Identifying Oklahoma Department of Transportation Mitigation Needs and Linking Needs with Opportunity at the Watershed Scale

FY2015, §104(b)(3), CD-01F10501, Project 1, Final Report

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January 2018

INTRODUCTION

The Oklahoma Conservation Commission (OCC) has partnered with the Oklahoma Department of Transportation (ODOT) to estimate Clean Water Act §404 mitigation needs (for wetlands and streams) as a result of ongoing and future road construction projects. Goals for this project were to (1) further build programmatic mitigation capacity by quantifying the spatial distribution of potential wetland and stream impacts and (2) use this knowledge to evaluate the feasibility of mitigation options including In-Lieu-Fee (ILF) programs. Specifically, our objectives were to (1) determine ODOT's current mitigation needs statewide, (2) estimate ODOT's future mitigation needs statewide, (3) based on these results, identify the top three watersheds with the highest potential aquatic resource impacts, and (4) identify potential restorable wetlands in these top watersheds and conduct a cost and feasibility analysis of HUC 8 Service Areas (SAs) for inclusion in an ILF program. This final report fulfills all tasks of the US Environmental Protection Agency (USEPA) Wetland Program Development Grant: FY15 §104(b)(3) CD-01F10501, Project 1.

METHODS

Current ODOT Projects

Estimation of current mitigation requirements for completed and ongoing ODOT projects was conducted through review of existing documentation and GIS analysis. OCC received information on 37 completed and ongoing road construction projects throughout Oklahoma. Available documentation varied by project and therefore estimation of mitigation requirements varied as well. When possible, mitigation plans were utilized to estimate mitigation requirements. These estimates are likely to be the most accurate, because these are based on assessed impacts to wetlands and streams within a construction footprint. When mitigation plans were not available, estimates were derived from "Jurisdictional Waters and Wetlands" documentation completed within National Environmental Policy Act (NEPA) footprints. When "Jurisdictional Waters and Wetlands" reports were unavailable, we estimated potential impacts to wetlands and streams in ArcGIS 10.4. The population of wetlands within project footprints was selected from the National Wetlands Inventory (NWI), and the population of streams and rivers was selected from the National Hydrography Dataset (NHD). Estimates of wetland and stream impacts are likely to vary based on the method used for estimation. Impacts based on mitigation plans use actual construction footprints and have the highest degree of certainty. Impacts assessed based on the "Jurisdictional Waters and Wetlands" evaluation follow the NEPA footprint, which uses a larger project area and may overestimate impacts. Finally, impacts based on GIS analysis, lack ground-truthing of wetland and stream locations and introduce potential error from GIS datasets.

Future ODOT Projects

We also estimated potential mitigation liability for future road construction projects outlined in the 8-year ODOT work plan (2016-2023) in ArcGIS 10.4. The spatial layer of future road construction projects initially consisted of 1,679 projects. Of these, 874 projects were believed to have no impacts and were removed. Projects with no wetland or stream impacts included right-of-way purchases and utilities projects. Road resurfacing and pavement rehabilitation were also removed from potential impact estimation, because mitigation (if required) would have been completed at the time of road construction. The final project layer used in analysis contained 805 projects.

Wetlands (NWI) and streams (NHD) adjacent to future road construction projects were considered potential mitigation liabilities. Potential wetland and stream impacts were calculated at both 100 ft and 200 ft buffers using the "buffer analysis" tool in ArcGIS 10.4. We used the intersect tool to identify areas in which NWI polygons fell within the buffered regions. In many cases, projects were in close proximity and buffered regions overlapped, resulting in a duplication of potential wetland impacts. To resolve this issue, we used the “find identical” tool to locate every instance in which wetland impacts may have been duplicated. Each potential duplication was manually reviewed to confirm if in fact, a NWI polygon had already been accounted for and all duplicated polygons were removed. NWI polygons were categorized based on wetland type (e.g. forested, emergent, etc.). The same process was repeated using the NHD layer to identify streams within buffered regions to represent potential impacts. We further refined stream impacts based on Strahler stream order. Streams were separated into two categories, Strahler Order 1-2 to represent possible ephemeral or intermittent streams, and Strahler Order 3-7 to represent perennial streams. Results were summarized by HUC 8 watershed, which represent potential ILF SAs.

Impact Assessment Scales

We reviewed past and current project documents (i.e., biological studies, construction plans, and mitigation project plans) to determine the relationship between project types (e.g., grade, drain, and surface, bridges and approaches, etc.) and the spatial extent of wetland and stream impacts. Initially, our goal was to determine an average distance at which aquatic resources are impacted due to a specific project type. After an extensive review, it became apparent that impacts vary across different project types, but they also vary significantly within the same project type due to a difference in project scope. For instance, a specific bridge rehabilitation project may impact wetlands or streams within 150 ft, whereas the impact zone may only be 100 ft for a different bridge rehabilitation project. Thus, we concluded that impacts must be assessed on a case-by-case basis and it would be difficult to assign a specific impact distance to each project type. Therefore, with guidance from ODOT staff, we identified two relevant scales (100 ft and 200 ft) at which to estimate potential impacts. A distance of 100 ft is more reflective of typical construction footprints, while the 200 ft distance represents the NEPA footprint and increases certainty in including all potentially impacted aquatic resources.

Stream and wetland impacts estimated for future project area buffers simply represent the length of streams and the areal coverage of wetlands. The actual impact to aquatic resources due to road construction projects will be significantly lower than those projected for this report. The impact estimates calculated for this project were derived for a preliminary feasibility determination of ILF SAs. As such, these impact estimates should be considered a means of comparing the relative abundance of the intersection of construction projects and aquatic resources between HUC 8 watersheds. The potential mitigation estimates in this report should not be considered an absolute measure of mitigation liability within a watershed. To create certainty in these estimates, more detailed knowledge of construction footprints and ground-truthing of aquatic resource locations will be necessary.

Restorable Wetland Identification Protocol (RWIP)

Our final objective was to apply the Restorable Wetlands Identification Protocol (RWIP) (OCC 2016) within each of the three watersheds with the greatest mitigation needs based on the number and extent of current and future ODOT construction projects (i.e., Lower Neosho Watershed, Deep Fork Watershed, and Lower North Canadian Watershed). The RWIP consists of three components (1) identification of potential historic wetland areas, (2) organization of sites based on the likelihood of restoration success, and (3) prioritization of restoration sites for the improvement of downstream receiving water quality.

The protocol developed to identify potential wetland restoration sites in Oklahoma was based on methods developed in Wyoming (Robertson 2012), Wisconsin (Hatch and Bernthal 2008) and Minnesota (Donnelly 2001). The RWIP was conducted in geographic information systems (GIS) and followed the steps outlined in Appendix A. The initial step is to identify where wetlands have likely been lost by comparing the historic extent of wetlands to the current extent. The potential historic extent is approximated by poorly drained soils from the NRCS Soil Survey Geographic Database (SSURGO) and the current extent is represented by the National Wetlands Inventory (NWI). Potential restorable wetlands exist where poorly drained soils occur and no NWI polygons are mapped. These areas were further filtered based on hydrology, topography and surrounding land-use to determine the likelihood of restoration success. Digital elevation models (DEM; 10 meter resolution) were used to identify basins and potentially restorable areas not in basins were excluded. Additionally, poorly drained soils that now occur in high intensity or mid intensity urban areas, water, or barren land-cover were deemed non-restorable. Land-use/land-cover data was obtained from the 2011 US Geological Survey (USGS) National Land Cover Dataset (NLCD). Furthermore, because wetland restoration sites require a water source, we filtered the list of potential restoration locations to ensure that sufficient flow was available to restore wetland hydrology. This was accomplished by creating a flow accumulation layer from DEMs. The degree of flow required was manually determined for each watershed based on best professional judgment of regional climate and drainage patterns.

Finally, the completed potential restorable wetlands layer was prioritized based on the potential for a site to improve the water quality of downstream receiving waters. Each potentially restorable polygon was attributed with (1) wetland size, (2) watershed to wetland ratio, and (3) percent crop and urban land-use within the restorable wetland watershed. These attributes provide information on the degree to which a restored wetland can improve water quality to downstream receiving waterbodies. Larger sites can capture and treat more runoff than smaller sites. Furthermore, sites that are relatively large compared to their watersheds have a greater probability of receiving and treating runoff prior to outflow. Sites surrounded by human-altered land-uses are more likely to receive runoff in need of treatment (e.g. high quantities of nutrients and sediment). Each attribute (e.g. wetland size) is scored 1 to 4. Scores for all three attributes are summed to provide a total possible score ranging from 3 (least likely to improve water quality) to 12 (most likely to improve water quality). For each attribute the scores (i.e. 1 through 4) are determined based on the quartiles for all the potentially restorable sites within the study watershed. For example, the largest 25% of sites within a specific watershed are given a score of 4 for the wetland size attribute, while the smallest 25% receive a score of 1. For each potentially restorable wetland, all attributes are also scored on a statewide scale with pre-determined thresholds set for the entirety of Oklahoma. Calculating the attribute on watershed and statewide scales allows for the comparison of sites to determine optimal restoration locations both within a watershed and for all of Oklahoma. More information on the development of the RWIP can be found in OCC (2016).

RESULTS and DISCUSSION

Current Mitigation Needs

The 37 current ODOT projects occur within 24 HUC 8 watersheds and 25 counties across the state (Figure 1). Of these, 33 projects involve bridge work, and the remaining 4 are grade, drain, and surface or widen and resurface projects. These ODOT projects have the potential to impact 83.15 acres of wetlands (75.6 ac of palustrine and 7.55 ac of lacustrine wetlands; Table 1). Additionally, current projects have the potential to impact 72,964.4 ft. of streams (21,430.5 ft. of ephemeral, 39,845.9 ft. of intermittent, and 10,892.6 ft. of perennial streams; Table 2). The greatest potential wetland impacts occur within the Poteau watershed and the greatest potential stream impacts occur within the Lower Canadian-Deer watershed.

Future Mitigation Needs

A total of 688 road projects have potential wetland (NWI) and/or stream (NHD) impacts. Of the projects with expected impacts, 67% involve bridge work (Table 3). A summary of the potential aquatic resource impacts within HUC 8 watersheds is presented in Table 4. Subsequent tables and figures present potential impacts to wetlands at 100 ft (Figure 2; Table 5) and 200 ft (Figure 3; Table 6) scales within each HUC 8 watershed. Potential impacts to streams at 100 ft are presented in Figure 4 and Table 7. Potential stream impacts at 200 ft are presented in Figure 5 and Table 8. Within 100 ft of projects, we found 525.2 acres of potentially impacted wetlands, of which almost half were riverine wetlands. Within 200 ft, we found 1426.1 acres of potentially impacted wetlands, with the majority being freshwater forested/shrub and riverine wetlands. Additionally, we observed 194,820 ft. of potentially impacted streams within 100 ft of projects (Figure 4; Table 7) and 449,805 ft. of streams within 200 ft (Figure 5; Table 8). These numbers are estimates and should only be used to compare relative impacts between HUC 8 watersheds.

We also identified the three watersheds with the greatest aquatic resource impacts (Figure 6). The Lower Neosho watershed has the highest acreage of potentially impacted wetlands within 100 ft (35.9 ac) and 200 ft (99.7 ac) of future projects. There is also one current project in the Lower Neosho watershed with potential impacts of 2.89 acres of wetlands and 2,733 ft of streams.

The Deep Fork watershed has the greatest length of potentially impacted streams within 100 ft and 200 ft of projected road projects. Currently there are three road construction projects in the Deep Fork watershed with potential impacts on 0.41 acres of wetlands and 3,597 ft of streams. Lastly, the Lower North Canadian watershed has the highest number of future projects, 62, of which 42 are expected to have wetland and/or stream impacts. An additional three current projects occur within the Lower North Canadian watershed with potential wetland impacts of 0.75 acres and 8,988 ft of stream impacts. Other watersheds with relatively large potential impacts to aquatic resources include Lower Cimarron, Middle Washita, and Lower Canadian- Walnut.

RWIP Results

The RWIP identified 131 potential wetland restoration sites in the Lower Neosho Watershed. Sites ranged from 0.5 to 109 acres, with a median of 1.9 acres. Of which, 26 received scores of 10 or above for potential to improve water quality within the watershed. The RWIP identified 225 potential wetland restoration sites in the Deep Fork Watershed. Sites ranged from 0.5 to 80.2 acres, with a median of 2.1 acres. Of those sites, 40 received scores of 10 or above for potential to improve water quality within the watershed. Lastly, 1,105 potential wetland restoration sites were identified in the Lower North Canadian Watershed. We determined that it is unrealistic to priortize such a high number of sites, therefore we narrowed our criteria for this watershed. We increased the minimum wetland size from 0.5 to 1.0 acre and increased the minimum degree of flow for the watershed from 500 to 1,500 pixels. With the updated criteria, the RWIP identified 487 potential wetland restoration sites. Sites ranged from 1.0 to 109 acres, with a median of 3.3 acres. Of which, 90 sites received scores of 10 or above. RWIP results are summarized by HUC-8 watershed in Table 9. Figures 7 and 8 display the distribution and examples of potential restoration sites.

After, identification of potential restoration sites in each watershed, we entered at least 10 of the highest ranked sites (score of 10-12) into the Wetland Registry (OCC 2014). Among the highest ranked sites, the 10 selected in each watershed were chosen after visual observation of aerial photography. Signs of restoration potential included proximity to water source, marginal hydrology (i.e. wet field or pasture), and obvious hydrologic alteration (e.g. ditching). The Wetland Registry (OCC 2014) is a database that can be queried to identify suitable restoration opportunities that meet the size and location requirements of a party in need of restoration. Fillable forms on the Wetland Program Website (www.wetlands.ok.gov) can be used to request a search of the database.

Initially we planned to field verify a subset of sites in each watershed and gauge landowner interest in pursuing restoration. However, after the initial application of RWIP in the North Canadian Watershed in 2016, we found that while several landowners granted us permission to assess the property, they were generally disinterested in continued communication (OCC 2016). We believe that in general the hypothetical concept of future restoration on private property is too vague to interest most landowners. As a result, given the amount of time required to gain landowner permission, we believe it is more efficient (in most cases) for those in need of restoration to determine the suitability of restoration sites listed in the Wetland Registry. The primary advantage of this being that landowerners are made aware of a more concrete opportunity to generate income through restoration. We plan to continue to add potential restoration sites identified through RWIP in these watersheds to the Wetland Registry as time allows. To date in 2017, we have received 8 requests for Wetland Registry searches. Continued promotion of the Wetland Registry will also be a priority moving forward.

CONCLUSION

ILF has the advantage of grouping impacts from multiple projects into larger restoration efforts, with greater likelihood for restoration success and functionality. Additionally, the permittee can transfer liability from ecosystem impacts to an external entity. When liability is transferred to a state-led conservation program, the goals are to complete restoration with maximum cost-effectiveness and functional benefit for the citizens. Through partnership with ODOT, we have identified watersheds with relatively high potential for both stream and wetland impacts, as well as locations where mitigation may be possible. We believe, pursuing a state-led ILF program for these watersheds would be beneficial. Our goal is that through continued partnership with ODOT, OCC can develop a state-led ILF program for Oklahoma that is bolstered by tools to streamline the identification of restoration opportunities (i.e. RWIP and Wetland Registry). This program would focus on producing functional ecosystem restoration that reduces the monetary expense and work-load for state partner projects.

REFERENCES

Donnelly, C. (2001) Evaluating the Potential of Using a GIS for a Drained Wetlands Inventory: 7-County Metropolitan Area, Minnesota. Minnesota Board of Water and Soil Resources.

Hatch, B and Bernthal T. (2008) Mapping Potentially Restorable Wetlands in the Rock River Basin. Final Report to the US Environmental Protection Agency, Region V. Wetland Grant #CD 96544501-0.

Robertson, A. (2012) Mapping Potentially Restorable Wetlands in Wyoming. Presentation at the Association of State Wetland Managers State/Tribal/Federal Coordination Meeting.

OCC (2017) Identifying Oklahoma Department of Transportation Mitigation Needs and Linking Needs with Opportunity at the Watershed Scale: Estimate of Current and Future Mitigation. FY2015 §104(b)(3) CD 01F10501, Project 1, Oklahoma City, OK.

OCC (2016) Method Development to Incorporate Wetland Resources into Watershed Planning efforts in Oklahoma: Final Report. FY2013 §104(b)(3) CD 00F56801, Project 1, Oklahoma City, OK.

OCC (2014) Wetland Registry: Final Report. FY 2014 §104(b)(3) CD 00F74001, Project 2, Oklahoma City, OK.

FIGURES and TABLES

Figure 1: The locations of current ODOT projects categorized by project type

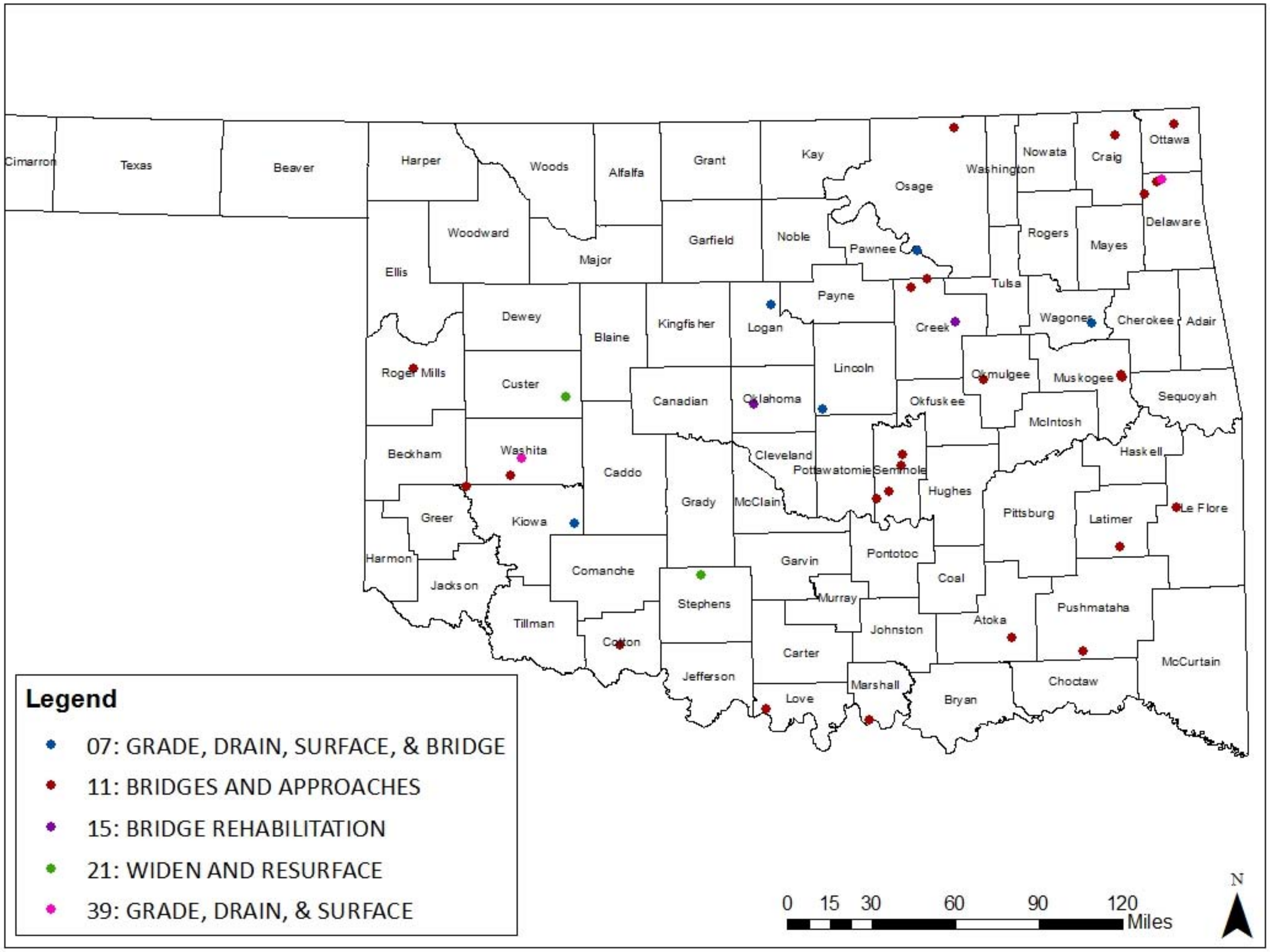


Figure 2: The number of future ODOT projects (p) and potential wetland acreage impacts within 100 ft per HUC 8 watershed.

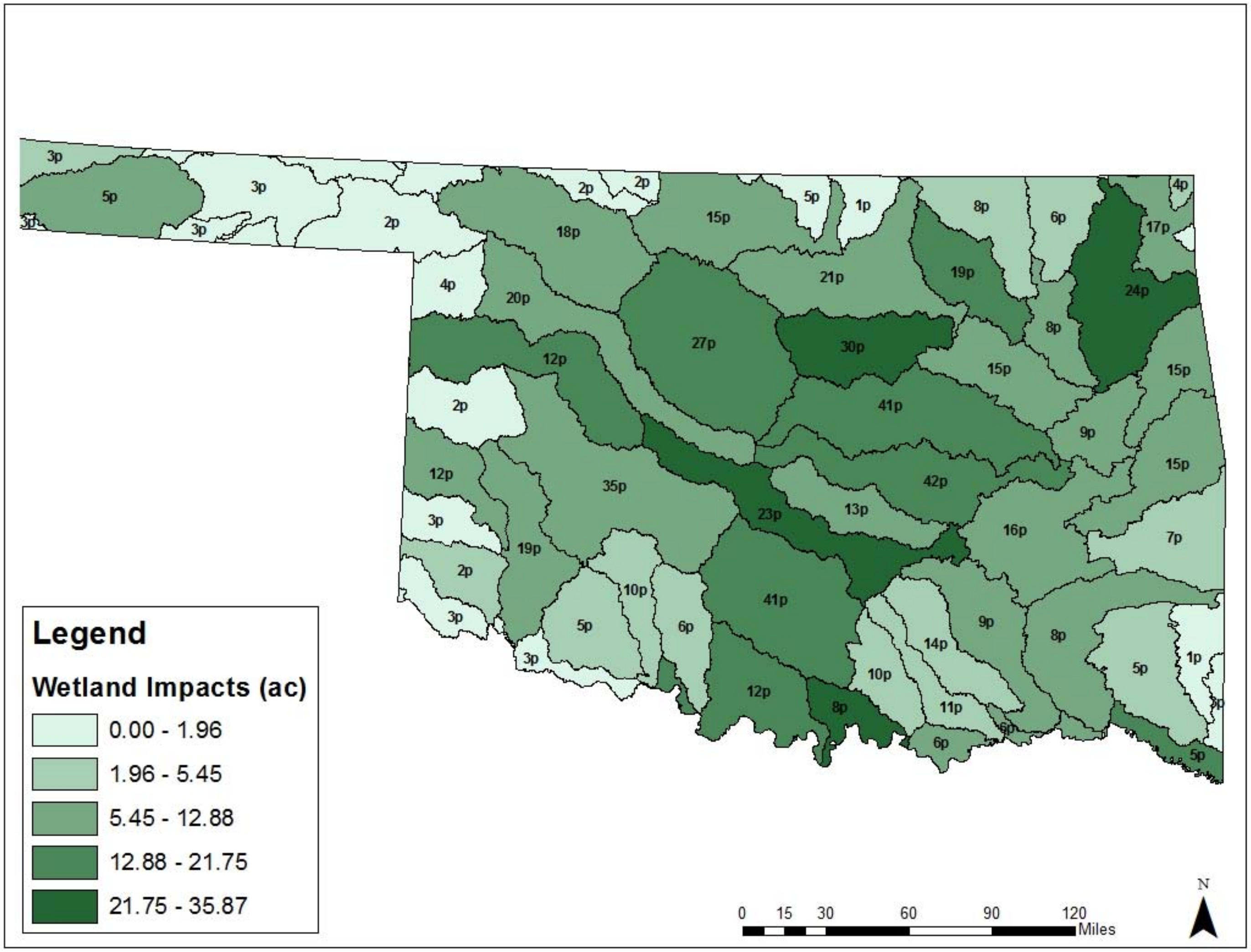


Figure 3: The number of future ODOT projects (p) and potential wetland acreage impacts within 200 ft per HUC 8 watershed.

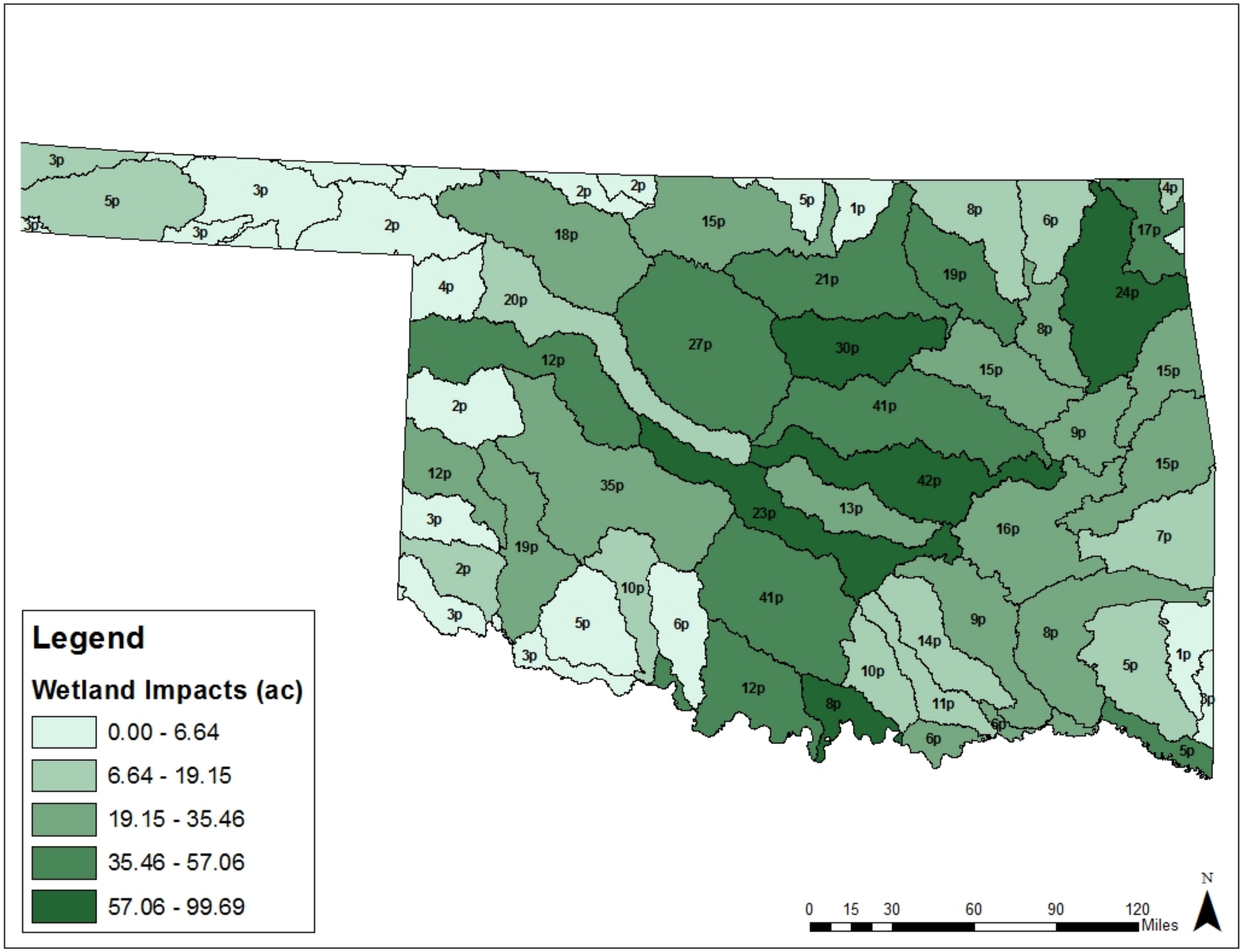


Figure 4: The number of future ODOT projects and potential linear ft. of stream impacts within 100 ft per HUC 8 watershed.

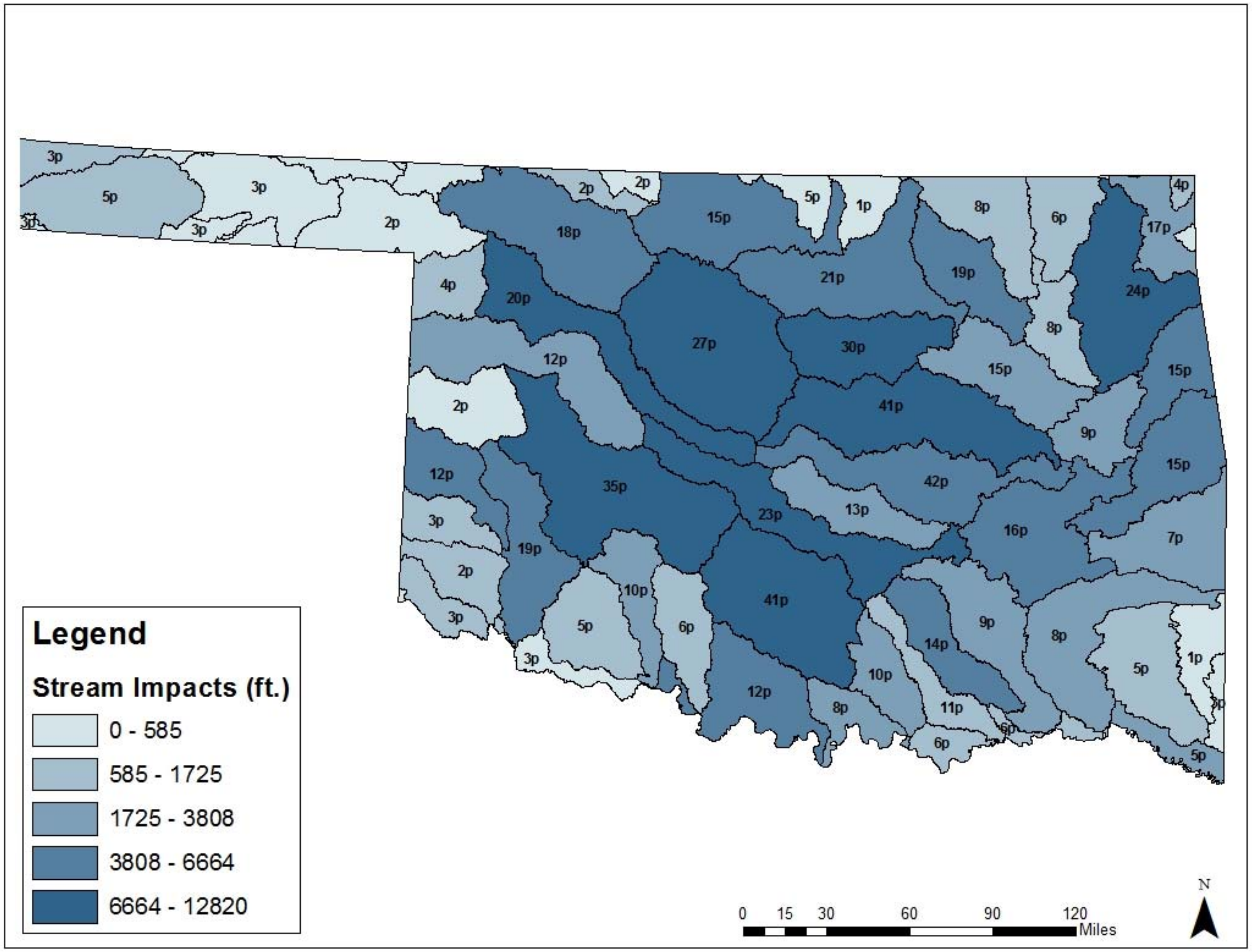


Figure 5: The number of future ODOT projects (p) and potential linear ft. of stream impacts within 200 ft per HUC 8 watershed.

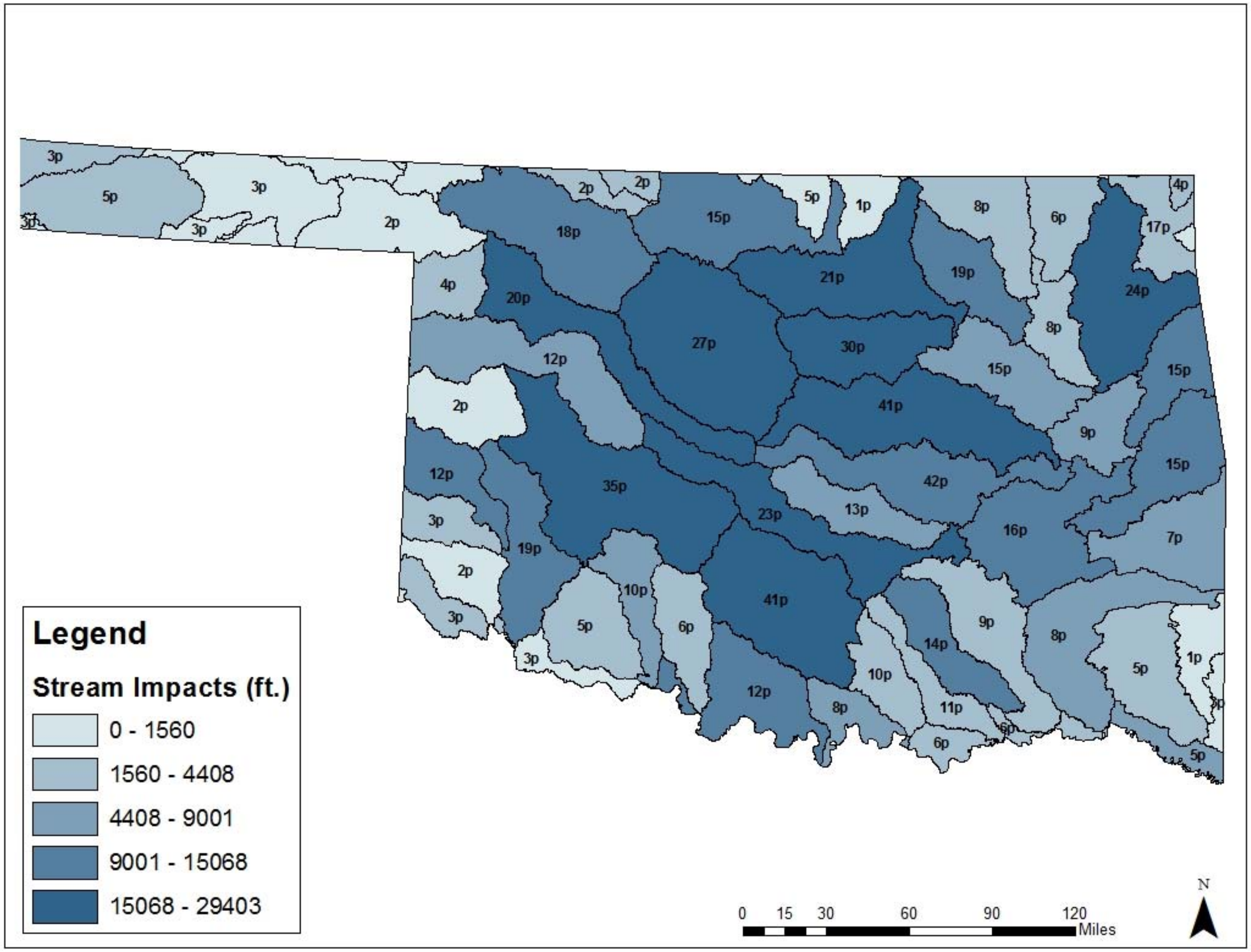
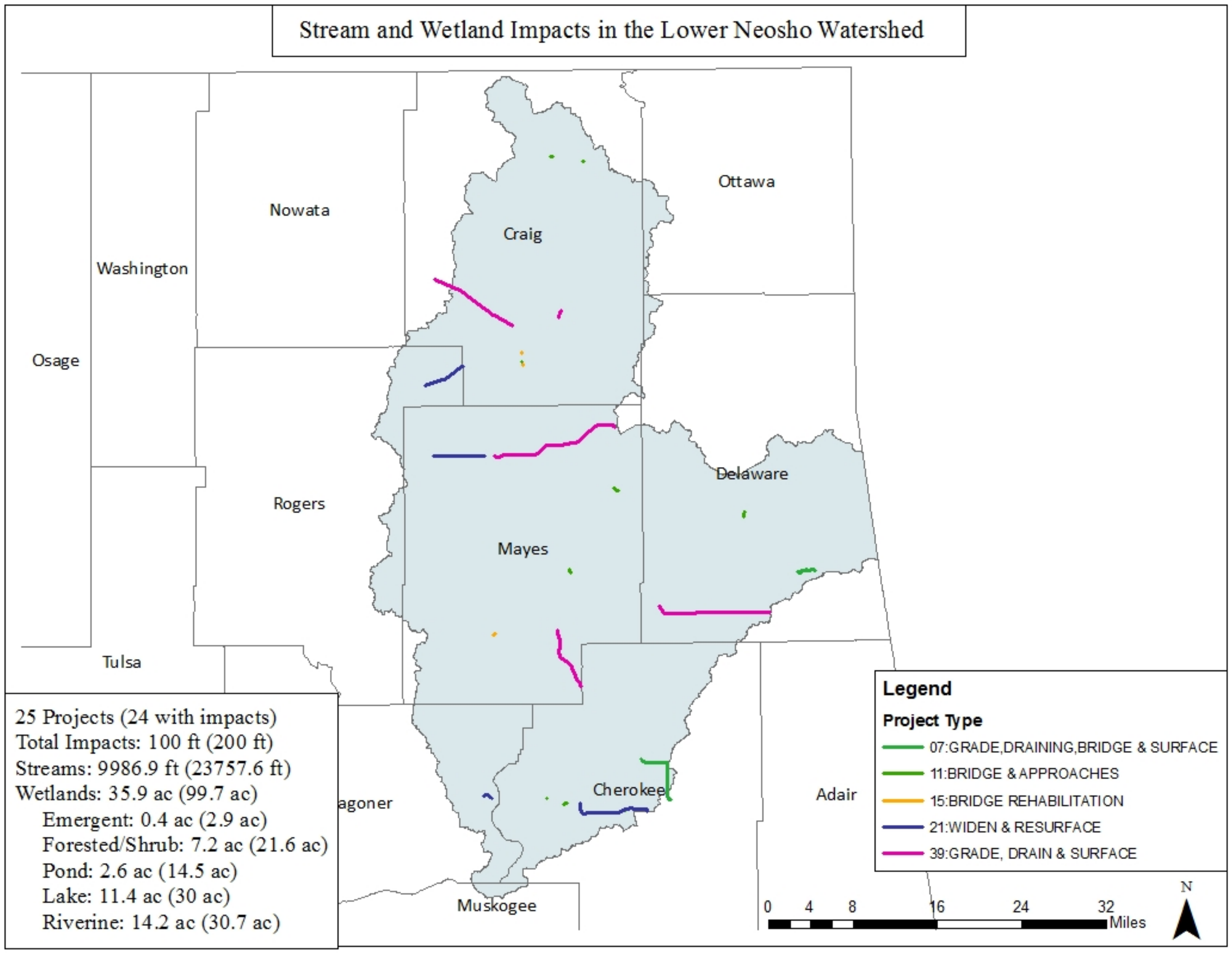
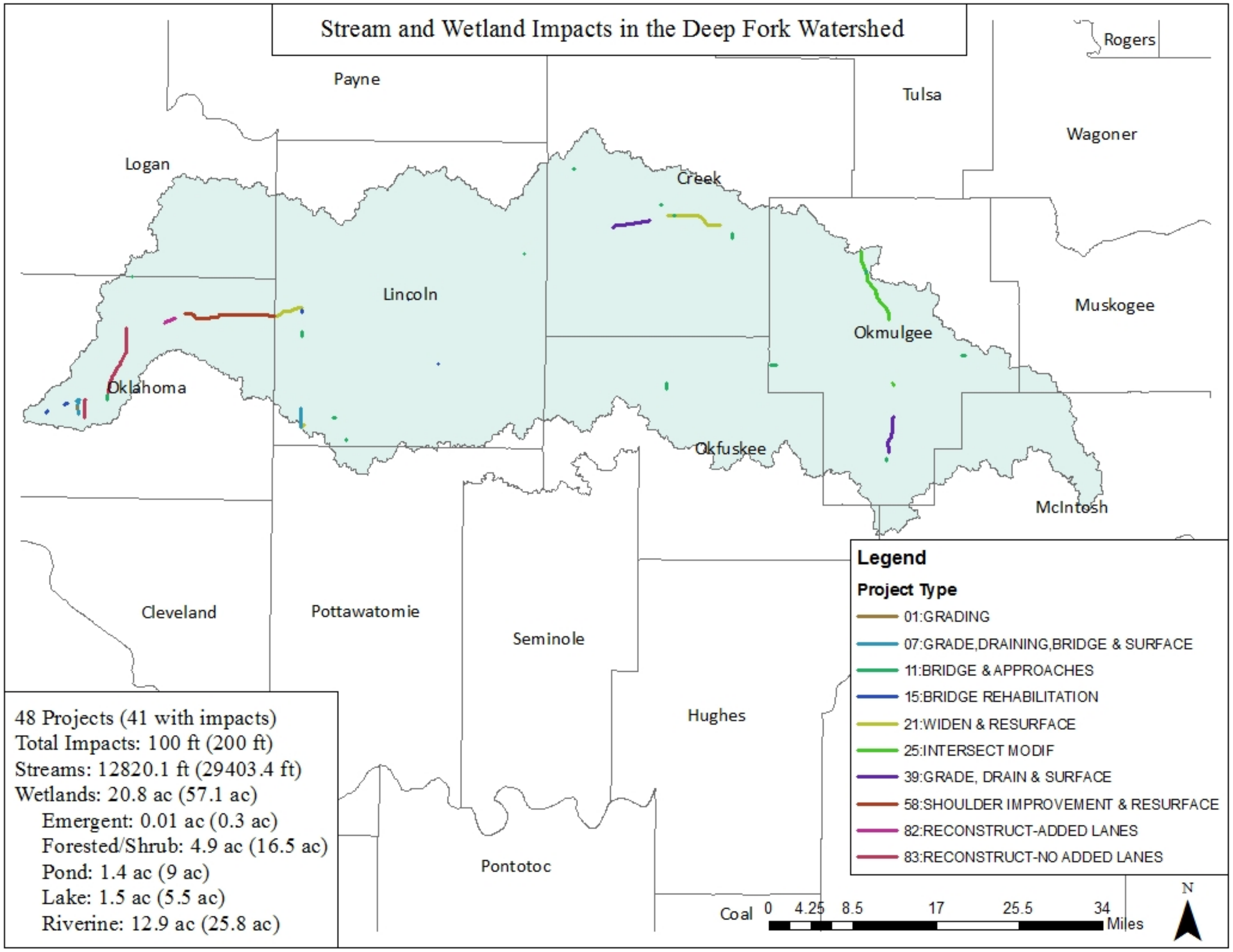


Figure 6: The locations of ODOT projects and potential stream and wetland impacts categorized by project type within the (a) Lower Neosho Watershed, (b) Deep Fork Watershed, and (c) Lower North Canadian Watershed.

(a)



(b)


Stream and Wetland Impacts in the Deep Fork Watershed
Rogers
Payne
Tulsa
Wagoner
Logan
Creek
Lincoln
Muskogee
Okmulgee
Oklahoma
Okfuskee
McIntosh
Legend
Project Type
01:GRADING
07:GRADE,DRAINING,BRIDGE & SURFACE
11:BRIDGE & APPROACHES
15:BRIDGE REHABILITATION
21:WIDEN & RESURFACE
25:INTERSECT MODIF
39:GRADE, DRAIN & SURFACE
58:SHOULDER IMPROVEMENT & RESURFACE
82:RECONSTRUCT-ADDED LANES
83:RECONSTRUCT-NO ADDED LANES
Cleveland
Pottawatomie
Seminole
Hughes
Pontotoc
Coal
0 4.25 8.5 17 25.5 34
Miles
N
48 Projects (41 with impacts)
Total Impacts: 100 ft (200 ft)
Streams: 12820.1 ft (29403.4 ft)
Wetlands: 20.8 ac (57.1 ac)
Emergent: 0.01 ac (0.3 ac)
Forested/Shrub: 4.9 ac (16.5 ac)
Pond: 1.4 ac (9 ac)
Lake: 1.5 ac (5.5 ac)
Riverine: 12.9 ac (25.8 ac)

(c)

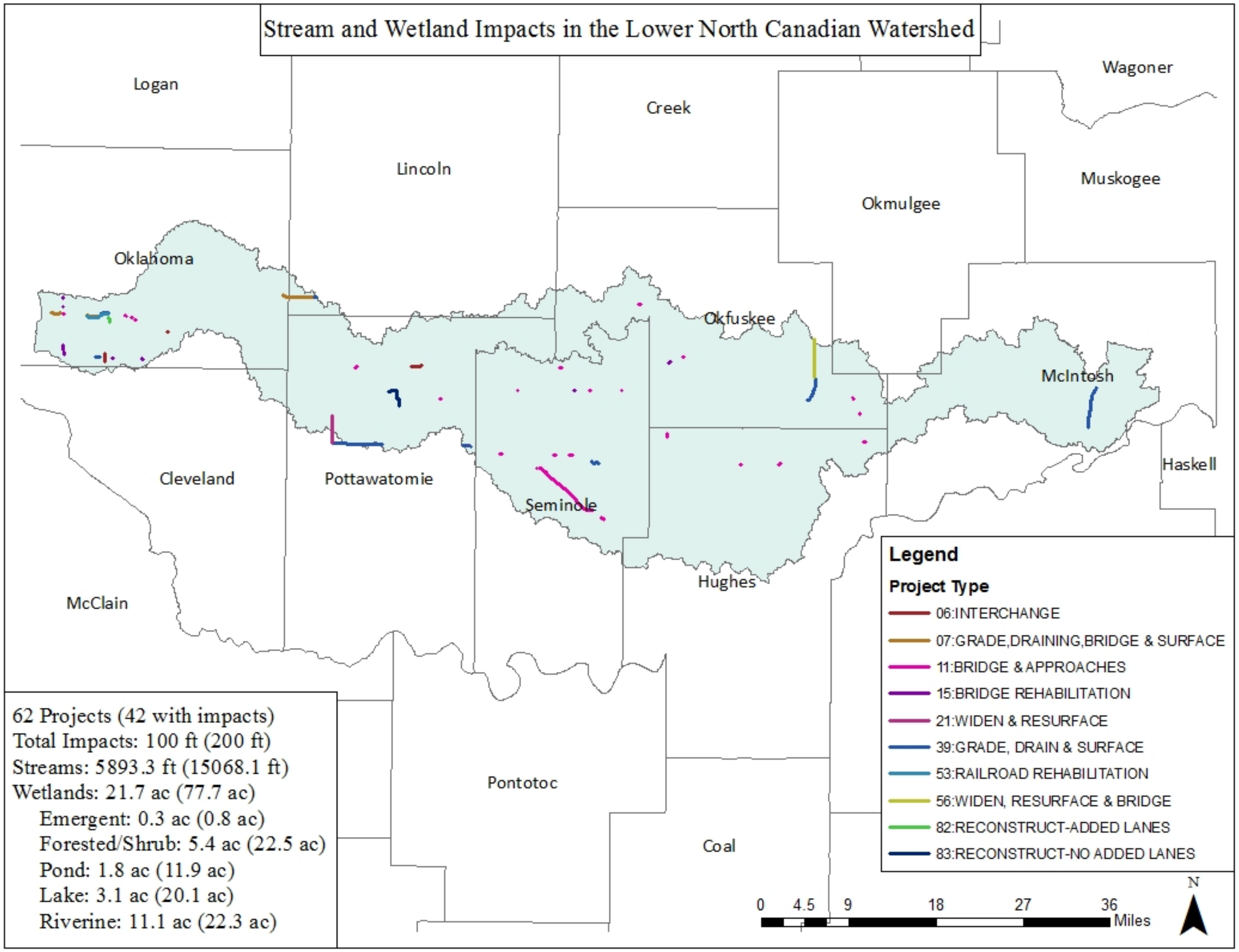
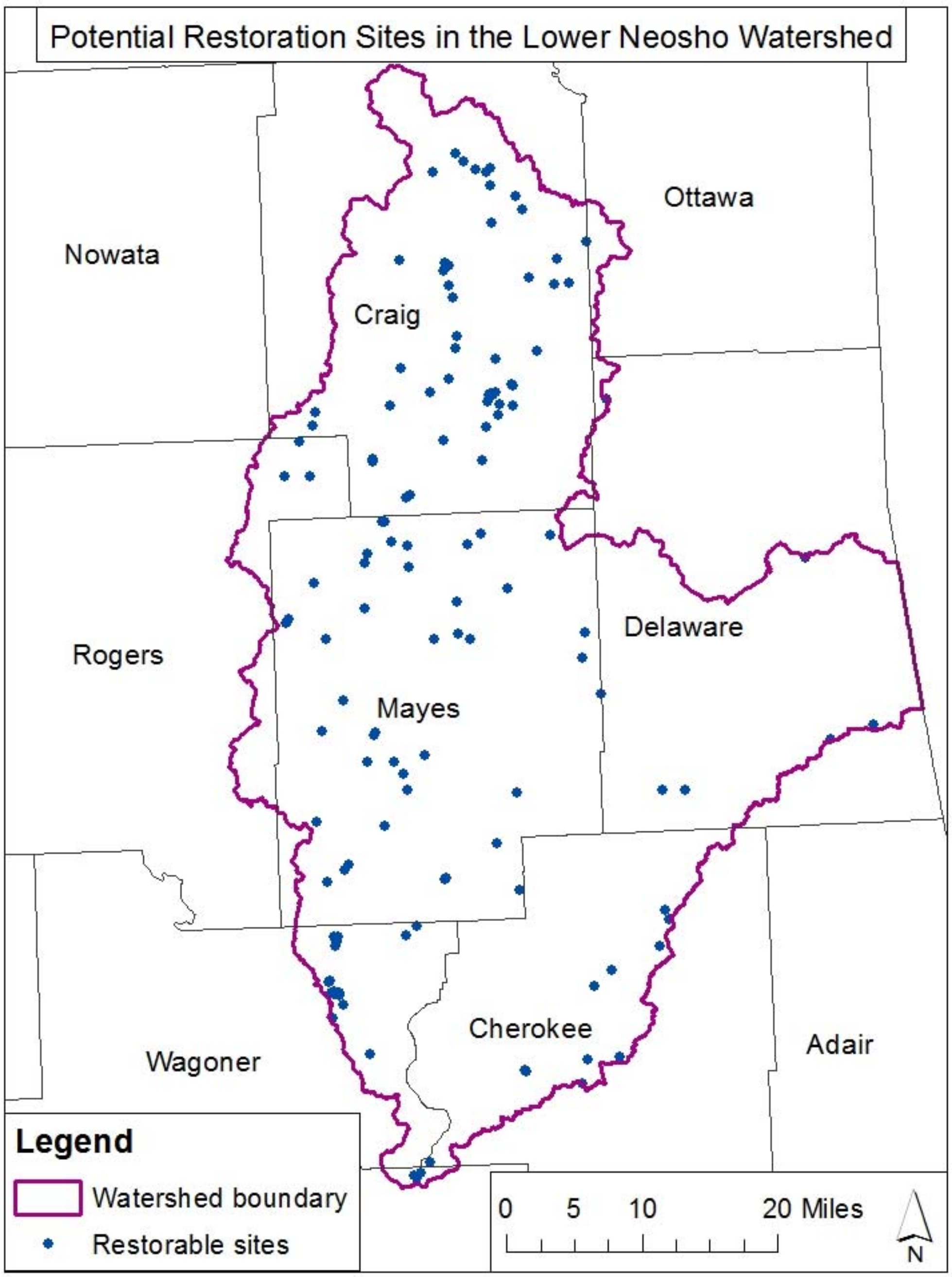
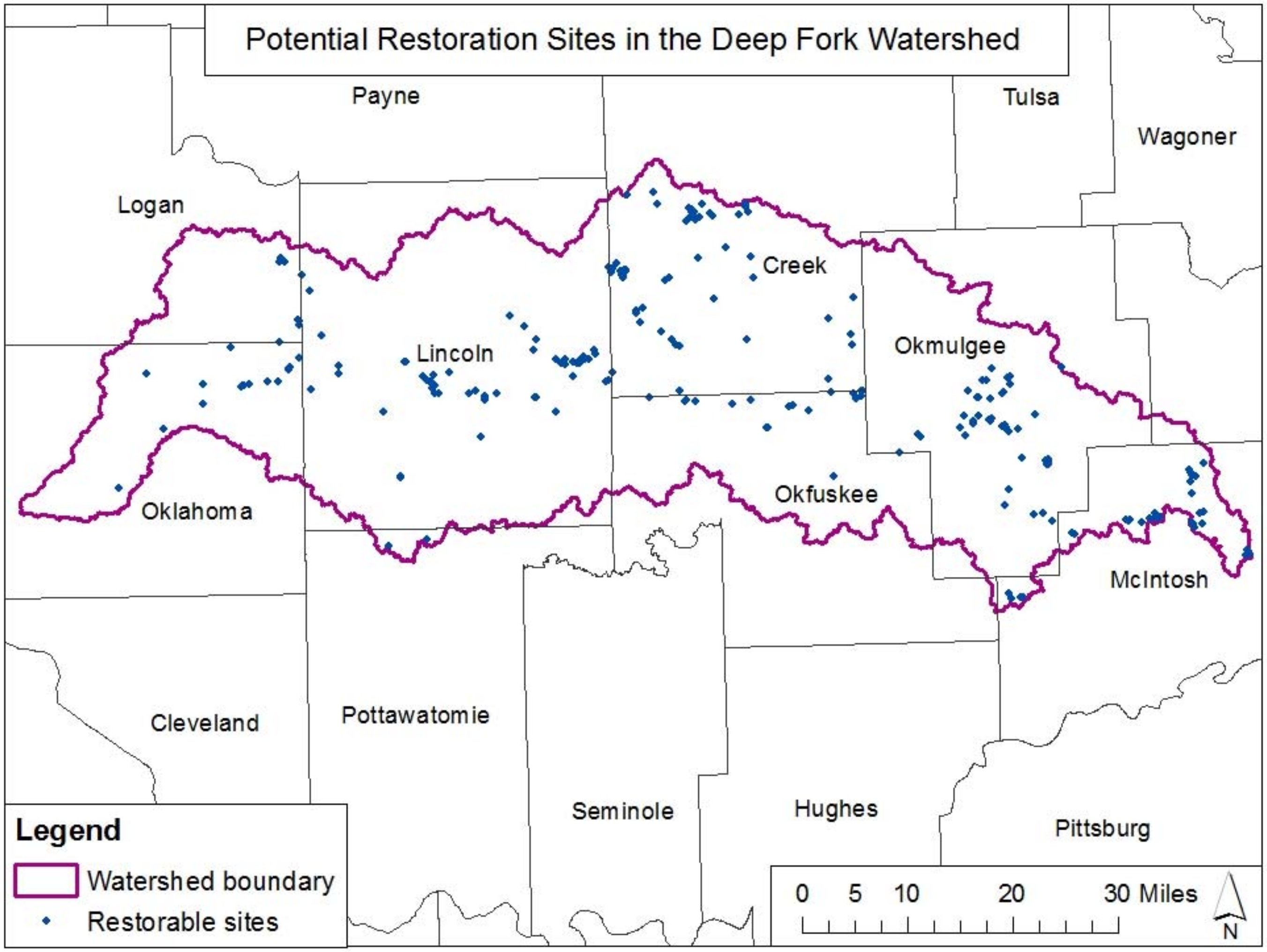

Stream and Wetland Impacts in the Lower North Canadian Watershed
Logan
Creek
Wagoner
Lincoln
Okmulgee
Muskogee
Oklahoma
Okfuskee
McIntosh
Haskell
Cleveland
Pottawatomie
Seminole
Hughes
McClain
Pontotoc
Coal
Legend
Project Type
06:INTERCHANGE
07:GRADE,DRAINING,BRIDGE & SURFACE
11:BRIDGE & APPROACHES
15:BRIDGE REHABILITATION
21:WIDEN & RESURFACE
39:GRADE, DRAIN & SURFACE
53:RAILROAD REHABILITATION
56:WIDEN, RESURFACE & BRIDGE
82:RECONSTRUCT-ADDED LANES
83:RECONSTRUCT-NO ADDED LANES
62 Projects (42 with impacts)
Total Impacts: 100 ft (200 ft)
Streams: 5893.3 ft (15068.1 ft)
Wetlands: 21.7 ac (77.7 ac)
Emergent: 0.3 ac (0.8 ac)
Forested/Shrub: 5.4 ac (22.5 ac)
Pond: 1.8 ac (11.9 ac)
Lake: 3.1 ac (20.1 ac)
Riverine: 11.1 ac (22.3 ac)
0 4.5 9 18 27 36
Miles
N

Figure 7: Locations of potential restoration sites identified through the Restorable Wetland Identification Protocol in the (a) Lower Neosho Watershed, (b) Deep Fork Watershed, and (c) Lower North Canadian Watershed.

(a)



(b)


Potential Restoration Sites in the Deep Fork Watershed
Payne
Tulsa
Wagoner
Logan
Creek
Lincoln
Okmulgee
Okfuskee
Oklahoma
McIntosh
Cleveland
Pottawatomie
Seminole
Hughes
Pittsburg
Legend
Watershed boundary
Restorable sites
0 5 10 20 30 Miles
N

(c)

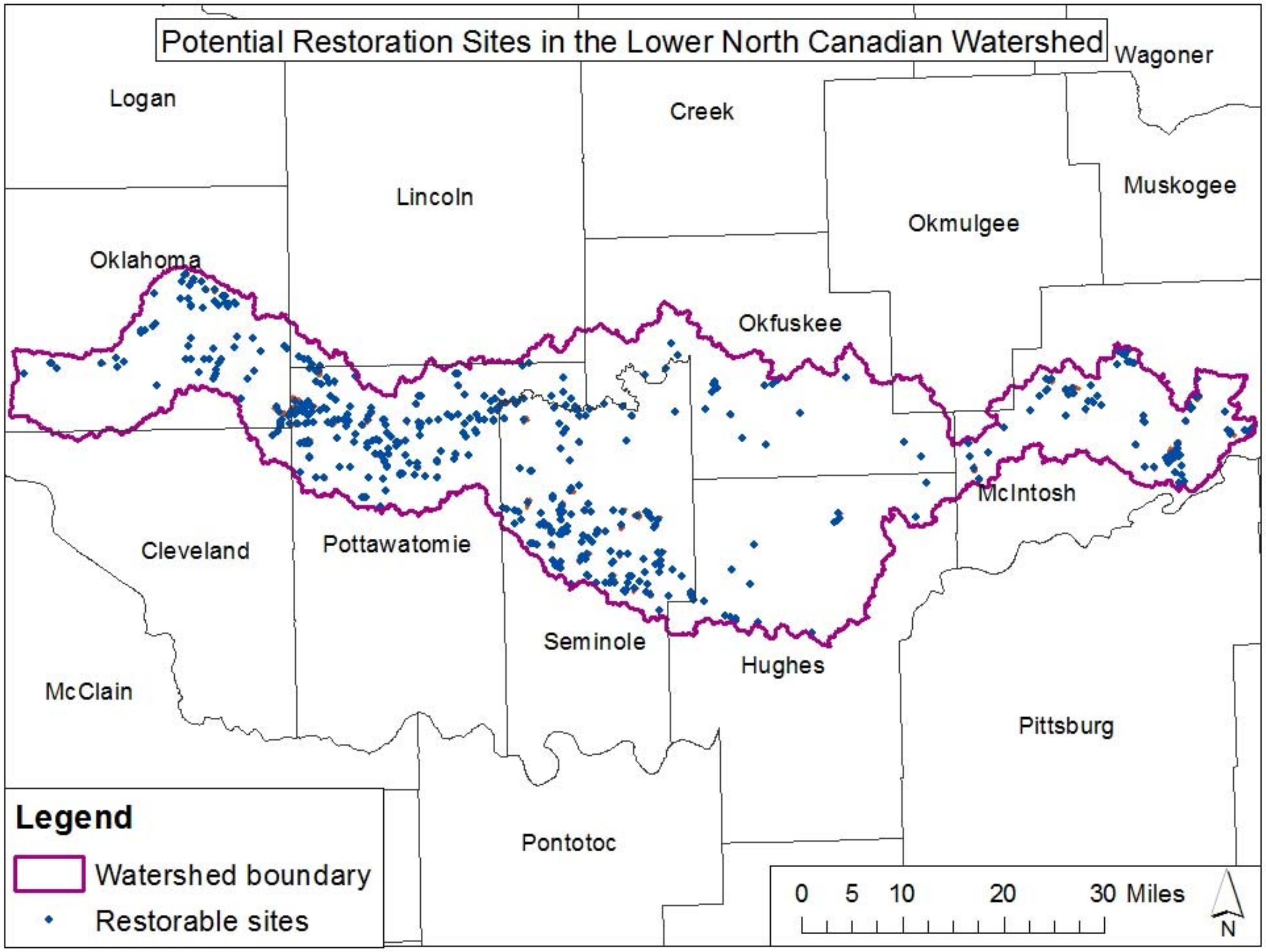
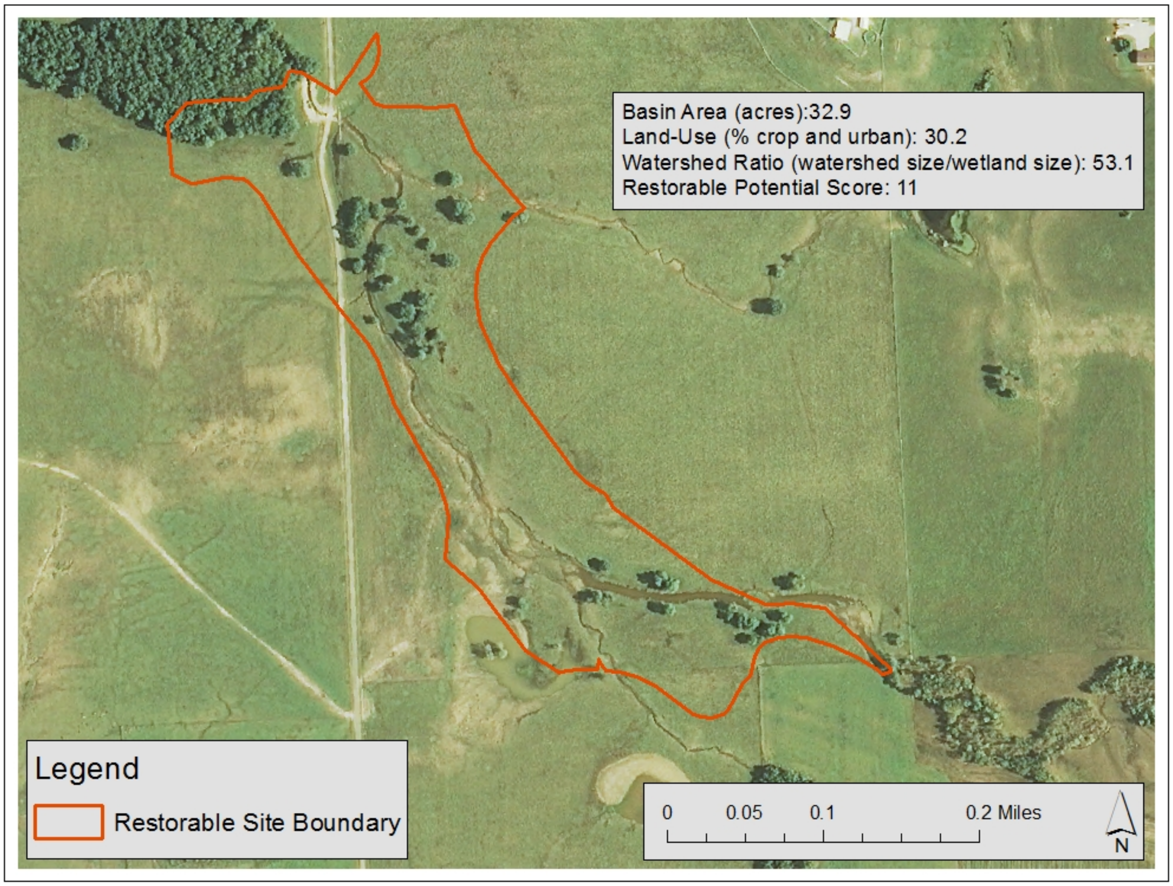
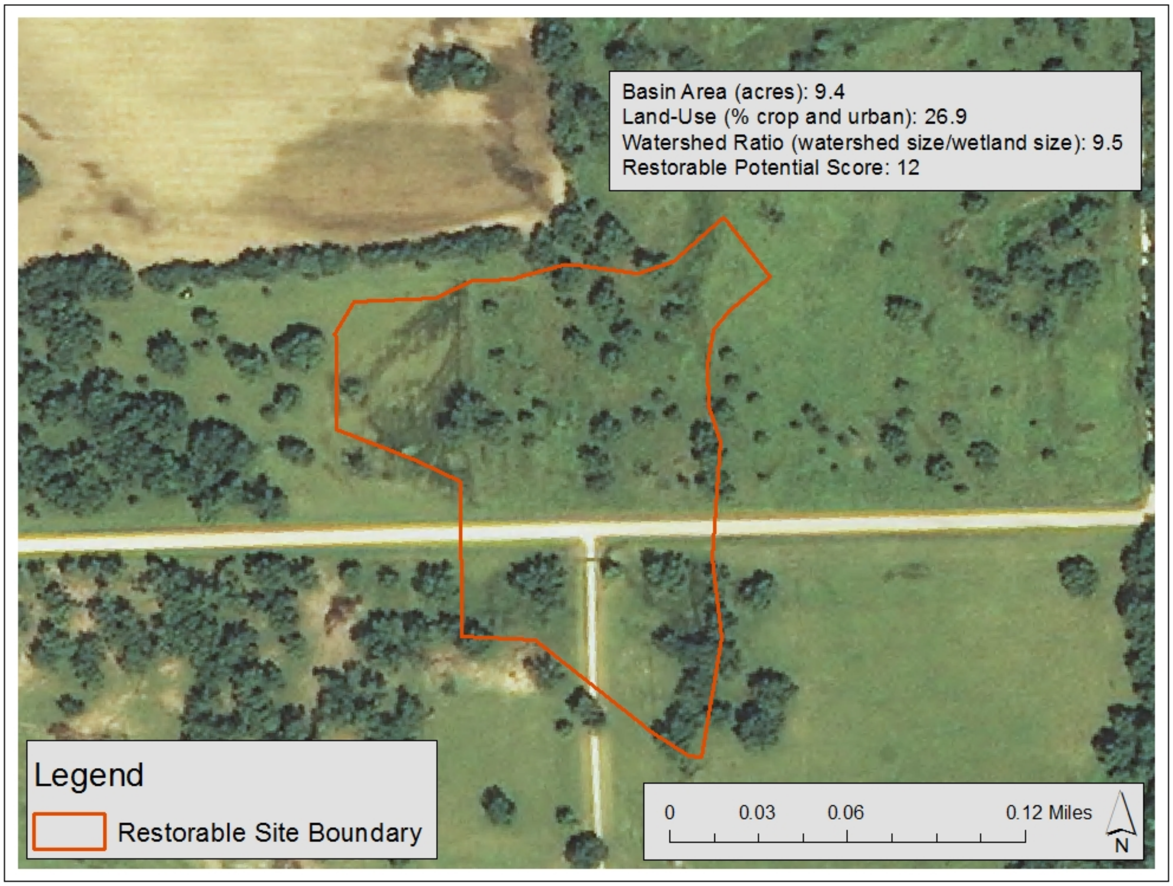

Potential Restoration Sites in the Lower North Canadian Watershed
Logan
Lincoln
Creek
Wagoner
Okmulgee
Muskogee
Oklahoma
Okfuskee
McIntosh
Cleveland
Pottawatomie
Seminole
Hughes
McClain
Pittsburg
Pontotoc
Legend
Watershed boundary
Restorable sites
0 5 10 20 30 Miles
N

Figure 8: Examples of potential restorable sites identified through the Restorable Wetland Identification Protocol in the (a) Lower Neosho Watershed, (b) Deep Fork Watershed, and (c) Lower North Canadian Watershed.

(a)



(b)


Basin Area (acres): 9.4
Land-Use (% crop and urban): 26.9
Watershed Ratio (watershed size/wetland size): 9.5
Restorable Potential Score: 12
Legend
Restorable Site Boundary
0
0.03
0.06
0.12 Miles
N

(c)

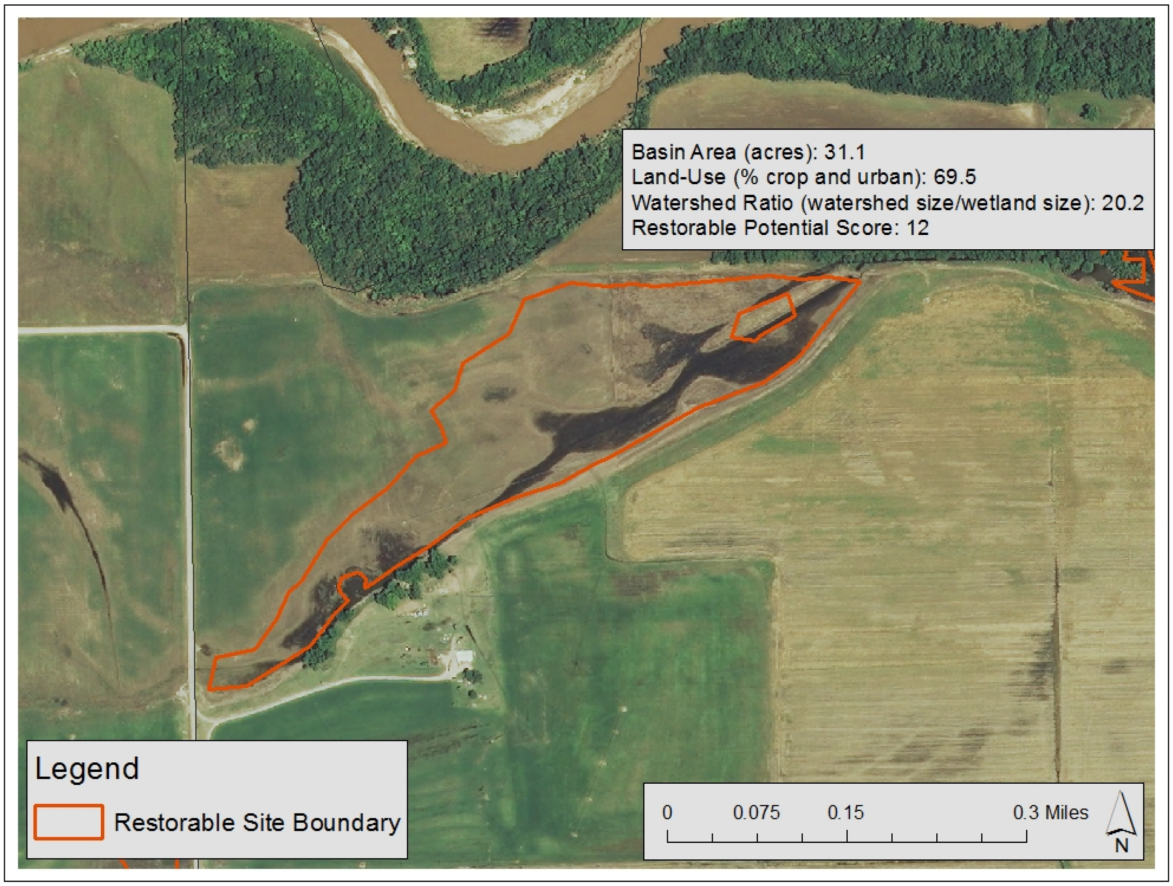

Basin Area (acres): 31.1
Land-Use (% crop and urban): 69.5
Watershed Ratio (watershed size/wetland size): 20.2
Restorable Potential Score: 12
Legend
Restorable Site Boundary
0
0.075
0.15
0.3 Miles
N

Table 1: ODOT potential project impacts to wetlands (ac) based on NEPA or construction footprints for completed or ongoing projects.

Watershed Name	County	Impact Scale	Project type	Palustrine	Lacustrine	Total (ac)
Black Bear - Red Rock	Pawnee	NEPA	07:GRADE, DRAIN, SURFACE, & BRIDGE	0.96	2.52	3.49
Caney	Osage	Construction	11:BRIDGES AND APPROACHES	0.88		0.88
Deep Fork	Lincoln	NEPA	07:GRADE, DRAIN, SURFACE, & BRIDGE	0.41		0.41
Deep Fork	Oklahoma	NEPA	15:BRIDGE REHABILITATION			0.00
Deep Fork	Okmulgee	Construction	11:BRIDGES AND APPROACHES			0.00
Dirty-Greenleaf	Muskogee	NEPA	11:BRIDGES AND APPROACHES	3.80		3.80
Farmers-Mud	Love	NEPA	11:BRIDGES AND APPROACHES	1.13		1.13
Kiamichi	Latimer	NEPA	11:BRIDGES AND APPROACHES	0.70		0.70
Kiamichi	Pushmataha	NEPA	11:BRIDGES AND APPROACHES	0.86		0.86
Lake O' the Cherokees	Delaware	NEPA	11:BRIDGES AND APPROACHES	0.72		0.72
Lake O' the Cherokees	Delaware	NEPA	11:BRIDGES AND APPROACHES		1.67	1.67
Lake O' the Cherokees	Delaware	NEPA	39:GRADE, DRAIN, & SURFACE	1.66	3.36	5.02
Lake Texoma	Marshall	Construction	11:BRIDGES AND APPROACHES	0.99		0.99
Lake Texoma	Marshall	NEPA	11:BRIDGES AND APPROACHES			0.00
Little	Seminole	Construction	11:BRIDGES AND APPROACHES			0.00
Little	Seminole	Construction	11:BRIDGES AND APPROACHES	0.02		0.02
Lower Canadian - Deer	Custer	NEPA	21:WIDEN AND RESURFACE			0.00
Lower Cimarron	Creek	Construction	11:BRIDGES AND APPROACHES	0.46		0.46
Lower Cimarron	Creek	NEPA	11:BRIDGES AND APPROACHES	3.53		3.53
Lower Cimarron	Logan	NEPA	11:BRIDGES AND APPROACHES	0.32		0.32
Lower Neosho	Craig	NEPA	11:BRIDGES AND APPROACHES	2.89		2.89
Lower North Canadian	Seminole	Construction	11:BRIDGES AND APPROACHES			0.00
Lower North Canadian	Seminole	NEPA	11:BRIDGES AND APPROACHES			0.00
Lower North Canadian	Seminole	NEPA	11:BRIDGES AND APPROACHES	0.75		0.75
Lower North Fork Red	Washita	NEPA	11:BRIDGES AND APPROACHES	0.89		0.89
Lower Verdigris	Wagoner	Construction	07:GRADE, DRAIN, SURFACE, & BRIDGE	1.89		1.89
Middle North Fork Red	Kiowa	NEPA	07:GRADE, DRAIN, SURFACE, & BRIDGE	0.04		0.04
Middle Washita	Stephens	NEPA	21:WIDEN AND RESURFACE	0.04		0.04
Muddy Boggy	Atoka	Construction	11:BRIDGES AND APPROACHES	0.63		0.63
Polecat-Snake	Creek	NEPA	15:BRIDGE REHABILITATION			0.00
Polecat-Snake	Muskogee	NEPA	11:BRIDGES AND APPROACHES	1.20		1.20
Poteau	Le Flore	NEPA	11:BRIDGES AND APPROACHES	47.80		47.80
Spring	Ottawa	NEPA	11:BRIDGES AND APPROACHES	0.41		0.41
Upper Washita	Kiowa	NEPA	11:BRIDGES AND APPROACHES	1.45		1.45
Upper Washita	Washita	NEPA	39:GRADE, DRAIN, & SURFACE	0.21		0.21
Washita Headwaters	Roger Mills	Construction	11:BRIDGES AND APPROACHES	0.05		0.05
West Cache	Cotton	NEPA	11:BRIDGES AND APPROACHES	0.92		0.92
Total Impacts				**75.60**	**7.55**	**83.15**

Table 2: ODOT potential project impacts to ephemeral, intermittent, and perennial streams (ft.) based on NEPA or construction footprints for current and ongoing projects.

Watershed Name	County	Impact Scale	Project type	Ephemeral	Intermittent	Perennial	Total (ft.)
Black Bear - Red Rock	Pawnee	NEPA	07:GRADE, DRAIN, SURFACE, & BRIDGE				0.0
Caney	Osage	Construction	11:BRIDGES AND APPROACHES		177.0		177.0
Deep Fork	Lincoln	NEPA	07:GRADE, DRAIN, SURFACE, & BRIDGE		744.0		744.0
Deep Fork	Oklahoma	NEPA	15:BRIDGE REHABILITATION	50.0		1535.0	1585.0
Deep Fork	Okmulgee	Construction	11:BRIDGES AND APPROACHES		1268.0		1268.0
Dirty-Greenleaf	Muskogee	NEPA	11:BRIDGES AND APPROACHES	128.0	712.0	800.0	1640.0
Farmers-Mud	Love	NEPA	11:BRIDGES AND APPROACHES	666.0	359.0	1250.0	2275.0
Kiamichi	Latimer	NEPA	11:BRIDGES AND APPROACHES		1207.0	410.0	1889.0
Kiamichi	Pushmataha	NEPA	11:BRIDGES AND APPROACHES		3441.6		3441.6
Lake O' the Cherokees	Delaware	NEPA	11:BRIDGES AND APPROACHES	840.0		450.0	1290.0
Lake O' the Cherokees	Delaware	NEPA	11:BRIDGES AND APPROACHES				0.0
Lake O' the Cherokees	Delaware	NEPA	39:GRADE, DRAIN, & SURFACE				0.0
Lake Texoma	Marshall	Construction	11:BRIDGES AND APPROACHES				0.0
Lake Texoma	Marshall	NEPA	11:BRIDGES AND APPROACHES				0.0
Little	Seminole	Construction	11:BRIDGES AND APPROACHES		1215.0		1215.0
Little	Seminole	Construction	11:BRIDGES AND APPROACHES		1974.0	10.0	1984.0
Lower Canadian - Deer	Custer	NEPA	21:WIDEN AND RESURFACE	5514.0	4341.0		9855.0
Lower Cimarron	Creek	Construction	11:BRIDGES AND APPROACHES				0.0
Lower Cimarron	Creek	NEPA	11:BRIDGES AND APPROACHES	1619.0			1619.0
Lower Cimarron	Logan	NEPA	11:BRIDGES AND APPROACHES		2440.3		2708.6
Lower Neosho	Craig	NEPA	11:BRIDGES AND APPROACHES	1289.0	1101.0	343.0	2733.0
Lower North Canadian	Seminole	Construction	11:BRIDGES AND APPROACHES	25.0	128.0	1403.0	1556.0
Lower North Canadian	Seminole	NEPA	11:BRIDGES AND APPROACHES		982.0	305.0	1287.0
Lower North Canadian	Seminole	NEPA	11:BRIDGES AND APPROACHES	4304.0	1608.0	232.9	6144.9
Lower North Fork Red	Washita	NEPA	11:BRIDGES AND APPROACHES	134.6		329.5	464.1
Lower Verdigris	Wagoner	Construction	07:GRADE, DRAIN, SURFACE, & BRIDGE				0.0
Middle North Fork Red	Kiowa	NEPA	07:GRADE, DRAIN, SURFACE, & BRIDGE	1513.0	1682.0		3195.0
Middle Washita	Stephens	NEPA	21:WIDEN AND RESURFACE		3914.0	453.0	4622.0
Muddy Boggy	Atoka	Construction	11:BRIDGES AND APPROACHES		1466.0	84.0	1550.0
Polecat-Snake	Creek	NEPA	15:BRIDGE REHABILITATION			100.7	100.7
Polecat-Snake	Muskogee	NEPA	11:BRIDGES AND APPROACHES		1141.0	257.0	1398.0
Poteau	LeFlore	NEPA	11:BRIDGES AND APPROACHES	921.0	5988.0	745.0	7654.0
Spring	Ottawa	NEPA	11:BRIDGES AND APPROACHES		541.0	161.0	702.0
Upper Washita	Kiowa	NEPA	11:BRIDGES AND APPROACHES	506.9		1401.5	1908.4
Upper Washita	Washita	NEPA	39:GRADE, DRAIN, & SURFACE	3920.0	3416.0		7336.0
Washita Headwaters	Roger Mills	Construction	11:BRIDGES AND APPROACHES				0.0
West Cache	Cotton	NEPA	11:BRIDGES AND APPROACHES			622.0	622.0
Total Impacts				**21430.5**	**39845.9**	**10892.6**	**72964.4**

Table 3: Future ODOT projects from the 8-year workplan categorized by project type, and whether each project has potential wetland and/or stream impacts.

Project Type	Projects	Projects with potential impacts
01: GRADING	1	1
03: GRADE & DRAIN	6	4
05: GRADE, DRAIN & BRIDGE	3	2
06: INTERCHANGE	16	10
07: GRADE,DRAINING,BRIDGE & SURFACE	106	96
11: BRIDGE & APPROACHES	336	287
15: BRIDGE REHABILITATION	107	55
21: WIDEN & RESURFACE	76	69
25: INTERSECT MODIF	24	14
30: INTERSECTION MOD. & TRAF. SIGNALS	1	0
39: GRADE, DRAIN & SURFACE	106	90
42: R/R CROSSING SURF	1	0
44: BANK PROTECTION/RIP-RAP	1	1
53: RAILROAD REHABILITATION	1	1
56: WIDEN, RESURFACE & BRIDGE	23	23
58: SHOULDER IMPROVEMENT & RESURFACE	16	15
65: SHOULDER REHAB.	1	1
82: RECONSTRUCT-ADDED LANES	9	6
83: RECONSTRUCT-NO ADDED LANES	17	13
Total Impacts	**851**	**688**

Table 4: Summary of the number of projects, projects with impacts, and potential stream and wetland impacts per HUC 8 watershed for future projects.

Watershed Name	Projects	Projects with Impacts	100 ft Stream (ft)	200 ft Stream (ft)	100 ft Wetlands (ac)	200 ft Wetlands (ac)
Bird	29	19	4744.4	11065.6	16.2	41.8
Black Bear-Red Rock	27	21	6664.1	18364.1	9.4	40.4
Blue	11	11	1276.7	2787.1	3.9	11.7
Blue-China	3	3	584.8	1309.8	1.1	5.5
Bois D'arc-Island	6	6	1078.7	2911.1	8.3	24.9
Cache	12	10	3807.7	8812.7	5.1	13.1
Caney	12	8	1227.4	2478.2	4.0	10.5
Chikaskia	9	5	236.5	471.2	1.0	2.1
Clear Boggy	14	14	5565.7	11065.8	5.0	17.6
Coldwater	3	3	391.1	784.4	0.4	0.8
Deep Fork	48	41	12820.1	29403.4	20.8	57.1
Dirty-Greenleaf	12	9	2888.0	5981.7	12.8	31.2
Elm Fork Red	4	3	688.1	2196.8	2.0	4.8
Farmers-Mud	13	12	4661.3	10356.7	16.4	44.6
Groesbeck-Sandy	3	3	692.9	1831.3	0.4	1.1
Illinois	18	15	4270.9	13204.0	9.0	27.3
Kaw Lake	1	1	0.0	0.0	0.2	0.4
Kiamichi	8	8	2787.6	5714.5	9.9	25.2
Lake O' The Cherokees	17	17	2001.8	4211.4	12.9	46.2
Lake Texoma	9	8	2437.4	5968.0	28.5	64.5
Little	15	13	2431.3	5113.3	8.9	24.7
Lower Beaver	3	2	273.1	865.0	0.5	1.3
Lower Canadian	24	16	4297.1	9383.3	12.0	35.5
Lower Canadian-Deer	16	12	3587.0	9001.5	16.5	38.0
Lower Canadian-Walnut	35	23	7870.4	19364.2	26.8	68.1
Lower Cimarron	34	30	9626.2	23724.2	29.1	67.2
Lower Cimarron-Eagle Chief	20	18	5668.2	13143.1	8.0	24.3
Lower Cimarron-Skeleton	31	27	8979.7	24642.4	17.4	49.9
Lower Little Arkansas, Oklahoma	3	3	579.2	1310.6	1.9	4.9
Lower Neosho	25	24	9986.9	23757.6	35.9	99.7
Lower North Canadian	62	42	5893.3	15068.1	21.7	77.7
Lower North Fork Red	20	19	5673.8	12546.2	10.9	28.2
Lower Salt Fork Arkansas	15	15	5775.6	11942.3	9.5	29.3
Lower Salt Fork Red	2	2	771.5	1559.8	4.0	12.4

Watershed Name	Projects	Projects with Impacts	100 ft Stream (ft)	200 ft Stream (ft)	100 ft Wetlands (ac)	200 ft Wetlands (ac)
Lower Verdigris	13	8	1312.5	2620.1	9.3	25.0
Lower Washita	11	10	2012.2	4085.6	3.4	10.0
Lower Wolf	5	4	1373.0	3067.2	1.0	2.0
Medicine Lodge	2	2	393.2	3700.4	1.4	4.4
Middle Beaver	8	3	302.1	602.6	0.7	4.9
Middle North Canadian	25	20	12366.5	18886.2	9.8	19.1
Middle North Fork Red	15	12	5245.9	11271.9	12.3	27.0
Middle Verdigris	6	6	1101.3	2221.4	2.4	11.5
Middle Washita	43	41	9247.8	19877.3	19.1	54.1
Mountain Fork	1	1	0.0	0.0	0.2	0.4
Muddy Boggy	10	9	1940.0	4407.5	10.9	21.3
Northern Beaver	6	6	1725.5	3426.1	2.6	5.7
Pecan-Waterhole	5	5	2918.0	6869.0	20.3	51.9
Polecat-Snake	46	15	2759.8	6906.4	10.7	28.5
Poteau	9	7	1902.8	6021.9	3.6	10.8
Robert S. Kerr Reservoir	17	15	5017.4	10473.6	9.1	25.9
Spring	4	4	686.5	3059.7	2.5	7.6
Upper Beaver	5	5	824.7	1662.9	7.2	15.2
Upper Cimarron	3	3	1507.2	3821.9	5.4	11.0
Upper Little	5	5	1042.3	2108.4	5.5	17.5
Upper Salt Fork Arkansas	2	2	1530.8	2368.0	1.2	1.6
Upper Washita	39	35	7737.8	18378.2	12.0	29.6
Washita Headwaters	2	2	453.8	995.0	0.8	2.5
West Cache	5	5	1180.3	2634.5	3.7	6.6
Total Impacts	**851**	**688**	**194819.7**	**449805.1**	**525.2**	**1426.1**

Table 5: Potentially Impacted Wetlands (ac) categorized by wetland type within 100 ft of future ODOT Projects

Watershed Name	Emergent	Forested/Shrub	Pond	Lake	Other	Riverine	Total Impacts
Bird	1.3	6.2	2.5			6.2	16.2
Black Bear-Red Rock		2.8	0.4	0.4		5.8	9.4
Blue	0.2		1.6			2.1	3.9
Blue-China	0.2	0.1				0.8	1.1
Bois D'arc-Island	0.5	4.2	0.1			3.4	8.3
Cache	0.1	1.0	0.6			3.4	5.1
Caney		0.3	0.1			3.6	4.0
Chikaskia						1.0	1.0
Clear Boggy	0.0	1.0	0.6			3.5	5.0
Coldwater	0.2					0.2	0.4
Deep Fork	0.0	4.9	1.4	1.5		12.9	20.8
Dirty-Greenleaf	0.1	0.2	1.7	7.9		2.9	12.8
Elm Fork Red		0.4				1.6	2.0
Farmers-Mud	0.5	4.1	0.9	0.0	0.0	10.8	16.4
Groesbeck-Sandy			0.0			0.4	0.4
Illinois		1.5	1.0	1.8		4.6	9.0
Kaw Lake						0.2	0.2
Kiamichi	0.3	4.5	1.0	0.8		3.3	9.9
Lake O' The Cherokees	0.0	1.1	1.4	8.1		2.3	12.9
Lake Texoma	0.0	1.4	0.6	24.3		2.2	28.5
Little	0.6	4.3	0.1			3.9	8.9
Lower Beaver		0.3				0.2	0.5
Lower Canadian	0.2	3.8	2.3	2.7		3.1	12.0
Lower Canadian-Deer	8.3	1.4				6.8	16.5
Lower Canadian-Walnut	0.5	10.1	2.3			13.9	26.8
Lower Cimarron	0.5	6.1	0.9	4.1		17.6	29.1
Lower Cimarron-Eagle Chief	0.4	1.8	0.7			5.1	8.0
Lower Cimarron-Skeleton	0.8	5.5	0.5			10.5	17.4
Lower Little Arkansas, Oklahoma		0.4				1.5	1.9
Lower Neosho	0.4	7.2	2.6	11.4		14.2	35.9
Lower North Canadian	0.3	5.4	1.8	3.2		11.1	21.7
Lower North Fork Red	0.7	4.7	0.3			5.2	10.9
Lower Salt Fork Arkansas	2.0	1.8	0.8			5.0	9.5
Lower Salt Fork Red	1.9	0.7				1.3	4.0
Watershed Name	**Emergent**	**Forested/Shrub**	**Pond**	**Lake**	**Other**	**Riverine**	**Total**

Watershed Name	Emergent	Forested/Shrub	Pond	Lake	Other	Riverine	Total Impacts
Lower Verdigris	0.0	1.5	1.1	1.8		4.9	9.3
Lower Washita		0.3	0.2			2.9	3.4
Lower Wolf		0.1				0.9	1.0
Medicine Lodge		0.2				1.2	1.4
Middle Beaver					0.6	0.1	0.7
Middle North Canadian	0.6	1.9	0.7			6.6	9.8
Middle North Fork Red	0.8	7.7	0.2			3.5	12.3
Middle Verdigris	0.6	0.3	0.0	0.7		0.7	2.4
Middle Washita	1.1	4.1	2.1	0.1		11.8	19.1
Mountain Fork						0.2	0.2
Muddy Boggy	2.6	4.1	0.8			3.4	10.9
Northern Beaver		0.4	0.5			1.7	2.6
Pecan-Waterhole	7.4	9.6	1.5			1.7	20.3
Polecat-Snake	0.8	4.2	1.0			4.7	10.7
Poteau		0.2	0.0			3.5	3.6
Robert S. Kerr Reservoir		0.6	0.8	2.2		5.5	9.1
Spring		0.2	0.3			2.0	2.5
Upper Beaver					3.8	3.4	7.2
Upper Cimarron		4.3				1.2	5.4
Upper Little		1.9	0.5			3.1	5.5
Upper Salt Fork Arkansas						1.2	1.2
Upper Washita	0.3	5.0	0.3			6.3	12.0
Washita Headwaters	0.4	0.1	0.0			0.3	0.8
West Cache		0.6	2.3			0.8	3.7
Total Impacts	**34.5**	**134.8**	**38.5**	**70.9**	**4.4**	**242.1**	**525.2**

Table 6: Potentially Impacted Wetlands (ac) categorized by wetland type within 200 ft of future ODOT Projects

Watershed Name	Emergent	Forested/Shrub	Pond	Lake	Other	Riverine	Total Impacts
Bird	5.0	15.6	8.1			13.1	41.8
Black Bear-Red Rock	0.7	10.8	3.8	9.8		15.4	40.4
Blue	0.7	0.1	6.7			4.2	11.7
Blue-China	1.4	1.7	0.0			2.5	5.5
Bois D'arc-Island	1.9	13.7	1.4			7.9	24.9
Cache	0.2	2.4	3.8			6.7	13.1
Caney	0.4	1.3	0.8			8.1	10.5
Chikaskia		0.2				1.9	2.1
Clear Boggy	0.4	5.8	4.0			7.4	17.6
Coldwater	0.4					0.4	0.8
Deep Fork	0.3	16.5	9.0	5.5		25.8	57.1
Dirty-Greenleaf	0.7	2.1	4.2	18.1		6.1	31.2
Elm Fork Red		1.1				3.7	4.8
Farmers-Mud	1.1	14.2	3.8			25.5	44.6
Groesbeck-Sandy			0.3			0.8	1.1
Illinois		3.6	3.5	6.0		14.2	27.3
Kaw Lake						0.4	0.4
Kiamichi	1.4	12.0	3.5	1.6		6.9	25.2
Lake O' The Cherokees	0.8	7.1	7.0	26.7		4.7	46.2
Lake Texoma	0.4	5.0	3.7	49.8		5.5	64.5
Little	1.6	12.7	1.8			8.7	24.7
Lower Beaver		0.9				0.4	1.3
Lower Canadian	0.4	10.3	7.9	10.2		6.7	35.5
Lower Canadian-Deer	17.8	6.9				13.3	38.0
Lower Canadian-Walnut	2.2	21.9	12.7			31.3	68.1
Lower Cimarron	1.1	16.6	4.3	10.1		35.1	67.2
Lower Cimarron-Eagle Chief	2.3	6.1	3.5			12.4	24.3
Lower Cimarron-Skeleton	3.6	15.0	3.8			27.5	49.9
Lower Little Arkansas, Oklahoma		1.5	0.4			3.0	4.9
Lower Neosho	2.9	21.6	14.5	30.0		30.7	99.7
Lower North Canadian	0.8	22.5	11.9	20.1		22.3	77.7
Lower North Fork Red	2.5	14.7	1.1			9.9	28.2
Lower Salt Fork Arkansas	6.0	7.6	3.9			11.8	29.3
Lower Salt Fork Red	3.6	4.0				4.8	12.4
Lower Verdigris	0.4	5.4	5.6	3.6		10.0	25.0
Lower Washita		0.8	3.2			5.9	10.0

Watershed Name	Emergent	Forested/Shrub	Pond	Lake	Other	Riverine	Total Impacts
Lower Wolf		0.2				1.8	2.0
Medicine Lodge		0.6				3.8	4.4
Middle Beaver				0.7	4.0	0.3	4.9
Middle North Canadian	2.8	5.0	1.3			10.0	19.1
Middle North Fork Red	2.3	16.4	0.5			7.8	27.0
Middle Verdigris	1.0	4.1	3.1	1.5		1.9	11.5
Middle Washita	4.3	12.1	12.0	0.2	0.0	25.5	54.1
Mountain Fork						0.4	0.4
Muddy Boggy	2.9	7.7	3.3			7.4	21.3
Northern Beaver		0.8	1.7			3.2	5.7
Pecan-Waterhole	14.1	27.7	5.5			4.7	51.9
Polecat-Snake	0.9	11.0	4.7			11.8	28.5
Poteau		1.5	0.6			8.7	10.8
Robert S. Kerr Reservoir	0.1	2.9	3.2	7.4		12.3	25.9
Spring	1.1	0.6	1.0			5.0	7.6
Upper Beaver					8.3	6.9	15.2
Upper Cimarron		8.3				2.6	11.0
Upper Little	0.1	7.5	2.6			7.3	17.5
Upper Salt Fork Arkansas						1.6	1.6
Upper Washita	1.5	12.6	2.1			13.4	29.6
Washita Headwaters	0.7	0.3	0.8			0.7	2.5
West Cache	0.1	1.6	3.2			1.8	6.6
Total Impacts	**92.9**	**402.3**	**183.6**	**201.1**	**12.2**	**534.0**	**1426.1**

Table 7: Potential Stream Impacts sorted by Strahler Stream Order within 100 ft of future ODOT Projects

Watershed Name	1st-2nd Order Streams ft.	3rd-7th Order Stream ft.	Total Impacts (ft.)
Bird	1809.9	2934.5	4744.4
Black Bear-Red Rock	5487.8	1176.4	6664.1
Blue	899.8	376.8	1276.7
Blue-China	394.0	190.8	584.8
Bois D'arc-Island	812.2	266.5	1078.7
Cache	2800.5	1007.2	3807.7
Caney	845.1	382.4	1227.4
Chikaskia	236.5	0	236.5
Clear Boggy	3524.8	2040.9	5565.7
Coldwater	391.1	0	391.1
Deep Fork	9449.3	3370.8	12820.1
Dirty-Greenleaf	2272.3	615.7	2888.0
Elm Fork Red	630.1	58.0	688.1
Farmers-Mud	3745.1	916.3	4661.3
Groesbeck-Sandy	435.1	257.8	692.9
Illinois	3630.7	640.2	4270.9
Kiamichi	1671.7	1115.9	2787.6
Lake O' The Cherokees	978.7	1023.1	2001.8
Lake Texoma	2095.0	342.4	2437.4
Little	1039.7	1391.6	2431.3
Lower Beaver	247.0	26.0	273.1
Lower Canadian	3195.1	1102.0	4297.1
Lower Canadian-Deer	2952.9	634.2	3587.0
Lower Canadian-Walnut	6713.8	1156.6	7870.4
Lower Cimarron	7966.0	1660.2	9626.2
Lower Cimarron-Eagle Chief	4507.6	1160.6	5668.2
Lower Cimarron-Skeleton	6493.4	2486.3	8979.7
Lower Little Arkansas, Oklahoma	390.0	189.2	579.2
Lower Neosho	7181.7	2805.2	9986.9
Lower North Canadian	4824.7	1068.6	5893.3
Lower North Fork Red	4531.0	1142.7	5673.8
Lower Salt Fork Arkansas	3918.3	1857.3	5775.6
Lower Salt Fork Red	363.9	407.6	771.5
Lower Verdigris	1312.5	0	1312.5
Lower Washita	1816.3	195.9	2012.2
Lower Wolf	991.5	381.5	1373.0
Medicine Lodge	203.8	189.4	393.2

Watershed Name	1st-2nd Order Streams ft.	3rd-7th Order Stream ft.	Total Impacts (ft.)
Middle Beaver	302.1	0	302.1
Middle North Canadian	5220.1	7146.3	12366.5
Middle North Fork Red	4399.5	846.5	5245.9
Middle Verdigris	838.3	263.0	1101.3
Middle Washita	6257.9	2989.9	9247.8
Muddy Boggy	1650.0	290.0	1940.0
Northern Beaver	1536.1	189.3	1725.5
Pecan-Waterhole	2918.0	0	2918.0
Polecat-Snake	1909.0	850.8	2759.8
Poteau	1302.6	600.2	1902.8
Robert S. Kerr Reservoir	3343.3	1674.1	5017.4
Spring	492.3	194.3	686.5
Upper Beaver	628.7	196.1	824.7
Upper Cimarron	1097.5	409.7	1507.2
Upper Little	791.0	251.3	1042.3
Upper Salt Fork Arkansas	1526.6	4.2	1530.8
Upper Washita	6962.0	775.8	7737.8
Washita Headwaters	453.8	0	453.8
West Cache	990.7	189.6	1180.3
Total Impacts	**143378.1**	**51441.6**	**194819.7**

Table 8: Potential Stream Impacts sorted by Strahler Stream Order within 200 ft of future ODOT Projects

Watershed Name	1st-2nd Order Streams ft.	3rd-7th Order Stream ft.	Total Impacts (ft.)
Bird	8119.1	2946.4	11065.6
Black Bear-Red Rock	12349.5	6014.7	18364.1
Blue	2639.3	147.8	2787.1
Blue-China	905.7	404.1	1309.8
Bois D'arc-Island	2531.6	379.5	2911.1
Cache	8158.3	654.4	8812.7
Caney	2057.3	420.9	2478.2
Chikaskia		471.2	471.2
Clear Boggy	9832.2	1233.6	11065.8
Coldwater	397.8	386.6	784.4
Deep Fork	24087.4	5316.0	29403.4
Dirty-Greenleaf	4549.1	1432.6	5981.7
Elm Fork Red	1332.6	864.2	2196.8
Farmers-Mud	7129.8	3226.8	10356.7
Groesbeck-Sandy	1166.5	664.7	1831.3
Illinois	10292.9	2911.1	13204.0
Kiamichi	3729.3	1985.2	5714.5
Lake O' The Cherokees	3926.6	284.8	4211.4
Lake Texoma	5210.0	758.1	5968.0
Little	4311.8	801.5	5113.3
Lower Beaver	397.7	467.3	865.0
Lower Canadian	7353.6	2029.7	9383.3
Lower Canadian-Deer	7019.6	1981.9	9001.5
Lower Canadian-Walnut	16497.5	2866.7	19364.2
Lower Cimarron	16535.8	7188.4	23724.2
Lower Cimarron-Eagle Chief	11412.9	1730.3	13143.1
Lower Cimarron-Skeleton	21407.3	3235.1	24642.4
Lower Little Arkansas, Oklahoma	930.8	379.7	1310.6
Lower Neosho	20817.7	2939.9	23757.6
Lower North Canadian	13450.1	1618.0	15068.1
Lower North Fork Red	9780.5	2765.7	12546.2
Lower Salt Fork Arkansas	10300.0	1642.3	11942.3
Lower Salt Fork Red	738.6	821.2	1559.8
Lower Verdigris	1837.4	782.6	2620.1
Lower Washita	3691.0	394.6	4085.6
Lower Wolf	2291.0	776.2	3067.2
Medicine Lodge	3319.8	380.6	3700.4

Watershed Name	1st-2nd Order Streams ft.	3rd-7th Order Stream ft.	Total Impacts (ft.)
Middle North Fork Red	8421.8	2850.1	11271.9
Middle Beaver	602.6	0	602.6
Middle North Canadian	16510.2	2376.0	18886.2
Middle Verdigris	1844.6	376.9	2221.4
Middle Washita	17415.2	2462.2	19877.3
Muddy Boggy	2721.8	1685.7	4407.5
Northern Beaver	3426.1		3426.1
Pecan-Waterhole	5219.8	1649.1	6869.0
Polecat-Snake	3922.0	2984.5	6906.4
Poteau	3539.0	2482.9	6021.9
Robert S. Kerr Reservoir	6039.7	4434.0	10473.6
Spring	2664.7	395.0	3059.7
Upper Beaver	802.9	859.9	1662.9
Upper Cimarron	3422.7	399.2	3821.9
Upper Little	1723.9	384.5	2108.4
Upper Salt Fork Arkansas	2368.0		2368.0
Upper Washita	14525.5	3852.7	18378.2
Washita Headwaters	602.8	392.1	995.0
West Cache	1480.5	1154.0	2634.5
Total Impacts	**357761.7**	**92043.5**	**449805.1**

Table 9: Potentially restorable wetlands by watershed.

Watershed	Restorable Sites	Potential to Improve Water Quality Score		
		12 through 10	9 through 7	6 through 3
Deep Fork	225	40	111	74
Lower North Canadian	487	90	232	165
Lower Neosho	131	26	58	47

APPENDIX A: GIS processing steps

Identify Restorable Wetlands

1. Create a poorly drained soils layer representing the potential historic extent of wetlands in the study area
    a. **Query** dominant drainage class (extremely poorly drained, poorly drained, somewhat poorly drained)
    b. **Export** to a new shapefile
    c. **Clip** to study area
2. Create National Wetlands Inventory layer representing the current extent of wetlands in the study area
    a. **Clip** to study area
3. Create basins layer
    a. **Fill sinks** on DEM
    b. **Convert** filled DEMs to slope.
    c. **Reclassify** the slope maps to separate 0 values from all other slope values
    d. **Vectorize** reclassed slope maps
    e. **Delete** non-zero slope polygons
        i. Uncheck create multipart features
    f. **Clip** to watershed
    g. **Dissolve** adjacent polygons
4. Create urban land-use layer
    a. **Reclassify** NLCD
        i. 1: Barren, water, developed medium intensity, developed high intensity
        ii. 2: All other cover
    b. Vectorize
    c. **Clip** to area
    d. **Delete** all polygons with a reclassified land-use class of "2"
5. **Union** NWI (layer 2) and poorly drained soils (layer 1)
    a. **Remove** polygons where NWI wetlands currently exist
6. **Union** poorly drained soils with no NWI wetlands (layer 5) with basins (layer 3)
    a. **Remove** basins not on poorly drained soils
    b. **Remove** poorly drained soils not in basins
7. **Union** poorly drained basins (layer 6) with developed land-use (layer 4)
    a. **Remove** developed land
8. Clean up poorly drained basins not developed (layer 7)
    a. **Dissolve** adjacent polygons
    b. **Multipart to singlepart** polygons
    c. Calculate area
    d. **Remove** polygons <0.5 acres
9. Limit polygons by flow
    a. **Fill Sinks** on DEM
    b. **Create flow direction** raster from filled DEM

   c. **Create flow accumulation** raster from flow direction (layer 9b)
   d. Manually determine flow threshold based on climate and drainage patterns (for North Canadian 500 pixel flow or >12.7 acres drainage area was used)
   e. Using **map algebra** on flow accumulation raster (layer 9c) [con(layer>=threshold,1) create a raster of only pixels above determined threshold
   f. Use **stream to feature** with processed flow accumulation raster (layer 9e) and flow direction raster (layer 9b)
   g. **Use select by location** on poorly drained basins (layer 8d) that intersect stream feature (layer 9f)
   h. **Export** selected features to new shapefile called restorable wetlands
      i. Use **trace** to merge polygons with near adjacency (e.g., < 10 meters)

<u>Prioritize Restorable Wetlands</u>

10. **Create** Watershed layer
   a. **Create** new point shapefile called pourpoints
   b. **Create** pourpoints at downstream intersection of restorable wetlands layer (layer 9h) and the flow accumulation raster (layer 9c)
      i. Note: Wetland boundaries can contain multiple pourpoints
   c. **Split** pourpoint layer by attributes to create a new shapefile for pourpoints at each restorable basin
   d. **Snap pour point** layers (layers 10c) to flow accumulation raster (layer 9c)
   e. Use **watershed tool** on snapped pour points (layer 10d) and flow direction layer (layer 9b)
   f. **Vectorize** watershed rasters (layer 10e)
   g. **Merge** watershed vectors (layer 10f)
   h. **Dissolve** merged layer by ID
   i. **Calculate area** for each watershed
11. **Create** crop and urban land-use layer
   a. **Reclassify** NLCD into two classes
      i. 1: All crops and urban land covers
      ii. 2: All others
   b. In Geospatial modeling run **isectpolyrst** and determine percent urban/crop in each watershed
   c. **Join** watershed to restorable wetland basins (layer 9h) by attribute ID
   d. **Export** layer to new shapefile called prioritized restorable wetlands
12. **Calculate** attributes for prioritized restorable wetlands
   a. **Calculate** watershed ratio by creating new field called “wat_rat” and using field calculator (watershed area/restorable basin area)
   b. **Calculate** scores using standard statewide scoring applied for all watersheds in Oklahoma
      i. **Create** four new fields for restorable basin size score (bas_sc), watershed ratio score (rat_sc), land-use score (lu_score) and site score (site_sc)
      ii. Restorable basin score is calculated as follows:
         1. 1: <2.5 acres

2. 2: 2.5-4.99 acres
3. 3: 5.0-9.99 acres
4. 4: >=10.0 acres

iii. Watershed Ratio score is calculated using "wat_rat" as follows:
1. 1: >50
2. 2: 50-20.01
3. 3: 20-10.01
4. 4: <=10

iv. Land-use score is calculated as follows
1. 1: <25% urban and crop
2. 2: 25%-49.99% urban and crop
3. 3: 50-74.99% urban and crop
4. 4: >=75% urban and crop

v. **Sum** restorable basin (bas_sc), watershed ratio (rat_sc) and land-use scores (lu_sc) in the site score (site_sc) field

c. **Calculate** scores specific for each watershed

i. **Create** four new fields for watershed specific restorable basin size score (ws_bas_sc), watershed specific watershed ratio score (ws_rat_sc), watershed specific land-use score (ws_lu_sc) and watershed specific site score (ws_site_sc)

ii. "Ws_bas_sc", "ws_rat_sc" and "ws_lu_sc" are calculated using quartiles.
1. First quartile =1
2. Second quartile=2
3. Third quartile=3
4. Fourth quartile=4

iii. **Sum** "ws_bas_sc", "ws_rat_sc" and "ws_lu_sc" in the watershed specific site score (ws_site_sc) field.

Note: Many of the steps outlined above can be accomplished in batch processor and/or model builder to expedite data processing.