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

FINAL REPORT

Riparian Corridor and Detention Basin Retrofit Load Reduction Assessment, Wilson Creek 319 Project, Springfield, Missouri

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SCOPE AND OBJECTIVES

The James River Basin of southwest Missouri is listed on the state's 303(d) list for being impaired by nutrients from multiple point and nonpoint sources (MDNR 2001). 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 urban nonpoint land use (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). However, nutrient concentrations still remain high in streams draining urban areas within the Wilson Creek-James River Watershed (Richards and Johnson 2002; Miller 2006; MEC 2007; Hutchinson 2010). Therefore, urban nonpoint source pollution must be addressed in order to meet water quality goals set forth in the TMDL.

In 2017, the James River Basin Partnership updating the watershed management plan for the Wilson Creek-James River watershed using the Soil and Water Assessment Tool (SWAT) water quality model. Initial SWAT model results showed the majority of the nutrient and sediment load was coming from the Wilson Creek watershed (Pavlowsky et al. 2016). Furthermore, model output suggested that the main source in the Upper Wilson Creek watershed was urban land uses. The model quantified existing loads as well as load reductions from Best Management Practice (BMP) implementation in the developed areas in the upper watershed. Model results show nonpoint source TP reduction should be the main focus of nonpoint source management efforts for improving water quality in Wilsons Creek and that a 70-80% reduction would be required to meet water quality goals. Load reduction analysis suggested BMPs to reduce stormwater pollution and implementation of conservation easements that protect and enhance the riparian corridor along Wilson Creek could also substantially reduce nutrient and sediment loads in the Wilson Creek watershed.

In 2019, JRBP and its partners implemented two detention basin retrofits and were able to obtain a 40.4 acre conservation easement along the main channel of Wilson Creek. The purpose of this report is to estimate potential nutrient and sediment load reduction from the implementation of the conservation easement and the detention basin retrofits using the Spreadsheet Tool of Estimating Pollutant Loads (STEPL) and results of BMP implementation monitoring studies in the area. The specific objectives of this report are: 1) estimate existing nutrient and sediment load using available information on soils, land use, and vegetation at each site; 2) determine the nutrient and sediment load using the newly implemented BMPs at each site; and 3) calculate the difference in the load before and after implementation at each site.

DESCRIPTION OF THE STUDY SITES

The Wilson Creek watershed is approximately 102 mi^2 and drains the central and western edges of the City of Springfield in Greene County before flowing south to the confluence of the James River (Figure 1). Land use in the watershed is 49.2% urban, 38.9% agricultural, and 11.7% forested. The urban area is concentrated in the upper 1/3 of the watershed while the lower 2/3 of the watershed are mostly grass/pasture land. Within the urban area approximately 42% is single-family residential land use. There are three sites that will be evaluated for this analysis. The first is a conservation easement along Wilson Creek at Rutledge-Wilson Park. The next site is a detention basin retrofit draining a single-family development along Seminole Street. The final site is another detention basin retrofit draining a single-family development from the Frisco Trails subdivision. Further details about each project area are given below.

Rutledge-Wilson Park Conservation Easement

The Rutledge-Wilson Park conservation easement is located along both banks of the main channel of Wilsons Creek upstream of the Farm Road 146 bridge in west Springfield (Figure 2). The site is approximately 40.4 acres in size and is a mix of forest (73%), grass (15%), and water (12%) (Table 1). The easement is located next to a trail along the east side of the easement (Photo 1). There are two small areas of grass along the east side of the easement (Photos 2 and 3). Trees in the forested area along the hillslope on the west side of the stream are mature, mixed deciduous species and red cedars, with various riparian species (willow, sycamore, etc.) along the valley bottoms with some underbrush (Photo 4). Soils within the easement are mostly floodplain soils (74%) with the majority classified in Hydrological Soil Group (HSG) C/D. The floodplain soils (Humansville and Dapue) are formed in silty-clay loam alluvium with nearly level slopes (1%) with slope length <200 ft. The remaining soils within the easement are hillslope soils (Goss, Gasconade, Wilderness) that are formed in mixed parent materials including loess, residuum, and colluvium with slopes ranging from 6-25% with slope lengths of <200 ft. Erodibility of these soils, expressed as a K-factor, range from 0.32-0.43 and are considered moderately erodible.

Seminole Street Detention Basin Retrofit

The Seminole Street detention basin retrofit is located along north side the 1400 block of west Seminole Street in west Springfield (Figure 3). Water exiting this basin flows south through a series of pipes and open ditches and eventually drains into South Creek just east of Kansas Expressway. The watershed area of the detention basin is approximately 56.7 acres and drains a single-family residential development with about ¼ acre lot sizes (Table 2). Impervious surface (roads, sidewalks, dwellings) covers approximately 41% of the watershed area connected by underground pipes all routing water to the detention basin. The soils (Wanda and Newtonia) within the watershed are typical upland soils for the area and are classified in HSG B. The detention basin is approximately 120 ft by 60 ft with an outlet structure along the south side of the basin. The new outlet structure has a water quality control perforated plate with several small holes to restrict the low flow outlet (Photo 5). Additionally, built-up sediment within the basin was removed and a concrete trickle channel was installed to make maintenance easier in the future.

Frisco Trails Subdivision Detention Basin Retrofit

The Frisco Trails Subdivision detention basin retrofit is located along the north side of the 3200 block of west Marcella Drive in southwest Springfield (Figure 4). This basin drains into Rountree Branch, which flows west to the confluence of Wilson Creek near Springfield's waste water treatment facility. The watershed area of the detention basin is approximately 24.7 acres and drains a single-family residential development with lot sizes generally ranging from 1/4-1/3 of an acre with larger (>1/2 acre) lots located along south Golden Avenue (Table 2). Total impervious surface covers about 42% of the watershed with curb and gutter streets, curb inlet boxes, and underground pipes all routing water to the detention basin. The soil (Creldon) mapped within the watershed is a typical upland soils for the area that includes a fragipan 26-33" below the surface and therefore is classified in HSG C. The detention basin is approximately 240 ft by 95 ft with an outlet structure along the northwest end of the basin. The outlet structure has a low flow opening with notched weir overflow. In the past this basin would not drain properly and held a shallow pool of water for extended periods that made establishing vegetation in the bottom of the basin difficult. To remedy this, over 100 plants that can tolerate wet conditions were planted in the bottom of the basin that can both filter pollutants and protect the bottom of the basin from erosion (Photo 6).

LOAD REDUCTION METHODS

Site specific nutrient and sediment loads and influence of BMP installation will be estimated from a predictive model (STEPL) (Tetra Tech 2010). Spreadsheet Tool for Estimating Pollutant Load (STEPL) uses simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions from implementation of BMPs that are already built into the model. Annual nutrient loading will be calculated based on the runoff volume and pollutant concentrations. The annual sediment load from sheet and rill erosion will be calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. Loading reductions resulting from the implementation of BMPs will be computed from the known BMP efficiencies. Accuracy is primarily limited by the wide variability in event mean concentrations (EMCs) across watersheds since EMCs are used to calculate annual pollutant loadings.

Conservation Easement Methods

Load results of existing conditions at the conservation easement site will be compared to several 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. Curve numbers (CN) within STEPL were used for the forest and grassland land use. The curve number for the pasture land use was modified using appropriate curve numbers for a meadow in fair condition from TR-55 (USDA, 1986). Greene County Missouri and the Springfield Regional Airport were selected within the STEPL user interface for rainfall and runoff data. USLE numbers for K and LS were based on a weighted average technique. Built-in default nutrient and sediment concentrations were used for each land use category within each scenario. These methods have been used to estimate load reduction from conservation easements in the past (Owen et al. 2013a, Owen et al. 2013b, Owen et al 2015, Owen and Pavlowsky 2015).

Detention Basin Retrofits Methods

Preconstruction detention basin loads will be estimated using drainage area, land use, and soil type and compared to the new load estimated after implementation of the BMP . Hydrological inputs into the model are obtained from soils information identified, clipped, and areas calculated using ArcGIS. The Hydrological Soil Group (HSG) was assigned to the appropriate soil mapping unit. Curve numbers (CN) within STEPL were used for single-family residential land use. 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. This annual runoff, sediment, and nutrient load was used in both the pre and post implementation scenario within the model to simulate what was entering the basin.

For the existing condition, a dry detention basin BMP was used at both the Seminole Street and Frisco Trails detention basins. For the post-implementation scenario at the Seminole Street site an extended wet detention BMP was chosen to simulate the new outlet structure at this site. Typical BMP efficiencies for dry detention basins are 30% for nitrogen, 26% for phosphorus, and 58% for sediment (Tetra-Tech 2010). However, for extended wet detention the efficiency increases to 55% for nitrogen, 69% for phosphorus, and 86% for sediment. For the post-implementation scenario at the Frisco Trails site a wetland detention BMP was chosen to simulate to new functionality of the basin at this site. The BMP efficiencies for wetland detention are 20% for nitrogen, 44% for phosphorus, and 78% for sediment. Dry detention basins were the existing condition used to determine existing loads for each site. Loads were then estimated for the new condition compared to the existing load to determine the appropriate reduction.

LOAD REDUCTION RESULTS

Rutledge-Wilson Park Conservation Easement

Model results indicate planting trees in the grass areas within the riparian corridor would help in reducing the nutrient and sediment loads for the Rutledge-Wilson Park Conservation Easement. Existing nutrient and sediment loads for this site are 81.4 lb/yr N, 15.6 lb/yr P, and 5.3 T/yr of sediment (Table 3). If the riparian areas within the easement were to be enhanced by establishing a forested riparian buffer throughout the easement, N load would be reduced to 26.2 lb/yr, P 11.5 lb/yr, and 4.4 T/yr of sediment. This would result in a 17-68% load reduction at this site. However, at this time there are no plans to enhance the existing riparian corridor in the easement area. Alternatively, if the area was converted to a mixture of urban area on the hillslopes and pasture along the floodplain, loads would increase to 296 lb/ac N, 34.2 lb/ac P, and 7.5 T/ac of sediment. By allowing this site to be developed and/or reverted to grazing land, nutrient and sediment loads would increase 42-264%.

Seminole Detention Basin

The decrease in nutrients and sediment loads due to the implementation of the BMP at the Seminole detention basin was similar load reductions measured in other area detention basins. The pre-construction nutrient and sediment loads for the Seminole detention basin site are 142.9 lb/yr N, 27.5 lb/yr P, and 2.0 T/yr of sediment (Table 4). With the implementation of the restriction in the low flow outlet, the estimated new load is 91.8 lb/yr N, 11.7 lb/yr P, and 0.7 T/yr of sediment. This amounts to an 36-67% reduction in nutrients and sediment leaving the detention basin. These are similar to local load reduction results measured at detention basin outlets in single-family residential neighborhoods which were 28% nitrogen, 61% phosphorus, and 41% for sediment (Owen and Pavlowsky 2011).

Frisco Trails Detention Basin

Results of the BMP implementation at the Frisco Basin show a decrease in the P and sediment load, however, there it also shows a small increase in the N load. The pre-construction nutrient and sediment loads for the Frisco Trails detention basin site are 91.8 lb/yr N, 17.6 lb/yr P, and 1.3 T/yr of sediment (Table 4). With the implementation of the wetland detention enhancement, the estimated new load is 104.9 lb/yr N, 13.4 lb/yr P, and 0.7 T/yr of sediment. While this amounts to an 24-47% reduction in P and sediment leaving the detention basin, there is about a 13.1% increase in N using these methods. While this outcome is not ideal, the reduction in P and sediment is more important due to P being the limiting nutrient for eutrophication in the James River (MDNR 2001).

Watershed-Scale Significance

While the reduction of sediment and nutrients from these three projects are significant at the catchment scale, they represent only a small fraction of the overall nonpoint source load in the Wilson Creek watershed. The total annual load reduction estimates for all three projects combined were 93.2 lbs/yr nitrogen, 24.1 lbs/yr phosphorus, and 2.8 T/yr of sediment. Previous studies have estimated the annual nonpoint source load at the Wilson Creek confluence to be 144,623 lbs/yr nitrogen, 37,919 lbs/yr phosphorus, and 23,295 T/yr of sediment (Owen et al. 2015). This equates to less than a 0.1% reduction in the total nonpoint source load for the Wilson Creek watershed. These results are similar to Soil and Water Assessment Tool (SWAT) model estimates in the Wilson Creek watershed that suggest implementing BMPs to the majority of the urban area in Springfield would result in a maximum reduction of around 25% of nonpoint nutrients and sediment in the watershed above the treatment plant (Pavlowsky et al. 2016). Therefore, the three projects installed for this study represent only a small fraction of the overall load in the Wilson Creek watershed, but demonstrate three examples of BMP designs that can be further implemented in the urban areas in the watershed.

CONCLUSIONS

The James River Basin of southwest Missouri is listed on the state's 303(d) list for being impaired by nutrients from multiple point and nonpoint sources. Point source improvements have reduced nutrient concentrations 60%-70%, but nonpoint contributions from urban areas remain high. Recent water quality models developed for the Wilson Creek-James River watershed showed the majority of the nutrient and sediment load was coming from the Wilson Creek watershed. To help reduce nonpoint contributions to the James River, JRBP and its partners implemented two detention basin retrofits and were able to obtain a 40.4 acre conservation easement along the main channel of Wilson Creek. The purpose of this report is to estimate nutrient and sediment load reduction from the implementation of the conservation easement and the detention basin retrofits using the Spreadsheet Tool of Estimating Pollutant Loads (STEPL) and results of BMP implementation monitoring studies in the area. The specific objectives of this report are: 1) estimate existing nutrient and sediment load using available information on soils, land use, and vegetation at each site; 2) determine the nutrient and sediment load using the newly implemented BMPs at each site; and 3) calculate the difference in the load before and after implementation at each site. There are four main conclusions from this report:

1) Model results indicate planting trees in the grass areas within the riparian corridor would help in reducing the nutrient and sediment loads for the Rutledge-Wilson Park Conservation Easement. Enhancing the forested buffer throughout the easement would result in a 17-68% load reduction of nutrients and sediment at this site. However, by allowing this site to be developed and/or reverted to grazing land, nutrient and sediment loads would increase 42-264%.

2) The decrease in nutrients and sediment loads due to the implementation of the BMP at the Seminole detention basin was similar to load reductions measured in other area detention basins. Load reduction estimates an 36-67% reduction in nutrients and sediment leaving the detention basin similar to local load reduction results measured at detention basin outlets in single-family residential neighborhoods.

3) Results of the BMP implementation at the Frisco Basin show a decrease in the P and sediment load, however, there it also shows a small increase in the N load. While this amounts to an 24-47% reduction in P and sediment leaving the detention basin, there is about a 13.1% increase in N using these methods, however P is the limiting nutrient for eutrophication in the James River.

4) While the reduction of sediment and nutrients from these three projects are significant at the catchment scale, they represent only a small fraction of the overall nonpoint source load in the Wilson Creek watershed. Load reduction from these three projects are less than 0.1% of the total nonpoint source load of nutrient and sediment in the Wilson Creek watershed. Therefore, the three projects installed for this study represent only a small fraction of the overall load in the Wilson Creek watershed but demonstrate three examples of BMP designs that can be further implemented in the urban areas in the watershed.

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TABLES

Table 1. Site Characteristics of Conservation Easement

Northing (m)*	Easting (m)*	Area (ac)	Land Use	Soil Description	HSG	CN
4,116,520.636	467,941.312	40.4	Forest (73%) Grassland (16%) Water (11%)	Humansville silt loam (74%) Goss-Gasconade complex (21%) Goss-Wilderness complex (4%) Dapue silt loam (1%)	C/D B B B	73 79

UTM NAD 83 Zone 15N

Table 2. Site Characteristics of Detention Basin Retrofits

Northing (m)*	Easting (m)*	Drainage Area (ac)	Land Use	Soil Description	HSG	CN	Existing	New BMP
<u>Seminole</u> 4,114,378.922	472,353.770	56.7	Single-family residential	Wanda silt loam (88%) Newtonia silt loam (12%)	B B	72	Dry Detention	Extended Wet Detention
<u>Frisco Trails</u> 4,110,123.650	469,431.024	24.7	Single-family residential	Creldon silt loam (100%)	C	81	Dry Detention	Wetland Detention

* UTM NAD 83 Zone 15N

Table 3. STEPL Modeling Results for Conservation Easement

Scenarios	N (lb/yr)	P (lb/yr)	Sed (T/yr)	Scenarios	N (lb/yr)	P (lb/yr)	Sed (T/yr)
Existing	81.4	15.6	5.3	Existing	81.4	15.6	5.3
Forest	26.2	11.5	4.4	Urban/Pasture	296.4	34.2	7.5
Load Reduction *(%)*	55.2 *(68%)*	4.1 *(26%)*	0.9 *(17%)*	Load Increase *(%)*	215.0 *(+264%)*	18.6 *(+119%)*	2.2 *(+42%)*

* Red indicates an increase in the load

Table 4 STEPL Modeling Results for Detention Basin Retrofits

Site	Existing Load			New Load			Load Reduction		
	N (lb/yr)	P (lb/yr)	Sed (T/yr)	N (lb/yr)	P (lb/yr)	Sed (T/yr)	N (lb/yr) *(%)*	P (lb/yr) *(%)*	Sed (T/yr) *(%)*
Seminole	142.9	27.5	2.0	91.8	11.7	0.7	51.1 *(36%)*	15.8 *(56%)*	1.3 *(67%)*
Frisco Trails	91.8	17.6	1.3	104.9	13.4	0.7	-13.1* *(+14%)*	4.2 *(24%)*	0.6 *(47%)*

* Red indicates an increase in the load

FIGURES

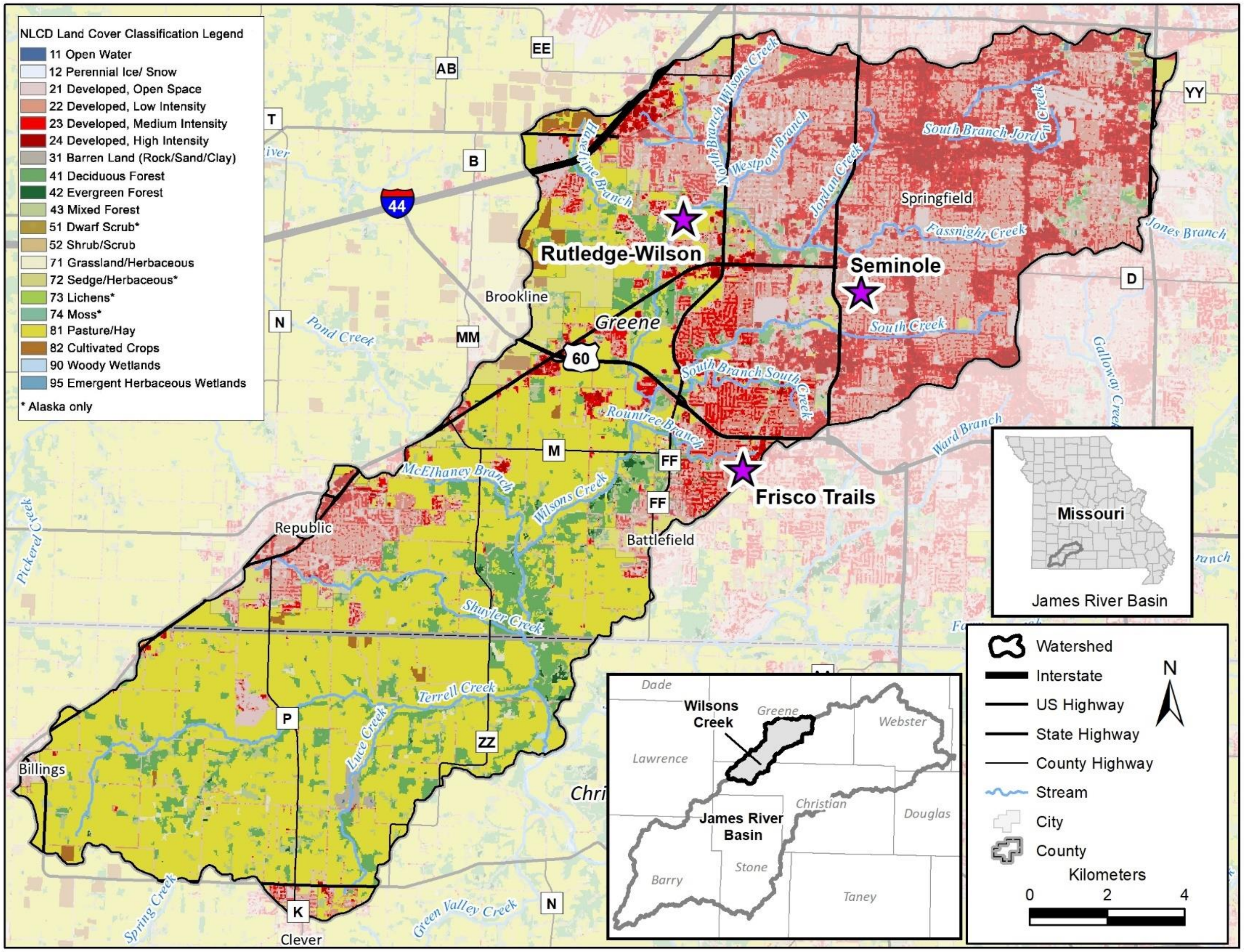

Figure 1. Project locations within the Wilson Creek watershed with 2016 land use and land cover data.

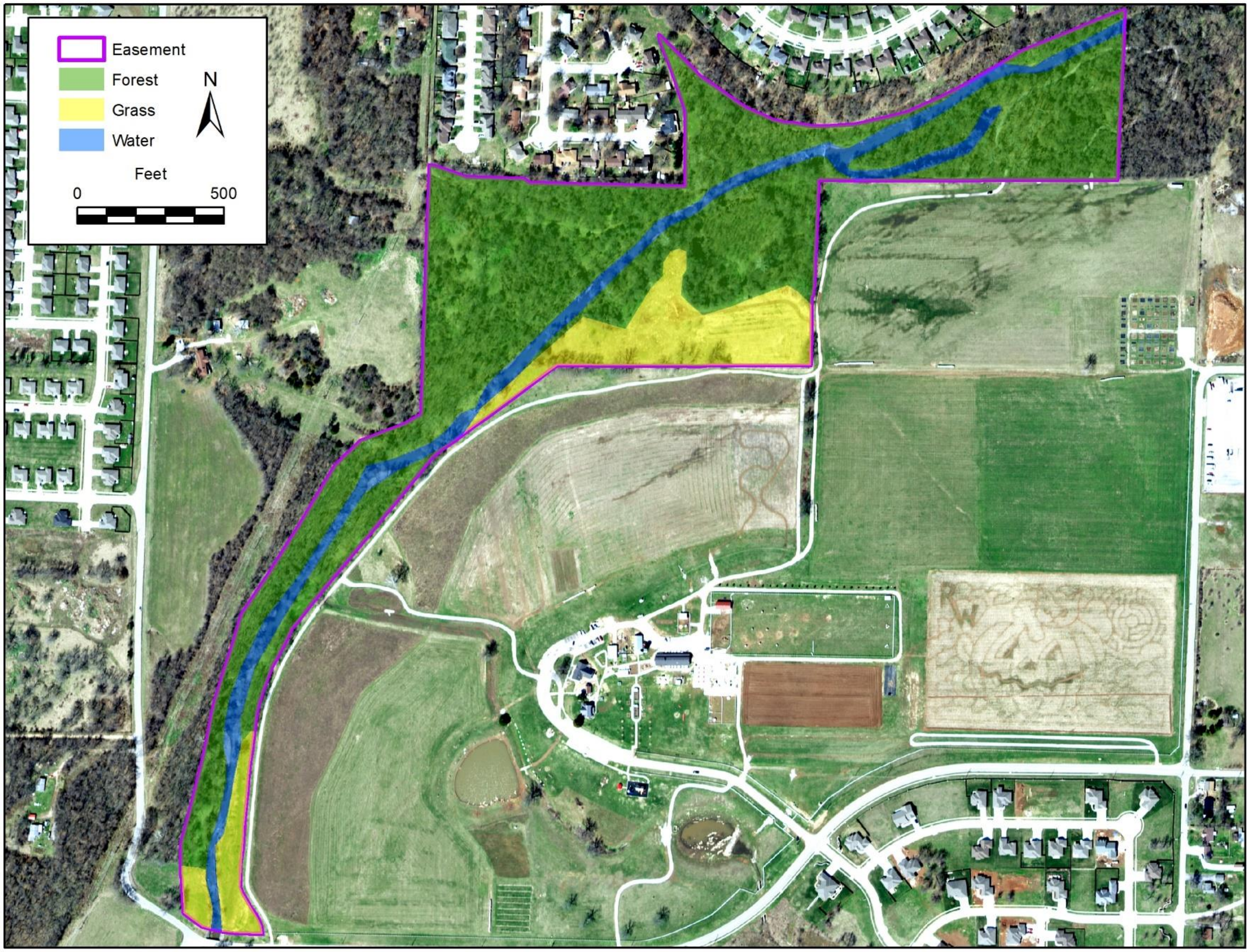

Figure 2. Rutledge-Wilson park conservation easement with land cover classification.

Figure 3. Seminole detention basin and catchment area.

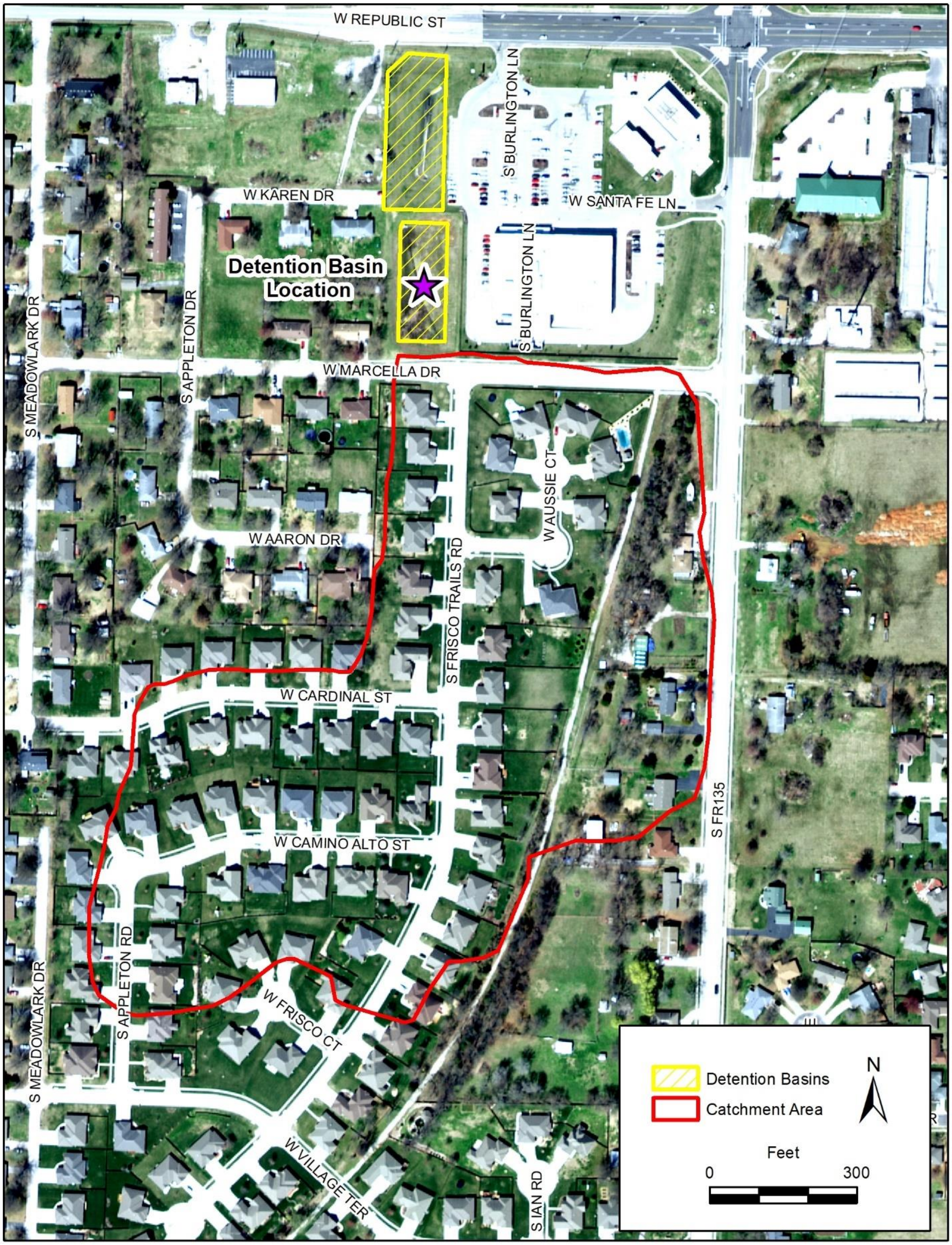

Figure 4. Frisco Trails detention basin and catchment area.

PHOTOS

Photo 1. Greenway Trail along the edge of the Rutledge-Wilson park conservation easement (Dec. 3, 2019).

Photo 2. Unmaintained grass buffer portion of the Rutledge-Wilson park conservation easement (Dec. 3, 2019).

Photo 3. Maintained grass buffer portion of the Rutledge-Wilson park conservation easement (Dec. 3, 2019).

Photo 4. Forested buffer within the Rutledge-Wilson park conservation easement (Dec. 3, 2019).

Photo 5. New outlet structure at the Seminole detention basin (Dec. 3, 2019).

Photo 6. Wetland plants were added to the Frisco Trails detention basin (Dec. 3, 2019).