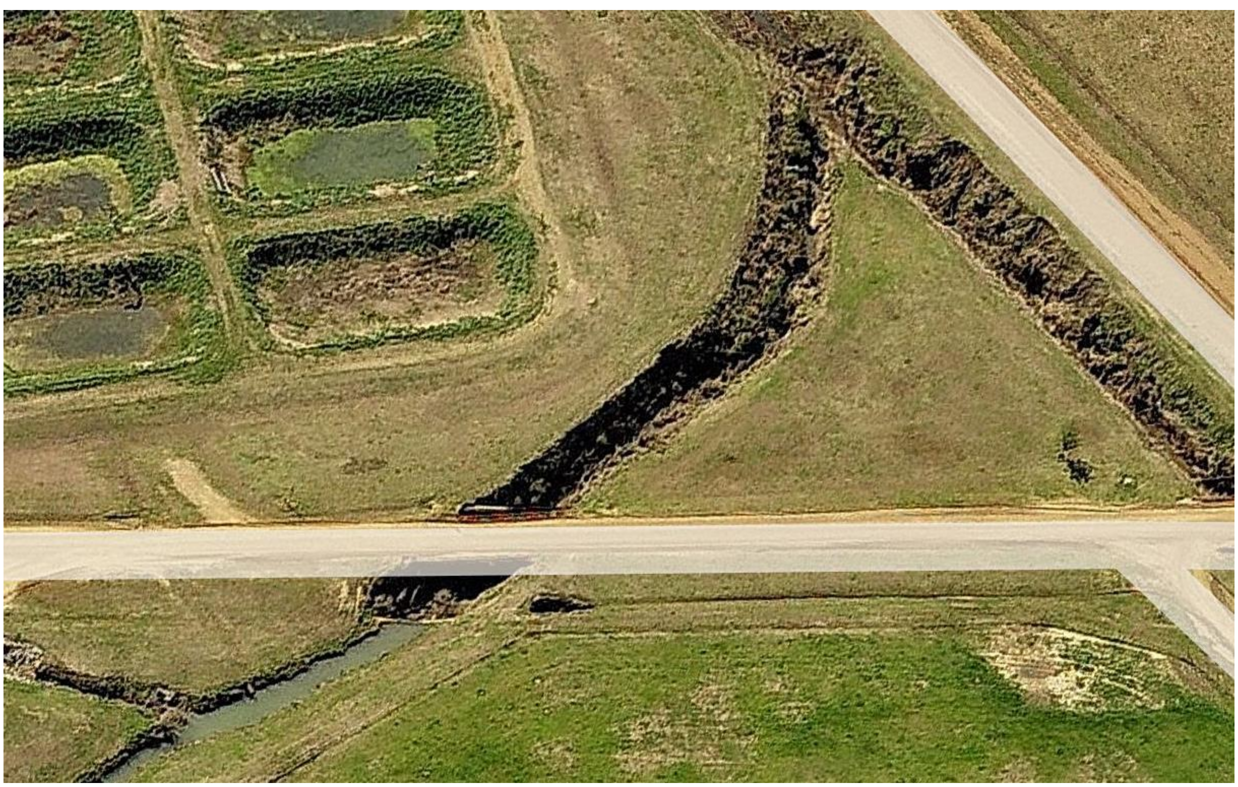
Stream processes have been well identified along different segments on the upper four miles of the main stream of the Catalpa Creek and some of its tributaries. Active eroding streambanks, streambed scouring and streambank undercutting processes are importantly increasing the load of sediments carried by the stream. The presence of sand and gravel bars observed a few feet upstream of road crossings and stream junctions, and inside of bend way segments are consequences of the erosion activity observed along the segments upstream. As discussed in the *Water Resources Management Plan for the Red Bud-Catalpa Creek Watershed*, at the boundary of the university's research farm, the stream maintains its incised conditions, but an increase in its sinuosity is evidenced by the frequent presence of segments with sequential patterns of rills and pools, and a reduction in the channel slope and the streambank sides' slopes.

A preliminary assessment completed by undergraduate students of the Civil and Environmental Engineering Department evidenced that sediment concentrations and turbidity along the main channel are high, while pH and dissolved oxygen levels are lower at downstream locations compared to measurements from a monitoring station located at the Campus boundaries on Blackjack Road. After leaving the campus, sediment concentrations and turbidity decreased, but an increasing trend was observed between transects 1.3 miles and 2.5 miles, where active streambanks were more frequently observed.



Active Streambanks along the Upper 4 Miles of the Main Stem of Catalpa Creek
(Images from Bing.com**)**

Active Stream Banks along the Upper 4 miles of the Main Stem of Catalpa Creek
(Images from Bing.com)



Stream Bank Instability Downstream of a Dam on a Catalpa Creek Tributary
(Images from Bing.com)