The Ozarks Environmental and Water Resources Institute (OEWRI)
Missouri State University (MSU)

FINAL REPORT

Nonpoint Source Bank Erosion and Load Reduction Assessment for the Pearson Creek 319 Riparian Corridor Easement Site, 5377 E. Foxgrove Lane Greene County, Missouri

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SCOPE AND OBJECTIVES

The James River Basin Partnership (JRBP) has implemented a riparian corridor easement on private property along Pearson Creek, a major tributary of the James River. This conservation easement is part of a Section 319 Grant from the Missouri Department of Natural Resources and the Environmental Protection Agency Region VII designed to reduce nonpoint source pollution to the James River. In 2001, a Total Maximum Daily Load (TMDL) was developed for the James River that set nutrient limits and targets for both wastewater treatment facilities and nonpoint sources in the watershed (MDNR, 2001). Efforts to control point sources through improved tertiary treatment have reduced nutrient concentrations in the Lower James River between 60%-70% (MDNR, 2004). Recent management efforts have focused on reducing pollution from nonpoint sources in the James River Basin, which includes contributions from bank erosion. Sediment released to the channel by erosion can supply excess nutrients to streams and cause sedimentation problems downstream (Owen et al. 2007; Owen and Pavlowsky 2008). By implementing conservation easements and restoring the riparian corridor, nutrients and sediment entering the stream by bank erosion and near-channel runoff can be reduced over time.

The Ozarks Environmental and Water Resources Institute (OEWRI) at Missouri State University was responsible for assessing nonpoint source pollution loads for this project to determine sediment and nutrient contributions to Pearson Creek for the ≈150 meter (m) long easement segment. Riparian easements remove the potential for future development or other disturbances that can increase runoff and nonpoint loads to the river. The purpose of this assessment is to evaluate the effects of the riparian easement implementation and reduced bank erosion rates on sediment and nutrient loads in Pearson Creek to support 319 requirements and the goals of the James River Total Maximum Daily Load (TMDL). The specific objectives of the assessment are to calculate nonpoint loads of sediment and phosphorus to the channel due to bank erosion and to quantify runoff load reductions from easement area using different scenarios based on land use management using the nonpoint source pollution model STEPL (Spreadsheet Tool for Estimating Pollutant Load).

STUDY AREA

The Pearson Creek watershed (12-digit Hydrologic Unit Code (HUC) 110100020107) is approximately 59.2 km^2 (22.9 mi^2) and drains the eastern edges of the City of Springfield Missouri in Greene County flowing south to the confluence of the James River (Figure 1). The underlying geology of the watershed is Mississippian age limestone within which a karst landscape has formed where sinkholes, losing streams, and springs are common (Bullard et al. 2001). Land use of the watershed ranges from high-low density urban in the western half of watershed to residential, livestock grazing, and forage crop production outside the city limits to

the east (Hutchison 2010). The easement is along the main channel of Pearson Creek between FR 199 and FR 205 on private property located at 5377 E. Foxgrove Lane in eastern Greene County, Missouri (Figure 2). The upstream drainage area is approximately 29.6 km^2. The total area of the easement is around 0.6 ha located along the south side of the stream that is currently 100% forested.

METHODS

The influence on water quality from establishing a riparian buffer along an easement was assessed by predicting the reduction of nutrients and sediment input to the stream from both bank erosion and runoff from the land area within the easement along the channel. Specific methods used in this assessment are detailed below.

Bank Erosion

The bank erosion rate used for this study was based on results of a recent erosion pin monitoring study in the area where the average bank erosion rate was 0.48 Mg/m/yr and the average phosphorus loss due to bank erosion was 0.17 kg/m/yr (Owen et al. 2015). This study looked at erosion from both banks of the stream. For this study, the erosion rate was cut in half to represent the easement that is only on the south bank of the stream. The average phosphorus concentration of 359 mg/kg for floodplain soils was used to calculate the total P load coming from bank erosion in the study reach (Owen et al. 2015). The average phosphorus concentration was calculated from a total of 50 samples collected at two different sites along Wilson Creek upstream of the wastewater treatment plant (Rodgers, 2005). Samples were collected at exposed cutbanks along the channel in 10 cm increments and were sent to ALS Chemex Laboratory (Sparks, Nevada) for hot aqua-regia extraction and geochemical analysis by inductively coupled plasma-atomic emission spectroscopy (ICP-AES).

STEPL Water Quality Model

STEPL is a customizable spreadsheet-based model for use in Excel. Using simple algorithms, it calculates nutrient and sediment loads from different land uses and the load reductions from the implementation of BMPs. Annual nutrient loading is calculated based on the runoff volume and pollutant concentrations. The annual sediment load from sheet and rill erosion is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. Accuracy is primarily limited by the wide variability in event mean concentrations (EMCs) across watersheds since EMCs drive the water quality calculations.

For this study, load results of existing conditions were compared to scenarios that change the hydrological and nutrient management characteristics of the site. Hydrological inputs into the model are controlled by soils information supplied by the user. Soils within the easement area

were identified, clipped, and areas calculated using ArcGIS. The Hydrological Soil Group (HSG) was assigned to the appropriate soil mapping unit. Combined curve numbers were calculated using techniques outlined in TR-55 (USDA, 1986). Greene County Missouri and the Springfield Regional Airport were selected within the STEPL user interface for rainfall and runoff data. Built-in default nutrient and sediment concentrations were used for each land use category within each scenario.

RESULTS AND DISCUSSION

Bank Erosion

Results of this study suggest that preserving the current land use within the conservation easement can protect Pearson Creek from potential contributions of nutrients and sediment if the land use was changed within the easement area. Total estimated bank erosion for the study site was 36.0 Mg/yr with 12.8 kg/yr of phosphorus (P) loss (Table 1). The upstream watershed loads were estimated at the site by extrapolating loads from the YY Bridge (25.8 km^2) located just upstream (Owen and Pavlowsky 2014). Annual loads at the State YY Bridge were 286.7 Mg of TSS, 20.0 Mg of TN and 1.5 Mg of TP (Table 2). Extrapolating that to the drainage area of the study site the annual loads are 331.5 Mg of TSS, 23.1 Mg of TN, and 1.5 Mg of TP. Using the nutrient and sediment yields estimates suggest that about 11% of the sediment load in Pearson Creek at this location could be coming from bank erosion from the easement area if erosion rates were similar to measured rates in other local streams (Table 3). Phosphorus contributions from bank erosion account for <1% of the annual load at the watershed outlet. However, assuming that the forested area was removed from the easement area and erosion would increase, there would be about a 3.6-11% increase in sediment and around 0.3-0.9% increase in P in Pearson Creek at this location. Results of this study suggest that bank erosion can have a significantly negative impact on water quality in Pearson Creek and the implementation of a conservation easement at this location can protect the stream from sediment contributions from bank erosion.

STEPL Modeling Results

Model results suggest there is a significant increase in nutrient and sediment loads in runoff from the easement when the land cover is changed from the existing conditions. The entire easement area is 0.6 ha and the Cedargap silt loam is only soil series mapped within the easement area and is classified hydrological soil group (HSG) B soil (Table 4). This soil classification was used to generate curve number (CN) values that were combined with different land use scenarios in STEPL to calculate pollutant loads. Using the existing land use in the model, the P load is 0.14 kg/yr, the nitrogen (N) load is 0.27 kg/yr, and the sediment load is 0.09 Mg/yr (Table 5). There is an increase in annual loads when the forest land cover is removed from the model and the site is converted to pasture land. Annual loads from the pasture scenario are 0.86 kg/yr P, 6.4 kg/yr N, and 0.82 Mg/yr sediment. These estimates are 6-23x higher than loads modeled from existing

conditions. Conservation easements produce much lower reduction in nutrients and sediment if they are applied to the channel when looking at runoff generated compared to bank erosion. At this location, the sediment and nutrient load entering the stream by runoff from the 0.6 ha easement area is extremely low compared to the entire watershed. However, it can improve water quality at the local scale through less near-channel loads and can act a buffer between more intense land use and the stream.

CONCLUSIONS

The JRBP has implemented a 150 m conservation easement along the south bank of Pearson Creek in Greene County, Missouri. This study estimates the annual nutrient and sediment loads using bank erosion rates measured in a local stream and by using STEPL water quality modeling. The results of this analysis are used to determine the impact protecting the land within the easement has on sediment and nutrient loads. There are three main conclusions from this study:

1. **Bank erosion from this site is potentially significant.** Total estimated bank erosion for the study site was 36.0 Mg/yr with 12.8 kg/yr of phosphorus (P) loss suggesting that about 11% of the sediment load in Pearson Creek at this location could be coming from bank erosion from the easement area if erosion rates were similar to measured rates in other local streams.

2. **STEPL water quality model created for easement area**. Conservation easements produce much lower reduction in nutrients and sediment if they are applied to the channel when looking at runoff generated compared to bank erosion. However, results of this assessment suggest that converting easement area to pasture could increase sediment and nutrient loads in runoff by 6-23x that of existing conditions. At this location, the sediment and nutrient load entering the stream by runoff from the 0.6 ha easement area is extremely low compared to the entire watershed. However, it can improve water quality at the local scale through less near-channel loads and can act a buffer between more intense land use and the stream.

3. **Results of this assessment suggest that riparian easements can have a significant impact on protecting water quality from sediment and nutrient inputs from bank erosion**. If the forested area was removed from the easement area and erosion would increase, there would be about a 3.6-11% increase in sediment and around 0.3-0.9% increase in P in Pearson Creek at this location. Results of this study suggest that bank erosion can have a significantly negative impact on water quality in Pearson Creek and the implementation of a conservation easement at this location can protect the stream from sediment contributions from bank erosion.

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TABLES

Table 1. Bank Erosion Estimate Results

Segment Length (m)	Annual Sed. Erosion Per Unit Length (Mg/m/yr)	Annual Phos. Loss Per Unit Length (kg/m/yr)	Sediment Eroded for S. Bank (Mg)	P to Stream from S. Bank (kg)
150	0.48	0.17	36.0	12.8

Table 2. Annual Nutrient and Sediment Loads

Station	Ad (km^2)	TSS Load (Mg)	TN Load (Mg)	TP Load (Mg)
YY	25.8	286.7	20.0	1.3
Study Site	29.6	331.5	23.1	1.5

Table 3. Estimated Reductions in Sediment and P from Bank Erosion

	TSS	TP
Annual Load Outlet (Mg)	331.5	1.5
Total from Bank Erosion (Mg/yr)	36.0	0.013
% at Outlet	11.0	0.9
Load with 25% increase (Mg/yr)	48.0	0.0173
% Increase at Outlet	3.6	0.3
Load with 50% increase (Mg/yr)	72.0	0.026
% Increase at Outlet	11.0	0.9

Table 4. Description of Soils in Easement Area

Soil Description	**HSG**	**Area (ha)**
Cedargap silt loam, 0 to 3 percent slopes, frequently flooded	B	0.6

Table 5. STEPL Modeling Results

Scenarios	**Land Use (Condition)**	**CN**	**TP (kg/yr)**	**TN (kg/yr)**	**TSS (Mg/yr)**
Existing Conditions	100% Woods	55	0.14	0.27	0.09
Pasture	100% Pasture	69	0.86	6.4	0.82

FIGURES

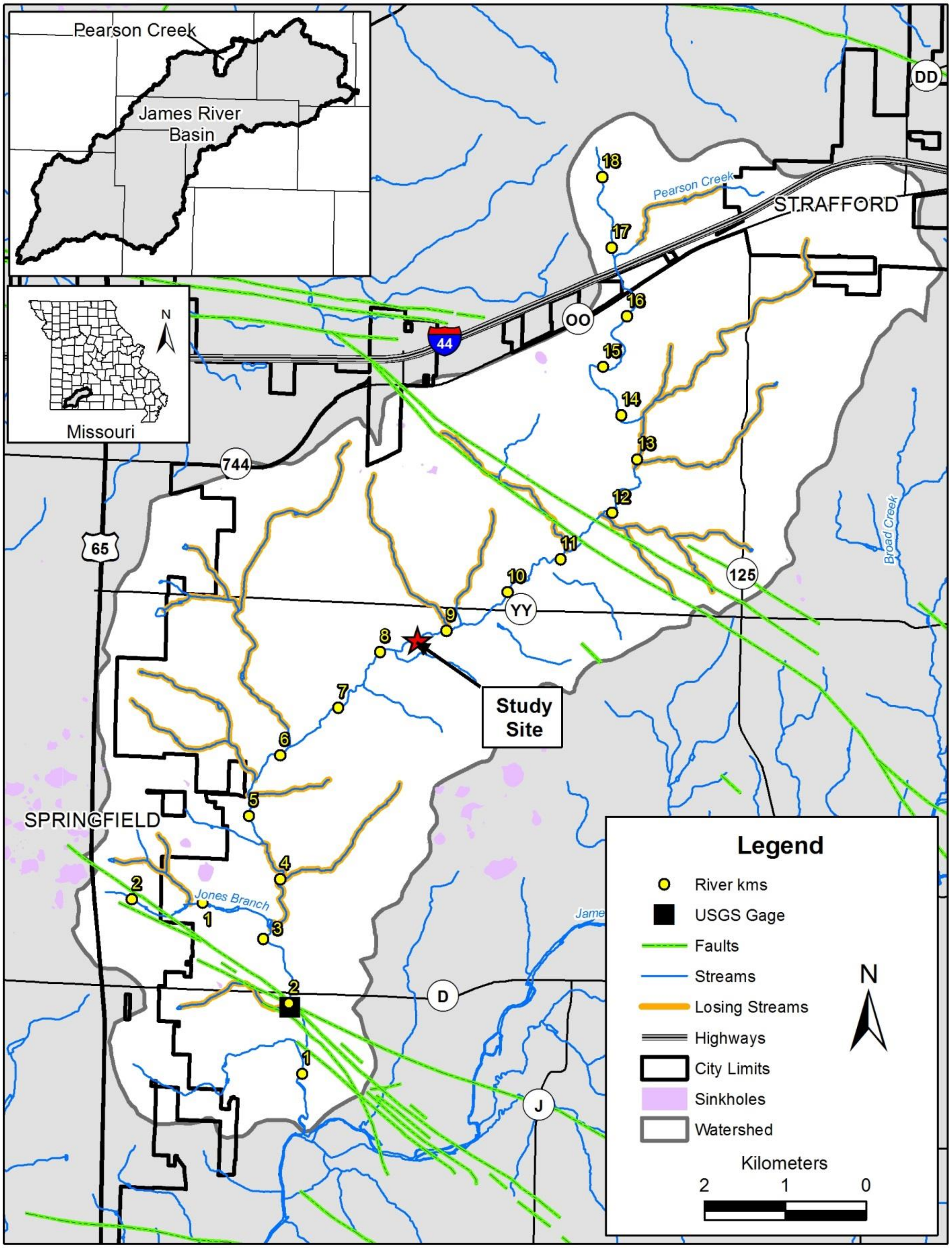

Figure 1. Pearson Creek watershed.

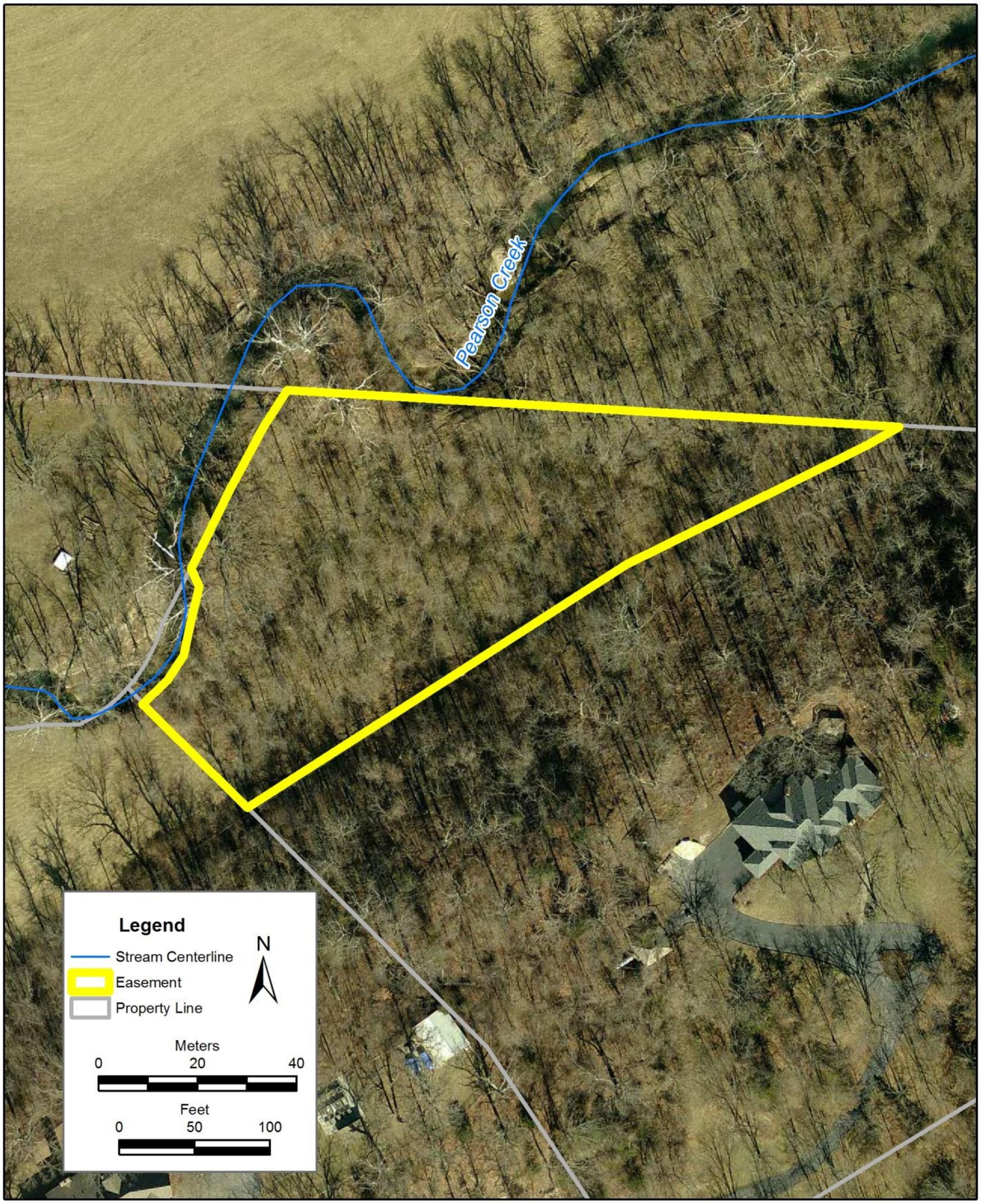

Figure 2. Study area map showing 0.6 ha easement area.